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A Manual on Building Construction

by: Rev. Harold K. Dancy

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A Manual on Building Construction

intermediate
technology Development Group Ltd
International Development Centre,
Parnell House, 26 Wilton Road, London SW1V 1JS.

A Manual of Building Construction

The author of this publication is the Rev. Harold K. Dancy, and it was originally published and copyrighted by the Sudan Interior Mission in 1948 in Toronto, Canada, entitled "Mission Building".

We would like to express our thanks for their kind permission to reprint, and to acknowledge their continuing copyright.

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Intermediate Technology Development
Group Ltd.
International Development Centre,
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FOREWORD

This book was written by Rev. Harold K. Dancy and was originally published under the title "Mission Buildings" by the Sudan Interior Mission, Toronto, Canada in 1948. The Intermediate Technology Development Group Ltd. feel that its exceptional value as a practical field building manual justifies reprinting, and the Mission have kindly granted permission for this so that it can be more widely circulated.

Mr. Dancy was the chief missionary builder for the Mission for many years, and this manual is the outcome of a thorough and wide experience of building under a great variety of ground and climatic conditions in different parts of Nigeria. The manual has since been used by senior staff of ITDG in East Africa, who found its simple and practical instructions could be readily followed and carried out.

Research and training activities carried out by IT Building project staff have revealed a general lack of suitable guidance for managers of small building units in both the private and public sectors. This dearth of suitable training material and facilities is a major constraint on the development of indigenous construction industries, and local contractors.

Thus IT Building have worked out a training methodology that can be used as a basis for a comprehensive construction industry training programme. The foundation of such a programme must be the formulation of long term training strategy which takes into consideration the type and length of courses, the subject area, the level of material, and the selection and evaluation of participants. Within this overall strategy, publications have a part to play and ITDG believes that this particular manual forms a valuable addition to the list of IT Building publications which appears at the back of this volume.

PREFACE

In many lands, Missionaries and Ministers are often compelled to design and/or erect their own buildings. Nearly all of them have done well but would have been glad of some help, for lack of which there has been loss of time, money, materials, energy, and in some instances, of health itself. This volume is sent forth to meet that need.

But, unless we are mistaken, it is a pioneer in its field, cutting a rough trail through the forest, reaching the goal, but admittedly rough and single file at certain points en route. We hope that those who are interested in seeing it develop into a smooth, broad, streamlined highway for all travellers, and at all speeds, will communicate with us at their earliest convenience.

It is inevitable that some readers will at least tend to chafe over the presentation, here and there, which does not suit their particular need or experience. But the material has been prepared for three groups of readers, amateur builders graded as excellent, fair, and those utterly inexperienced and quite without building and mechanical instinct, of both sexes. In an attempt to help the latter we may weary the former.

We believe that the material in some sections of the book could have been used, with varying degrees of profit, right here in the home land.

In distant lands there is a growing number of artisans and contractors who, in seeking to combine Eastern and Western ideas, materials and skills, should find help in these pages.

By certain friends some of the suggestions contained herein may be challenged, but we beg to remind them that as Missionaries we are unable, often, to work in the conventional way, but are compelled, by various circumstances, to do something the best way we can. Hence, the book is not to tell Missionaries what they ought to do, but, a help for them in doing what they must and will do. Its Biblical category is 'helps', I Corinthians, 12:28.

Its over-all purpose is to conserve the time, energy, health, materials and money of those whose chief business it is to preach, in season and out of season, the glorious Gospel of the blessed God, so hastening the return of His Son, Jesus Christ, who loved us and gave Himself for us; and to Him alone be the glory for ever.

H.K.Dancy.

New York,
April, 1948.

ACKNOWLEDGMENTS

We extend our thanks to everyone who has had a part in this work, directly or indirectly.

Our particular thanks are expressed to the following.

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To the Canada Cement Company for literature and correspondence over a period of years.

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Miss Amelia J. Buchanan of the Conservative Baptist Foreign Missionary Society for suggestions about the tile roof.

Rev. P.W. Barnden, M.D., of the Sudan United Mission, Vom, Nigeria, West Africa, for an introduction to metal ant coursing and to weatherproof protection for mud walls.

Theo. Audel & Co., Publishers, New York City, who, by publishing most excellent trade manuals have helped the author through the years.

Rev. Paul London, S.I.M., and Mrs. Dancy for most valued assistance with the architectural drawings; and to my wife also for much tedious labour while preparing the pages for the printer.

Mr. H.B. Courtney, S.I.M., New York, Plumbing Engineer, for counsel in preparing the material in the chapters on Plumbing.

And to the Directorate of the Sudan Interior Mission for the freedom necessary to bring this work to its completion.

While thanking all the contributors for their most acceptable co-operation, we excuse them entirely for error of any kind which may be found in the text.

The Author.

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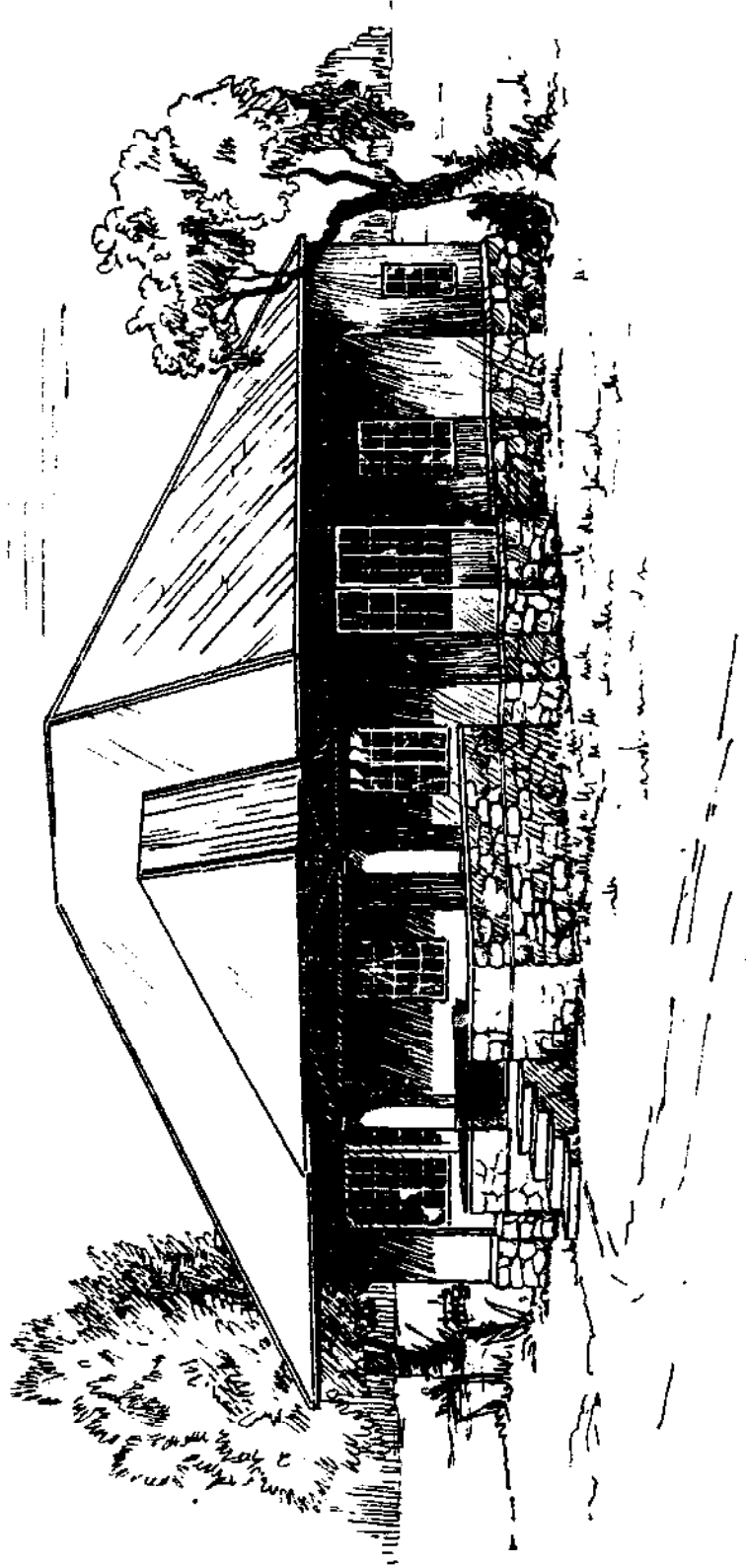
A LIST OF ILLUSTRATIONS

From the 870 illustrations in this book we have selected a limited number, - a conducted tour to points of special interest. The house shown in the Frontispiece is a 'Mission House', and the following list indicates the main drawings essential to its planning and erection. It should be understood that not many 'Mission' houses have the square porch, and of these very few have a porch roof.

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The Mission Home of Rev.S.P.Goertz, Sudan Interior Mission,
Yerwa, Nasarawa P.O. via Gudi, Northern Nigeria.

Designed and erected by the author. Sketch by Rev.C.J.Guth, M.A., S.I.M.

BOOK ONE PREPARATIONS

CHAPTER ONE GENERAL APPROACH

I. SEEKING ADVICE.

BECAUSE in the planning and erection of a building there are many costly pitfalls, and because, for many of us, buildings involve the largest expenditures of our lifetime, therefore we should make every reasonable effort to secure the advice of an architect or an experienced builder.

But when we must build without the advantage of such advice, then let us

1. Plan carefully all that we would make or build.
2. Make all our changes and mistakes on paper.
3. Place all our ideas on paper for the benefit of all those who will have a part in the project, before, during, and after construction.

OUR BUILDING IS AN INVESTMENT AS WELL AS A UTILITY;
AND IN PROPORTION TO THOROUGH PLANNING, THE USE OF
GOOD MATERIALS, LABOUR AND CONSTRUCTION WE WILL AVOID
ENDLESS AND UNNECESSARY EXPENSE, INEFFICIENCY, AND
DISSATISFACTION.

AND, AS A RULE, MISTAKES, WHETHER IN DESIGN
OR CONSTRUCTION, ARE COSTLY, APPARENT, PERMANENT.

II. SELECTING A SITE.

It is unwise to make the final decision on a building design until the site has actually been secured and all its important features are known. A house which is satisfactory on one site will not be so acceptable, necessarily, on another.

Secure information about the conditions on and around the site in all seasons, with respect to its suitability for:

1. Your Health.

Temperature, humidity, altitude; the time, value and direction of winds; soil erosion; swamp; rainfall; the prevalence of disease; proximity to unsanitary conditions or places over which you will have no control; depth of soil; the presence of large masses of rock which radiate heat; the presence and value of trees; whether the site is on a hill or in plain or valley; its proximity to other buildings and the character of those buildings; etc., etc.

2. Your Work. Accessibility to and from the people; centres of population and appeal; government favour; proximity to other work whether of your own society or otherwise; etc.

3. Building Conditions.

Enquire about supplies, labour, weather, building by-laws, restrictions, future developments, etc. Occasionally an area is found which is quite unsuitable for building and/or compound.

4. Environment.

Especially in built up areas. The proxim-

ity of the site to congested areas, institutions, roads, rivers, railways, objectionable features, etc.

5. Utilities.

Water, light, sanitary services, etc.

III. SECURING AUTHORITY.

1. All officers of your society who have anything to do with buildings should be acquainted with the project. The application to plan and build should state what the building is for, why it must be built, its general size and location, and what funds you have for it.

FINAL PERMISSION IN WRITING should be secured upon the basis of approved plans, specifications and estimates before any expenditure is made.

2. Be sure of all necessary Government permission before entering into any financial obligations. Almost invariably this will mean a Government stamp or signature of approval on your plans or in a letter.

Consider the compensation for, or purchase of land; survey fees and requirements, etc.

Native paths and/or roads through a site are sometimes objectionable. Acquaint yourself with the law respecting the closing of such thoroughfares.

3. Inform yourself about municipal building laws and conditions, fees, inspections, sanitation, lighting, etc.

4. Financial ability. Consult those who have erected buildings something like your own. Compare prices and conditions. Be sure that there is enough money to complete a sizeable unit of the work before going to the expense of bringing a gang of workmen to the job. Secure written authority for ceiling expenditure and considerable caution needs to be exercised to keep within that limit. Actual construction must cease before the money is all used up because there are many expenditures connected with closing down a job.

5. Consider the reactions of associates, neighbours, and others who, although they have no authority to hinder the project, may, nevertheless, be so inconvenienced or offended as to make the building more or less a liability to your work.

IV. SCANNING THE FUTURE.

1. Faith. With respect to outlay, it is well to exercise faith and believe that if it is God's will to live and build and work in a certain place, it is also His will to build wisely, adequately. We may not be able to build very much at one time, but we can envisage and draw up a complete set of buildings, and then build permanent units, one at a time if necessary, until at the last an organized, efficient, durable, and attractive plant has been developed to the glory of God.

2. The unit system. It is incomparably more satisfactory to plan a properly appointed house and build it section by section, as able, through a period of time, than it is to restrict the main

plan to something inadequate, and then have to add and alter, or even abandon, never being able to bring it to perfection.

3. Permanence. Determine that every building is to be permanent. To this end, lay out the whole site as for a period of 25 years. Sketch in every possible building and feature. If it is necessary to live in some smaller building until the main dwelling is erected, put up a garage, workshop or kitchen block in its proper place, and of permanent construction.

V. SURVEY OF OPERATIONS.

START EARLY TO PLAN. By early, we mean months or even a year or more ahead. By planning, we mean the policy, the design, the method, the season, the schedule, the builder's arrangements, orders for materials, etc.

We offer the following calendar or schedule as a guide to enable the builder to see at a glance the full scope of building activities so that he may have all the materials, personnel, and preparation ready and moving down the assembly line on time.

GENERAL BUILDING CALENDAR

1. Necessity for the project thoroughly established.
2. Mission approval.
3. Government approval.
4. Financial ability.
5. Conference of interested parties.
6. Rough sketch.
7. Proper drawings and specifications.
8. Estimates.
9. Final authority to go ahead, in writing, Mission and Government.
10. Orders for all materials, labour, transport, etc.
11. Contracts awarded.
12. Lumber sawn or purchased.
13. Bricks made.
14. Work and storage sheds erected.
15. Make scaffold, frames, doors and windows, built in furniture.
16. Local materials gathered.
17. Building site cleared.
18. Construction begun: Layout.
 19. Excavations. (and manufacture of frames if none ready.)
 20. Footings and foundation walls. (Ladders and scaffold, inr.)
 21. Concrete and metal ant coursing. (inr = if none ready.)
 22. Door frames set in wall. (And all arch forms, lintels, inr.)
 23. Main walls built. (And roof frame preparation.)
 24. Roof frame erection. (And ceilings made and erected)
 25. Outside plaster. (And roof covering and completion.)
 26. Plumbing, wiring, built in cupboards, etc.
 27. Inside plaster.
 28. Doors and windows fitted and hung.
 29. Concrete floors, verandahs, steps, foundation pointing.
 30. Interior trim, screens and cupboards, etc.
 31. Painting and glazing.
 32. Grading and drainage.
 33. Inventory, salvage, completed records, wind up whole building project.

CHAPTER TWO DESIGN

I. POLICY.

A wrong policy or attitude will produce trouble in any building enterprise, sooner or later. We therefore suggest that a building policy be formulated, and we offer the following, in their order, as a guide:

1. Efficiency. That is that the completed structure will serve a specific purpose, adequately.

First, let there be sufficient room for all activity, and for furniture, equipment, special features, storage, etc. Arrange the plan so that all occupants will have all reasonable convenience.

Safeguard health by providing sufficient cubic air space, ventilation, insulation, shade, quiet, privacy, damp and insect protection, etc.

Beware lest you curtail the efficiency of a building by a little misapplied economy.

2. Durability. Ruskin says, "When we build, let us think that we build forever." Most of us are not in a position to build forever, but we can at least build durably. We may not be able to afford granite, tile and bronze, but we should not on the other hand assent to shacks for dwellings, schools and churches. Resist the penny wisdom which results in pound foolishness.

Let there be durability to withstand weight and stress, weather and decomposition, wear and abuse, invasion by insects, animals or man.

3. Economy. Design and erect efficient, durable buildings economically. Missionary finance restricts us in style, richness of materials, workmanship and appointments to that which is absolutely necessary. But it is false economy to cut below practical efficiency and sound construction. We repeat, plan what is right, and then when there is enough money to properly build the essentials of one unit, go ahead.

A great deal of waste can be avoided by consulting an experienced builder about the quantity, quality, and use of certain materials: lumber in ceiling and in roof frames; cement principles, etc.

4. Form and Finish. This means making the most of what is necessary and finishing it as attractively as is practical. This enhances the value of the property by giving it a pleasing appearance as well as by preserving it. Proper colours also contribute to rest, light, coolness and general satisfaction; not altogether to be ignored in countries where the general tendency is to deteriorate our culture.

II. PLOT LAYOUT.

1. Plan the entire plot, site or compound before commencing the erection of any building. Make a scale drawing of the compound, place all buildings:- dwellings, school, church, dispensary, store, shop, garage, kitchen, staff quarters, guest house, etc. Drainage and sanitary arrangements and equipment provided for; Also mark out gardens, farm and recreational areas, roads, wells,

trees, etc.

2. Provide space for dwellings for new staff in the future; for the extension of church, school, native staff quarters, etc.

3. Make the dwelling fit the site as to orientation, convenience, weather, elevation, etc. Place the house far enough forward on the plot to make room for secondary buildings where they belong, - at the side or in the rear.

Compounds can be laid out so that the entrance to every building can be observed from one or more points in the main dwelling, if this is a desirable arrangement.

Another advantage of plot layout is that work sheds, stock piles and many other features of a new compound can be accurately placed the first time and so avoid much moving and confusion.

Be sure that no building in its original or completed form including verandahs, steps, roof overhang, etc. even touches the boundary line of the site.

In municipalities there is often a building line at a determined distance from the street or road and within the boundary line of the site. Buildings must not extend beyond that line. Enquire of the municipal architect's department whether there be such a line and if there be, have it located for you on your site by some authority.

There are thirty two principal ways of using or placing one house plan on an ordinary site. It costs little or nothing to consider every possible arrangement in an effort to find the best.

There are eight principal locations or positions for a house on many plots, and in any one of these there are four ways of using the one plan.

In Figure 1 are shown the eight principal locations for a house on a compound or site. Any one of these can be moved farther back from the plot line.

Figure 2 is a simple house plan. It can be used in any one of the eight plots in four different ways.

A house plan.



Fig.2.

Various arrangements of a house on a building plot.

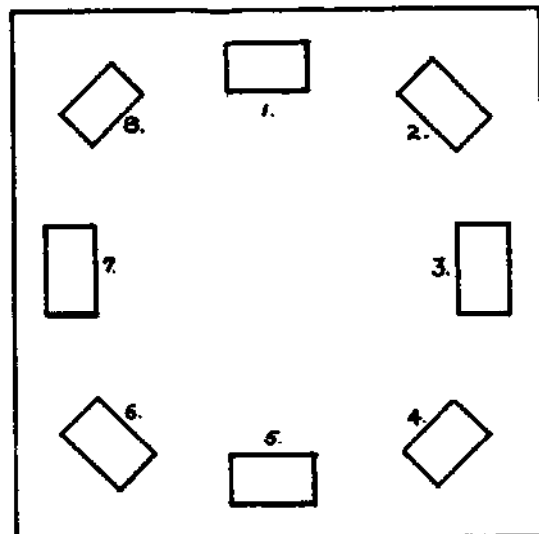


Fig.1.

Fig.3



Fig.5



Fig.4



Fig.6



In Figs.3-6 are shown four arrangements of one plan. Any one of these can be used on any one of the eight house sites shown in Fig.1.

Fig. 7. Compound Layout NO.1

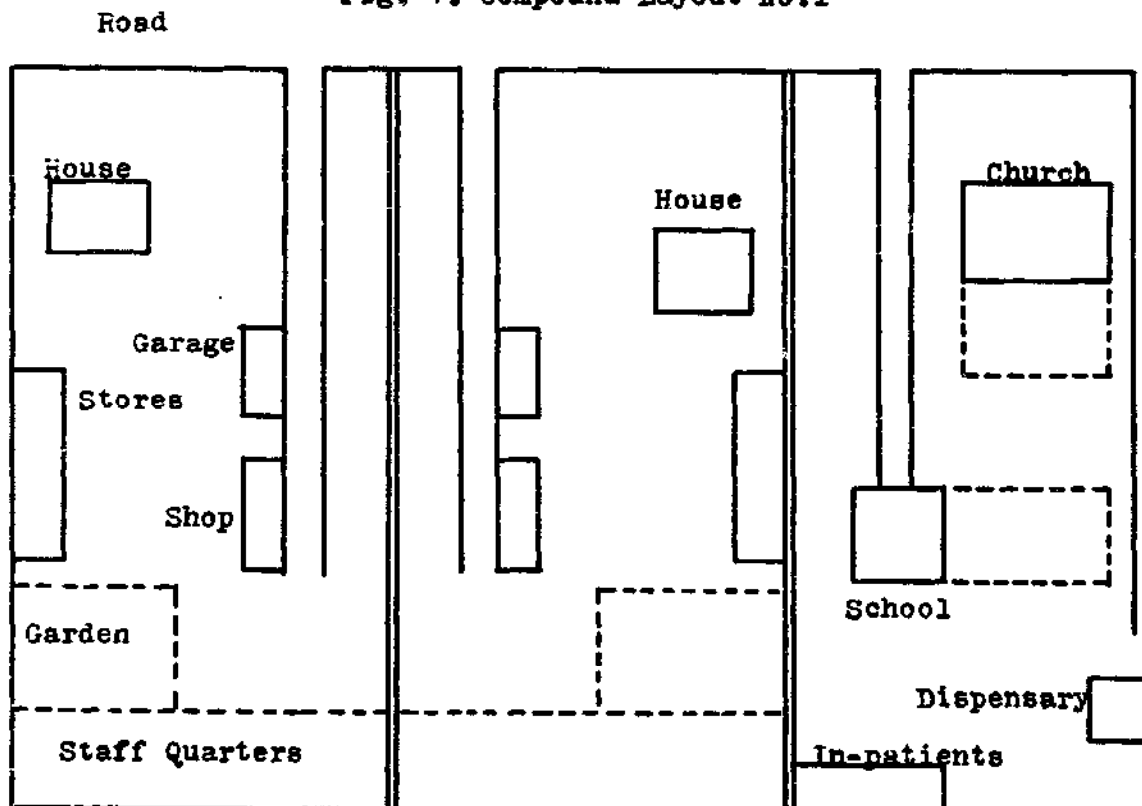


Fig. 8. Compound Layout NO.2

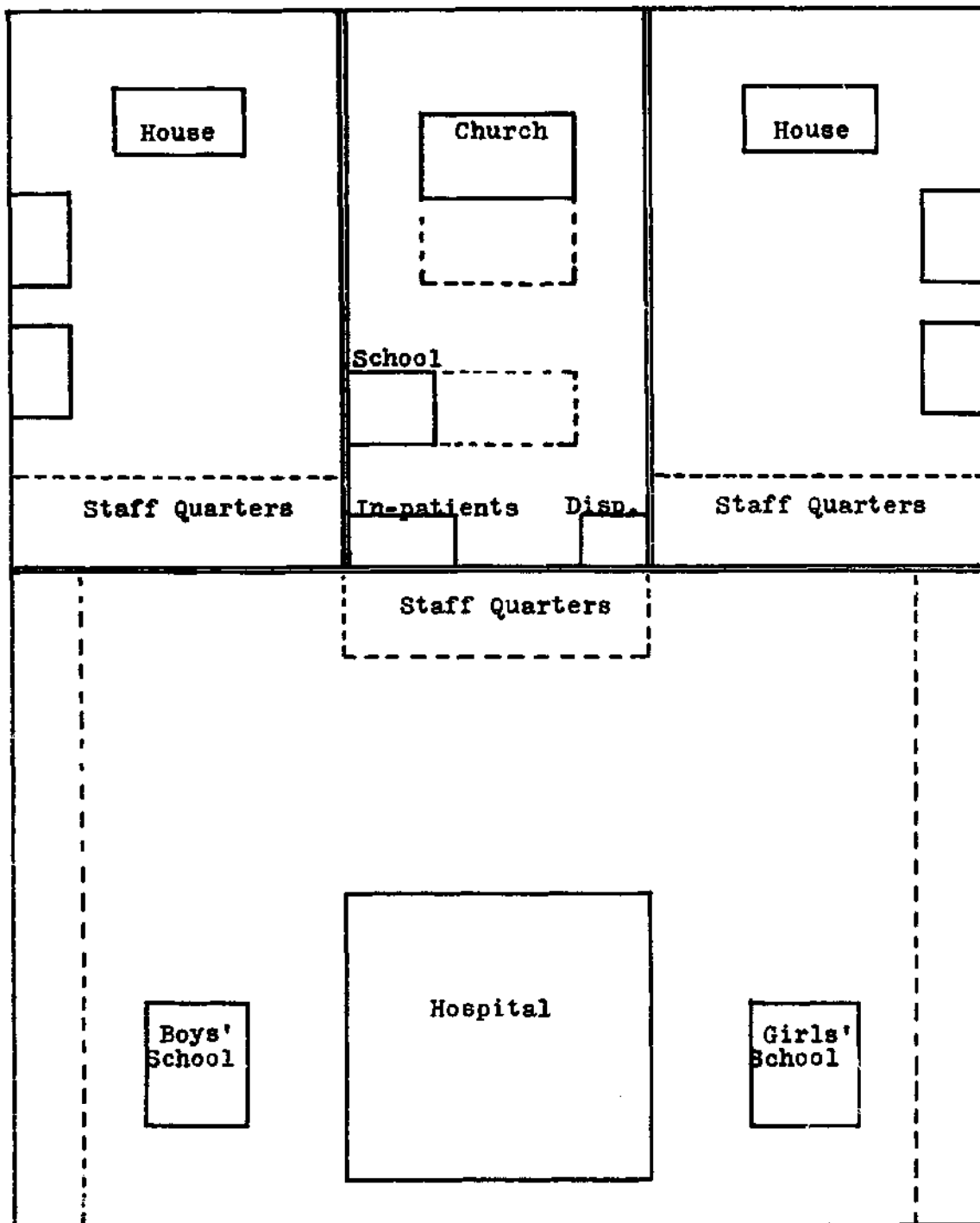


Fig. 9. Compound Layout NO.3

These compound layouts are the merest suggestions. The main thing is to sit down and carefully consider the growth of the work through the years and make provision for expansion, allocating a suitable area to each main department of the work. In most cases, hospitals, boarding schools, seminaries will be better off by themselves with large compounds. This ultimate planning is more necessary for the first station planted in a tribe or section than for the ones which follow.

III. FLANS.

1. DRAWINGS AND SPECIFICATIONS express on paper the architect's conception of the building.

THE DRAWINGS show the area, arrangements, measurements, openings, features, details of construction, etc.

THE SPECIFICATIONS are written particulars about property, excavations, the quality, quantity, and care of materials; and about workmanship, contracts, etc.

Few builders can dispense with a fairly full set of drawings and specifications without wasting time and money, and without incurring unpleasant misunderstandings and permanent dissatisfaction.

Drawings and specifications are absolutely essential to a proper understanding between building associates, architect, owner, owner's wife, building superintendents, foremen, contractors, Mission officers, municipal and other Government officials, etc.

The builder should have signed drawings and specifications from his director, - and follow them.

Proper quantity lists and full estimates can only be made from an adequate set of drawings and specifications.

Once more, make all your mistakes, change your mind as often as you want to, - on paper, - but when you come to final drawings, stick to them. Changes after this stage should only be made upon the most careful consideration.

2. Factors in the preparation of the first sketch.

(1) In the tropics we intend to build a house which will be sun, rain, and storm proof; lightning, heat and glare proof; ant, insect and beast proof; thief, and stare proof; damp, cold and dust proof; wear, stress and abuse proof.

(2) First make a list of all the rooms and features desired: living rooms, store rooms, study, bathroom, pantry, etc., built in cupboards, book cases, fireplaces, etc., and all porches, verandahs, steps, etc. Be sure that each occupant of the house has opportunity to share in the discussion.

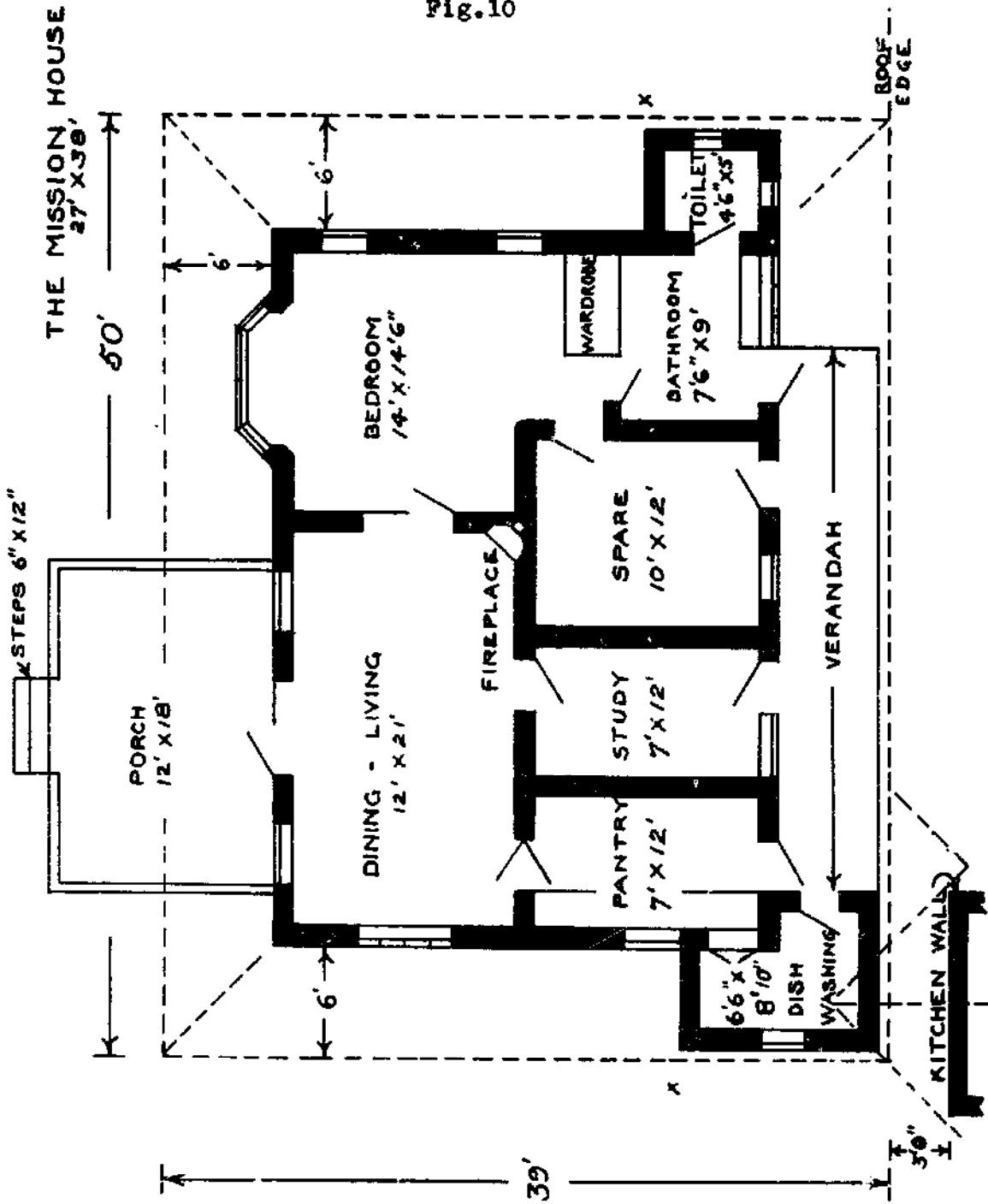
(3) Determine the general style of the house, whether square, rectangular or 'L' shaped.

(4) Consider the privacy and quiet necessary for bedrooms, living room, study; freedom from intrusion, kitchen heat, smells and noises, etc.

The 'Mission House' shown in Fig. 10 is an excellent example of segregating the main living rooms to give them the greatest possible measure of privacy and quiet. The whole front of the house can be kept free of the business and clamor of the day's work.

(5) Various plans. The 'Mission' House Plan.

Fig.10



If a hedge or fence runs from the toilet wall corner marked 'x' to the nearest boundary of the front yard, and a similar fence from the corner 'x' of the dish-washing room, the front of the house can be kept free of uninvited guests and passersby.

In turning the Mission House plan end for end, keep the office window and door in their left-right relation as here. The window is at the left of the desk as it always should be.

Book cases can line the entire wall between and behind the two doors of the study or office.

The cupboard between the dish-washing room and the pantry is open both sides. When the dishes are dried they can be put in there while the door on the pantry side is locked.

A swing door is very convenient between the pantry and the dining room.

The dotted lines between the kitchen and the house indicate the roof joint. The kitchen can be built 6" above the grade and this is low enough to take advantage of the extension of the main roof without changing pitch.

The house hip rafter at that corner can be made long enough to reach the kitchen roof.

The straight line from the kitchen to the house hip is the ridge of the kitchen roof. As shown it is the ridge of a roof which has equal sides but it offers no protection over the walk from the pantry to the kitchen. If such protection is desired, make the front pitch of the kitchen roof longer and move the ridge to the right.

The 45 degree dotted line to the right of the ridge is the valley formed at the junction of the two roofs. The dotted line to the extreme right is the extended eave of the main roof.

The spare room, of course, may be a store room, sewing room, nursery or guest room.

The bay window is useful as well as ornamental, but is not an essential. The bay frame can be set on the main wall if desired. If the bay is not used at all, then put the 4 unit window in the main wall in the usual way.

Note that this house has four through air currents, the bedroom being the best ventilated room in the building.

This house may be considered as the minimum size of a permanent dwelling for a normal family where visitors are few and infrequent.

What will be termed the 'Large Mission House' will be found more suitable where there are frequent visitors. It is 29' X 40', roof 41' X 52'. The living room is two feet wider and two feet longer, and the pantry is two feet wider.

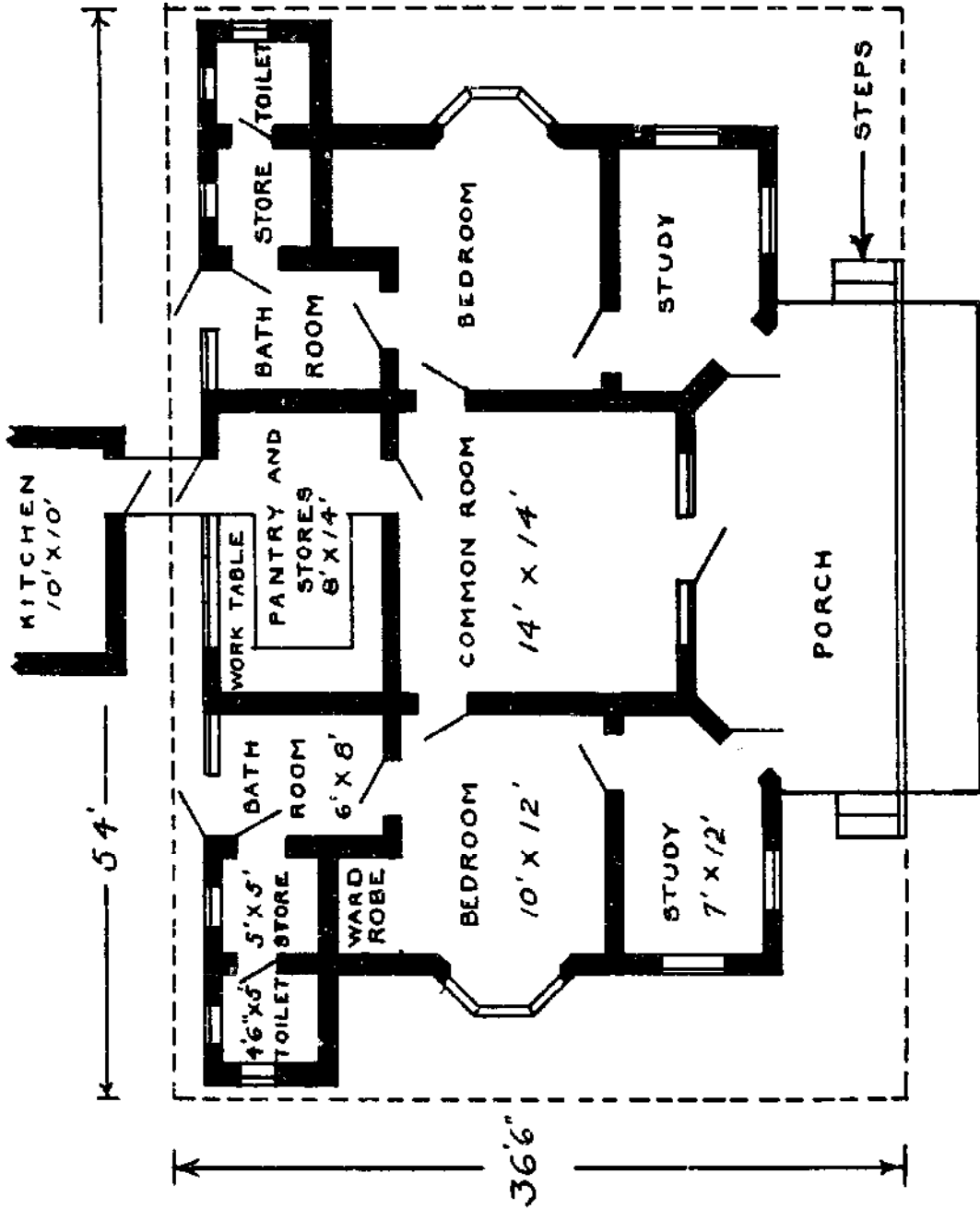
On main mission stations where more than a small family are regularly served meals, the 'MAIN MISSION HOUSE' plan should be used. This is four feet longer again, measuring 29' X 44', and the roof 41' X 56'.

The living room is now 14' X 27'. The pantry becomes 8', the office 8', and a 3' passage leads from the rear verandah to the living room between the office and the spare room. The width of eight feet is sufficient for the pantry when it does not have to be used as a passage as is the case in the 'Large' style plan.

THE MISSION DUPLEX

For two single workers.

Fig.11



The 'MISSION DUPELX' is a gesture toward an economical solution of the problem of securing the maximum privacy and freedom for two persons living under one roof.

Some of these rooms may be reduced, but only at the expense of the convenience and comfort of the inmates.

The common room serves as both living and dining room. If we consider a 12' X 21' living-dining room not out of the way for a married couple in the 'Mission' house, then 14' X 14' is not extravagance for two single workers.

The study serves as a private reception room and also is most acceptable for language study with the native teacher.

The partition between the study and the bedroom may be of plywood and non-transparent glass, and be only door height. This arrangement would give the bedroom more air and light and give the impression of being a larger room.

The toilet and store rooms may be interchanged. There would be this advantage that the store room door could be left locked. However, the virtue of the present arrangement is that the toilet is as far removed from the bedroom as possible.

The passage from the pantry to the kitchen should be covered, the roof making a proper joint at each end with the two larger roofs.

DWELLINGS FOR ONE PERSON.

The 'JUNIOR', the 'INTERMEDIATE', and the 'SENIOR' plans, Figs. 12,13,14, may be used in a progressive way: as duties and age increase from term to term even so greater accommodation and convenience and comfort are required.

The 'Intermediate' might be adapted for housekeeping. Since the route to and from the kitchen through bathroom and bedroom is quite inadvisable, and that through the front door would be very inconvenient, it would be well to add a side door to the living room. The pantry and kitchen unit could be at the rear of the house, easily accessible from the house for the convenience of the occupant.

In all of these house plans it is to be understood that if dry earth toilets are used, the bucket is removed through a trap door; there is no need for anyone to enter the house for this purpose.

(6) The Passage Principle. To obtain the utmost use of every bit of floor space use the passage principle in which all furniture and equipment are placed in the room before doorways are located. And, not merely place the furniture but streamline it so that no space is lost and there will be no awkward corners. If at all possible do not place doorways next to a wall, but fill in the corner with some furniture, even though it be an 8" bookcase.

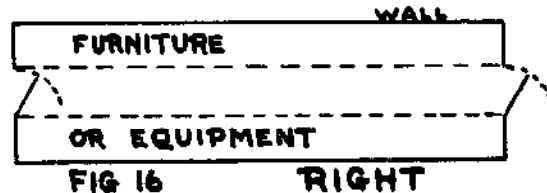
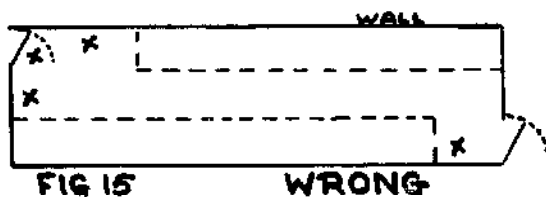
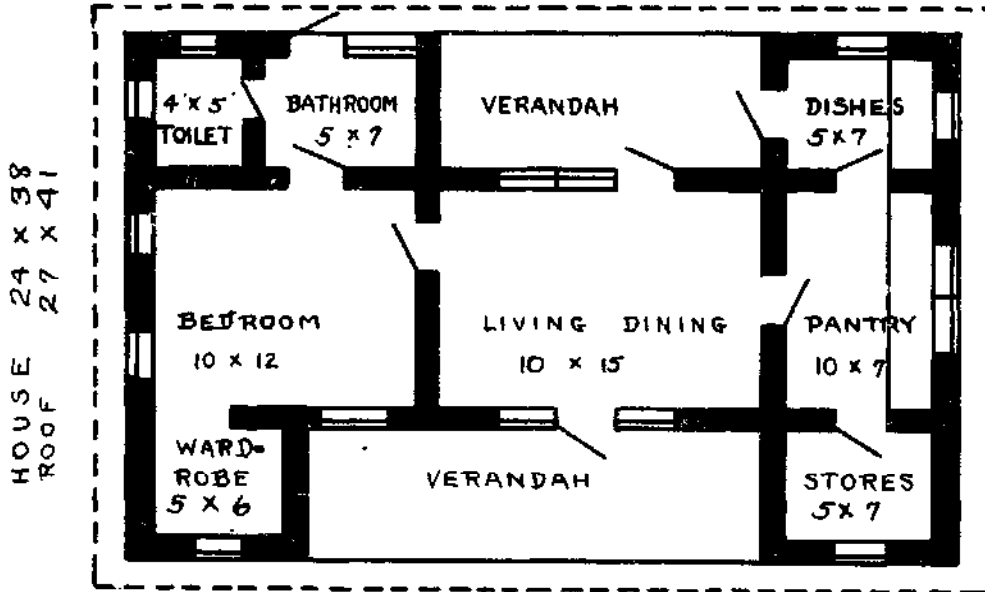


Fig. 14 THE 'SENIOR'



HOUSE 14 x 31
ROOF 17 x 34

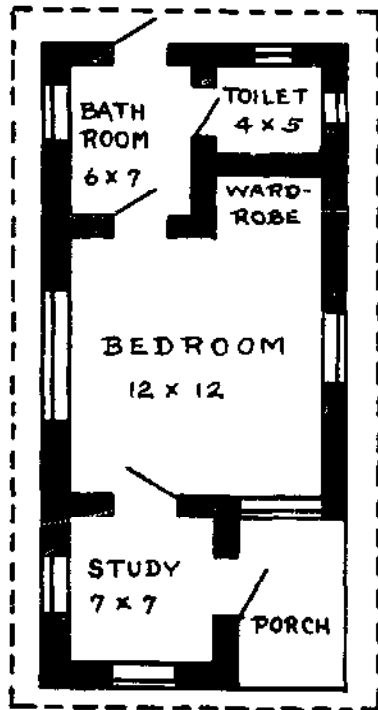


FIG. 12

'THE JUNIOR'

HOUSE 14 x 38
ROOF 17 x 41

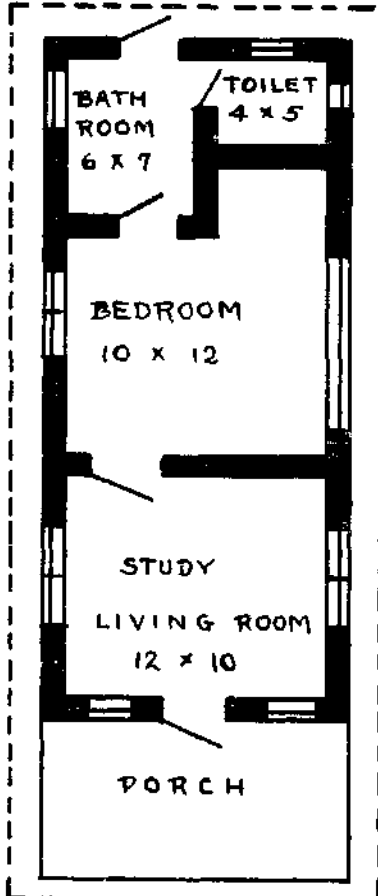


FIG. 13

THE 'INTERMEDIATE'

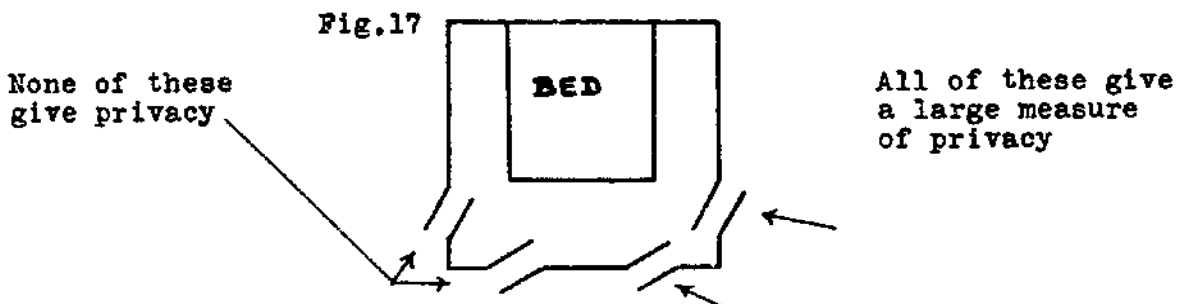
Of course we cannot always place doors just as we want to but if we are on the alert we can eliminate all possible waste areas. In the illustration, the door at one end could as well be a window if the room were merely a store room. In the 'Mission' house plan the passage principle has been thoroughly worked out. Even in the office, there is an eight inch space behind the doors to allow for book shelves. Although this is a very narrow room it is an excellent example of using every inch of space to good purpose.

3. Final Form of the Sketch.

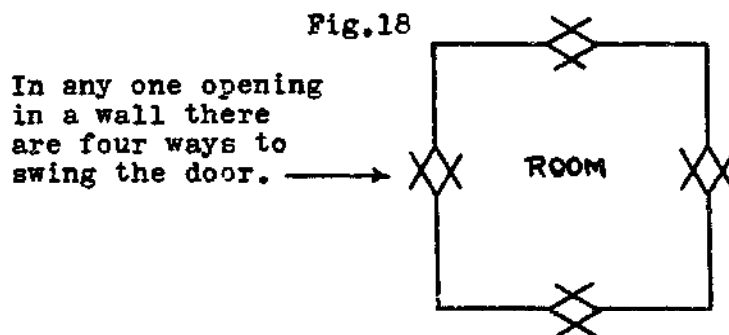
Make a sketch incorporating, if possible, all your ideas. Use a large sheet of paper and draw in two or three of your main rooms to the scale of one half inch to the foot. This will give some good idea of how your various rooms can be fitted in.

(1) Check your plan for balanced layout. Be as careful with the pantry as with the office; consider the importance of each room to your work and avoid having very large living rooms with small bedroom and/or office. Large rooms should have commensurate ceiling height; balance the rooms as well as the whole house. No bedroom should have less than 120 square feet of floor space, nor ceiling less than 9' average height.

(2) Provide bedrooms with adequate privacy. Hang doors the right way. Failure in this has made a bedroom inconvenient, especially for the early afternoon rest period. The open door meant no privacy, the closed door meant no air.



(3) Convenience. Study the position and direction-swing of every door in the building. There are sixteen different arrangements for hanging one door in any one room!



(4) Ventilation. Many factors govern the ventilation and temperature of tropical buildings where there is no mechanical air conditioning.

Other things being normal: coolness in any building is proportional to the amount of shaded, ventilated air space and the degree of that shade.

The sources of heat are direct sun, glare, light, radiation from sand, rock, stones, walls and ceilings, stove and body heat, all lamps etc. Coolness cannot be expected in places where there is no current of air as for example a room in which there is no opening except the door which is nearly always closed.

The principles involved and the methods used to obtain coolness:

(a) Volume of air. Other things being equal, the larger the room or the building the cooler it will be. This does not necessarily include porches and verandahs because, very often, these are hot. High ceilings are good but not necessarily effective. If the pocket above the door height is not ventilated the room may be quite warm.

(b) Adequate openings. Large doors and windows, properly placed, are essential to good ventilation. Large interior doors or other openings promote circulation but it should be possible to close them. Ventilators close to the ceiling should be standard installation. Further coolness and ventilation is secured by building-in ventilators close to the floor in outside walls. These must be screened and provided with doors to close in cool seasons. Ventilators in the ceiling are not always effective. Some buildings have closely built in spaces over the ceilings with the result that during the heat of the day hot air is forced downward through every opening. Even where there is a well ventilated space between roof and ceiling, control shutters should be part of the ceiling ventilator. Strictly, a conduit should lead from the ceiling ventilator to a ventilator in the top of the roof. This will be effective to draw off hot air from the room but in cool seasons this conduit should be closed.

A well ventilated space over the ceiling is recommended; also a well insulated ceiling. And the more air and light there is under the roof the less attraction there is for birds, bats, rodents and vermin.

A well ventilated gable end roof is cooler than a hip roof. On the other hand a hip roof gives required shade on all four sides whereas the gable roof can give shade on only the long sides of the building.

French windows and double doors are helpful in obtaining maximum air currents.

Ordinary window sills should be low, never more than 2'6" in a bedroom. If some are at this height, one at least in another place may be 5'.

In all living rooms window area should be at least one tenth of the floor area. Screens, curtains, blinds, etc. curtail the effectiveness of window ventilation. Make allowances for this. As much as one third the area of some windows is covered by curtains or other air-impeding accessories.

Space and locate windows to catch and transmit air cur-

It may be necessary to turn the house one way or another to get the full benefit of the breezes. Air may be funnelled into certain rooms by having them back in a little pocket formed by other rooms projecting somewhat. An 'L' shaped building properly oriented would do this also. A bay window may be necessary to catch air currents which would otherwise be lost.

If possible place and orient the house to catch all breezes. And avoid placing the house in proximity to walls or other structures which will seriously impede air currents.

(c) Shade. Permanent shade is provided by the eave of the roof and/or a good evergreen tree. The roof eave can be located so that the sun will be cut off from the window sills at any desired hour of the day. For example, in an east wall, the sun will be cut from the window sill at approximately 9 A.M. if the eave is set at 45 degrees from the sill. Similarly, the afternoon sun will not rest upon a west sill until 3 P.M. if the eave is at the same angle.

Shade can be controlled daily by the manipulation of solid or of louver shutters, the closing of doors or of heavy curtains. At night open everything. As the heat of the day draws on, close doors and shutters to keep out the maximum of sun, glare, or even a warm wind. Let there be an air current of the coolest available air.

The ordinary verandah floor generates heat when the sun is upon it. If a verandah is necessary, shade it as much as possible. A roof may have considerable overhang without the necessity of a floor under it. Brackets instead of posts can be used to support the roof. A deep eave or overhang is not always necessary to give coolness but almost invariably in the tropics it gives welcome protection to the windows from heavy rain and dust storms.

(d) Insulation. With all of the above properly attended to, the house may yet be heated somewhat through walls and ceilings, doors and windows which absorb and transmit heat. Texture, colour and angle are chiefly responsible for the attraction and absorption of heat. Untreated mud walls often transmit heat into the interior. Thin rock and untreated concrete walls also transmit heat. The outer surface of all masonry walls should be smooth in texture and light in colour. Rock walls should be at least 15" thick. Mud mortar will be less heat conducting than cement, although the former should be cement pointed. Glass windows should always be shaded from the sun for at least the six hours of greatest heat.

Corrugated iron doors and shutters should be backed with some solid insulating material such as plywood.

Corrugated iron walls can be insulated by backing them up with mud brick. Anchor the brickwork at the studding, but leave at least one clear inch of air space between the iron and the bricks all the way up. If possible provide for the escape of the hot air generated in this space.

Wood and various kinds of manufactured sheeting used for ceilings are popular, but may need earth or other insulation from roof heat. These ceilings without insulation are often noisy and dirty from the variegated life which frequents the garret. Corrugated iron ceilings can be insulated with two inches of earth. Plastered ceilings are recommended. Ceilings less than two feet

from a roof should be provided with extra thickness of insulation.

Roofs. A high roof, that is one set on high walls is cooler than one set on low walls. A roof with a steep pitch or angle is cooler than one with a low or flat pitch. In spite of the great heat from corrugated iron roofs there are several ways of avoiding this drawback, or at least mitigating it somewhat.

Allow plenty of cool air to circulate under the roof. This has at least one virtue that when sun heat falls the iron and the air under it immediately cool off. The iron can be painted a light colour, preferably aluminum. Or, a light thatch can be put upon the iron, care being taken not to puncture the iron roof with nails.

Floor heights. Almost invariably lower floors are cooler than upper floors. This may be due to one or more of the following factors: more shade, better insulation, greater distance from warm air pockets under roof, etc. A well ventilated upper floor with properly controlled shutters and adequate insulation from roof heat ought to be cooler than the lower floor because it receives more and cooler wind. Where there is just one floor it should be as high as is practicable and economical. Two feet to three foot six above the grade would seem to be ideal.

(e) **Isolation.** Heat from kitchens, wash up rooms, laundry, etc. can be entirely eliminated by placing these rooms in a building unit of their own, or at least cut off from the main house by a masonry wall. They should be on the lee side if possible.

(f) **Colour.** Light colours refract light rays while dark colours attract heat rays. The difference is often as much as fifteen degrees. But light walls and other surroundings will of course intensify the heat of any building.

(g) **Dampness.** Artificial coolness can be produced by damping floors, mats, screens, and areas around the house on dry hot days.

(h) **Outside features.** Sandy and rocky areas near a house will contribute heat, sometimes to a very considerable extent. Insofar as these unfavourable conditions exist seek to neutralize them by grass, flowers, bushes, trees, etc. Keep all bushes down to a five foot level and trim all trees which are close to the house up to at least ten feet from the ground. A solid row of trees may act as a barrier to much needed breezes, whereas plenty of trees scattered about will cool the breezes which pass under and around them. However be advised about the trees which give the best shade and are the least likely to harbour offensive birds, and bats, insects, etc.

Artificial air currents. Mammoth fans called punkas are made of wood and canvas, suspended from the ceiling and motivated at certain times by a cord pulled by a servant. They are most used over a desk and over the dining table. The cord passes through the wall and over a pulley to the one who pulls it. The punka is about 2'6" wide and 4 to 6 feet long and weighted at the lower edge to facilitate the pendulum motion necessary. The lower edge would not be closer to the floor than seven feet. Where there are no screens, one of the most welcome functions of the punka is to discourage the presence of flies whether in office or din-

ing room.

Screens. When every breath of air is required for ventilation, there is no doubt that screening shuts out some much needed air. However, since health and the freedom from the nuisance of insects is more important, every house and kitchen should be screened. Screen need not be finer than 24 per inch. By itself it may not bar sandflies, but then a screen fine enough to do that might be a liability. There can be little doubt that sleeping without a mosquito net over the bed is cooler. To do this safely one would need to be very sure that the house was mosquito free. With this in mind, it may be well to have double screen doors leading to the outside, one on each end of a vestibule.

(5) Doors, windows, ventilators, etc. Standard door sizes are as follows:

2'6" X 6'6"
2'8" X 6'8"
2'10" X 6'10"
3' X 7'

6'6" is minimum door height.

When it is known that a person over six feet in height is to live in a house make all door heights 6'10" at least.

French Windows:

18" X 6'6" each
20" X 6'8" "
22" X 6'10" "
24" X 7' "

Consider carefully all sill heights. And when decided, mark them on plan and also make a list of them. We offer the following suggestions for sill heights:

Living, dining rooms	2'6" to 3' 5' over furniture.
Bedrooms	2'6" for common windows and 5' for long windows over a bed.
Office	3'
Pantry	6" above work table. (About 3'4" from the floor)
Storeroom	3'
Bathroom	5' to 5'6" long window
Toilet	6'

A double door between the bedroom and the living room is a great help to maximum interior air current.

Ventilation without draft is achieved by the use of ventilators near the ceiling and by transoms over doors. What we call the 'Mission' window is along the same line. It consists of two solid shutters in one window opening. The lower shutter, 2'5" wide by 3' high is hinged at the side; the upper shutter is 2'5" wide by 2' high and is hinged at the top. When privacy is desired, or when glare is objectionable, the lower shutter is closed. This has proved to be an excellent bedroom feature.

(6) Indicate on the sketch all furniture and equipment.

(7) Do not worry about the roof. A roof can be arranged to fit any floor plan. The floor plan is the most important part of house planning. If you want a gable roof, have it. It can be built safely.

(8) When your sketch is as near perfect as you can make it, offer it to others for suggestions. Pay careful attention to all advice but do not consider seriously any untested idea if a

failure would interfere with the usefulness, durability, or appearance of the building, or incur monetary loss.

4. The Scale Drawing.

Having brought the sketch to completion, draw it to scale, putting in every detail and measurement. One quarter inch to the foot is a suitable scale to use for this drawing.

Draw in every piece of furniture and equipment to scale. If this does not work out, make small pieces of paper to scale to represent the various articles and move them about until every-important piece has its proper place. It may be necessary to move doors and windows a little here and there to obtain the greatest convenience.

The measurement of a door is the actual doorway. Do not fit furniture to the last inch. Plaster thickness does not show on most plans. Plaster reduces the measure of a room by at least one and a half inches.

Check all your measurements with buildings, rooms, and equipment to which you have access. The importance of this can scarcely be over-emphasized. If you check carefully you can be sure you will get what you want. Also you will not be tempted as so many have been to change the plan during construction.

Once more, when you have done your best, consult with the most experienced friends within reach. If the plan is done well in time, there will be opportunity to send the plan by mail to ask for comment, to say nothing of official approval.

5. The Cross Section.

We have been dealing with the drawing called the Plan showing rooms, openings, etc. We must now see what heights there are in the building, character of the roof, some details of construction, etc. The cross section may be described as a picture of what we would see if the building were sawn in two from front to back, one half were removed, and the saw cut photographed. Provided of course that we saw the true length of every line.

We would see the ground level, the depth of the footings and their dimensions, materials, construction; the foundation wall built upon them, the ant coursing, the height, thickness and construction of the floor, the height and construction of the ceiling, the details of the roof, etc. Full instructions on laying out a roof are given in Book Three, Chapter Seven, but the elements of design are given here that we may draw up the cross section.

(1) First of all, determine which type of roofing the building must, or may, have, whether mud, tile, grass, galvanized or other metal or composition sheeting. Shingles are almost never used.

If, for any reason, the building must be mud roofed, the walls must be massive, the roof supports rigid. No dwelling roof of mud construction should be less than sixteen feet from the floor.

Tile roof. This is a heavy roof and would not ordinarily be undertaken without experienced advice. See notes in Book Four for further information.

Grass Roof. If large, the frame should be designed, and the erection at least supervised, by the missionary. The grass is heavy, but the

frame does not present any problem. Grass roofs should not have less lope than 45 degrees. Avoid sharp hip corners.

Corrugated iron roofs. Because they are fireproof and otherwise so practical they are very popular.

(2) Types or styles of roofs.

(a) So-called flat roofs. These are used on buildings which are not used for missionaries' living quarters. The roof may be built over the two walls or it may be encircled on three sides with a masonry parapet for appearances. Due to driving tropical rains, it is not wise to use less pitch than one foot in six. If less than this is used, the end and side joints should have greater lap or else be well jointed and have some filler to prevent rain from driving in.

CROSS SECTIONS OF FLAT ROOFS

FIG. 19

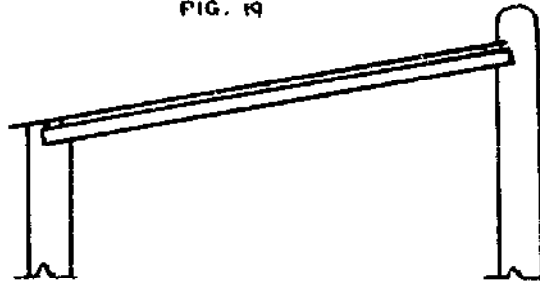


FIG. 20

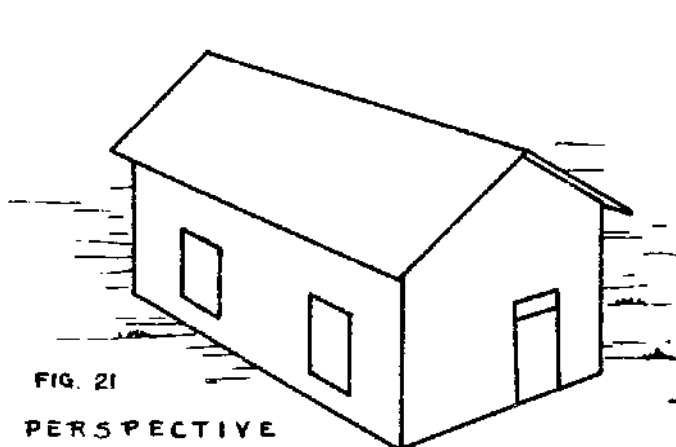
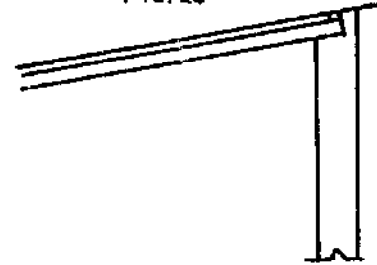


FIG. 21
PERSPECTIVE
OF GABLE ROOF BUILDING

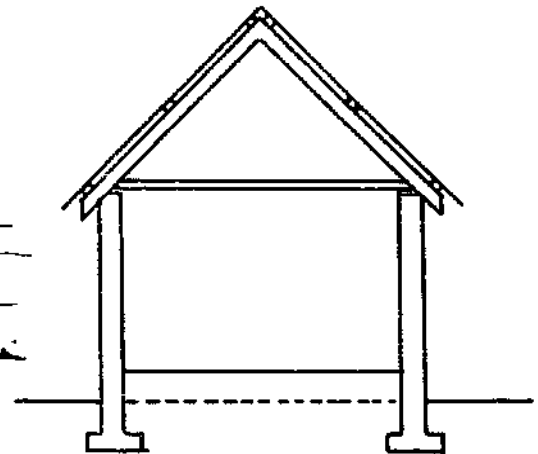


FIG. 22
CROSS SECTION FOR
GABLE OR HIP ROOF

(b) Gable end roofs are suitable for practically any type of building. Gable roofs are cheaper than hip roofs although they have the same area of iron or other covering. The difference in cost is the extra labour and materials involved in the hips. And there is always some waste in cutting the iron for the hips. There is a nat-

ural disclination to build gable walls, but this is largely due no doubt to failures in the past and lack of expert advice as to the cause of those failures. The two main causes of collapse are: inadequate foundation, either in lack of masonry or solid earth base or both, or, inadequate supporting wall in the first storey.

A gable end roof is eminently suitable for a church or other assembly building. Church roofs should not be less than 45 degree pitch for the sake of appearance as well as coolness.

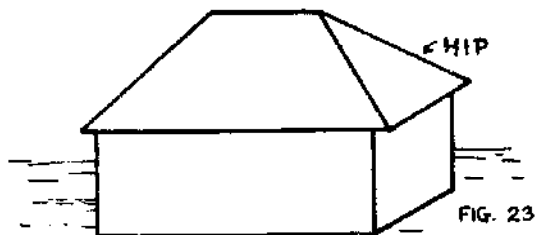


FIG. 23
HIP ROOF FOR
RECTANGULAR BUILDING

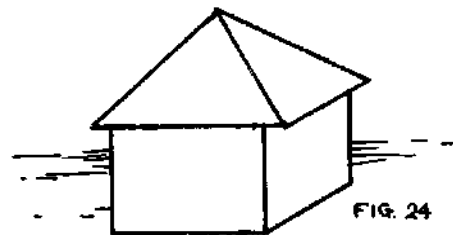


FIG. 24
PYRAMID ROOF FOR
SQUARE BUILDING

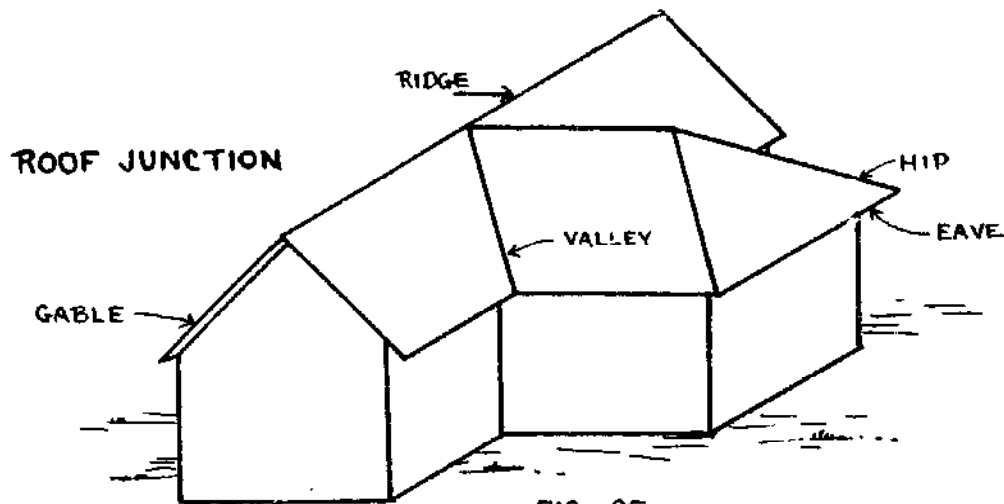


FIG. 25

Having determined the style of roof, develop the rest of the cross section drawing.

Draw in lightly a grade line to represent the ground level. Then draw in the floor, the ceiling and the roof. Now go below grade showing solid earth. The foundation wall extends down from the floor and is four to six inches thicker than the upper wall. The footing which rests upon the hard earth is at least one foot wider than the foundation wall which rests upon it. The projection of the footing beyond the foundation wall must not exceed the thickness of the footing. Interior walls do not need foundation walls thicker below floor

height. But it does need to go down to solid earth and rest on a footing. A solid foundation wall without a footing as shown at the right is a waste of material by misapplication.

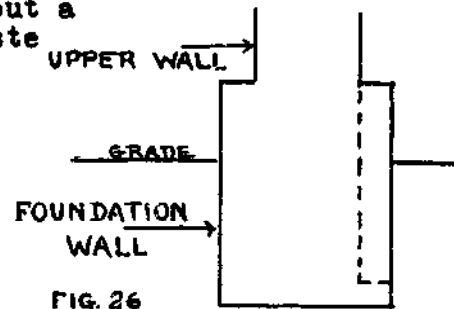


FIG. 26

Determining the roof angle when corrugated iron or similar roofing material is used. Draw a cross section of the walls, floor, and ceiling of your house, with scale of one quarter inch equal to one foot as here:

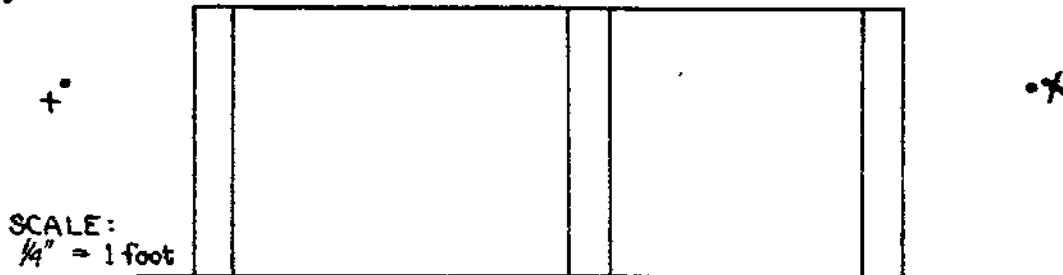


FIG. 27

Indicate the point of the eave. That is how high it is to be above the floor height and how far out from the wall.

Seven feet above floor is a good height. And six feet out from the wall has been found to be a practicable overhang. It can be supported by brackets and is effective in giving adequate shade. Mark the eave point on each side of the house. Ordinarily these will be level.

Now make a centre line between them, regardless of where walls come. The ridge of the roof will be on this line.

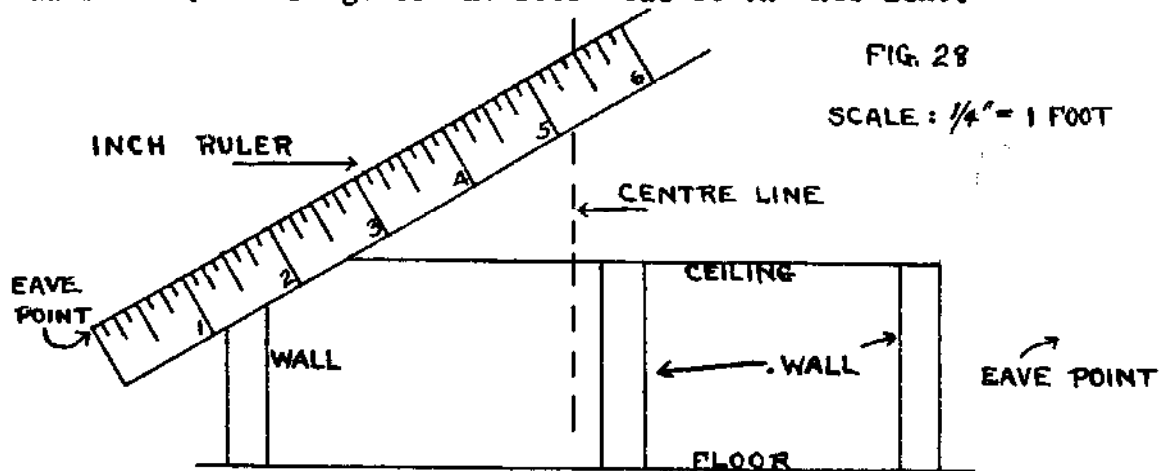
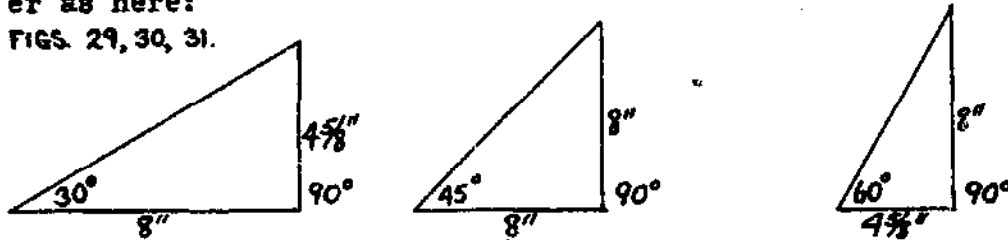


FIG. 28

SCALE: $\frac{1}{4}'' = 1 \text{ FOOT}$

Now put a common ruler from the left hand eave mark to the centre line as shown in Fig.28. Place it at the angle you want for your roof. Thirty degrees is about as low as a house roof should be, and forty five degrees for a church roof. To obtain several angles without special instruments use a common ruler as here:

FIGS. 29, 30, 31.



The following is a useful table for determining the length of any roof slope:

No. of lengths	Various lengths of pan obtainable					
	6'	7'	8'	9'	10'	12'
1 length gives-	6'	7'	8'	9'	10'	12'
1 1/2 "	8'6"	10'	11'6"	13'	14'6"	17'6"
2 "	11'6"	13'6"	15'6"	17'6"	19'6"	23'
2 1/2 "	14'	16'6"	19'	21'6"	24'	28'6"
3 "	17'	20'	23'	26'	29'	35'
3 1/2 "	19'6"	23'	26'6"	30'	33'6"	39'
4 "	22'6"	26'6"	30'6"	34'6"	38'6"	46'6"
4 1/2 "	25'	29'6"	34'	38'6"	43'	52'
5 "	28'	33'	38'	43'	48'	58'

Using a 6" lap joint.

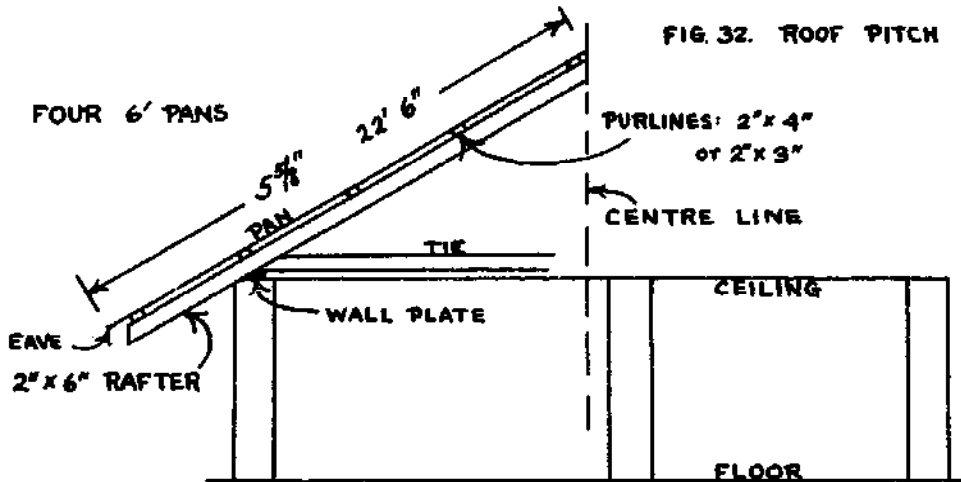
By using this table you can have the approximate pitch you want and use every inch of iron, whereas in determining a pitch and holding to it there is usually waste in joints, or in cutting pieces, or in having the eave come out farther than is necessary. Since 6' lengths are the most widely sold, we will use them in our present calculation.

With the ruler placed at 30 degrees, one end on the eave point, the reading at the centre line is five and a half inches. Since the drawing is to the scale of one quarter inch equals one foot, the five and a half inches represents 22'. We now refer to the table and read down the 6' length column and find that four lengths of 6' iron give a 22'6" coverage on the roof. Keeping the end of the ruler on the eave point, turn it upward until the reading is five and five eights inches which means 22'6" on the roof.

Draw a line from the eave point to the centre line. This represents the roof iron. To get the rafter line, measure 2" and 8" beneath the iron line in a perpendicular direction.

Now perhaps this rafter seriously cuts into the wall top as planned. Determine now whether the wall, (and ceiling) will have to be lowered to accommodate the roof, or whether the whole roof will lift enough to clear the wall. One choice would be to slide the roof, as it were, over the wall corner. This will lower the ridge and move the eave point out and up a little.

To obtain the maximum strength in the part of the rafter which overhangs the wall we recommend that no cut be made for the wall plate. The under edge of the rafter rests on the wall plate.



Examples of roofs with unequal eave overhang.

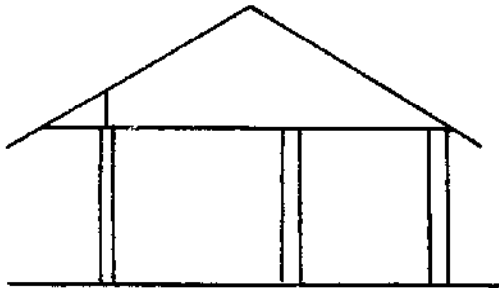


FIG. 33

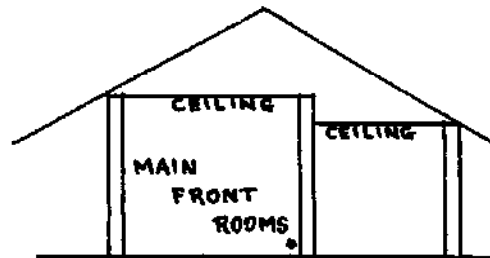


FIG. 34

In Fig. 33 a regular roof has unequal eaves or overhang. If in this arrangement the eaves are too high, the whole roof may be lowered until it touches the ceiling of the main front rooms as in Fig. 34. This will mean lower ceilings for the rear rooms which is permissible. In both of the examples given above the roof may be either hip or gable type.

Example of irregular type of roof. This is usually confined to smaller buildings and almost always to gable type of roof. An irregular roof is less attractive but is often a necessity.

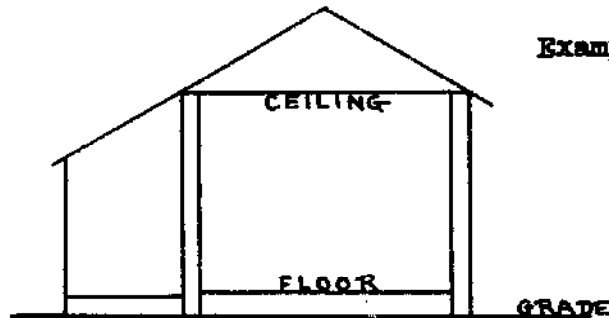


FIG. 35

Example of irregular roof.

CROSS SECTION - 'MISSION' HOUSE (SEE PAGES 9)

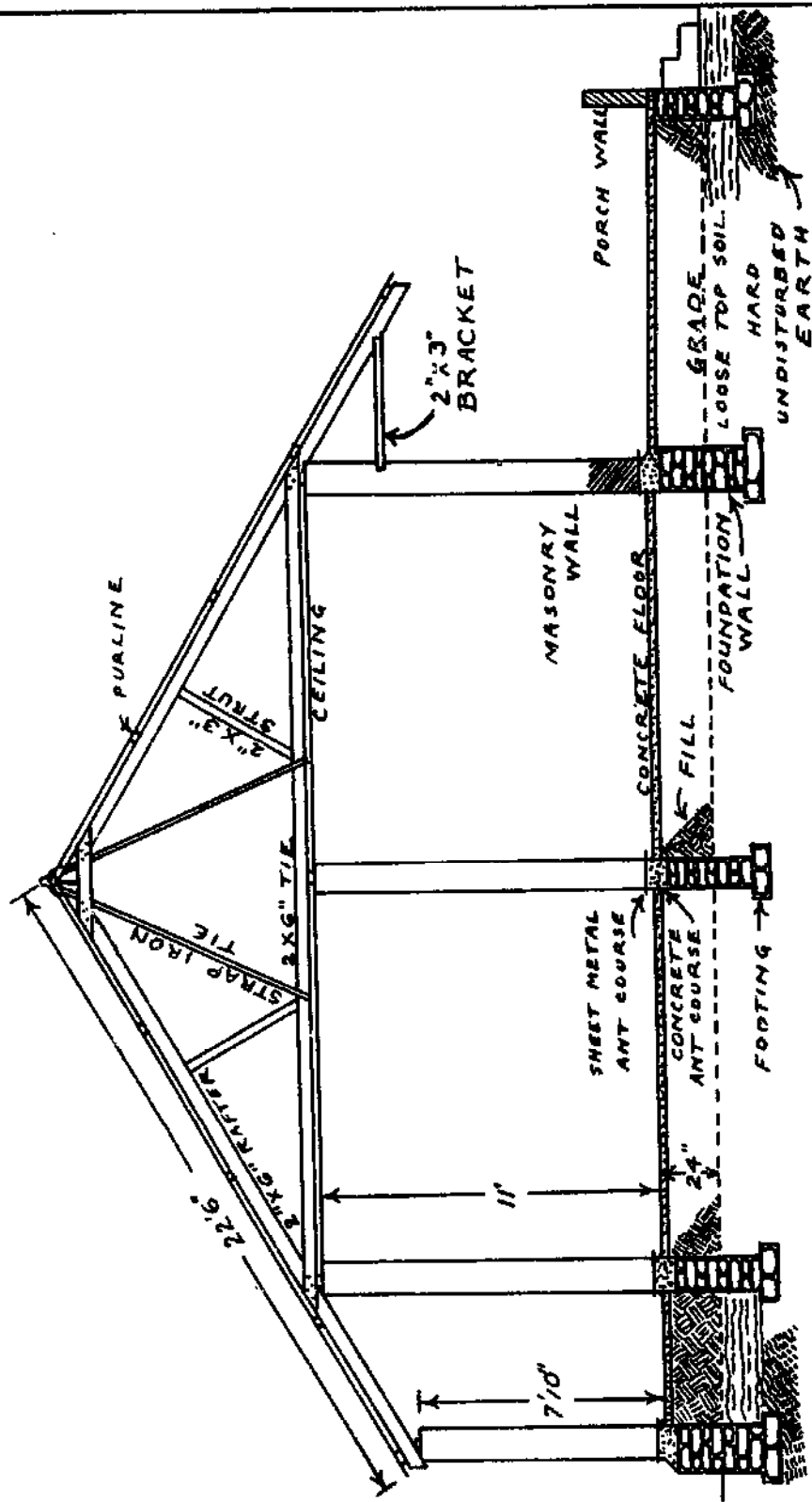


FIG. 36

6. Elevation Drawings.

An elevation is the front, side or end view of a building showing the roof, end lines of masonry, doors, windows, etc. We show the cross section, end view and front view to demonstrate how the various heights are transferred.

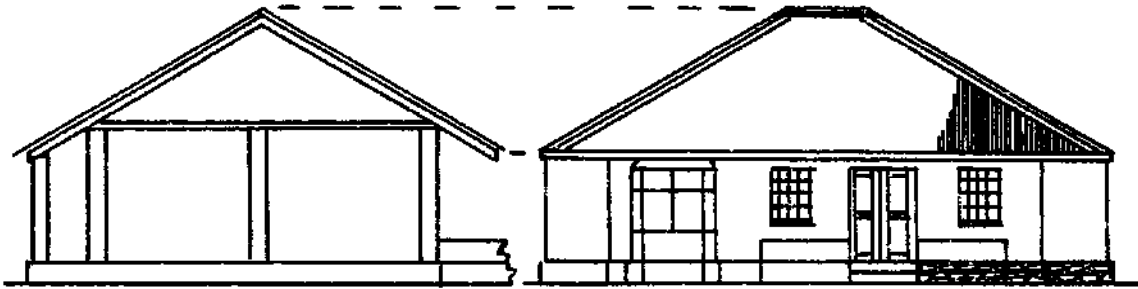


FIG. 37. CROSS SECTION

FIG. 38. FRONT ELEVATION.

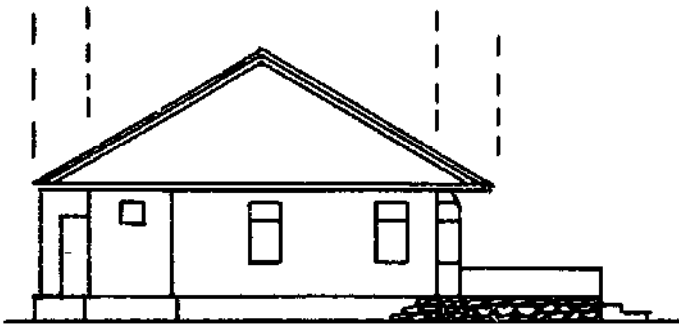


FIG. 39. BEDROOM-END VIEW

Elevations of all walls will be a help to the contractor as well as to others. They help to get into the minds of the builders the details of the wall. So often in the stress of building operations an opening is forgotten and some brick-work must be taken down. This elevation view and the list of sill heights

ELEVATIONS OF WALLS

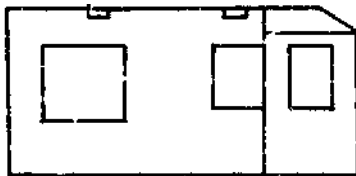


FIG. 40. LIVING ROOM-END WALL

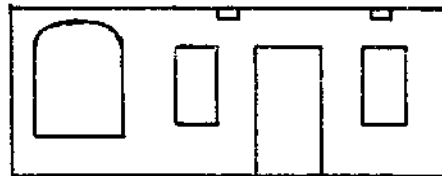


FIG. 40 A. FRONT WALL

is a great help in doing the right thing at the right time.

7. Detail Drawings.

Special architectural and structural features should be drawn to large scale in what are called detail drawings which show how they are built. This is especially valuable for the workmen. They should show every part clearly and have every essential measurement written in. And it should be understood that the workman is to abide the figures so written in. Make detail drawings of large arches, lintels, fireplaces, doors, sash, built in furn-

iture, special joints of the ant course, reinforced concrete, chimney tops, etc. In fact any part of the structure whose details of construction are not clear from the plan section and elevations. Examples of detail drawings.

Lintel over door and wardrobe in 'Mission' House.

FIG. 41. ELEVATION FROM BATHROOM SIDE

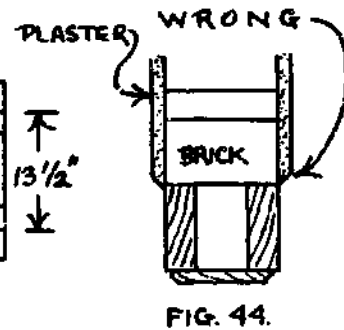
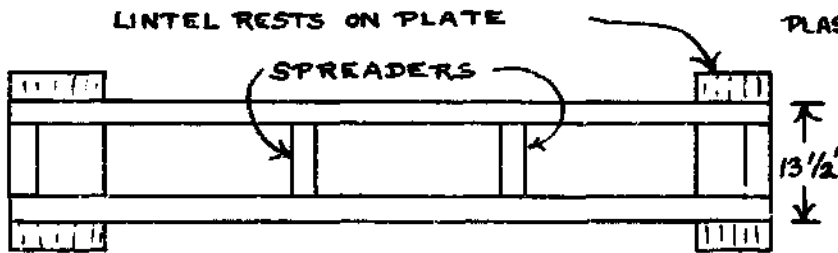
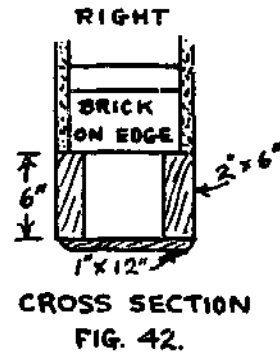
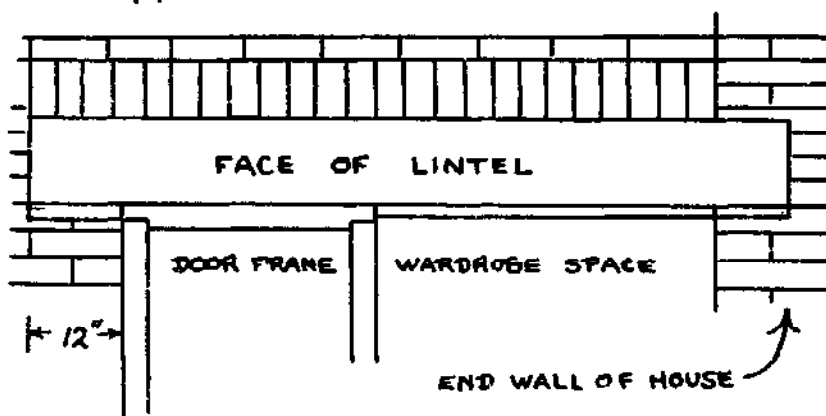
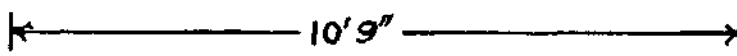


FIG. 43. TOP VIEW OF WOOD LINTEL



Lintel specifications: The over all width must be from outside the plaster line and not as in Fig.44. The first row of bricks on the lintel must be on edge. The under side of the lintel is completed with a 1" X 12" board called a soffit. The ends of the lintel rest on wood plates, the grain running at right angles to the lintel.

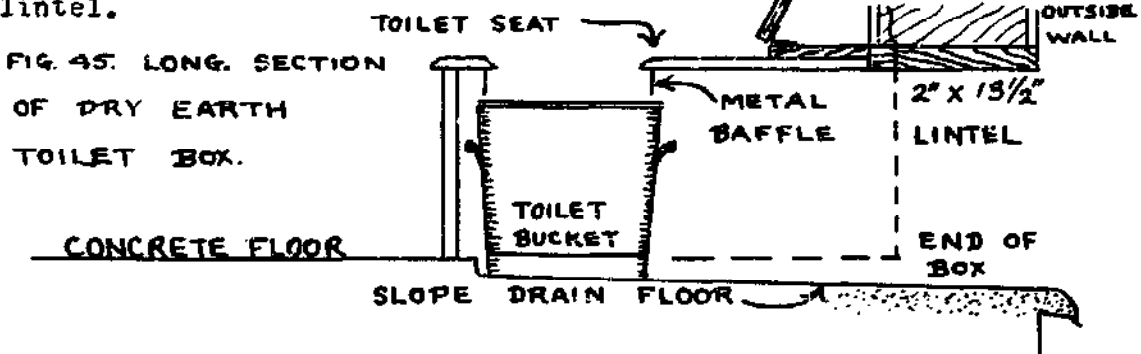
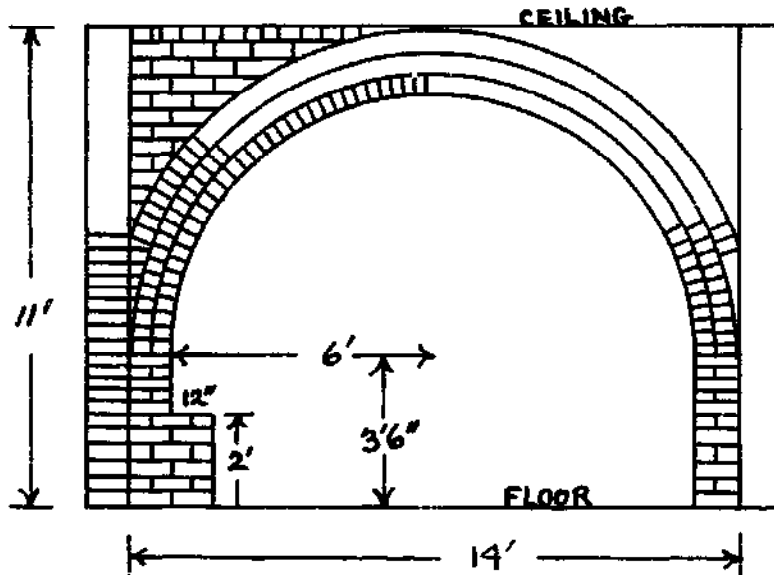


FIG. 45. LONG. SECTION OF DRY EARTH TOILET BOX.

Detail of arch between dining and living room in 'Large' and 'main' mission houses.



3-RING ARCH
BETWEEN DIN-
ING AND LIVING
ROOMS. FOR
LARGE OR
MAIN MISSION
HOUSES ONLY.

FIG. 46.

One of the chief values of an arch drawing of this kind is that the right allowance will be left at the top for the three rings of the arch. Better leave an inch to spare than have the third ring extend above ceiling line and so necessitate cutting. If a small projection is desired at the base of the arch as shown at the left, build it in at the first so that it may be bonded in with the wall supporting the arch. These little projections are often used to set a potted plant or other decoration.

IV. SPECIFICATIONS.

Because misunderstandings on buildings result in mistakes, whether left or remedied, write down what you want the builder or others concerned to do. It is so much easier and pleasanter to write it down than take it for granted they can read your mind and then reproach them for not being able to.

A set of specifications should accompany each set of drawings sent to the Mission office, government officials, contractor, etc. The following is a guide to writing up the specifications.

1. Particulars about the exact position of the building to complement the graphic location in the plot plan.

2. Any requirement of Government or Municipal authorities with respect to a new building, as for example notification to a department before a building is begun and again after the foundation has been put in.

3. Municipal requirements about the protection of the public from building operations, pits, etc. and any regulations of labour relations, etc.

4. Clearance of the building site and the disposition

of any trees, shrubs, boulders, buildings, fences, etc., which have to be moved.

5. The nature of the soil on which the footing is to rest, particularly with respect to hardness, dryness, etc.

6. The kind and quality of materials used in the footings and foundation walls and the proportions of any mortar, plaster, concrete which may be used.

7. All particulars about the concrete and metal ant course.

8. The type of masonry in the main walls, and bond, mortar, plaster, pointing, workmanship, etc.

9. Ceiling material, construction, insulation, finish.

10. Roof material, frame, workmanship, joints, iron lap end and side, tying, nailing, and gutters and down pipes, etc.

11. Outside and inside plaster.

12. Concrete floors, thickness, proportions, workmanship, curing and care, etc.

13. Decoration.

14. Doors and windows.

CHAPTER THREE BUSINESS DETAIL

I ESTIMATES.

If buildings cost more than is expected it is generally due to lack of estimates or to the lack of care and/or experience in their preparation.

ESTIMATING GUIDE.

Outline.

I. The Compound.

II. Lumber.

III. Wall Materials.

IV. Cement.

V. Roofing.

VI. General Hardware.

VII. Imported Goods.

VIII. Local Building Materials.

IX. Building Equipment.

X. General Wages.

XI. General Expenses.

I. The Compound.

- (1) Clearance, grass, bush, trees, rocks, buildings.
- (2) Wells. Digging, preservation at the bottom, at the top.
- (3) Roads, entrance to the compound, on the compound.
- (4) Grading, cutting down knolls, filling holes, terracing, etc.
- (5) Drainage, ditches, culverts, bridges, etc.
- (6) Equipment for digging, cleaning, hoisting, climbing, clearing, etc.

II. Lumber.

1. Production. Sawyer contract, saws, files, carriage.
2. Uses.
 - (1) Temporary dwellings and furniture.

- (2) Equipment, ladders, scaffold, saw benches, brick making moulds, tables, etc., hardware and material racks, etc.
- (3) Shop, tool sheds, work benches, material shelters.
- (4) Frames, doors, windows, built-in-cupboards, wall ventilators, battens, door and window stops, etc.
- (5) Roof, posts, verandah and wall plates, rafters, ties, struts, purlines, face boards, etc.
- (6) Ceilings, joists, support beams, trap doors and frames.
- (7) Doors, windows, shutters, screen frames, etc.
- (8) Miscellaneous, beams, lintels, arch forming, sills, trusses, partitions, stairs and steps, railings, concrete forming, fences, barricades, clothes line posts, etc.
- (9) Furniture and equipment.

III. MASONRY.

1. Stone for footings, foundation walls, main walls, verandah walls, posts, tanks, floors, terrace walls, etc.
2. Brick for all purposes in all buildings, manufacture, carriage, etc.
3. Concrete block construction. Cement, sand, water, machine manufacture or rental, contract, carriage of blocks, curing, etc.
4. Other types of wall, materials, labour, etc.

IV. Cement, Lime.

1. Floors,
2. Foundations, footings, pointing, ant course.
3. Plaster.
4. Miscellaneous, well tops, steps, water tanks, window sills, platforms, etc.
5. Lime for plaster, whitewash, mortar, etc.

V. ROOFING.

1. Sheet metal for ant coursing,
2. Roofing. including ridging, gutters, down pipes, facing.
3. Ceiling.
4. Doors and windows.
5. Miscellaneous, stove pipes, sinks, brackets, shelves, funnels, weather strips, furniture reinforcement, ventilators, chimney caps, roof flashing, etc.

VI. GENERAL HARDWARE.

1. Nails, common for equipment, tool boxes, stores, benches, brickmaking or concrete blockmaking equipment, lodgings, scaffold, bracing, frames, doors and windows, roof framing, ceilings, furniture, etc.
Old nails for driving into brick wall to hold plaster.
Special nails for furniture, galvanized nails for roof, tacks for screen, etc.
2. Screws for hinges, hasps, locks, frame ties, fittings.

-
3. Bolts for roof, roof iron, equipment, etc.
 4. Hinges for doors, windows, traps, cupboards, screens,
 5. Fastenings, hooks and eyes, door bolts, locks, night latches, casement fasteners, etc.
 6. Handles, drawers, doors, shutters, and knobs.
 7. Bale or strap iron for frame ties, ceiling supports, trusses, roof ties, repairs, ladders, etc.
 8. Wire, mosquito screen, for doors, windows, food safes, baby cribs, ventilators, etc.
 9. Water system, pipes, taps, fittings, tanks, red lead.
 10. Expanded metal or woven wire for concrete reinforcement, store partitions, thief guards for windows,
 11. Rod iron, $\frac{1}{4}$ " , $\frac{3}{8}$ " , $\frac{1}{2}$ " for concrete lintel reinforcement, water tanks, roof frame pins, shutter fasteners, etc. chicken netting, rivets for all sheet metal work, building cord, well rope, building lines, fittings, door closers, curtain rods, blinds, lamp brackets, etc.
 12. Electrical supplies of all kinds.
 13. Fire and lightning protection equipment.
 14. Health and sanitation necessities.
 15. Paints, oils, varnish, stain, filler, turpentine, colours and pigments, distemper, lime, cement paint, tar, glass, putty, points, sandpaper, brushes for all purposes.

VII. IMPORTED GOODS. (From another country.)

1. Construction, wall boards, doors, windows, etc.
2. All house hardware.
3. Furnishings, curtains, blinds, rugs, etc.
4. Equipment, pump, tools, garden tools, etc.

VIII. LOCAL BUILDING MATERIALS.

1. Rock for foundations, see under Masonry.
2. Sand for all purposes.
3. Water for mortar, concrete, sand washing; concrete curing, plaster.
4. Carrying receptacles for mortar, cement, water, mud.
5. Mats and poles for temporary shelters.

IX. BUILDING EQUIPMENT.

Picks, shovels, hammers, axes, crow bars, buckets, sand screens, putty knife, glass cutter, bench vise, etc.

X. GENERAL WAGES.

1. Excavation fill, carriage of rock or mud from a distance, unloading railway cars, general labouring on the building, cleaning up, etc.
2. Masons, all departments.
3. Carpenters, all departments.
4. Concrete.
5. Plumbing.
6. Sheet metal.
7. Electrical.
8. Painting and decorating.

XI. GENERAL EXPENSES.

1. Government fees, leases, expropriations, survey, tree licenses, etc.
2. Architect's fees, transportation, stationery supplies.
3. Builder's expenses, travelling, equipment, accommodation, etc.
4. Owner's expenses, travelling before and during construction.
5. Transportation of materials, workmen.
6. Quarters for workmen, built or rented.

If possible secure a copy of estimates of a building as near like your own as possible. A great many items will appear there that will be almost unpredictable and which should be allowed for. Get comment of the other builder upon costs and the conditions which helped or hindered their enterprise.

The same building as yours in another locality may have cost much more or much less. Get the fullest information possible about building costs in your locality.

This is the conclusion of the estimating guide. The text continues with Section II. Orders.

II. ORDERS.

The order is the final quantities list, giving only the particulars necessary to a business transaction in the purchase of materials.

But to get the best service from your supply dealer state for instance that 20 pieces of 2" X 6" are required for scaffold, 20 for frames, 20 for roof, 10 for doors, 10 for furniture, etc. so that the right grade of lumber for each type of work will be supplied if possible.

Write every order, for record purposes at least, including orders for trucking and for water, mud, stone, sand, etc. Then check up afterward and see that the full amounts delivered is shown under the heading Materials ordered. Whether the material is ordered or not, paid for or contributed, write it down.

Always keep a copy of your orders.

III. CONTRACTS.

Here again an experienced builder's advice is invaluable. Too many contractors are unable to give a fair figure or tender of the work. If they bid too low and you accept their tender there will be loss and bad feeling or what is more probable there will be fraud and hard feeling the other way. It is poor business ethic to take advantage of an inexperienced and hard up contractor or artisan by accepting a **palpably low bid and trying to hold him to it.**

Conversely, of course, contractors may try to take advantage of inexperienced builder-owners. Hence it is good for all parties if quantities of materials and cubic content of concrete and masonry work is submitted to the contractor. And it is also well to have at least two contractors bid for one job. The lowest tender is not necessarily the best. Nor is the highest a guarantee of good work. The best contractors are the best guarantee.

The contract, in writing, should always include:

1. The name of the final authority on the job, the one from whom the contractor takes orders and who is to interpret the plans and specifications for the owner. There should be also the name of a mutually satisfactory third party to adjudicate in case of difference of opinion between the contractor and the building superintendent mentioned above.
2. The interpretation of drawings and specifications. Generally the figures on the drawing are to be followed. State whose is the financial responsibility if the contractor takes the wrong meaning of two which are possible. He ought to seek interpretation if he is in doubt and pay for misinterpretation if he goes ahead on the wrong line.
3. The contractor's responsibility with respect to care of materials, equipment, bad workmanship, etc.
4. What amounts are to be paid as the work progresses, when they are to be paid, and on what basis. In this connection it is well to have the contractor's requisition for Saturday's wages in your hand on Friday night.
5. Bonus, if any, for completing the job by a certain date, and contrariwise penalty for going beyond a certain date.
6. Extra work. That is, some alteration or addition to the plans after the contract has been awarded. One solution is to agree on paying the contractor 10% or 15% on the cost of such addition or alteration. But the order for the extra work must be in writing, each party having a copy.
7. The contract may also have to include some arrangement about the kind of labour employed. Certain tribes may have been found to be troublesome.

All business transactions between architect, builder, owner, including receipts for funds, to be recorded.

IV. ACCOUNTING.

It is excellent practice to have an account book for each building in which to record every expenditure and every item used whether paid for or received as gift. In other words a record of the true cost. This record will be of assistance to the Mission staff as well as to yourself and other builders later on.

Make remarks which will throw light on the conditions under which you carried on.

If all dates are properly entered the account will show the amount of time taken for the whole job. There should be a record of how long the foundations, walls, roof, concrete work, etc. were in process.

The pay book itself may well be in duplicate, showing each man's pay each pay day. The copy of this can be sent to the Mission office.

The account should show the quantities, grades, and costs of all materials. Finally make a list, with cost, of all left over materials, equipment, etc. Complete the whole project in every detail as soon as possible and wind up all accounts.

V. CARE OF MATERIALS.**1. Lumber.**

Lumber should be stacked on strong, straight cross pieces about 2'6" apart so that when the pile is completed it will be held in its original straight position. If the lumber is very green it may be stacked with considerable air space, but not in such a way that the lumber will warp.

Protect the wood from sun, rain, pilfering. The ends of the sticks tend to split. It may be necessary to hang a mat or old cloth over the end of the pile and soak it occasionally.

It pays to be on hand to supervise the drawing of stock. See that wood suitable for each job is taken. Otherwise the best will be taken first. See that the pile is left in a neat condition. If sticks get left here and there during the day, have them picked up and stacked again. They will soon warp out in the open.

2. Cement.

This material is so susceptible to moisture that it is very difficult to keep it strictly dry through a rainy season. Keep it off the floor and in the driest room available. If it has to be kept over the rainy season attempt to seal it in absolutely waterproof containers. Cement absorbs moisture from the air. A little period of exposure may not do much harm to cement in the ordinary containers, but a whole wet season would be fatal. When the cement granulates it deteriorates, whether it can be reduced to powder again or not.

3. Hardware must be kept dry in proper receptacles. Keep nails sorted and under lock and key. See that the nail boxes are stocked each morning. This will help you to keep a check on the quantity being used.

4. Door and window frames should be well braced, stacked on a level floor or bars, and protected.

5. Mud bricks can be made ahead of time. If there is no danger of rain, they may be neatly stacked around the building site within easy reach of the labourers serving the masons. If there is danger of rain damage, pile the bricks as compactly as possible, cover them, and drain the base of the pile by an encircling trench.

6. Roof iron is not only expensive but mishandling seriously interferes with its usefulness. Hence take every precaution to have it carefully handled, from the suppliers. It must not be thrown down on its end, either in the bundle or in separate sheets. If carriers bring it by head load, ensure if at all possible against their stealing the banding iron, or bending the sheets double to make handy head loads. This latter practice results in distortion of the corrugations and makes a tight joint roof almost impossible.

Care in Design, thorough preparation, and adequate supervision are essentials in keeping down building costs. Everything that can be brought and prepared for use before the building gang comes will help to get the job off to a good start. All the lumber should be on hand; and also if possible, all scaffold, benches, shelters, frames, doors, windows, lintels, arch forms, etc., be prepared by the time the gang comes.

If transportation is uncertain for any cause at the critical construction period, be sure that everything is brought to the site well ahead of time.

Make provision for an adequate supply of water for all building operations as needed, without fail. Lack of water, as well as of other materials, for even brief periods adds heavily and unnecessarily to labour costs. If necessary secure drums or make some other provision for a constant supply throughout each day. Always have water in good supply before the water carriers go home each night.

CHAPTER FOUR LABOUR

I SELECTION OF LABOUR.

The following factors should be kept in mind when making a selection of labour.

1. Season. All seasons are not equally suitable for building operations for various reasons. There are the busy seasons when labour is scarce, the wet season when travel is difficult, seasons when housing is scarce, etc. Sometimes, feasts, fasts, and other religious customs interfere with building programs.

2. The number employed. This should depend upon one or more of the following: the urgency of the particular project; the amount of time at the builder's disposal; his ability to handle a gang; distance from which a gang must be brought; the possibility of sharing this cost of transport with someone else in the more or less immediate neighbourhood; the equipment on the job to keep the men going if they did come; the number of local labourers available at the time of building is a considerable item especially with respect to supplying the masons at all times with all the materials they require.

We have found on standard dwelling jobs that a gang of twelve to sixteen masons and eight carpenters was an ample and well-proportioned gang. A number of 'Mission' houses were built with a gang like this, each house being completely constructed in from 24 to 26 working days.

When time is not a vital factor, the gang brought any considerable distance must be cut down to a minimum.

3. The various types of labour employed. Try to have a gang which is accustomed to your speech and method. This applies particularly to those who are kept busy building. Failing this, have a nucleus of at least one good mason and one good carpenter who have been with you previously. But it is better to have at least four masons who can build plumb corners, and of carpenters, two good on doors and windows, and two good on roofs. Masons' apprentices should be restricted to one for every four bricklayers. Carpenters' apprentices are more acceptable, and may be employed, one to every three or every two of the skilled men.

Usually labourers are not imported, but occasionally the local labourers are so unused to cement mixing and kindred jobs that one or two strong, experienced and reliable men may profitably be brought in.

Tribal wrangling may be serious enough to restrict the

labour on any one job to one tribe. That is, one tribe from which labourers are drawn, and one tribe from which artisans are drawn.

II LABOUR AGREEMENTS.

When labour is first engaged, some fair idea should be given of the locality of the job; its approximate duration; the missionary purpose and status; the general wage level and hours of work; sick, overtime and travel pay, if any; whether or not a man may bring his wife; it is frequently necessary for one man out of five or six to bring his wife who will cook for that group; discuss the food supply problem and come to some satisfactory arrangement about it; the men are often upset on the job because there is not the kind of food they are used to; rental arrangements where men are already paying rent on their own homes.

Show the men that you want to do the right thing by them and ask for a fair return on their part.

III LABOUR RELATIONS.

Christian employers have a three-fold responsibility, social, economic, and religious, which may not always be recognized until too late. We live in critical days and need to be informed of the labour view-point and temper before the job begins. Get acquainted with labour laws in your district. A very small incident can, as often in the past, lead to widespread and long lasting trouble, injurious to the missionary testimony and sometimes adversely affecting the labour market over a wide area.

Hence, be slow to discipline, as for example dismissing a man summarily for an offence. It may be wiser to separate him from the other workers and give him a different job as well. Then if necessary, release him on pay day, saying that you do not require his services any further. If advisable, give him a little gift for good will. This may save yourself and your mission much serious trouble.

Never resort to violence. Never lay hands on a man if it can be avoided. If physical restraint is necessary, let the workmen attend to him.

Sit down tactics may be encountered. In one case there were no more men to be had, and these labourers knew it. The case was handled wisely and there was no further trouble.

It is unjustifiable in most areas to set one price for any one trade. Wages vary considerably between one part and another. We need not pay the highest wages, but we nearly always lose, in various ways, if we pay the lowest that men will take, or if we hire the poorest workmen.

A missionary may not know what it is to mix concrete all day and be tempted to hustle men who do. Let willing workers have a breathing spell occasionally. Concrete mixing by hand is very heavy work. The golden rule ought never to be an abstraction on mission buildings.

Before work commences, some mention should be made of the conduct expected. Many if not all of the men will have been accustomed to quite different working conditions and leisure time regulations than a missionary is able to countenance.

Loss and waste due to deliberate disobedience of an order is to be made up, as far as possible, by the man responsible.

Pay should be cut for deliberate idleness and excessive lateness, early quitting, etc. Mention should be made of it at the time, a record made in the book and the fine deducted on pay day. Since this is the most distasteful experience for the man, give him the opportunity to make it up by overtime work.

Positively no building materials should be appropriated for the private use of the workmen. They tend to pick up scraps, but these very scraps are worth money and have many uses, during building operations and for years afterward. If any man wishes to use anything he must ask for it, and failure to do this ought to be punishable.

Fighting, quarrelling with food vendors, bringing a woman on the compound, gambling, drinking, smoking, etc., on the compound should be forbidden from the very start.

Keep food vendors off the site at all times if possible. They may be allowed to come near enough to be convenient for the men at pre-arranged times for breakfast or some other lunch time.

Discourage carousing and other objectionable irregularities of conduct with the townspeople.

It is generally very much to the disadvantage of the employer to allow carpenters particularly to do piece work for outsiders after working hours, certainly if such work is done on the compound. The carpenter is strongly tempted to sharpen tools, for this job, in his regular employer's time, use his nails and other materials surreptitiously, to say nothing of depleting his energy for the next day's regular work.

Encourage, or demand as may be advisable, the keeping of a record by each artisan himself of all monies received from the time of employment until he is finally released.

Make it known that thieving and burglary will be severely dealt with.

To minimize temptation, pick up all cuttings, nails and other attractive bits as often as is practicable.

IV SUPERVISION OF LABOUR.

1. Proper technical direction is a problem. It is difficult to obtain satisfaction apart from one man's full time supervision of labour. Another missionary should be on hand to order and check materials, employ local labour, attend to all correspondence, cash, time, wages, station duties, etc.

The wage bill goes up unnecessarily when there is no supervision, even for a few minutes. This is due in part to inexperience and in part to the universal tendency to let down when left alone.

Very often the artisan has no adequate conception of what he has been told to do, especially if he has not worked previously for this employer. In an attempt to preclude the many costly mistakes due to misunderstanding we have developed and employed the following technique with good results. It is no reflection on labour in any part of the world and its use will improve relations with labour rather than the reverse.

The Building Superintendent's Five Commandments:

1. Tell the workman, plainly, several times and one thing at a time, what you want.
2. Show him, as may be most practicable, what you want; put your hand on the material, mark it if necessary, anything so that there can be no question what you mean.
3. Stand by him, or frequently visit him to see that he is doing what you want, especially if it is a new job for him.
4. Do not ask questions which you can answer for yourself by investigation. This does not infer misrepresentation on their part; it means that they give what they think is the correct answer to the impression they received from your question. And their answer is the very reverse of the facts too often. Why not save time and confusion by seeing things for yourself?
5. Take away their finished work before they spoil it.

State, repeat, emphasize, that when you give an order it must be carried out as given, and not be changed because they think so and so.

Urge, beg, plead, demand that if they think the order is faulty, they must first call your attention to it. If it is faulty, acknowledge it and thank them for pointing it out. Whenever possible employ the piece work principle; it is mutually helpful.

2. Manipulation of labour. Thorough preparation of the work as a whole, and for each particular job will richly repay the effort. Have all equipment, materials and supplies ready for the men every time they come on the job.

When men have been well started on one section of the work, thoroughly prepare the next stage so that there will be a minimum loss of time when they change over.

Keep each tradesman to his own occupation as far as possible; let labourers prepare scaffold; masons should not, except perhaps one who may superintend the job. Do not let a carpenter do what his apprentice can do, and do not permit the apprentice to do what a labourer can do. Sometimes a simple gadget will do the work of holding material that labourers have been accustomed to do.

In cement work especially, constant supervision and forethought is needed to prevent confusion, delay, waste. Keep every part of the assembly line moving.

Discourage advance payments, especially after the men have had one pay day. Have the pay made up in good time so that when the wages are handed out, every man will have what is right and so avoid dickering and argument. Pay the men every penny that is due from the very start. Let pay day be as happy as possible.

Be punctual; start and stop work on time.

Saturday afternoon off has sometimes been a problem. We have met it by working a 48 hour week ending about 12.30 Saturday noon. Daily hours, Monday to Friday, 8-1/2 hours per day, Saturday 5-1/2 hours. It is customary in many places to give the men time off for breakfast about 9.A.M.

Most men are eager to have early closing, and that means working through from 7 A.M. until about 3 P.M. with just a little time out for lunches. This program is pretty strenuous for the missionary and it is doubtful if it is as good as the two half days.

BOOK TWO

MASONRY

CHAPTER ONE TYPES OF WALLS

Economy demands that we make the best use of materials, local or imported. It is not always wise to build with the cheapest materials that are ready to hand. Be sure that you have the best construction as seen through a period of years. A few suggestions are offered here of different types of walls; look them over before deciding what your job will have.

I MUD OR ADOBE BRICK.

This has been found to be one of the most practical types of wall construction where the clay is suitable and there is enough dry, hot weather to bake the brick.

Mud bricks are adaptable to all building requirements with the exception of staff bath houses and toilets where there is a constant washing or splashing of water. Mud bricks lend themselves to corners, jambs, arches and other awkward as well as straight wall work. On a proper foundation they may be classed as sound and permanent construction.

The greatest drawbacks are inability, more in some localities than in others, to withstand rain, and their complete vulnerability to the ravages of the termite or white ant.

The first has been overcome, at least in some areas, by waterproofing the mud plaster with cotton seed tar, which when dried in will hold cement wash and that in turn is a satisfactory base for lime washes. In a few instances a weak cement plaster has held to the mud brick, but this seems to be the exception rather than the rule. The different rate of expansion in mud brick and in cement plaster causes the latter to peel from the face of the brick. Brick sizes are given in the chapter on brickmaking.

II MUD BLOCK. Many builders prefer mud blocks to mud bricks. They lay up faster, and on a good foundation may be considered permanent construction. They require special bonding at corners to give adequate strength, and they are definitely not so satisfactory for odd measurements, awkward corners, and special features. Mud blocks are heavy and missionaries will be well advised not to do much of that kind of work themselves.

III BURNED BRICKS. These have been used where cement plaster was considered a requisite, where the mud was of such poor quality that mud bricks were not satisfactory, or where, for foundations, stone or concrete were prohibitive in cost. They cost more to make, nearly always have to be carried a greater distance, take longer to lay up than mud brick. And, in main house walls, their size involves a three brick wall which is thicker than the

standard mud brick wall and is obviously more expensive. Burned bricks are not always strictly waterproof. It seems that the clay lacks the properties necessary to an impervious product.

IV. CONCRETE BLOCK. It is hardly necessary to enumerate the advantages of this type of construction. It is indestructible as far as wetting is concerned, is ant proof, is clean and strong, is always acceptable to the authorities, and is, or ought to be eminently attractive. It has also this great virtue that it can be built anywhere at any time.

But, to the missionary, it has the great and obvious drawback of considerable cost. Especially in regions remote from railways and roads, the cost of the cement alone is invariably prohibitive. Then there is the question of the block-making machine. Very few workers care to make a block mould and the alternative is to import the commercial product. This is tremendously heavy and added to it is the weight of the scores of metal pallets. The lay up is also expensive if the work is to be done neatly.

However it should be said that some builders have learned by hard experience that the attempt to save money has resulted in so much patching and other trouble throughout the years that a concrete block building would have been the best after all. Of course this does not apply to all buildings but to those which are for public or semi public use, which should have been soundly and attractively built at the first, and in which the first cost would have been the last cost.

Useful information about concrete blocks will be found in Book Four.

V. STONE WALLS. In many places stone is the most practical material for footings and foundation walls. But it has not always been recognized as a pretty costly material for the house walls. It does not lend itself to fine measures, jambs, special features; It costs considerable to lay up properly; and must be pointed with cement, another costly item. Then, if cement plaster is used on the inside, there are enormous cavities, comparatively speaking, which must be filled and this just eats money. And stone walls have to be thicker than mud brick walls to provide the necessary stability.

Of course a well built stone wall is permanent, attractive, substantial. It may be a necessity where mud is unsatisfactory and where stone is not expensive.

VI. CORRUGATED IRON. This type of wall is not commonly used for dwellings but for some other types of structures it is often the most practicable. It has some unique properties. It can be built in a day or two, is a waterproof and finished job when fastened to its place, never requires attention, and, may be used at some later time for another purpose. It can serve as a dwelling house wall very acceptably for a year or two if it is backed up by mud, which in turn is plastered. Like cement blocks this type of wall can be built anywhere at any time, and if skilled labour is not available does not involve heavy work to instal.

VII. VENEER WALLS. We have already dealt with corrugated iron veneer walls. The same principle applies to burned brick and to concrete block. It is possible and permissible to build a thin outer course of waterproof brick or concrete block with a thicker backing of mud brick or mud block. Details are taken up in the various chapters dealing with the bonding of bricks and blocks. This veneer type of wall is strongly commended as the solution to many of our problems. It should be stated here that one of the essentials to good construction is frequent and adequate ties between the veneer and the backing, whether by iron or by the more satisfactory method of headers or cross blocks and bricks.

VIII. PISÉ OR RAMMED EARTH.

In this method, slightly damp soil is rammed in a removable form. When the form is full, it is taken down and set up again along the wall where it is again filled.

The builder's preference, climatic conditions, the presence of the right soil, shrinkage, the scarcity or complete lack of bricklayers, the ability to make and properly handle the mould, cleanliness, reduced handling, etc., are perhaps the chief factors in determining whether this type of building construction will be adopted.

IX. COMMON MUD WALLS.

In some localities this type of wall is amazingly durable. We do not recommend it for permanent dwellings, but it should not be ignored as a possible type for other buildings. For instance, if it is built on a stone foundation with concrete ant course and sheet metal ant course, and is plastered and waterproofed, it is practically permanent. The greatest difficulty would seem to be that of persuading the native builder to keep his walls plumb and straight.

If staff houses and other buildings must be constructed of mud, why not make them permanent by putting in the stone footings, foundation walls, and ant course? This does not mean a great outlay, and it will certainly save further building expense.

X. THICKNESS AND HEIGHT OF WALLS AND GABLES.

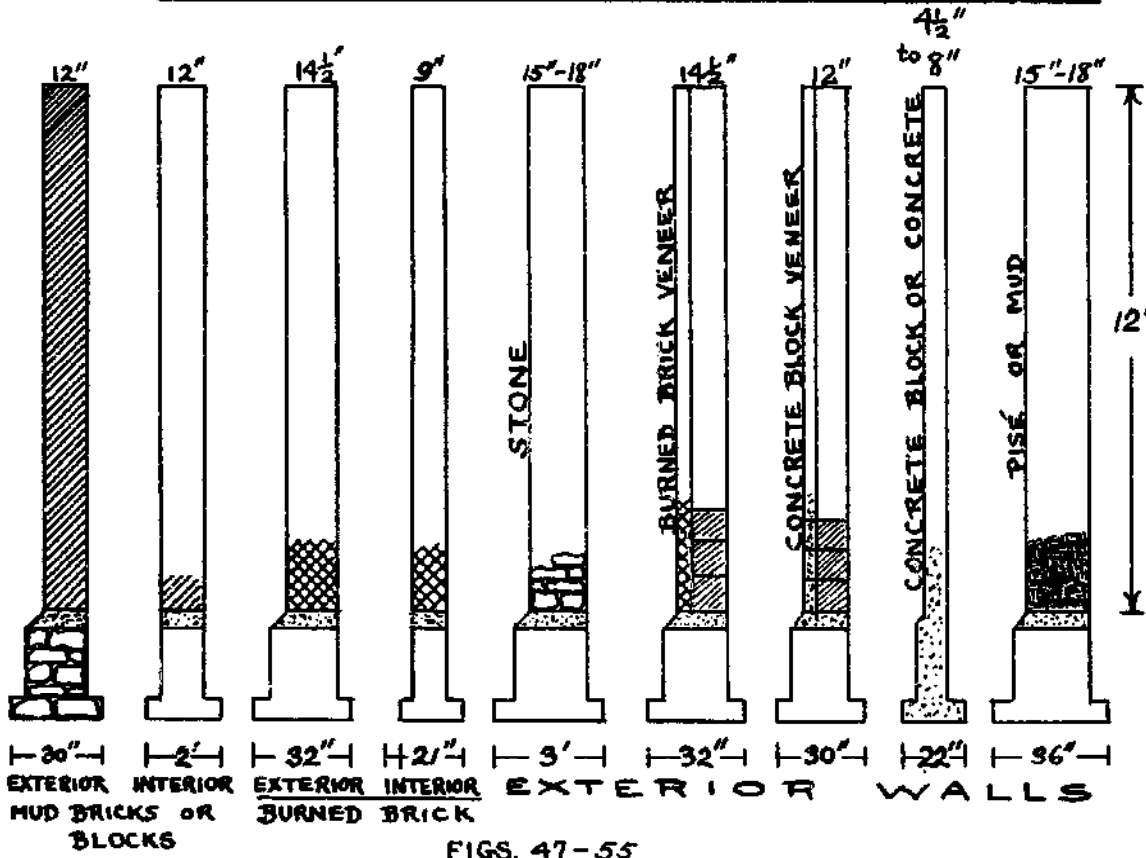
This is a consideration in selecting the type of wall for a building. Gables, two storey buildings, high church walls, etc., require special care in design. The following is recommended as safe procedure in most cases.

With all of the designs given it should be understood that a base of firm, undisturbed earth, thorough waterproofing inside and outside, and adequate stiffening or bracing at every storey height are absolutely essential contributors to the stability of every masonry wall.

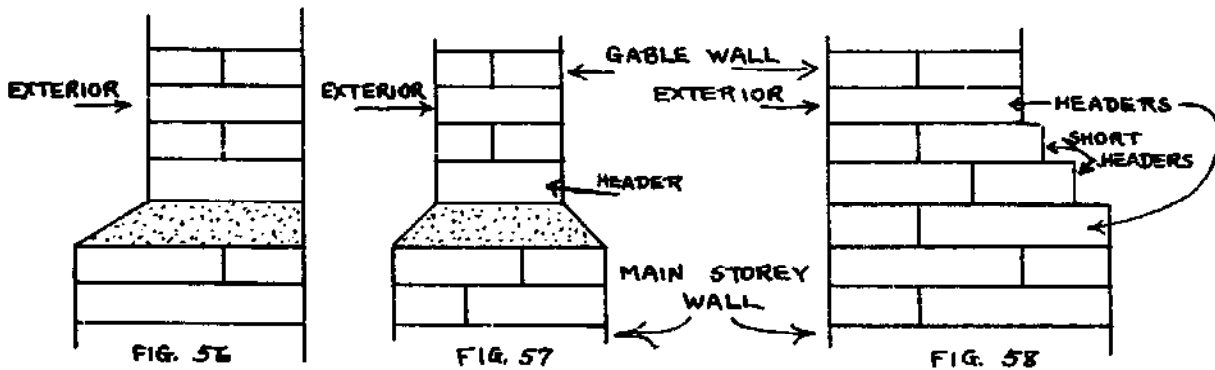
The drawings themselves do not make sufficiently clear that mass is an essential constituent of masonry durability. In some if not all of the examples given the thickness of the wall

may be quite inadequate due to the presence of unusual stress by weight or by vibration. Masonry walls, including partitions must be massive enough to resist cracking due to above ground conditions.

The thickness of walls for common one storey buildings.



Three types of base for gable walls



Note that in Figs. 56 and 57 the concrete course provides a solid base for the gable even though there might be a plaster failure through which water might find a way. In Fig. 58 there is no vulnerable spot.

Thicknesses of gables and their supporting walls.

Neither scaffold nor any other kind of stress should be borne by high gable walls. Unless there are a couple of buttresses, there should be a rigid stay to the top of the main wall and a stay for every ten feet above it. These stays should not be removed until all heavy work including roofing is completed and the frame which is to hold the roof permanently is in its final place. Movement in a green, unsupported masonry wall is dangerous. In a house wall there are usually cross walls to stiffen the end wall supporting the gable. Leave the masons' scaffold in place until the roof frame has been secured to the gable wall.

GABLE WALL BASE →

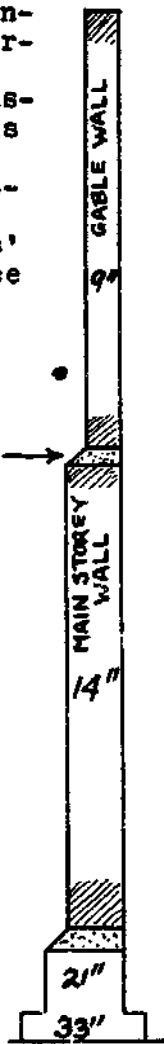


FIG. 59

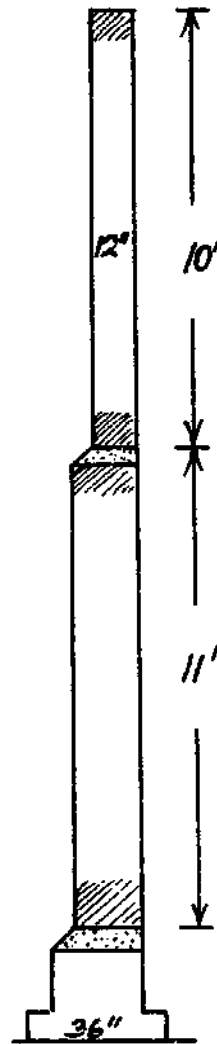


FIG. 60

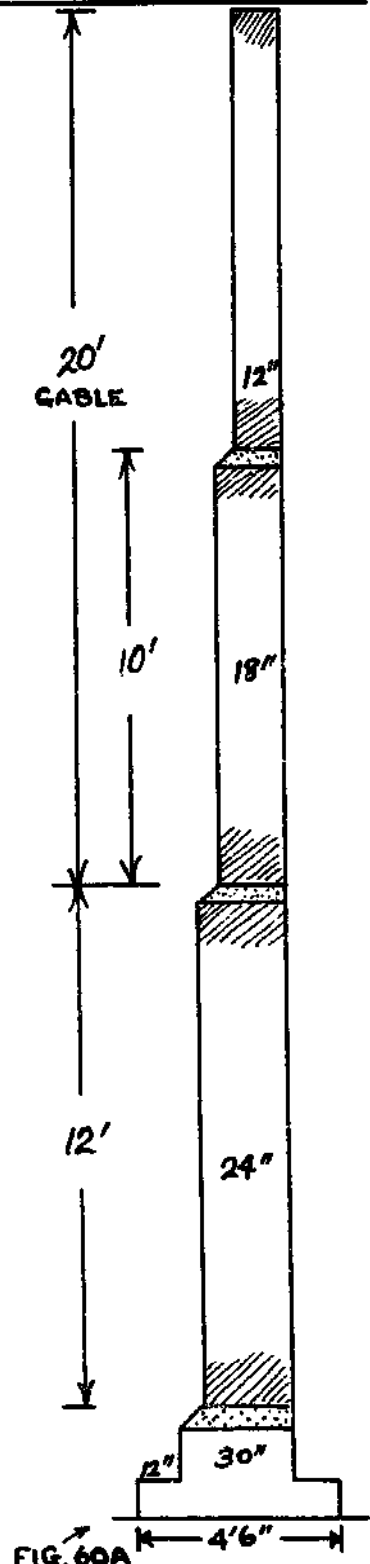


FIG. 60A

 CHAPTER TWO BRICKMAKING.

I. MUD BRICKS.

1. Earth in many tropical and sub-tropical countries has properties which, with a hot sun and dry air, are favourable to making durable mud bricks, blocks, and walls of mud.

Clay and sand are essential. Clay alone shrinks and cracks; sand mixed in with the clay in the right proportions will prevent shrinking and cracking, but too much sand will weaken the clay and also make it too soluble. Hence no more sand should be added to the clay than is absolutely necessary. If the best bricks you can make without cracking are too weak, add plenty of chopped grass or straw or hemp to the mixture and mix thoroughly.

2. Digging the brick clay. Brick clay should be dug early in the dry season because it is so much easier to handle it then and because it will not require so much water to make mud.

The local builder has a simple device for determining and maintaining the proportions.

He first of all clears away everything extraneous from the earth he intends to use. He then digs a pit with two or three vertical walls. When he digs, he cuts through two layers, the sandy one and the clayey one. He maintains the same depth for one batch of mud if he is testing. If that one proves to be satisfactory he always keeps his clay pit the same depth, always has the same proportions of sand and clay. Some earth is so happily blended that it can be dug and used indefinitely.



FIG. 61

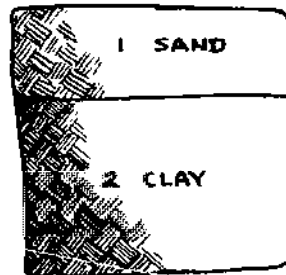


FIG. 62

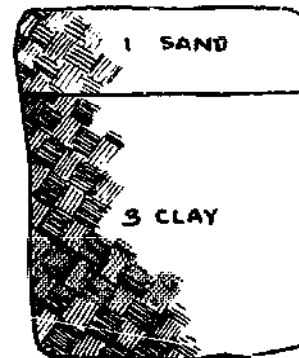


FIG. 63.

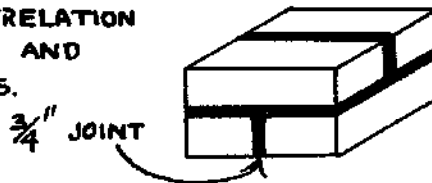
3. The native builder digs and mixes the mud about three days before he wants to build or make bricks with it. He piles up a good quantity, pours water on it and covers it. At the end of three days very little water and mixing produce good mud. Whether the mud has tempering properties we do not know, but it is an established practice for both mud and lime mortar to prepare them some time before use. On the first soaking, cover will prevent too much baking, hardening.

No large lumps or stones are permissible in brick mud but small stones of not over 5/8 inch diameter are not objectionable, they may even be beneficial.

4. Brick sizes. It is well to follow some tested method

in brick sizes. Bricks require to have a depth proportional to their length so that they will not easily break in two. Their length should work in well with building measurements and their width should always be a little less than half their length. Carefully plan your brick size if you do not follow standard sizes.

FIG. 64. SHOWING RELATION BETWEEN LENGTH AND WIDTH OF BRICKS.



The following has been found eminently practical:

width, 5-5/8 inches; length, 12 inches; thickness, 3-1/2 inches. One of the advantages of this size is that just six bricks make one cubic foot when laid up in the wall.

5. Brick moulds. Make these of hard wood, strictly to size and accurately squared. If hardwood cannot be secured, run a metal strip along the top of the soft wood to prevent wear as a striker moves over the edge to shear off excess mud.

FIG 65 TOP VIEW

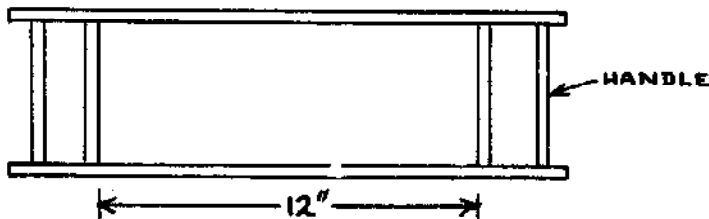


FIG. 67. END VIEW

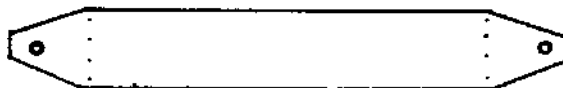
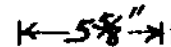


FIG 66 SIDE VIEW

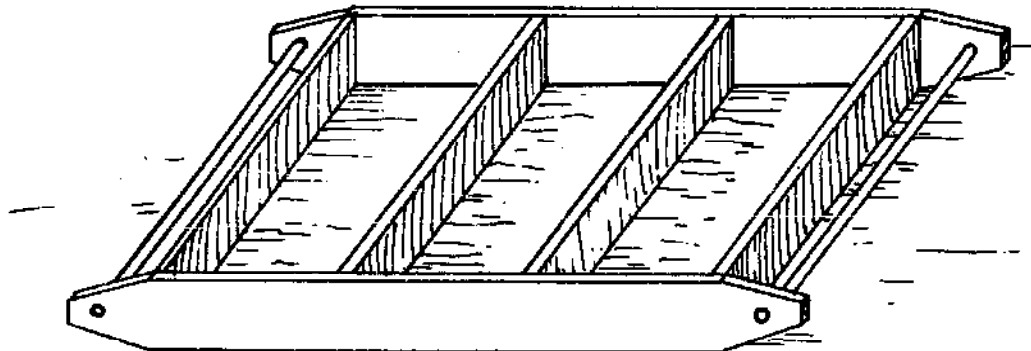


FIG 67A MULTIPLE MOULD

6. Special shaped bricks. It is possible without extra cost to beautify masonry by the use of round corners. The round corner is also a more durable corner than the conventional sharp corner which is so easily damaged, especially if made with mud plaster. But a slotted brick for use against all door and window jambs is a virtual necessity. The slot accommodates the strip on the frame so that the frame will not shake loose in the wall.

MOULD FOR ROUND CORNER (BULL NOSE) BRICK.

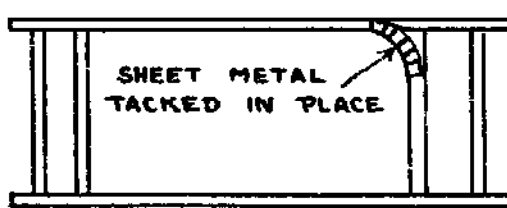


FIG. 68

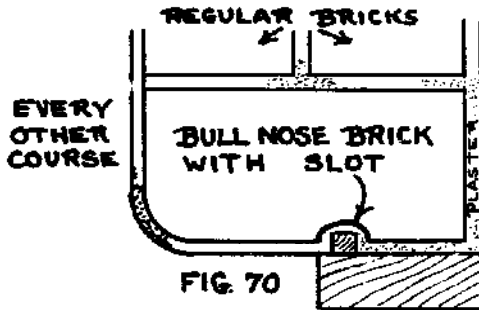


FIG. 70

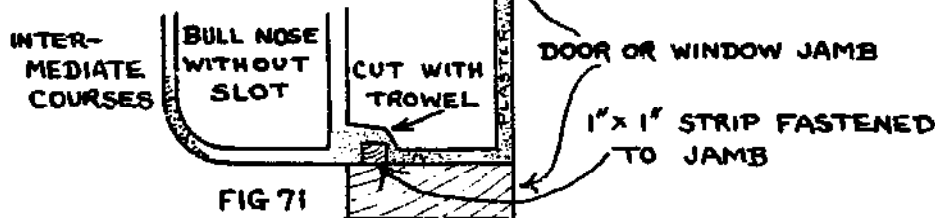


FIG. 71

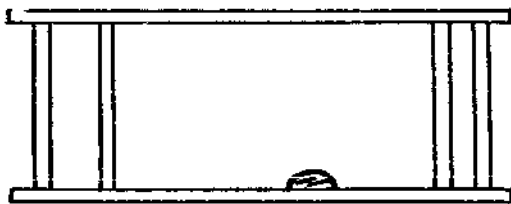


FIG. 72. SLOT BLOCK SCREWED IN PLACE

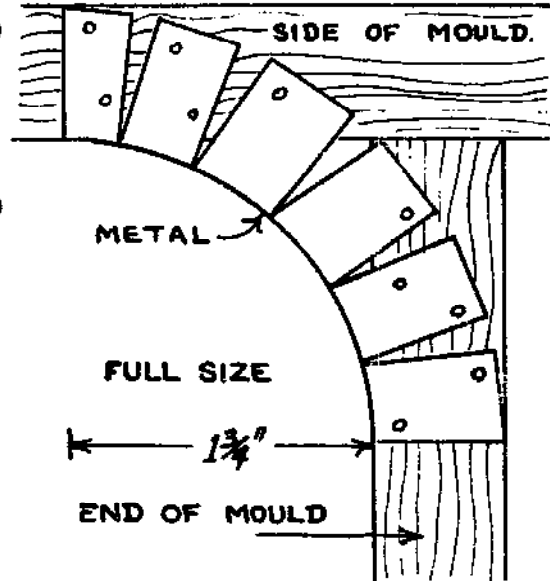


FIG. 69. TOP VIEW OF METAL CORNER FASTENED TO MOULD.



FIG. 73. FULL SIZE TOP VIEW OF SLOT BLOCK

When manufacturing bricks, have as many as four moulds if there are that many skilful men, and there are enough labourers to keep them going.

If bull nosed and slotted bricks are required, make up one mould with bull nose metal corner and the slot block attached. With this mould make all the bull nose slotted brick required. Then remove slot block and make all the plain bull nose brick wanted. When that is done, remove the metal corner and use the mould for regular brick.

7. Brick quantities. Calculate the total area of all the walls. Multiply the total lineal feet of wall and multiply by the height. There are six standard brick to every square foot of 12" thick wall. The area of a gable is the width multiplied by one half the height. The total area of two identical gables is their width multiplied by their height.

In estimating brick quantities do not deduct for openings except for some special reason. All extra brick will be useful. In fact if you have the money, make a few thousand extra.

Estimating bull nose bricks. Count on 10 for the arch of every 2'6" door, or 3 per lineal foot of every corner they are used on. For example, 18 are required for every door opening. Each door also requires 18 bull nose slotted bricks. Make plenty of all special brick; if any are left over after all openings are built in, they can be used up in dead walls.

8. Making mud bricks. There are two main methods. Bricks can be moulded on a table and carried to the drying area in the mould. Or, they can be moulded right on the ground. The former is probably the best for making accurate bricks, but most jobs do not require such exactitude.

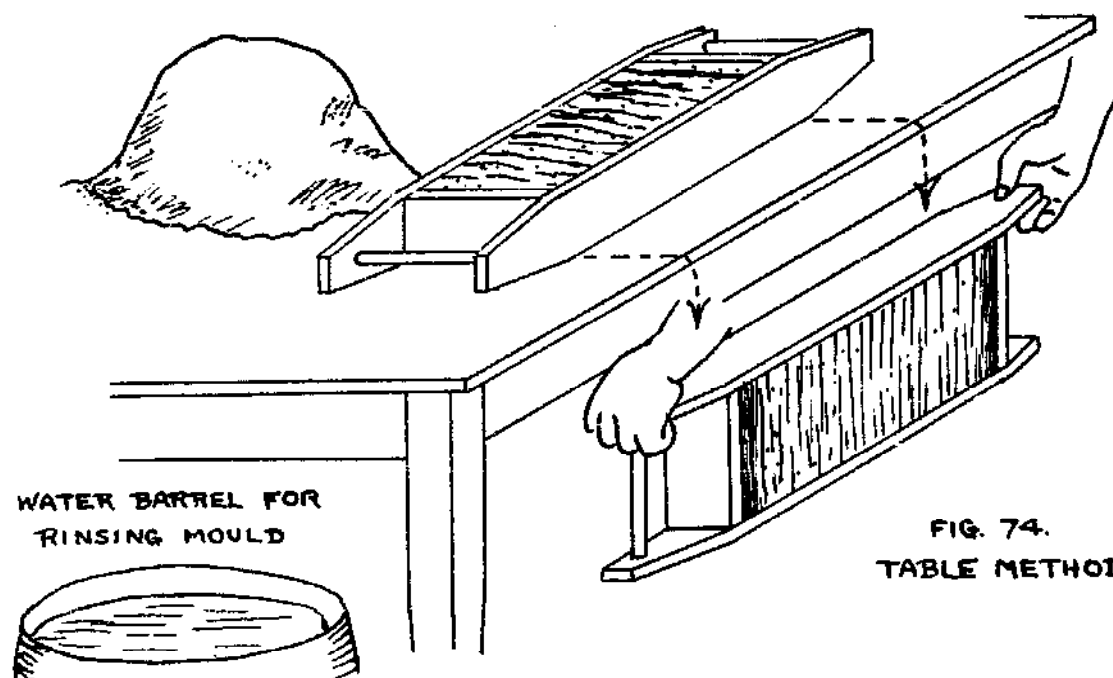
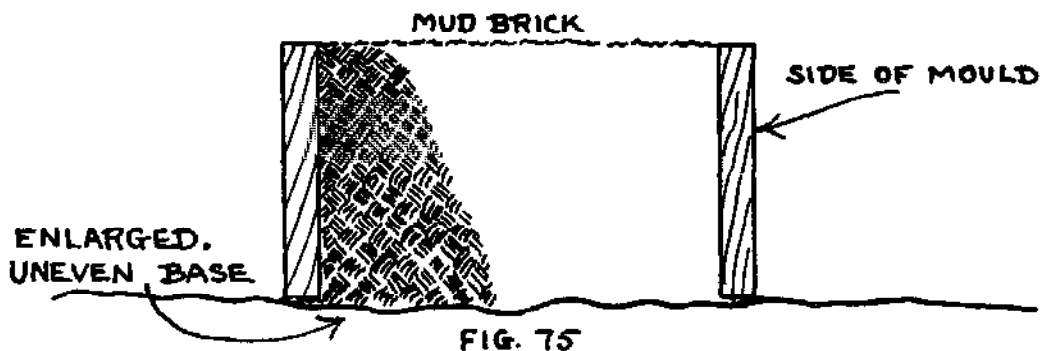


Table method: a quantity of plastic but not sloppy mud is placed on the table. The brickmaker rinses the mould, making sure that the surfaces are clean. The mould is filled, care being taken that the corners are well packed. The excess at the top is struck off with a board or some easily handled tool with a sharp edge. If the mud is stony or filled with straw, a fast back and forth movement of the striker board may be necessary to produce a straight surface. We recommend that the surface be not smoothed. A broken surface will hold mortar better.

The full mould is then grasped in such a way that it can be drawn to and over the edge in one deft movement which will not dislocate the moulded brick. The mould is carried on edge as shown to the smooth, hard drying ground where it is deposited carefully. When the mould has rested on the ground for just a moment, lift the mould carefully. A little practice will teach how to make the whole process most satisfactory. Once accuracy of technique has been achieved, speed is the great factor. The bricks are laid as closely, in rows, as is practicable, because invariably good drying space is at a premium.

Ground method: make a small platform like a stone boat on which to place the mud for the moulder. Every moment or two, the labourer who brings the mud to the moulder, draws the mud along to keep it handy for the man who uses it. On the platform there should also be a receptacle in which the moulder may rinse the mould each time he uses it. The mould is placed on the ground, filled, scraped, lifted, rinsed. All the area on which bricks are to be laid should be carefully smoothed and made as hard as possible so that the moulder does not have to work over it each time he wants to make a brick.

The following sketch shows what happens when a brick, moulded on the table is dumped abruptly on the drying ground, or is placed carefully on uneven ground either from the table or on the ground.



If the brick mud is too wet, the brick will slump when the mould is lifted. This slump widens the brick so that when two of them are placed side by side in the wall, their combined width is greater than the length of a cross, or header brick. It makes for bad bricklaying, excessive plaster coats and other irregularities. The mud is to be just plastic enough to make solid brick.

The drying area should be as close to the job as is convenient every way, and if at all possible, protected from the in-

vasions of dogs and goats particularly. The latter have been known to have destroyed a large number of bricks in a few minutes of running about.

If there is danger of rain falling, make numerous shallow trenches to carry off surface water which would otherwise ruin the brick. The bricks would have to be covered with sheets of roof iron. Every reasonable opportunity should be taken to make bricks when rains are completely over.

Adopt some system to preserve the moulds from drying and warping. They may be soaked in kerosene each night, or merely left in the barrel, submerged. Pores, roughness, or accretion will mar the bricks. It may be necessary to line the moulds with sheet metal. However, if this is done, sandpaper the metal to a slippery smoothness and soak with kerosene before using.

9. Trimming the bricks. If in spite of the best you can do for a smooth and hard drying ground the under side of the brick is objectionably uneven, trim it. This can be done when the brick has hardened enough to be turned on its edge for more even drying and baking.

10. Care of the bricks. Each one is of value. When sufficiently baked to be stacked, take them to convenient places close to the building from which they can be quickly picked up and handed to the masons. If you have been able to leave the brick on the ground long enough to be thoroughly baked, then the piles can be tightly packed. But, if on breaking several, it is seen that they are not quite dry and hard, then pack them loosely, but evenly in the piles. Bricks not completely dried when laid, will shrink in the wall. Usually this is not necessary.

II. MUD BLOCKS.

It is hardly necessary to say that mud blocks should be moulded close to the job. More than bricks, they need chopped grass, straw or hemp to make them strong enough to handle without breaking.

Pieces of block will be required on the job. Usually, cut blocks are mangled, weak. To obviate this as far as possible, carefully plan out your bond in every wall and try to work out a system whereby one or two or even three sizes of pieces will serve the whole job. Then figure out about how many of each you will require, and make them. For further suggestions about block bonding, see Section IV Block Bonding, in Chapter Eleven.

Blocks take longer to dry out than bricks. Make allowance for this.

III. BURNED BRICK.

1. Clay. Clay for burned brick is a common earth of various colours, compact and brittle when dry, but plastic and tenacious when wet. It is a hydrous aluminum silicate, generally mixed with powdered feldspar, quartz, sand, iron oxide, and various other minerals.

Experiment with as many different samples and burning arrangements as is practicable. Try different temperatures for

slightly varying periods on each sample of clay before incurring the expense of burning a large number which may not be satisfactory.

Usually the addition of clean, sharp sand to pure clay will correct the tendency to warp, fuse, or crack. "The strongest brick clays are those possessing the greatest plasticity and tensile strength, and are usually those which contain the highest percentage of hydrated aluminum silicates." The latter ingredient is necessary to the tensile strength of burned bricks. Keep out organic matter.

2. Moulding. Mould the bricks as ordinary mud bricks are moulded, but try to have them as near the true shape and size as possible. They must be absolutely dry before being built into the kiln. Break them open to make sure. Multiple moulds should be used.

3. Size. The same principle applies to burned brick as to mud brick in connection with the relation between the width and the length. One American size is 8" X 3-3/4" X 2-1/4". This will work in very well with Mission practice. So also will the 9" X 4-1/4" X 2-1/2" size. It will be well to use at least two multiple moulds of four compartments each when making these small brick.

4. The kiln. The dry brick are stacked on edge, about 2" apart, in rows so that the fire can reach to all bricks and as evenly as possible. According to the number of brick required, there are one or more firing chambers, formed by arching the dry bricks to make a tunnel about 30" wide and 15' to 20' long.

FIG. 76. GROUND PLAN OF BRICK KILN

20' X 50' KILN
WILL ACCOM-
MODATE BRICK
FOR AN ORDI-
NARY HOUSE

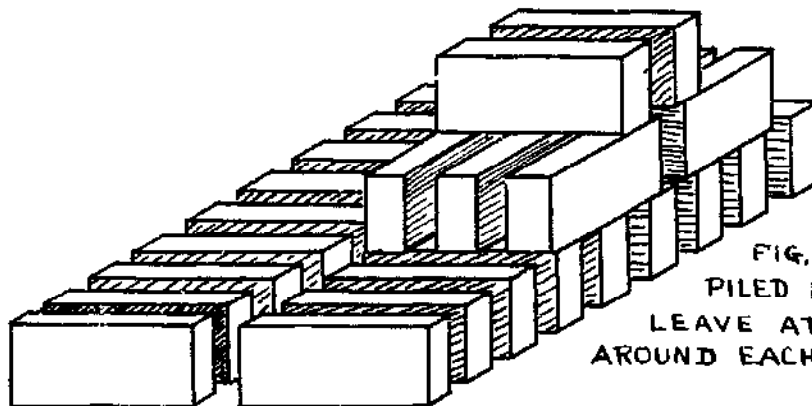
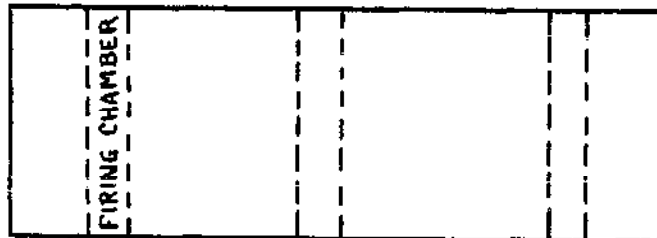


FIG. 77. BRICK BEING
PILED IN THE KILN.
LEAVE AT LEAST 1/2" SPACE
AROUND EACH BRICK.

The firing of the kiln should be well in advance of the job. The bricks must all be thoroughly dry before being built in

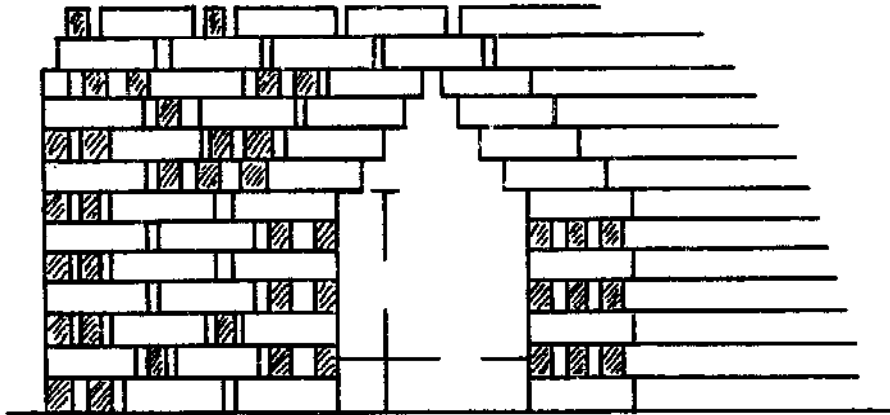


FIG. 78. FRONT VIEW IN PROCESS.

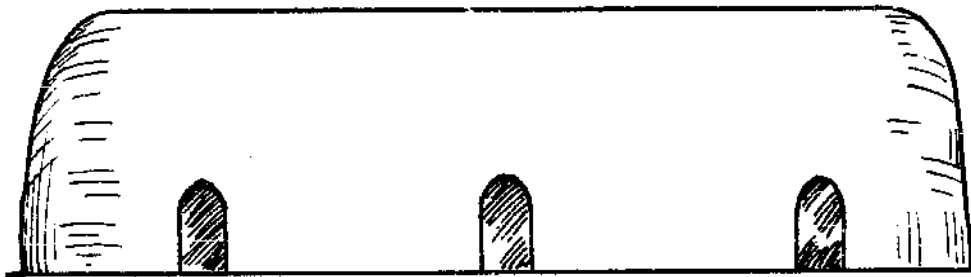


FIG. 79. FRONT VIEW COMPLETED KILN PLASTERED.

the kiln; the mud plaster on the outside the kiln should be quite dry before firing; and after firing, the kiln will take some time to cool, even after the plaster is removed.

Gather plenty of firewood so that there will be no possibility of running short during the firing period. Some care should be taken to get the driest and hottest fuel. During the firing period a fireman will have to be on duty all night. Four days may be sufficient for the burning, but probably this will be insufficient. The openings to the fire chambers should be kept pretty well closed when not stoking the fires.

Remove the plaster when it can be handled. When the brick are cool enough to handle, see that they are sorted out. The best burned brick are for the outer face of the main walls and the least burned brick are for partition walls. If burned brick are made for the exterior walls only, the best burned are for the lower part of the wall which is most exposed to water. Usually the upper part of the exterior wall is protected by the roof.

Burned brick are often more fragile than mud brick. Handle them carefully. Burned brick should be drenched just before being laid in the wall, especially if cement mortar is used.

CHAPTER THREELAYOUTI. AUTHORITY.

1. Be sure that Government and municipal requirements have been met even before layout work is done.

2. If the plot plan has not been drawn up, figured and signed by a Mission officer, the builder should have some senior colleague indicate the exact position and orientation of the building and drive pegs at once to preclude any misunderstanding. Leave the pegs until someone in authority sees that the building is where it ought to be.

II. CLEARANCE.

Prepare the entire building area so that all layout, digging, and construction work can be carried out without unnecessary obstruction. Cut down grass, remove boulders, level mounds.

Layout requires quiet and thoroughness. If possible, therefore, do it when there are no unnecessary workers about and you have no preoccupations. Try to layout the entire foundation at one time.

III. ACCURACY.

If at all possible, have a properly drawn and figured plot plan and foundation trench plan. Do not guess nor try to do figuring out in the sun.

We recommend a metallic wired cloth tape for ordinary building work. Old tapes should be checked, whether your own or borrowed. The greatest drawback to steel tapes is that they are so easily broken, and once broken very difficult to repair. To aid in laying out the trench plan, have one or more neat sticks cut to the exact width of the trench. A helper can follow your outside line and peg out your inside line with such a stick. Check every line for accuracy before turning the layout over to the diggers.

FIG. 80 BUILDING SITE LAID OUT ON PLOT.

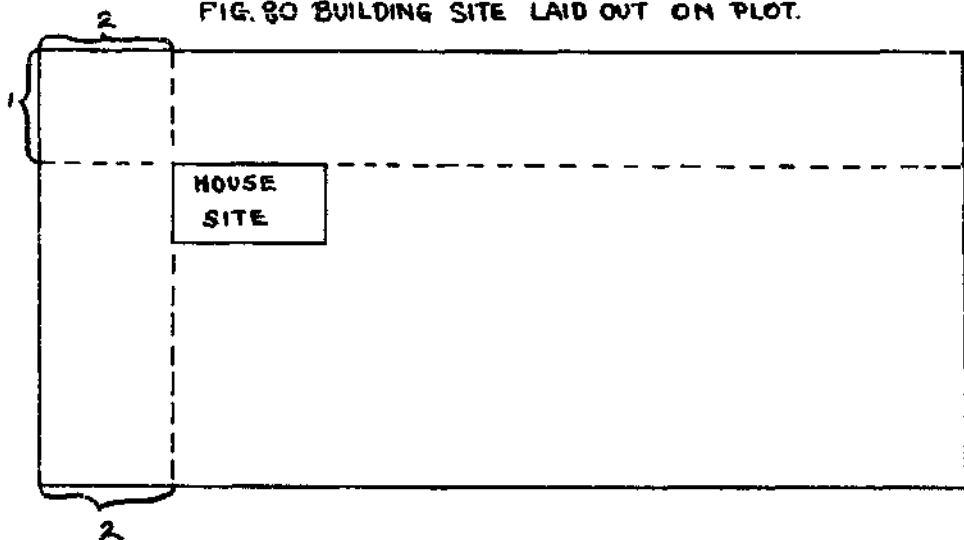
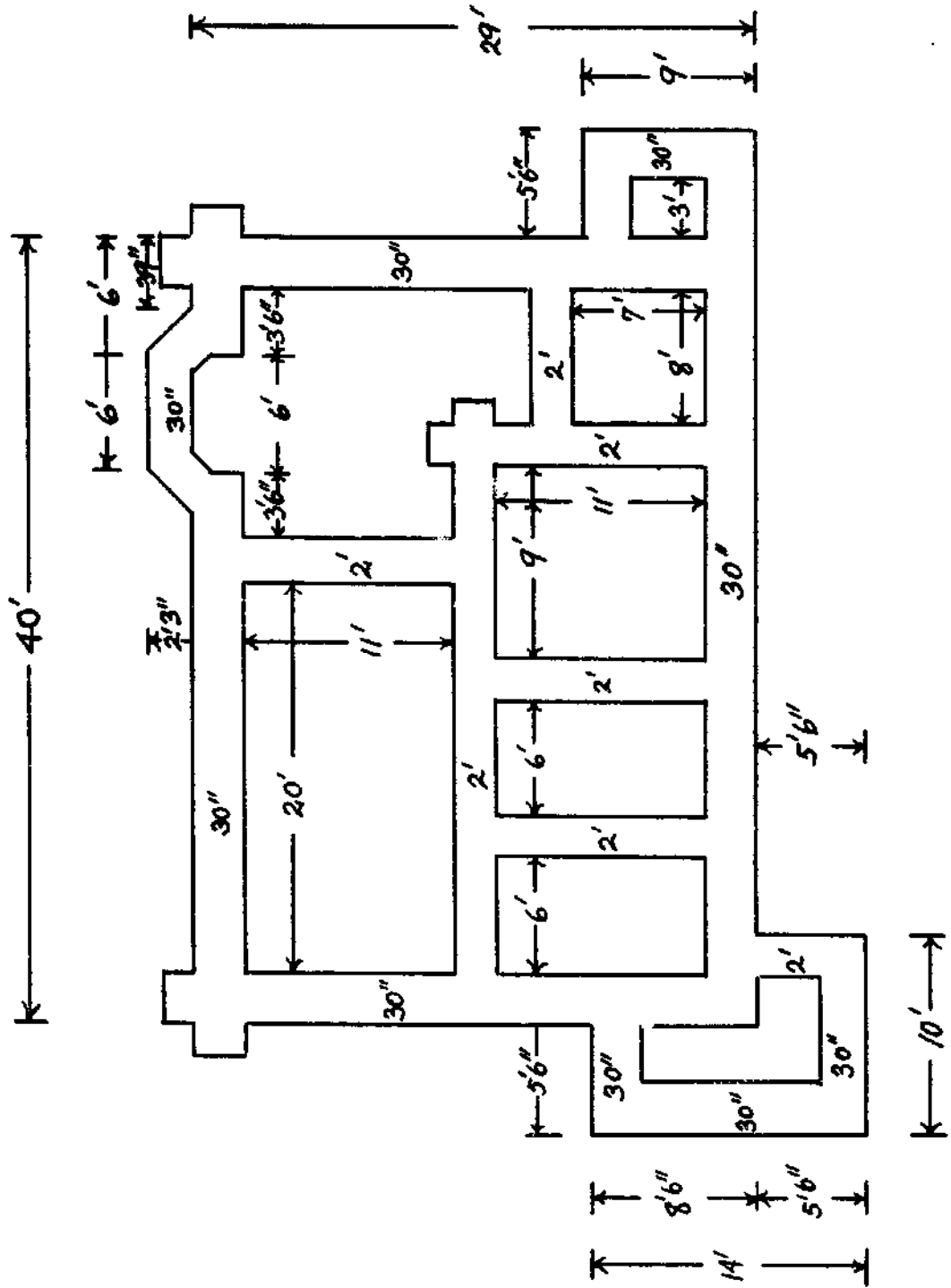


FIG. 81 FOUNDATION TRENCH PLAN FOR 'MISSION' HOUSE

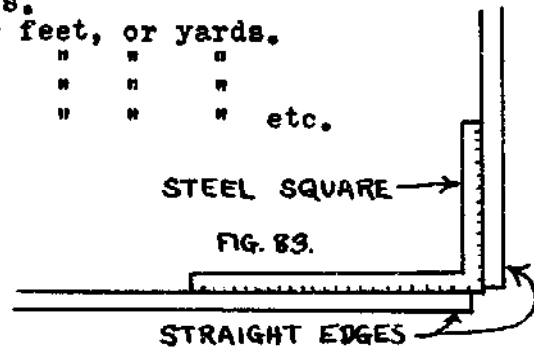
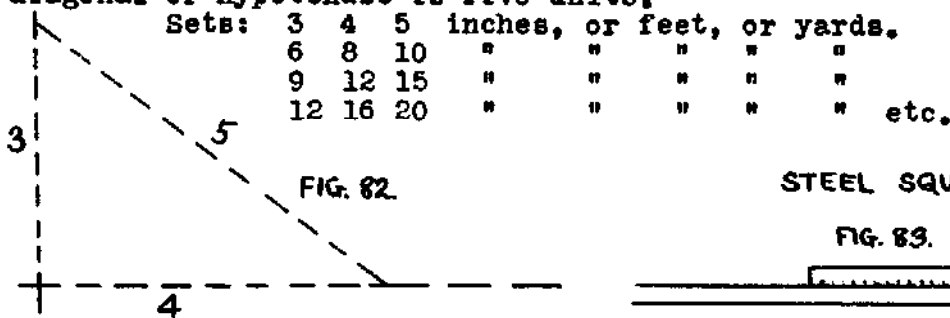


IV. Squaring the layout. It is difficult to overemphasize the importance of making the layout square and accurately dimensioned. One man must make sure. If you are the builder, do not take any line, or angle, or measure for granted; you may have an assistant but see with your own eyes that every measure is absolutely correct. Discrepancy in the foundation, particularly in the squaring makes trouble all the way in construction.

Methods of squaring:

1. The steel square for very small buildings, not larger than 10' X 10'. With the square use two straight edges at one time.

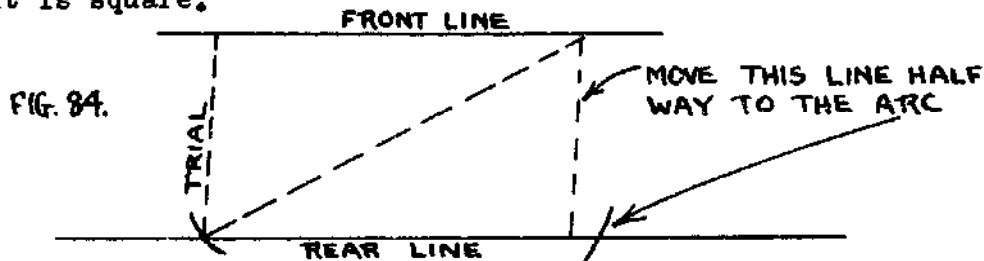
2. The three-four-five method. Any angle is square when the two sides are three units and four units respectively and the diagonal or hypotenuse is five units.



3. Diagonal by experiment.

Determine the front line of the building. Mark the two corners. Make the rear line of the building parallel to the front line. Make the two end lines from the two front corners and as near square as you can with the eye or a steel square. Move one or other until the distance between them at the rear line is the same as it is at the front line.

From one of the front corners measure the diagonal; then from the other front corner measure that diagonal; probably they will be unequal. Move the end lines together, one way or the other until the two diagonals are equal. When they are, the layout is square.



4. Diagonals by square root. This is the most accurate, least exasperating method of squaring, if done at the desk. Example: To find the diagonal of the Mission House main trench layout, 29' X 40'.

Add the square of these two numbers:

$$29 \times 29 = 841$$

$$40 \times 40 = 1600$$

2441 the sum of the squares of the two sides.

Find the square root of 2441. Mark off in two's from the right:

24,41

Find the largest number which will square within the first set:

$$\begin{array}{r} \underline{4} \mid 24,41 \quad \underline{4} \end{array}$$

and place it before and after. Place the square of 4 that is 16 under the first set and subtract:

$$\begin{array}{r} \underline{4} \mid 24,41 \quad \underline{4} \\ \underline{16} \\ 8 \end{array}$$

Bring down the next set and double the number in the quotient, bringing it down to repeat the first operation.

$$\begin{array}{r} \underline{4} \mid 24,41 \quad \underline{4} \\ \underline{16} \\ 8 \mid \underline{8}41 \end{array}$$

Now add to the divisor, 8, that number which when used to multiply the complete divisor will not exceed the main number.

$$\begin{array}{r} \underline{4} \mid 24,41 \quad \underline{49.} \\ \underline{16} \\ 89 \mid \underline{8}41 \\ \underline{801} \\ 40 \end{array}$$

In this case it is 9. We add the 9 and multiply 89 by 9. Again we subtract Place 9 in the quotient and make the decimal point.

$$\begin{array}{r} \underline{4} \mid 24,41 \quad \underline{49.4} \\ \underline{16} \\ 89 \mid \underline{8}41 \\ \underline{801} \\ 984 \mid \underline{4000} \\ \underline{3936} \end{array}$$

Since we have no more sets to the left of the decimal point, we bring down two ciphers. Again we double the quotient and add a number by which we can multiply the divisor

Here the remainder is so small that our .4 in the quotient is close enough. If there were considerable remainder, then the former process would be taken another step to get another figure in the quotient.

.4 is in this case .4 or 4/10ths of a foot.

This is not good enough, so we take 4/10ths of a foot in quarter inches which is $4 \times 12 \times 4$ which comes out to $\frac{19}{4}$ inches which is 4-3/4 inches.

The diagonal we have found is 49 feet, 4-3/4 inches.

To use this figure in laying out, place the ring of the measuring tape on one front corner of the building and make an arc across the rear line of the building at the 49 foot, 4-3/4 inch mark.

Where this arc cuts the rear line is the corner of the building or layout. Measure from this point along the rear line the same length you have in the front line and connect the point with the corresponding front corner. Just for certainty, measure the other diagonal. If there is a discrepancy it will be due to arithmetical calculation or to inaccuracy of measurement on the layout. It is well to have the diagonal of the house walls whether you have the diagonals of the trench plan or not. The foundation may or may not be absolutely square by the time the men have finished with it, but the house must be square and the four corn-

ers when started must be absolutely square. Again, if you are responsible for the building, see this is right with your own eyes.

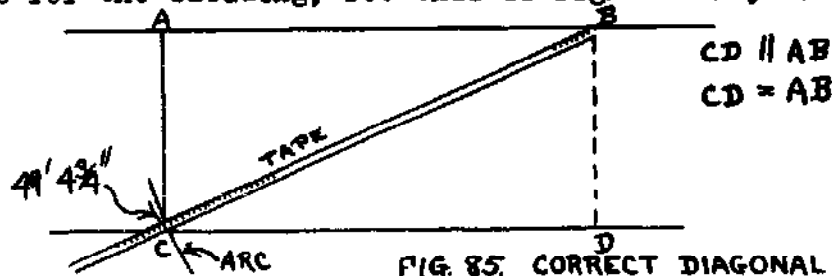


FIG. 85. CORRECT DIAGONAL LAYOUT.

5. Determining the diagonal by the use of the steel square. The common steel square is 12" X 24". We would distinguish between this steel square and the true framing square used by carpenters which is 16" X 24". However, although both are useful, try to get the use of a framing square for your building.

To use the former example, we will calculate the diagonal of the two sides, - 29' and 40'.

FIG. 86. FULL SIZE DETAIL OF READING

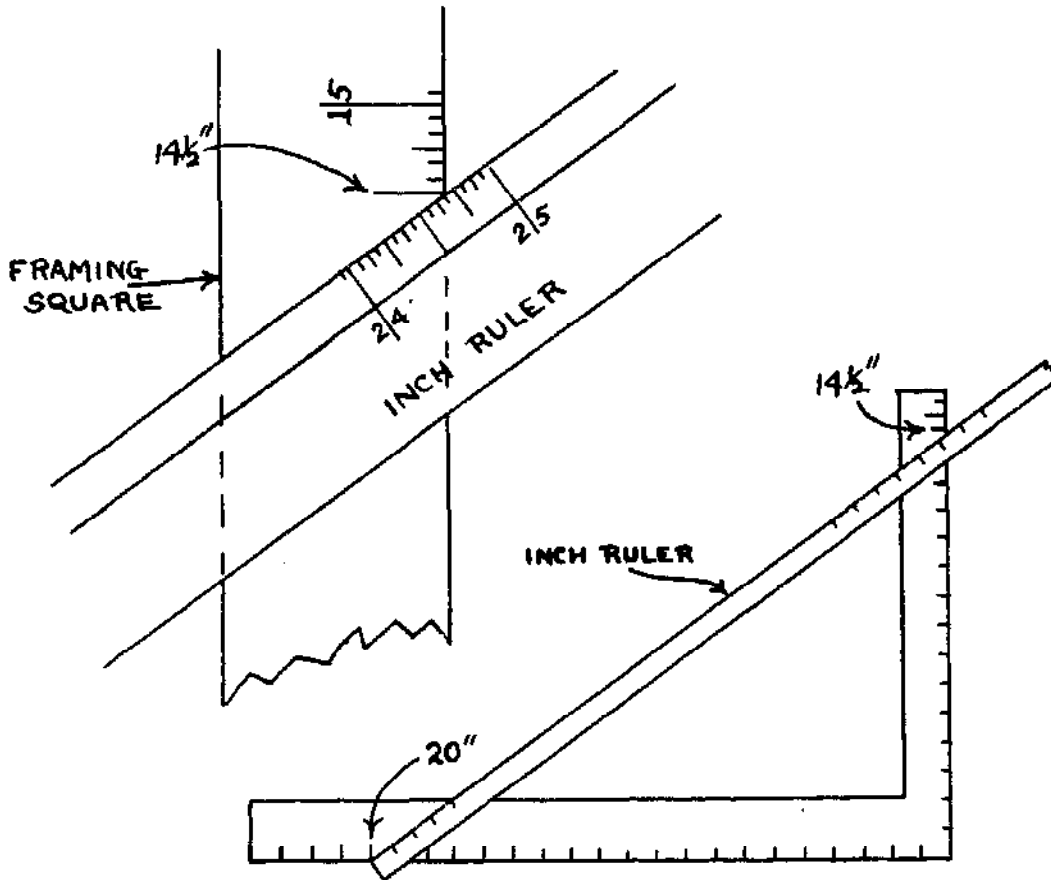


FIG. 87.

Every framing square has two different sets of inch markings, one on each side. By examining the square closely you will find that the inch markings on one side have only three divisions per quarter inch, twelve per inch. This constitutes what is termed the scale of one inch to the foot wherein each division in the inch represents one inch in the full size; one inch being equal to one foot.

Thus, we can draw up a small building by the use of the framing square. Now if, as often happens, the building dimension exceeds 16' X 24' we may still use the square by counting each half inch as equal to one foot. In this case each division on the square would be two inches. In our present example, we will have to use the half inch equals one foot scale.

On the tongue we locate 14-1/2" for 29 feet, and on the blade we locate 20" for 40'. On the latter, place the end of an ordinary ruler, unless of course you have a scale of your own. Let the ruler pass over the 14-1/2" mark. In figure 87 it will be seen that the reading is just beyond the 3/16" mark past the 24-1/2" mark which to us is 49'. Each quarter inch in the half inch scale represents 6" and so the 1/8" represents 3". One must calculate that in our present reading we have something just over 4-1/2". In practice this is good enough, for when the four building lines are stretched and the diagonal is checked, it takes only a moment to move one or other or both to make each diagonal equal. What with the sag in the tape, or the thickness of a nail or the slightest movement of a peg, it is practically impossible to get diagonals closer than one quarter inch to each other.

However diagonals are calculated, write them down at once on your plan so that they will not be lost.

6. Where there are a number of buildings to be erected, especially of the smaller size, it may be well to make a template of wood. This is really a gigantic square or better still, a 45-90 triangle as shown here.

V. REFERENCE PEGS.

When the four main lines have been located, drive reference pegs on each, about five feet from each corner of the building as shown in Fig. 89, and protect them from dislocation. It may be necessary to drive the peg nearly to ground level. These pegs conserve the accurate measuring and squaring work done in the layout. Once the building has been begun, such work is difficult, almost impossible. If possible, make level marks on these pegs, so that the whole

levelling job does not have to be done when the walls are going up. Always use the inside edge of a peg for the purpose of measurement.

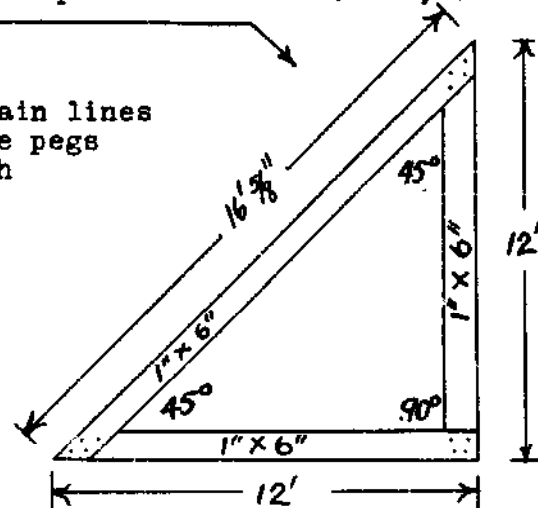


FIG 88 SQUARING TEMPLATE

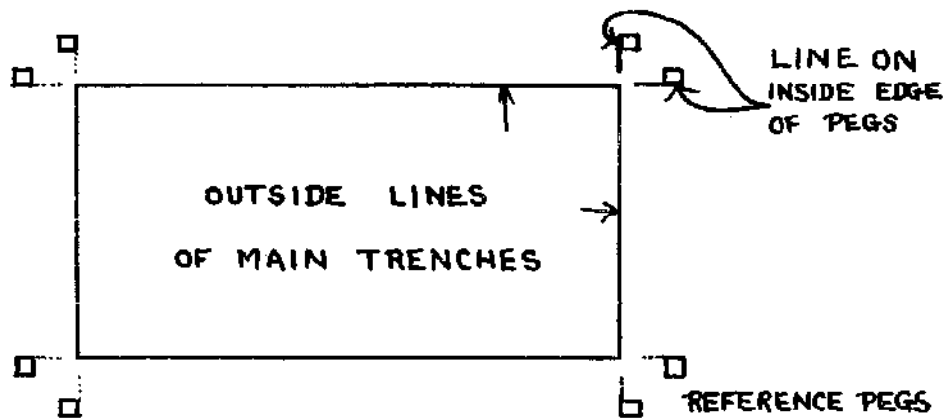


FIG. 89. LAYOUT REFERENCE PEGS

VI. LEVELS.

1. The conventional method of securing levels is by the engineer's level. For a large building such as a hospital, this instrument is to be used if at all possible. If it is used, place level pegs or marks at all the key points.

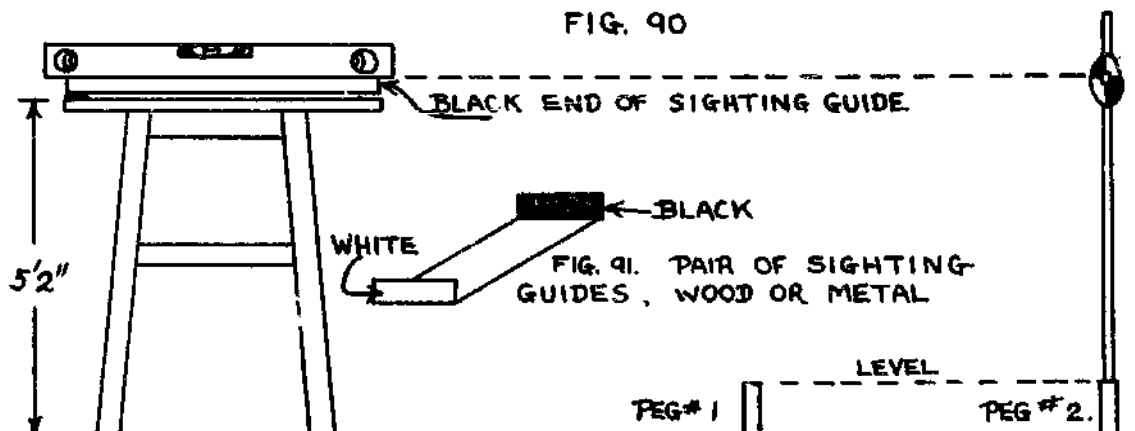
2. The commonest, slowest, and most erratic method is by straight edge and common level.

3. The fastest, most practical method on ordinary buildings is the use of the line level. This is just a level glass in a metal case and fitted with two hooks by which to hang the level on a line.

These three methods of levelling are demonstrated in Chapter Six, FOUNDATIONS.

4. Levelling improvisations.

(1) A sighting stand on a tripod, using a tested level.



Of course this crude instrument can only be used in a straight line with one set up, but it has proved a very good substitute for an engineer's level. Use a high lamp stand or other easily portable table on which to rest the sighting guide device. This

may be made of metal or wood, but in either case rigid enough to resist distortion once it has been set in the level position. It may be screwed or even tied to the board or table top which supports it. Make the table top as level as you can with the use of the level. Then place the level on top of the level guides and pack one end or the other until they are perfectly level. We can sight over the guides with or without the level remaining on them. If it does not interfere with your sighting, leave it there to refer to constantly to make sure that your guides have not altered. To test any level, turn it end for end.

Make as many level pegs in one row as you will require, then set up the stand near number one peg once more but in line with the cross wall at that point and set out another line of pegs. You will now have two lines intersecting.

Again set up the stand by number one peg, but this time in line with the far diagonal peg. When this has been marked or set for level, you will have levels at the four corners. The two remaining sides can be filled in if necessary by sighting a line or by the use of 'T' sticks.

(2) By the use of a level and three 'T' sticks. Drive two pegs in the line you wish to level, and close enough together so that your level will reach from the one to the other. Now place the 'T' sticks as shown and drive the highest peg down until the tops of the two sticks are level. Now go down your line to the position of the first level peg you want, and drive it. Put the third 'T' stick on it and drive down the peg until all three sticks are in line.

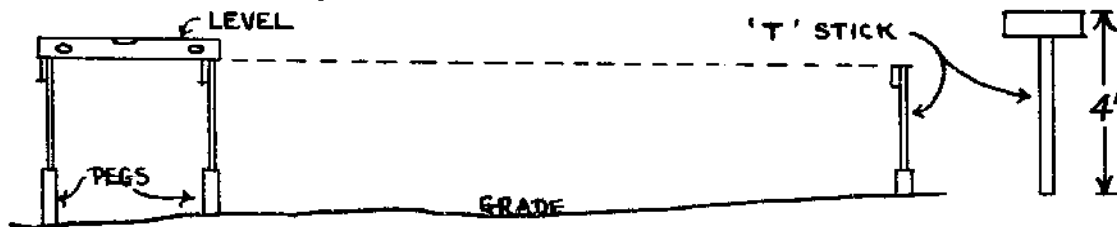


FIG. 92. COMMON LEVEL ON 'T' STICKS

(3) Finding levels where you have no levelling instrument. Make a triangle as shown and place it on top of two 'T's. Use it as a level. When the plumb bob hangs dead across the centre line marked in the base, the base is level.

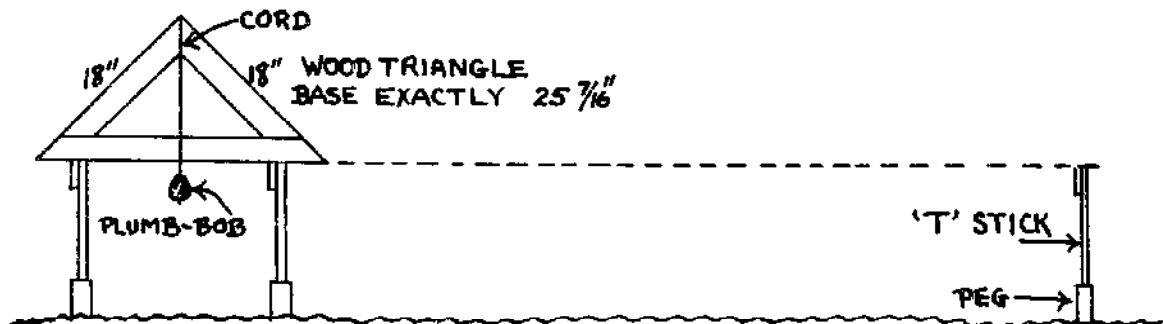


FIG. 93. LEVEL BY PLUMB-BOB

CHAPTER FOUR

EXCAVATION

I. MARKING ACCURACY.

When all the trench lines are in place, make accurate marks in the ground before removing the lines. If through lack of cord, all the lines cannot be laid out at once, mark all the outside trenches, then, before there is any digging, and the area is still clear, lay out and mark all inside trenches. When this has been done, earth dug from trenches will be thrown in the unmarked spaces and so will avoid interference and unnecessary movement of the heaps.



FIG. 94. MARKING TRENCHES.

II. DISPOSITION OF EARTH.

Before digging commences decide just where the earth is to be put. Generally all the trench earth can be used inside the foundation for fill to support the floor. But if the trenches happen to be deep and there will be little fill for the floor, dispose of the earth so that labour will not be wasted.

III. ACCURATE DIGGING.

Poorly dug trenches can be a major source of wall settling. There is no object in digging the trenches too large or too small. In the first case there will be waste of digging effort and then waste of materials. In the second case there will be insufficient bearing for the building and usually in this kind of carelessness, the wrong kind of base as shown at the left. It will help workmen achieve accuracy if each is given a measuring stick the exact width of the trench.

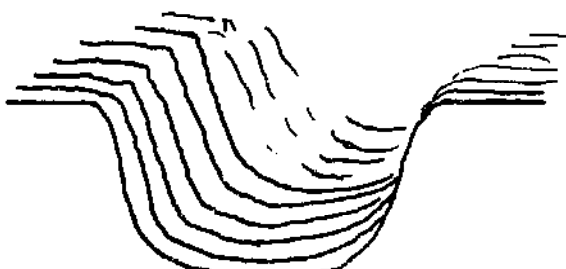


FIG. 95. INCORRECT TRENCH

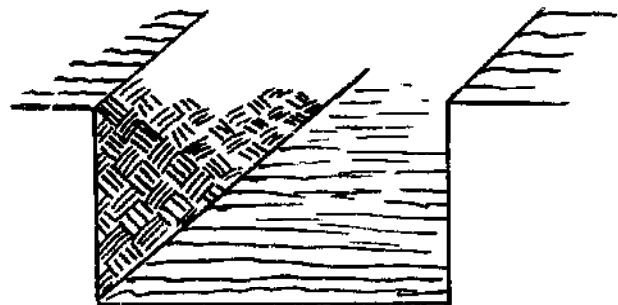


FIG. 96 CORRECT TRENCH

IV. DEPTH.

Do not dig deeper than is necessary. A safe rule is to remove all loose, disturbed earth, and all vegetation, rubbish, building debris, etc. so that you come to hard, undisturbed earth. It may not be hard for a long way down, but it will be firm.

Where there is no frost, depth is no particular advantage. If the site has a heavy wash of rain, the surface may wear away as much as an inch a year. In this case put the foundations down a bit and try to divert the wash. When the subsoil is very

waterlogged, it would seem to be wiser to have the footing near the surface and of extra width.

Footings should be kept level as shown in Fig. 97. The dotted line represents the contour of the surface of the hard earth.

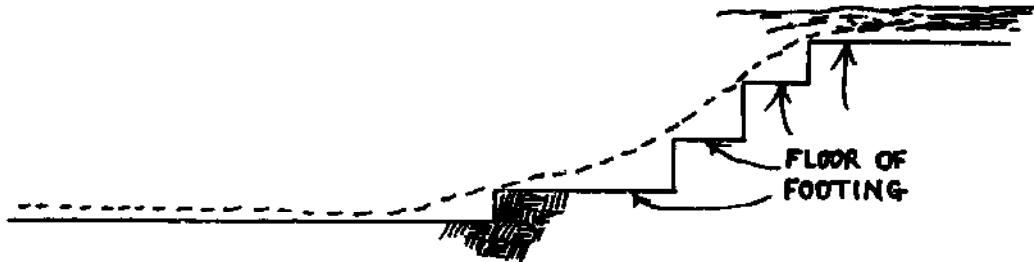


FIG. 97. FOOTINGS ON A SLOPE.

V. EMERGENCIES.

If when the trench is being dug, good, solid, undisturbed earth is not found due to swampy earth, old stream bed, fill, etc., it may be necessary to:

1. Select another building site.
 2. Bridge the gap
 3. Go to the bottom
 4. Use a grille
 5. Make special corners.
2. Bridging the gap.

FIG. 98. SOLID CONCRETE FOOTING BRIDGE OVER FILLED EARTH



3. Going to the bottom

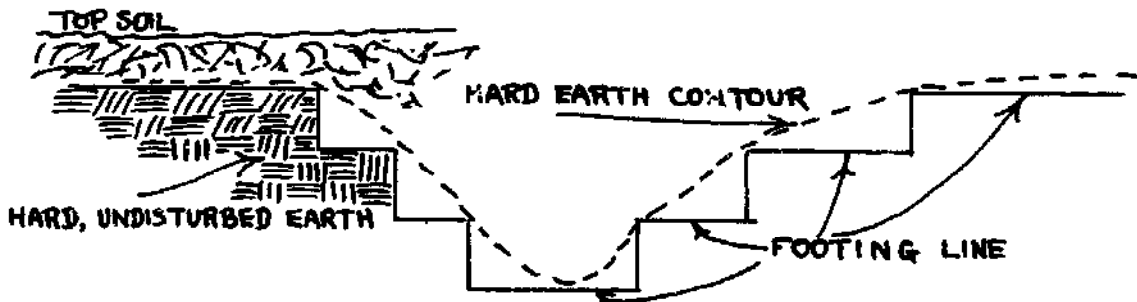


FIG. 99. DEPRESSION FOOTINGS

4. Using a grille.

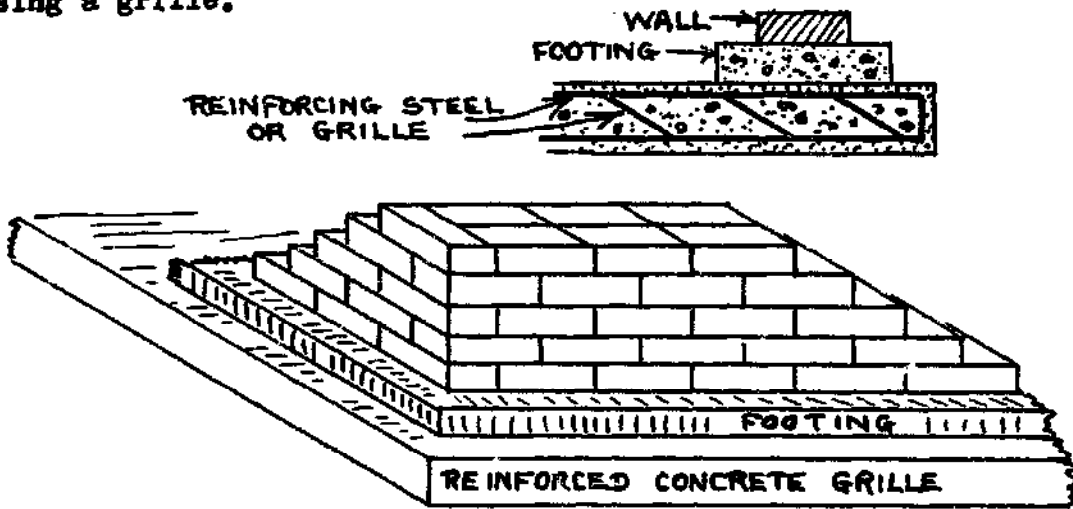


FIG 100 CONCRETE PLATFORM FOR ENTIRE BUILDING

5. Special corners.

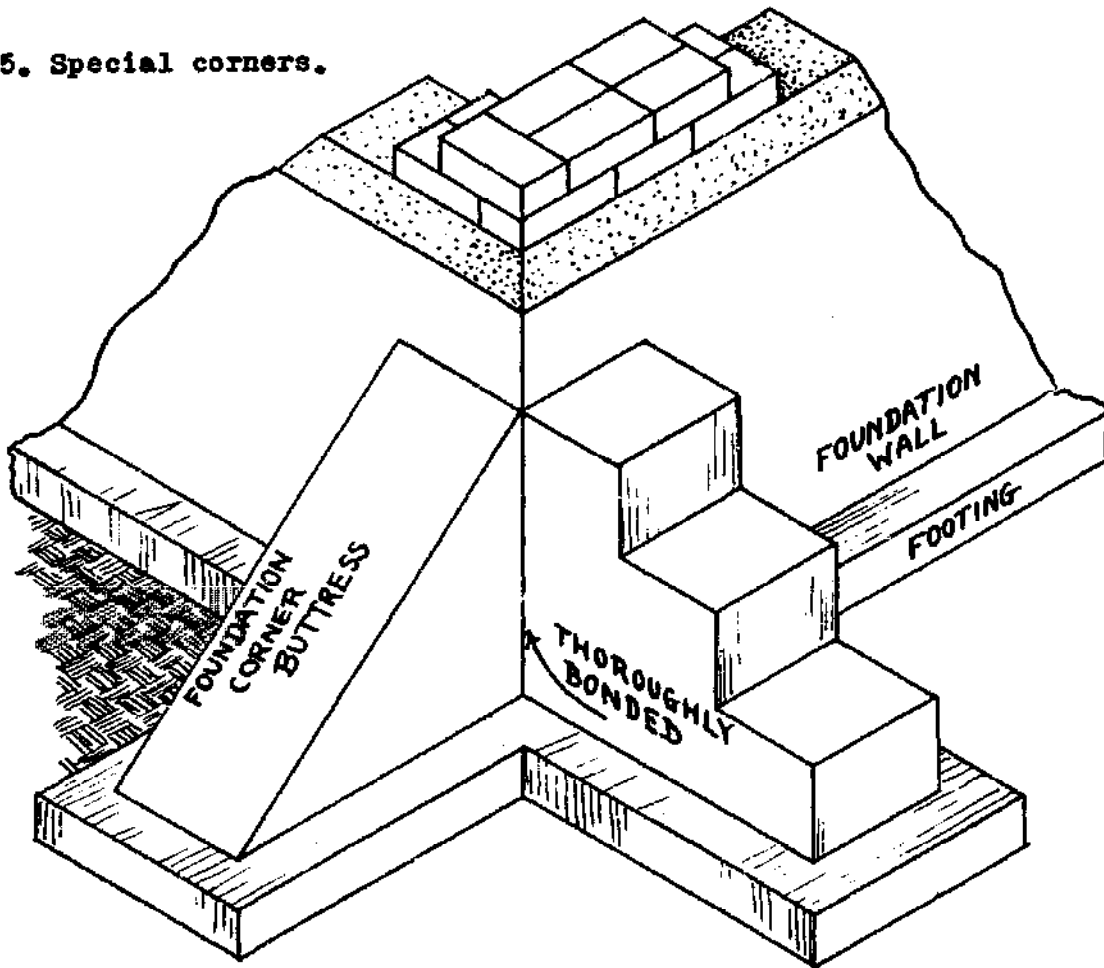


FIG 101.

The grille would not be used unless a building had to be put in a place where no other device would make proper support. The reinforcement shown would be 5/8" bars, certainly nothing less than 1/2". They should be spaced every two feet for a wall up to 11' in height. The concrete should not be less than six inches in thickness; eight inches would be best.

Special corner support is often required, and since it can be put in when the footings are put in with negligibly small extra cost, it will be worth while to put them in where there is the least doubt about the corner settling. What is shown in Fig. 101 is supposed to be below ground and hence it does not have to have the smart appearance indicated in the drawing. The stepped buttress is used when a porch or other wall is to be built there later. The sloping buttress is not a suitable joint for another wall.

Another and more expensive device for preventing corners from settling and so causing more or less dangerous cracks up the wall near the corner, is to put metal rod reinforcement in the concrete at course, another reinforcement just above window height, and a last one at wall height. Since the tendency is for the corner to fall away, the reinforcement prevents it by tying the four corners together at the vital points. Such reinforcement should be about two inches from the exterior of the wall and be securely joined around the building. At window height and wall top the reinforcement should be such that a metal rod would fracture the mud brick corner. To prevent this, embed the metal rod in concrete.

FIVE FOOTINGS.

I. FOOTING REQUIREMENTS.

By definition, a footing is the wide base of a wall, or the wide base for a wall.

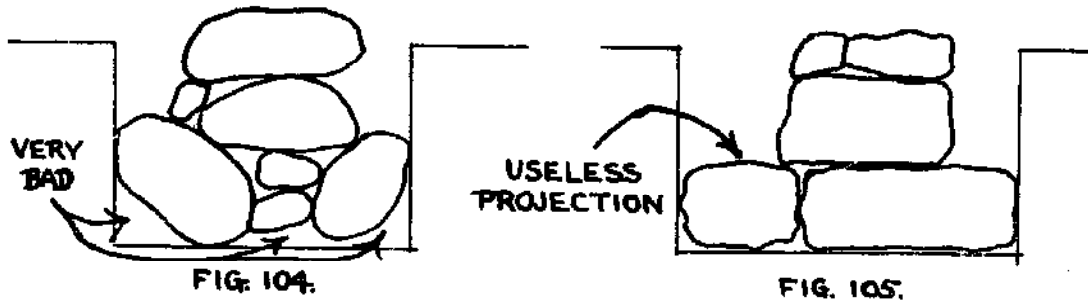
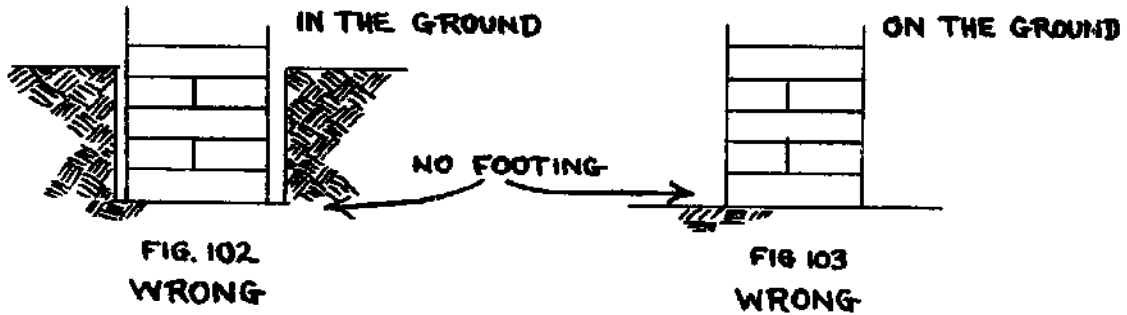
It distributes the weight of the wall over a larger area than the ordinary base of the wall. Its width depends on the nature of the subsoil and the weight to be imposed upon it.

The thickness of the footing depends upon the projection. A safe rule is: thickness of footing equals its projection beyond the wall.

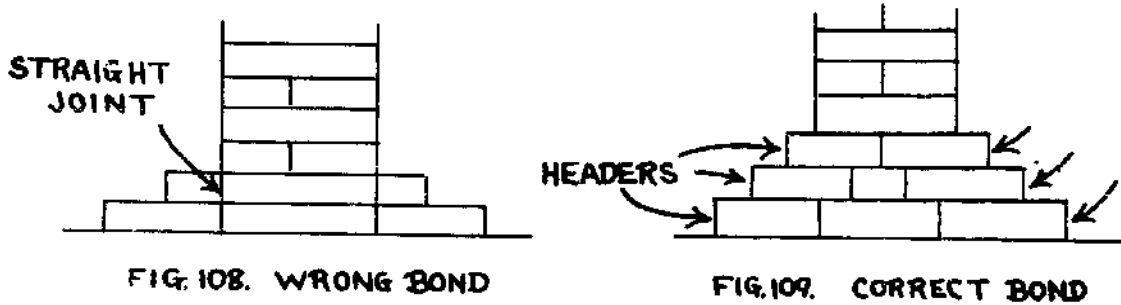
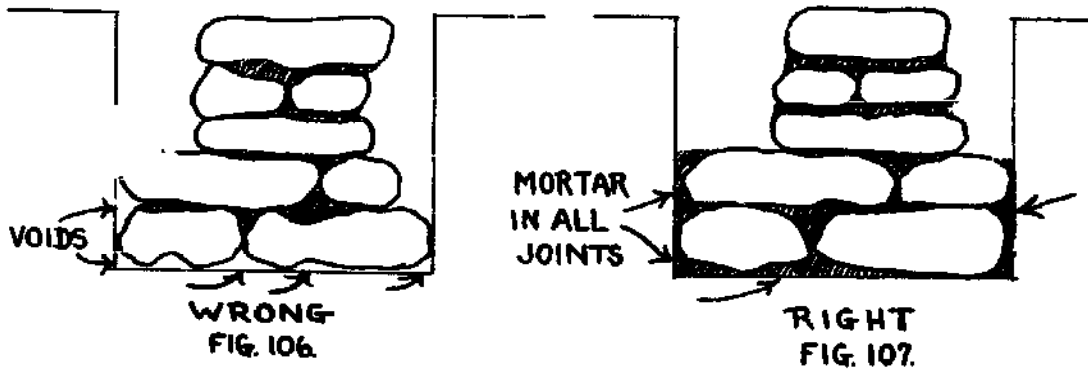
Footings must be impervious to moisture in the sense that moisture will never disintegrate them. In other words, footings must be made of rock, burned brick which will not dissolve in water, or, concrete. And the rock or burned brick must be laid in cement mortar, or at least be pointed with cement mortar so that water will not get at the mud mortar sufficiently to soften it. Never use mud bricks below ground unless there is never any moisture below ground nor at the surface.

The best footing is made of solid concrete and we would always use it except for the high cost of it. It ought to be used for the footings of two storey buildings, towers, etc., and wherever a solid, flat bearing is required for durability or safety. Small stone should never be used in a footing by itself. It may be used to fill in interstices between larger stones, or in concrete.

Brick wall without a footing.



Why walls will not stand up.



In Fig. 104 a too common footing is shown. A little consideration shows why it is very bad. In the wet season, water will soften the earth and the whole weight of the building on such points of stone as are shown will send these stones down into that soft earth. Just a very little of that sort of thing will crack a house dangerously.

Study each of the diagrams and learn to avoid the faults and incorporate the good points.

As long as cement mortar is used to point the surface joints of all footings and foundation walls, mud mortar may be used in the interior joints. But if there is danger of excessive moisture in the footing trench after the building is erected, then it will be safer to use cement mortar in all joints. Sand and cement mortar is more effective if one half part of lime is put in for every part of cement.

Every type of footing with the exception of concrete must have a bed joint of mortar. When the whole foundation is complete, there should be no voids.

All cement pointing should be done when the mud mortar or other mortar is still green.(moist)

Where excessive dampness is present and there is danger of it soaking up into the walls through the footing, lay a damp course of tar paper as shown on top of the concrete footing in Fig.110.

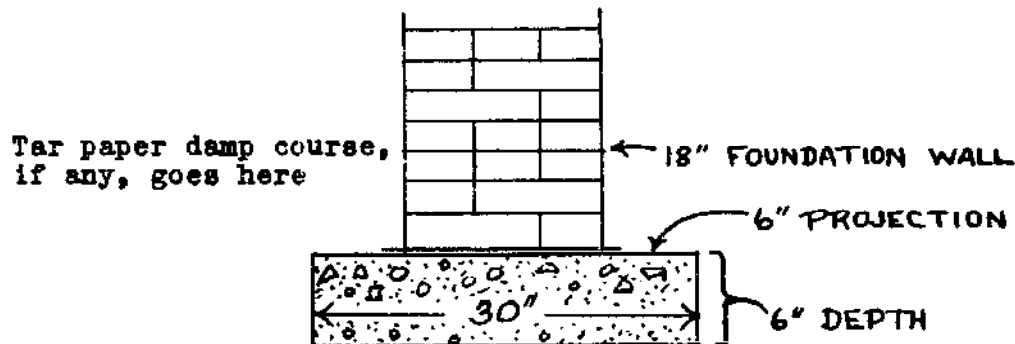


FIG. 110. CONCRETE FOOTING

CHAPTER SIX FOUNDATION WALLS.

I. SPECIFICATIONS.

If the footing trenches have been accurately dug, the foundation walls can be built upon them without further measure, allowing of course for the right projection. But before the foundation wall emerges from the ground, it should be carefully checked from the reference pegs so that no change in its line will be necessary above ground for the purpose of correction of measurement.

If possible, tie in all cross walls with the main walls of the foundation as it is built.

If rain threatens while the foundation wall is being built, smear the joints, inside and outside, with mud plaster.

Fig. 111 MASTER DRAWING OF FOUNDATION

The heavy shading indicates 1:4 cement mortar and pointing.
The light shading indicates 1:6 cement mortar or mud mortar.

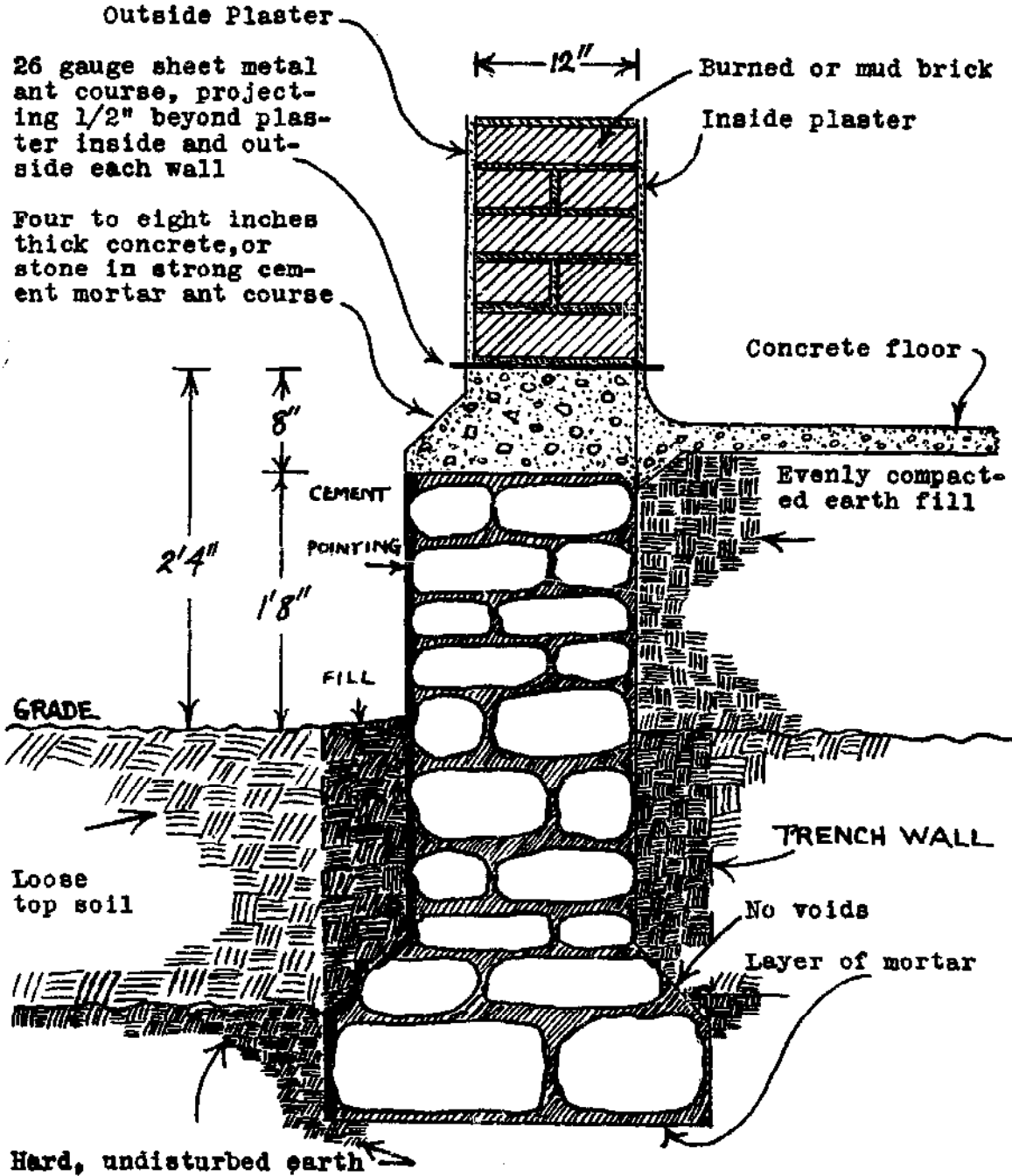


FIG. III.

This may be soaked or even washed off during the storm, but if it protects the mortar from washing out, it will be well worth while.

Study Fig. 111 carefully and apply it to your own foundation drawing. The first terminus of the foundation wall is the base of the ant course. That in turn is the underside of the floor. Whether concrete or stone is used for ant course, level off the foundation wall at this point. Do not merely plaster it with thick mud, but build it solidly. Be sure that it does not sag between corners. If a line is used to bring it to proper level, support the line in one or more places and sight it to make sure that it does not sag. Sag means loss of money in the cement of the ant course.

II. LEVELLING THE FOUNDATION WALL.

If the reference pegs were marked for level at the time the job was laid out, then get levels from them for each corner of the building.

Using the line level. Get one corner up to the determined height and stretch a line from the top of that to the next corner. Measure half way between resting points and hang the line level there. Make a note of the level at corner two and proceed from there to corner three and thence to four. Try the level from there to number one again to check. Once you have been accustomed to the line level you will find it a very useful tool.

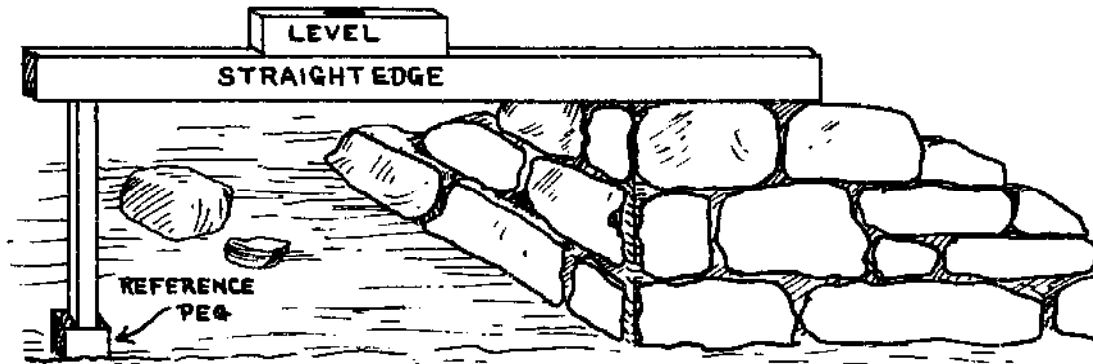


FIG. 112. USING THE REFERENCE PEG LEVEL

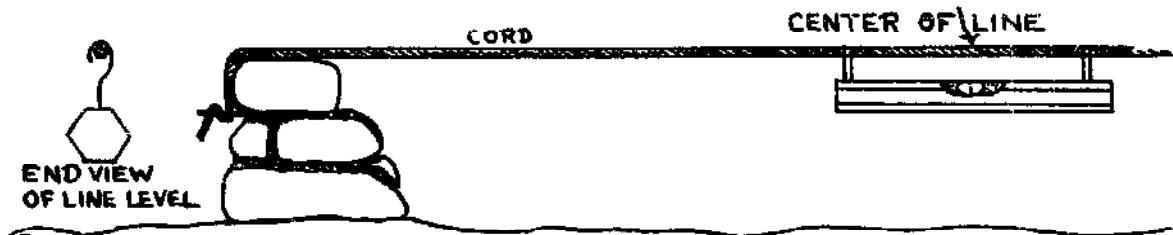


FIG. 113 USING LINE LEVEL

If you have no line level, use the level and straight-edge as in Fig. 112 and proceed from the first corner to a point on the wall at the extremity of the straight edge. Establish that level with an embedded stone or sawn piece of wood. Go on from there right around the building. Turn level and straight edge end for end to check for accuracy.

Ant coursing consists of a continuous layer of concrete on every foundation wall, and on this a strip of sheet metal with soldered joints, the metal wide enough to project at least one half inch beyond the finish line of the plaster inside and outside. It does not guarantee to be ant proof, but it does make it exceedingly difficult for them to get as far as the metal, and, if they get that far, they must then come out and around the exposed edge of the metal before they can get into the upper wall. The metal is approximately four inches above the floor and this gives opportunity to spot the invasion and seal off the opening through which the ants have come.

Ants will go through wet cement. So to keep them at bay while the cement and water, or cement mortar is hardening, pour kerosene or D.D.T. or any other repellent you have found satisfactory down the hole first. Then plug it with the cement.

The fact that the white ant can operate through a hole the size of one standard period of a typewriter shows with what care ant coursing must be laid down, and the very worth whileness of putting in plenty of cement to make it right. Round house ant coursing is dealt with in the section XII, Chapter Seven, Book 3.

I. Concrete ant coursing. According to your pocket book it will be from four to eight inches thick. Six inches makes a very good job. The concrete itself should not be weaker than a 1:4:4 mixture. (One part of cement, four parts sand, four parts small stone.

The ant course may be reinforced with a 1/2 inch steel rod near the outer edge and completely circling the building.

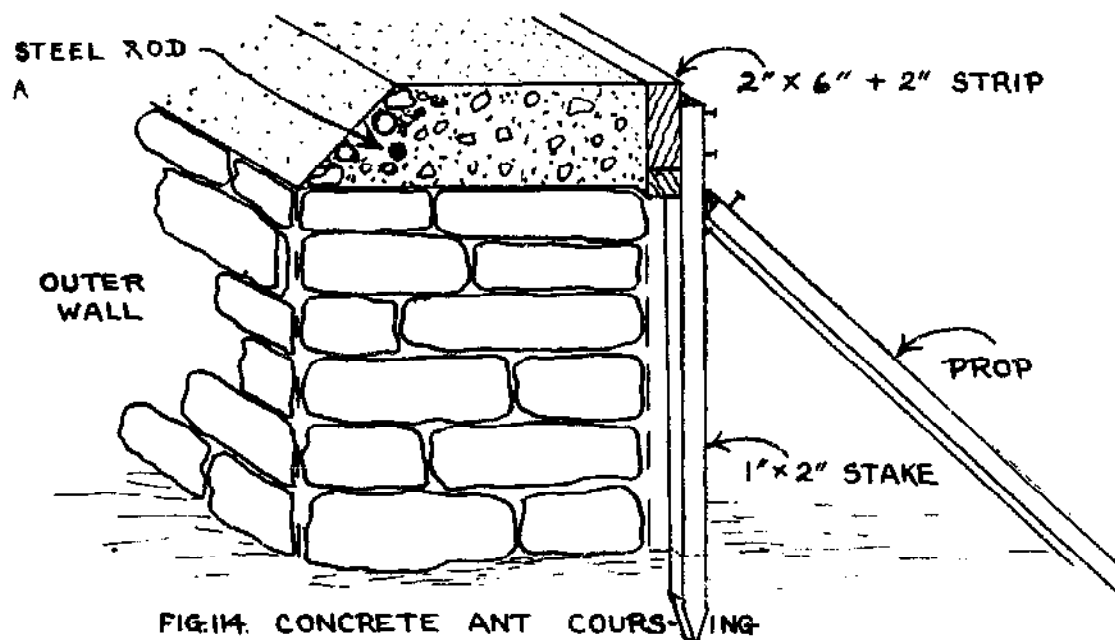


FIG. 114. CONCRETE ANT COURSING

Note the chamfer or cut off corner at the inner edge of the wall. This is to make the longest possible concrete joint with the floor to reduce to a minimum the access sought by ants to the upper levels.

It is very important that the upper edge of the 2" X 6" or 2" X 8" used for the forming of the ant course be perfectly straight and smooth, and that it be made perfectly level before the concrete is poured. Otherwise, it and the metal ant course laid on it will not be of a uniform height above the floor, and besides being very untidy may give trouble when the time comes to attend to ant invasions.

In Fig. 114, it will be observed that some larger stones are set in the outer edge of the concrete. By having such stones ready when the concrete is poured, a wood form on the outside edge becomes unnecessary. When a little concrete is laid, place a row of these stones at the edge, then a little more concrete and more stones until completed.

At every cross wall, leave a jagged cavity for the cross wall concrete to fill, making the most effective bond possible.

At every door position, depress the top of the ant course so that at least one inch of the top coat of floor will cover the ant course. It is most advisable to run the ant course continuously past every door. If you are using only a four inch ant course you will have to depress the level of the foundation wall at every door to accommodate this continuous strip, as shown in Fig. 115.



FIG. 115. DEPRESSION IN FOUNDATION WALL

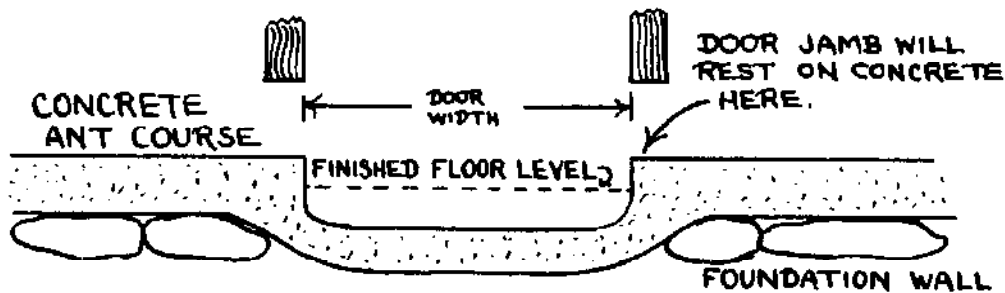


FIG. 116. DEPRESSION OF CONCRETE ANT COURSE AT DOOR

Before completing the foundation wall, be sure that provision has been made for all plumbing. Where each pipe is to pass through the wall, insert, when building, a slightly wedge shaped round block larger than the pipe.

The depressed foundation and ant course is an attempt to close off one of the most vulnerable points. If the ant course stops at door ways and separate concrete is poured in the door way later on, the inevitable crack will invite the ants.

Wet the top of the foundation wall and the forming edge of the 2" X 6" just before pouring the concrete. Every effort must be made to prevent the concrete drying out in less than four days.

Finish the top of the ant course as you would a floor. Sometimes little irregularities in the sheet metal allow rain to be driven through the wall. To prevent this somewhat, make the surface of the concrete to slope outward, $3/16$ " ought to be ample.

As soon as the concrete can withstand wetting, cover it with grass and wet it. Keep it wet for at least four days. In most cases, there will be need to build on it as soon as possible. Great care should be taken not to pound on it or otherwise abuse it.

FIG. 117 JOINT OF CONCRETE COURSE

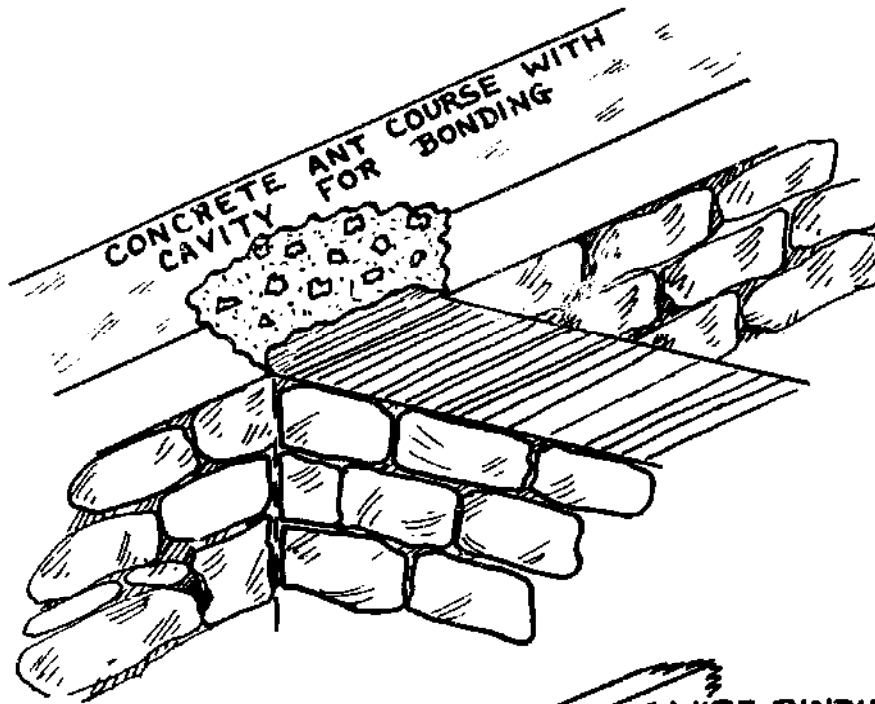
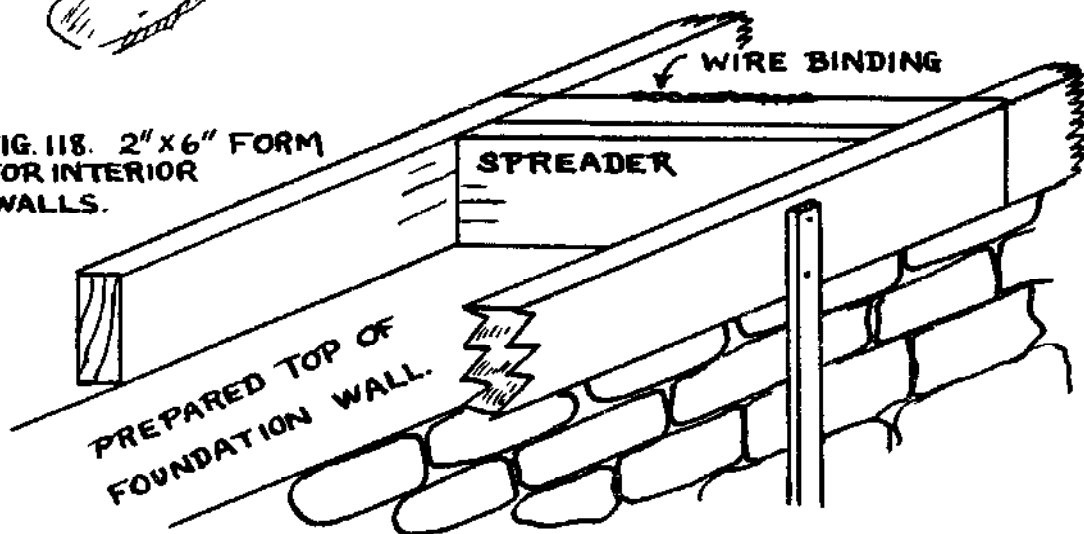


FIG. 118. 2" X 6" FORM FOR INTERIOR WALLS.



II. Metal ant coursing. If you do not intend to make this a continuous sheet, both edges everywhere exposed and absolutely without noles, do not bother with it for it will be wasted.

The metal itself. Where money seems of little object, copper is used. Except in a dispensary or chemical store where it might possibly become exposed to sulphuric acid, it is practically indestructible from a chemical point of view. But in handling it and laying it in the wall, it will require great care to prevent puncture and tearing.

Nothing lighter than 28 gauge (British) galvanized iron should be used for ant course. 26 gauge is the best because it is about as heavy as we can handle. If 24 gauge is jointed at the factory it might be alright as then we only have to make corner joints.

Width. If you are using flattened pans, you are more or less limited to a half pan for main walls. This will give about fourteen to fourteen and a half inches. This means that the brick wall cannot be even a little over 12" for the plaster is usually nearer 3/4" thick than 1/2". So we need all the 14-1/2" of metal to give us the minimum of 1/2" projection beyond plaster finish each side of the wall. Be very particular in cutting the iron that there be no feather edges. On all outside walls, turn the cut edge outside. The other, factory edge, is usually less dangerous. The reason for feather edges and how to avoid them is given in Sheet Metal Work, Book Five. Directions for flattening corrugated iron are also given there.

One of the preparatory jobs for any building might well be the jointing of the ant course so that when the concrete ant course is laid, there will be a roll of ant coursing from which lengths can be cut, and so that the only work necessary will be intersections.

Making the common joint:

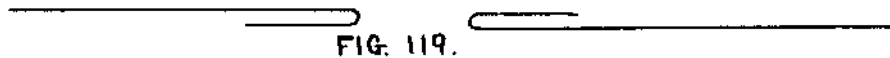


FIG. 119.

- (1) Bend one 5/8" seam under, one over, as here



FIG. 120.

- (2) Hook them together, as here, then line up the two pans and flatten the seam as here

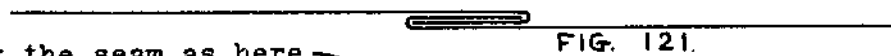


FIG. 121.

- (3) Lock the seam as here



FIG. 122.

(4) Rivet the seam as shown, but be sure that the line of the two sheets is straight. Failure here means trouble later.

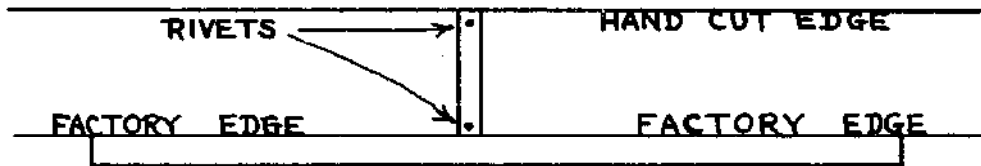


FIG. 123.

STRAIGHT EDGE

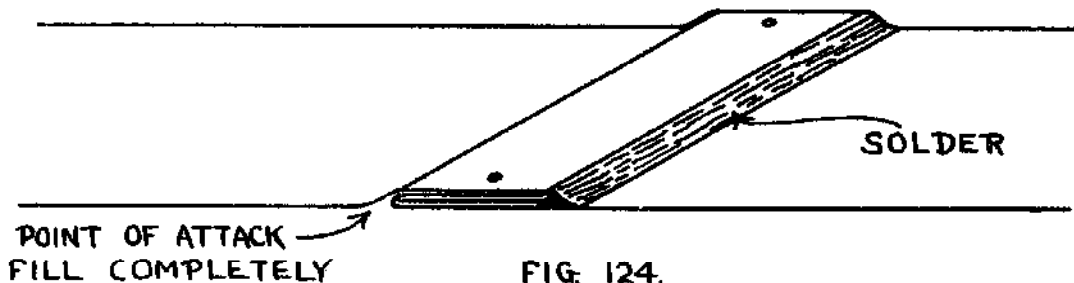


FIG. 124.

(5) Solder the joint as shown. To make the best job, solder the under side as well.

When all the ant coursing is ready to lay on the wall, it is turned upside down and the under side is thoroughly coated with coal tar. Be sure that the opening in the joint, if you have not already soldered it, is completely filled.

The following method of making right angle and 'T' joints may appeal to some. First make a list of all right angle and 'T' joints required. Then lay out what you require on the full width of the flattened roof pans as shown here. Do not cut any pans in two strips until you have calculated how much straight iron you will have as by-product of the special joint cutting.

FIG. 125.

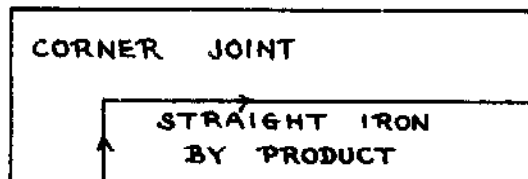
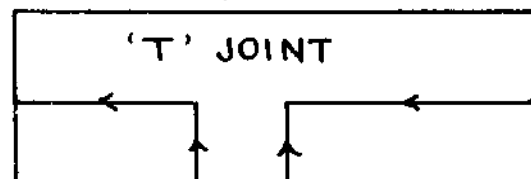


FIG. 126



When making the joint between two pieces, the far ends of which are anchored, it is easy to cut a piece short, and this involves putting in a short patch and a lot more trouble. In any common joint, allow three widths of the joint extra as shown in

Fig. 127. For example, if the width of seam you make is $5/8"$, then the allowance will be $1-7/8"$.

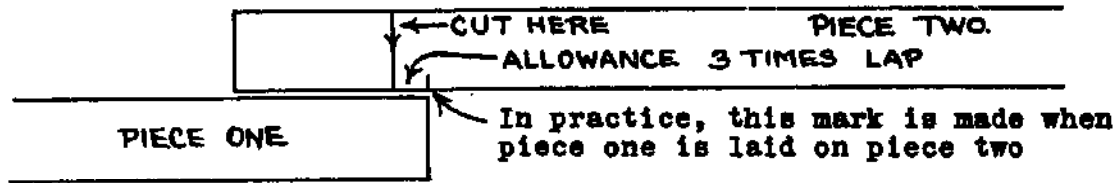


FIG. 127.

Corner joints:

- (1) Place the end of one piece over the side of the other piece as shown, and mark. Be careful that the two pieces are at right angles to each other when you mark.

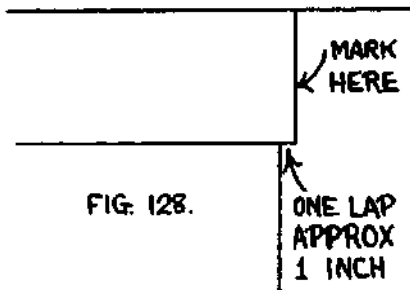


FIG. 128.

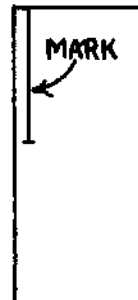
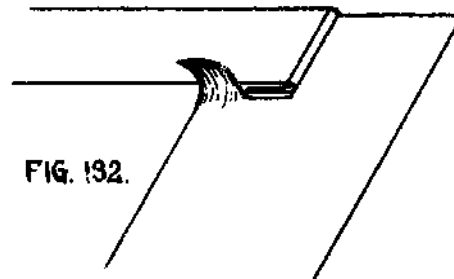
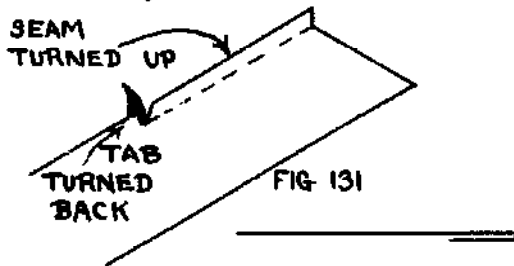


FIG. 129



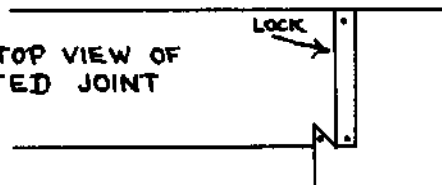
FIG. 130.

- (2) Mark a triangular tab and cut on this triangular mark so that the tab can be turned back and the seam can be folded up then back.



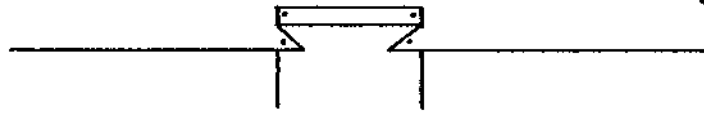
- (3) Make an equal seam on the other piece of metal and fold down. Hook this into the other and complete the joint as for a common joint. When this has been done, turn the tab down and rivet it in place. Practice will show how to manipulate the tab so that there will be no aperture between it and the iron entering from the side. Of course all joints will be soldered, but it is well to make every joint as iron-fast as possible, and not count entirely on the solder. Join up all corners and 'T's before working on common joints.

FIG. 133. TOP VIEW OF COMPLETED JOINT



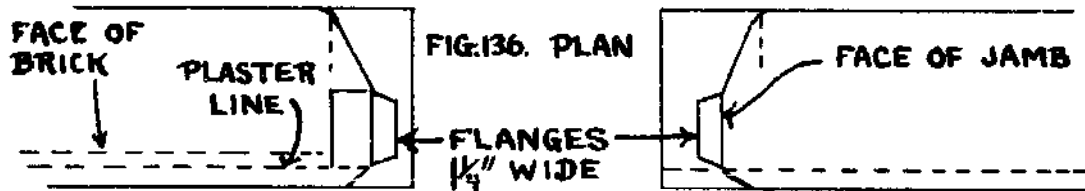
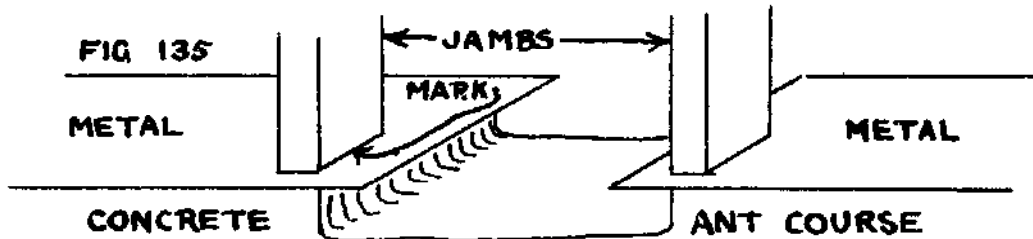
The 'T' joint is made like the corner joint, except that there are two tabs instead of one.

FIG. 134. TOP VIEW
OF COMPLETED
'T' JOINT

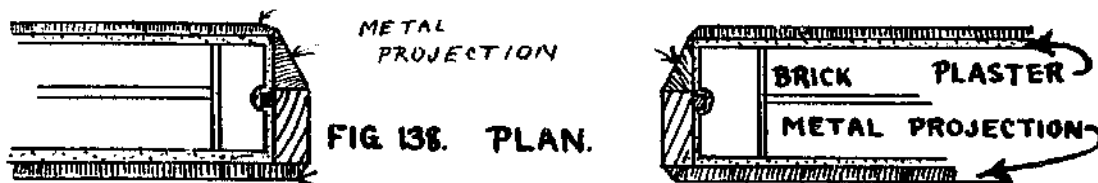
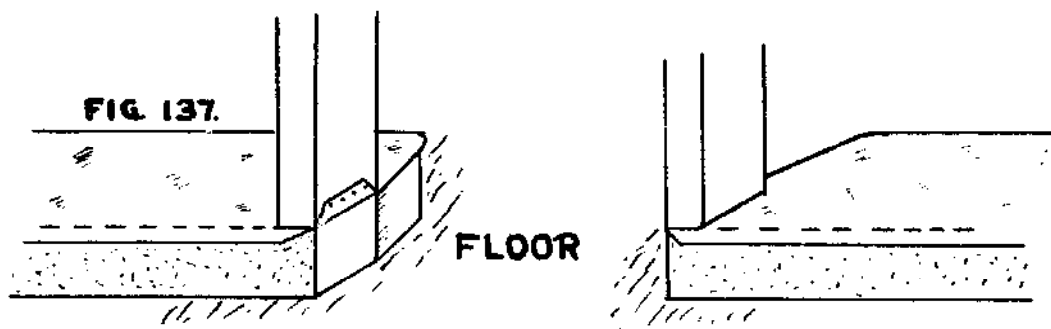


Ant course at door ways.

- (1) Get your plan and see which way each door opens. At door ways let the metal project about 1-1/2". When the metal is secured along the wall in its right place, stand the door frame on the metal in its final position, and mark the face of the jamb on the metal as in Fig. 135. Then further mark the metal as in Fig. 136.



- (2) Cut on the arrow lines and bend up the flange. This will be nailed to the jamb.



CHAPTER EIGHT

FILL

It may be well at this point to discuss the relative merits of two distinct ways of developing the building calendar. In one, the entire foundation is put down, including the floor, and the whole building then, built, as it were, on the floor.

In the other, the walls are built right up from the footings as a vertical unit so to speak, and the floors are put in when all other construction work is done.

In the one mentioned first, there is one obvious merit and one other possible merit. If there is to be a very busy building season and every day counts, then it may be justifiable to put down the foundation with floor over all during the wet season. There is no doubt that the moist air is better for concrete work. The possible merit is that a very good job of floor and foundation put down in this way means that there is no structural break between the wall and the floor, hence less opportunity for invasion by white ants.

But this very good job does take more cement than the floor requires in the other development. And further, it depends somewhat on what we might call perfect earth or semi-rock base. Of course this latter condition is more the exception than the rule.

The greatest objection to the early floor method is that there is almost invariably a difference in settlement between the walls and the floors and this causes cracks in the floors anywhere from the wall out to a distance of 18".

Another objection is that the ordinary building operations will almost certainly destroy the fine finish of the floor. A less important matter is the unsuitability of the concrete for some scaffolding bases.

To have a good ant course on this over-all floor, there needs to be a 4" wall of concrete built on the concrete floor. Otherwise the metal, which there should be in every building, will rest on the floor. This is a most unsatisfactory arrangement because dust collects under the metal, and, if ants do find access it is a most difficult matter to stop them.

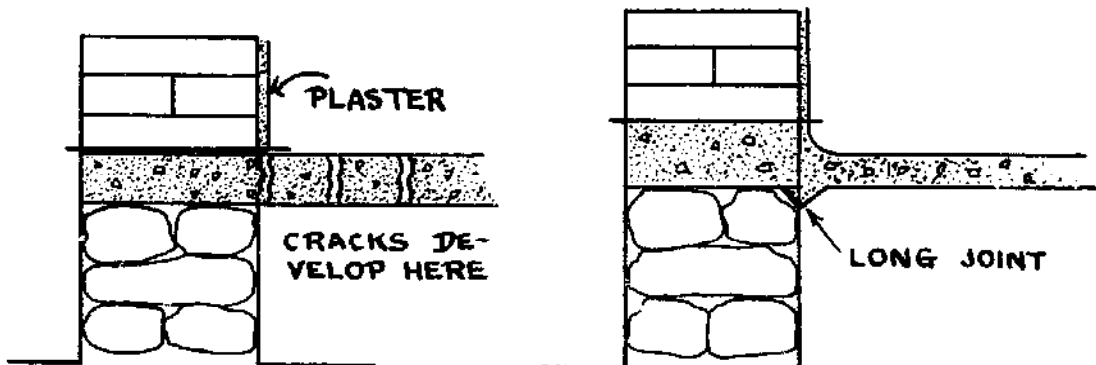


FIG. 139. OVER-ALL FLOOR

FIG. 140. SEPARATE WALL UNIT

Other disadvantages of the over-all floor construction are: labour has to be brought in, as a rule, and this makes for additional expense; the cracks which do appear will be quite irregular, unpredictable; there is the very great difficulty of putting down a large concrete floor in one day and making a good job of it; if it is not put down in one day, there will be joints between the two sections, and there will almost certainly be cracks at such points; if these cracks are in the room they will be unsightly, if they are in the wall area they become an invitation to ants.

The advantages of the other method are now more or less obvious: the whole building job is done at one time, is one transportation job, the wall is one unit and if it settles a little, before or after the house is completed, it will not affect the floor much if at all; as a matter of fact in a good foundation, there will not be much settlement after the roof and ceilings are on; in the rough and tumble of building there will be no floor to damage or stain; scaffold supports will be much more conveniently fixed and much more safely too; when all construction work is done, each floor can be put in without rush, in the cool shade, can be protected, wetted, segregated, etc.; and when the house is to be occupied there will be a flawless, clean, natural-cement colour floor.

CHAPTER NINE MORTAR

I COMPOSITION.

Mortar for stonework should be as strong as possible having a good proportion of clay. It does not matter very much if there are some stones in it, but preferably none.

For brickwork, the mortar is usually made from the same mud as the bricks themselves. It should not have any stones in it but if the only mud available has very small stones, say one eighth inch in size, the mortar can be used provided that it is put on thick enough.

If there are larger stones, they must be screened out by reducing the mortar to a fluid state and running it from a bed or pool through a screen to a lower pool where it can dry out somewhat before use.

II QUANTITY.

It is easy to underestimate the quantity of mortar required on an ordinary masonry job; and the miscalculation often leads to shortage of supply so that masons are without it too often. Hence, have large quantities of the mud ready, a large amount always ready mixed. And this means at quitting time at noon or night. The all too common practice is for the mud mixers to relax about half an hour before quitting time, when they see that they have enough for the masons. Of course it is quite impossible for them to have any ready when the masons start again. To keep costs down, every artisan should be waited upon by an adequate number of labourers who keep him supplied at all times with the materials he requires. Carrying receptacles for mud mortar is often quite a problem. Have a good supply in readiness.

Be economical in the use of mortar; even mud mortar costs money to make and to carry. And remember, we are building a brick wall, not a mud one. Wherever practicable, pick up excess mud and throw it back into the receptacle or on the mortar board. At noon or at night, have all receptacles with as much mortar as is left over taken back to the mortar pool and thrown in.

The thickness of mortar should depend upon the accuracy of the brick surfaces. If these were perfect, a mere buttering would be enough. But since the function of mortar is to take up the inequalities between bricks, as well as to provide some adhesive medium, then the less mortar that can be used the better.

Wet mortar is more difficult to handle, but it is vastly superior to more or less dry mortar. Fill all joints with wet mortar.

III APPLICATION.

The most economical method of applying mortar to the wall is not by trowel, but by pouring. As the masons are completing one course of brick, the labourer with a suitable can, pours mud on the wall, starting from the corner. A very little practice will show how this can be done so that all the mason has to do is spread it evenly with his trowel. He then drops his trowel and lays bricks with both hands, pushing each one up against the last one laid so that an end joint is gathered up and compressed between the two bricks. On most jobs this method will cut masons' wages bill by as much as one third.

IV FINISH.

While a true surface is most desirable, the actual appearance is not of any importance. But a great deal of time is spent on some jobs smoothing the joints and giving the wall a very regular aspect. This is objectionable on two grounds: it is unnecessary and hence expensive, and secondly it is a positive hindrance to the proper adhesion of plaster. If mortar projects from new work it can be left; if there are rough, sunken joints, leave them so, they make excellent keys or grip for plaster. Any projections will harden and when they are broken off later will be irregular which is desirable. If wet joints and projections are trimmed they should be cut or scraped to leave a rough surface, not smooth.

V. LIME MORTAR.

Where weather resistant burned bricks are to be used as the permanent face of the wall, or when stone or concrete blocks are to be similarly used, lime mortar may be used. It is not advised where there is constant dampness.

Lime comes in two common forms, lump or unslaked lime, and, hydrated lime. The latter is a commercial product in powder form put up in bags. It is mixed with sand, one part of lime to three or more parts of sand according to the desired strength. Of course this is most convenient to handle, but it is not commonly procurable in many outlying sections.

The lump lime has to be slaked, broken down by soaking it in a leak proof box. The lumps are spread out and water is poured

on them so that they are thoroughly soaked. The operation requires continuous supervision because there is violent action and if the lime gets some water and dries or burns it is rendered less effective. On the other hand the lime is not to be submerged for then it will not slake normally. Eventually the whole mass becomes a thick fluid. This is usually achieved by the attendant using a hoe.

It is quite alright to make a pool of sand in which to slake the lime. When lumps fail to break down, or if, as in poor quality lime, there are many lumps after the slaking process, screen the lot into a lower bed where the sand will be added.

The sand should be free of all stones. It is mixed with the new hot lime until it becomes almost solid. It is then left for about a week. Longer periods help rather than hinder the best results.

When the mortar is required, it is taken in batches in its hard state and wetted and mixed until all white lumps are broken down and the whole is a homogeneous mass and reduced to workable consistency. In this condition it will slip easily from the trowel.

VI. CEMENT-LIME MORTAR.

This is, probably the best mortar made. It is made of a combination of lime mortar as described in the last section, and cement mortar.

Have the lime mortar prepared in ample quantities well ahead. When the cement-lime mortar is to be made, make cement mortar of one part of cement to three parts of sand, and to the usual consistency. Then combine the two mortars in equal quantities and use at once. No mortar with cement in it should be unused for over one and a half hours. Use it within that time, whether it means overtime work or not.

This mortar has all the advantages of lime mortar in easy workability, cohesiveness, and adhesiveness; and of cement mortar's hardness, water-proof qualities, etc. Cement-lime mortar is particularly valuable in footings and foundations and all other masonry subjected to regular or irregular wetting or dampness.

CHAPTER TEN BRICKLAYING.

I. Corners. Brickwork is commenced at corners, or, in the case of chimneys or columns, built by corners. If possible, have a corner built at each end of a wall before the masons come to do the body of the wall. Of course corners are to be plumb and square, and so usually, you will put your best mason on this part of the work. When the corners are up about two to three feet, stretch a line and go to work on the rest of the wall.

Before using mortar, lay dry bricks from one corner of the building to the other, leaving 'dry' joints, and so determine what the bond for the wall is to be. Having determined whether the first brick is to be longwise, a 'stretcher', or crosswise, called a 'return' in a corner, lay it in mortar and proceed with building a shell corner. That is the outside bricks and only as many of the inside bricks as are necessary for the corner itself.

STANDARD CORNER MASTER DRAWING

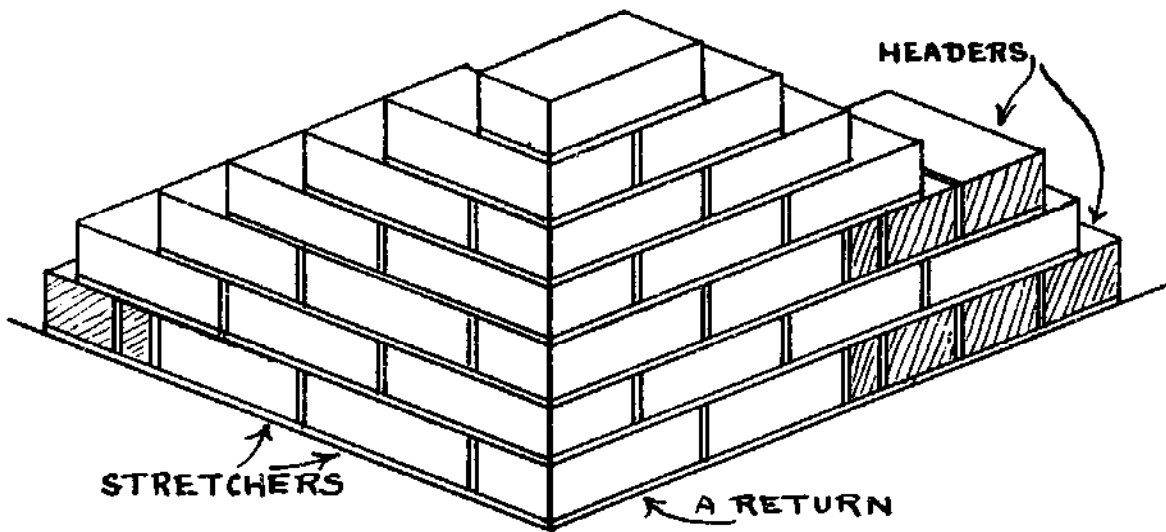


FIG. 141. STANDARD CORNER

Each layer of brick is called a 'course'.

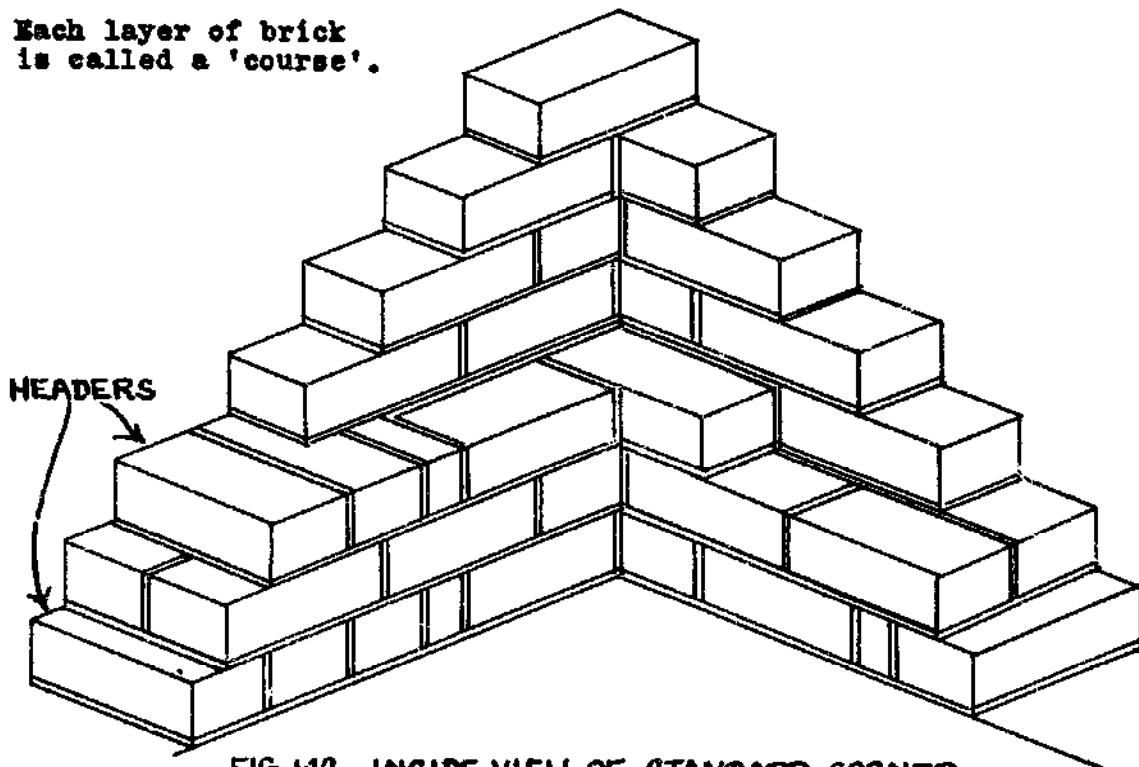


FIG. 142. INSIDE VIEW OF STANDARD CORNER

As soon as the four corners are established by measure and squared by diagonal, stretch a line all the way around and lay the first course of the corner each way to the line. As bricks are added to the corner, place a straight edge from the corner to the bottom course. This will keep the entire corner in line.

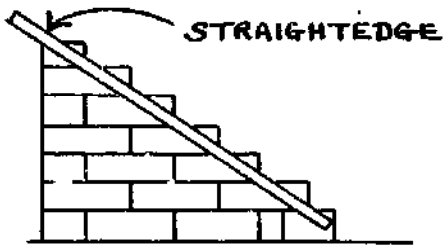


FIG. 143.

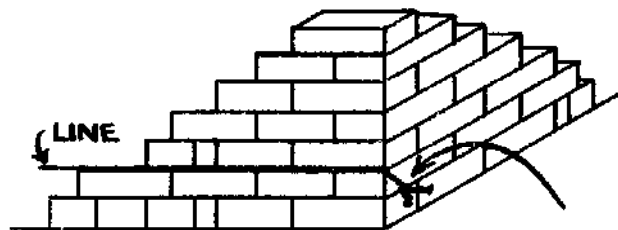
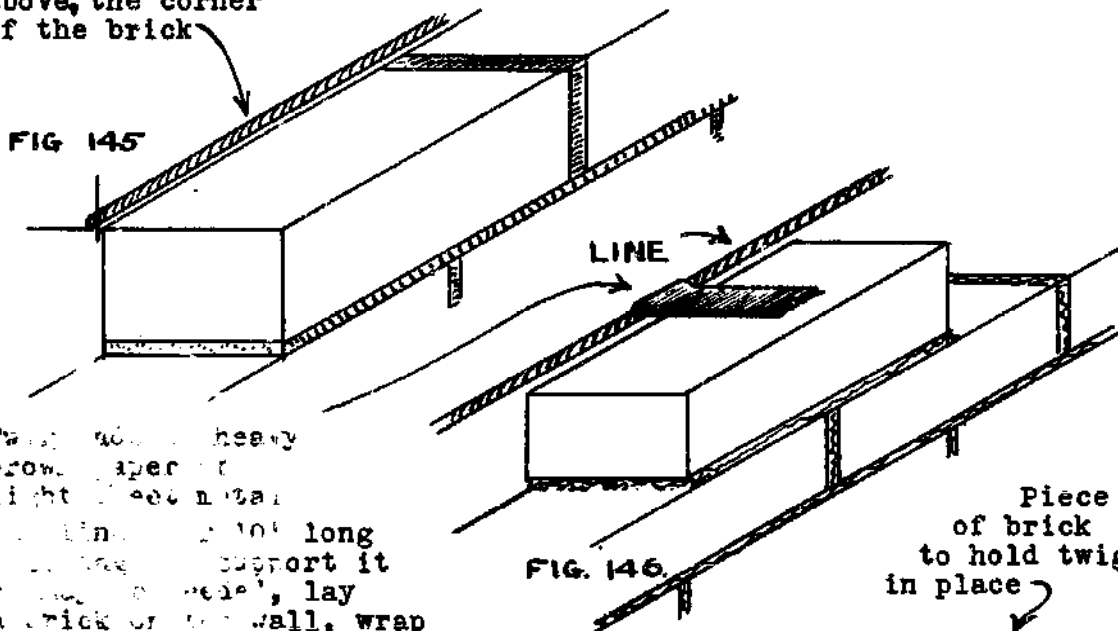


FIG. 144. HOW TO PUT A LINE ON A CORNER.

Line out from, and above, the corner of the brick



Take a piece of heavy brown paper or light sheet metal

the line is 10' long and use it to support it on the corner. Lay a brick on the wall, wrap a twig around the line as shown and hold with the finger until the man at the end who is sighting the line gives his O.K. If your brick is too low, it must be lifted, more mortar put under it. When all is O.K. place a piece of brick on the twig to hold it in place. If the supporting brick is laid in the right place it will not have to be moved when the wall is built up to it.

The reason we prefer the line above the brick as well as

Piece of brick to hold twig in place

TWIG

FIG. 147.

clear of the face is that so many lines have light ends protruding and they get coated with mud. Also, the brick often have small irregularities which would touch the line were the line to be at all below the upper line of the brick. At each corner the line can be held off from the wall by a piece of grass or cardboard.

One of the best plumb rules that can be used may be made in your shop. It is absolutely foolproof in itself. We admit that it is not so convenient as the glass and bubble type, but these latter do get out of order, and too often, unfortunately, the user is not aware of it. Of course one great advantage of the store variety is that it combines level glass with the plumb glass in the one tool. Whenever a glass type plumb or level is being used, reverse it frequently to make sure that it is correct. All glass levels and plumb rules should be checked before the job begins. We have found masons using a level that was 'out' to the extent of four inches in five feet!

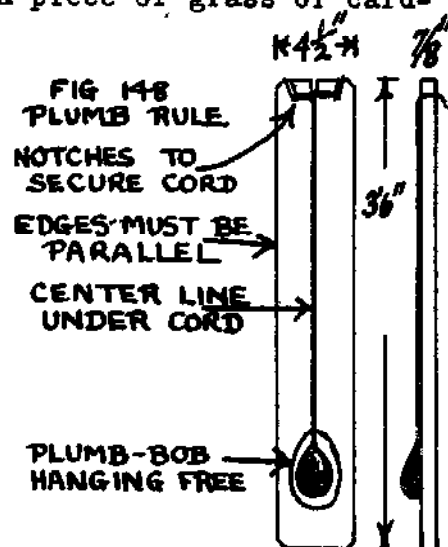
Walls which are plastered on the inside do not need an inside line. Each row of headers is a guide to the line of the inside face of the wall. With properly designed and made bricks there is no need for stretchers on the inside face to protrude.

Masons building corners should be cautioned against using too little mortar for if they do, the men out on the wall will find it impossible to get their brick down to the line.

II. Wall heights. Before the masons start the corners, prepare a storey rod. It should be the height of the wall from the ant course to the top. Lay up several bricks on the mortar joint you want maintained throughout the job. Measure one complete course-brick plus its joint. Then mark out the whole rod, lightly, with the height of one joint. If it does not come out evenly, increase or decrease the joint to make the courses come out right. Then make heavy marks. Two storey rods are sufficient on a house. See that its use is explained to the mason on the corner, and see also that he uses it. This practice will save a lot of trouble later on.

Make a list of all sill heights, built-in furniture positions, and any other features about the walls which may otherwise be forgotten by a busy superintendent until wall has been built which must be torn down again.

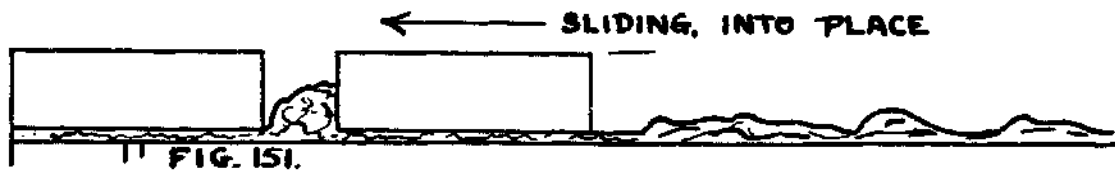
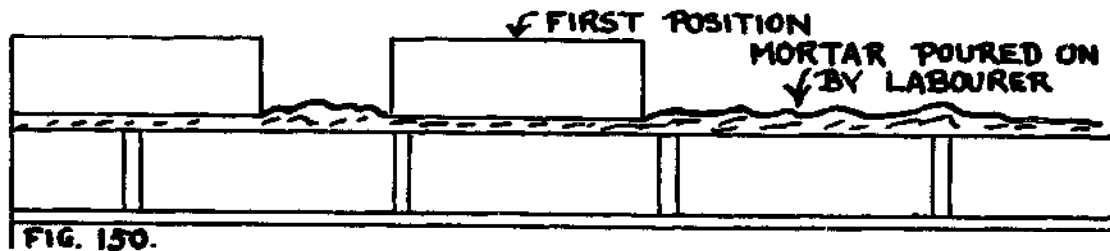
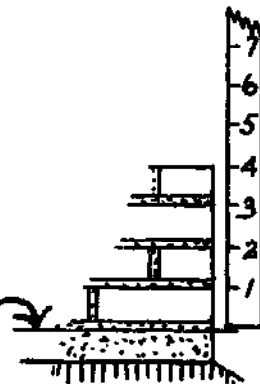
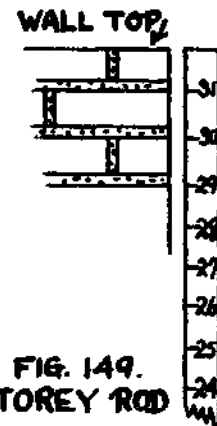
III. Speed in bricklaying. Eliminate every condition which causes bottlenecks, idleness, and other waste. For instance, one mason about the middle of the wall has to put in the one piece required. See that he or someone else has that piece ready before the course starts, so that he will not hold up the entire gang while he fumbles around getting a piece and putting it in. See that all the mortar and brick are ready before the course starts.



Speed in getting the bricks into the wall has already been referred to under the Section dealing with mortar consistency. The method whereby the labourers pour the mortar on the wall and the bricklayer just puts the brick to the line, will meet with considerable opposition, but it is worth trying. It is not a question of driving the men, but of getting the greatest amount of work done for the labour they give.

As soon as the bricklayer nearest to the corner has laid pairs of bricks or headers for three feet, the labourer can start to pour the mud for the next course. When the corner man has met the next man, he and his corresponding mason at the other end of the line can loose the line, so that the moment the course is completed, the line can be pulled tight and bricklaying commence again.

The very common practice of placing a row of bricks, or blocks, on fairly stiff mortar leaving the cross joints empty, and then when the row has been filled in, puttering around filling cross joints, using straight edges, etc., cannot be too strongly condemned. The best cross joint is made by squeezing some bed mortar against the previous brick laid. Before the mason's hands leave the brick it should be 'on the line' so that it will require no further adjustment.



The whole question of bonding is taken up in the next chapter.

IV. Frame setting and tying. Frames improperly built in cause a great deal of trouble later on. Encourage the mason to call for the carpenter in plenty of time to brace the frame and tie it into the wall.

The first frames to be set are the doors in the outside wall. As shown in the chapter on ant course, the foot of the frame is nailed in place. Be sure that the face of the frame is on the finish line of the plaster, and not on the line of brick.

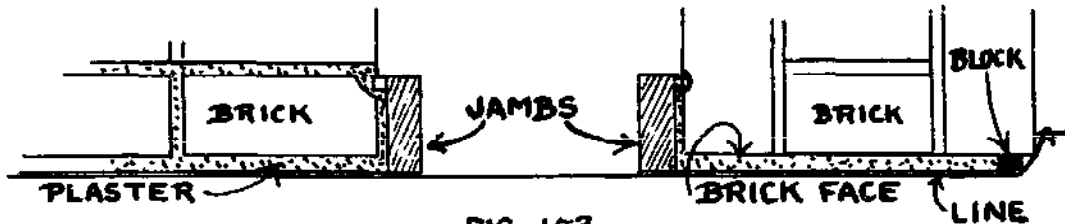


FIG. 153.

To line up the frames in one wall, make little blocks $5/8$ " thick and place them behind the line at each corner. These blocks will have to be retained for the masons, which means that instead of having the line close to the bricks, it will be at least $5/8$ " away. Each mason can be supplied with a gauge block if necessary so that if he is uncertain whether his bricks are the correct distance from the line, he can check. This may seem a very precarious way to lay brick, but it works. Since the plaster takes up the inequality, there is no really valid objection. The final result justifies it because the plaster and the face of the frames is one straight line, whereas if the frames are placed in line with the brickwork, the plaster will extend beyond the frame and a very unsatisfactory joint will result at every frame.

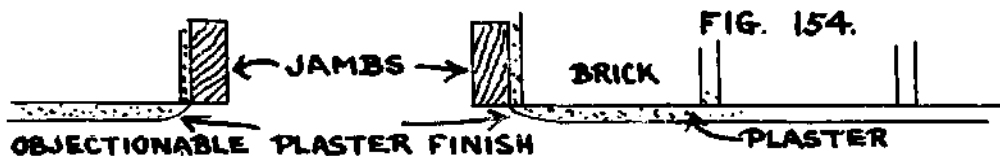


FIG. 154.

The masons are tempted to anchor the line intermediately along the wall. Absolutely forbid this practice. While the sections may be straight, the whole wall certainly will not be. Insist on a free line from corner to corner, no frame, or brick, or mortar touching it anywhere. Otherwise it will not be straight. We have shown that a line may be supported intermediately, but that is only done when the corner man sights through each time to see that the line is not only level but in direct line from corner to corner.

We have not tried to finally brace frames in the plumb position until there has been a few courses of brick laid against it to 'anchor' it at the bottom. Further details of frame setting are given on that subject in Book Three, Carpentry.

When setting a sill, whether of stone or wood, do not bed the whole length with mortar. Use fairly thick mortar only under

the points of the sill which have jambs. Otherwise, the concentration at these points will cause the sill to bend up or crack between these points.

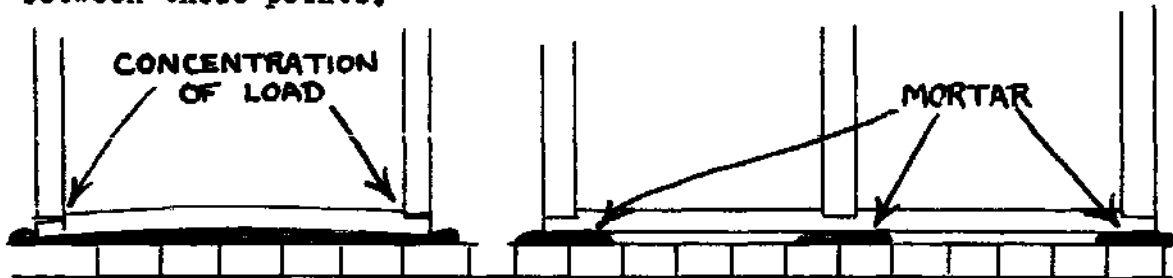


FIG. 155.

FIG. 156. PROPERLY SET SILL

V. Scaffold. This subject is taken up in Book Three, Carpentry, but at this point we may discuss the merits of the inside and outside methods of scaffolding.

On buildings of over one storey, the floors of the building are used for the workmen, particularly the masons, during the erection of the walls. But there are difficulties in working from the inside when there are small rooms. Scaffold becomes a problem. Not only because planks have to be cut but because of the congestion and the delivery of materials. Hence we use the outside for scaffolding wherever possible.

The scaffold itself was a problem until we adopted the shinglers' jack scaffold. Of course it would not be satisfactory for regular bricklayers under many conditions, but it does work on mission buildings. It provides a platform three feet wide if necessary, but it is seldom necessary to make it more than two feet. It is cheap, fast, safe.

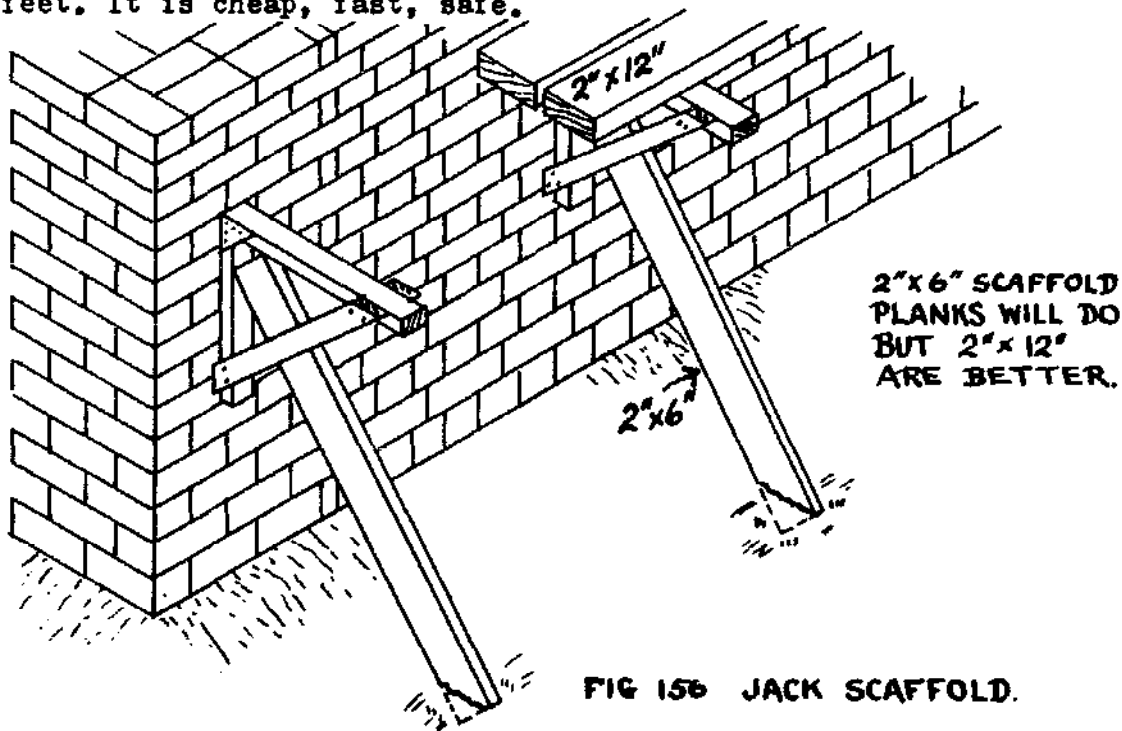


FIG 156 JACK SCAFFOLD.

CHAPTER ELEVEN BONDINGI. VALUES.

Masonry walls have little tensile strength compared to their great weight, hence, when there is the least settlement, especially near a corner, the wall tends to crack. The bonding or tying together of units of masonry, bricks, blocks, stones, etc., is the best practical way of preventing cracks. Contrary to opinion in some quarters, care in bonding saves time also, for if the bond is studied out a little in the first two courses of a wall, there will be the minimum of trouble all the rest of the way. Provided that a wall is plumb,

The greatest fault in bricklaying is a straight joint. Not only avoid them but do not make joints that are nearly and virtually straight joints.

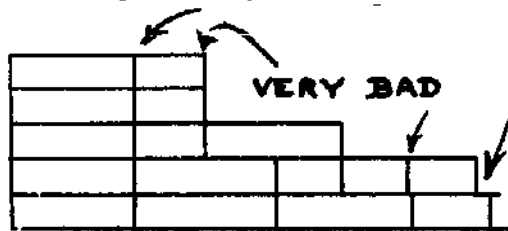


FIG. 157 STRAIGHT JOINTS

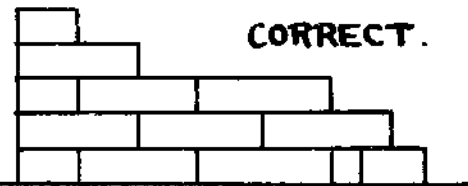


FIG. 158.

The next great fault is to build too many courses of stretchers without a course of headers, as in Fig. 159. Even if this wall does stand up, header courses can be laid up faster than stretcher courses.

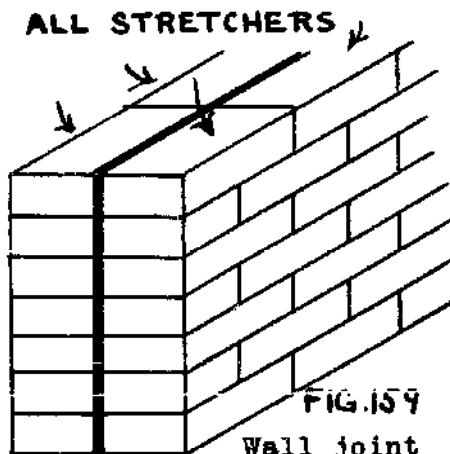


FIG. 159
Wall joint
all the way, wrong, weak.

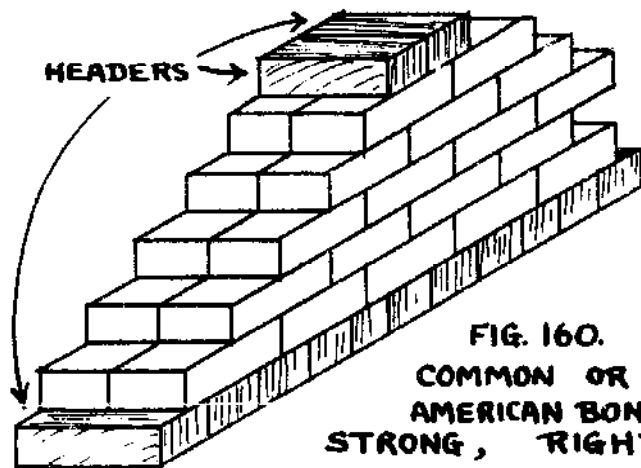


FIG. 160.
COMMON OR
AMERICAN BOND.
STRONG, RIGHT.

But because we do need longitudinal strength, we use more stretchers than headers. We do not recommend having more than five courses of stretchers to every course of headers. To prevent as far as possible the harbouring of vermin, see that there are no extensive voids, wall joints, etc. in the wall.

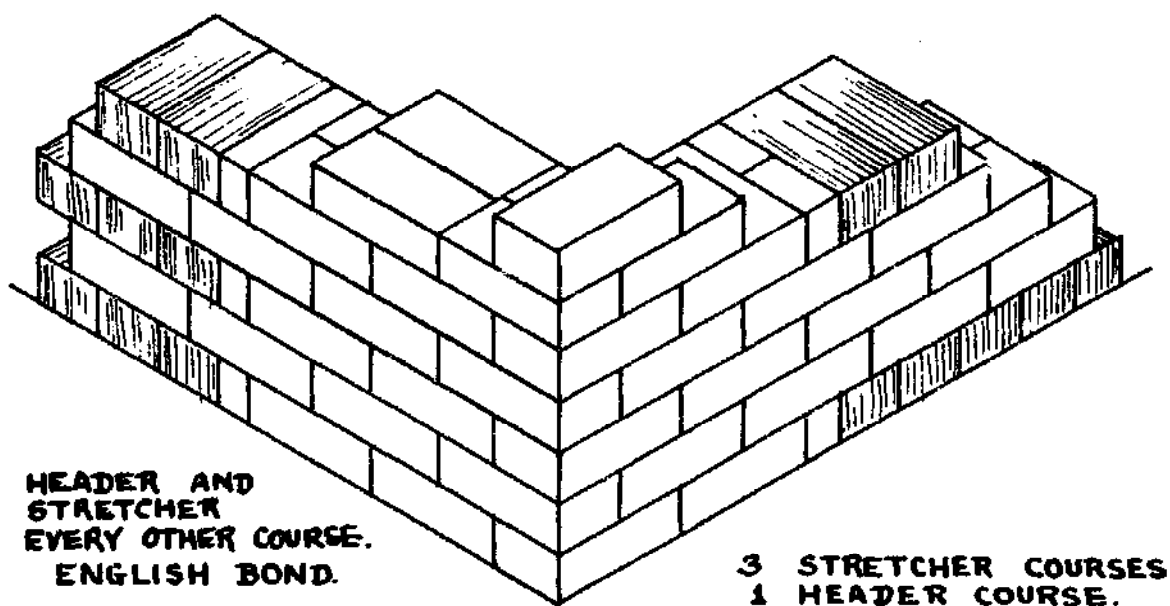


FIG. 161.

For mud or burned brickwork we recommend either of the two bonds shown above. The one on the right gives a large amount of longitudinal strength while it has enough headers to not only make it knit together cross wise but be also fast in the lay up. It is easier to lay two headers than two stretchers.

The headers in each case given above, and in all examples in this book start at two or two and a half bricks length from the corner. The reason is that the corner is thoroughly well bonded cross-wise and does not need headers to hold things together. What we do want near the corner is longitudinal strength, and wherever headers are introduced there tends to be poorer bond as far as longitudinal strength is concerned.

Along the same line, and to save cutting pieces, we recommend that no headers be used at all in walls shorter than 5' For every such wall has cross bricks either at jambs or by intersection with another wall.

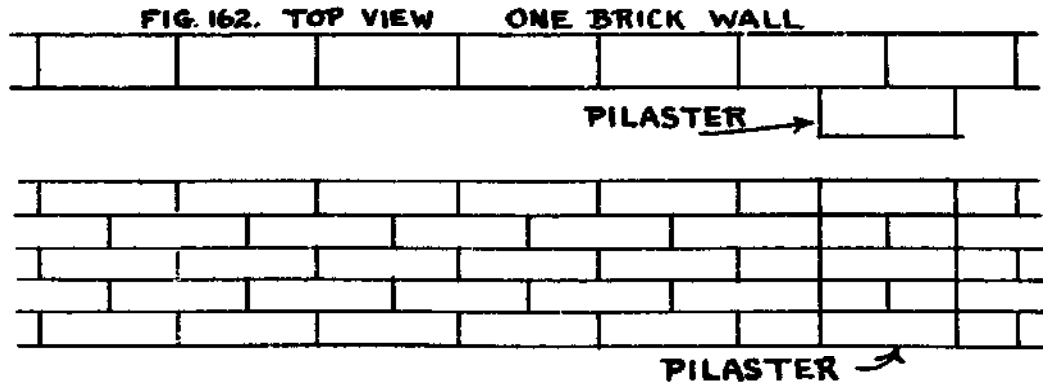
For the same reason that we keep headers well away from corners, we keep them away from all jambs or other termini of masonry.

Note that on the right side, the 1/4 brick used to start the headers, is in two pieces. There are so many pieces lying about that it is waste to cut a long brick in two for the purpose. Note that the only purpose of this piece is to make the header come evenly over the joint beneath. Hence, wherever headers are to be started, they must come squarely over the joint beneath, no matter what size piece is required for the purpose. Many masons use a 3/4 piece to start headers.

On the extreme left, the second course is indented at the end. This is called 'toothing' and is sometimes done when one part must be built up at once and joined up later.

II. BOND AND THICKNESS AND CORNERS.

1. The one brick wall. This is acceptable for partitions where they will not be subjected to vibration, bumping, etc. This type can also be used in panels where there are frequent posts or pilasters into which the panel is secured by bond or by metal tie.



2. The two brick wall, in commonest use. FIG. 163



FIG. 164.

Note the bonding of headers and stretchers

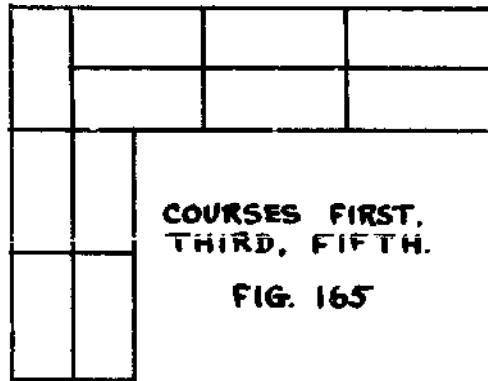


FIG. 165

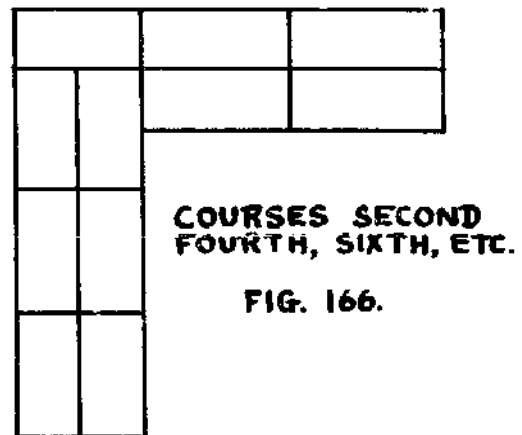


FIG. 166.

Every corner in a two brick wall uses these two courses alternately. Never put pieces in or near a corner or at jambs.

Two-brick walls, 'T' joints.

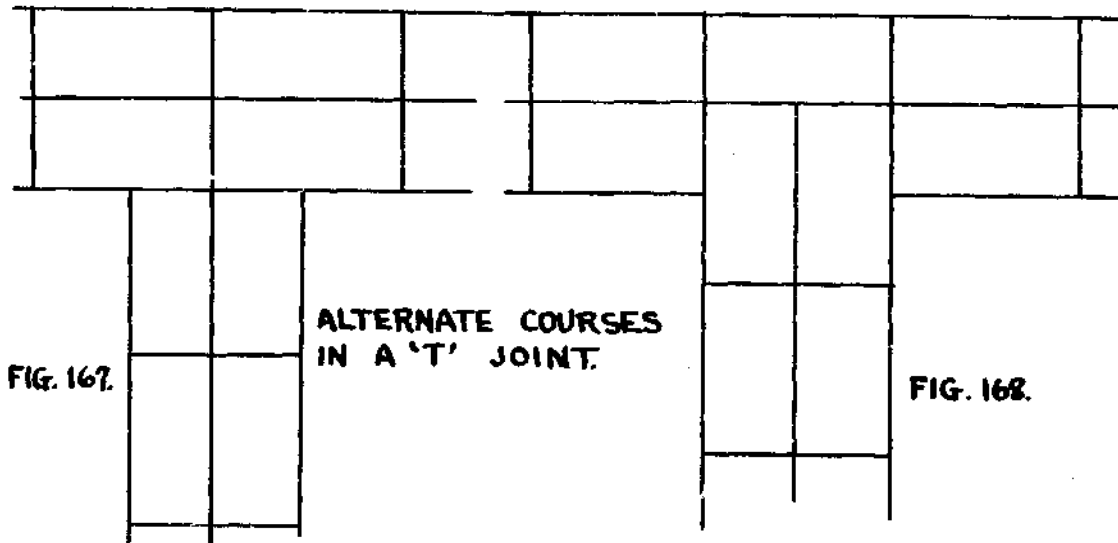


FIG. 167.

ALTERNATE COURSES
IN A 'T' JOINT.

FIG. 168.

3. Three-brick wall bond.

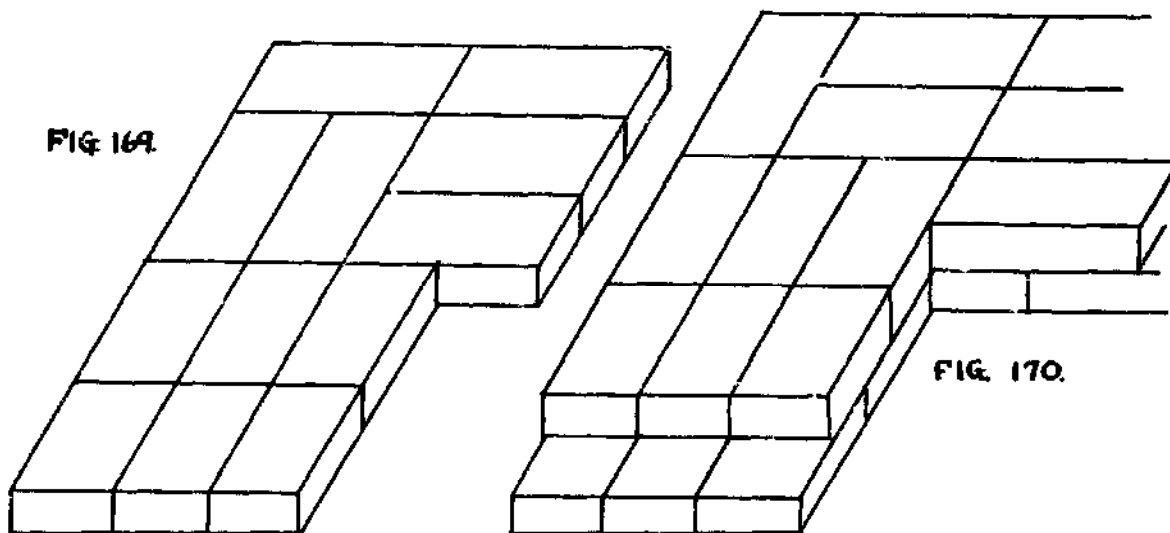


FIG. 169.

FIG. 170.

Alternate courses in three brick wall corners.

Pricks not on the face of the wall are pushed into place as shown in Fig. 150, 151, 152. But in the backing up of a wall like this three brick wall, there has to be a sidewise movement as well to fill up the wall or long joint. It is not easy to do this, and that is why we say that headers lay up faster than stretchers. If the wall and cross joints have not been completely filled by the pushing process, the new spread of wet mud will flow down into the unfilled spaces. No end of money has been wasted by

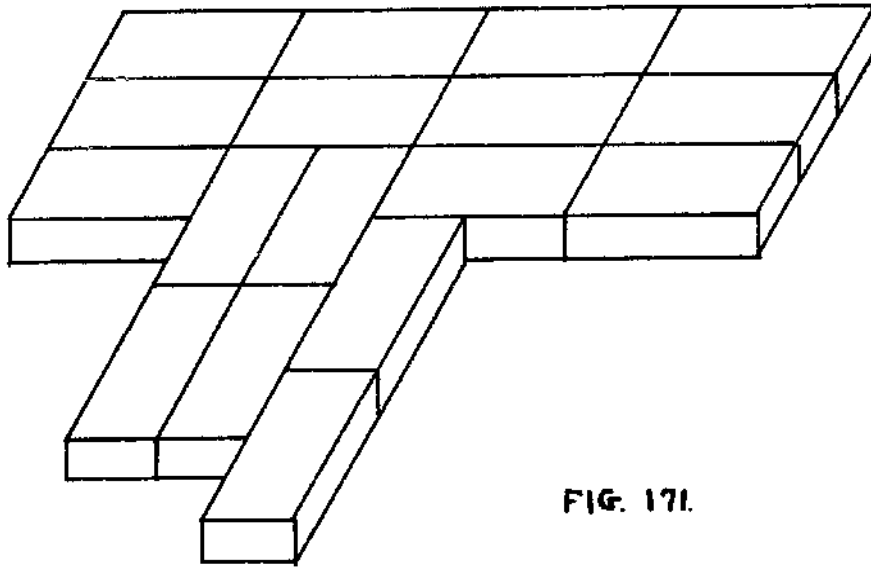
 Three-brick wall 'T' joints.


FIG. 171.

Alternate courses.

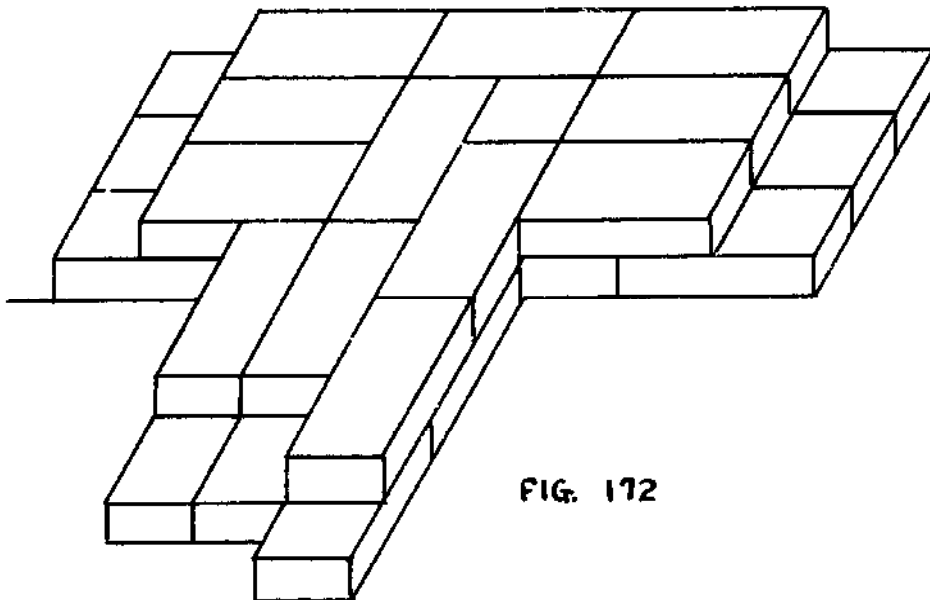
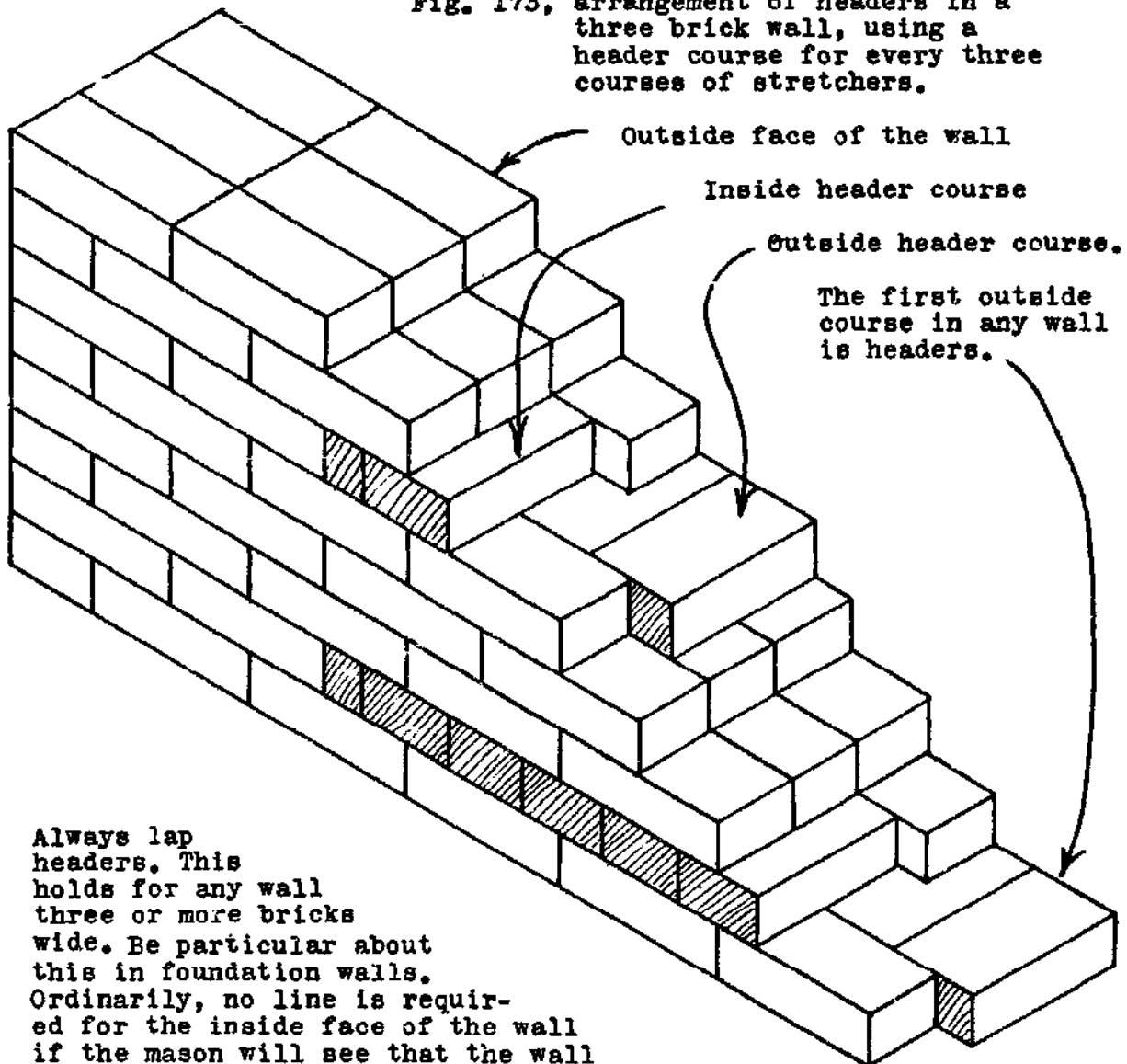


FIG. 172

masons filling these cross and wall joints after the bricks have been laid. The waste begins by having rather stiff mortar on which the bricks are placed, more or less gently, and with no mortar in the cross joint at all. When all the bricks of a course are laid, the 'chucking' of joints begins, a sort of pause that refreshes. The mortar being rather stiff seldom sticks to the bricks, and so the wall is weaker and more expensive than is necessary.

Fig. 173, arrangement of headers in a three brick wall, using a header course for every three courses of stretchers.



Always lap headers. This holds for any wall three or more bricks wide. Be particular about this in foundation walls. Ordinarily, no line is required for the inside face of the wall if the mason will see that the wall joint between the outside header and inside stretcher is maintained at a uniform thickness throughout the whole wall.

Some masons have a habit of using a straight edge to true up a wall, instead of using the line. The habit should be discouraged. Very small irregularities in the face of a wall which is to be plastered are somewhat of an advantage.

Sometimes there is need for tying between one wall and another where the courses are not level, or for some other reason headers cannot overlap as in Fig. 173. In this case use metal ties, and preferably of course, of non-rusting material.

Brick on edge. When any feature, a frame, piece of built in furniture, a lintel, etc., must come at a height not in agreement with the courses of brickwork, use less mortar, more mortar, or else a course of bricks on edge to accommodate the frame.

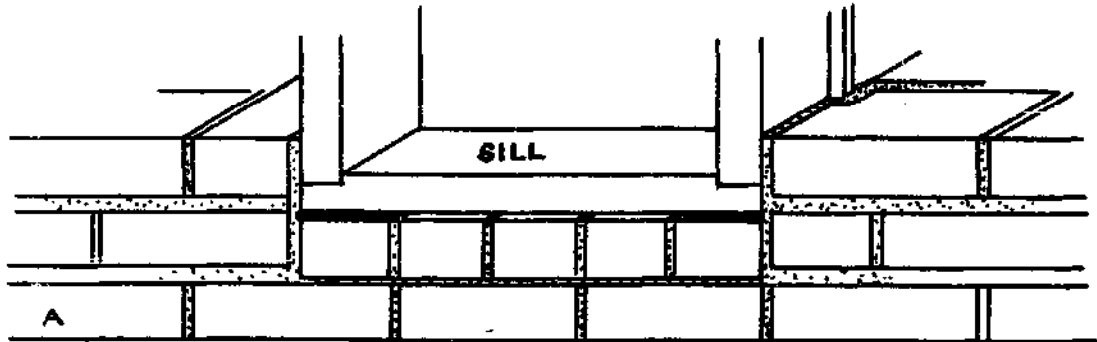


FIG. 174.

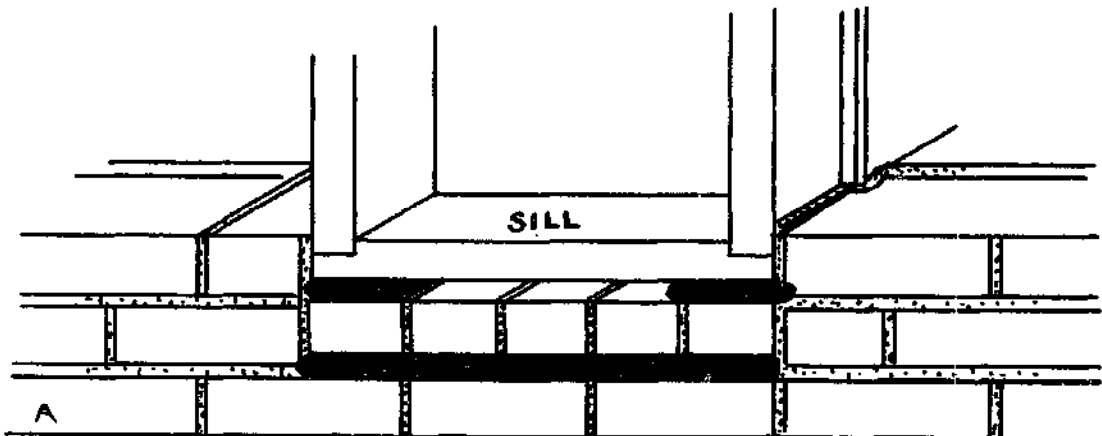


FIG. 175

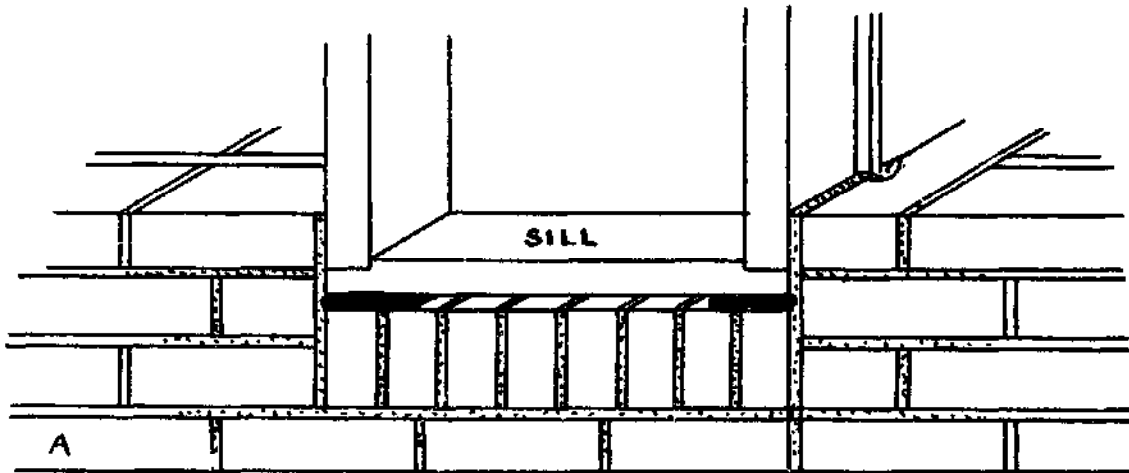


FIG. 176.

III. BLOCK BOND.

1. Blocks which are oblong.

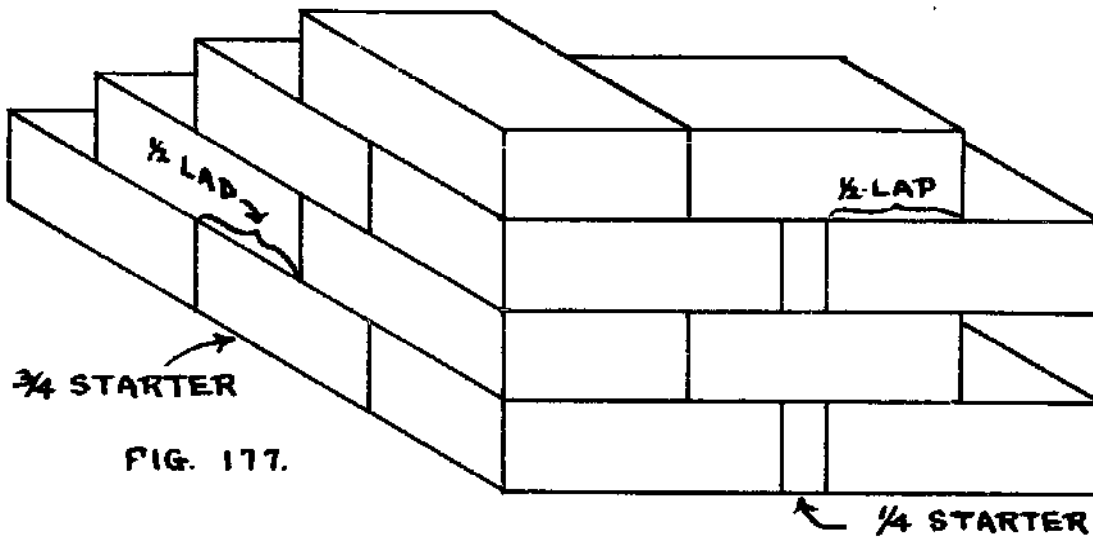


FIG. 177.

2. Blocks which are square.

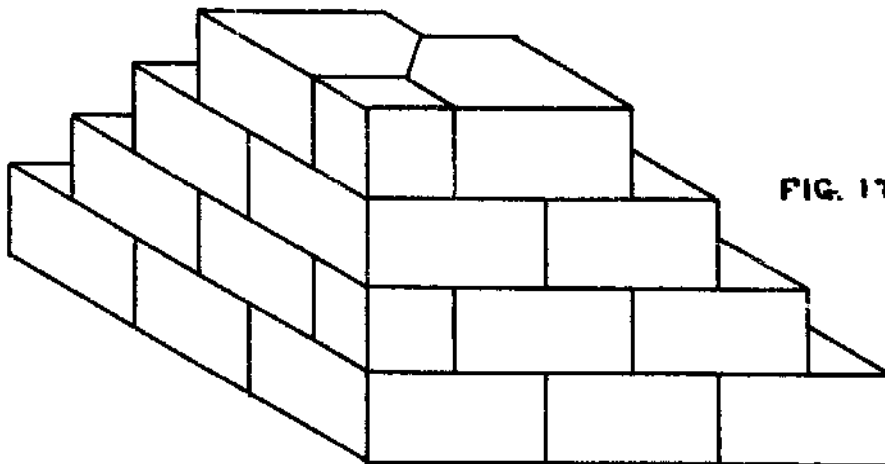


FIG. 178.

In Fig. 177 we have shown how square blocks, 6" X 12" X 18" may be bonded at the corner either by the use of a one-quarter piece or by the use of a three-quarter piece.

In Fig. 178 is shown one way to bond square blocks at the corner. In Fig. 179 another method for square blocks. Whenever the bond has been figured out, make the pieces necessary in the moulds; do not count on masons cutting pieces on the job. It takes time, and the pieces are not strong when cut.

In the main part of the wall have all blocks arranged to lap one half on the blocks beneath.

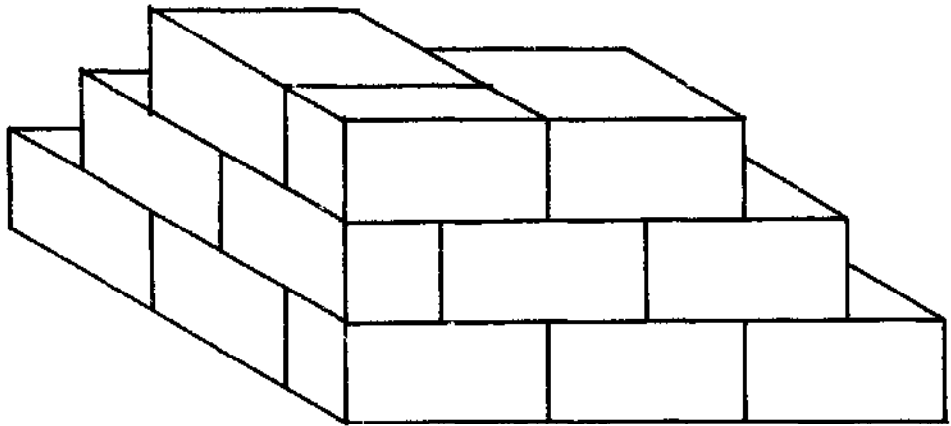


FIG. 179. SQUARE BLOCK BOND.

IV QUOINS.

These are chiefly ornamental, but in some cases they are the strengthening device for a corner and very little extra work is required to accentuate them and so give a very attractive appearance.

FIG. 180.

QUOINS

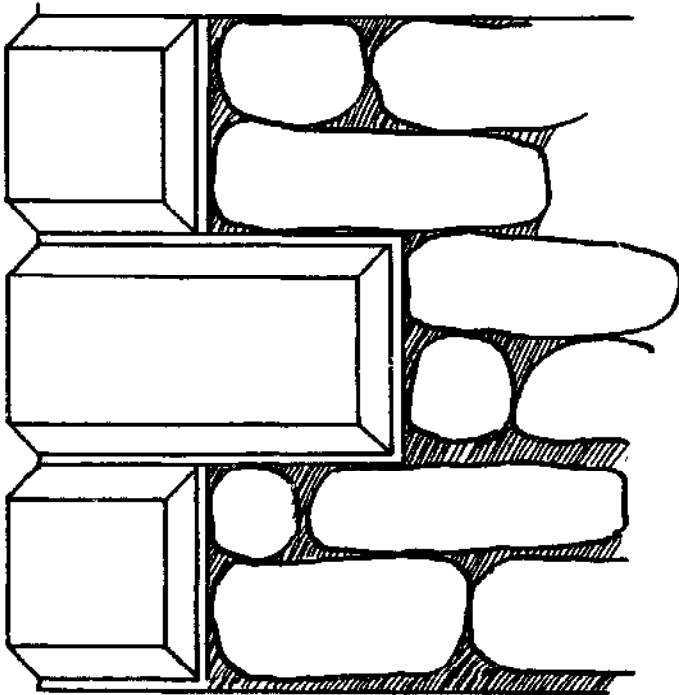
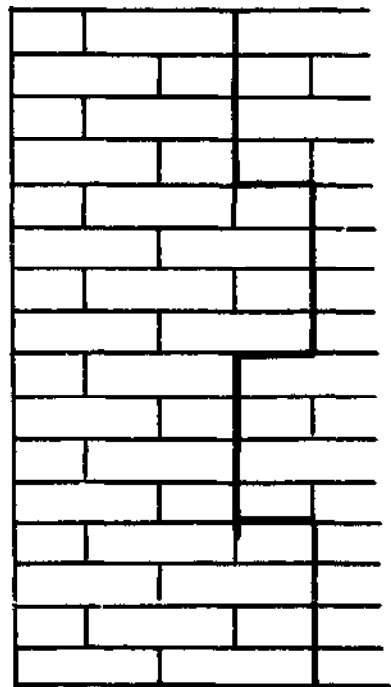


FIG 181



In Fig. 180 we are merely showing what was done with the concrete reinforcement used on the corner of a stone wall building. The concrete forms were fitted with appropriately shaped moulding which produced the chamfer effect. The concrete was poured into a mould about six feet high, and rammed into the part which projects as a tooth into the stonework. When the concrete was completed, masons plastered it and finished it neatly as in the illustration.

In Fig. 181 the heavy line indicates the quoin which may be distinguished from the rest of the wall in various ways: by a different colour of brick; by itself projecting from the wall an inch or inch and a half; or by projection plus a course of brick between each quoin laid even with the rest of the wall.

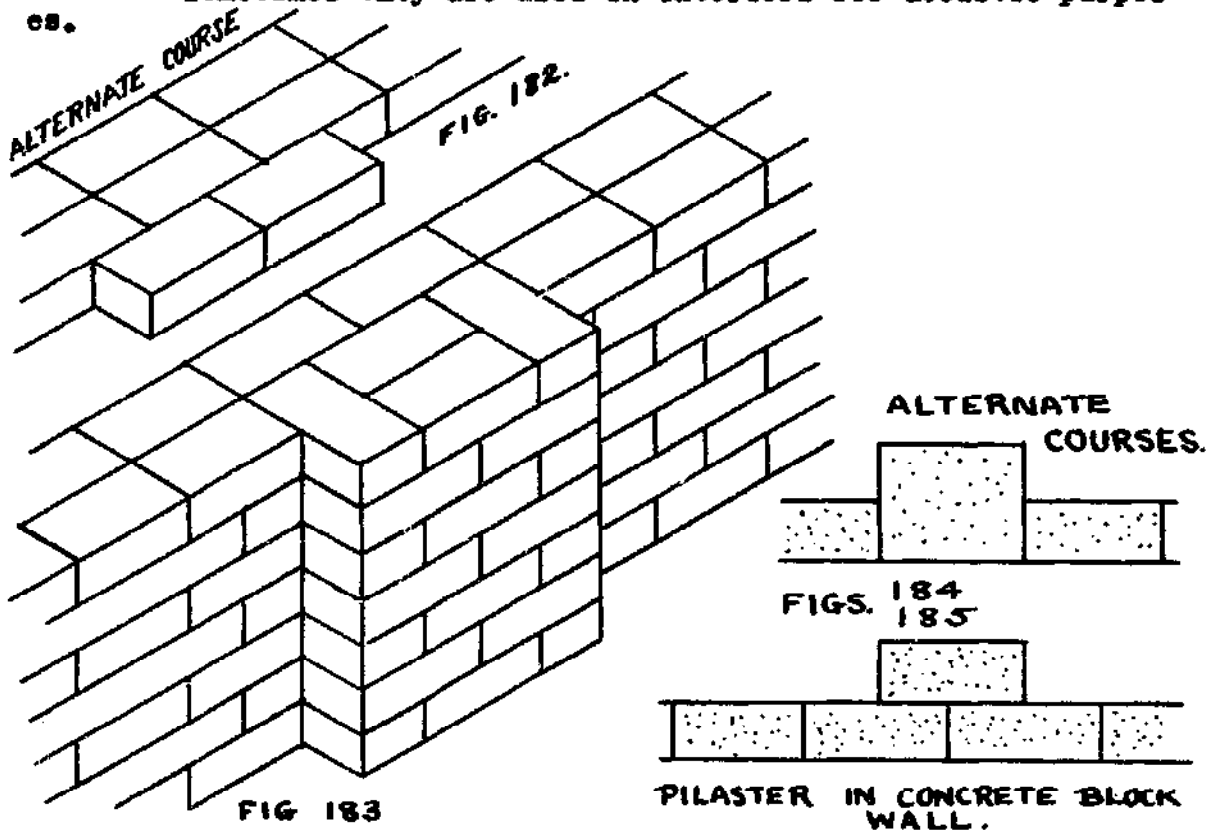
V. PILASTERS.

We may define pilasters as piers built into and with the wall. They serve a variety of purposes.

Instead of building a heavy wall the entire length of a building, we may have a number of pilasters which afford the requisite strength, the intervening wall being lighter. Very often the intervening wall is very light and may be called a panel.

Where a wall is adequate in itself but unable to support concentrated loads as from roof trusses or other heavy beams, the pilasters are designed to carry that extra load.

Sometimes they are used in interiors for acoustic purposes.



VI. BUTTRESSES.

Buttresses are piers or webs built against walls to stiffen them, especially where there are roof thrusts. Sometimes the wall requires support after it has been built and a buttress seems the only practical answer. In this latter case, dig out a goodly number of bricks so that the buttress can be tied into the wall.

Buttress foundations should be as solid as for a house, with footings resting on hard undisturbed earth.

Thoroughly waterproof the buttress, especially, of course if it is made of mud brick. Otherwise it will conduct moisture to the main wall. Each projection of a buttress should be capped with at least two inches of reinforced concrete. This cap may be

made on the buttress or on the ground.

If the former, make a cavity in the brick so as to form the anchor on the underside as in Fig. 187

FIG. 186.

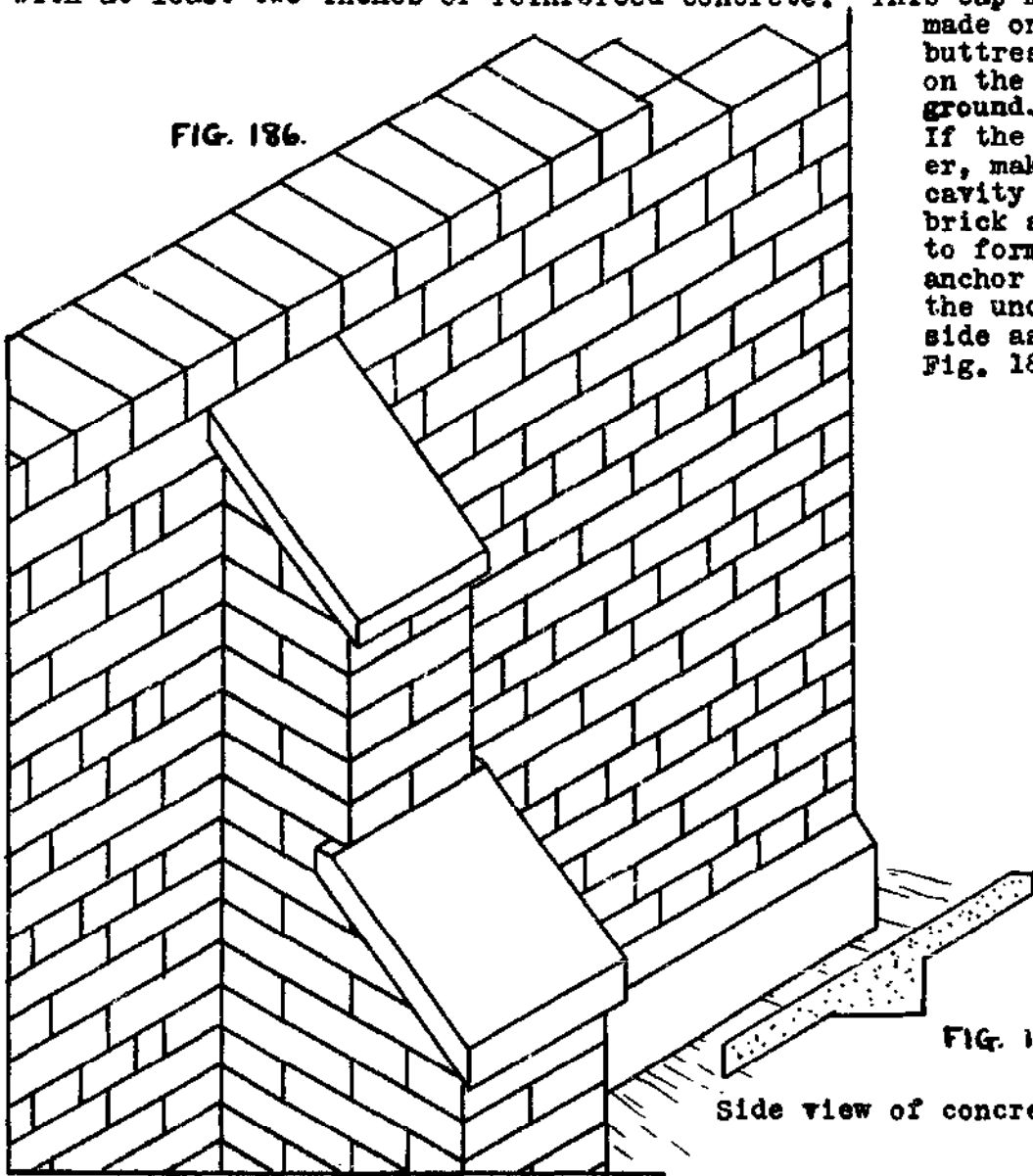
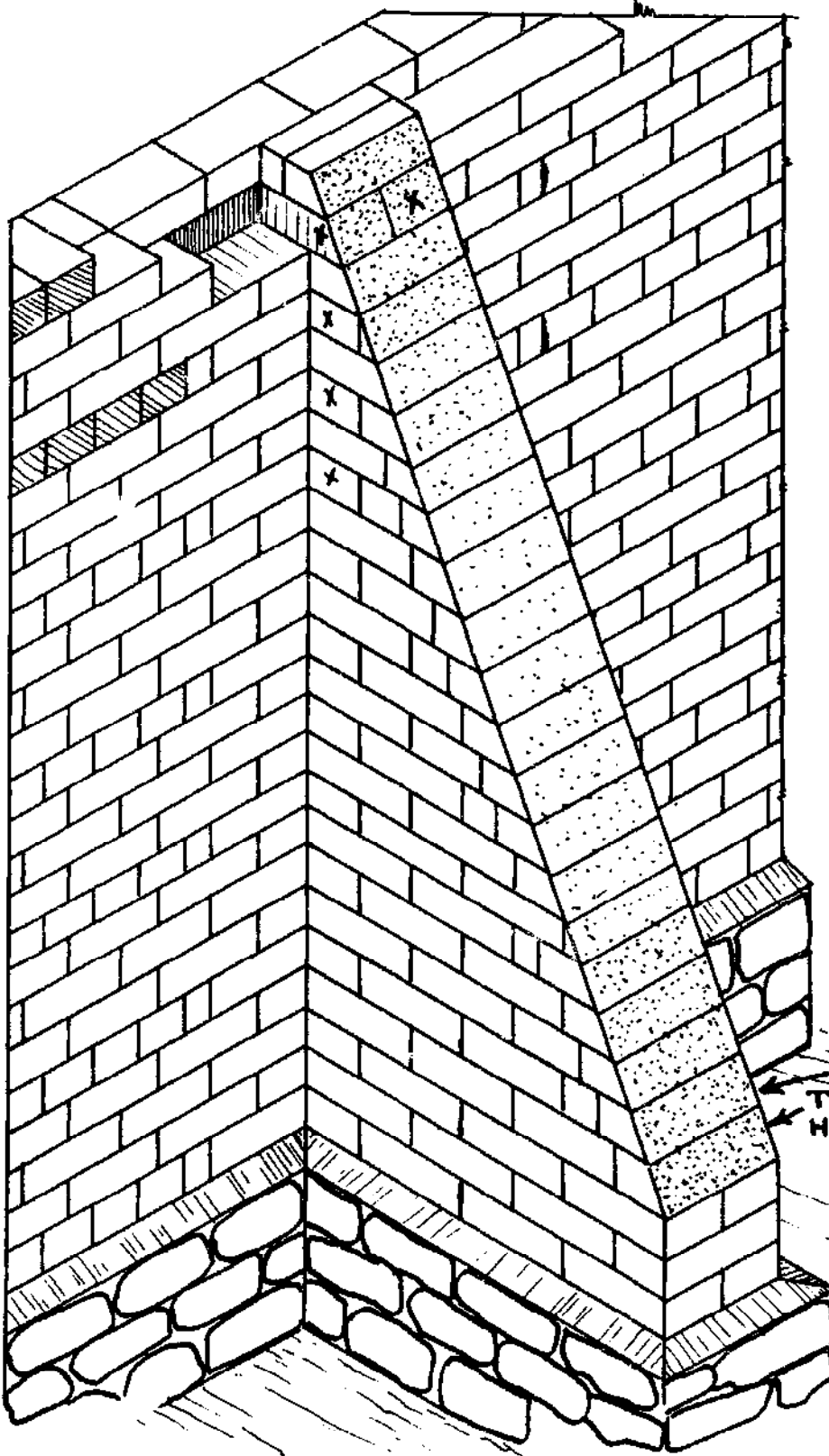


FIG. 187.

Side view of concrete cap.



Every brick marked X, and all corresponding bricks below them, bond into the main wall as do the pair X X at the top.

Note that all other bricks on the face of the buttress are trimmed headers.

While this type of buttress is not very attractive, its looks are improved in proportion to the steepness of the angle.

If a buttress is not plastered, the headers are laid as in the top course of a gable wall.

TRIMMED
HEADERS

FIG 188.

VII. BURNED BRICK AND CONCRETE BLOCK VENEER.

1. Burned Brick. The following diagram shows how to build a mud brick wall with a burned brick veneer for that part of the wall exposed to the weather. As previously indicated, the only real problem is adequate tying. To reduce expense to a minimum, use only one course of headers for every five or seven of stretchers and somewhere in between use metal ties. These ought to be waterproofed, durable and heavy, and equipped with lugs or other device for gripping the mortar.

The block marked T in the partition wall ties in with the main wall. Wherever possible tie in this way.

M.T. indicates a metal tie not less than 1/16" thick. If iron is flat, make an effective hook at each end. If necessary, gouge a small hole in the brick to accommodate this hook. The masons are tempted to hammer the iron straight. Mud bricks and blocks may be used in the foundation wall above grade level.

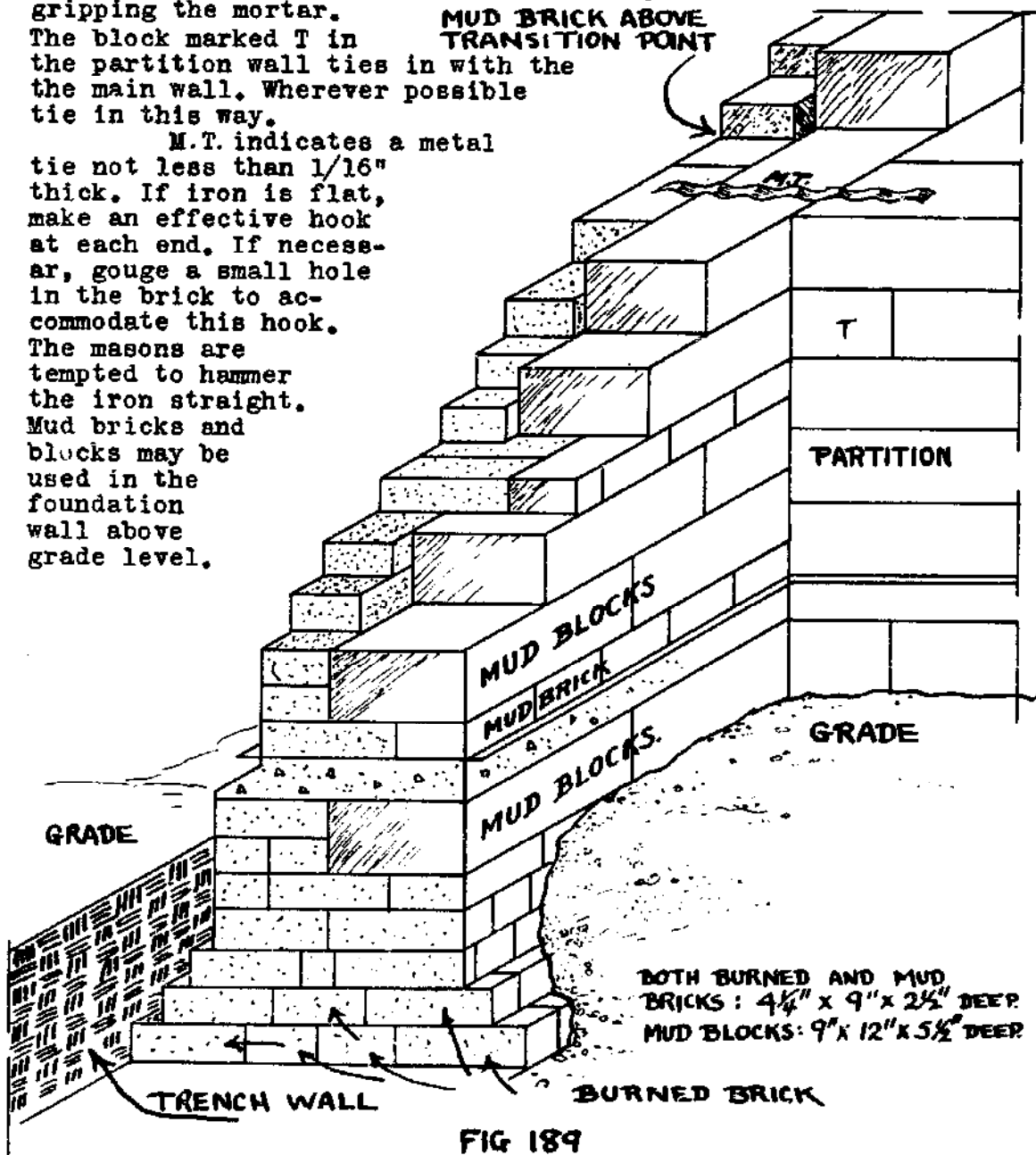
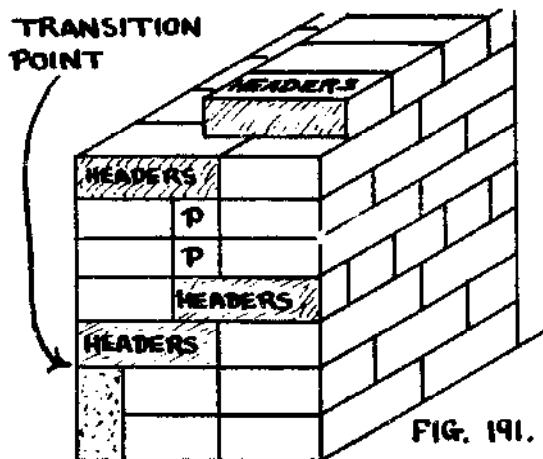
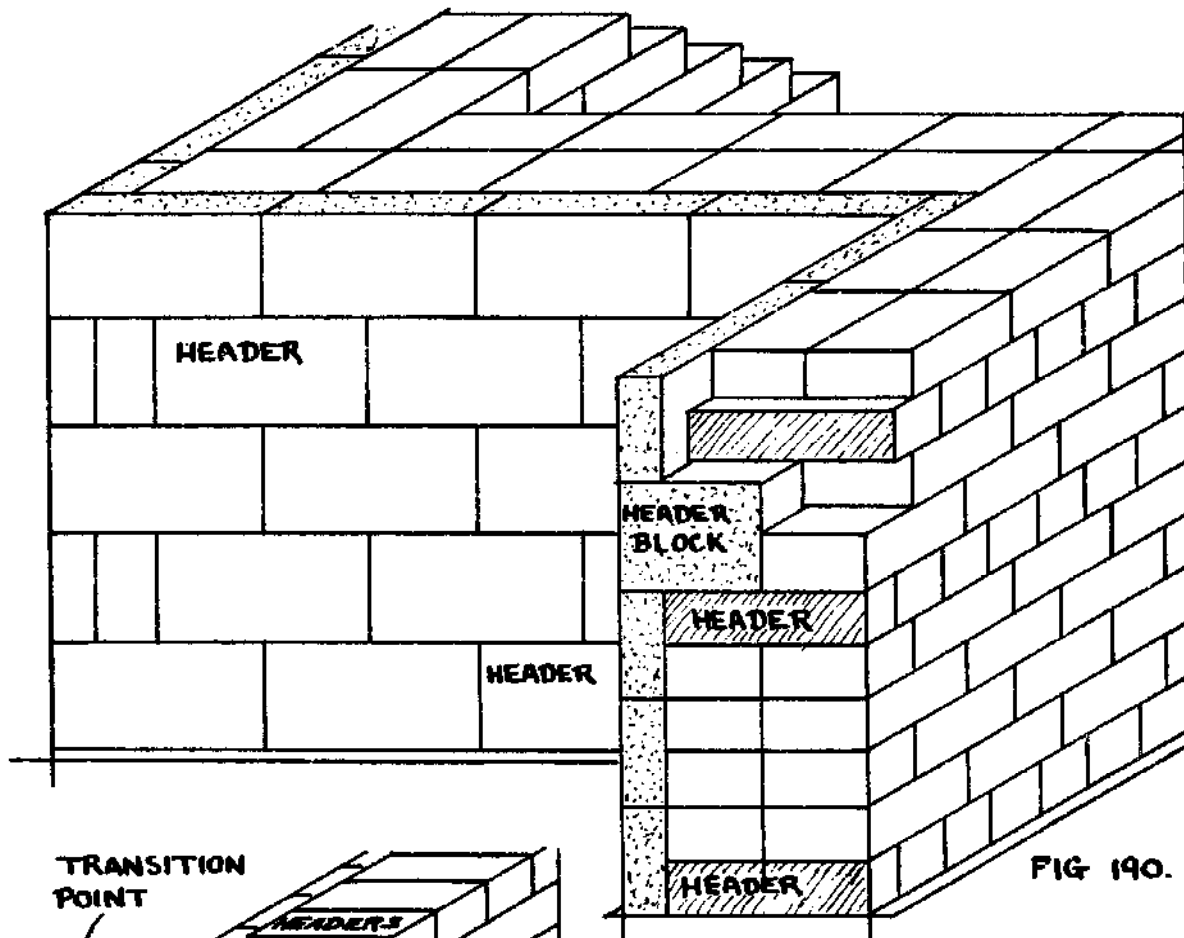


FIG 189

2. Concrete block veneer. The blocks need not be thicker than two inches, but ought to be laid in cement mortar, be tied every course to the backing bricks, whether by headers or by metal ties. As with the burned brick, it need not be used higher than the level of the roof eave. That is, if weatherproofing is its sole purpose. If it is neatly laid and pointed, it can be painted with cement wash or other decoration. It need not be plastered.



Transition from concrete block veneer to mud brick at the level of the roof eave.

From this point up there will be an irregular cavity the width of the concrete block, but only for two courses at a time. This can be filled with pieces shown in the diagram and marked 'p'.

The concrete block in Figs. 189, 190, are 2" or 2-1/2" or 3" thick, 8" high, and 16" long. The bricks are the standard size mentioned elsewhere, 5-5/8" wide, 12" long and 3-1/2" deep.

The occasional concrete header block shown can be used if desired. It is 8" high, 8" wide, and 16" long. Its effectiveness will be increased if the top and bottom surfaces are rough, moulded that way.

The cement block can be made with one part cement to six parts of sand. The maximum strength which is practicable, is obtained by making these blocks in the rainy season and keeping them wet for at least ten days. But the longer they are kept wet, the more they harden.

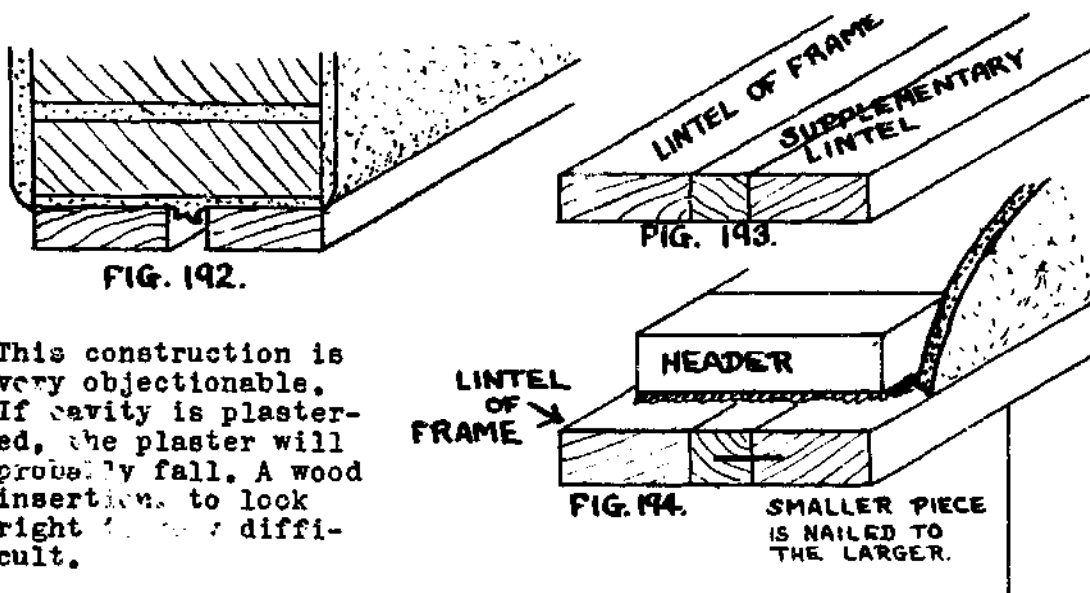
CHAPTER TWELVE LINTELS

A lintel is any beam supporting a wall over an opening. It may be part of a door frame, or it may be separate, or it may be over the door or window lintel to bear weight which is too great for the frame lintel.

In this latter class there are three main types: the concrete lintel, the wood lintel, and the angle iron lintel. The concrete lintel is described in Book Four, Concrete.

The wood lintel. For mud brick, this lintel need only be 2" thick over a three foot opening. If the opening is wider than this, there would be presumably, intermediate jambs, technically known as mullions.

Wood lintels placed along side the lintels of frames, should take up all the space and be even with the plaster finish. It is a little extra work at the time, but it saves a deal of trouble later on.



Building over this lintel.

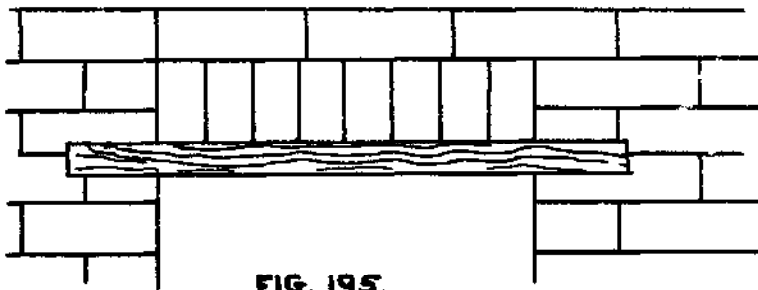


FIG. 195.

Brick on edge or headers are the best construction over lintels.

Brick on end, called 'Soldiers' are often used for appearances, but are invariably supported by an angle iron lintel.

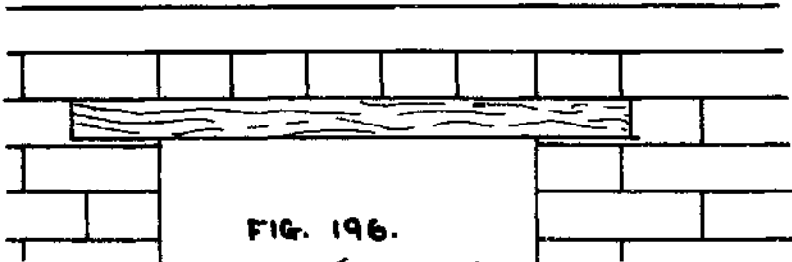


FIG. 196.

Mud blocks are poor construction over lintels. To relieve the dead weight on the lintel, shape the blocks just a little as shown. Note that the bed of mortar is arched a little.

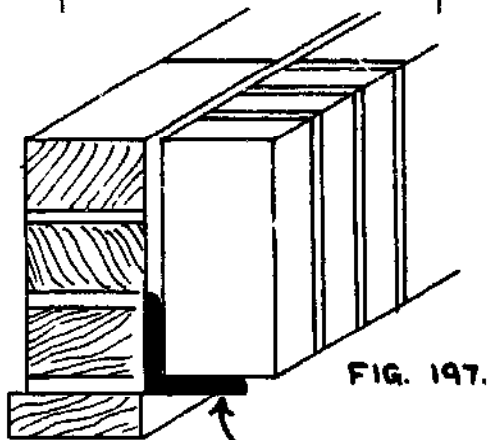
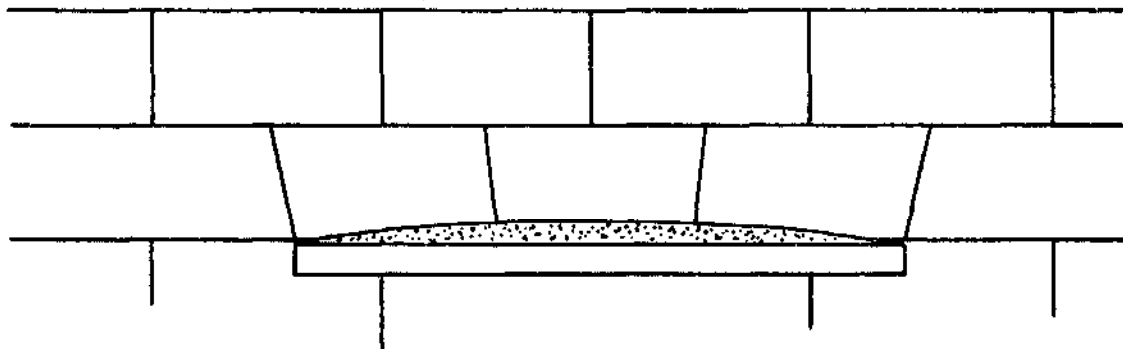


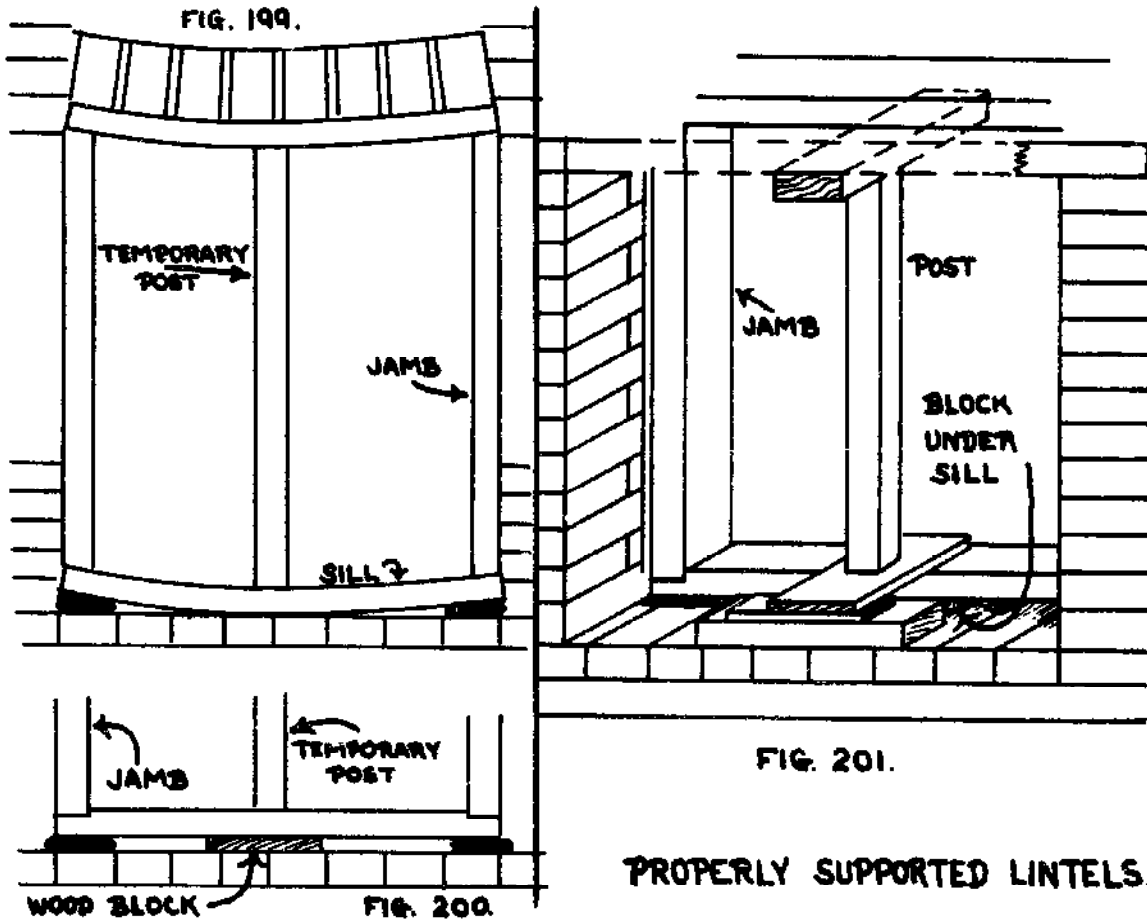
FIG. 197.

ANGLE IRON LINTEL

FIG. 198. MUD BLOCKS ON LINTEL.



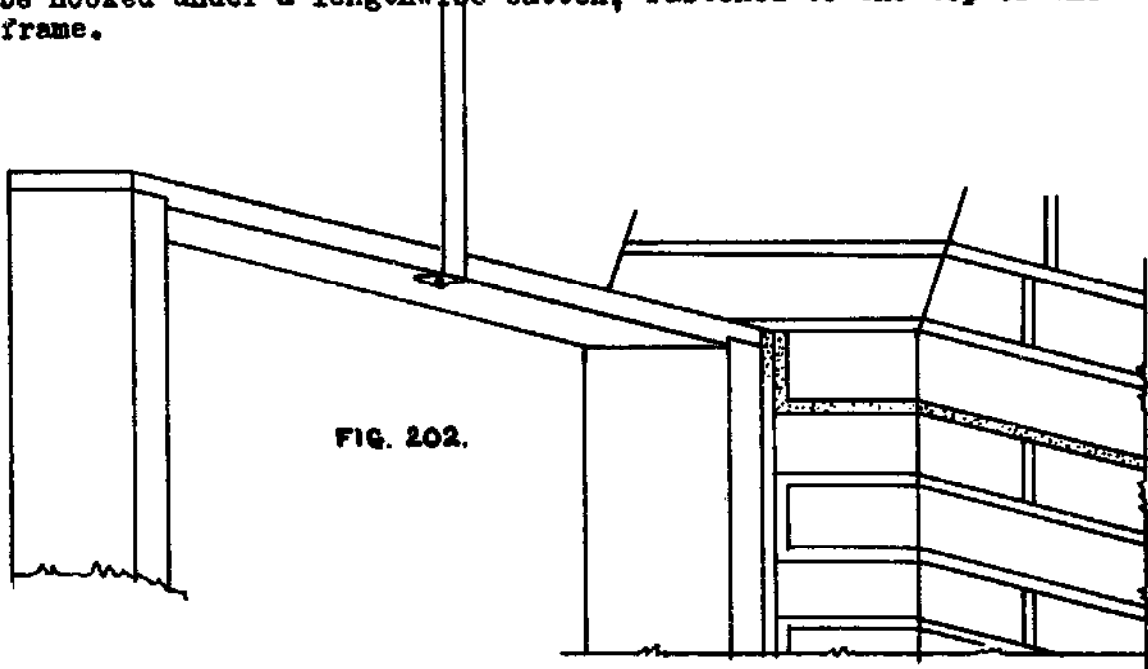
Nearly all lintels require the additional support afforded by a temporary post in the middle while the blocks or bricks are being laid, and until the mortar has hardened. Be sure that if the post rests on a frame, the under side of the frame has a block. If the post is on a masonry sill, place a block base for it, at least a foot long. One post is all that is required as a rule.



The support of wood lintels over wide or double doors is a problem. The solution which seems the least obtrusive and most satisfactory is a bale iron support from the lintel to the top of the wall. The length of the bale iron is calculated, the lower end is formed to hook the lintel as shown, and then the bale iron is led up through the wall as the wall is built. At the top it is secured to a block.

Of course the lintel requires a post support, and the sooner it is put in the better. If possible, force the lintel up in the middle as much as $1/2$ " in a five foot opening. It will help to warp the lintel in an upward curve which is preferable to a perfectly straight line when all the work is done. Be sure that the post has a wood block and otherwise solid support.

Bale iron affixed to door lintel when there is an arch over the other half of the opening. If preferable, the iron may be hooked under a lengthwise batten, fastened to the top of the frame.



In Fig. 202 the double lintel is supported by a bale iron hooked under a stout batten well fastened by screws or nails to both lintels.

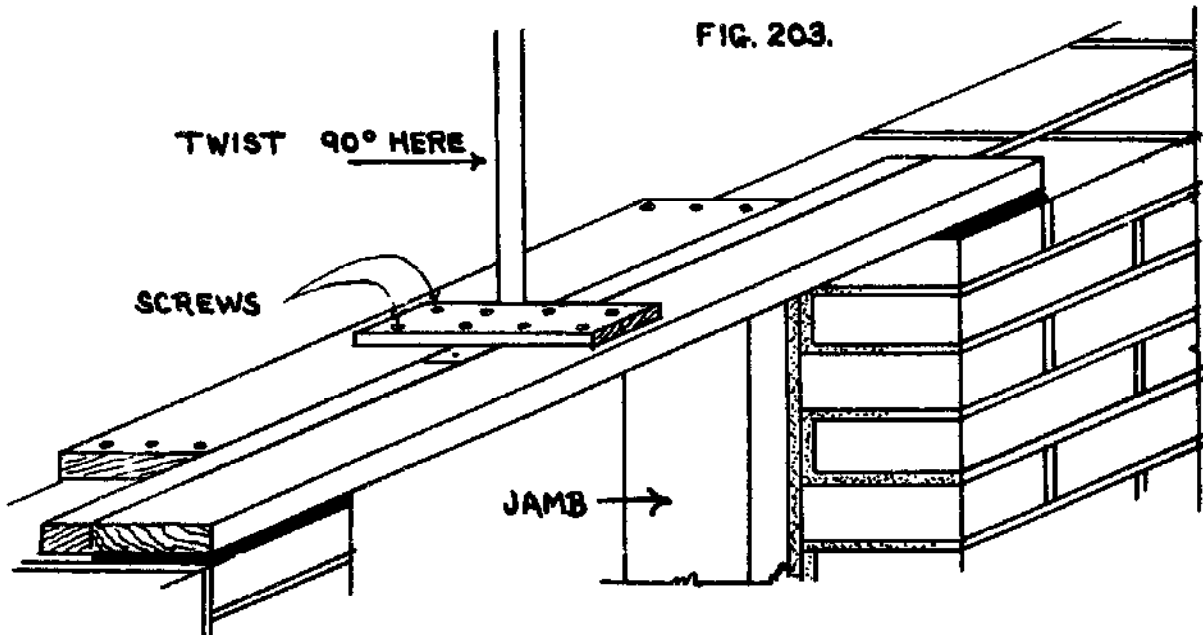
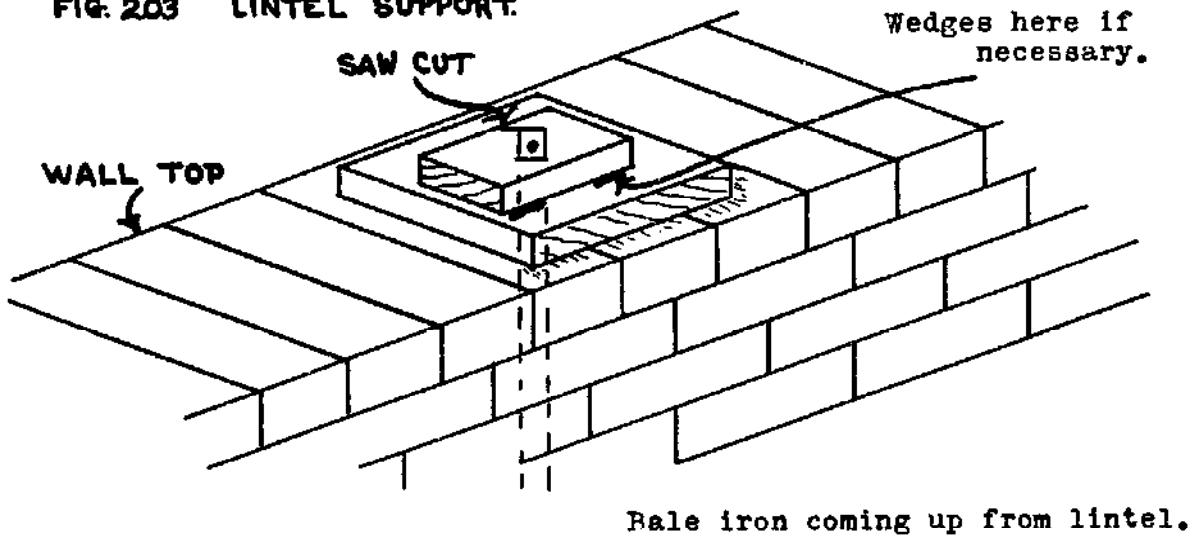


FIG. 203 LINTEL SUPPORT.



CHAPTER THIRTEEN ARCHES

I. SEGMENT.

Mark out the curve with a tape or a measured rod. The radius for an arch like this is approximately five thirds, $\frac{5}{3}$ times the opening. An ordinary 2'6" door has a masonry opening of approximately 36".

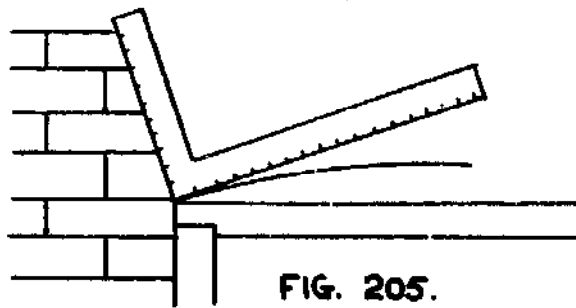


FIG. 205.

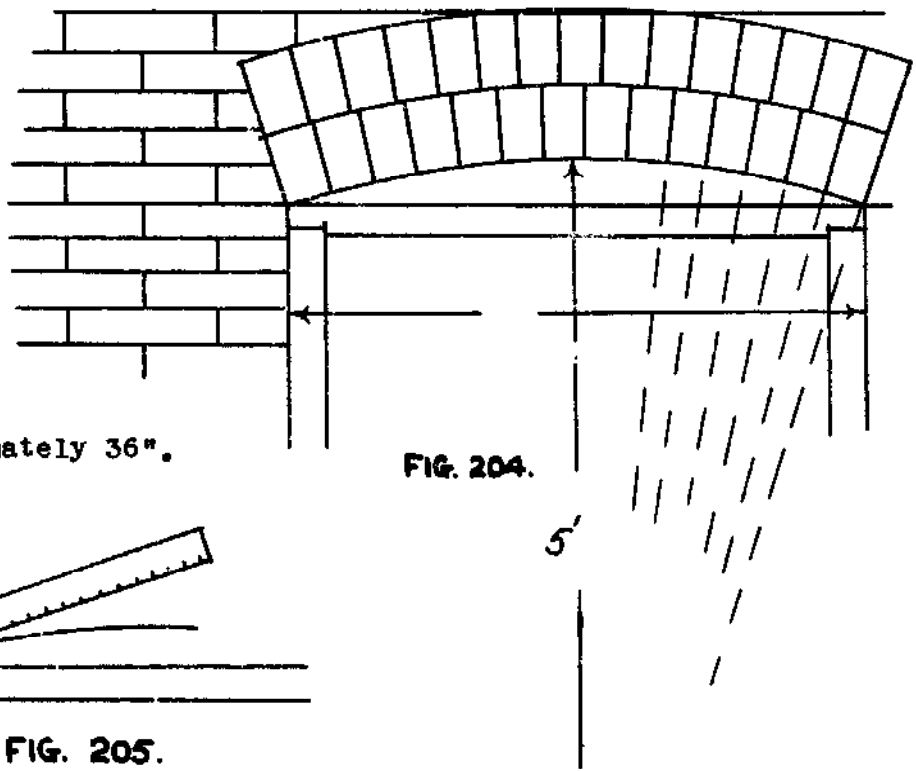


FIG. 204.

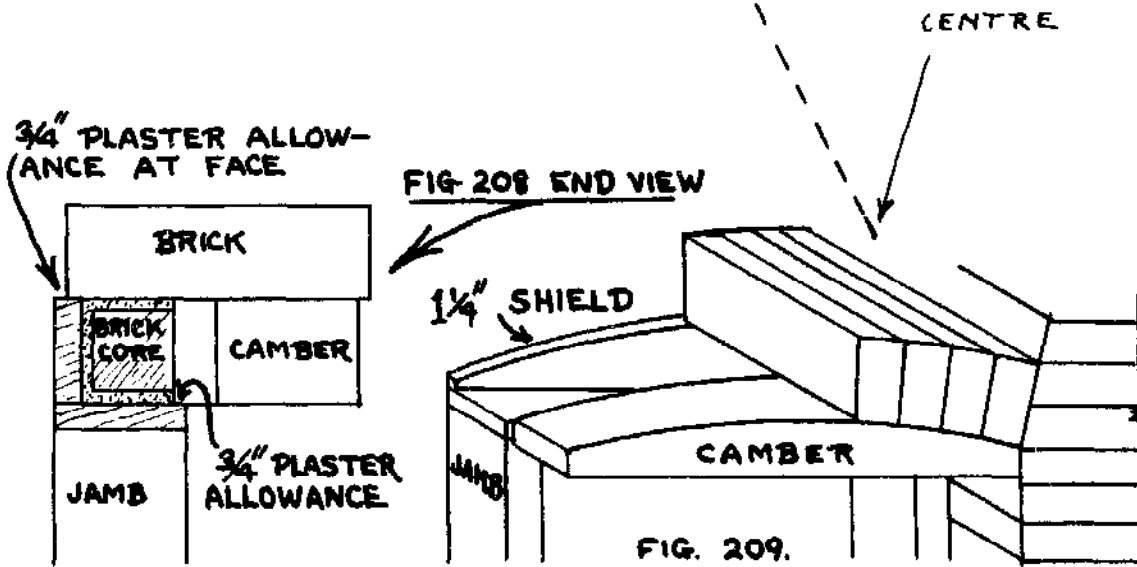
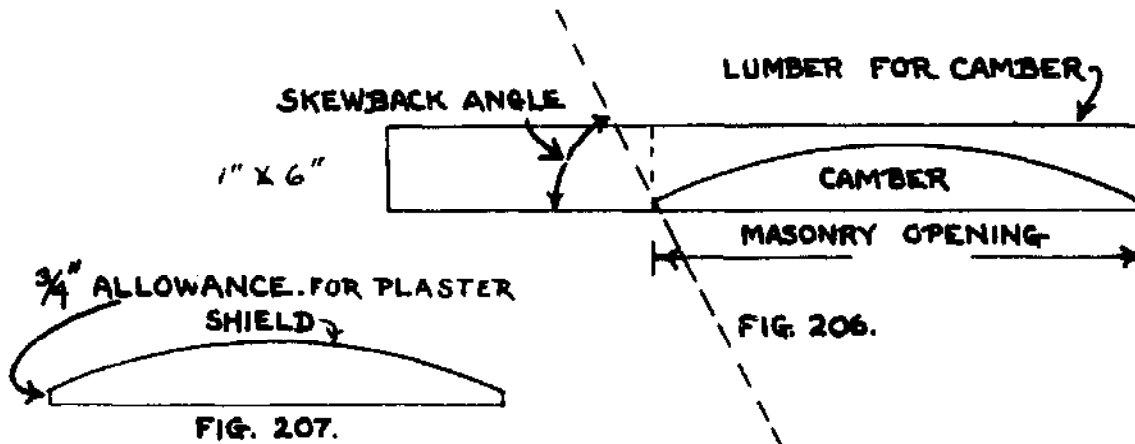
This would give a radius of five feet.

If arches such as this are desired throughout the house for door and window openings, make one or two arch supports, called cambers. Directions for making are found in Book Three, Chapter Six.

If the masonry between the arch and the frame is to be covered by a wood shield, then mark out the shield as well as the camber when you are using the tape or rod.

Keep the end of the arch about $\frac{3}{4}$ " above the frame to allow for plaster.

The brickwork cut at an angle to receive the arch is called a skewback. One method of finding this angle is to place a square on the camber so that the corner of the square is almost touching the camber. Another way to get it is by extending the lower line of the camber wood when the curve is being made. Extend the tape or rod beyond the curve, and the angle formed between the two lines is the angle of the skewback.



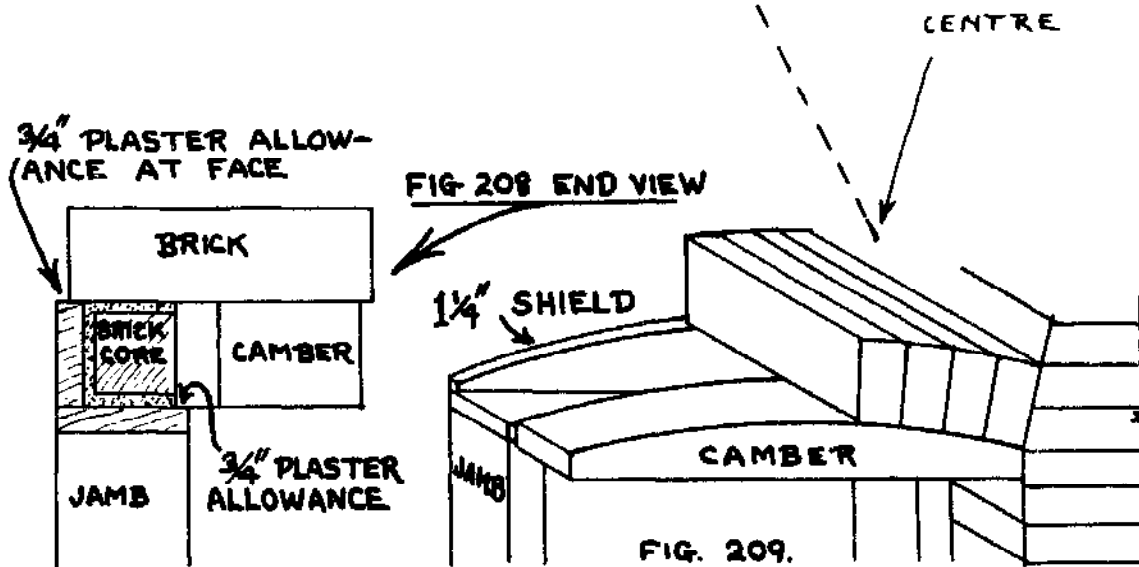
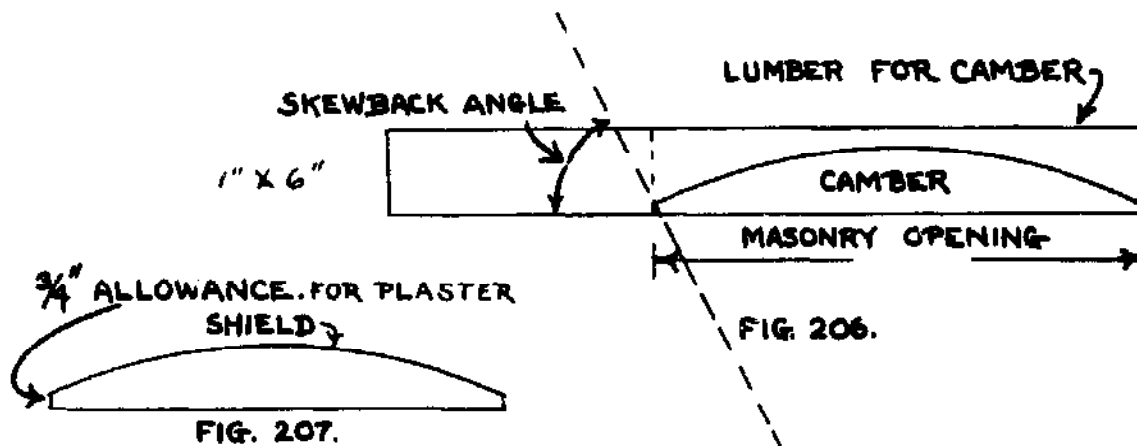
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Make allowance everywhere around the arch for plaster. If the wood shield is used, note in Fig. 207 that there is a stub end on the shield. This will keep the brick of the arch up from the frame at the front. At the rear face, the camber is to be even with the shield. When the plaster is applied to the under side of the arch, it will not come below the top edge of the door frame.

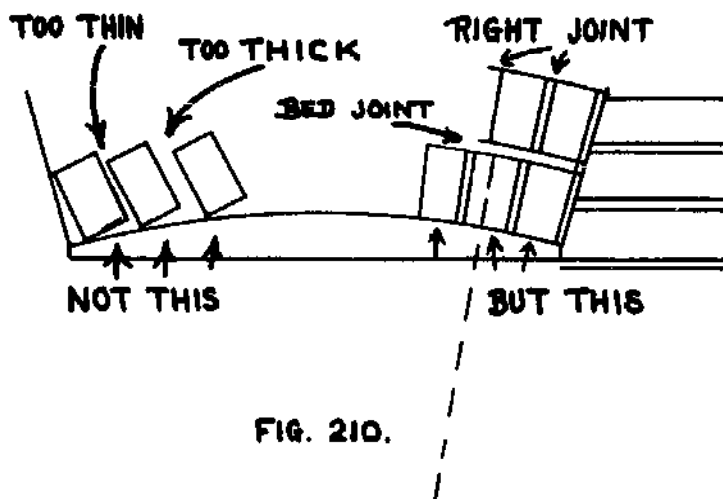


FIG. 210.

Note that in Fig. 208 the face of the brick is back from the face of the shield. This again allows for the plaster finishing flush with the face of the shield and the frame.

Again note that the brick core on the frame lintel is kept back from the rear face of the lintel so that when plaster is applied it will not project beyond the wood.

When a shield is used the brick is laid directly on it without mortar between. Mortar is never used on the camber. But mortar is always used on the core and for the bed joint of any brick above the first ring.

As on the right in Fig. 210, always lay the edge of the brick solidly on the support, whether camber or bed joint. The radius line should be the centre line of every brick of the arch. Masons not used to doing arch work sometimes get things confused as at left in Fig. 210.

In all arch work, use only enough mortar to keep the brick from touching each other and to supply the wedge joint.

Lay up about half the arch on one side, then start the other side. Measure the intervening space as you approach the centre in an attempt to avoid cutting, or the use of a very thin brick for the centre or key brick. It does not take long to place dry bricks right over the arch first to see how they will come out. By keeping the joints very thin, or by trimming each brick a little and using thin joints, you may avoid trouble at the last. On the other hand, just a very little extra mortar in each joint may enable you to come out even.

To avoid hold up and the making of many cambers, get one opening ready ahead of the others, and arch it. Since the mud mortar dries very well in about five hours, try to put in three in one day with one camber, one at 7.A.M., one at noon, and one just before closing time.

A quick release device for holding the camber is described in Book Three, Chapter Six.

The segment arch should not be closer to a corner than two feet for a three foot opening, four feet for a five foot opening.

II VERANDAH AND PARTITION ARCHES. The half-round, or 'Roman' arch is the strongest and best for most purposes. The radius is one half the opening.

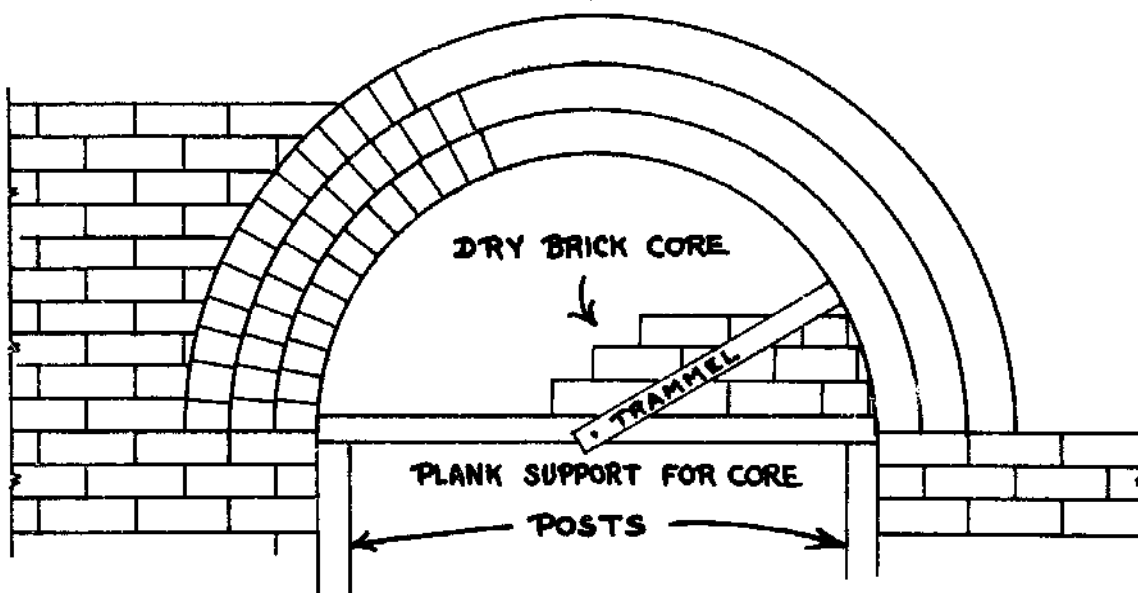


FIG. 211. THE ROMAN ARCH.

A wood form called a centring is expensive to make and is unnecessary. First make a deck or support of 2" X 6" or 2" X 12" and hold up with posts. The center line of the horizontal piece should be level with the centre of the arch so that a nail can be driven as shown. Make a trammel as shown. 3/4" X 2" is satisfactory for this. Now lay dry brick on the deck, the outer corners at each end being placed even with the end of the trammel, or just a little short of it. When the entire semi-circle has been outlined this way, fill the spaces between corners with thick mud and make the outer line conform perfectly to the circle described by the end of the trammel. Make sure that the surface of this mud is perfectly level cross-wise, because this is actually the finish line of the under side of the completed arch.

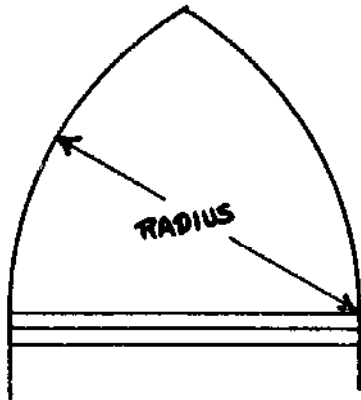
When the mud has dried, lay the first ring upon it, without out mortar between the form and the brick.

The segment arch or the semi-elliptical arch can be used also between rooms or for outer verandah walls. But the elliptical type should not be used close to the end of the verandah wall. It requires considerable resistance in the supporting pier.

The semi-elliptical arch construction is described in the next sub-section, in dealing with bay windows.

III GOTHIC ARCHES. This is the strongest arch, and the strength of the Gothic is proportional to its height. For the best effect, the height of the door or window should never be less than twice the width. The support for the arch is made in the same way as for other arches.

FIG. 212. MEDIUM.



To open window in top of frame, hinge at the cross bar as shown in Fig. 212.

Gothic doors are expensive and are likely to warp. Divide the opening as shown in Fig. 215, using plain, square-top doors.

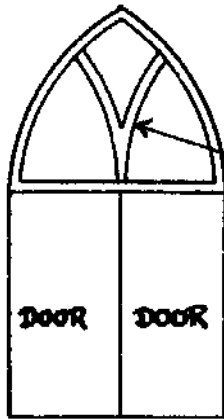


FIG 215. DOOR.

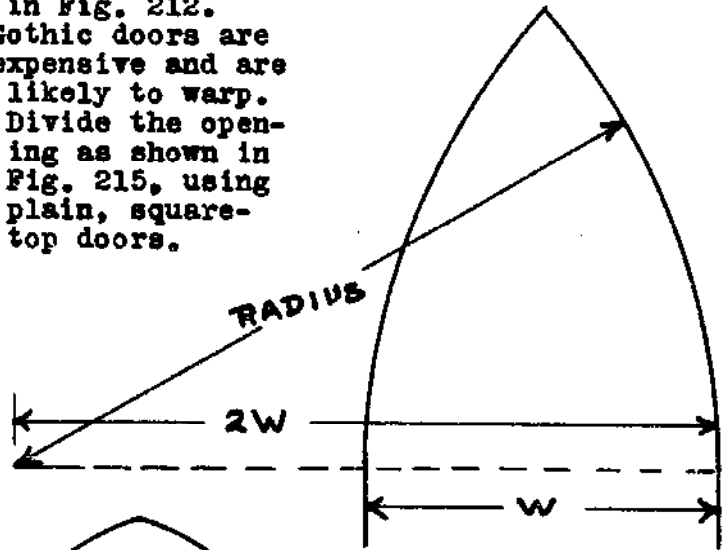


FIG 213. HIGH.

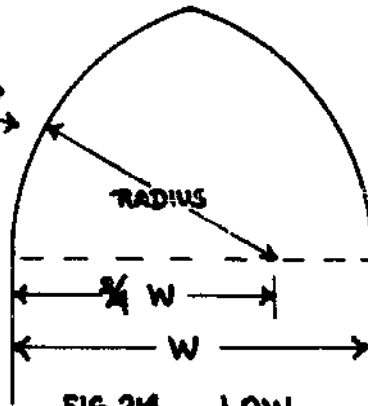


FIG. 214. LOW.

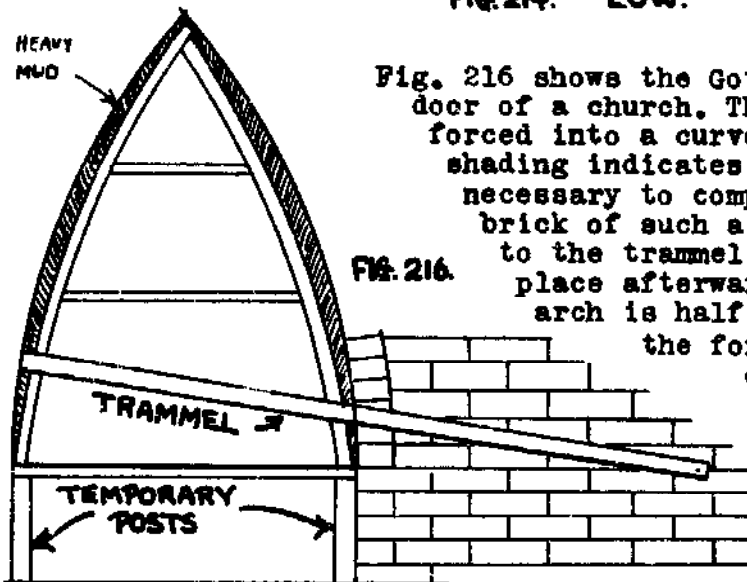


FIG. 216.

Fig. 216 shows the Gothic-arched interior door of a church. The forming is of 1" X 12" forced into a curve and well braced. Heavy shading indicates the brick and mud fill necessary to complete the true curve. The brick of such a steep arch can be laid to the trammel and the fill put in place afterward. That is, until the arch is half built. In the second half the forming can be built ahead of the arch bricks.

In a very high arch the wall should be built up as the arch proceeds. As a matter of fact, the corners of the wall at each end should be built first.

CHAPTER FOURTEEN BAY WINDOWS.

Apart from the fact that a bay window is an attractive feature, it has decidedly utilitarian values in a house, especially in a bedroom. It increases the floor area without increasing size of roof or main walls. It commands a view which is not otherwise possible and which is frequently more than merely aesthetic. Most important of all, however, is the fact that it is able to catch air currents which cannot be utilized without it. The particular bay window shown here is the highest that can be used with an eleven foot ceiling.

FIG 217 FRONT VIEW

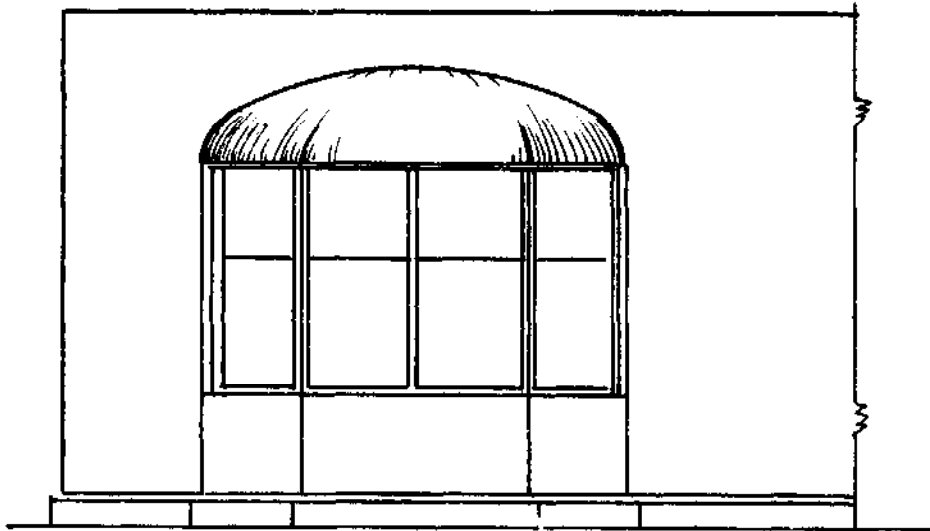
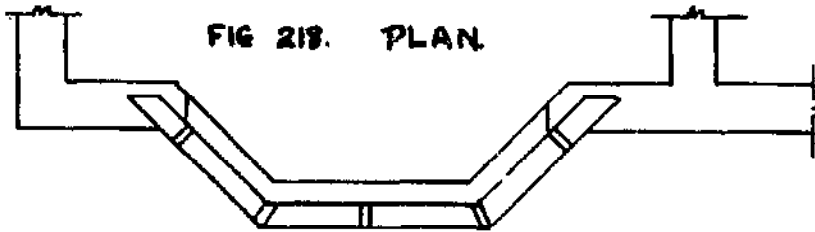


FIG 218. PLAN.



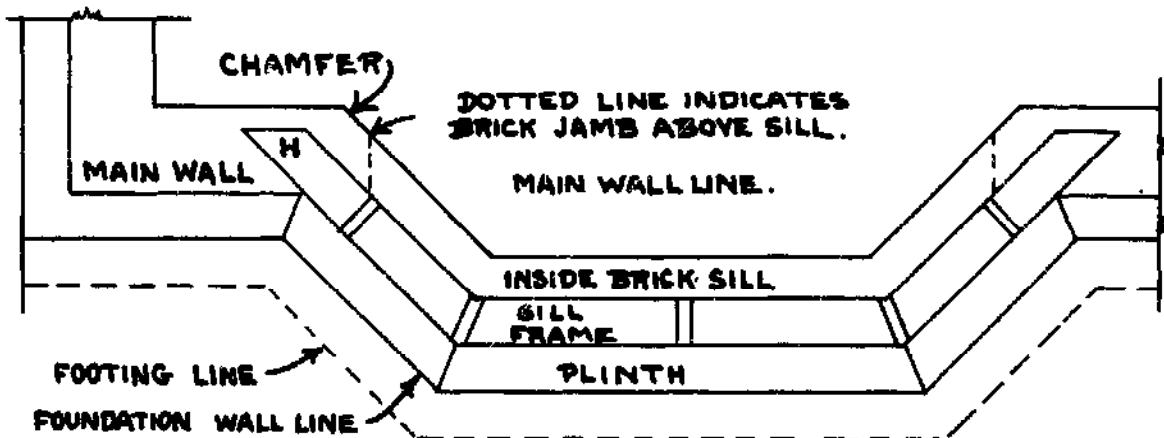
Steps in construction of the Bay Window.

1. Follow closely the foundation trench plan on Page 53.
2. Put in footings the full width of the trench.
3. Make the bay window sill and brace it according to instructions in Book Three, Chapter Two, sub-section of Bay window.
4. Lay this sill on the footing and start the foundation wall six inches outside of this sill face. At ground level, check the foundation wall, making sure that it is just six inches outside the frame face.

5. Make the ant course outside line to conform exactly to the sill face. If the ant course is to be plastered, keep it back of the sill face about one half inch.
6. Before jointing the metal ant course, lay the sill on it to check every measure and angle.
7. Lay the first course of brick in the bay, and then lay the sill on them, to check that the brick face is $3/4$ " back from the face of the sill. This is to allow for plaster. If these brick are not disturbed after this checking, and are plumbed from, the sill does not have to be used again for dimension, and can be joined up to the rest of the bay window frame.

The line on the face of the brick wall is $1/2$ " back from the rear corner of the jamb which is next to the wall.

FIG. 219. SILL ON WALL.

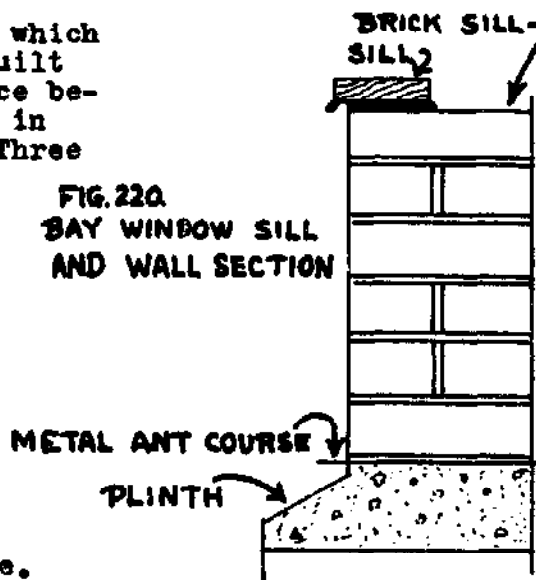


In Fig. 219 note the dotted line which indicates the brick jamb to be built above the brick sill. The distance between these jambs, $8\frac{1}{4}$ " is noted in the drawing of the sill in Book Three and it is important that this measure be carefully maintained. The chamfer is to be corbelled to a square corner 18 " from the top of the window frame.

The horn of the window sill, marked 'H' is to be completely built in as shown. Brace frame well when plumbed.

Corbel is the architectural term for a masonry bracket on the face of a wall, formed by the successive projections of courses of brick or stone.

FIG. 220. BAY WINDOW SILL AND WALL SECTION



As soon as the frame has been built in, prepare the arch support as follows:

Get three long posts of 2" X 4" or 2" X 6" or 3" X 4" seven feet long;

three short posts about 4'6" long;

three cross pieces about 5' long, 2" X 6".

Place the three cross pieces as shown in Fig. 221 and support by the posts as indicated. None of this scaffold must project beyond the line of the inside face of the wall, although the cross pieces should come to within one inch of the line.

On top of the cross pieces place two 2" X 6" X 8'4" and when this is on the line of the wall, and level with the top of the frame, wedge it in place. This is the support for the great weight of the dry brick core which supports the arch. See that all posts are firmly based, and all cross pieces and other parts are secured against movement.

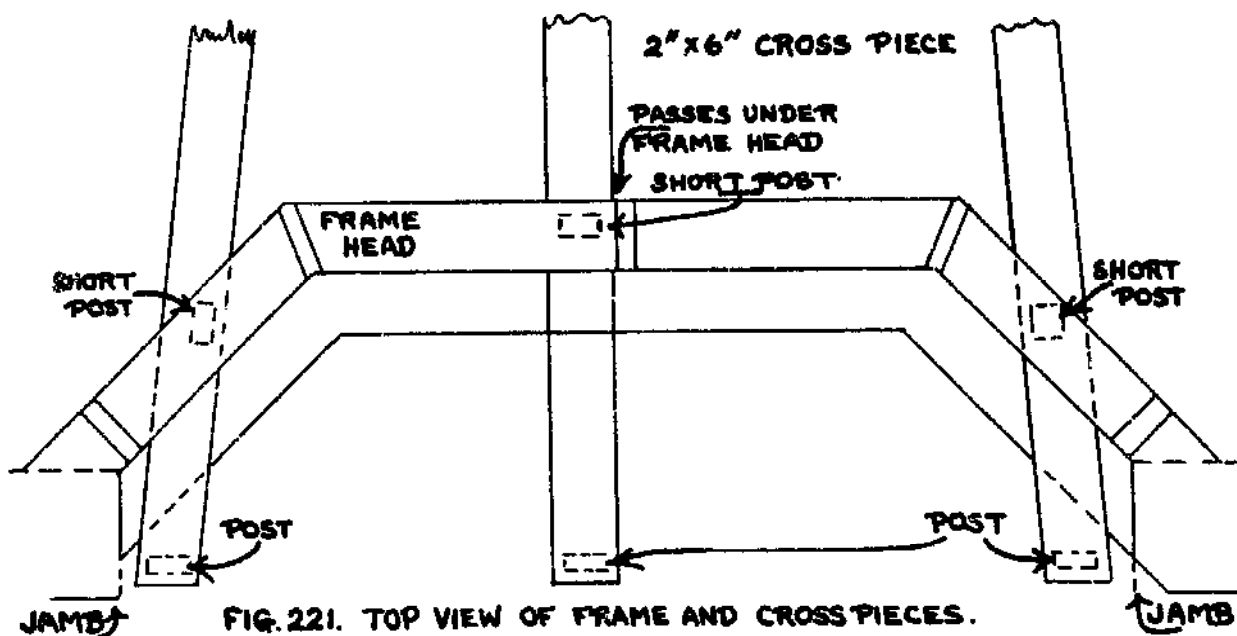


FIG. 221. TOP VIEW OF FRAME AND CROSSPIECES.

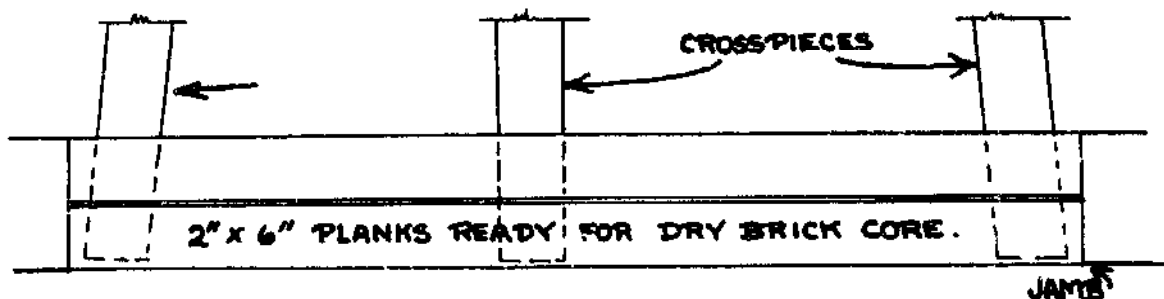


FIG. 222. TOP VIEW OF CORE SUPPORT.

Now at 12" from each end of the plank support and about 1/2" down from the upper edge, drive the nail of the 12" trammel shown in the diagram. The end of the trammel must just touch the jamb in each case.

Then make the 7'4" trammel for the centre and fasten it to a 2" X 6" post. The essential condition for this centre trammel is that when fastened and swung over the short trammel, the two ends will perfectly coincide. When the trammels are all in place, the building of the dry brick core can be begun.

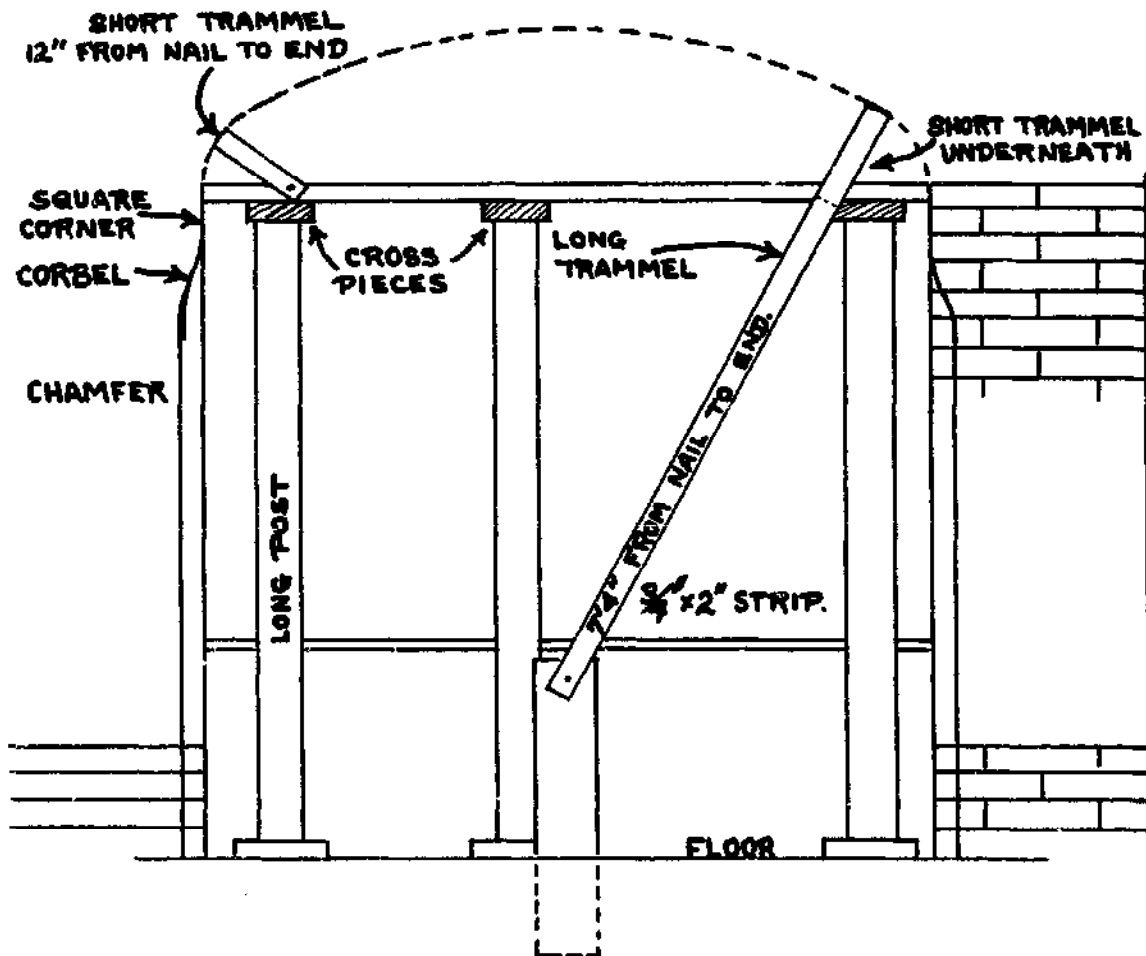


FIG. 223. ARCH CORE SUPPORT.

The 2" X 6" cross pieces which project outside the frame are used for scaffold support. Inside the frame they will be used for the core which supports the dome. This is the reason these cross pieces must be underneath the window head. They may be nailed to the window head, to their posts and to the support plank with 3" nails. The nails into the frame head must be driven up.

Now lay dry bricks on the plank support as is described on page 106 for the Roman arch.

FIG. 224. INSIDE VIEW OF COMPLETED ARCH

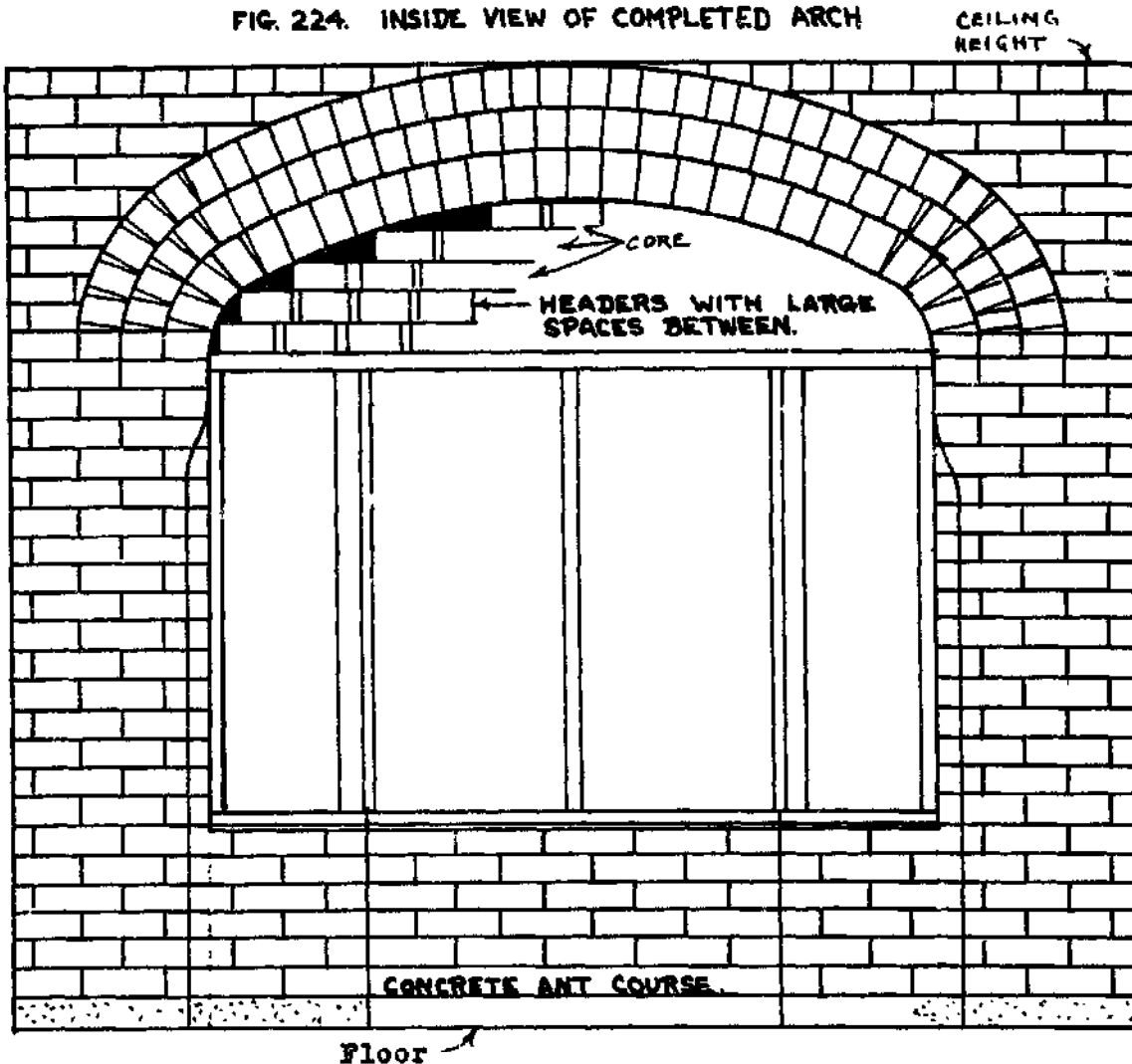


Fig. 224 Completed bay window arch on dry brick core with mud surfacing. When ring number two is complete, attach a strong bale iron to the upper horn of the frame nearest to the corner of the house, and lay the bale iron on the course so that it can be brought out at the top as shown. The entire support for the arch is left in place until the dome is complete and has had opportunity to dry out.

When this large arch is complete, floor the lay on top of the cross pieces, and fill the dome space with empty drums or boxes; anything which will take up space. Then throw on pieces of brick to an approximation of a segment of dome, and round out with mud.

Before any brick are laid on the frame, nail a 1" X 1" strip to the upper side of the frame head, about 1/2" back from the face. This strip is essential to the anchorage of the dome bricks to the frame head. The strip extends from wall to wall.

FIG 225

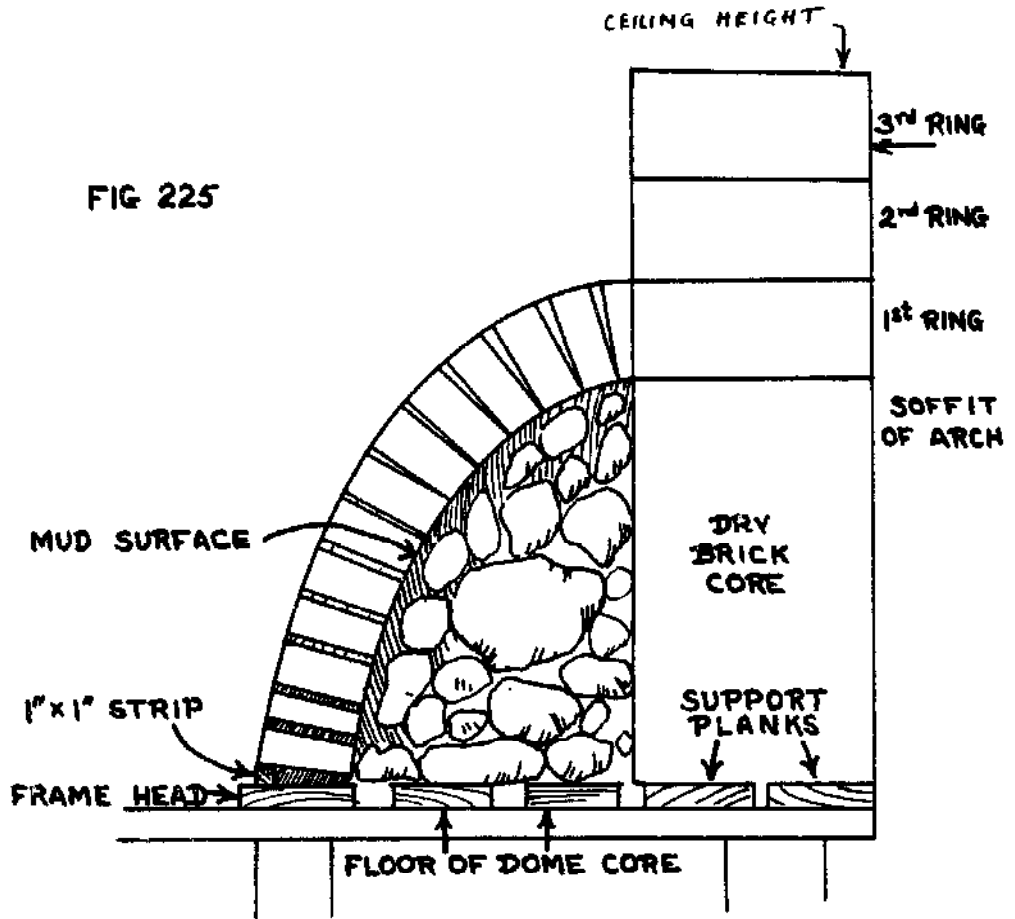
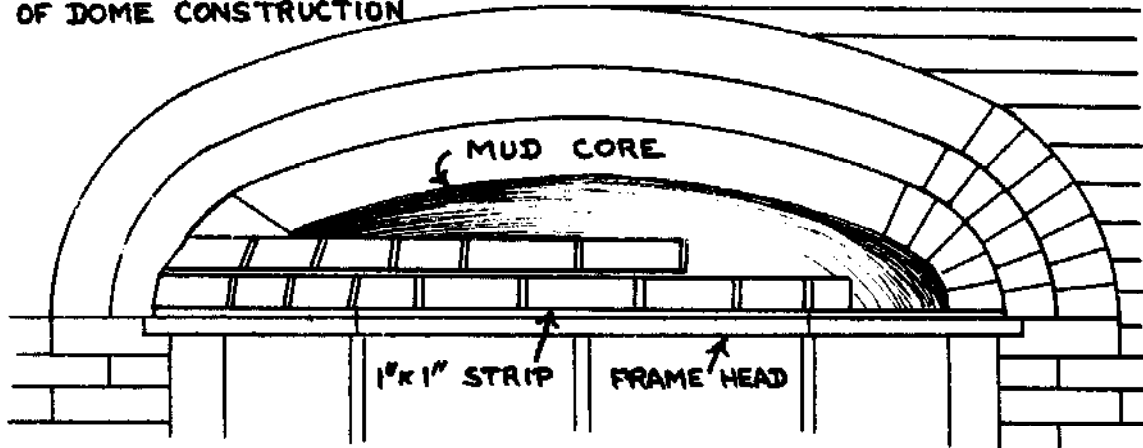


FIG. 226. FRONT VIEW OF DOME CONSTRUCTION

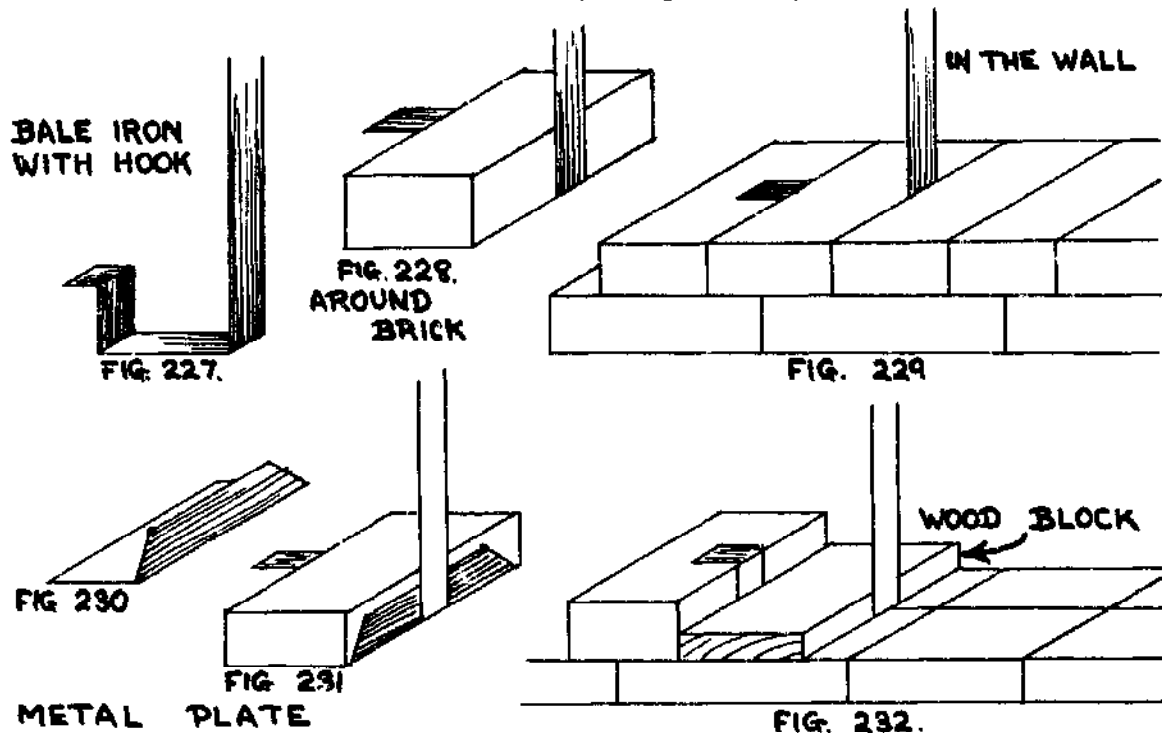


CHAPTER FIFTEEN ROOF TYING.

The time to think about tying the roof to the masonry is when the masonry walls are still about five feet from the top. Prepare bale iron straps as shown here. A simple calculation will show how long they must be to provide for the hook at the bottom end and to wrap sufficiently on the rafter at the top. To make the the lower end amply secure, wrap the bale iron hook around a block or a sheet of metal as shown.

The method of tying the roof after the wall is up is not satisfactory. Grooves must be dug in the wall and plastered up again when the iron has been inserted. The slightest movement of the roof causes the iron to move and so the plaster over the iron cracks.

If it is felt that two iron ties are required for each rafter, place them in pairs, and let them emerge from the wall, one on each side of the rafter. The actual tying of the rafter is further dealt with in Book Three, Chapter Eight.



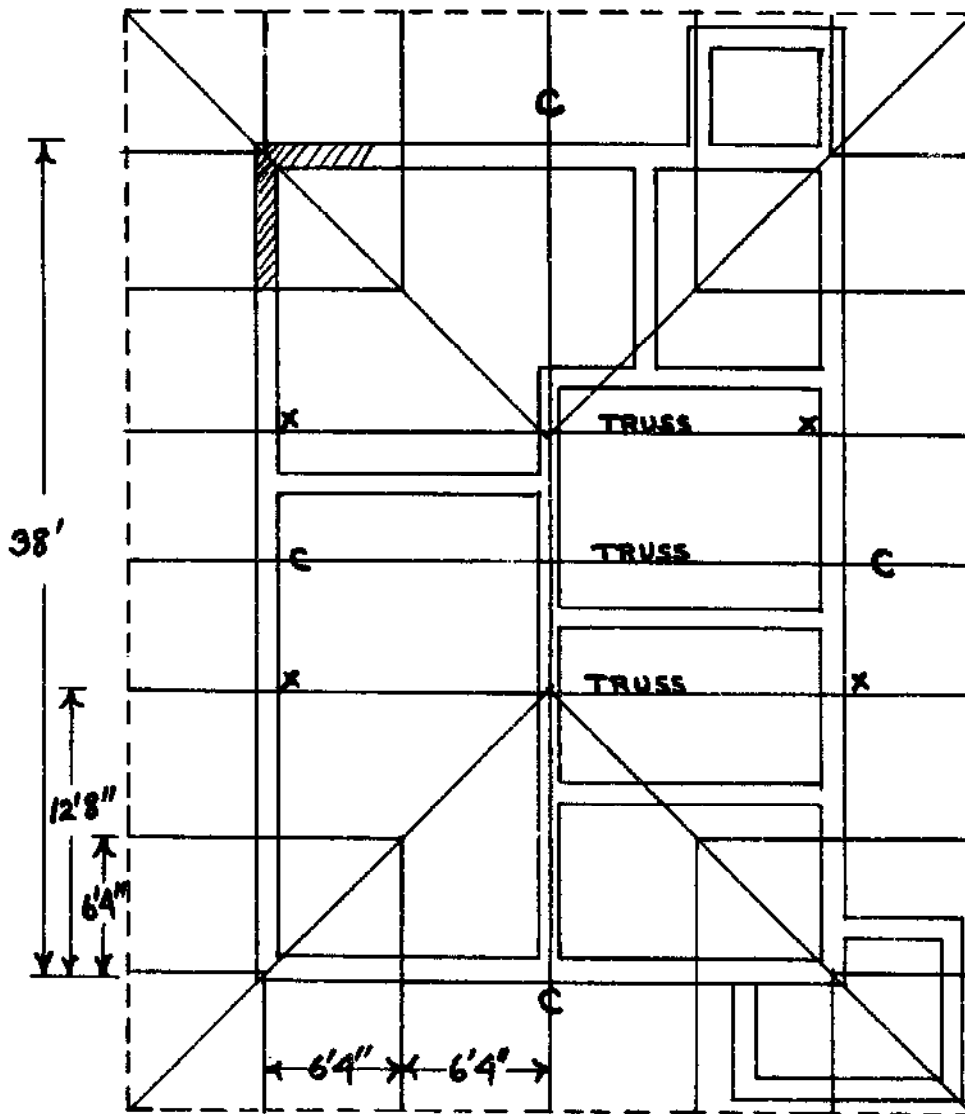
Tying verandah posts. Whether the post is of masonry or of wood, it requires a thorough anchorage. A wood post is anchored and the anchor iron is fastened to the lower part of the post. At the top another iron connects with the plate. But with masonry posts, it is necessary to run the anchor iron from its anchor below the floor right up through the post and to the plate. Heavy posts have been seen swinging because they did not have this con-

tinuous anchor-to-plate iron.

Roof brackets. Due to the great difficulty in accurately placing roof or rafter brackets while the walls are being built, we recommend putting them in after the rafters have been fixed in position. This also is taken up in Book Three, Chapter Eight.

To accurately place the wall ties for each rafter, draw a plan of wall tops and roof frame.

Fig. 233, Roof and Wall Plan of 'Mission' House, showing where roof ties are to be placed.



'C' rafters are central between corners. 'X' shows the four main bearings of roof trusses. Every rafter should be tied to the wall it rests on. Two at the far end and three at this end should be tied to the exterior wall whether tied elsewhere or not.

CHAPTER SIXTEEN WALL TOPS AND GABLES.

The last course of bricks on any wall should be headers. The last three courses of a wall should be strictly level, whatever the others are. As shown in the diagram, level up the wall at the fourth course down.

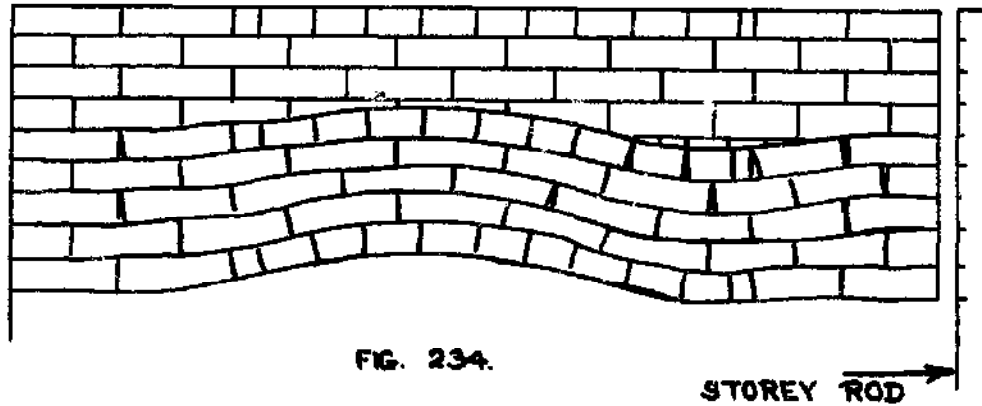


FIG. 234.

STOREY ROD

Finishing a slant top or gable wall.

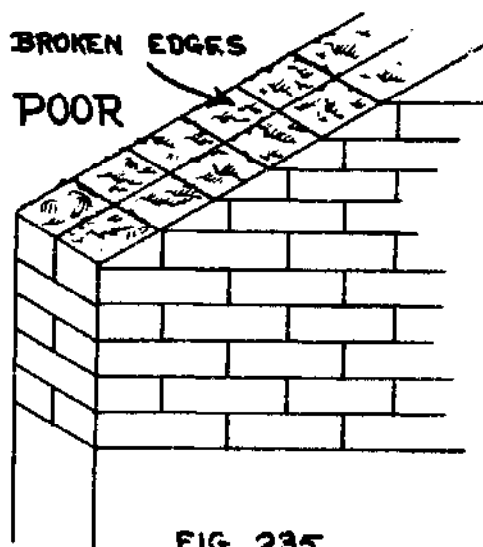


FIG. 235.

Note the change of bond so that the first header of the gable might rest upon two stretchers and not upon a header.

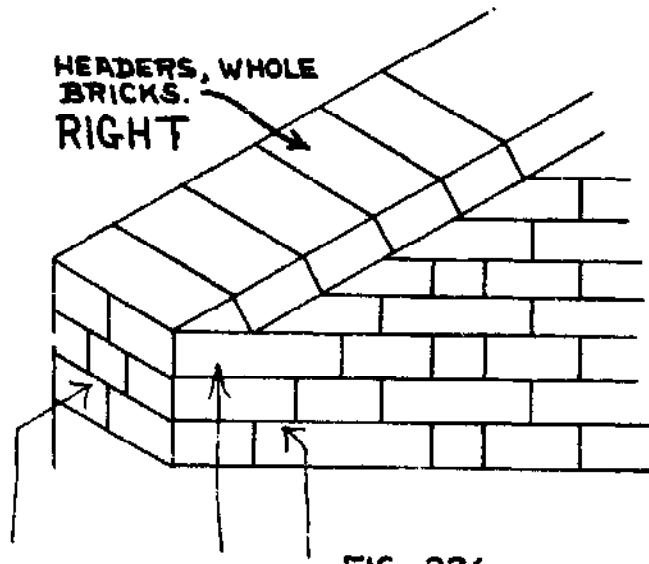
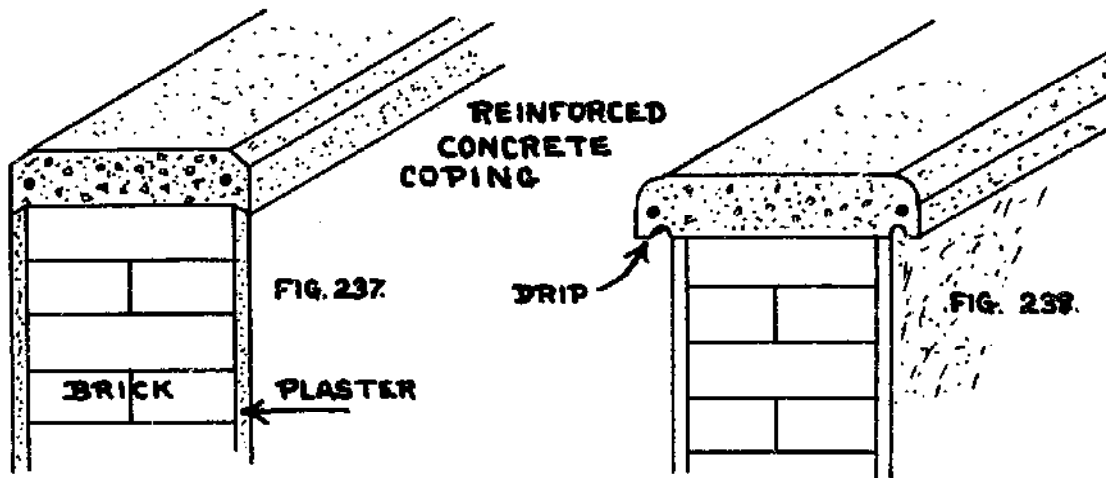


FIG. 236.

Capping a masonry wall with concrete.



CHAPTER SEVENTEEN FIREPLACES AND CHIMNEYS.

It is worthwhile going to the trouble to make your fireplace and chimney as effective as possible. The general design given here is accepted as the latest word in fireplace construction.

Heat is deflected into the room by the overhanging back wall of the hearth. The opening immediately above the hearth for the escape of the smoke is called the throat. It is long and narrow, and as near the front as possible. In practice, the smoke clings to the back wall of the throat until the curve changes and then the smoke is beyond chance of coming out into the room.

The wind shelf immediately over the hearth, and at the base base of the chimney, acts as a buffer to cold down drafts. The flue should be of uniform cross section all the way to the outlet above the roof, and should be as smooth as possible. Metal pipes tend to collect soot more quickly than masonry because they are cooler when the heat and smoke strike them. This slows down the speed of the column of smoke, gas, etc. by chilling it, and deposits on the metal are more quickly made.

If possible, have a clean out door behind the wind shelf, and in any case, keep the flue clean.

Before a fire is lit, the air in the flue is cold. It is good practice to take a good handful of paper, light it, and stuff it up the throat toward the wind shelf before lighting the fire in the hearth. This preliminary fire heats the air in the flue and often prevents that first back draft of smoke that is sometimes experienced.

The fireplace may be put in a corner as shown in the plan of the 'Mission' house. Another location is the wall opposite the front door, between the pantry and the office doors. In this case, the hearth and face of the fireplace need only project into the room six inches. The chimney and any other adjustment can be accommodated in the office wall and space. The clean out door can be arranged this way.

FIG. 239. PLAN OF FIREPLACE.

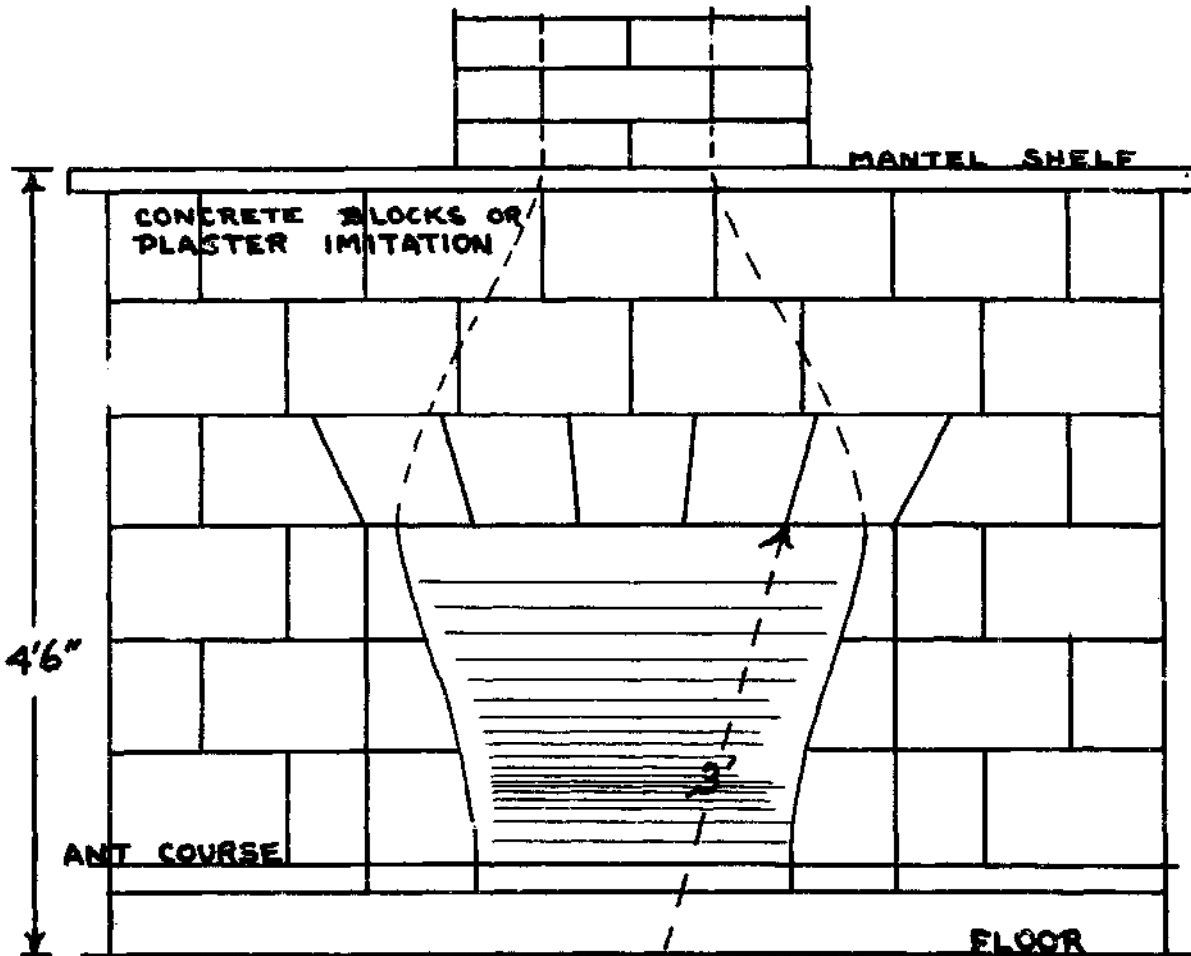
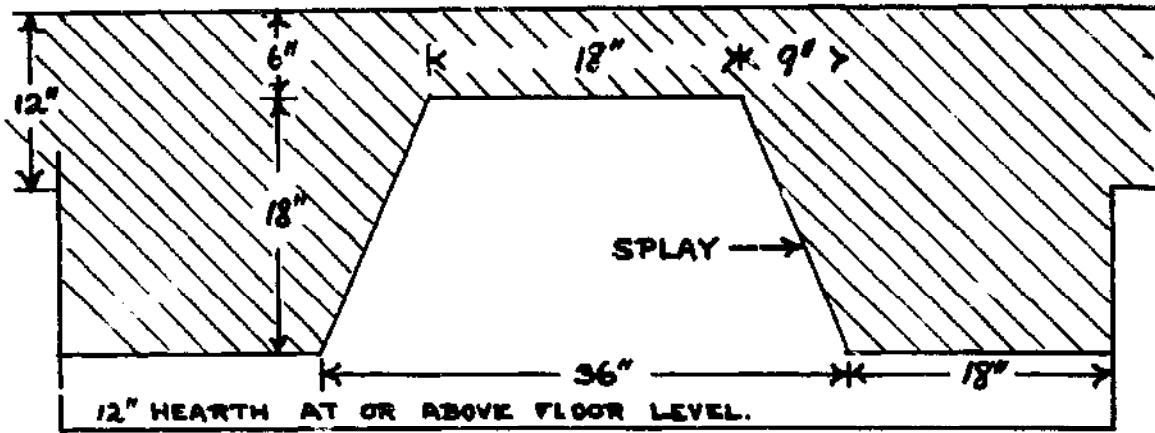


FIG. 240. FRONT VIEW OF FIREPLACE.

Build up the fireplace as the house walls go up. On top of the hearth, lay out one course of masonry as shown in the plan. Then build a core of brick and mortar as indicated in Fig. 243. With this as support, build the back wall of stone and cement, or of concrete, bonding each course with those on the splay or side walls. When the cold air shelf has been formed, continue the brick core as indicated by the dotted lines. Put paper between this core and the back wall so that when the core is removed it will leave a smooth surface. When this core is complete, smooth the front surface and put paper on it. This serves as the back face of the concrete lintel. When the lintel is formed and hard, the entire brick core is removed revealing a fully moulded firebox and throat. The rest of the construction is indicated in the section and plan at the right. The directions for making the concrete lintel are given in Book Four.

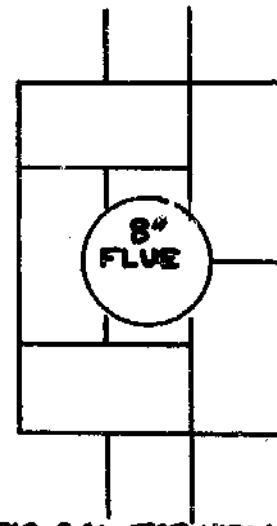


FIG. 241. TOP VIEW

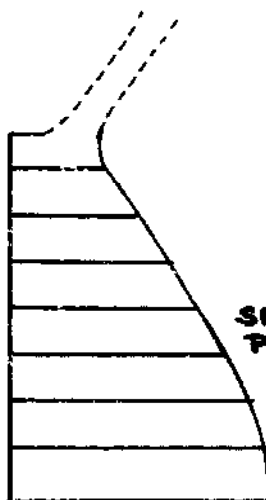


FIG 243

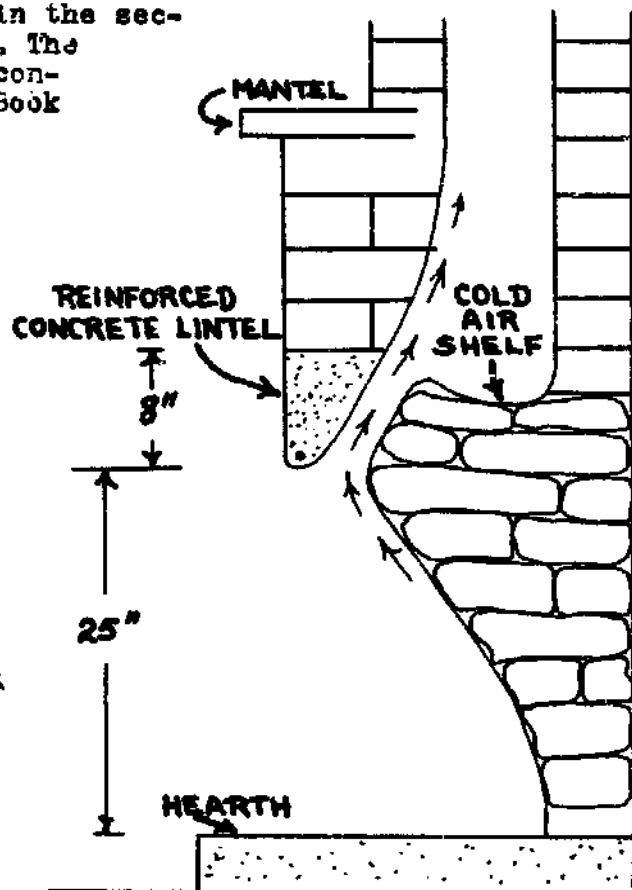


FIG 242 CROSS SECTION OF FIREPLACE.

Flues should always be circular. The upward current of air is circular and if the flue is square, there are air pockets in the corners which impede the upward flow. The circular flue is more easily built and more easily cleaned.

Building the circular flue: Procure a piece of stove pipe the size of the flue you want. For the fireplace the flue might better be at least 8" diameter. As this is not a regular stovepipe size, make a piece this size. Sandpaper or otherwise smooth the exterior as much as possible and smear with kerosene so that it will slip past the plaster easily.

When you have a course or two of the chimney started, insert the pipe and fill all corners with mud. As each course is laid up, fill around the pipe until about $\frac{3}{4}$ of the pipe is built in. Then by a circular motion, gently withdraw the pipe until it is only about $\frac{1}{4}$ built in. Repeat the process.

FIG. 244. METAL PIPE TO FORM FLUE.

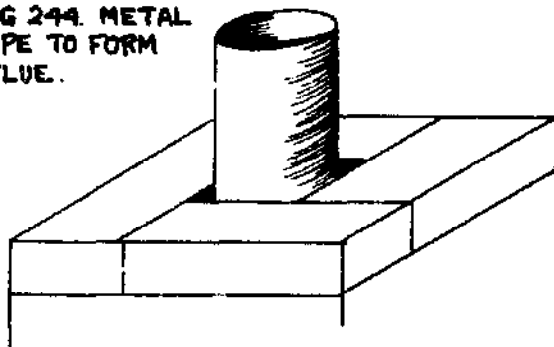
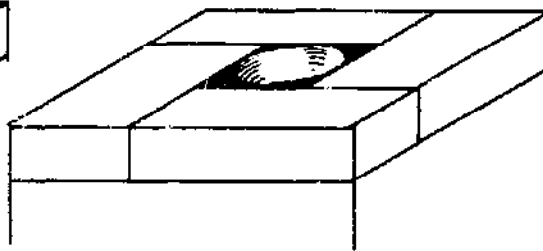


FIG. 245. MOULDED FLUE AFTER PIPE IS WITHDRAWN.



Permanent Kitchen Chimneys.

As for house walls, go down to solid earth and dig a proper flat excavation to take a footing capable of supporting the chimney. The chimney may be part of the kitchen wall or be separate as shown here. An iron bracket can be used near the top of the wall to steady the chimney. Observe the gutter fastened to the chimney to preserve it from the roof wash.

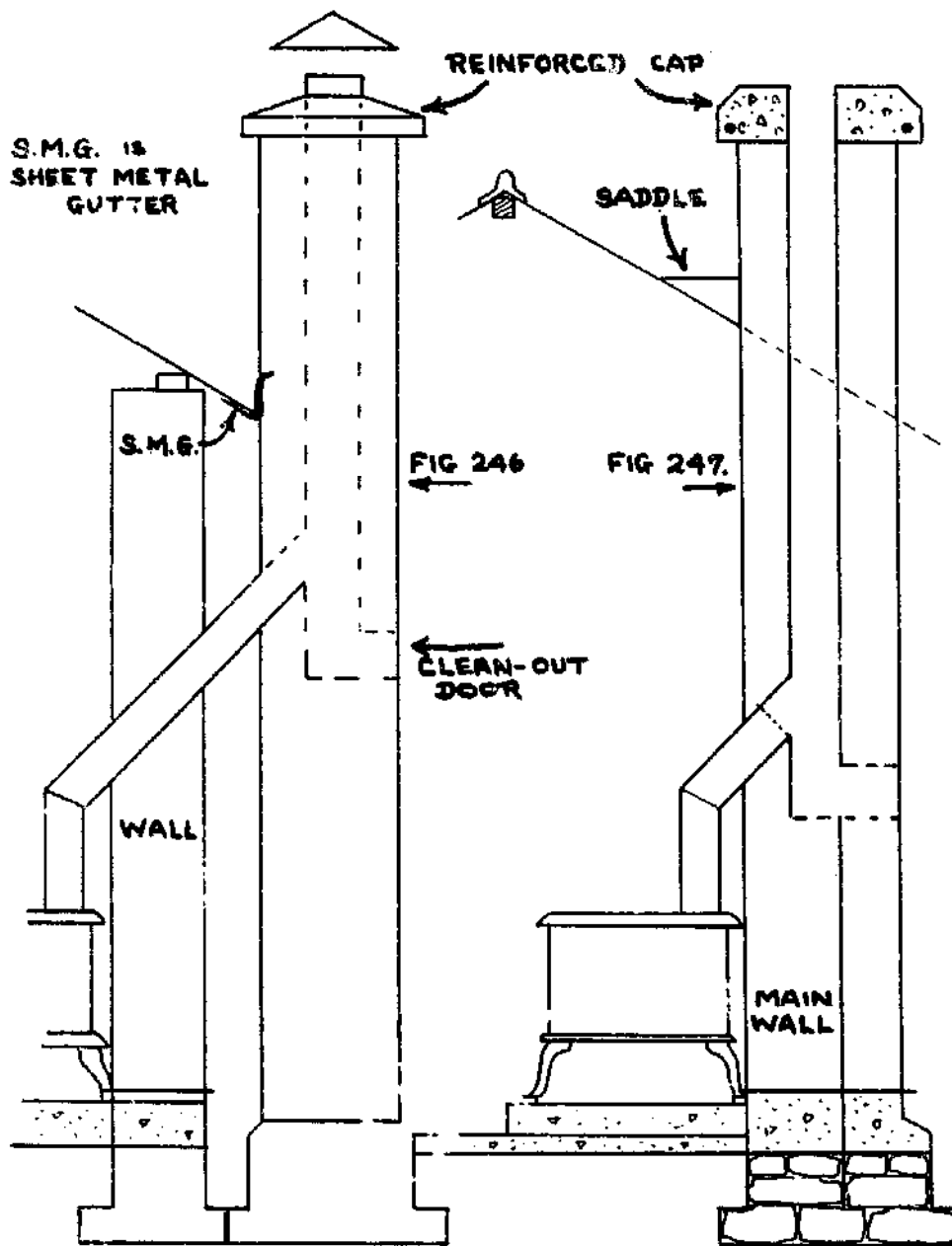
It pays to put a cement cap on the chimney at the very first building and so save much trouble in later years.

Use 45 degree angle elbows for leading smoke from stove to chimney. The draft will be better. Use as little metal chimney as possible and as little exposed in the kitchen as you can. It heats the place.

Avoid angles, corners, drafts, pockets, constrictions in flues, and poorly constructed chimney caps which interfere with draft.

Metal chimney manufacture is described in Book Five, Part Two.

One of the most difficult operations in building chimneys is to obtain a plaster finish which will resist cracking. For cracking means that water enters. On a burned brick chimney use cement plaster. Do one patch right around the chimney so that it will all dry together. Round the corners. See the next chapter.



The 'Saddle' or weatherproofing of a chimney against a roof is described in Book Five, Chapter Four. Concrete chimney caps construction detailed in Book Four, Chapter Three, Stovepipe manufacture directions in Book Five.

FIG 248
PLAN

CHAPTER EIGHTEEN PLASTERING AND POINTINGI OUTSIDE PLASTER.

1. On burned brick. Presumably, only cement plaster would be used on burned brick. Ordinary cement plaster is made of building sand and cement. Proportions being one part of cement to six parts of sand.

There should be some experiment about proportions because sometimes a weak mixture stays on better than a strong mix. It has always been laid down as an essential that the sand must be clean, but we have seen sand with a great deal of impurity used with cement and holding perfectly.

It may be stated that if the hardness of the outside plaster exceeds the hardness of the wall to which it is applied, it will probably peel off because it expands at a greater rate when the sun strikes it.

We strongly recommend the inclusion of lime in the cement plaster. The lime gives what the trade calls a fatty texture which is so effective in causing the plaster to work well and to adhere to the masonry. The proportions of cement-lime plaster are as follows: one part of lime mortar added to one part of cement mortar.

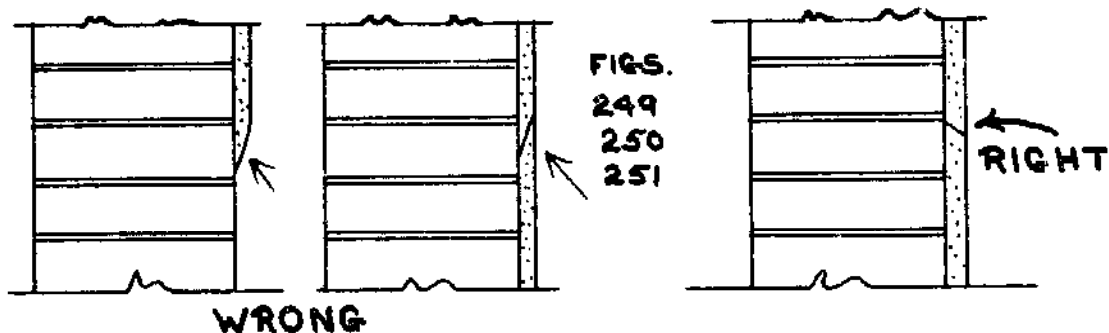
The lime mortar is first made as described in the chapter on Mortar, one part of lime to three or more parts of sand, according to the strength or quality of the lime. On the day that the lime mortar is required, it should be mixed to the consistency of the plaster. When the cement-sand plaster has been mixed, an equal amount of lime plaster is added. Mix together thoroughly.

The part of the wall to be plastered should be wetted just before plaster is applied.

All supplies and equipment ought to be ready the night before so that the actual plaster can be applied the first thing in the morning when the first batch is ready. Each wall should be plastered in one continuous operation in one day.

If possible, arrange the scaffold so that the men may cover from the ceiling or top of the wall to a point they may reach from the ground or floor. This means that when they have done this first top patch, they can continue without delay when the scaffold has been removed.

For outside plaster particularly, take care with the edge of the top patch to which the bottom patch will be joined. Almost invariably it is done as at left in the diagram with the result that weather gets in and the plaster peels off.



It may be faster in the long run to make a strip of wood with the upper edge bevelled, and nail it to the wall where you want the upper patch to conclude. This would ensure the full thickness of the plaster at the joint, as well as give it that definite tip of overhang which is admittedly hard to make.

Mix small batches of plaster, according to the number of masons, so that all mortar of each batch will be on the wall and finished not later than an hour from the time the cement has first been wetted. On no account must cement plaster be left over when men go to lunch. Impress upon the men that when plaster comes to the scaffold, they are to be prepared to stay there until all the mortar has been applied and finished.

Put enough men on a wall to finish it in the shortest possible time, so that joints between patches will not show nor crack open.

If it is impossible to do two walls which meet at a corner, in one continuous operation, stop short of the corner or go around it at least six inches so that the joint will not be at, or on, the corner itself. The joint should be a perfectly plumb line, and care taken when the joint is made up that it is as even a surface as possible.

If the front wall of a house is done first, make this top to bottom joint around the corner on the end wall.

The plaster should not be thicker than is necessary to make a true surface over the whole.

All plaster must be quite free from all lumps, granules, stones, etc.

Experience may have shown that the plaster which is ironed to a glass-like surface does not hold the decorative covering so well as a surface more or less porous. We are of that opinion and hence try to effect a more or less porous surface.

Usually the first stroke or two of the iron trowel on a new coat of plaster brings water to the surface. If there is no further trowelling, the surface assumes a porous looking finish due to the recession of the water. This is an objectionable finish for floors and other types of work, but it is desirable for plaster which is to hold a coat of decorative covering. And of course it is cheaper. Of course, too, it may not have such an even or true surface as an ironed finish, and so to overcome this probability, bring the plaster to as true a surface as possible with the wood float or trowel used just prior to the metal trowel.

If the masonry does not have a true surface it will be difficult for the plasterer to obtain a true surface for the plaster without the use of a straight edge which is moved over the wall vertically and horizontally to remove high spots. In the best practice the wall is trued up with a straight edge the height or the length of the wall, and then a long tool called a 'darby,' is used to even out the surface. Following that, a 'float' or wood trowel, and finally the metal trowel. One of the shortcomings of the masons is the use of a trowel which is little better than a spoon. The effective edge used for plaster finish is rounded and about three to five inches long! Encourage the masons to use the regular plasterers' trowel, 12" long, rectangular, or at least a pointed trowel of not less than eight inches

in length, along the working edge.

Apply cement plaster on the shady side of the building if possible, and as soon as the plaster can resist washing, wet it to prevent too-quick drying. Here again, the longer it is kept wet, the better the cement will set.

Plaster applied to the west side of the building in the morning may be dried too quickly by the afternoon sun and it is well to protect it if you can.

Try to have all constructional work complete before plastering work is done, so that there will be no cutting and patching later on.

If ladders must be used against the wall after plaster has been put on, pad the ladder top with rags.

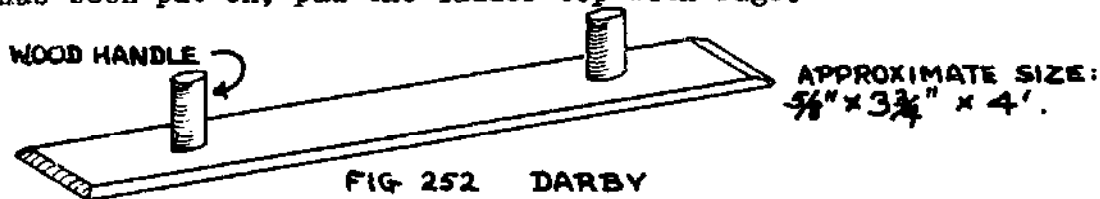


FIG 252 DARBY

2. Outside plaster on mud brick. Experiment may lead to the conclusion that cement plaster can be used on mud brick. In one case it did so. The proportions were one part of cement to ten parts of sand which was not at all clean. The surface of the brick in that particular wall was rough and the small stones in the brick mud were somewhat prominent. Presumably the rains had been allowed to wash the wall somewhat. But this condition is an exception rather than the rule.

In other cases, the mud bricks were studded with rusty nails, three and four inches long, the heads being allowed to protrude about one half an inch to give a key for the plaster. In other cases again, chicken wire was nailed to the mud brick wall. We do not recommend any of these examples, we simply mention them to provide ideas which may in certain circumstances prove of value.

We do recommend that mud plaster be applied to mud brick, that the horizontal joints especially be rough, depressed, that the mud plaster be as strong as possible.

It is customary to look for ant-hill or worm cast or similar local clays which have been specially prepared, naturally or artificially, and mix a suitable quantity of this special clay with the building clay used in the manufacture of the brick.

Be acquainted with the very best preparations of the local builders, but be sure that you see how their work has stood up to the weather before adopting their formula.

The remarks about the porous finish of cement plaster are very particularly applicable to mud plaster finish which is to take some waterproof coating. These are dealt with in Book Five, Part Four.

All the remarks about cement plastering should be read before doing mud plastering, for with few exceptions they apply also to mud plastering.

Whatever the material used in plaster, if there are depressions in the wall which have to be filled with plaster, do not

attempt to fill them with one or two thick coats, but apply thin coats and let each one dry out before applying the next. Any plaster coat which is to receive another coat should be 'scratched'. That is, scored with a small rake-like tool which will leave small rough scratches to which the next coat will adhere.

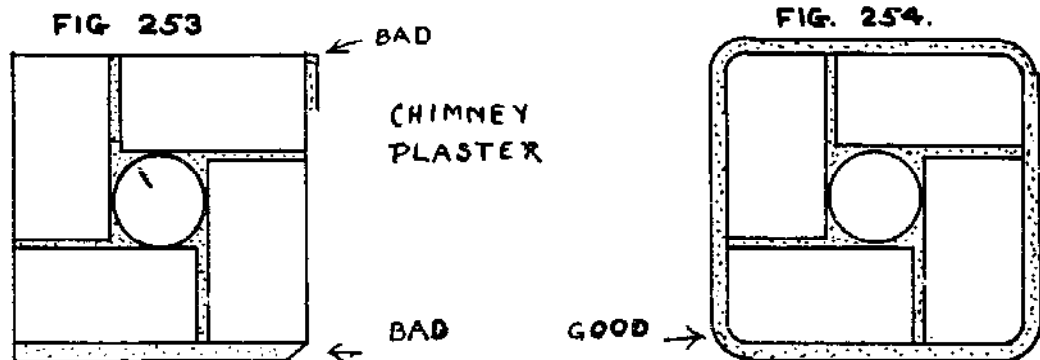
If mud plaster cracks too readily, use more building sand in it. But remember that building sand is soluble and therefore use no more of it in the plaster than is absolutely necessary.

Mud plaster should be applied as tacky as possible. If it is too wet it will crack. If it is applied too thick, it will crack.

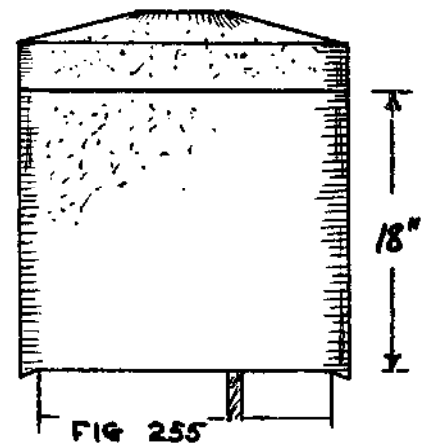
3. Chimney plaster. Being entirely exposed to the weather, and subject also to the inside heat, chimneys merit special attention to plaster and weatherproofing because failure leads to softening by water. This if unchecked causes collapse.

The concrete chimney cap should have a downward cut similar to that at the lower edge of the plaster patch so that if a crack does develop, water will not run into it.

Whether with mud or cement, plaster the chimney all around from the top down for about two feet. Joints are almost negligible when made in a few minutes; nevertheless, do not finish the vertical edge of a patch at the corner, but stop short or go around. Round the corners. When one patch is completed right around the chimney, do the next as for a wall, continuing down to the ground.



The usual method of plastering a chimney is to finish a patch on one side as deep as five or six feet. Inevitably these edges at the corners, whether abrupt or tapering, will develop cracks. We recommend, therefore that the brick corners be chipped a little as shown in Fig. 254, and plaster applied right around the chimney to a depth of 18" or 24" without attempting to finish the surface until it is all on the wall. In this way there will be no joints.



A special brick may be made which will eliminate several chimney weaknesses at once. The mud should be well reinforced with grass or sisal.

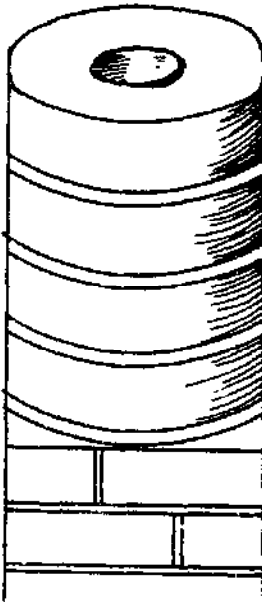


FIG. 256.

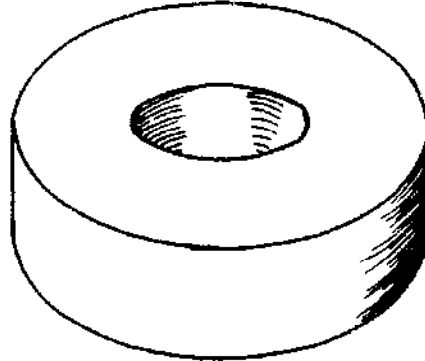


FIG. 257. CHIMNEY RING BRICK.

With this type of chimney, there will be no vertical joints or weak spots in either the masonry or the plaster. It requires plumbing on only two sides and not at eight corners, eliminates the trouble of forming a flue, and will lay up faster.

II. INSIDE PLASTER.

We have had little or no trouble with inside plaster, whether of cement or mud.

When able, plaster the lower 4'6" of all walls liable to abrasion through passage of persons or objects being carried, with cement plaster. Also all walls requiring washing, or which are exposed to moisture as in bathrooms, dish washing rooms, etc. Whether this cement plaster is painted or merely kalsomined, heavy wear will not do the damage which is done to mud plaster.

If round corner brick are not being used in the interior, it will be well to knock off the corners of the bricks of door and window jambs and either round the corner or form a chamfer. This too will save the plaster and decoration from much disfigurement.

Ceiling plaster. The first essential is tough grass or sisal ingredient to give the greatest possible tensile strength. We believe that good mud with this reinforcement makes as reliable a plaster ceiling as the common run of plaster made with lime and sand. Indeed there is no reason why cement-lime mortar with sisal carefully mixed in should not form a perfectly satisfactory plaster for ceilings.

To make the job as secure as possible, place one man above the ceiling with a supply of the plaster, and he will press

the plaster down through the chinks of the lath, leaving a considerable amount above the lath. In this way there will be no doubt about a complete key for the plaster. See Fig. 732, page 293.

Wood lath for this job are approximately 1/2" X 1". In some cases it will be cheaper to buy expanded metal lath.

Whether wood or metal lath is used for a ceiling, a second or even a third coat is required to give a proper finish.

The metal lath is particularly useful in giving artistic effects without any additional cost. As for instance a rounded corner, or cove, between the ceiling and the wall. In large rooms with high ceilings, this is particularly desirable as it kills the barn-like effect of a square corner between a high wall and ceiling. The metal would be slit at the corners and shaped as desired, the edge being nailed to the brick wall.

This plastered ceiling has no drawbacks. When the first or scratch coat is hard, dry earth can be spread over it to give further insulation from the heat and to deaden any sounds of scampering later on. The reason we suggest putting the dry earth on when the scratch coat is hard is that if there are any mishaps during the operation, it will result only in cracking the scratch coat. Let all work above the ceiling be done before the final coat of plaster is applied.

Application of wood and metal lath and the suspension of the ceiling is dealt with in Book Three, Chapter Ten.

III. TECHNIQUE.

An advance in plastering technique is long overdue. We do not expect to see a mason who is bricklayer, stone mason, and concrete floor worker develop also into an expert modern plasterer. But that does not mean that plastering need continue in its present very primitive method.

The equipment. Several effective straight edges of various lengths long enough to give line-perfect guidance to the gauging strip from floor to ceiling at each corner, or corner to corner at floor and ceiling.

The darby mentioned in the previous section.

The float or wood trowel, rectangular in shape, about 4" X 12".

The plasterers' smoothing trowel, of metal, and the same size as above.

The plasterers' hawk. This is a square mortar board held in the left hand, and from which mortar is scooped by the trowel.

A large mortar board with legs, or, supported on a box. This may seem like a large order, but in our opinion, the plastering work on a building can be speeded up at least four times the present rate by the use of this comparatively inexpensive equipment.

Modern plastering technique adapted for mission buildings:

With all of the equipment assembled, apply a strip of plaster about eight to ten inches wide from ceiling to floor at each end of the wall of the room. Plumb each strip. The main thing is that they be parallel. In first class work they must be. But when compelled to work where walls are not always plumb, then make each

strip as near plumb as possible, but they must be of equal batter if not plumb. Batter is divergence from the plumb line inwards.

If the straight edge does not reach from one of these strips to the other, then make a strip part way. This too, must be parallel with the others, and a line will be necessary. Get three $3/4$ " blocks, holding the line on one at each end, and bringing the middle strip of plaster up to the point where the third block will just fit between the line and the plaster. In first class work, strips of wood or metal are used for these guide strips and they are called screeds. We use the name screed for these plaster guide strips.

When the two end screeds are ready, we plaster from the ceiling down for about three feet, and from end to end. The plaster is applied with a strong pressing sweep, and as quickly as possible. Then a straight edge is placed horizontally from screed to screed and with a slight back and forth motion is moved up to the ceiling. It will pick up all excess and leave the wall essentially true. But there will be horizontal ridges left by the straight edge. The darby now comes into use. Grasping it with both hands swing it in large arcs, and vertically, and horizontally until the whole surface is evened up. It may be possible to use the metal trowel on this directly and with a few skilful strokes produce the desired finish. If not, use the float, and then the smooth trowel.

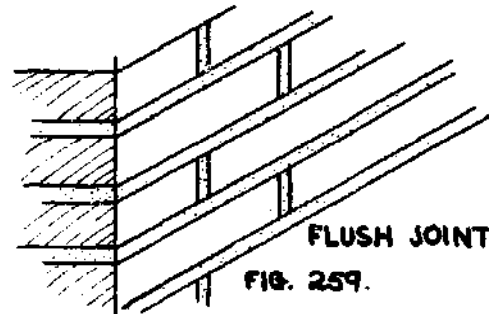
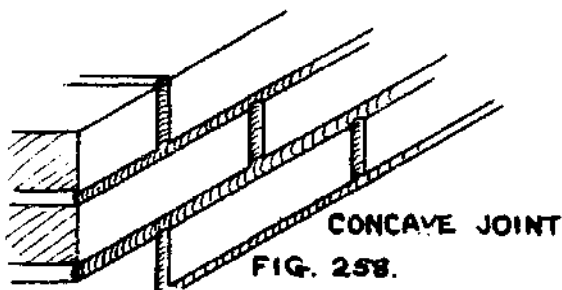
If water comes to the surface freely, leave that particular part for awhile.

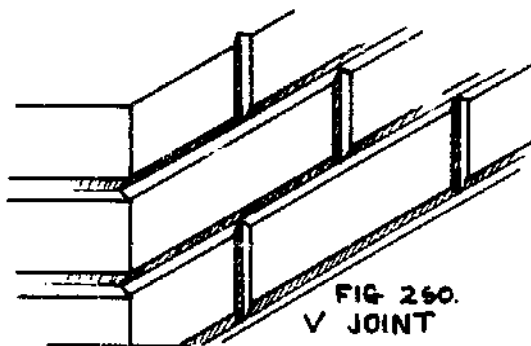
IV. POINTING.

This is the making or the touching up of the exterior joints of bricks, blocks, or stones, or the making of artificial joints on paint, plaster, concrete, etc.

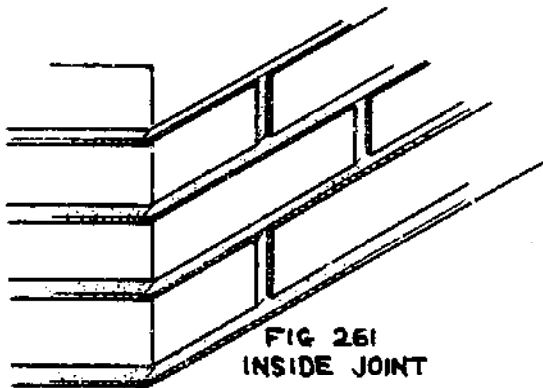
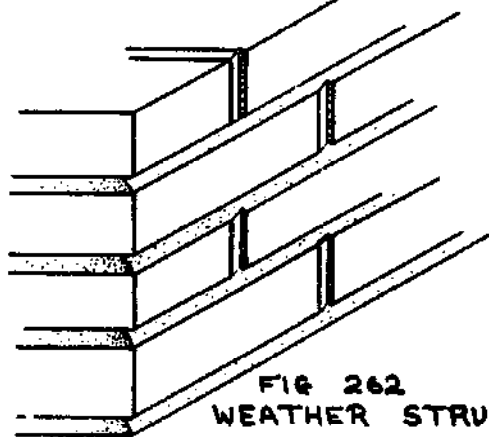
1. Pointing burned brick. In some quarters a protruded joint is used. It may have some merit. The only thing that commends it to us is that it hides the irregularities of the brick behind them. It seems inevitable too, that in making this most conspicuous joint, a considerable area of the brick is messed up with the pointing mortar, and this covering no doubt helps to preserve a poor brick from the rigours of the weather. Considering the great amount of time required to do this job, the cement wasted as the joint is formed, and poor appearance when all is done, it seems to us that a job of cement plastering is quite superior.

Commonly used joints on burned brick are as follows:



FIG. 260.
V JOINT

The concave and 'V' joints are easily made and lend themselves to heightened colour. It is not difficult to run a brush along the joint. Cement paint makes an effective finish. If the brick have good edges the flush joint is fair, but it is not an attractive job. The inside joint may be used inside but it has no feature to commend it. The narrow ledge

FIG. 261
INSIDE JOINTFIG. 262
WEATHER STRUCK

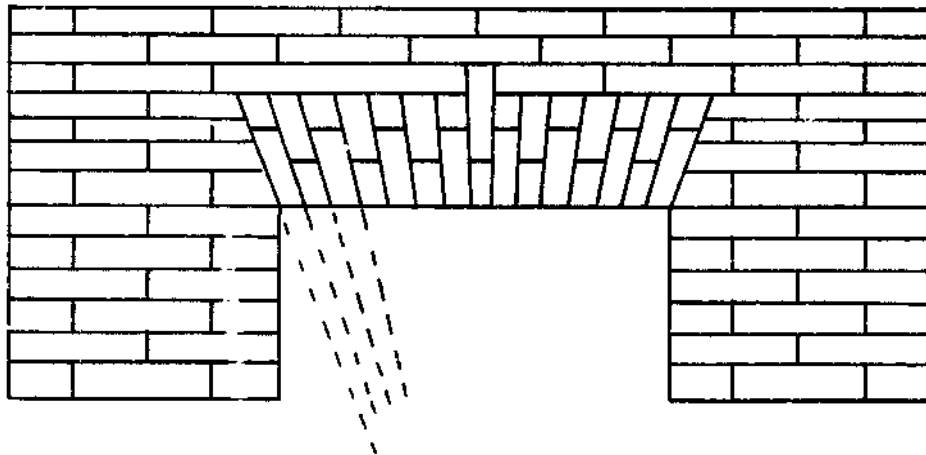
of the under brick is a dust gatherer. The weather joint is one of the best. The overhang throws weather and dust, outlines the brick sufficiently, and is easily made.

Imitation of brick or block on plaster.

An addition to a concrete block house may be plastered, and the plaster marked to simulate the blocks in the house wall.

A fireplace may be plastered and the surface marked and coloured to represent bricks or blocks.

FIG. 263. IMITATION GAUGED BRICK ARCH.



The plaster can be painted, or coloured when it is made. Red colour makes good imitation of brick, and cement paint in the joints is a fair representation of lime mortar.

Have your sketch and equipment all ready when the plasterer commences applying plaster to the upper part. While the finished plaster is still moist, line it with a 1/4" or 3/8" round steel rod guided on a straight edge,

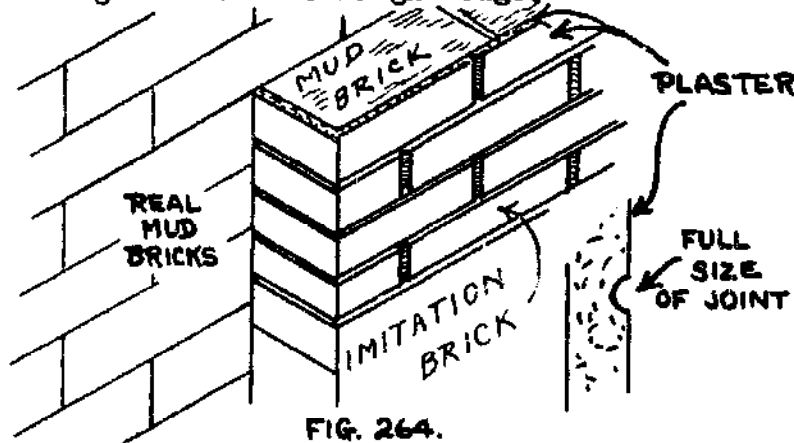


FIG. 266. SHAPE OF POINT BLOCK TO MAKE 'V' JOINTS FOR STONE BLOCK POINTING.

FIG. 264.

CHAPTER NINETEEN STONEMWORK

The advantages and disadvantages of this kind of construction have been discussed in the first chapter, Types of Walls.

It is sometimes possible to build with stone and yet not have to trim the stone. By all means seek this type of wall because stone trimming will add very much to the wage bill.

Seek first and all the time to bind the wall. That is have as many stones as possible tie across two, either in the face of the wall, or across it. You may have to sacrifice appearance somewhat, but that is definitely secondary.

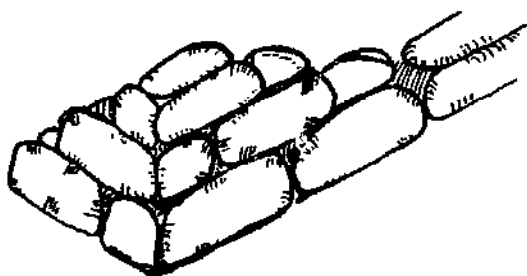


FIG. 267 CORNER

FIG. 268. TOP VIEW.

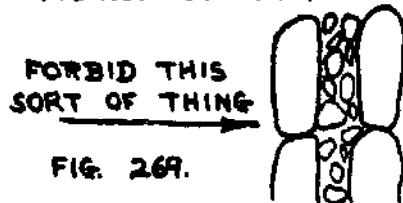


FIG. 269.

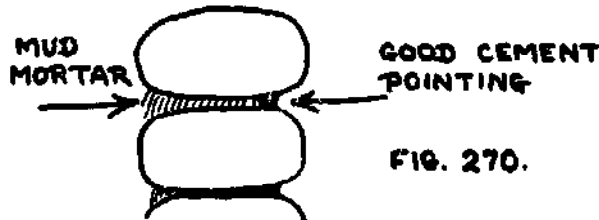


FIG. 270.

CHAPTER TWENTY PISE RAMMED EARTH WALL

Pise is snort for pisé de terre, which means rammed earth. Pronounce pee-zay.

Pisé is not so strong as mud brick or block, but given the right conditions, makes a strong wall.

It does not lend itself to alteration or repair. It is awkward in corners, for features, at frames, etc.

There is greater difficulty in making plumb corners and perfectly straight walls.

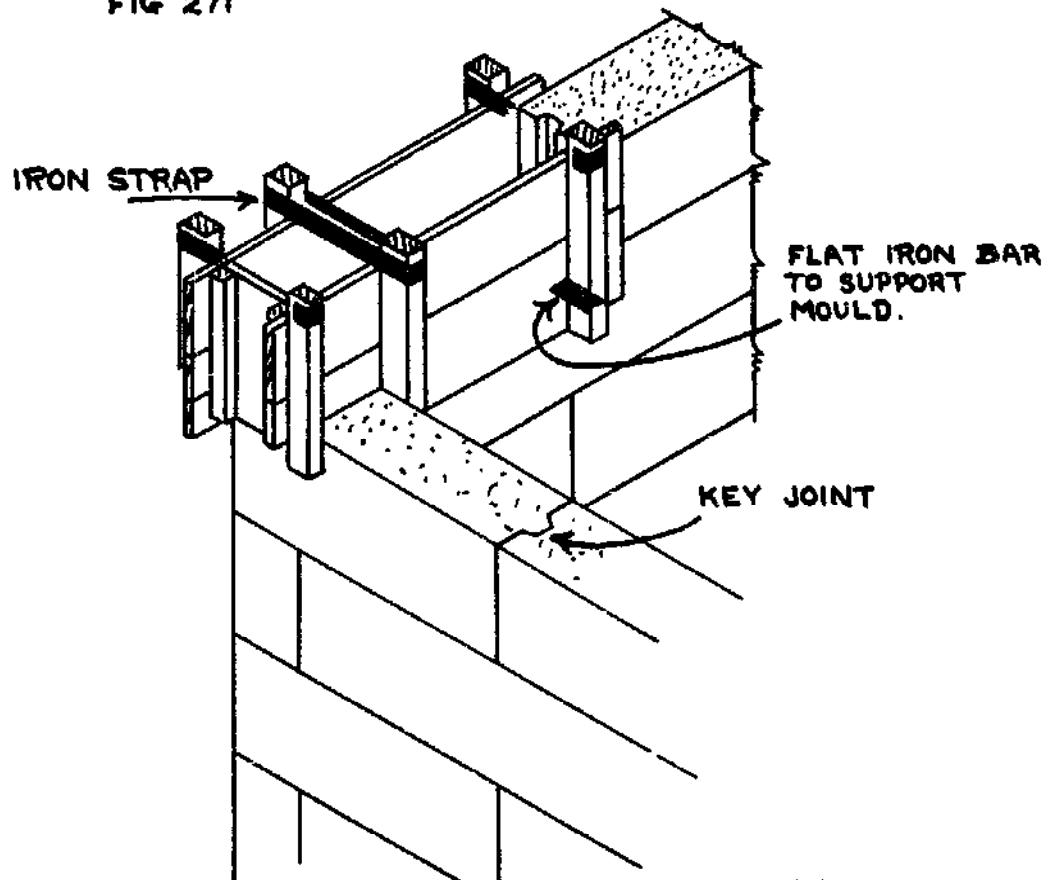
The forms must be strong, accurately dimensioned, easily moved.

The forms themselves. We suggest 12" courses, with 18" deep frames so that the frame will grip the wall for 6" below the surface.

It will be well to have all door and window frames the full width of the wall.

Lap corners.

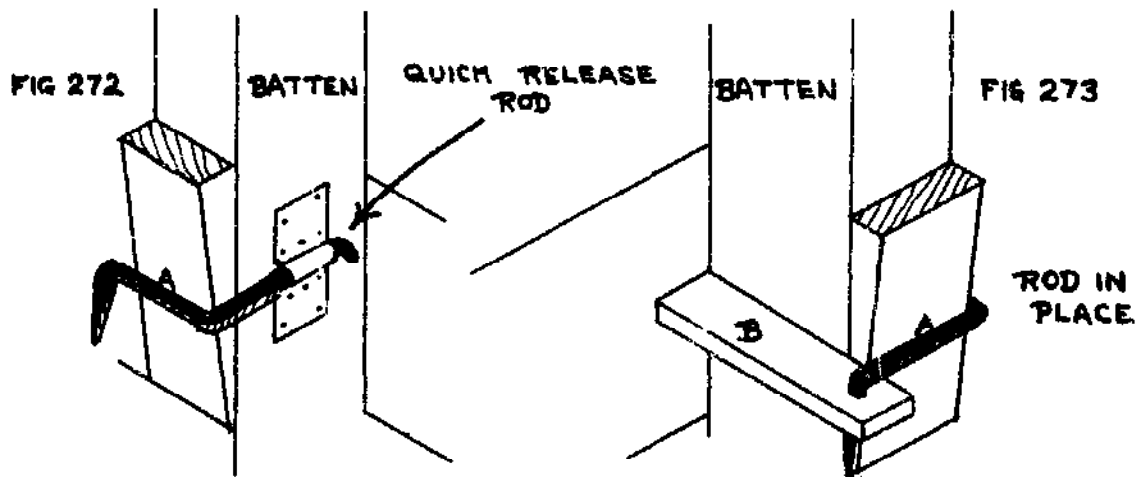
FIG 271



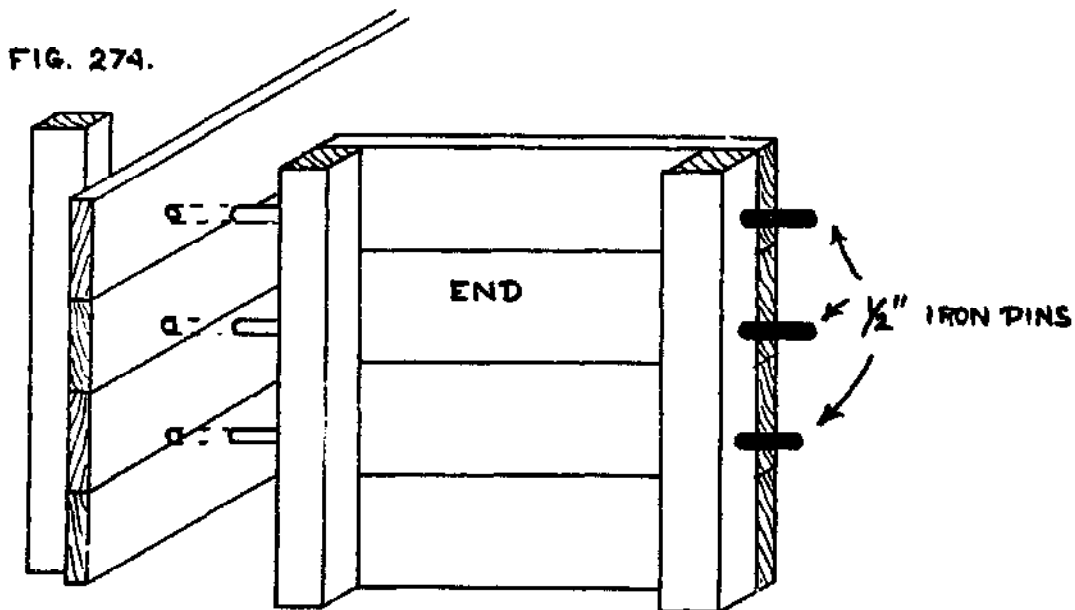
This type of mould can be used on corners or straight wall. If there are enough skilled men to look after two moulds, one could look after straight wall work and the other take care of the corners.

The clamping device with quick release arrangement will have to be made with your tool shop, metal stock, and skill in mind. We are obliged to do the best we can with what we have.

The bar 'B' rests on the block below and supports that end of the form. It is bored at each end to receive the pin or rod which withstands the pressure while the mould is being filled.



In order to use this type of mould for straight wall work, we cannot have any battens on the inner surface of the side pieces. To keep the end in position while the form is being filled, some such method as we show is needed.



If the three pins are spaced evenly, the end may be reversed for straight wall work as shown here. For the sake of clarity, the mould shown here is very short; in practice it should be about six feet long.

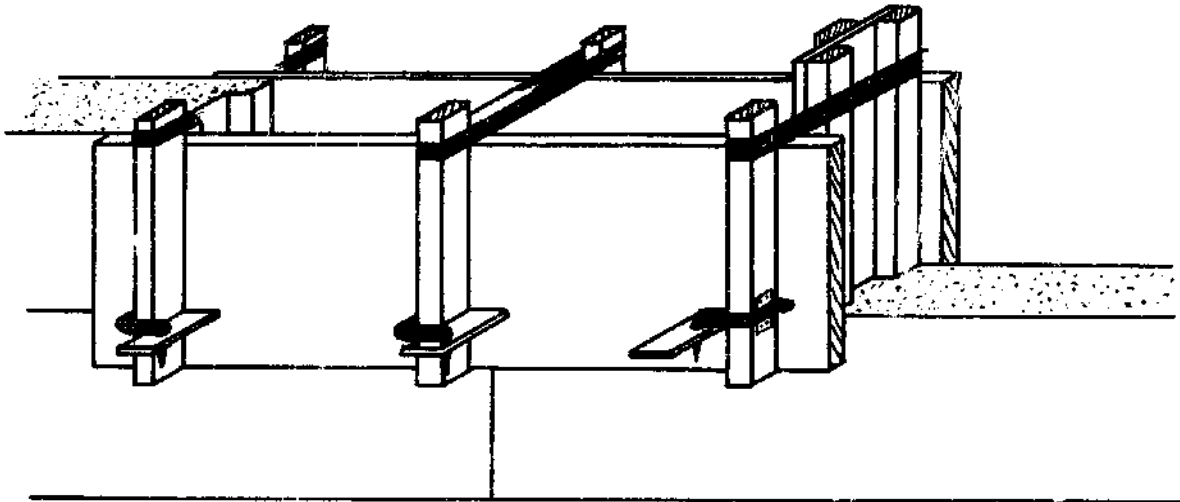


FIG 275

TURNED CORNER
FIG 276.

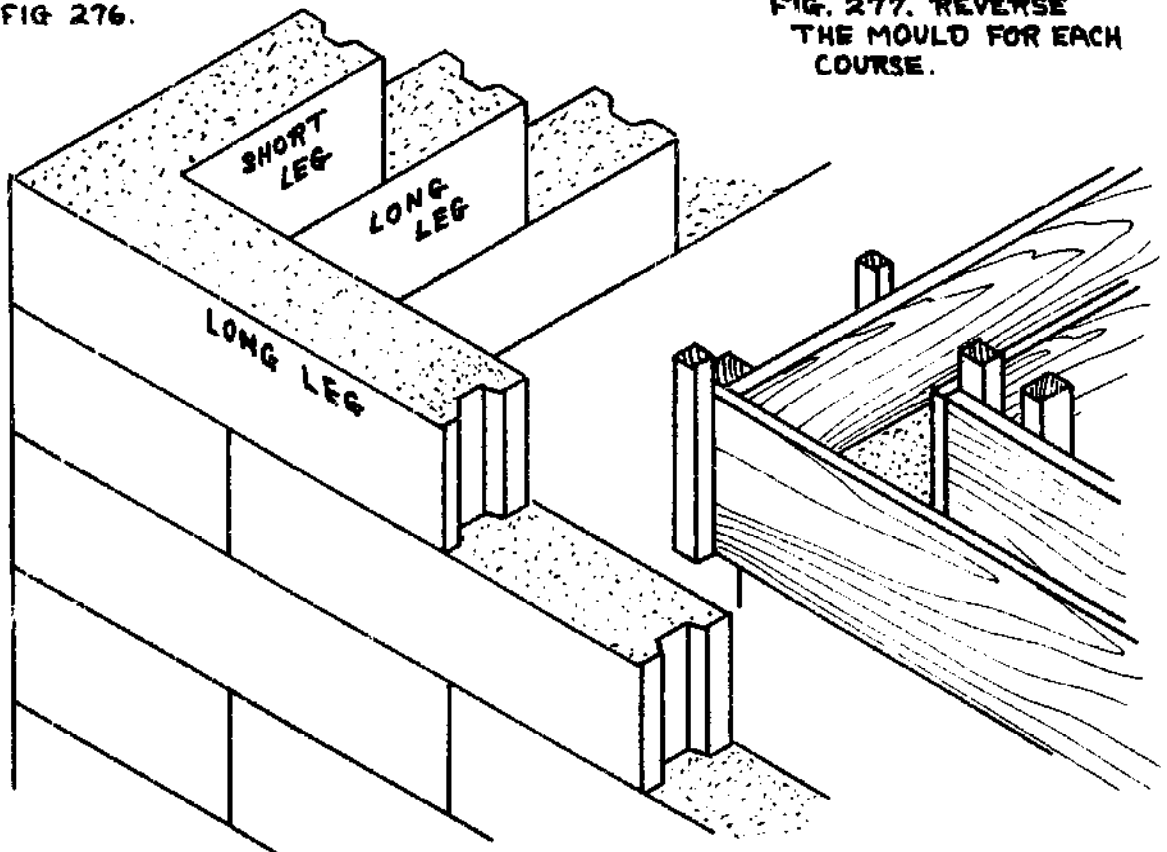
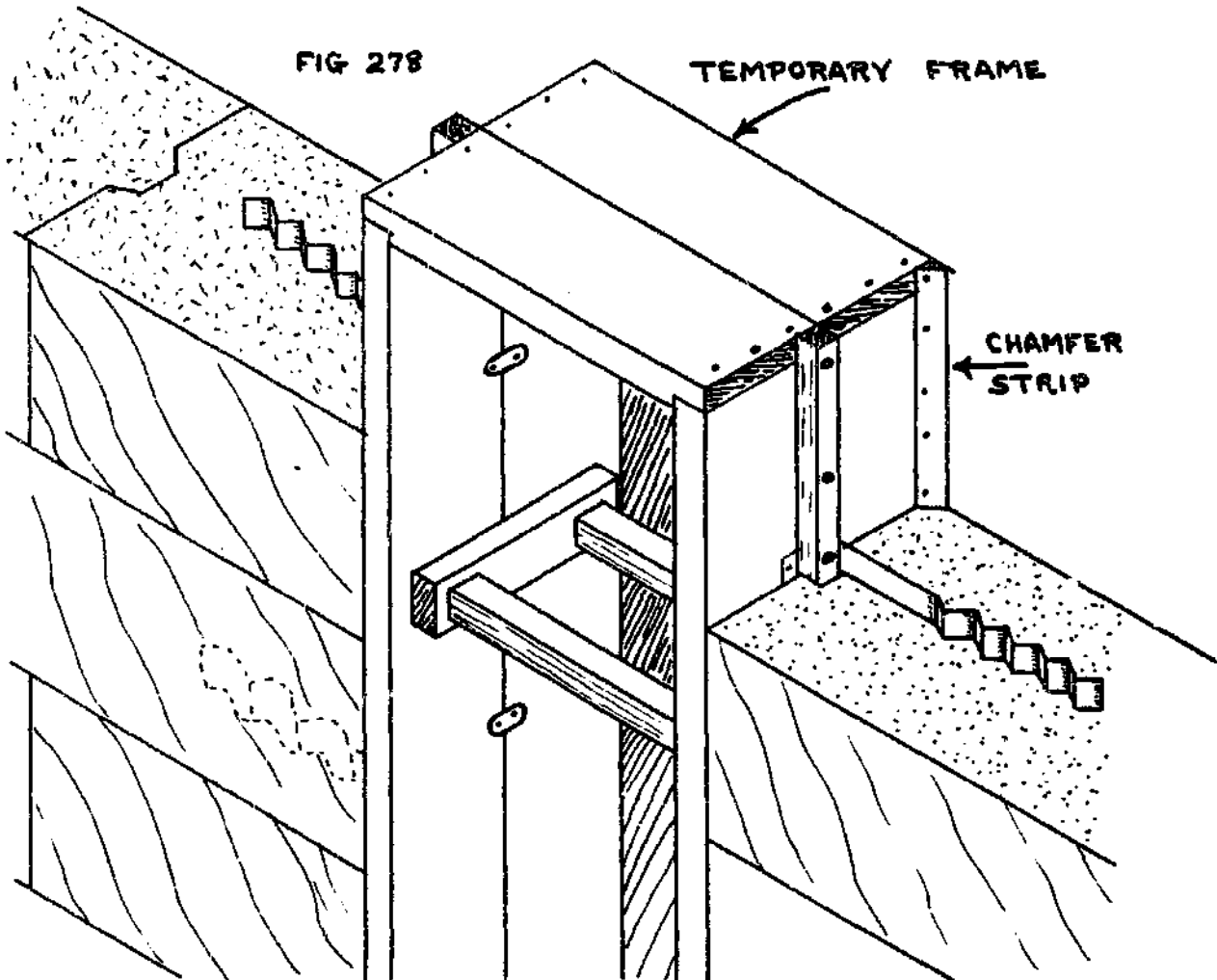


FIG. 277. REVERSE
THE MOULD FOR EACH
COURSE.

Working around a frame.



The temporary frame and strip for a chamfered jamb is shown because there is no problem connected with a full width frame. It does not need a chamfered jamb of course.

Earth texture. The earth when brought to the forms for moulding, should be just damp enough to cake, but not moist enough to puddle when tamped.

This will take some care, because if the sun is on this earth for just a little while, it will dry out essential moisture. It would seem to be ideal if the earth could be dug just after the rainy season when the earth is still just a little moist. Then, provided there is enough reserve for each day's work, keep the pit moistened and covered. If this can be arranged there will not be the expense and trouble of fetching water, mixing, etc. The earth might even be brought straight from the pit.

However, we recommend a good quantity of straw to be mixed in with the earth used in pisé.

Actual construction. Plumb and check all forms carefully before beginning to fill them. All the corner blocks should be levelled. This type of wall does not lend itself to alterations, insertions, repairs, etc. Hence, check over carefully all the places where plugs, blocks, frames, etc., are to go. Have a list of all the features of every wall, and be ready to put them in when the time comes, and not be delayed by a last minute preparation.

Avoid shaking, vibrating the wall as much as possible. Place 4" of earth in the form and tamp with quick, short strokes. Be sure that corners are specially tamped with a small rod, say 1-1/2" X 1-1/2". It would be better to have all corners chamfered as well as well pounded.

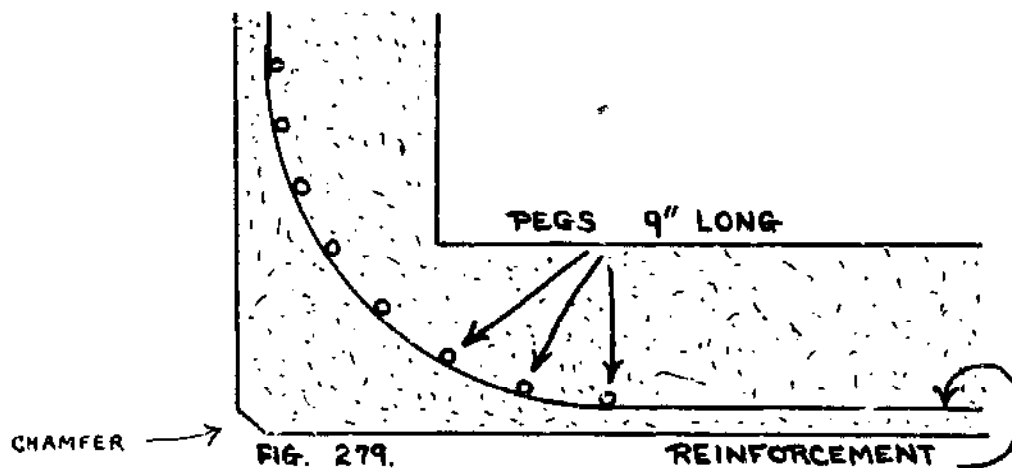
When the mould has been filled, the surface should be scored a little to give the necessary grip to the block to be formed above it.

Usually the new section being put in will be on one that is at least an hour old. Probably the top earth will be dry. When the form is in place, and just before the new earth is put in, sprinkle a little water on the old portion.

When the forms are not in use, they should be covered. At noon and at night, perhaps they should be soaked in kerosene or water, anything to keep them from warping.

Reinforcement. Since there is so little strength in pise walls, we suggest two reinforcing bands which will girdle the building; one just above door height, and the other at the top of the wall.

To avoid fracture at corners, we suggest the following:



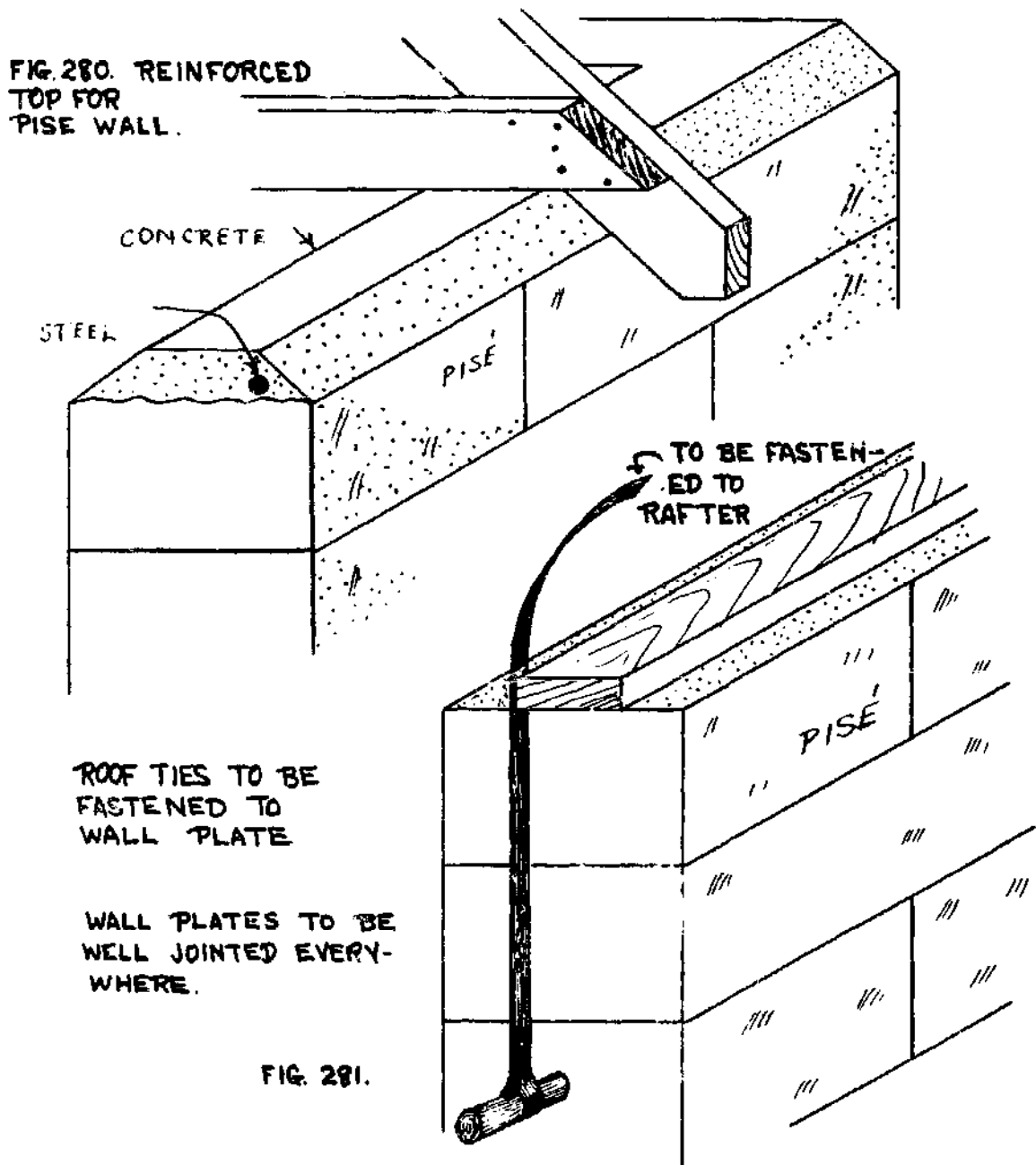
The reinforcement should be continuous all the way round the building, and be well secured at the joints.

A wood wall plate for the roof may be sufficient to bind the top of the walls together, but a 6" reinforced cap would be better. This latter may serve as wall plate if roof tying irons are brought right up through it where the rafters rest.

If pise is carefully done, the surface of the wall ought

to make a good finished surface. If this seems to be feasible when you have begun to get a few feet high, then take a trowel and touch up any bad places before the wall dries out. It is possible that you may moisten the surface and give it a good finish at once. Success here will save the trouble and expense of a plastering job.

When the job is complete, take care of the forms. They have cost something, and if you are pleased with the job, you will doubtless want them again. Even if you do not, someone else may.



BOOK THREECARPENTRYCHAPTER ONE LUMBERI. SOURCE.

Lumber will be obtained from a dealer, or from a tree purchased from the Government, and sawn under the direction of the builder. Frequently, there is no choice of supply, but where there is, consider the following factors:

If a tree is to be cut, there is purchase transaction, palaver with the sawyer, green lumber, an extended period of oversight of the whole operation until all the lumber is safely on the building site, etc. Advantages include, less transportation expenses, the sizes most suitable to your work, etc.

II. THE LUMBER ORDER.

Before placing a lumber order, see that the correct sizes, quantities, and uses are listed. In all probability the lumber will be hardwood, insect proof and durable. Of course there is inferior lumber in nearly every pile. Get the best lumber within your means. Look around as much as a year ahead at the lumber available in your district.

Estimate carefully the amount of lumber for each part of the work: frames, doors, windows, roof, scaffold, furniture, etc.

All beams and rafters should be of rectangular section, and always on edge when in position. Commonest sizes for all beams, rafters, joists, etc.

1" X 12", 1-1/2" X 12", 2" X 12",

2" X 10", 2" X 8", 2" X 6", 2" X 4".

Posts of all kinds should be square or approximately square. Commonest sizes are,

3" X 4", 4" X 4", 6" X 6".

Where there is any scale in prices, it pays to order just the right amount of each grade of lumber.

Usually, 1" X 12" costs more per foot than 2" X 6" or 3" X 4" although there is the same volume of lumber per foot in each. The reason is that in the 1" lumber there is considerably more sawing in the perimeter for the 1" lumber; it has a perimeter of 26" while the 2" X 6" has only 16" and the 3" X 4" only 14" perimeter.

Door frames require over six feet per jamb, unless there is an ant course 4" above the floor. In this case, a jamb needs to be only 6' and 1/2" for a 6'6" door. The movement of furniture is so often made difficult when the doors are the standard minimum of 2'6" X 6'6" that we are recommending a 2'8" X 6'8" door. In some countries, lumber is sold in 12' lengths. In this case one length is required for each door jamb over 6' in length. But the remainder is no loss for all of it can be utilized by careful planning.

We are against the use of 3" X 4" lumber for door and window jambs for the following reasons. First, they are not as attractive as 2" X 6". They cannot be made as secure in the wall

as a 2" X 6" without greater trouble. Mud brick, or even burned brick walls are so susceptible to vibration, and are so weak, that every precaution must be taken to fasten the frame securely, once for all.

A 3" X 4" jamb will have either of the two positions shown. If the first, then its fastening is dependent almost entirely on the metal straps. If the second, then the door is likely to bind on the corner of the brickwork and be wrenched from its hinges. It cannot swing back against the wall either, and this is objectionable.

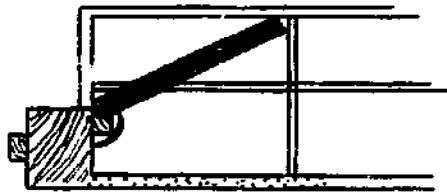


FIG. 282.

3"x4" JAMB

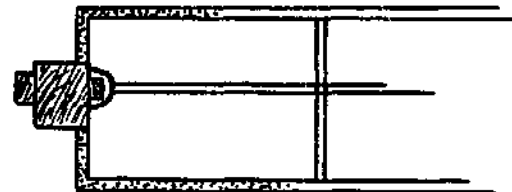


FIG. 283.

3"x4" JAMB

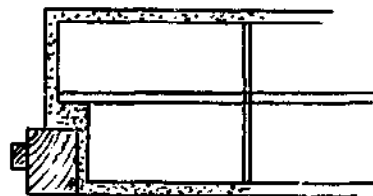


FIG. 284.

3"x4" JAMB



FIG. 285.

2"x12" JAMB

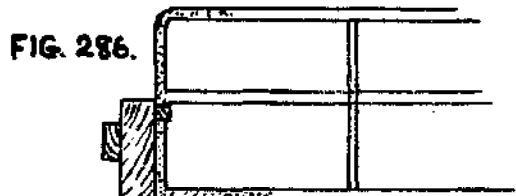


FIG. 286.

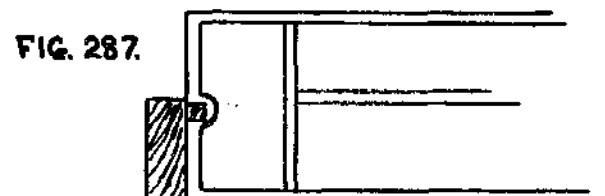


FIG. 287.

ALTERNATE COURSES

The two by twelve and the two by six jambs lend themselves to secure fastening and perfect brick bonding. The three by four in Fig. 284 interferes with bond.

We do not recommend rabbetting jambs. There is so much tendency to warping in the doors and windows in the tropics that an adjustment is often required to maintain a good weather joint. With the use of an attached batten or door stop, the adjustment

for locks or warp is easily made. But with the rabbetted jamb it is real trouble. The rabbett must be gouged or the door pared.

III. BUYING FROM THE DEALER.

1. The state of the lumber market is such that you should buy as soon as possible and of best quality and price, and have it delivered to your building site or to the property of the mission somewhere. Stocks are so low, and the demand so erratic, that the delay of a few hours may mean loss of choice or even a bought out market.

2. Select the lumber personally if you can.

3. When received, stack carefully to prevent warping or splitting; do not allow the lumber pile to be the source of wood for other jobs, large or small.

IV. LUMBER CUT FROM THE TREE.

1. Hand the sawyer a list of the sizes you want.

2. Make a contract with the sawyer. Take care to provide him with as little advance money as is right until the lumber begins to come in. Once the account has been balanced by value in the stock pile you can make the weekly payments agree with the output for the week. But retain sufficient of the total amount to ensure the proper completion of the work.

3. Keep a duplicate record of all transactions with the sawyer.

4. The contract will specify the basis of the payments, the degree of accuracy of the sawing, care of the equipment, care taken of the lumber, prevention of and responsibility for pilfering, including the practice of making domestic requirements for the local inhabitants!

5. The lumber must not be allowed to accumulate at the site of the tree, but be brought in to the mission property every day for proper stacking.

6. Frequent visits must be made to the sawyer's camp to see that all is well.

V. CURING AND PRESERVATION.

If you have the opportunity to experiment, immerse some samples of your wood for not more than three months. It is claimed by some that soaking the lumber renders it less liable to splitting and decay and enables it to dry more readily and completely.

Take care in making the support for every lumber pile, that it be true and strong. The cross pieces should line up perfectly from end to end and also be without twist. The pile should be level from side to side, but may slope from end to end.

Place the cross pieces about 2'6" apart. The end ones should be about 6" from the end.

The entire pile should be shaded from the sun. The ends especially should be covered. That wood which is for the best work may have the ends secured by tacking a short stick to them.

Supervise the carpenters as they withdraw lumber from the pile, making sure that they take what suits their current job and then leave the pile in order and covered.

CHAPTER TWO DOOR AND WINDOW FRAMES.

I. COMMENCE EARLY.

If possible, have an experienced and reliable carpenter and his apprentice come to the building site well in advance of the actual building operations. He can erect a work shelter, make benches, nail boxes, and then make all the door and window frames and doors and windows; lintels and arch forms, built-in furniture, scaffold, etc. If time permits he can build any necessary furniture too. He can be watched more closely and his work will not be affected by the hurry which is likely to be the case if all these things have to be made after the whole gang comes when the building superintendent will want to spend all his time out on the building. And, there will be no delays for frames and such like as the walls are going up.

II. SHELTER.

The ideal work place will have a waterproof shade, open on three sides. The fourth side should be arranged to lay out the carpenter's boxes and tools, and if possible, have a locked tool room adjoining. The work shed should be close to the lumber pile, in full view of the house where the superintendent lives, and as far away from the usual gathering places of travellers, gossipers, and other distractors. Do not nail the pans. Hold them down with sticks of lumber.

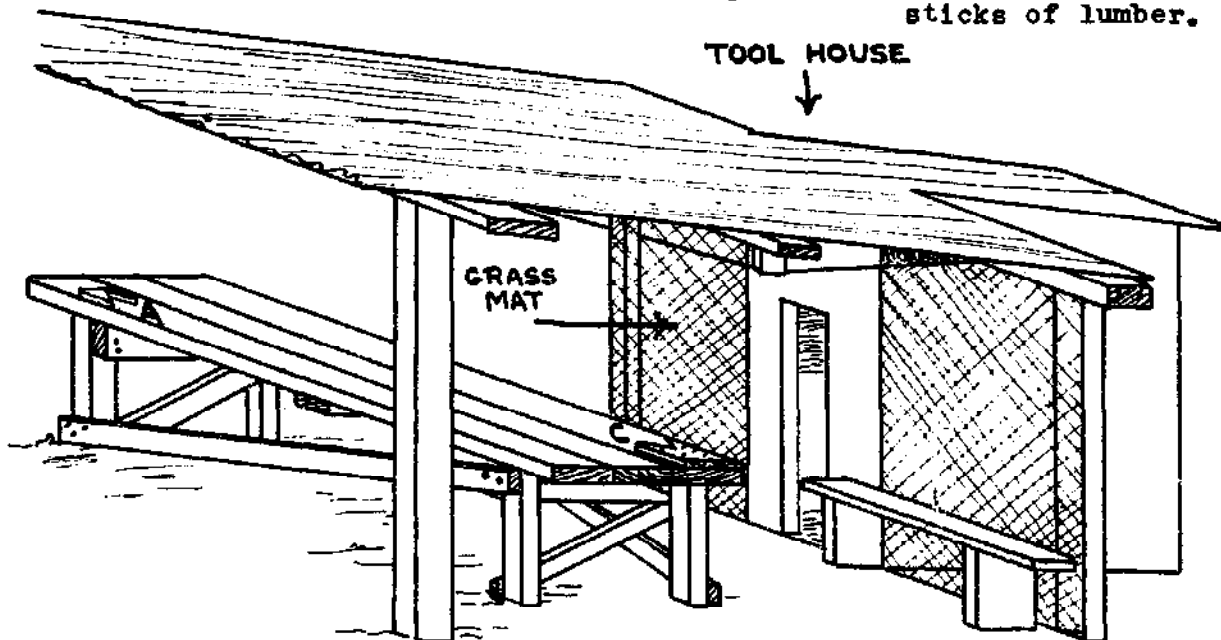


FIG. 288.

MAIN WORK SHELTER.

Anchor the shelter roof against high wind.

III. WORK BENCHES.

That for the carpenter need not involve any loss of lumber. Make the top or deck of three 2" X 12" X 12' planks; the sets of legs if made solidly will do for some work table after the job is done. The legs of the work bench should be about 29" long. If with the 2" deck on this, the bench is too high, let the feet into the earth somewhat.

The work bench shown in Fig. 288 is correctly braced. The 'c' block is for the carpenter, the 'A' for the apprentice. The leg sets should be 2' back from the ends. There should be a batten tacked on the underside of the deck halfway down the bench.

Once all these operations commence there seems to be a number of mechanical jobs requiring attention, and sometimes a backlog of jobs not related to building, undone because there was no bench on which to mount good tools such as a vise, a grinder, etc. If such has been the case, it will be well to have the carpenter help you get a station bench ready; one that will be used in the station work shop through the years. We mention this because we have never seen the station that did not need one; have seen many suffer for lack of a good one, and have seen stations properly equipped at the first very much profitted thereby. Description of this good bench, 2' X 6' X 34" high is given in Chapter Four. If it is made at the very first it will serve the whole building program. There is considerable preparation of iron, mending of tools, repair of pails, etc. which requires a solid bench.

IV. SIZES OF FRAMES.

Standard door sizes:

2'6" X 6'6"	No door opening should be less than 6'6" in height.
2'8" X 6'8"	
2'10" X 6'10"	Some very small rooms may have a door width of 2'3".
3' X 7'	

Nearly all modern furniture has one dimension which is 30" or less. Standard tables are 2'6" high, and by a little twisting they will pass the 2'6" opening. But with two battens of approximately 3/4" inch each on the door jambs, the opening is reduced to something like 28-1/2". Some things do not pass this with all the twisting in the world. And so we recommend 2'8" X 6'8" doors throughout. The large door between living room and bedroom is for purposes of ventilation. It would be 5' X 6'6" normally, and this is large enough, but if there was to be uniformity of doors, then this double door would have to be 5'4" X 6'8".

A frame is measured from inside to inside. Take care in marking the jamb length. It is the length of the door plus the 1/2" for the upper joint, less the thickness of the concrete ant course.

We urge that outside doors open out, and that they extend 2" below the level of the inside floor. This is to prevent most if not all entrance of driven rain. Porch roofs are little protection in these fierce storms.

To keep the door heights uniform inside, the doors themselves in these outside frames will need to be that two inches extra in length.

Large baths are carried in and out of the bathroom when there is no permanent bath built in. The bathroom door should be 3' X 7'. This height works in with the window head which needs to be high.

The bucket removal door in the toilet is 14" wide, 16" high, and the wood is the full width of the wall and plaster.

Window frames. Living room, pantry and office windows may well be glass. Otherwise in inclement weather there is some discomfort and inconvenience due to closed windows. Calculate the most economical sizes of glass and design the window accordingly. In this method, the window frame will be the last detail to receive attention. Steel sash can sometimes be bought for less than the cost of making and completing home made wood sash. In case you intend to use steel sash, buy them if possible and have them on the job for the carpenter to use as he makes the frames for them. In sound burned brick and concrete walls a wood frame is not required for a steel sash, but in mud brick and weak burned brick walls, a wood frame is recommended. If the delivery of the steel sash is impossible before the carpenter makes the frames, get the directions issued by the manufacturers, or measure the sample frames in the store so that when the time comes to fasten these steel sash in their frames there will not be misfits.

Sometimes windows interfere with the space necessary for furniture. In some cases it is well to have a high and long window as for example for the space over a buffet.

We recommend at least three windows, each approximately 3' X 5' in the living room, one like these in the pantry, and one in the office.

In many places the bedroom windows are a problem. Plenty of air is required at times. During the day glare, and very often stare, is unwelcome. We recommend for bedrooms, a solid shuttered window, not less than 2'5" wide by 5' high; there are two shutters, the lower being 3' high and hinged at the side; the upper in the remaining space is hinged at the top. The upper edge of the lower shutter is to be above the line of vision of persons outside. When privacy is desired without loss of ventilation, the lower shutter is closed. This window has proved very convenient. The Mission house has five of these units in the bedroom.

We recommend a high and long style window for the bathroom so that privacy can be achieved without forfeiting ventilation. The sill should be at least 5'2" from the floor.

The toilet windows ought to be at least 12" X 12" each, 18" X 18" is best, with the sill 6' from the floor.

V. THE MANUFACTURE OF DOOR FRAMES.

1. Door frame heads, or lintels. The most economical efficient door frame head has squared ends even with the outer edge of the jamb. In this joint there is a minimum of wood used, a minimum of labour expended, and it has the best appearance of any frame head. We reject the practice of

making the door head project beyond the jamb into the wall. It is unsightly, and its purpose can be better achieved by another device. If the builder persists in using these horns as they are called, cut the forepart off. It will make a better anchor also.

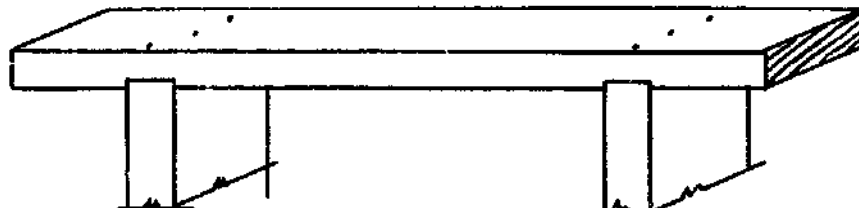


FIG. 289. HEAD PROJECTING BEYOND JAMBS.

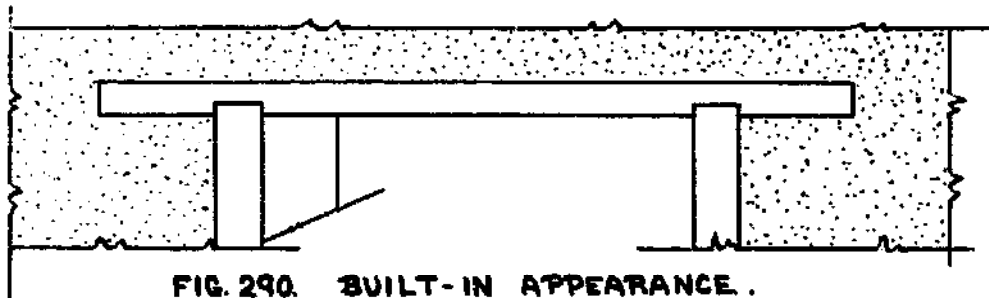


FIG. 290. BUILT-IN APPEARANCE.

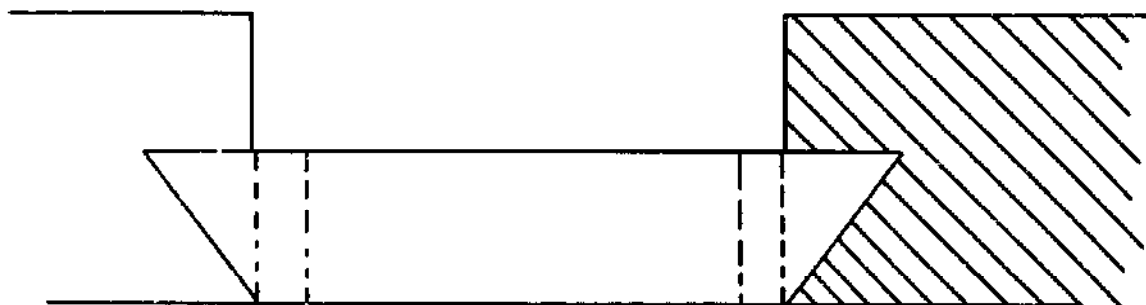


FIG. 291. TOP VIEW OF TRIMMED HORNS SHOWING ANCHORAGE.

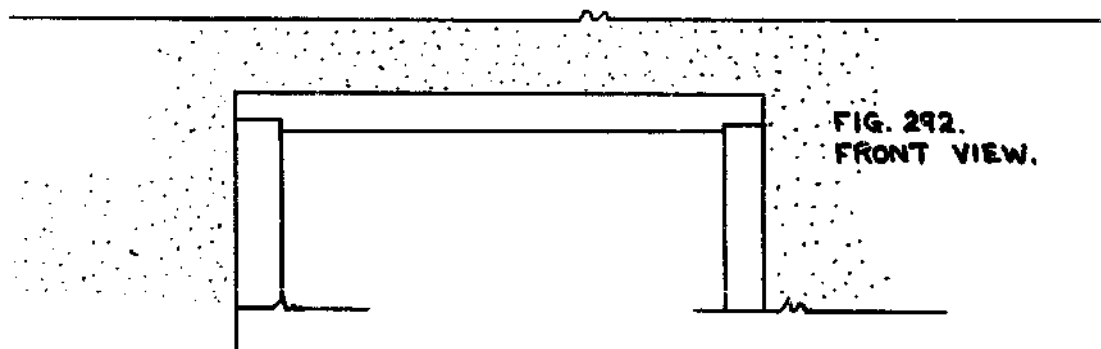


FIG. 292.
FRONT VIEW.

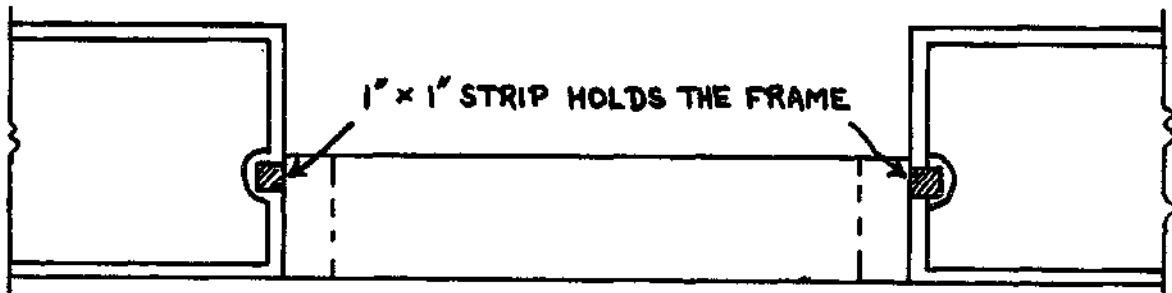
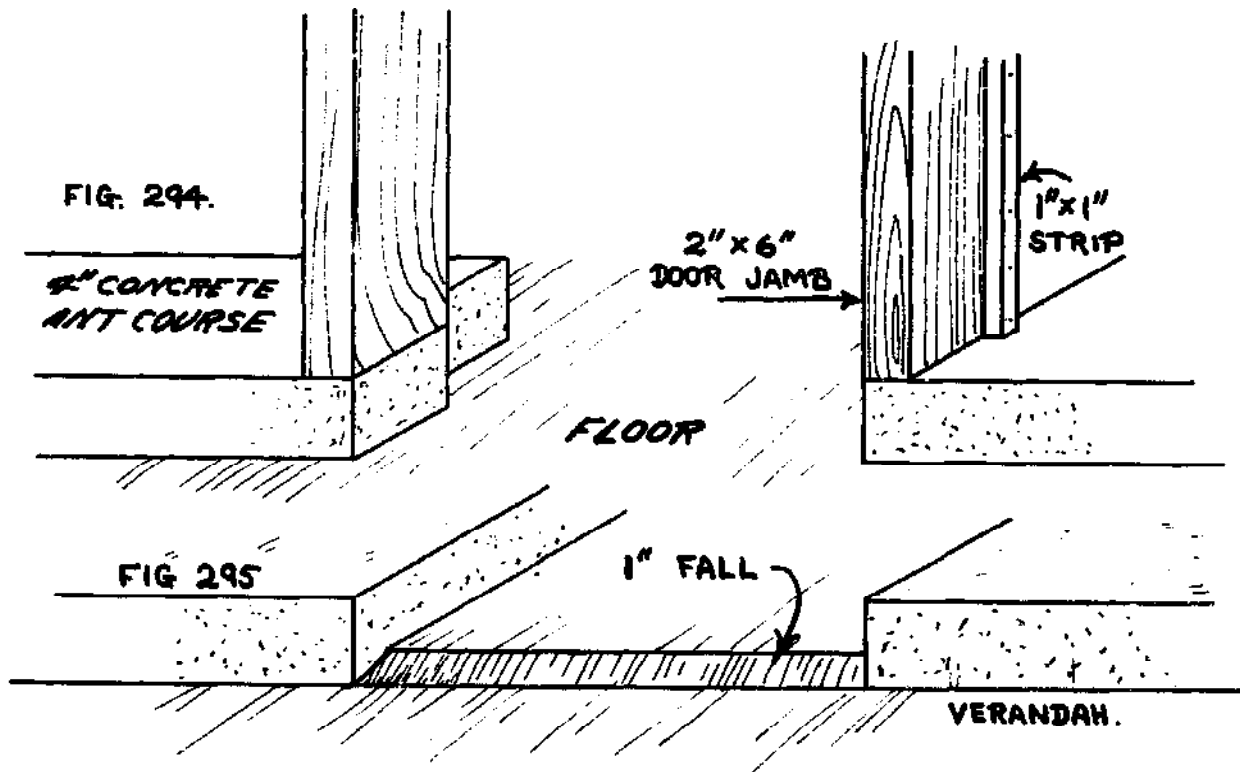


FIG. 293. TOP VIEW OF SHORT HEAD.

The 1" X 1" strip shown on each side of the frame extends to the base of the jamb and so is effective all the way. Too often this feature is considered of such minor importance that any old scrap approximating 1" X 1" is nailed on. This is a fallacy. We would suggest that this method of anchoring the frame merits enough expense to put in a 1-1/2" X 1-1/2" strip to make sure that the wall really grips it.

The face view of this frame head is the same as shown in Fig. 292.

2. The bottom of the door frame. Whether outside or inside frame, it will rest on the ant course, if there is one.



In Fig. 295 we show one arrangement for weatherproofing an outside door. It will prevent most of a flood from invading the interior. But it is not as effective as the two inch step. The latter is also more effective in excluding snakes and lizards.

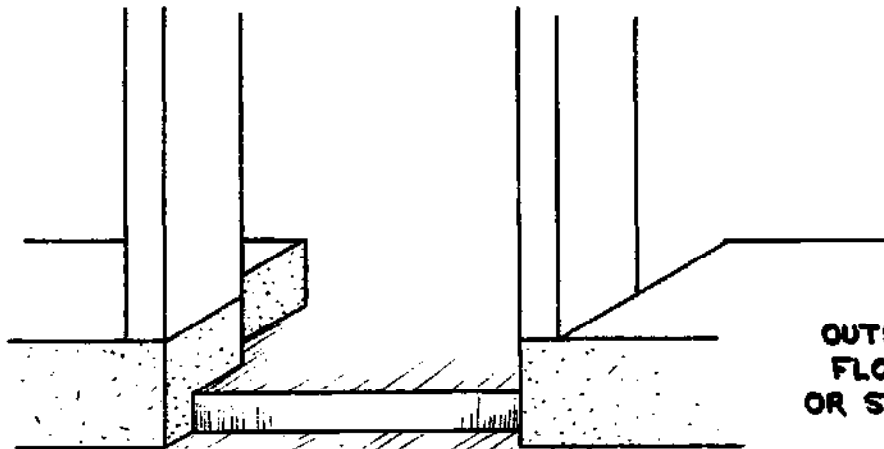


FIG 296 2" WEATHER STRIP. FRONT VIEW.

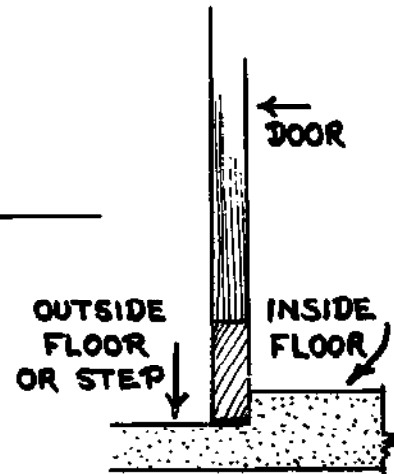


FIG 297 CROSS SECTION.

In Fig. 296 we have not shown the ant course metal which would obscure somewhat the detail of the 2" step. Note the almost perfect weather protection of the step as shown in Fig. 297.

In Fig. 298, 299, is illustrated a method for anchoring the door jambs in place on a straight cement floor. In Fig. 300 is seen an effective way to hold top or bottom of any frame in a mud wall. The metal should be at least 26 gauge. When used for the top of a frame, the flange to grip the mud is turned downward.

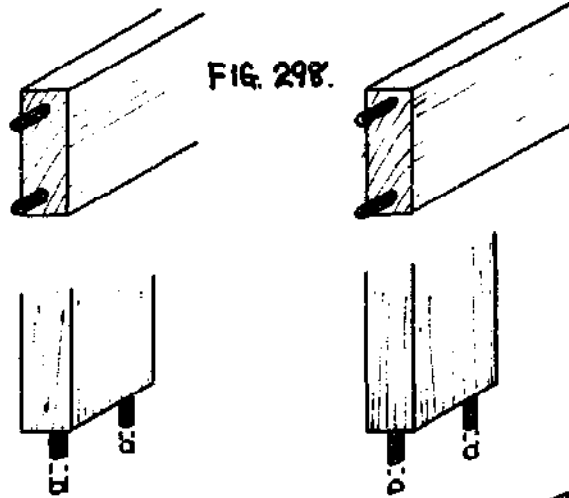
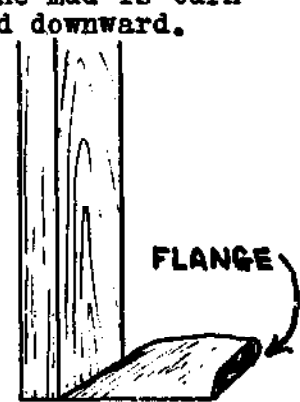


FIG 299 JAMBS ANCHORED IN CEMENT FLOOR

SHEET METAL



FIG 300 ANCHOR IN MUD WALL



Sometimes we get lumber that is not well gauged, that is it varies in thickness, even in one piece. Where this would be objectionable in a finished wall, trim the edges only, as shown.

FIG. 301.
ROUGHLY SAWN STOCK

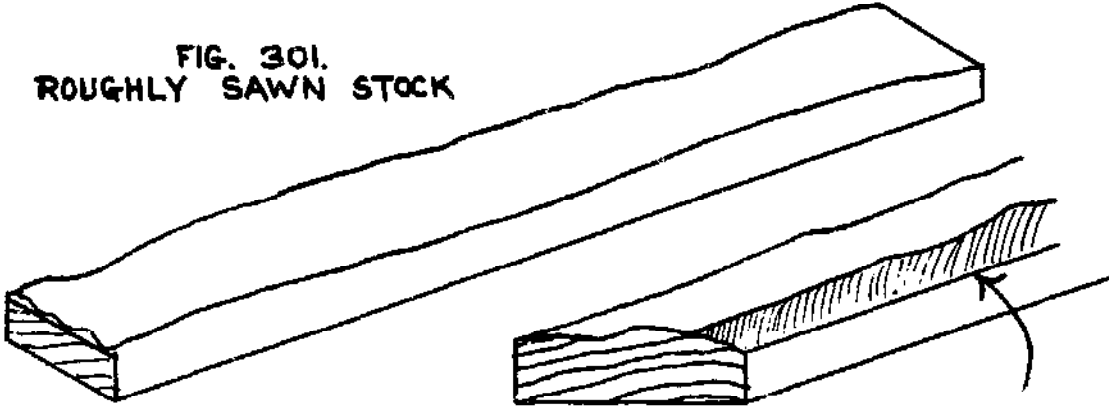


FIG. 302. GAUGED EDGE.

It is necessary to trim only one edge of each jamb and head. On any one frame, the gauged edge should be uniform, but in most jobs, it is not necessary to gauge all frames the same.

A fine appearance and a more durable edge is obtainable by rounding each exposed corner of door and window frame members

FIG. 303.

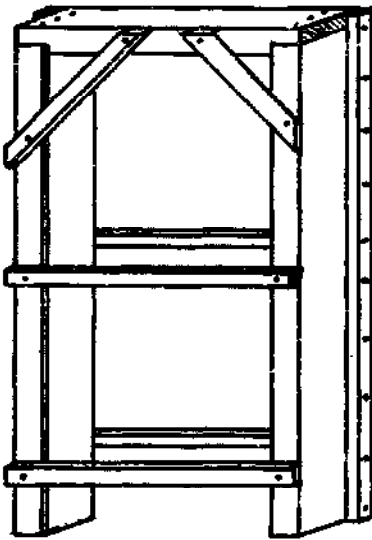
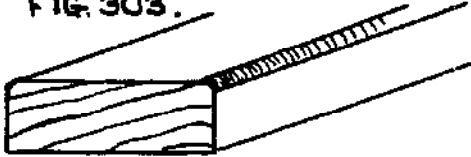
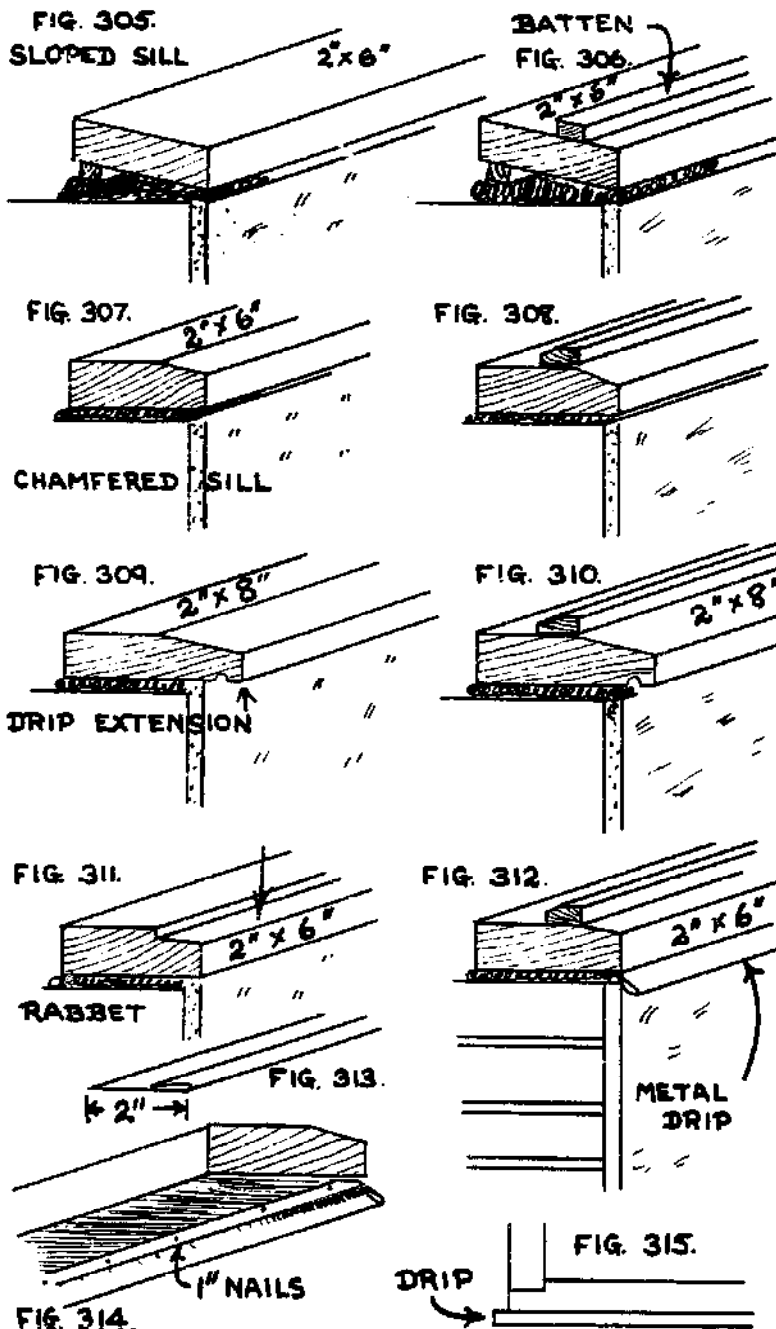


FIG. 304.

as shown in section in Fig. 303. Fasten the frame together with 3" nails. Select the best side of the frame as face, and then attach the 1" X 1" X 6' stay strip to the back of the jamb at the rear edge. It is best to keep it 1/2" back from the edge to allow cover for the plaster. Brace the frame as shown in Fig. 304. All the braces should remain until the feet of the frame have been secured by the metal ant course, and several courses of brick have been laid next each jamb. Then only may the lower braces be removed. The middle braces should always be on the frame while the mason is laying brick against the frame. If the door must be used for passage by workmen after work has ceased for a period, then remove the brace. But keep it in place as much as possible until the frame is almost entirely built in. Completed frames may be given a treatment of linseed oil and well rubbed before being stacked.

VI. WINDOW FRAMES.

1. Sills. Various types are shown. The sloped sill is the best and the one with the chamfered outer edge is next in weather protection. Every sill that does not project beyond the face of the plaster should have a metal weather drip as shown in the last few illustrations. All so-called flat or level



sills should have a slight fall outward, about 1/8" in a 6" wide sill. Except for the sills which project beyond the plaster, all sills must come out as far as the finish line of the plaster. The rabbetted sill should be at least 2-1/2" in thickness, and the rabbet 3/4" deep. We recommend the sill shown in Fig. 307 for it has all essential features and is easily made. Given ideal conditions, sash should open inwards, but warping is so unpredictable, and masonry requires so much protection that we cannot recommend sash which open inwards. Also, double hung sash restrict the volume of air currents unless there is a pocket above the window. This latter adds to the expense but it is a very efficient window. Since this type of window requires a different frame we demonstrate it with the frames. The metal drip

should be so related to the sill that water dripping from the wood to the metal will not run inwards. The sloping edge of the metal should reach just inside the face line of the sill. Note in Fig. 315 that the metal drip extends beyond the end of the sill. If it did not, the wash from the end of the frame would do damage to the plaster at this point which the drip all along the sill prevents the rest of the way.

To give the sloping sills stability, a 1" X 1" strip is fastened to the under side at each end as shown in Figs. 305, 306.

The drip in the overhanging sill is made with the plough plane. It may be either round or rectangular, in section.

A double hung window with recess to accommodate both sash.

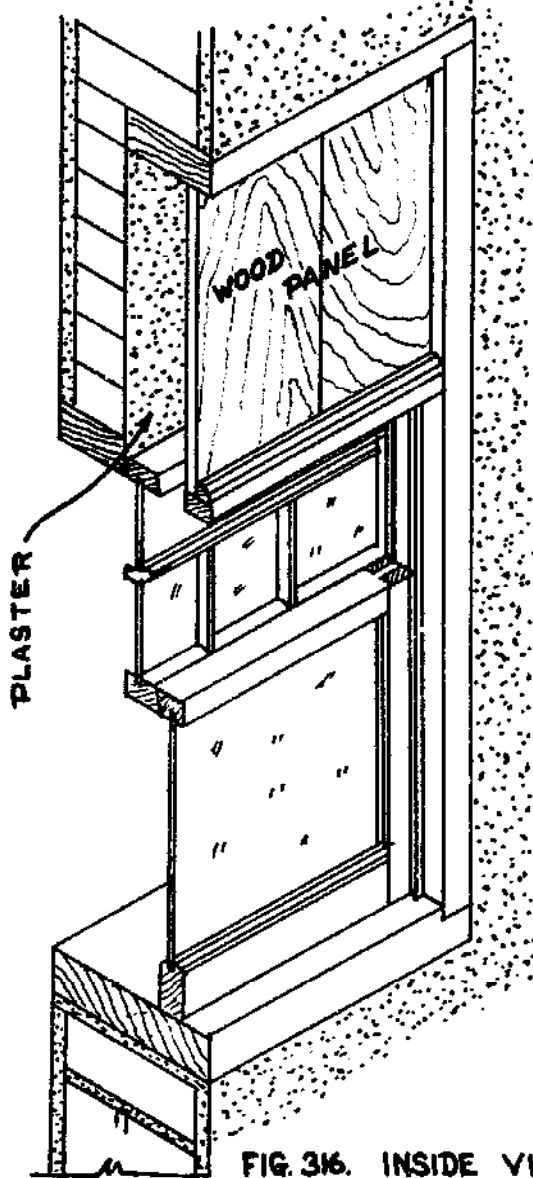


FIG. 316. INSIDE VIEW

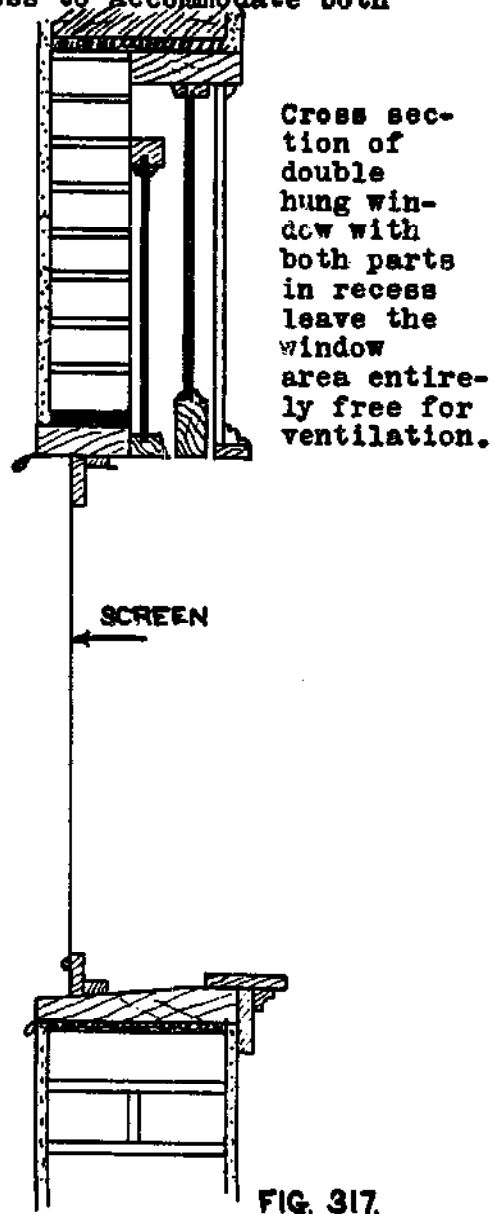
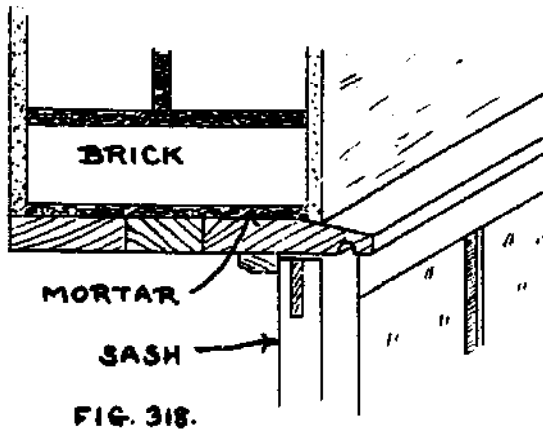


FIG. 317.

The brick panel outside the recess should be the burned brick size, or else the mud brick on edge. Before committing yourself to this type of window, enquire about the springs which are now made to help lift sash, taking the place of sash cord and weights.

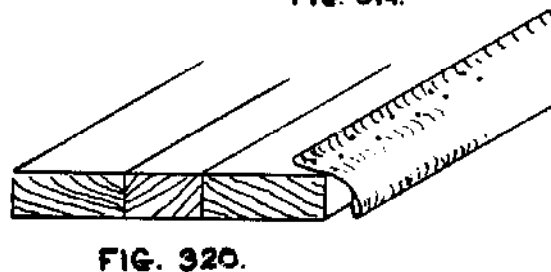
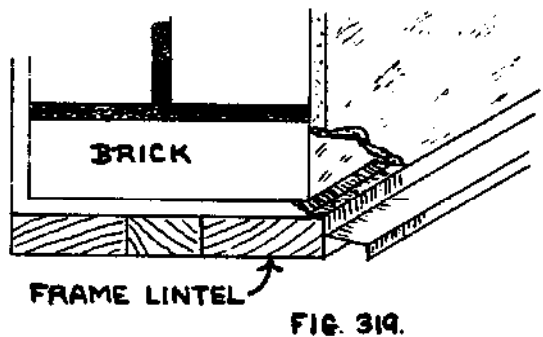
2. Frame heads. If the sill is flush with the plaster, the head may be too. If the sill projects, the head may also. Some arrangement must be made to prevent the weather from entering the top joint of the window, especially if it is a casement. The sheet metal drip shown is not easy to make without machinery of some sort. The curved one may not be so attractive, in practice, as the other, but it is infinitely better than none. The flange which enters the wall at the base of the plaster should have just a slight turn up to prevent water running inwards.



Note in Fig. 318 that the inclined edge of the head recedes back of the plaster line. This will prevent water turning inwards.

In Fig. 319 the inner flange of the metal strip is turned up, and is slightly behind the plaster inner edge.

In Fig. 320 note that the line of nails is staggered. This gives necessary rigidity; otherwise, any movement of the drip would probably loosen the plaster. Note too that the lower edge is seamed. This gives a much better appearance and is safer. Wherever possible, seam edges of sheet metal to prevent flesh wounds to workmen.



The metal drips may be put on when the frame is put up, or left until just before the plasterers start work. In the first method, the inner flange will be properly bedded in the mortar, but workmen will probably bend the metal plenty before the plasterers come to it. And before the painter can paint it, it must be straightened. On the other hand, when the drips are put on after the wall is built, there is likelihood of the inner flange being mangled or otherwise rendered less effective because of the trouble of digging out the hard mortar.

The 1" X 1" strip down each jamb is necessary for the window frames as well as for the door frames.

Jamb over three feet long should have a bale iron tie half way up to prevent warp inwards.

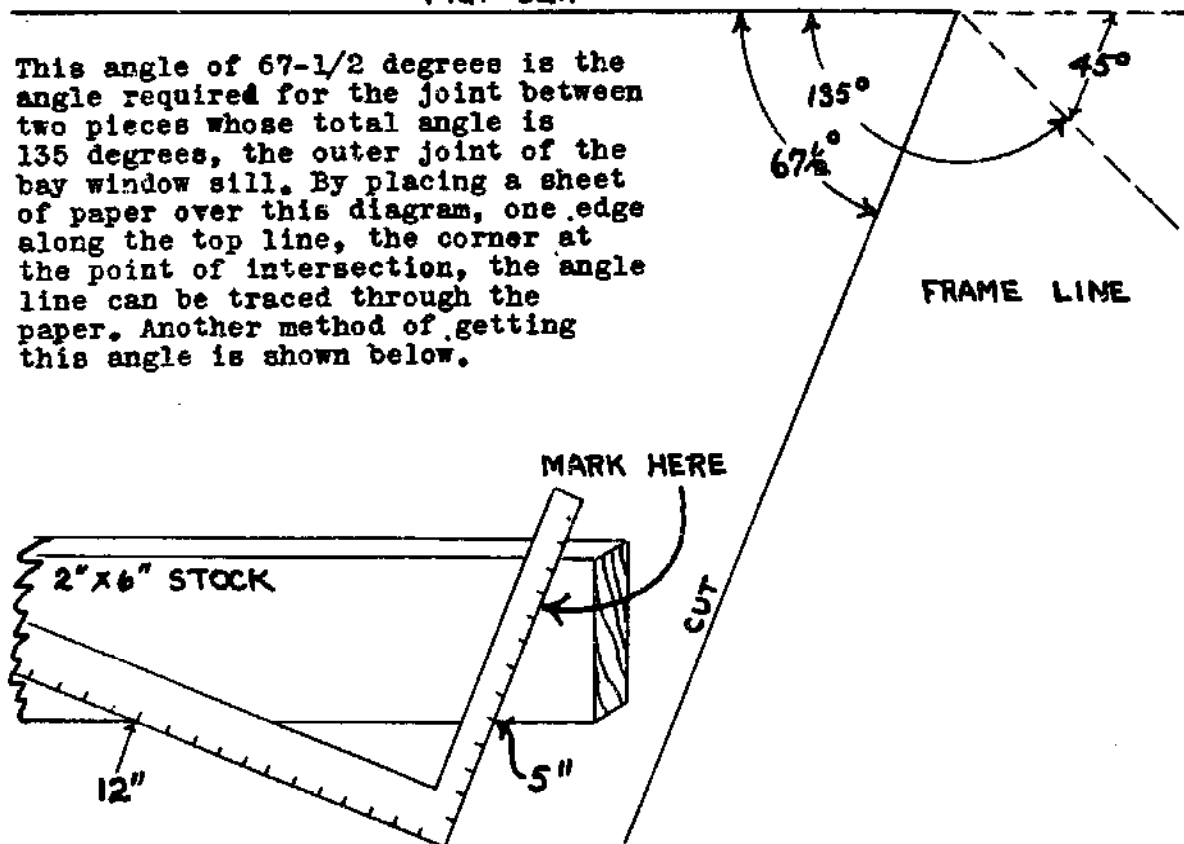
Some metal guard is usually put on to prevent burglars entering by the windows. This is discussed in chapter three, but it is an open question whether it should be put on the frame when the frame is made, or put on when all the construction work is done except the plastering. If it is put on after the plastering, there will be a certain amount of chipping off at the joints with frames, due to the hammering which is almost inevitable. The wire guard can be put on with screws and short iron straps. But there is much to be said for leaving the wire off until all the heavy work is done. The window openings are most handy for passage of men, materials and scaffold during construction.

VII. THE BAY WINDOW FRAME.

The masonry part of the bay window is detailed in Book Two, Chapter Fourteen.

FIG. 321.

This angle of $67\frac{1}{2}$ degrees is the angle required for the joint between two pieces whose total angle is 135 degrees, the outer joint of the bay window sill. By placing a sheet of paper over this diagram, one edge along the top line, the corner at the point of intersection, the angle line can be traced through the paper. Another method of getting this angle is shown below.



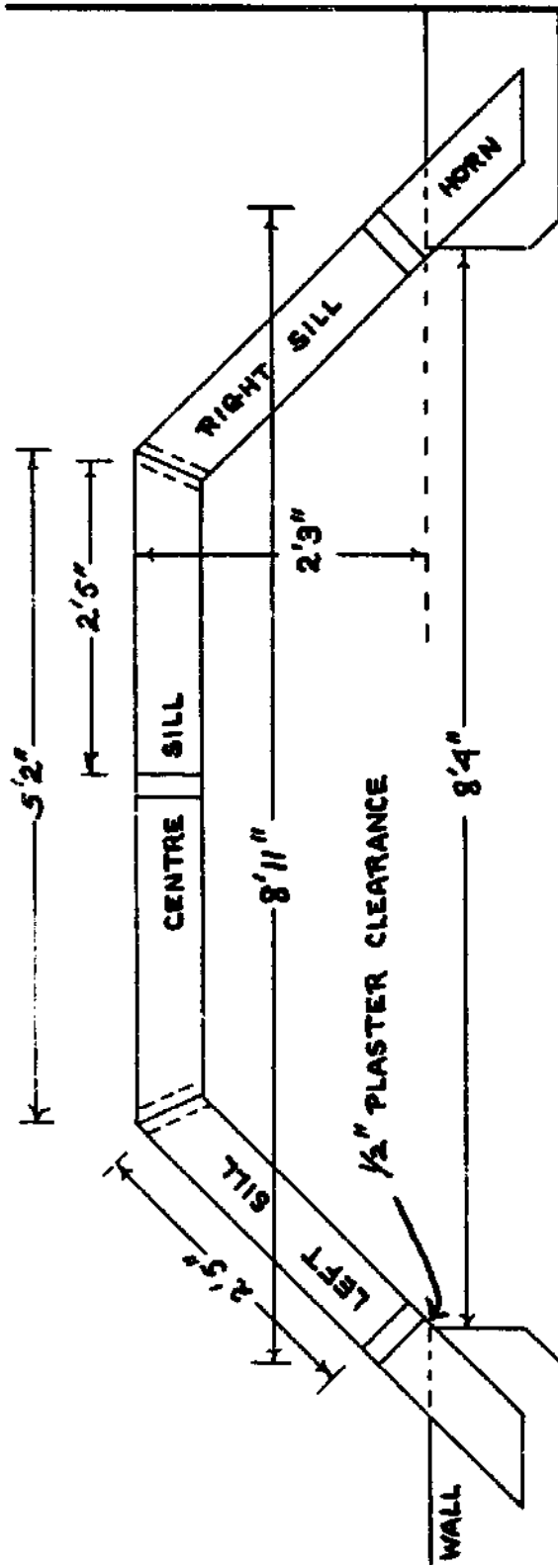


FIG. 323.

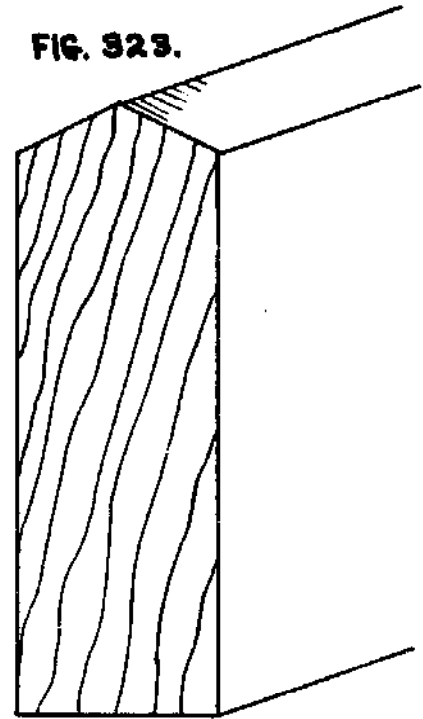


FIG. 322. BAY WINDOW SILL DETAIL.

The two corner jambs are chamfered as shown above. The planing had better be done after the jambs have been fastened in the frame.

When the entire frame has been fastened together and braced according to the measurements, reinforce the corner joints as shown;

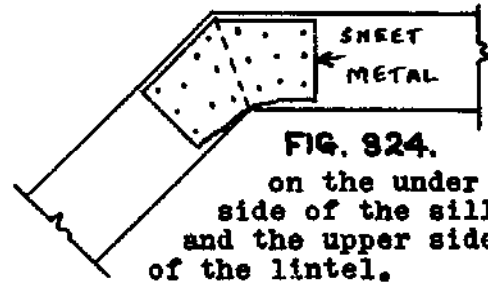


FIG. 324.

on the under side of the sill and the upper side of the lintel.

Take two pieces of good stock and plane the best side and two edges of each. If there is an unsquared end, take advantage of its extra length on the piece you are cutting, so that the point-

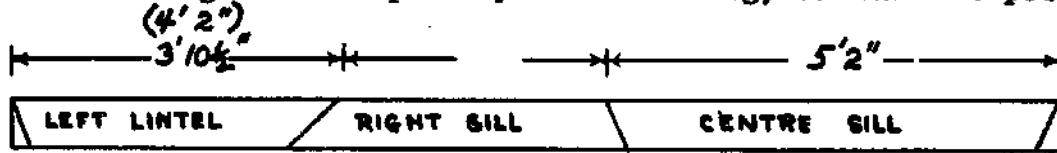


FIG. 325.

ed end of your piece extends to the point of the irregular end.

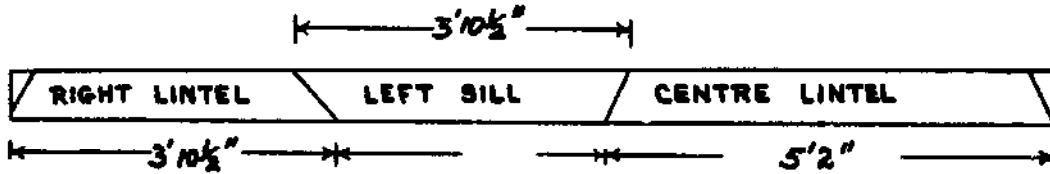


FIG. 326.

In Fig. 325 the top left and bottom right pieces should be $4'2''$, the figures given in brackets. But a $12'$ stick will only give $3'10\frac{1}{2}''$ each. Often the $12'$ stick has an inch or two extra length. Put this to advantage by dividing the stick that is left after cutting the sill. Measure from 'M' to the end, divide this exactly in two, and make the 45° mark through the half way line as shown in Fig. 327. Another way to get maximum length of horn is to increase the length of the cut, that is make it a smaller angle as shown in Fig. 328. A thirty degree angle increases the length of each piece $2\frac{1}{4}''$, making a total length of $4\frac{3}{4}''$. Of course if you have $12'6''$ or $13'$ length of stick there will be plenty to get the $4'2''$ ideal length. The reason we shift

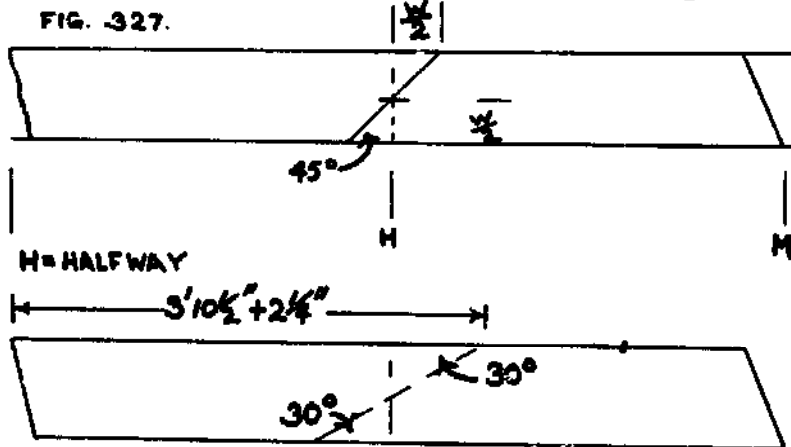
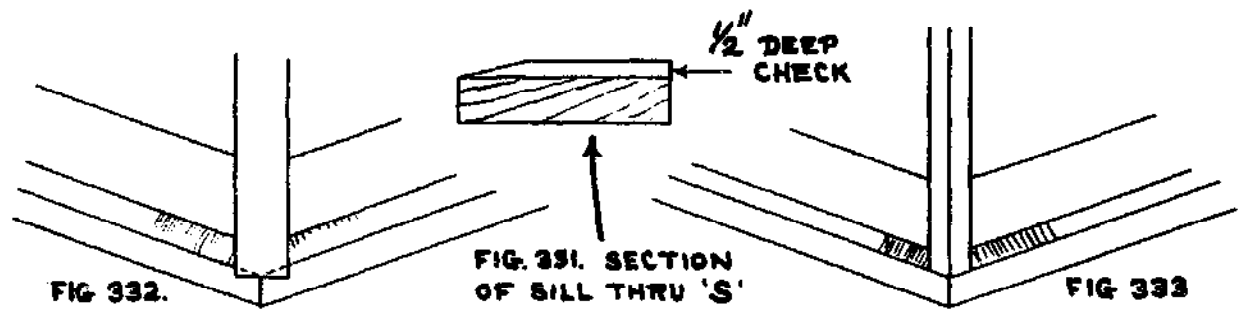
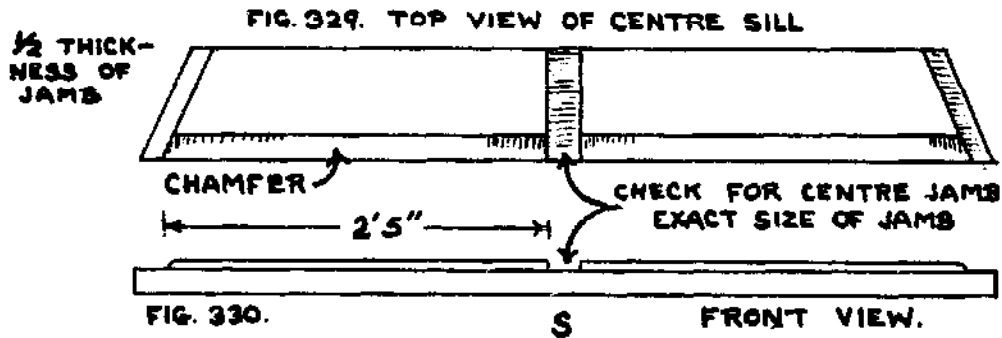


FIG. 327.

FIG. 328.

from one side of the stick to the other in measuring is that the width of the stick varies; so we measure the face edge of each member. One of the advantages of using this method of cutting stock is that it saves saw cuts. The reason we try to have the full $4'2''$ length is that the whole bay frame is

considerably more substantial when well anchored in the masonry.



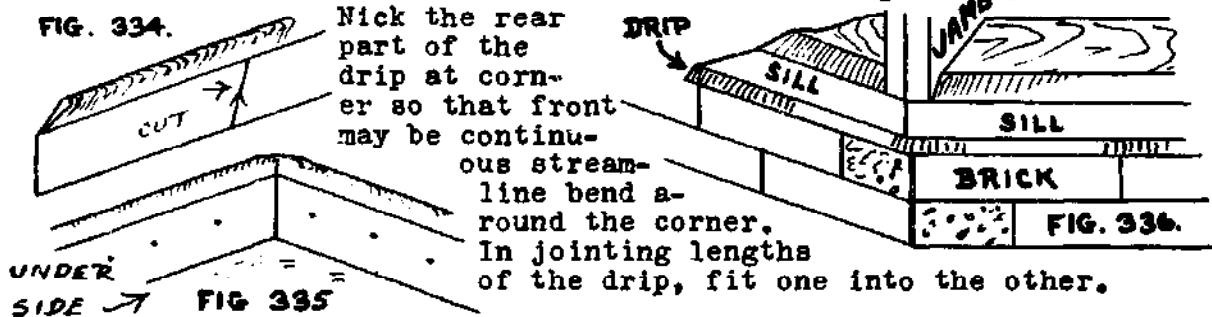
Before marking the sills for checking for the jambs, prepare the jambs. The three front ones will be dressed all four sides. Select and place the jambs in position and number them. Then put each in its position on the sill and mark for the check.

In fastening the corner jamb, bring its outer edge right out to the intersection of the face of the sills, with corners projecting as in Fig. 332. When the jamb has been nailed in place the projecting corners are planed off as shown in Fig. 333.

When nailing the long braces across the frame to hold it in accurate dimension during the building-in operation, fasten the brace to the top side of the sills and the other to the under side of the lintels so that the brace will not interfere with building.

Do not forget to affix the metal weather drip to the sill before the frame is finally set.

Use your level and plumb frequently in the early stages of the building in. Be sure that the edge of the sills is beyond the face of the brick at least $5/8$ " to allow for plaster.



CHAPTER THREE

DOORS AND WINDOWS

I. FRAME DOORS.

We designate a frame door one which has a frame, to which is attached sheet metal, plywood, plain wood, or other type of sheeting. The corners may be half lap as in Fig. 337 or mortise as in Fig. 338. Never cut the face of a frame stile part way down as in Fig. 339. Mortise or nail any cross piece.

We condemn wood pins for holding carpentry joints except in the framing of barns. Scarcity of tools may preclude the use of metal pins in some instances, but wood pins, especially if they appear on the surface, are unsightly and unnecessary. Use metal pins, and insert them from the rear or most covered and hidden side. Wood pins shrink, and, if there is a wrenching of the joint which will strain something, the wood pin is sure to tear away part of the wood in which it is inserted. A metal pin will tend to bend and tear its way through the wood. But it is out of sight and does not mar the surface. Note the position of the pins in these illustrations, one in the middle of each end, and one in the corner. No two pins are in one line of the grain.

FIG. 337.
LAP JOINT

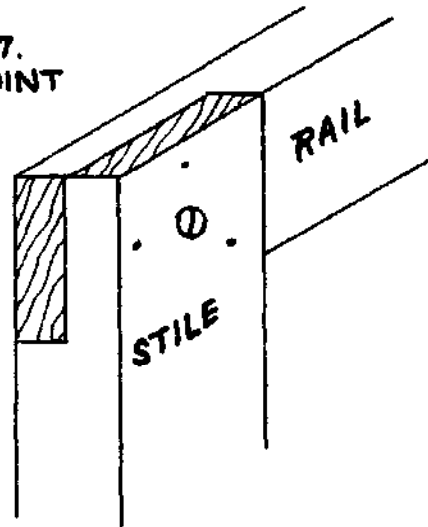


FIG. 338.
MORTISE JOINT

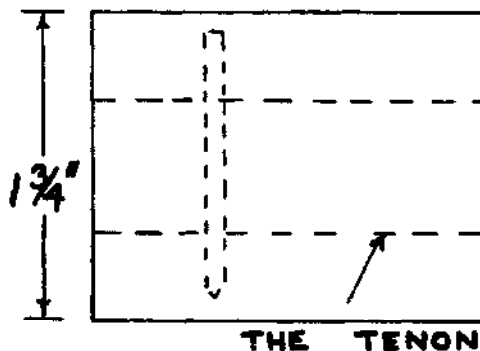
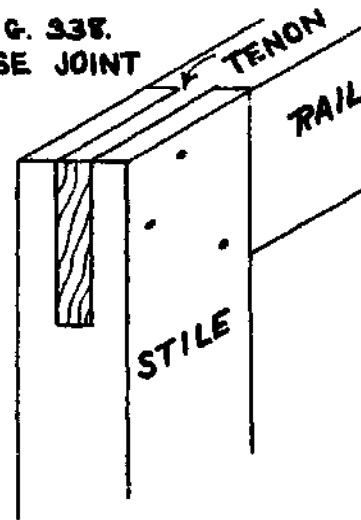


Fig. 340.
joint with metal pin in place. Pin is a 2-1/2" or 3" nail shortened so that it may be 'set' and yet not

threaten the face opposite the point.

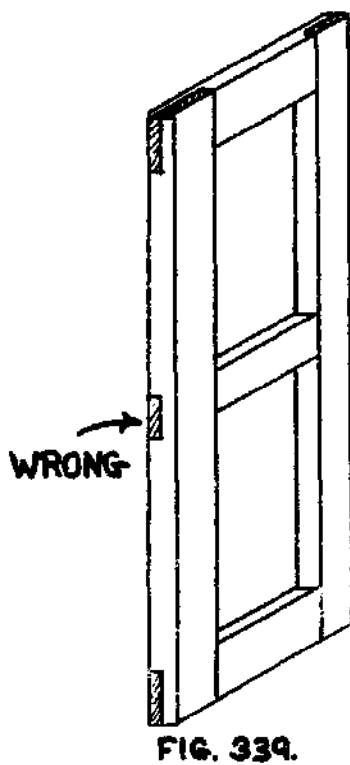


FIG. 339.



FIG. 341.

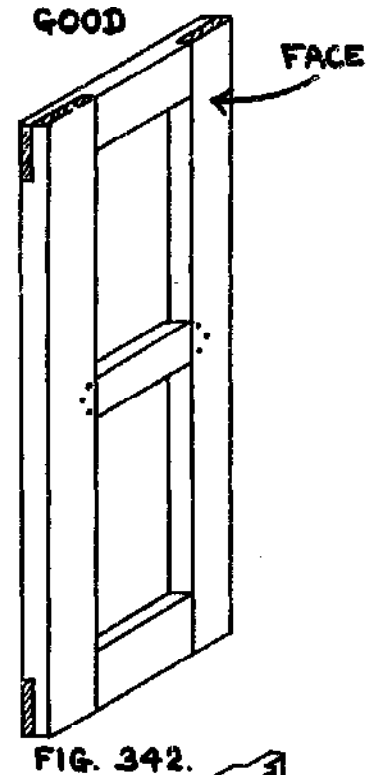


FIG. 342.

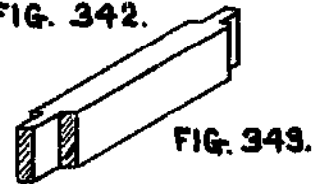


FIG. 343.

CENTRE RAIL

The lightest frame should not be thinner than 1". For doors, table tops, chair seats, church and school benches etc., 1-1/2" lumber is very useful. Use it for doors if at all possible. In dressing lumber for doors, try to communicate to the carpenter the idea that the frame is to be as thick as possible; that not a shaving more than necessary is to be taken off the wood. If there is a slight fault in one place, try to smooth over it rather than dress the whole stick down to that level.

Doors covered with sheet metal, ply wood, and other similar sheeting, do not need braces to prevent sag. A diagonal batten may be put in to supply extra resistance to warp.

Where panel doors are considered too expensive, and when ply wood is reasonable enough, beautiful doors can be made with a 1" or 1-1/8" frame covered one or both sides. The ply wood should reach the edge of the frame, and should be thoroughly coated with some waterproofing preparation.

Corrugated iron makes a good panel. Nail it securely at all edges, and across the middle batten. The open ends of the corrugations can be closed, giving the job a finished appearance.

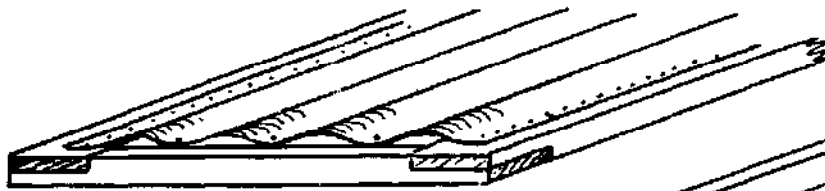


FIG. 344.

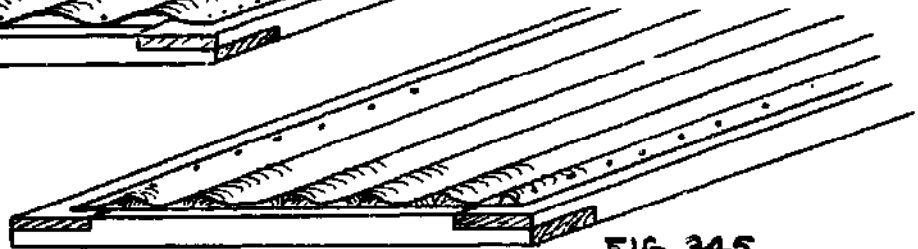


FIG. 345.



FIG. 348.

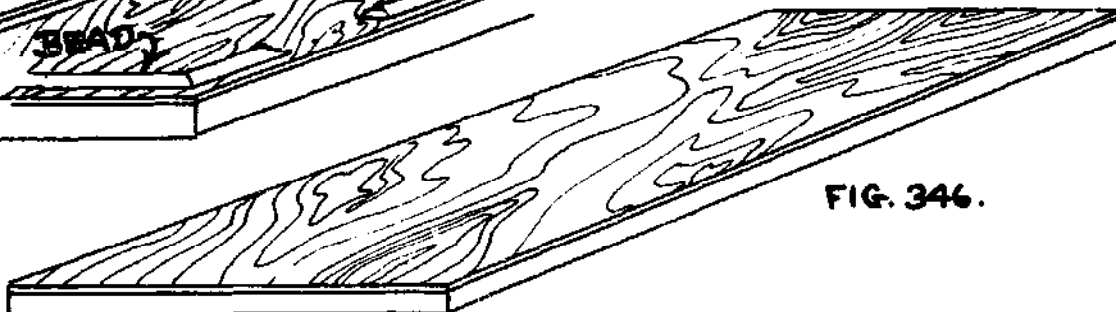


FIG. 346.

$1\frac{1}{2}$ " x 6" FRAME

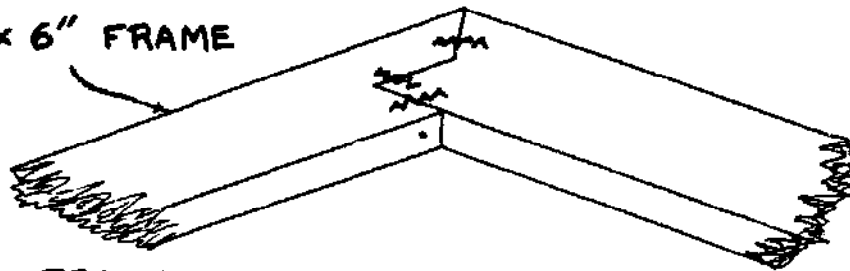


FIG. 347. FRAME JOINT FOR PLYWOOD DOOR.

Use seasoned lumber for the plywood door framework. The joint shown in Fig. 347 is recommended for this type of door. If the lumber is soft enough, or the wiggly nails are strong enough, use them in this joint. When the entire framework is ready, and the plywood cut near enough to size, glue the plywood to the frame. The frame must lie perfectly even and true, so that there is no warp. Use great weights or clamps to hold the glue job in place. A few very small head nails may be used to secure this joint. If nails are desired as the main holding job, try to get fancy head, upholstering nails with metallic top. Failing this, use common 1" nails and place a neat bead over the nail heads.

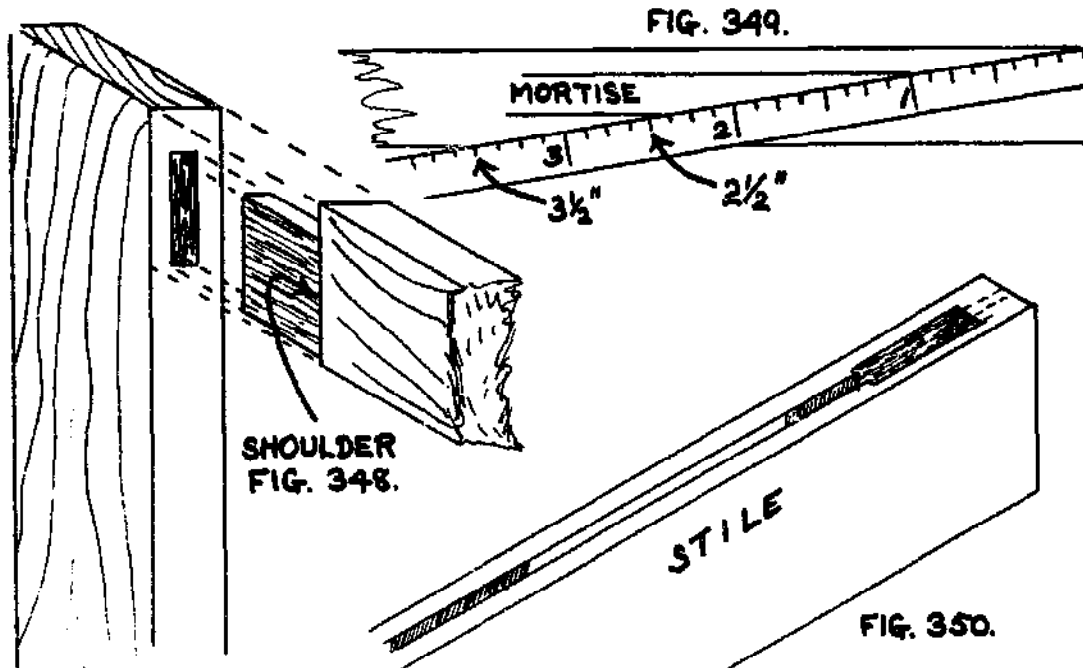
It may be well to do the preliminary work on fitting the lock to the framework of this door before fastening the plywood.

II PANEL DOORS.

A panel door has a grooved framework into which is fitted a panel of plywood or of lumber joined to make a solid sheet between the stiles. The panel may be full length, or there may be one or more cross pieces in the frame making several panels.

A panel door is heavy, more or less sound proof, durable if well made, and, of course, somewhat expensive. But the latter item must be taken into account as spread over the years in which no repair or replacement is required. The pinning of the tenons and even further fastening may have to be extra well done in countries where there is excessive dryness which causes all joints to shrink and the frames to sag.

We recommend what is called the blind mortise for panel door joints.



The tenon should be $\frac{3}{7}$ the thickness of the stile. To ascertain this dimension, place a common inch rule across the stile diagonally, as shown in Fig. 349, with the end of the rule at one extremity and the 3-1/2" mark at the other extremity of the edge of the stile. Make a pin prick at 1" and at 2-1/2". Draw lines through these pin pricks parallel to the edges.

The strength of mortise and tenon joints is proportional to the width and length of the tenon and to the strength of whatever device is used to hold the shoulder in to the mortised stile. There should not be less than 18" of shoulder altogether against one stile in any one door. Ordinarily this is made up of three shoulders of 6" each.

Make the rails of the door first, with their tenons, before making the mortises. There are various reasons for this, the

least obvious of which is that the tenons invariably shrink, the lumber not being perfectly seasoned. When all the rails and their tenons have been cut, start at the first one, and mark the mortise from it. Avoid splitting the stile, but make the fit as snug as possible.

Fig. 350 shows the stile grooved for the panel. Make the groove $\frac{3}{8}$ " wide and $\frac{5}{8}$ " deep. If the plough does not require to run right out to the end, well, but if it does as indicated by the dotted line, take care that it does not deform the slight bearing for the tenon which should be left.

The panels may be made of $\frac{3}{8}$ " or $\frac{1}{2}$ " plywood or of 1" lumber, well jointed. In the latter case, the wood is chamfered on one side at least.

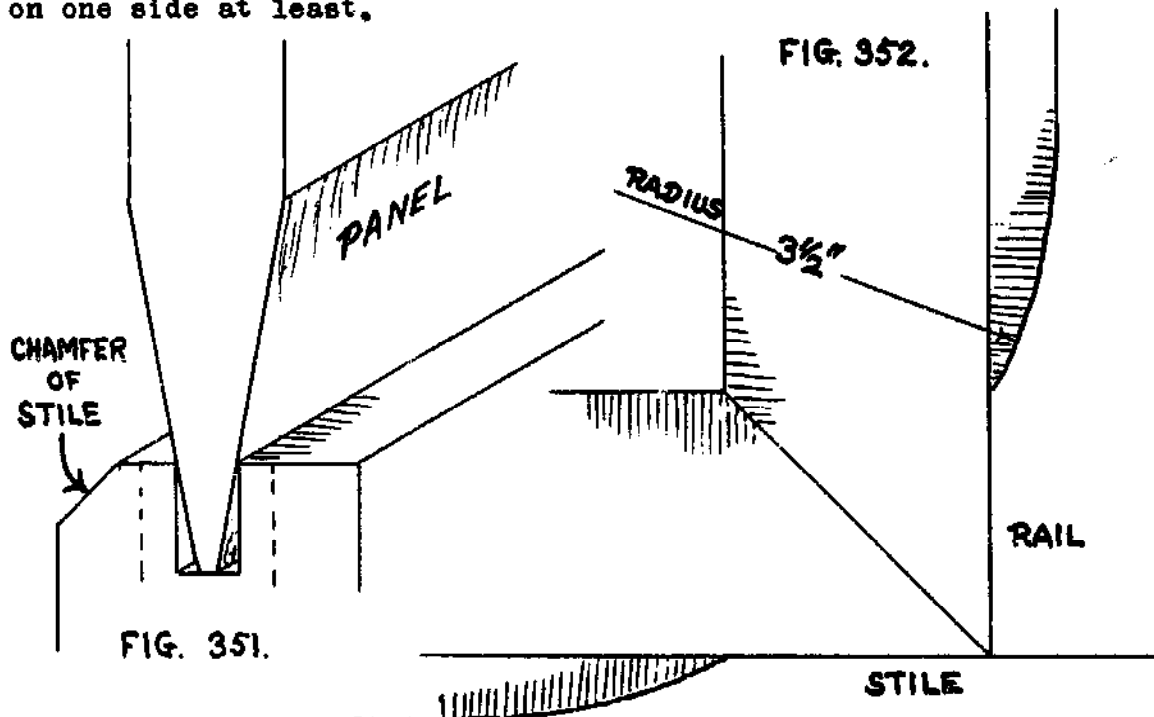
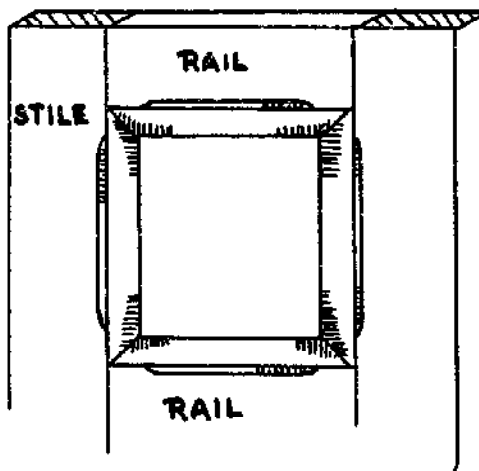


FIG. 353.



WHY RAILS LEAVE STILES

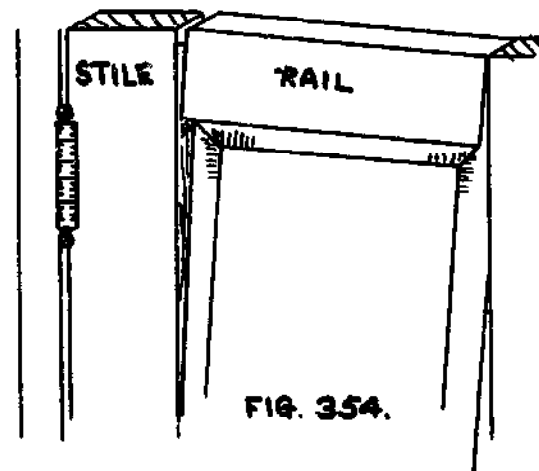
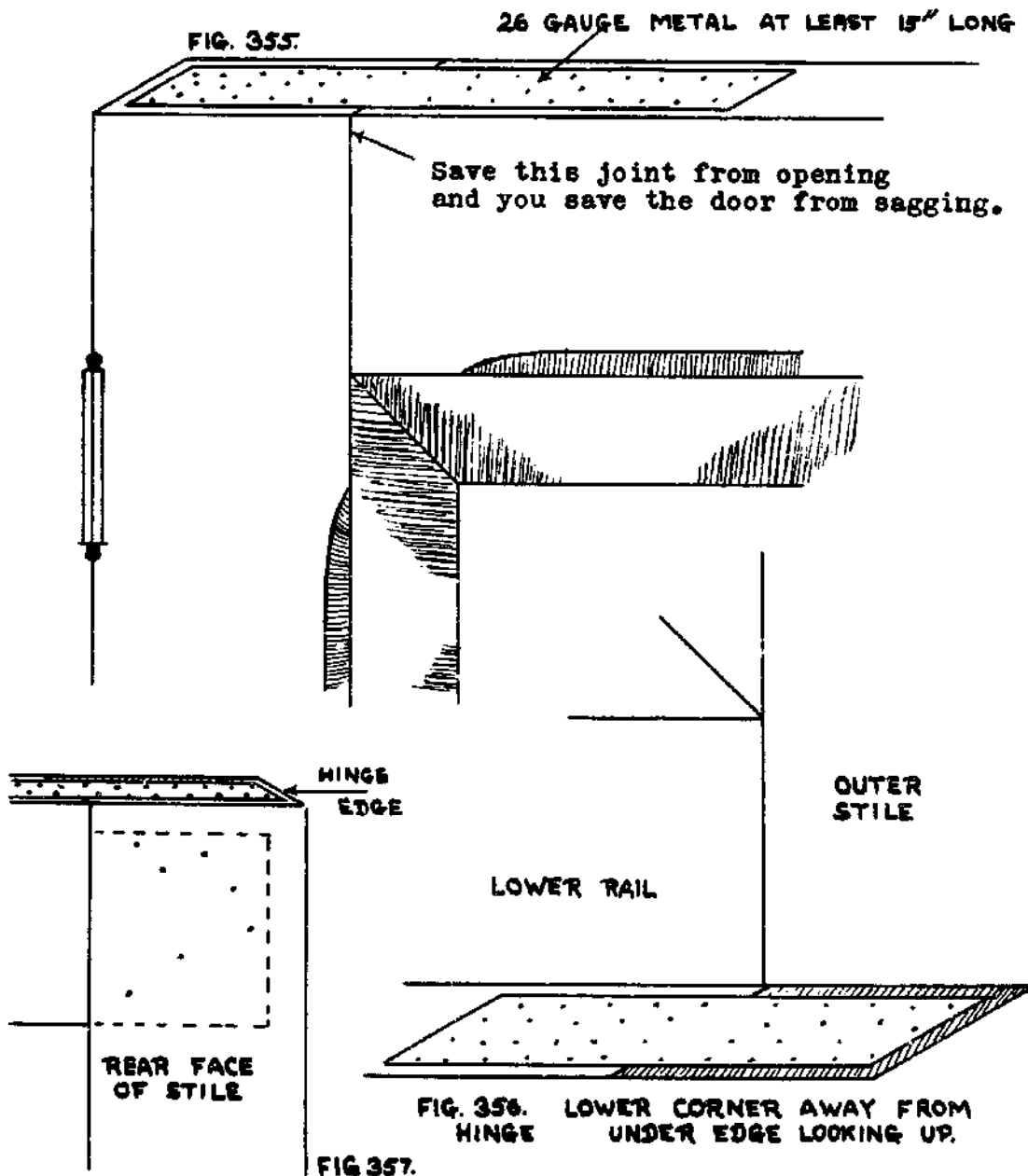


Fig. 352 shows the inside edges of the rails and stiles chamfered in the conventional way. Gauge the edge $5/16"$ to $3/8"$. The chamfer should never be wider than $3/8"$ on doors. A $3-1/2"$ radius as shown will give a satisfactory terminus to the adjacent chamfers.

Fig. 354 is a too common sight. Home and abroad. It can be prevented, at the start. The method is not conventional, but when we cannot see the mortise and tenon job, or when we have reason to think that it might fail, any method of stopping it is better than none at all.



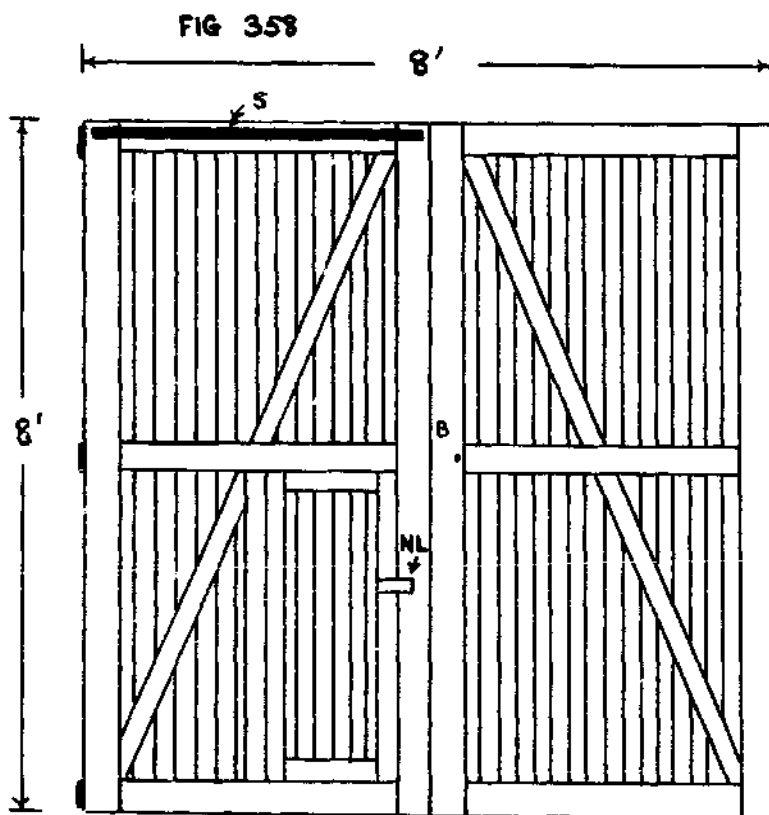
On the hinge stile, every shoulder tends to pull away at the top edge, and on the far stile, every shoulder tends to pull away at its lower edge. We may only put sheet metal at the top hinge corner and at the lower corner farthest from the hinges. To augment these metal ties, we multiply pins into the tenon, and on the rear face of the door only. We put more pins near the top of the tenon in the hinge stile and near the bottom of the tenon on the far stile. We also keep the pins as far away from the stile inner edge as possible, to prevent splitting. These measures should not relax our care with a close fit of tenon and mortise, and all the gluing and other tricks of the trade to keep the article from falling apart.

Perhaps it needs to be said that the metal ties should not be put on the door until it has been properly fitted and hung on its hinges. Give it a clearance of $1/8$ " at each side and the top, and at least $1/4$ " at the bottom, making allowance for rugs. When all this is done, put on the metal ties.

As soon as a panel door is finished it merits some good preservative and protection from damage.

III. GARAGE DOORS.

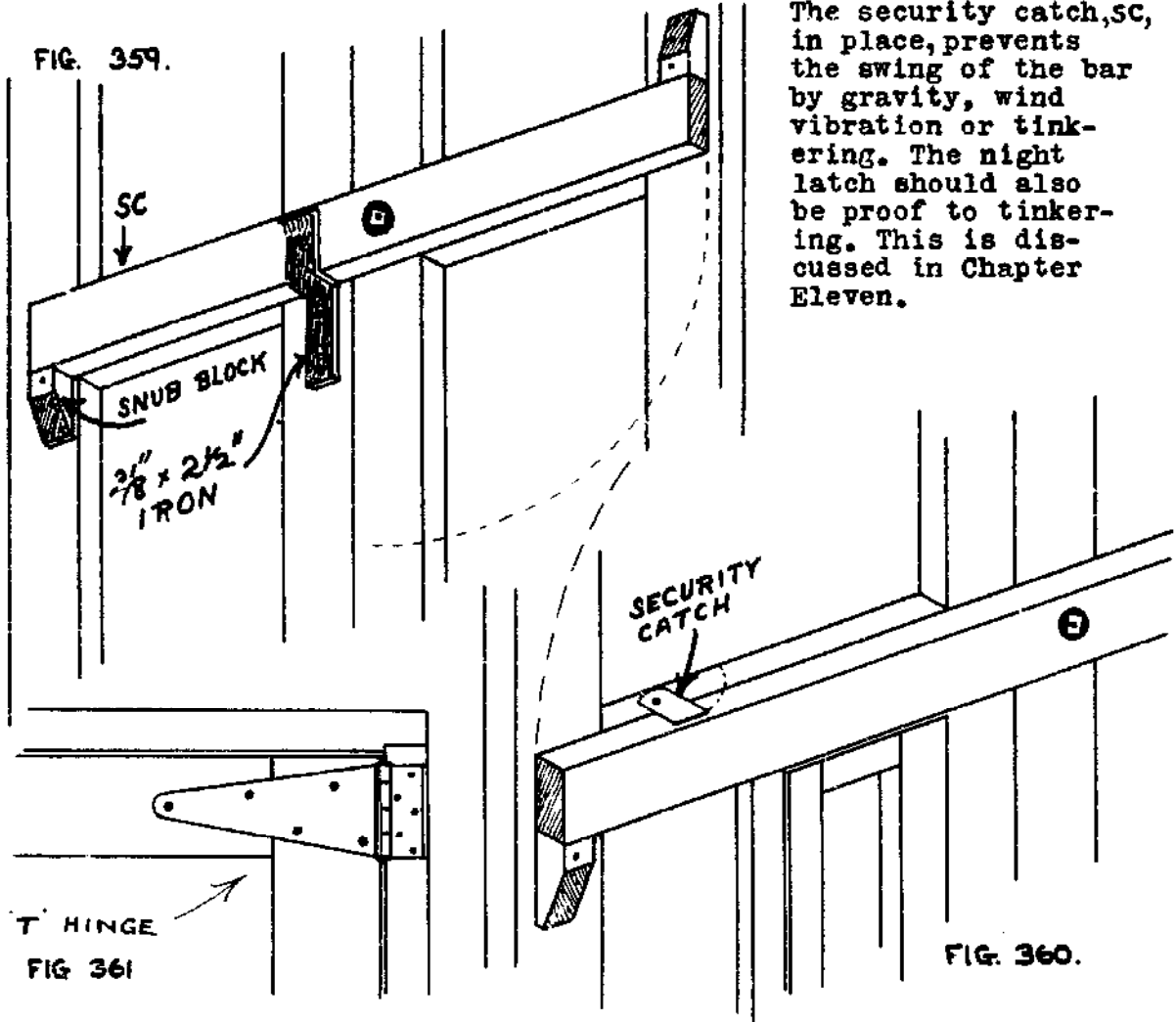
This section includes also large doors on stores where motor trucks sometimes enter to deliver goods. The frame for the opening should be heavier than for an ordinary house door, and the lintel have extra strong iron tying to hold it up.



'N.L.' is the night latch on the 2' X 4' latch door. The framework of this door should not be less than 2" stuff. Diagonal wood braces on doors always run from the hinge side at the bottom to the far side at the top. If iron braces are used, they run from hinge side at the top to the far side at the bottom. This is because they are in tension. The wood are in compression; each kind put on to prevent sag. Each large door should have three strap hinges; failing strap, then 'T' hinges, the tongue reaching from the jamb to a good hold on the upper rail.

'S' is a strap iron tie from the hinge side to the far side at the top only, when there is no strap hinge used, and there is no real hold on the outer stile. The wood brace tends to thrust the stile away. If there is a good strap hinge tongue to reach the upper rail, then there needs only to be a strap iron tie from the upper rail to the far stile.

'B' is the bolt hole for the long, stout wood bar which in its proper fastenings holds the two large doors securely shut.



The security catch, SC, in place, prevents the swing of the bar by gravity, wind vibration or tinkering. The night latch should also be proof to tinkering. This is discussed in Chapter Eleven.

IV WINDOW SASH.

As suggested before, glass windows should be carefully figured out before even the frames are made. Get stock lists from your dealers and determine the most economical and practical arrangement. For instance, 24" X 24" is a common size of stock in some places. This will cut into six panes 8" X 12" without waste. Rectangular glass on end seems to be more in style than square panes or lights as they are known to the trade.

A sash with three such lights made according to the accompanying diagrams will be 3'7" high and 3'7" wide.

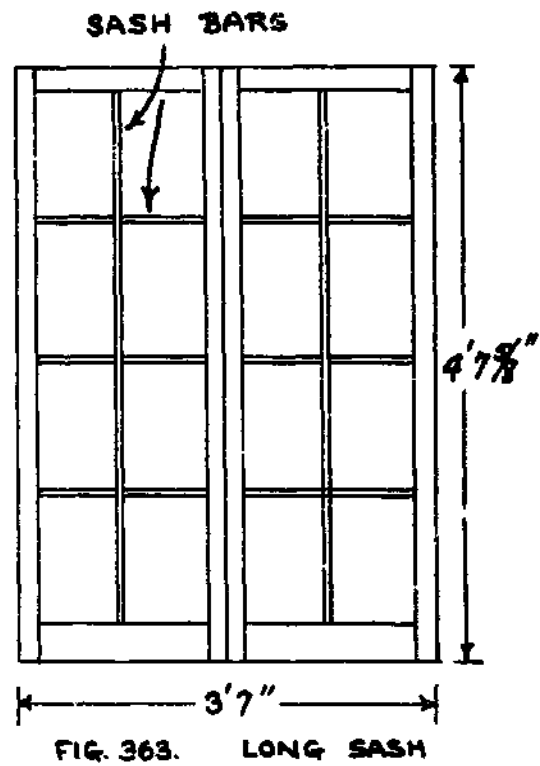
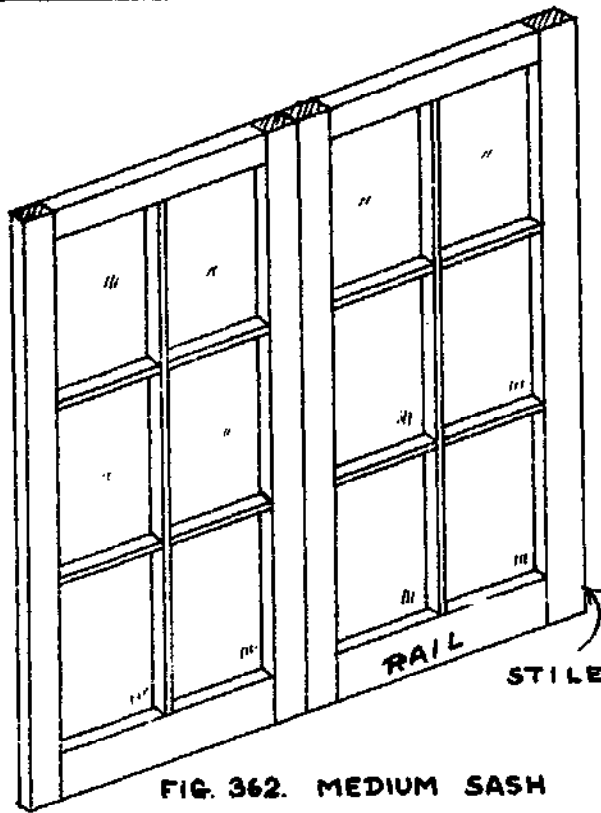


FIG. 364. SECTION OF STILE

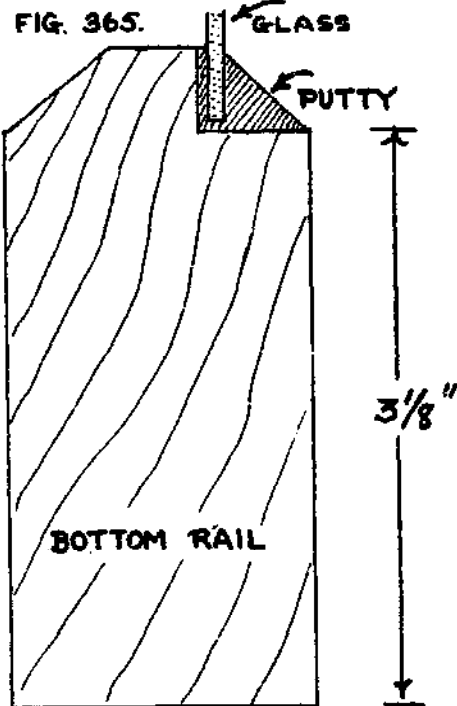
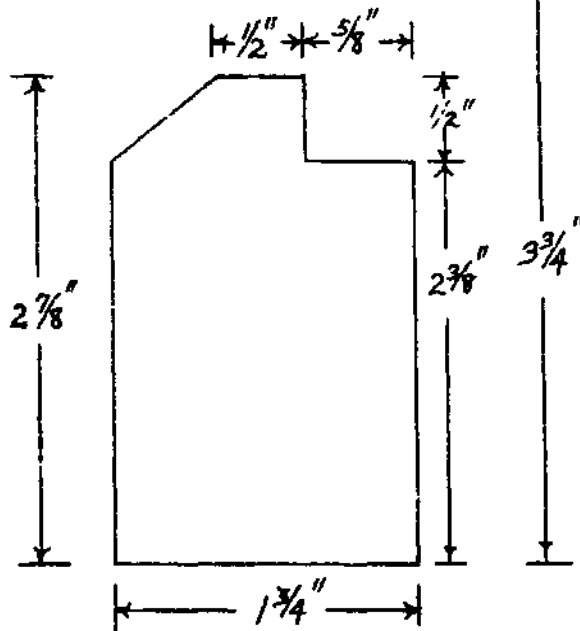
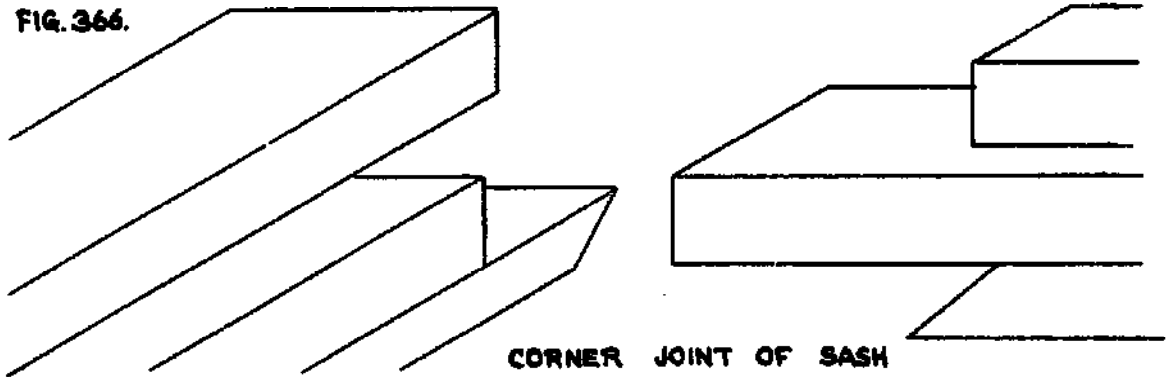


FIG. 366.



CORNER JOINT OF SASH

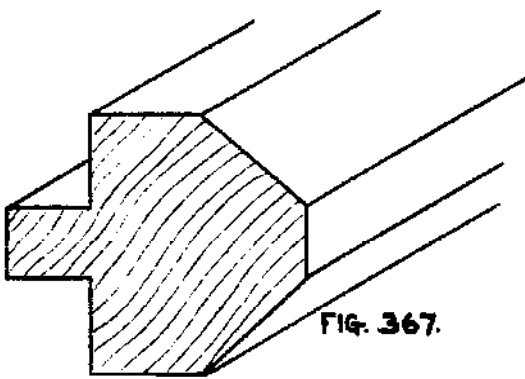


FIG. 367.

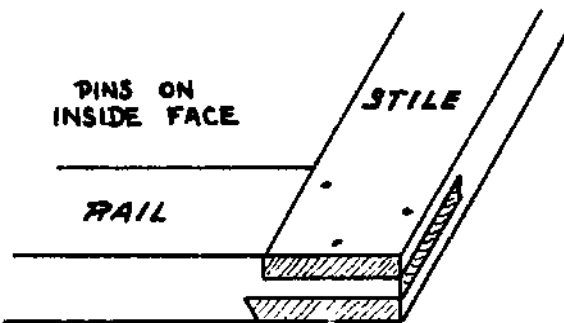
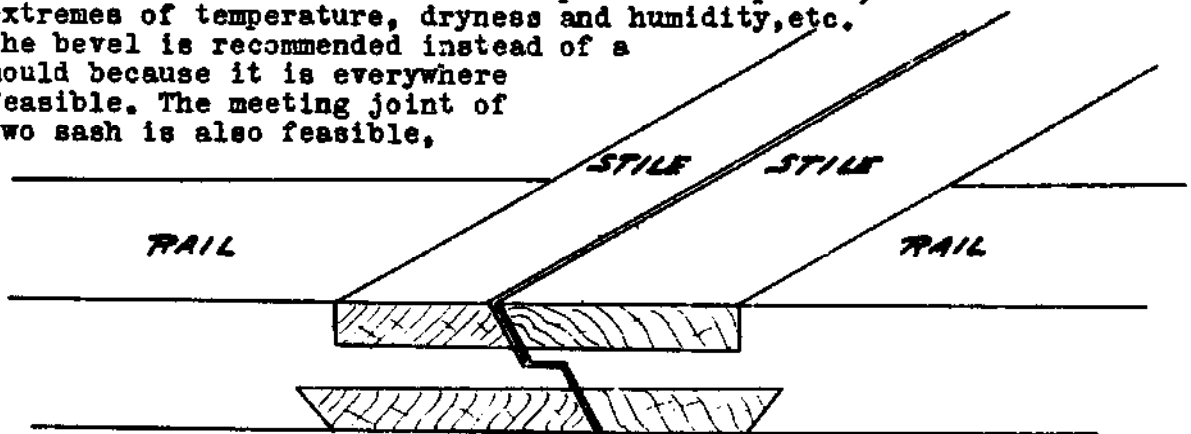


FIG. 368. OUTSIDE VIEW OF COMPLETED JOINT

The sizes of stiles, rails and sash bars is admittedly heavier than standard. It is because they are hand made, are often of poor grain, and are more liable to warp due to exposure, extremes of temperature, dryness and humidity, etc. The bevel is recommended instead of a mould because it is everywhere feasible. The meeting joint of two sash is also feasible,

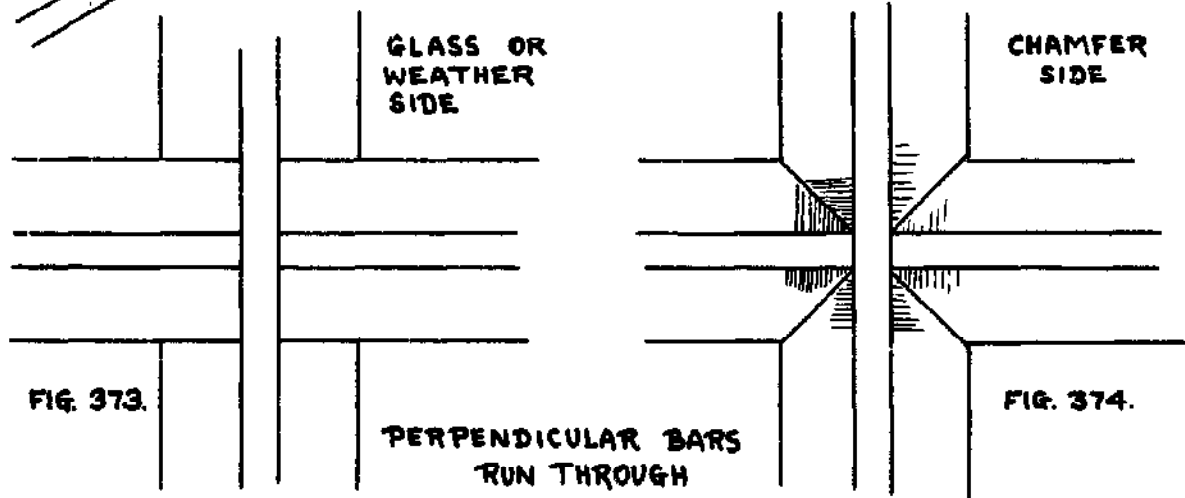
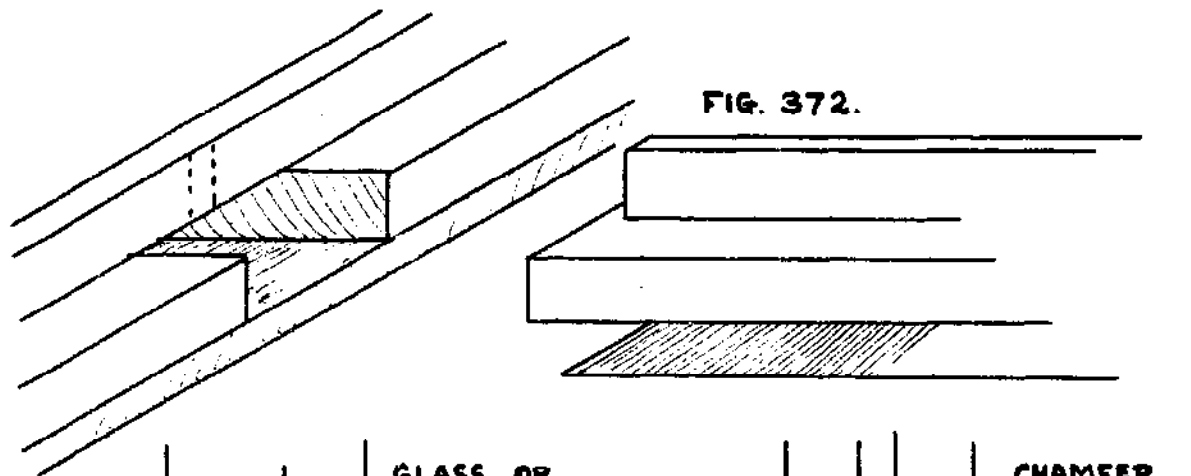
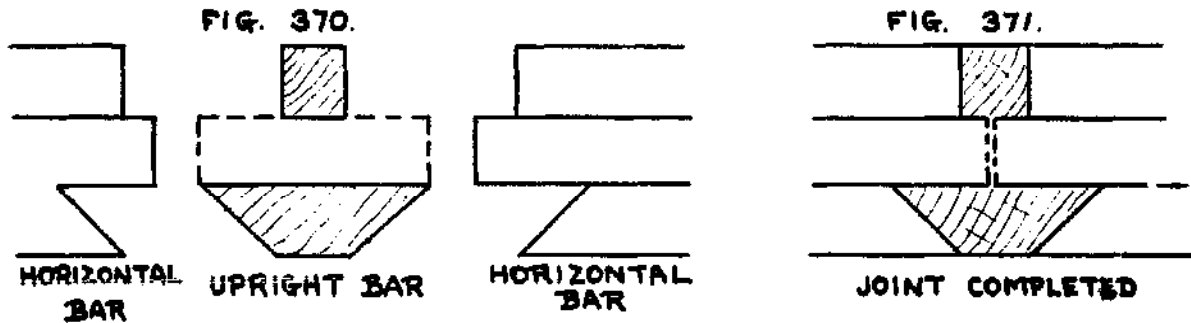


Meeting joint of two sash.

FIG. 369.

In Fig. 362 and in all other drawings of panel doors, sash, and furniture note that stiles always run right through from top to bottom while the rails stop, or are cut in between. The only exception is when a half lap is used. In this case, the stiles run through on the face, and the rails run through on the rear.

The measure of 1/2" X 5/8" for the rabbet accommodating the glass may be considered a minimum. A study of Fig. 365 will show the reason for this.



We have allowed 12" for each pane of glass plus 1/16" allowance at each edge. All measurements are made on the glass side. 2-3/8" is allowed for the top rail, 3-1/8" for the bottom rail, 1/2" for each sash bar. Lay all this out carefully before commencing to cut the sash wood into lengths. Sash wood is customarily cut at least 1/8" long at each end.

In Fig. 380 is seen the end view of the upright sash bar and the side view of the two horizontal bars ready cut and in position to enter the mortise of the upright bar. The mortise is indicated by the dotted lines. The dotted lines in Fig. 381 show that the ends of the tenon should not quite meet. The visible joint of the chamfers and the top joint on the other side should be as accurate and tight as possible. Fig. 382 shows more clearly the mortise in the upright bar. This is the same as in the stile where the sash bar joins it.

The rabbet for the glass and putty is on the out, or weather side of the sash.

In Fig. 363 we show the longer sash with four lights high. This is an attractive window, and should be used in pantry, and office at least.

V SOLID SHUTTERS.

This type of window is often necessary, and sometimes, the best solution to the needs of the particular room as is the case with the bedroom, where privacy with air are essential during the day; and also, in inclement weather, is very acceptable.

Five feet is the common height of this window, but in very hot localities, a six foot window is advisable.

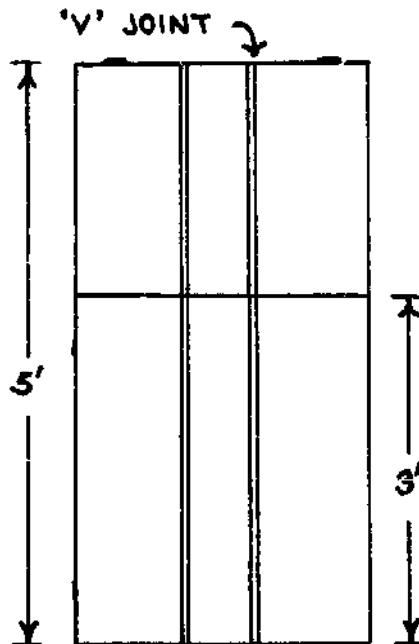


FIG 375

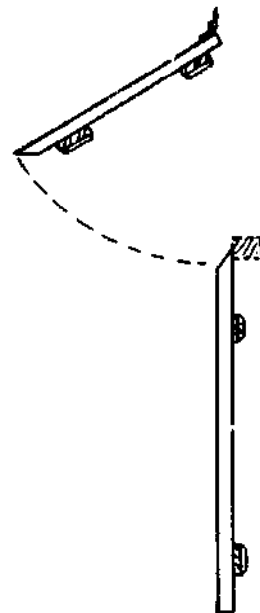


FIG 376

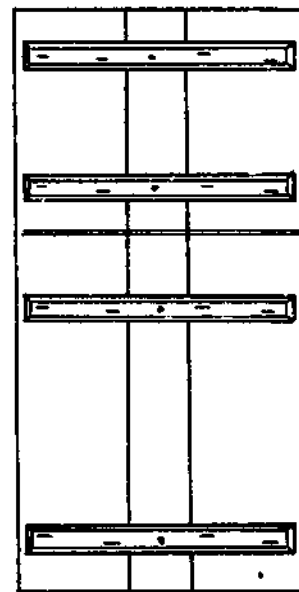
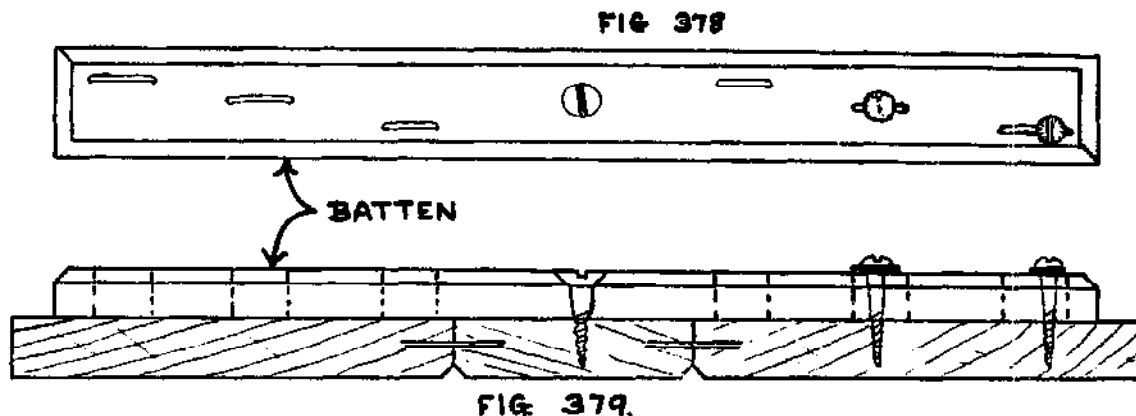


FIG. 377.

Figs. 385,6,7, are almost self explanatory. The dotted line enclosure where the two shutters meet is a bar set in the frame. It provides for a firm joint at the middle and assists with the locking device for the top shutter.

Note that the battens have just one screw in the middle of each; there are also slots in the battens. This indicates that the screws, apart from the one middle screw, are free to move in these slots when the boards of the shutter swell and shrink.



Try to get full size 1" boards for these shutters, and of course, as seasoned and true as possible. When the various pieces have been joined by metal dowel, clamp as tightly as possible and fasten. Leave the rough edges until the shutter is fitted. By that time it will have shrunk somewhat, and adjustment can be made in the movement of the screws along the batten. Even when the shutter is fitted, do not leave any more allowance at the sides than is absolutely necessary.

VI. BURGLAR PROOFING.

It is practically impossible to keep burglars out of a house when the occupants are away and out of earshot; when the doors and windows can be literally smashed to pieces to effect an entrance. But it is possible to burglar proof windows so that they cannot be entered without enough noise to arouse sleepers or summon persons from another part of the building. The commonest thief guard is expanded metal, of all sizes, from 3-1/2" to 1/2". The former is made for concrete reinforcement, the latter is expanded metal lath for plaster.

Expanded metal being diamond shaped, looks very much better with the diamonds in the upright position, but this results in considerable waste in cutting. There is now on the market a square mesh of round wire, and all we have seen of it is favourable. It has no sharp edged like the expanded metal, is not brittle, can be used lengthwise or crosswise and hence has practically no waste.

Having gone to the expense of wire guard, it is worthwhile to fasten it so that it cannot be torn through or away without considerable noise and trouble, or without a special cutting tool.

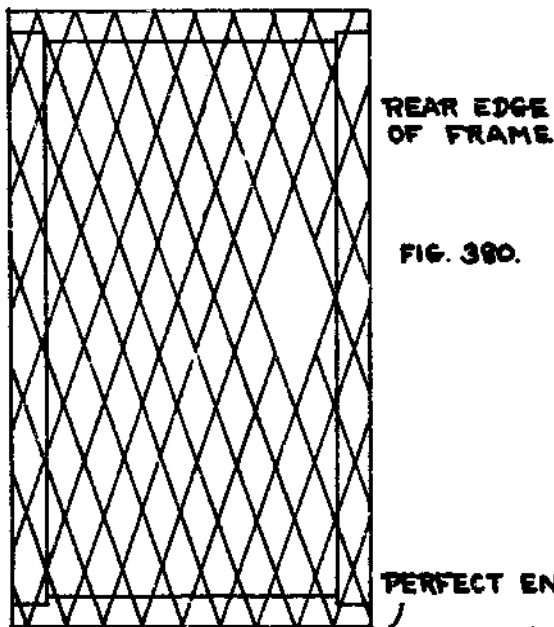


FIG. 390 shows the appearance of the common 3" expanded metal guard cut to size on a window frame. Have at least the bottom end and one side with connected wire edges. In this illustration both ends are perfect, the sides are fair. The connected ends give strong fastening.

PERFECT END

IMPERFECT END

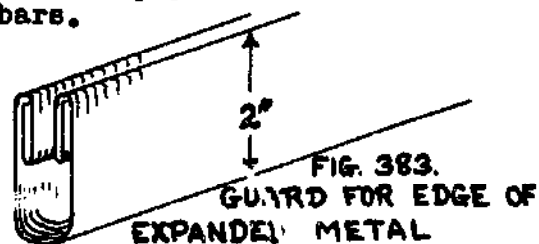
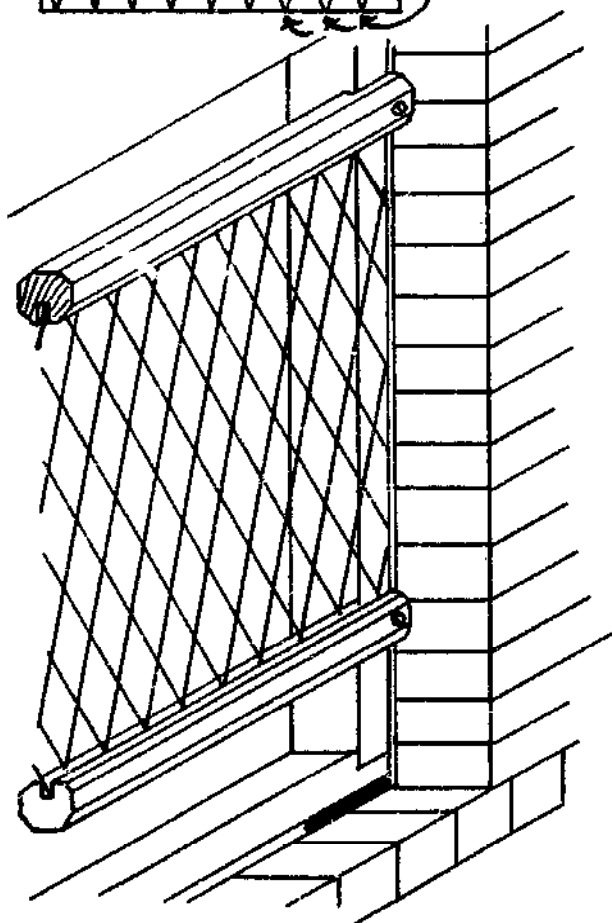
PERFECT SIDE

IMPERFECT SIDE

The opening shown is for the hand and arm when opening and closing the window.

In Fig. 392 we show a method of saving iron, as well as saving inconvenience. There are two grooved bars, into which the ends of the iron fit. The last six inches at the top of the window does not need guarding; the lower four inches can be left open to allow the hand and arm necessary freedom in opening and closing the lower casement or shutter which has a fastener for various positions. Note that the bar is checked to fit on the frame in a way to allow the iron to lay flat. Thieves have been caught putting their arms through this lower opening, and, with the use of a long hook, drawing bedding to the reach of their fingers. Some device should be attached to interfere with this activity.

Sheet metal bars can be made simply instead of the wood bars.



In buildings where appearance is not so important, round iron bars may be used. Of course these must be built right into the frame, or else have some brackets or frame of their own which would have to be fastened to the window frame. Not only must the bars be built into the frame, but something must be done to prevent their being moved either up or down a little which would enable a muscular person to pull outward, bend the bar down, then pass through the aperture so made.

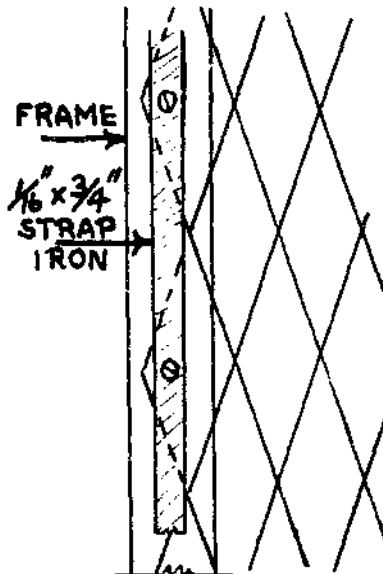


FIG. 384

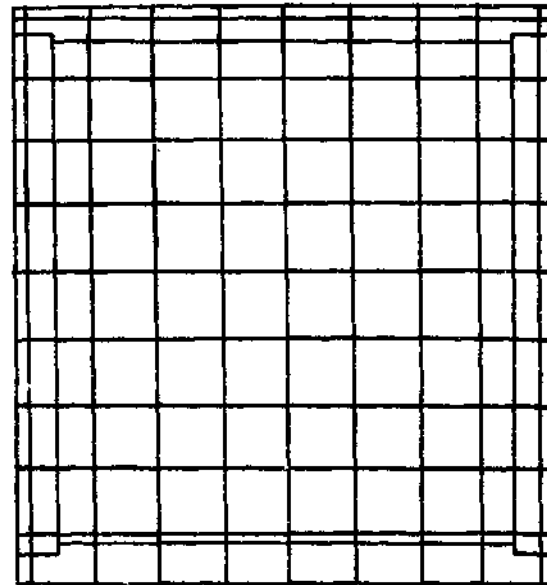


FIG. 385. SQUARE MESH GUARD.

See to it that all locks and bolts are as secure as you can make them. Some suggestions are to be found in Chapter Eleven.

Every building which is to be locked should have one well made door with a night latch, often called a Yale Lock, and every other door in the place should have strong bolts well fitted.

CHAPTER FOUR SCAFFOLD.

I. LIST.

Useful equipment when starting to build on any station:

- 1 - 12' ladder for permanent use on the station.
- 1 - 12' " of rough lumber for current building only.
- 1 - 6' " " " " " " " " " " " "
- 1 - 6' step ladder for permanent station use.
- 1 - 18' ladder on jobs with high buildings, or high points.
- 1 - 2' X 6' X 34" high permanent work bench.
- 1 - 3' X 12' X 30" high temporary work bench for carpenters.
- 1 - saw bench, permanent.
- 1 - set of two or more scaffold jacks for supporting planks.
- 1 - set of scaffold planks.

II. LADDERS.

1. Permanent station ladder. Dimensions, 18" X 12'
 Materials: two 2" X 3" X 12' or two 1-1/2" X 4" X 12'.
 eleven rungs 1" X 2" X 18". All pieces planed at least
 a little.

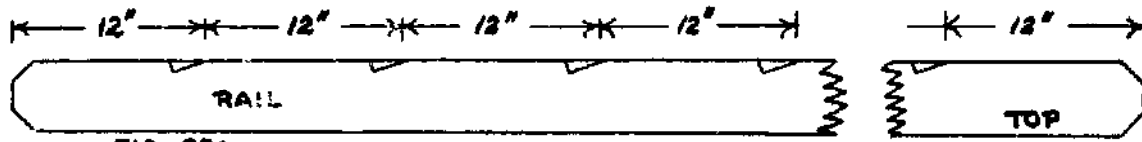


FIG. 388.

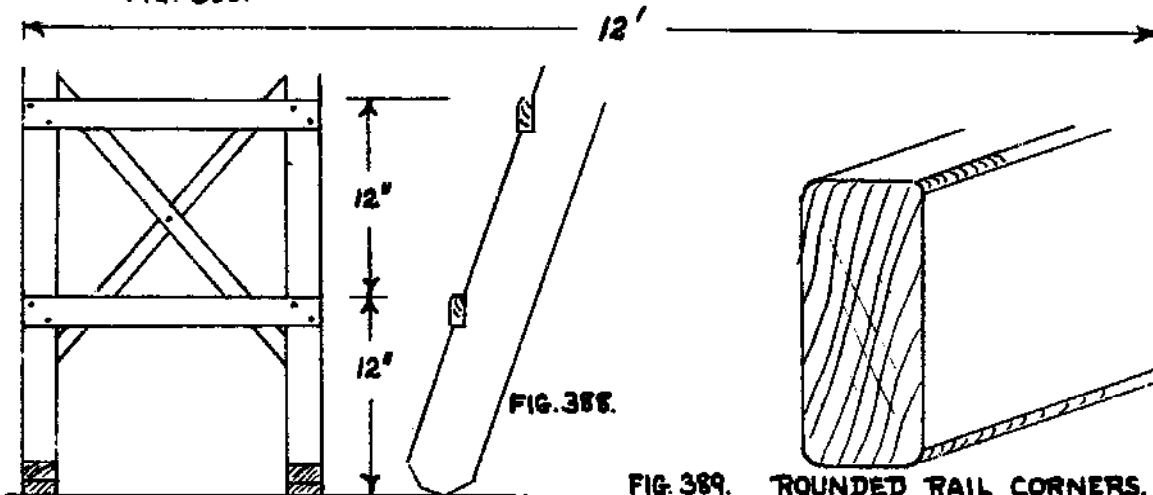


FIG. 388.

FIG. 389. ROUNDED RAIL CORNERS.

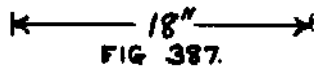


FIG. 387.

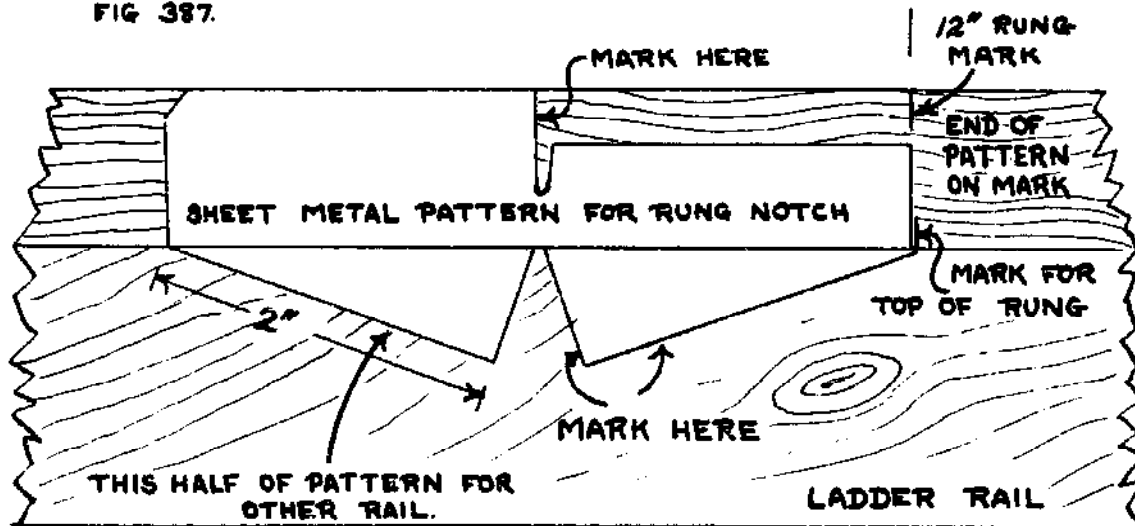


FIG. 390. MARKING NOTCH FOR RUNG

The over-all width of 18" gives an inside width of 14" necessary for two 2" X 6" scaffold planks to rest on the rung. The 2" clearance is theoretical only, because the planks are not straight, and the edges may be encrusted with mud.

The rails must have straight grain. Both rails and rungs ought to be full size, that is as near 2" X 3" and 1" X 2" as possible. Round the rail corners. This will prevent splintering and so help toward safe movement of the hands up and down the rails. Incidentally, when climbing and descending ladders, keep the hands off the rungs. Grip the rear edge of the rail.

Use 3" nails when fastening the rungs to the rails. Round the top edge of the rail where it touches the wall; cut off all other corners at 45 degrees as shown.

The metal pattern shown in Fig. 400 is very handy in marking the notch for the rungs. Place the two rails together; mark them every 12" by the use of a square so that one mark right across the two will suffice. Now using the right side of the pattern, move right up one corner marking all the notches. The pattern has facility for the marking of the top, so that no further marking is required. For the best work, mark the other rail too.

For cutting the notch and for carpentry work in general, do not cut out the mark. Adopt a system whereby you leave the mark in its entirety, or at least leave half of it; enough evidence that you have cut to it and not beyond it.

In cutting this notch, it is permissible to 'under cut' just a little, so that the angle will be a trifle less than 90 degrees. This will allow the rung to fit snugly at the two outer corners. Otherwise, with the constant use, the rung will work loose.

Sometimes ladders are reinforced by the fastening of a wire along the rear edge of each rail, and securely anchored at or rather around each end. The wire should not be less than 1/8" to be effective, and should be frequently stapled.

A good ladder merits a rubbing of linseed oil or other preservative. Dried out wood is the greatest threat to the safety of the ladder. Keep this ladder under shade when building is done.

Dropping the ladder a few feet on to one of its feet is likely to wrench the joints and loosen them. It is well, therefore, to brace the ladder as shown in Fig. 397. Brace it as near the bottom as possible so that the braces will not interfere with scaffold planks. But not right at the bottom, for that would be a nuisance where the feet of the ladder are planted amongst debris.

The rough 12' ladder for current building work is not planed and the rails are not notched. The lumber may be used for something else. But the measurements are the same. This rough ladder is useful as a stay with the good ladder, the two making a 12' step ladder; it is particularly helpful at roof corners where the wall scaffold does not reach.

The six foot rough ladder has been found to be very useful for work on walls about 6' high where a 12' ladder is of no use. It is also handy in that it does not get in the way in small rooms. Long ladders are nearly always in use and the short ladder precludes the constant moving about of these longer ladders. The short ladder also can be made into a rough step ladder. With a big gang, two step ladders are always in demand.

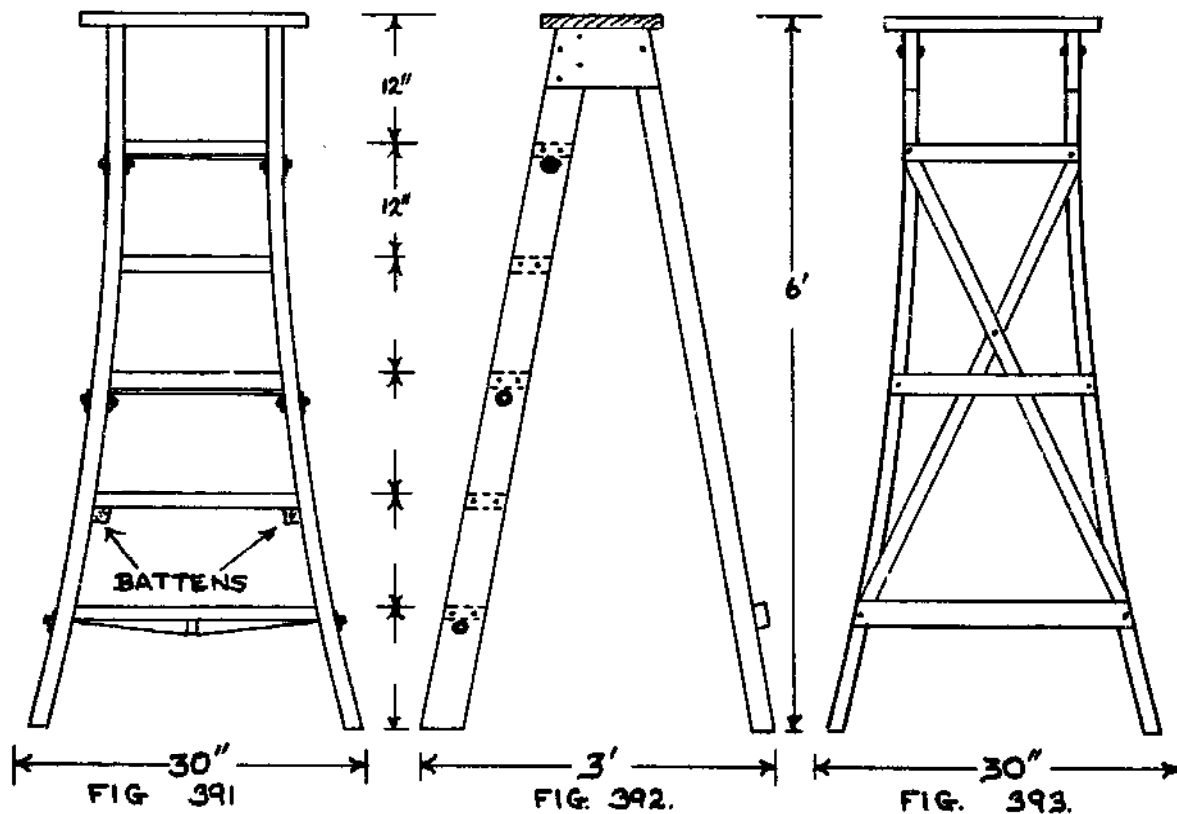
The permanent step ladder. Every house needs such a piece of equipment. Why not make it at the very beginning and have the use of it throughout the building operations when it will be

used over a hundred times, during the work of decorating when it is practically an essential?

Material. All good grain, full size, dressed.				
2	pieces	7/8" X 3-3/4"	X 6'2"	for front rails
2	"	7/8" X 1-7/8"	X 6'2"	" rear stays
1		7/8" X 8"	X 18"	" platform at top
1		7/8" X 4"	X 28"	" bottom step
1		7/8" X 4"	X 24"	" "
1		7/8" X 4"	X 19"	" "
1		7/8" X 4"	X 16"	" "
1		7/8" X 4"	X 13"	" "

The ideal joint for each step with the side rail is a notch. But in hand made work, with wood difficult to work, and with scarcity of tools, and sometimes skill, to make a perfect job, the notched step support is neutralized. But if it is attempted, add twice the depth of the notch to the measurement of each step given above. The top step should not be less than 13" clear to allow for scaffold planks.

Bale iron for the brace at the back, one batten across the stays, and, if a shelf is required, material for that also should be added to the above list of materials. The hinge arrangement can be effected by metal or wood.



Make the curve suit the wood you have to work with. Put the top step, 13", in place and tack it. Then put in the bottom step and tack it. Now clamp the two sides together just below the third step, about 2'6" from the bottom. Squeeze the sides as much as you can, or dare, without threat of a fracture either during construction or in the future. If you wish a deep curve, soak or steam the sides accordingly. The same method will have to be followed for the rear braces.

When the drawing together has reached its maximum, mark the step accurately and tack in place. Before releasing the clamp secure the sides with a through bolt as shown under the bottom step, or a bolted bale iron as shown under the third step. To tighten the tie, insert a block as shown; this block helps to stiffen the step.

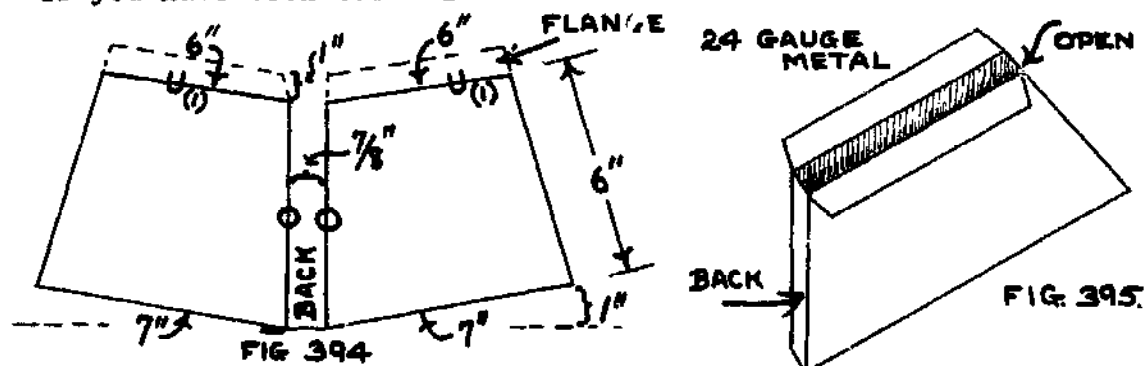
The step support. Something beside the nails from the outside is required to make the steps safe. We make one suggestion with illustrations. Use whatever device you can make most easily which is also foolproof. Make the stepladder so that no one will ever have a mishap on it due to faulty design or workmanship or materials. A stepladder fall is amongst the worst, and least expected, around a building.

Brace the rear unit as shown. Do it so that the brace will be taut.

Round, chamfer, or sandpaper the sharp edges and corners throughout the ladder.

The hinge. In the side view of the stepladder, Fig. 402, it is not obvious whether the hinge device is wood or metal. If you wish to make it of wood, tack the feet of the step ladder so that the rear brace and the front rail are 3' apart, out to out at the bottom and the top edges are 6" out to out. Shape a piece of 7/8" X 6" wood like the hinge in the side view. Make two. Nail on to the rail; bolt through the brace so that the brace can swing.

If the hinge is to be of metal, the material should not be less than 24 gauge. Take a sheet of brown paper and determine the shape of the hinge you need. It will look something like this if you have been careful:



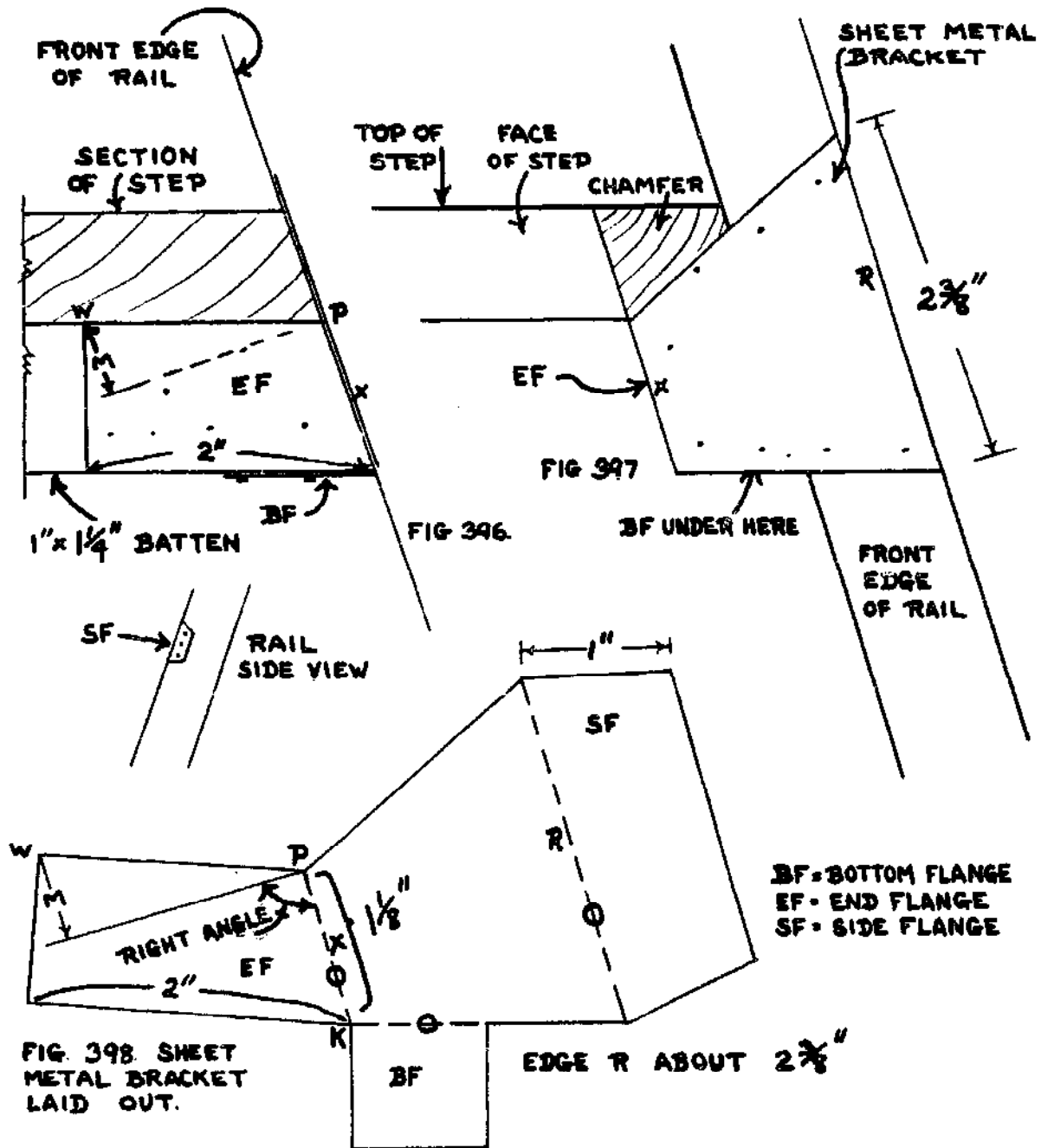
Make a new pattern with added flanges as indicated by the dotted lines, or put your pattern right on the metal and add the flanges in your marking. When you have cut out the first one, mark another from it, but do not cut out the second until you have shaped the first one. If it is alright, go ahead with the second.

⊖ on a sheet metal pattern means bend over or down from the line.

⊔ means fold up. (1) means fold this one first.

The flange is to be fastened securely to the platform.

STEP BRACKET DRAWINGS

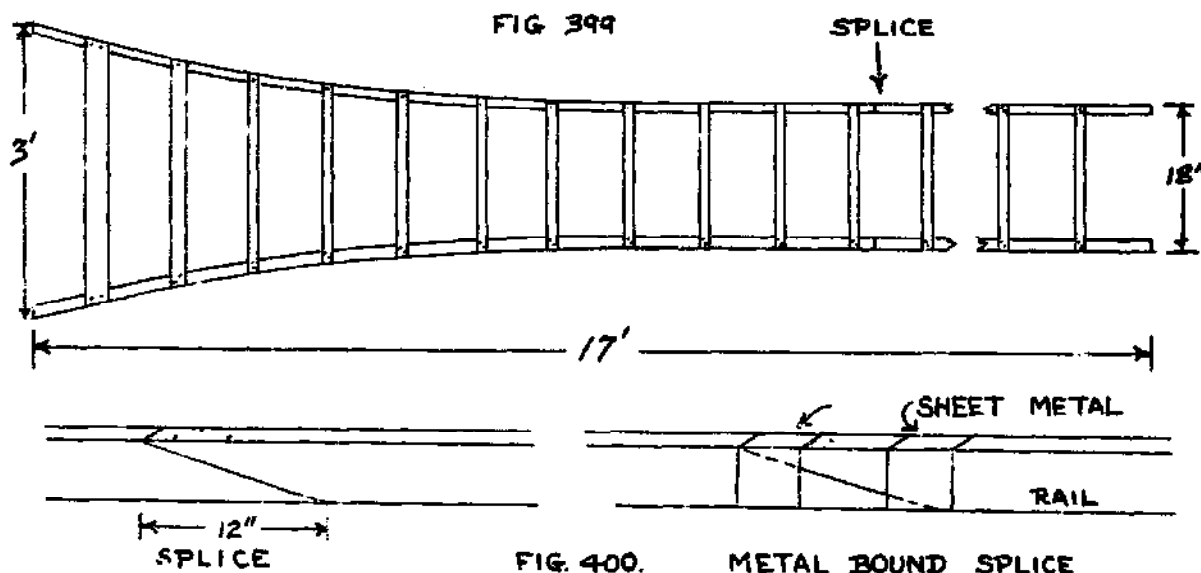


The step support. In Fig. 401 the second step shows the 1" X 1-1/4" batten under the end of the step. In Fig. 406 the view is from the side of this batten, the eye being under the step, so to speak. EF the edge flange is seen nailed to the side of the batten. In Fig. 407 the metal runs across a corner of the step. The shading shows that the step is chamfered to correspond with the angle of the rail face. The metal lies across the chamfer.

In Fig. 408 a pattern layout is shown for the metal. What you make on your step ladder will not have exactly the same angles, probably, but it will be similar. The only problem line is the angle at which the line PW breaks from the line PK.

If a paper pattern is made with a square projection beyond PK, the upper edge will assume the dotted line from P in Fig. 406. Measure from this dotted line up to W which is the bottom of the step. The flange BF may be 1-1/2" long. Try the paper pattern on all the steps, and you may be able to calculate the divergence on each and transfer it to the metal without a new pattern. With this type of pattern, a couple of 2" nails can be driven down through the step into the batten. Hold a heavy hammer under the batten as you drive.

A long ladder.



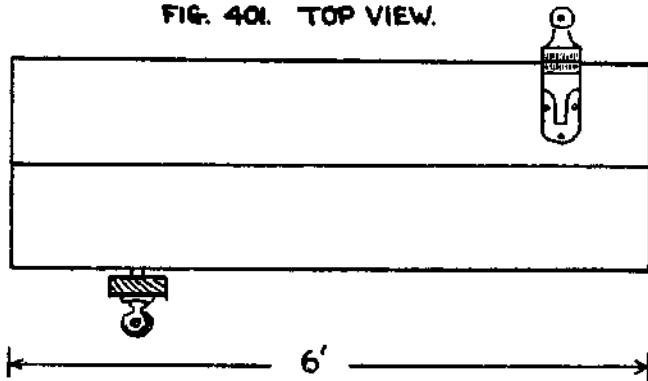
The two important things about this ladder are, first, the wide foot, second that the splice, if any is required, is near the top. The bottom rung should be 4" wide and the next rung about 3-1/2" wide. A ladder like this should have special rails made: about 1-3/4" X 3-7/8". It is a valuable piece of equipment and should be well taken care of. Ordinarily, it would require three men to raise it to position safely. One man stands on the bottom rung with all his weight on it, while the other two raise the ladder. Of course this ladder should be well finished and oiled.

III. BENCHES.

A permanent work bench for the station, is a good investment. It is solid, heavy, and on it can be mounted good shop equipment, grinders, vises, etc. The top or deck is made of

two pieces of 2" X 12" X 6' of solid hard wood; the posts and their cross bars of 2"X4" also of hard wood. The joint between the two top planks is to be tight, well fitted; use metal dowels, (4" nails) and on the under side hold the joint together with sheet metal patches.

FIG. 401. TOP VIEW.



24"
Y

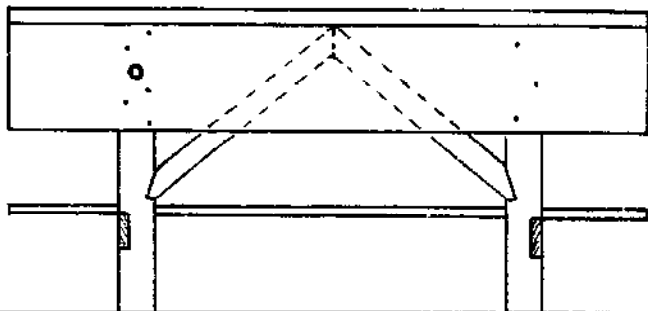


FIG. 402. CARPENTRY SIDE

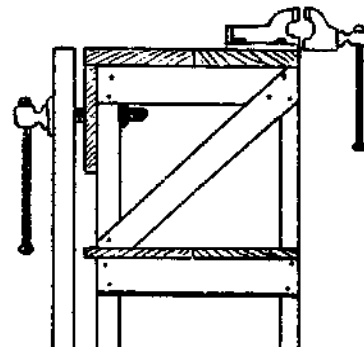


FIG. 403. MACHINE END VIEW

WISE HERE

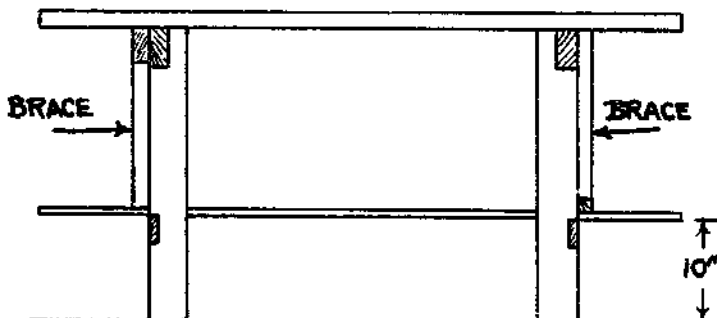


FIG. 404. MACHINE SIDE

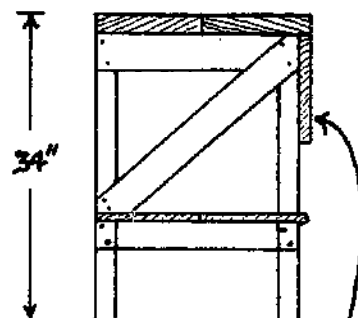
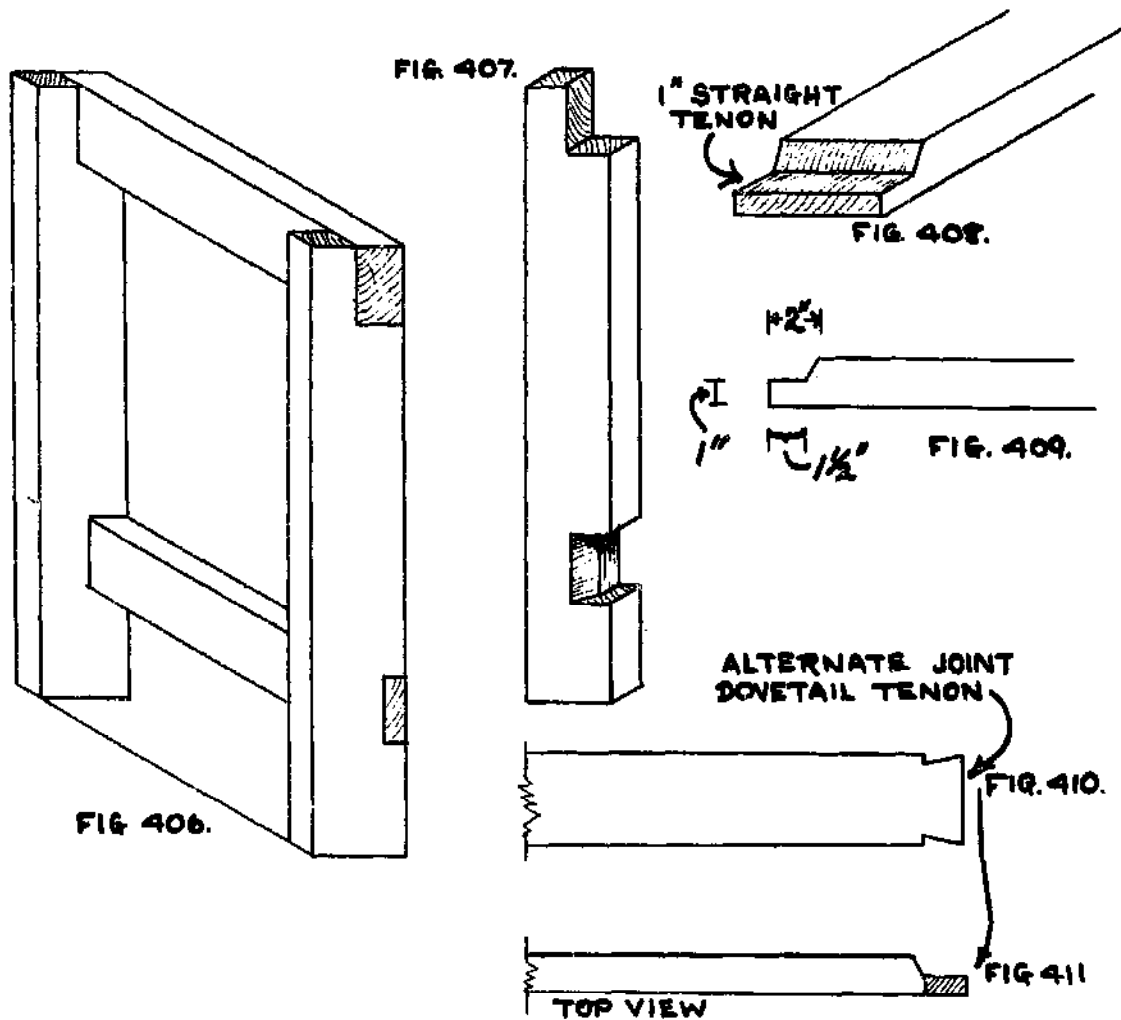


FIG. 405. FACE BOARD

When the deck is complete and nailed or otherwise fastened to the posts and frames, it should be square, level, even, true. It does not need to be planed smooth so long as a straight edge placed in any position across its surface does not reveal humps or cavities.

The front left end must be the carpentry end and side, the rear and right end for machine work. Take care that the braces are put on as shown. Make the frames as solid as possible. If the wood shrinks later on, drive strips of sheet metal in the cracks to keep the joint firm at all times.



The carpenter's bench. This need not take long to build, and when its purpose has been fulfilled, the top planks may be used again for other things. The post frames may be used for a rough work or store room table. Three sets of post frames may be needed. At first try the batten across the middle. If the top is too flexible, put in a single post under the batten; if this fails to give satisfaction, put in the post frame. Again, take care to brace the bench as is shown in the illustration in Fig. 288.

If there is a gang of carpenters, set up drums or posts and arrange planks so that there are several rough benches on one set of supports. But this is hardly good enough for door and window manufacture.

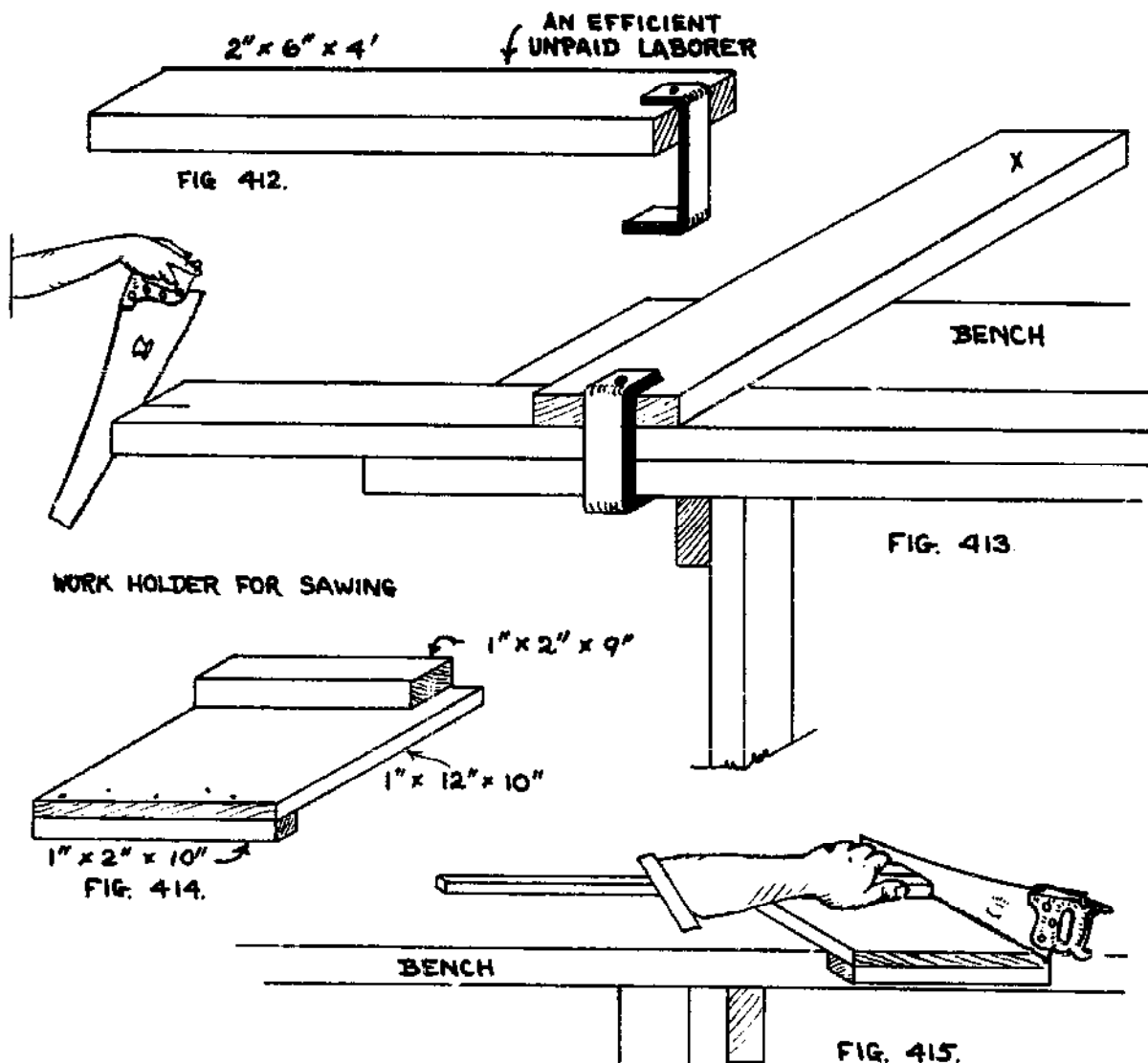


Fig. 422 shows a very handy helper. The iron clamp should be about 7" inside measure to allow for oversize planks and for some ease in handling. A 1" or 1/2" block can be kept handy to insert between the 2" X 6" holder and the piece of work being held. Many carpenters saw as indicated in Fig. 423. Usually a labourer or apprentice is required to hold the plank being sawn. This mechanical unpaid labourer does the work as well or perhaps better. If the four foot stick has not enough weight in itself to hold the work, have a stone or another piece of wood handy and place it on the end of the holder at 'X'.

Figs. 424, 5, show a very handy holder of another kind. It is especially useful where there is no vise, and when small sticks, mouldings, round or otherwise awkward shapes, are to be sawn.

A saw bench. One of the handiest pieces of equipment around the home, as well as the building, is the saw bench. Too often a chair is used to stand on or place things on, when a saw bench would do so much better. Of course, the saw bench is always extremely useful in the work shop.

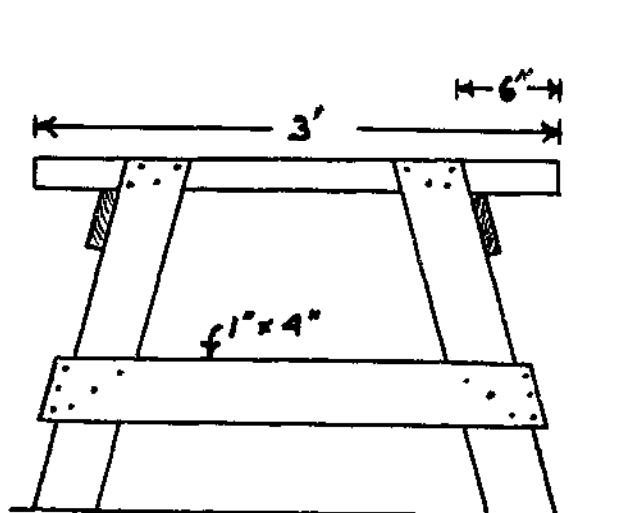


FIG. 416.

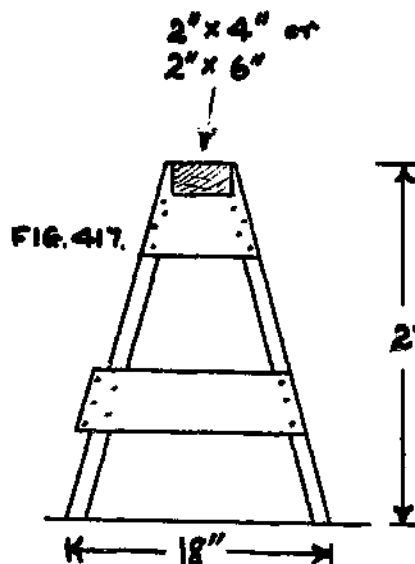


FIG. 417.

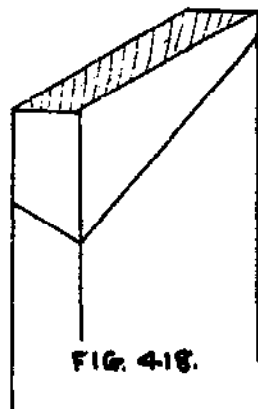


FIG. 418.

LEG 1" x 4"
MARK AND
CUT FACE

INSIDE VIEW OF CUT

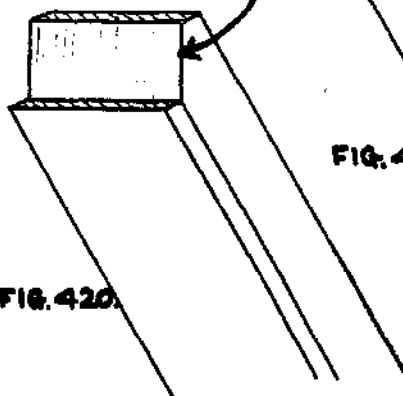


FIG. 420.

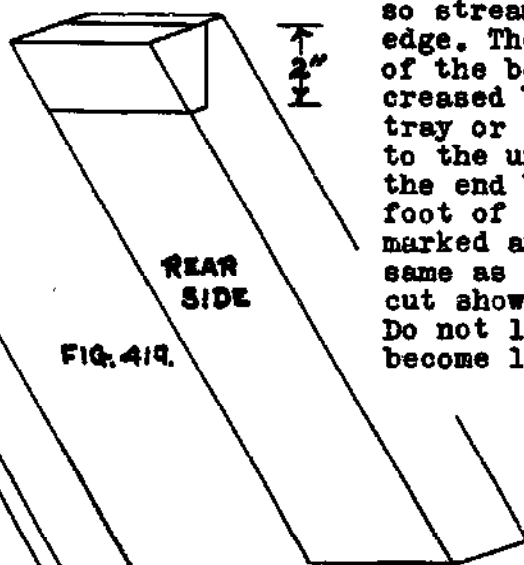


FIG. 419.

The angles marked and cut on the leg may be copied by placing a sheet of paper over these drawings, tracing the angles, cutting out the pattern and transferring it to the wood. It is a refinement to check the top piece for each leg to set in and so streamline the top edge. The usefulness of the bench is increased by adding a tray or shelf, nailed to the underside of the end battens. The foot of the leg is marked and cut the same as the the first cut shown in Fig. 428. Do not let the joints become loose.

IV. SCAFFOLD SUPPORT.

We have found the scaffold jack to be satisfactory for most of our work. It is originally a shingler's jack, used to enable workmen to start shingling a roof at the eave. Our bricklayers do very well on an eighteen inch scaffold, but of course two feet or two feet six inches is better. For 12' planks, space the jacks about every ten feet or less. Have two sets of props, one about eight feet and the other twelve feet. For high work, you may have to splice lumber to make long enough props. Be sure that the feet are properly set in the ground so that they will not settle when the men mount scaffold. Especially new men, who are inclined to be suspicious of a scaffold that stays up by pressure and not by posts. And be sure that they do not seek to make it safe by propping the leg of the jack! Just trot around and inspect the scaffold before the men start work. See that the jacks are in good repair, the feet are non-slip, planks are not cracked, and that there are no scaffold traps. A trap is a place

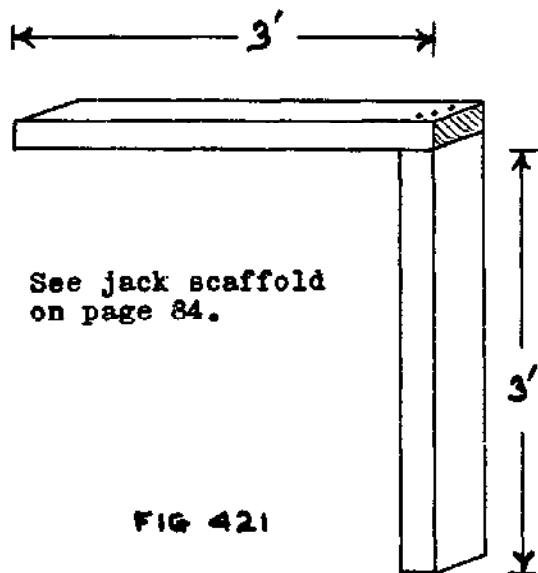


FIG 421

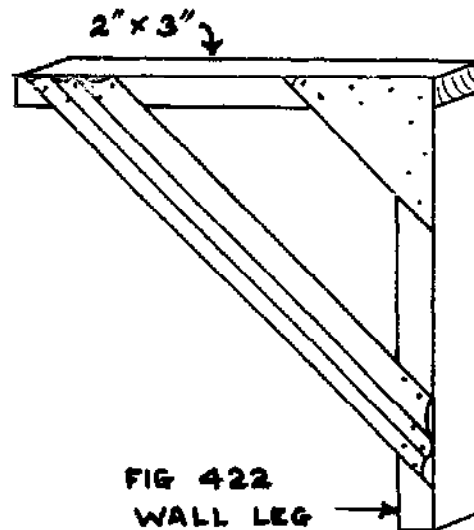


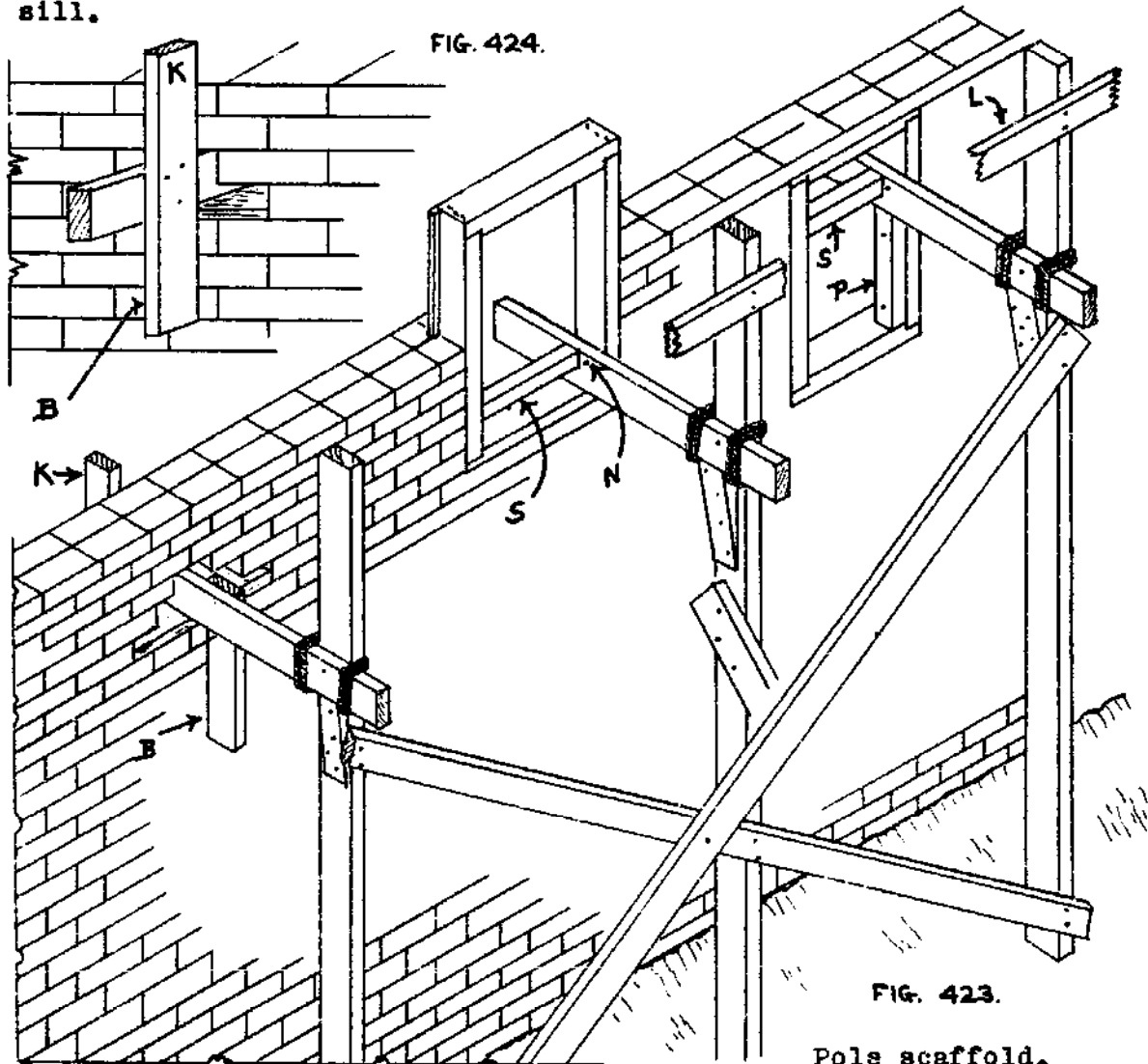
FIG 422

WALL LEG

that looks safe, and ought to be safe but is not. 2" X 3" lumber for the jacks is the lightest advisable. Four jacks can be made from one 2" X 6" X 12' stick. 2" X 6" props can be used on edge with these. If so, tack a 3/4" stick on the upper end of the prop so that it will not have play in its place in the jack. 2" X 4" or 2" X 6" can be used for the jacks. In which case, the props ought to be used flatwise. The corner tie might be better made of metal. Bring it out far enough to catch and hold the end of the prop. The outer edge of the tie should be flanged, the edge being turned once or twice. The long brace may be 1" X 3" wood or be a couple of corrugations from a piece of pan. The edges of this metal brace should be given a double flange, about 5/8" wide.

Pole scaffold. Walls over fifteen feet should have a pole scaffold or else walls should be built from the floors inside the building. Originally pole scaffold was made with smooth poles or saplings for uprights and cross pieces. The joints were made with rope tyings by an experienced scaffolder. A sawn timber pole scaffold is usually nailed together. A combination of the two is most practical. Determine where the cross pieces, or ledgers as they are called, are to be. Then nail wedge-shaped support blocks to the post. Done carefully, this does not need alteration. Or, if different heights are required, leave the block there and use a new one at the new height. When all scaffold is no longer needed, remove all the blocks, easily, without danger.

It is very important that the ledgers be firmly secured so that the end which rests in the wall, cannot pull out, or be worked out. It may rest in a hole left for it in the masonry, or on a window sill, or part way up a window jamb, with a post to the sill.



The higher the scaffold is, the more care is necessary in its construction. If there were a heavy concentration near the central pole in Fig. 433 and someone pushed on the wall, the window frame set in new mud brick wall construction, might conceivably give way and eventuate in casualty. Think about this before it happens to you. Make the scaffold so that it will not give way. If perchance the pole leaned toward the wall, it could not go far, but the sudden panic of a shifting scaffold might lead to disaster. The inside as well as the outside of the ledgers should have battens or, if they are horizontal, liners nailed to them. Then on the posts themselves, a liner should be run from end to end as shown; this would serve as a railing in case a workman lost balance among the debris on the scaffold. A brace outward from the central post is barely indicated as a method of securing stability if no inside batten or liner were used. The scaffold cord shown should be wrapped as shown, tied, and then wrapped once more and tied. There is a nail driven almost home in each ledger to the jamb of the window. There is a strut to keep the ledger in place. In the far window there is a post as well as a strut. Nail or rather tack all posts and struts so that movement of the scaffold will not endanger the structure and life.

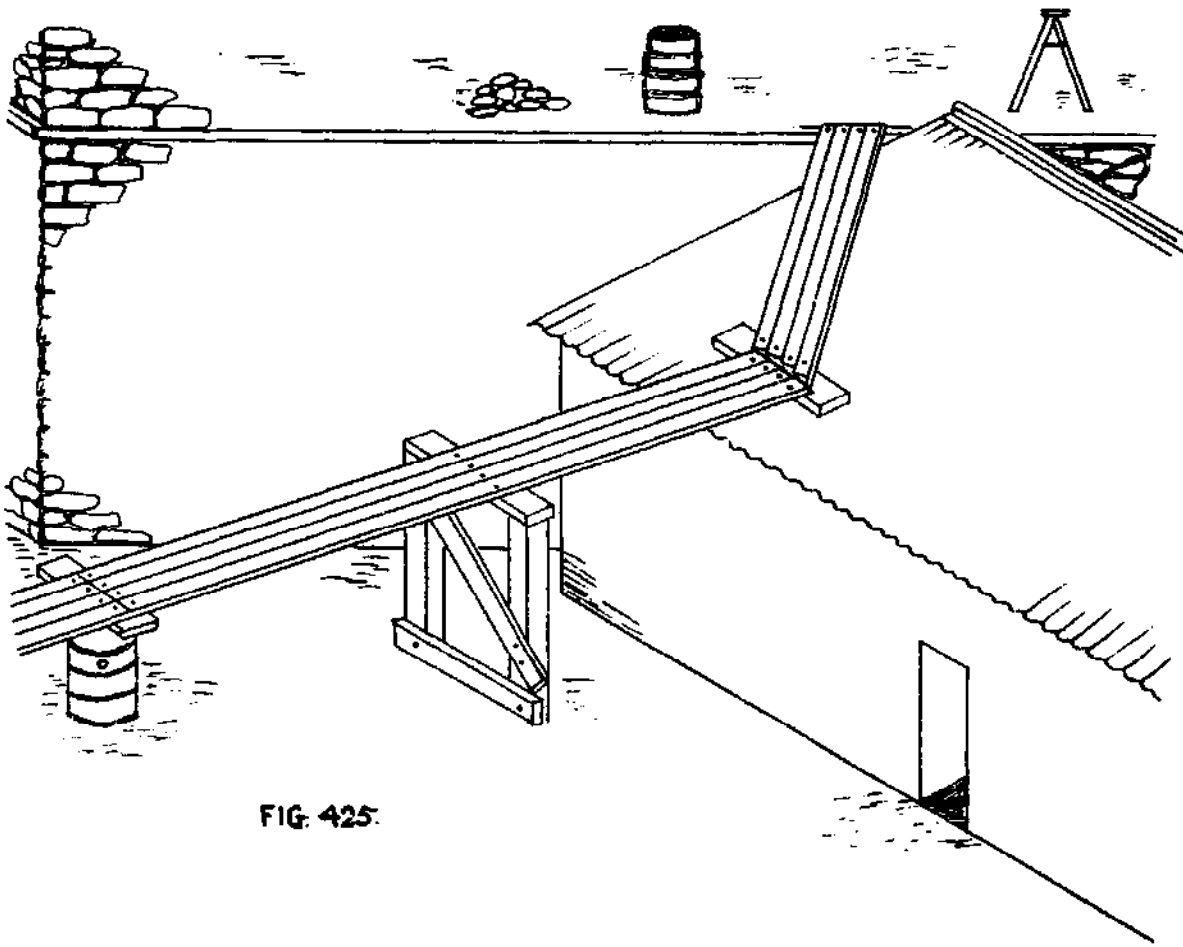


FIG. 425.

Buildings with upstairs present a problem of carriage of materials. If there is a building nearby, use it, if possible, as shown in Fig. 435, to support a ramp or runway. If a staircase is to be built, build it at once and have it ready for all upstairs work. Almost anything is better than to have to carry all materials upstairs by ladder.

Chimney scaffold. The great expense of making a proper chimney is a considerable inducement to make the chimney right the first time. However when the scaffold is necessary, make it on the same principle as the pole scaffold. Anchor it to the building at every lift or length of poles. At chimney height the following arrangement is advisable.

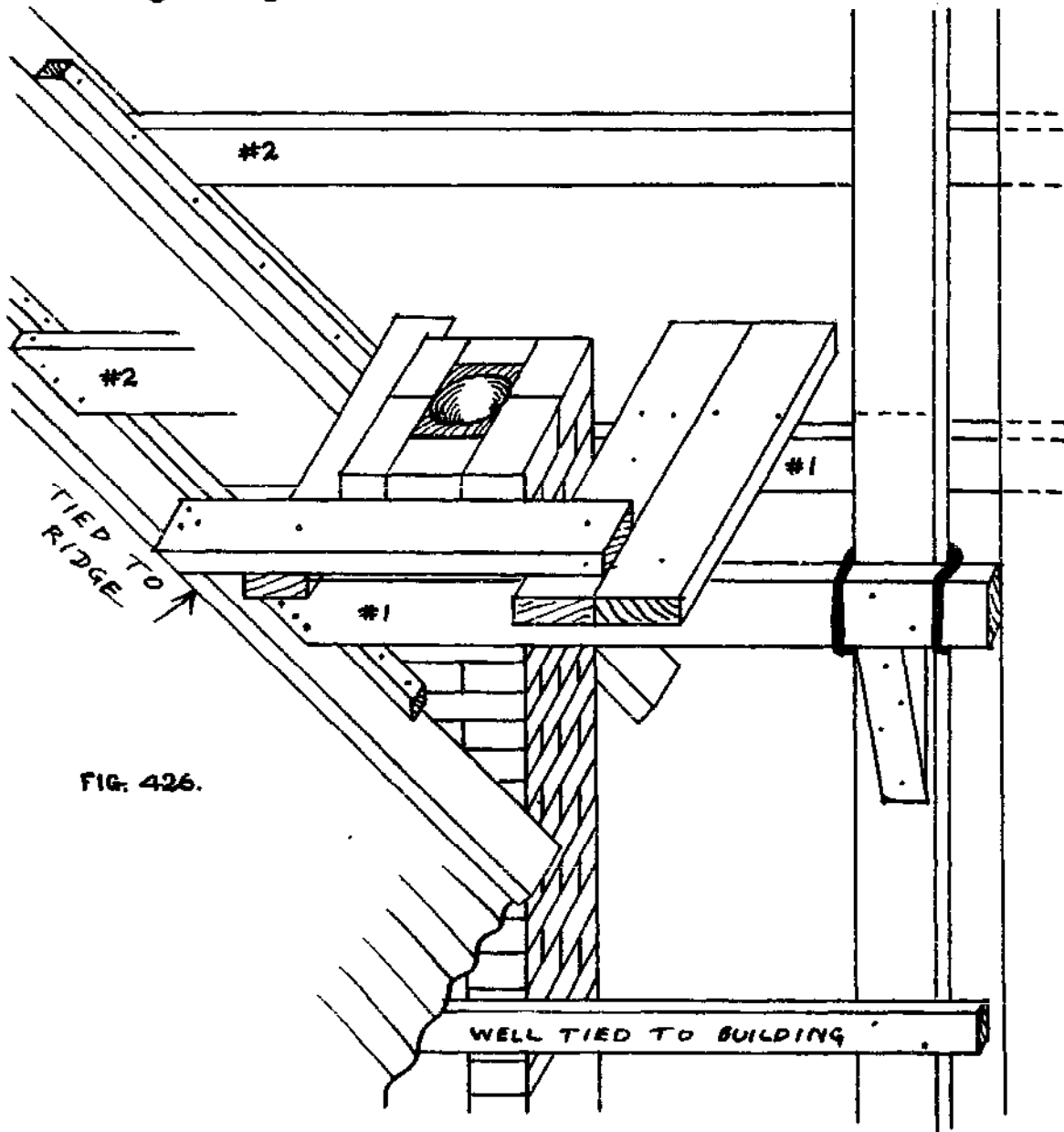


FIG. 426.

Bricklayers should not have to set frames, except for those door frames which rest directly on the concrete floor, and have iron pins to secure them against movement. The bricklayer will set the frame in place to make sure that the holes for the pins are in the right place. Then fill the hole with thin cement paste, (cement and water only) and set up the frame. The carpenter should have the braces to secure the frame in a true and plumb position at once. Level the lintel, plumb each jamb.

Door frames set on metal ant course.

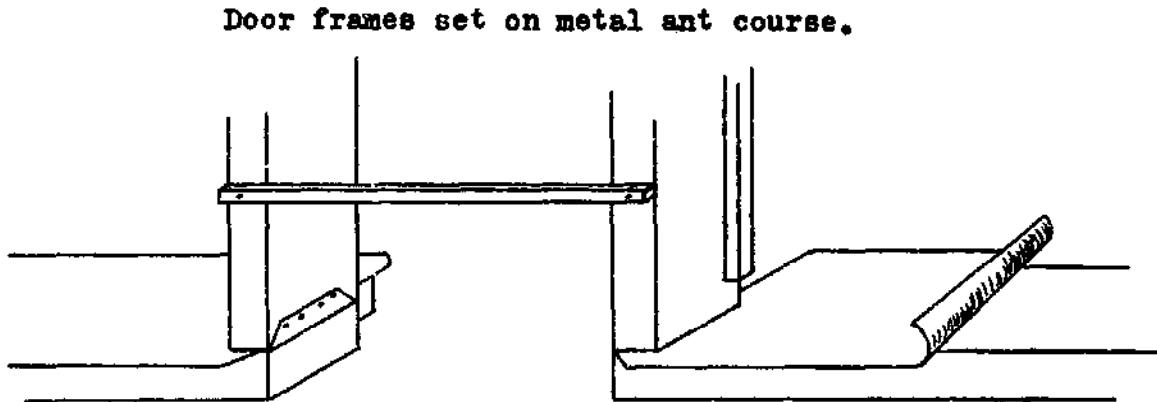


FIG. 427.

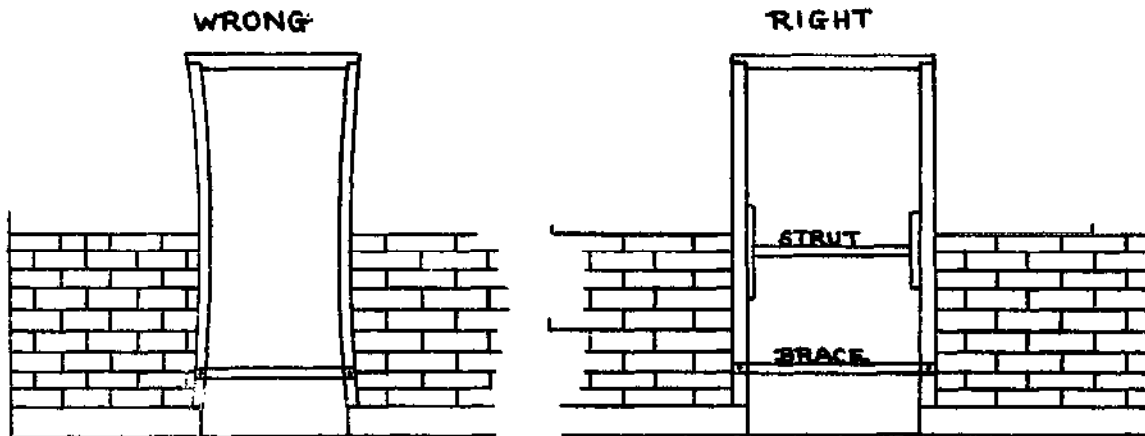


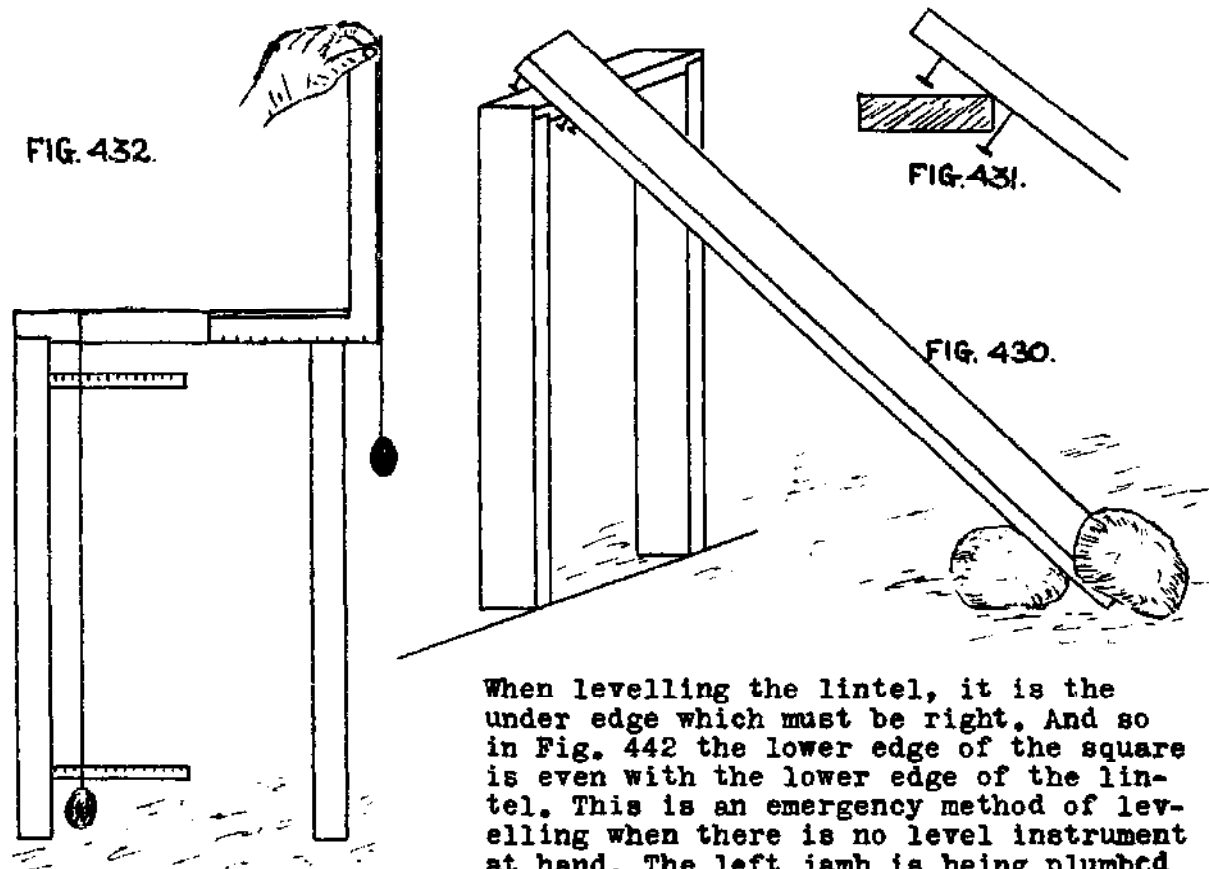
FIG. 428.

FIG. 429.

In Fig. 438 the strut has been left out, or taken out, and the thrust of each brick against the jamb has had the cumulative effect of distorting it. Even with the strut, if one side is built up and not the other, the frame is almost certainly to be pushed out of plumb. The heavy line indicates the wall ties. When these have been built in and the work has set for a few hours, the struts may be taken out. Constant checking of level and plumb edges is necessary.

In Book Two, Chapter Ten, there is a subdivision dealing with some points on frame setting to the line.

We recommend that the frame be held erect merely, until the foot has been nailed to the first course, and several courses of brick have been laid, before attempting to plumb it accurately and fasten it permanently. The first staying can be a piece of 2" X 6" with two nails as shown. After the feet of the frame have been anchored, there are at least two ways of making permanent fastening. In the one, the frame is braced with four braces as shown. Or, it may be braced from a post which itself has been firmly braced. This latter is convenient if there are a number of frames within the reach of the longest sticks you have.



When levelling the lintel, it is the under edge which must be right. And so in Fig. 442 the lower edge of the square is even with the lower edge of the lintel. This is an emergency method of levelling when there is no level instrument at hand. The left jamb is being plumbcd with a string and plumb bob. This is an excellent method of plumbing a frame. Set the string at the top so that there is room for the bob to swing free. Measure to the inside edge of the string at the top, and then at the bottom. Adjust the frame until the bottom measure agrees with that at the top. To adjust a properly made and braced frame, it ought only to be necessary to lift one or other of the feet a little. With the line method, the face of the frame can be plumbcd at the same time. Merely step to the side of the frame and sight the edges of the jamb and the line. When all are in line, the frame is plumb with respect to the face of the wall.

Braces from the ground as in Fig.441 are not satisfactory after the first few minutes; workmen are continually knocking them.

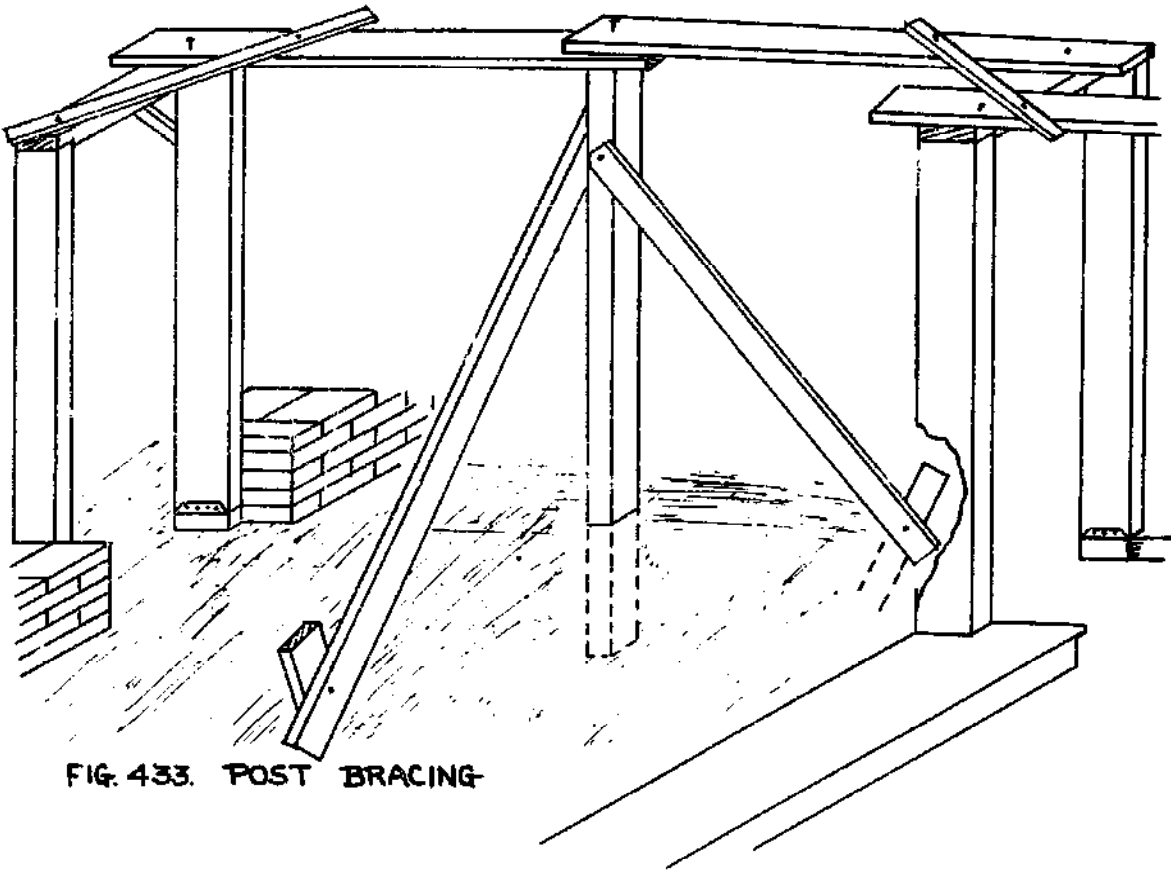


FIG. 433. POST BRACING

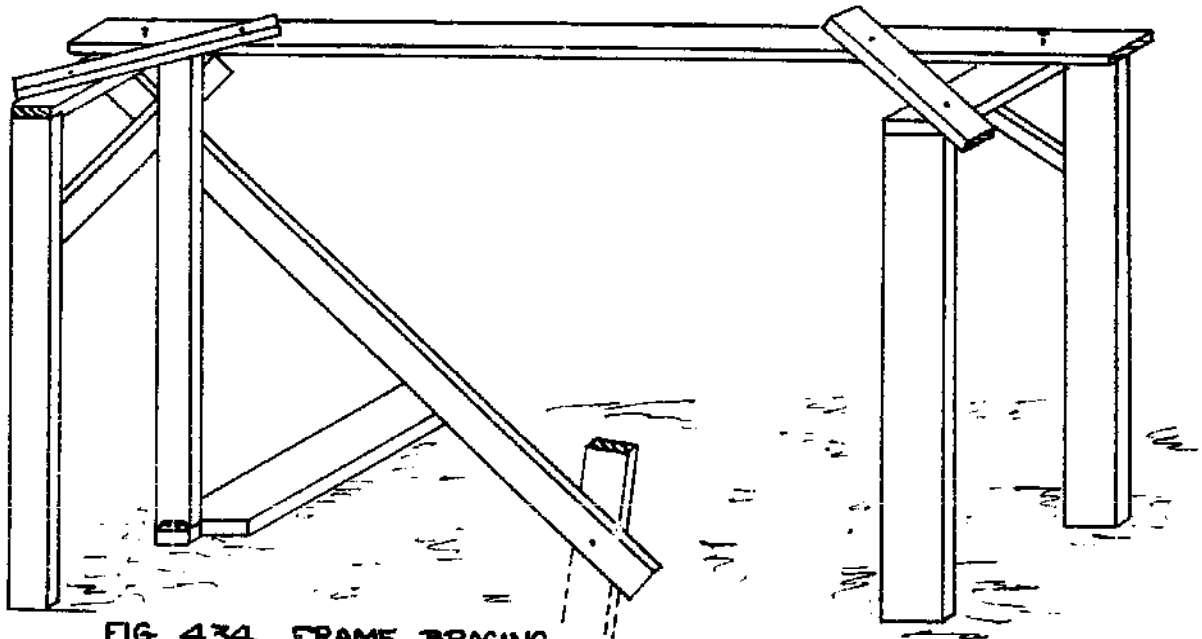
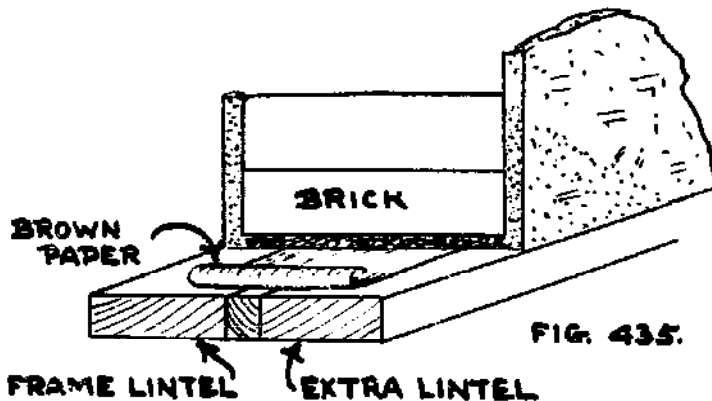


FIG. 434. FRAME BRACING

The extra wood lintel required for door and window openings should be made individually to fit the particular frame lintel it will be used with. The reason is that lumber varies so in width, that one lintel will be a full six inches wide and another just 5-1/4". It is a waste of time to reduce all frame lumber to the same size. So, measure the width of one lintel and name or number it. Then make the lintel that will be used with it. Of course the over-all width of all lintels should be the same; which is width of brick plus the thickness of plaster both sides.

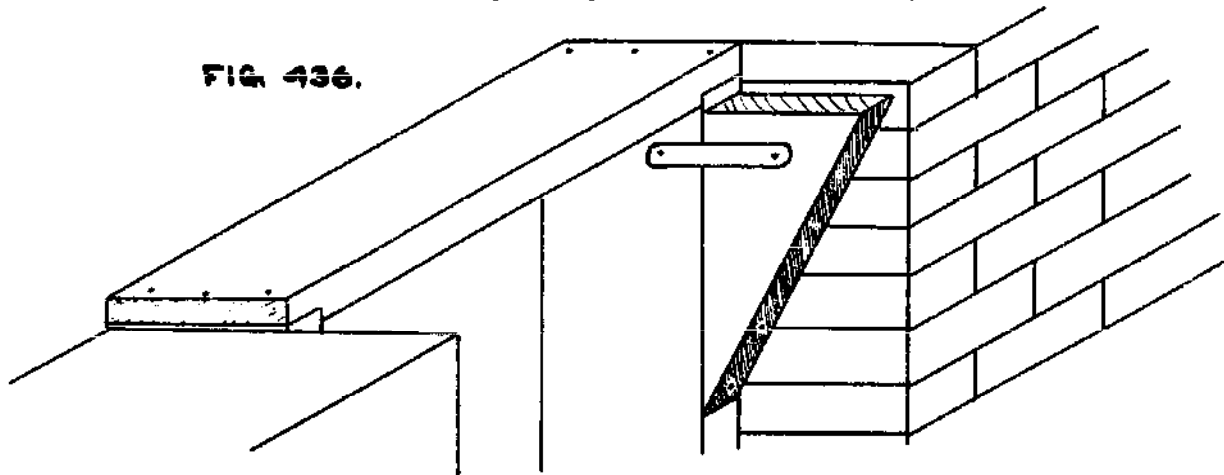
Under cut the joint of the extra lintel so that as close a joint as possible will be made with the frame lintel. If you have plenty of thick brown paper, lay a sheet over the entire lintel to prevent the sifting of sand through the cracks.

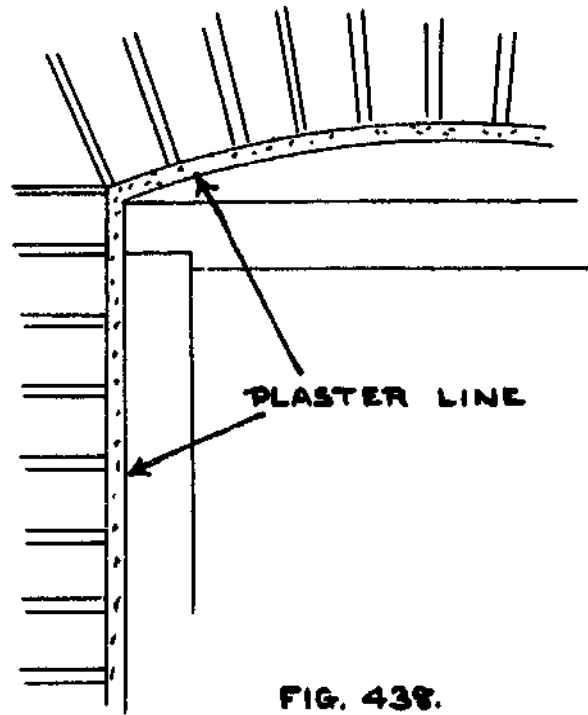
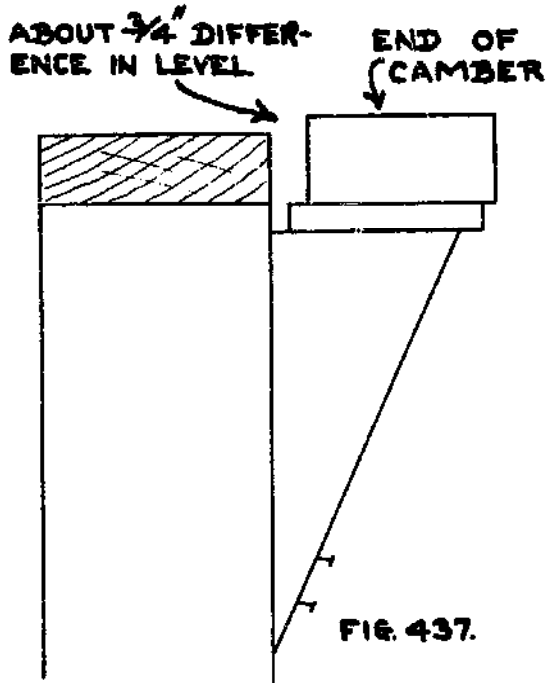


In setting lintels, the less mortar used the better. If, to bring the lower face of the lintel even with the other lintel, a great deal of mortar would have to be used, get a thin piece of wood, bed it in mortar and rest the lintel on it. A very common fault is the second lintel depressed below the first. This is entirely due to building on the lintel with too much mortar under it. Another method would be to use

small stones and mud and then when the lintel has been on it some hours, commence to build on it.

Take care that the ends of the lintel project equally into the brickwork each side. They are seen; they are often used for curtain supports, and inequality will be observed.





In Fig. 446 the wedge used to support the camber is tacked to the edge of the jamb to support the weight; the metal tie is used to keep the wedge from falling outward. 1" nails in this sheet metal tie are adequate.

In Fig. 448 a wood block has been placed on the top of the wedge block to bring the end of the camber about 3/4" above the top edge of the frame lintel. In Fig. 448 the reason for this is shown. The bricks of the arch must be above the lintel to allow for the plaster. Otherwise the plaster will cover the frame, and this is undesirable.

CHAPTER SEVEN

ROOF FRAME PREPARATION

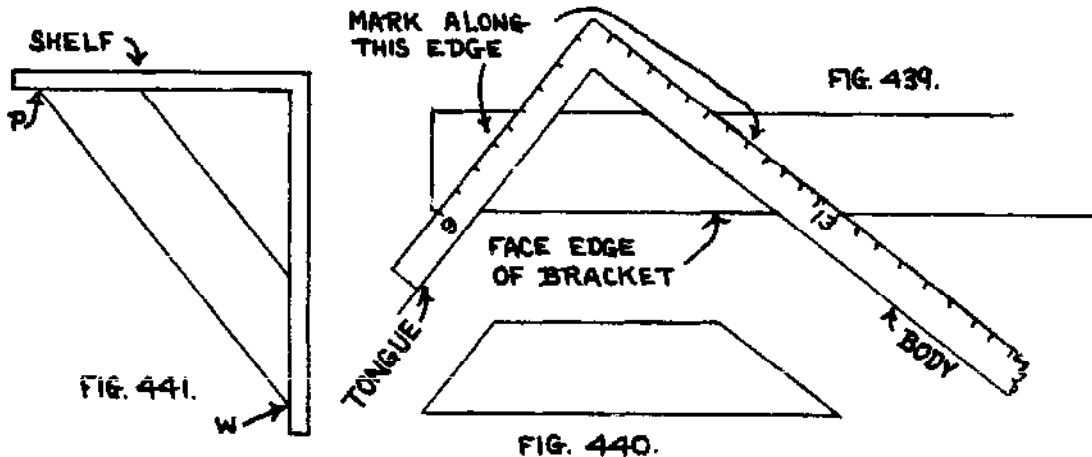
I THE STEEL SQUARE.

The framing square, commonly called the steel square, has a number of uses beside squaring an angle and laying out a roof. We do not take up the question of pitch roofs in this volume because there are a number of excellent treatises on the subject in print, chief of which in our estimation are Audels Carpenters and Builders Guide of general carpentry, and also Hodgsons Steel Square. The fact is that this department of the steel square is seldom required because corrugated iron requires few rafters and the few on the hip are probably irregular in spacing. The pitch of an iron roof is determined, economically, by the lengths of iron.

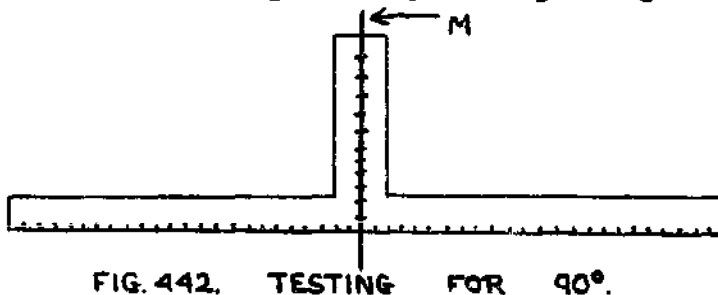
The study of the steel square for irregularly pitched roofs is more or less elementary and to lead up to it, we will consider some simple applications of this handy tool.

1. How to cut a shelf bracket with the use of the steel square.

Determine the distance from the wall or the line of the bracket bearing to the toe or point of the bracket. Also the point where the lower extremity of the bracket is to be. In the diagram these points are P and W respectively. Suppose that these distances are 9" and 13". Take the material of which the bracket is to be made and place the square on it so that 9" on the tongue and 13" on the body are on the face edge of the wood, as shown in Fig. 439. Mark the board along the edges of the square.



2 How to draw various angles and figures. Do not take it for granted that any square is really 90 degrees, that is if you wish to do accurate work with it. Below is shown how to test any square. Place it on a perfectly straight edge or line, and make a mark 'M'.



Then turn the square over, with the edge of the body along the first straight edge or line and draw it toward the mark M. If the tongue agrees perfectly with this line the square is 'square'. If it is not, take care how you correct it. The

steel square is a comparatively fragile tool and is easily broken where the tongue joins the body.

Note that a real framing square figures on each side are not the same. On one side the inch is divided into sixteenths; on the other side the inch is divided into twelfths.

Making the angles of forty five degrees, sixty seven and a half degrees, thirty degrees, sixty degrees, etc.

The degrees in the angles of any triangle add to 180. If, therefore, one angle be 90 degrees and another be 30 degrees, the third will be 60 degrees. Hence if we do not show all the common angles required, it will be because they are to be found through the angles we do give.

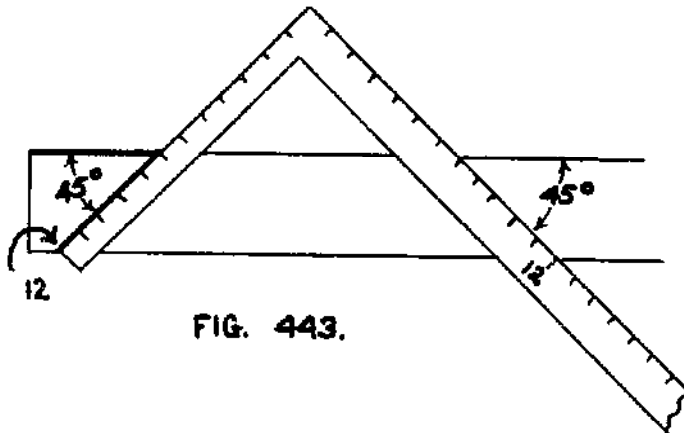


FIG. 443.

In the illustration the figure 12 is used but any pair of figures will do to obtain the 45 degree angle on the square. This angle is often required to mitre cut two pieces in a right angle such as a frame, or in wood trim.

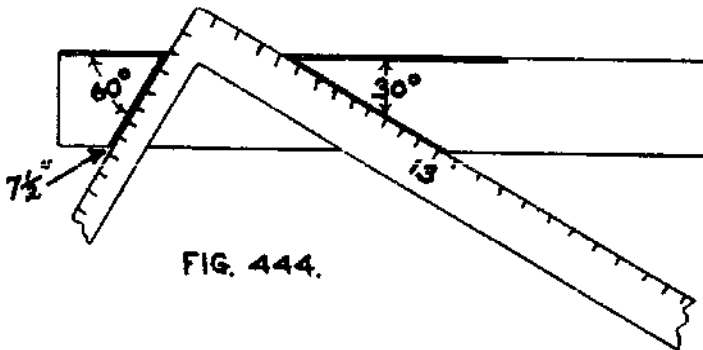


FIG. 444.

The 60 degree angle is prominent because the triangle with three equal sides has three 60 degree angles.

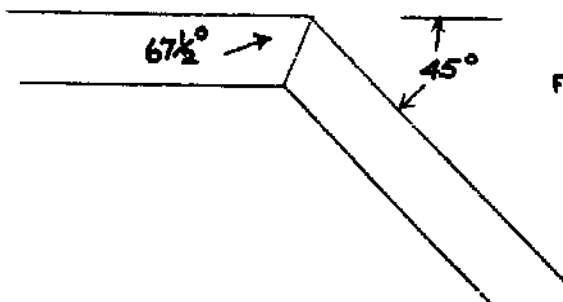
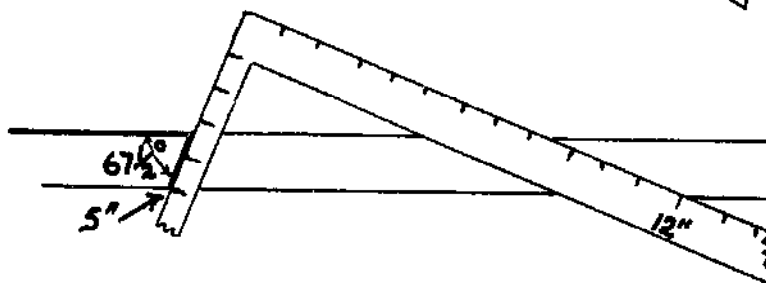


FIG. 445.

The 67-1/2 degree angle is shown because it is used to mitre cut each of two pieces whose exterior angle is 45 degrees. That is, the angle in the sill of the bay window whose side sill is 45 degrees off the main line.

The irregular brace. It may be necessary to obtain the angle on a brace which is not parallel with the diagonal of the rectangle in which it fits. It is no problem on a door where the material can be laid on the frame and marked at once. But when the diagonal exceeds in length the material being used, or for some other reason the angle is desired, the following will be helpful.

FIG. 446. THE PROBLEM.

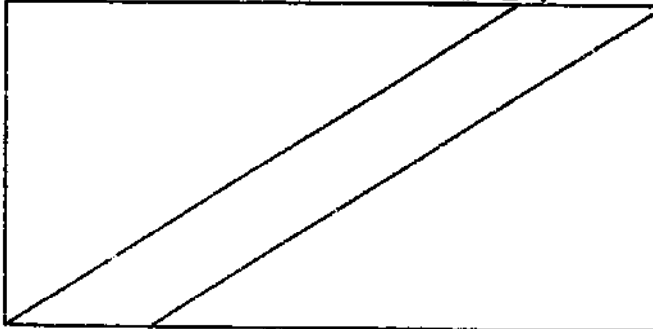


FIG. 447. THE SOLUTION

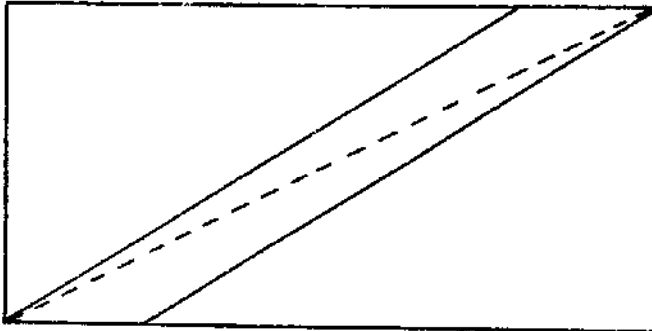


FIG. 448.

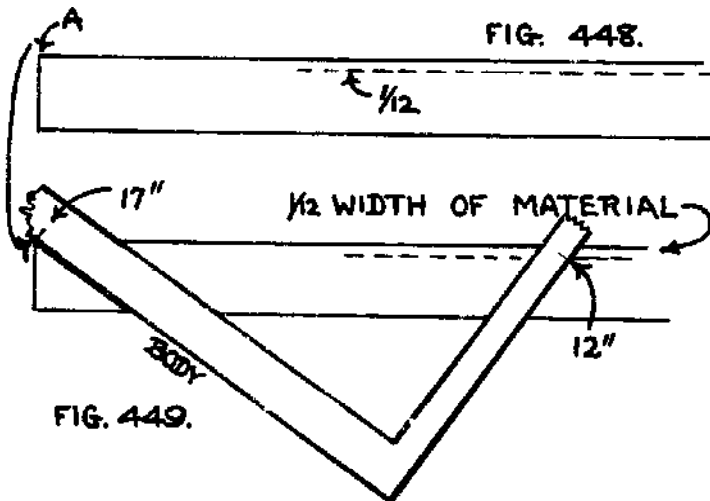


FIG. 449.

Make a drawing of the rectangle and the brace to the scale of one inch equal to one foot. Suppose the length to be 17' and the height 12'. Draw in the dotted line from one corner to the other. We now proceed to reproduce this dotted line in part on the material of which the brace is to be made.

Mark off $\frac{1}{12}$ of the width of the board and make a pencil point. Through this point draw a dotted line parallel with the edge of the board. (See the next page for method of dividing a given line into a number of equal parts.) Now place the square on the material with the 17" mark on 'A' and the 12" mark on the dotted line. Mark across the material from 'A' along the edge of the square. This is the angle required for each end of the brace.

The length of the brace can be scaled from the square. Place a rule on 17" mark and on the 12" mark. The length of the brace in feet is the number of inches. If your rule is not divided in twelfths make a line that long and use the twelfths on the square. If the square has not twelfths, the following table will probably be close enough.

In the scale of one inch equals one foot, the following fractions of one inch on an ordinary inch ruler denote the inches indicated.

1"	is equal to	12"
3/4"	" " "	9"
1/2"	" " "	6"
1/4"	" " "	3"
1/8"	" " "	1-1/2"

If in the foregoing problem you cannot use the one inch scale, then herewith a table for finding the dotted line with the other common scales.

For 1" scale mark off 1/12 the width of the material.

" 3/4"	"	"	"	1/16"	"	"	"	"
" 1/2"	"	"	"	1/24"	"	"	"	"
" 1/4"	"	"	"	1/48"	"	"	"	"

Problem: To divide any width board or line into any given number of equal parts. Example one. A board. To divide the board into five equal parts. The board we have chosen is wider than five inches. We place the heel or corner of the square on one edge and the figure 10 on the other edge. Then 2", 4", 5" and 8" are in order, one fifth, two fifths, three fifths and four fifths the width of the board.

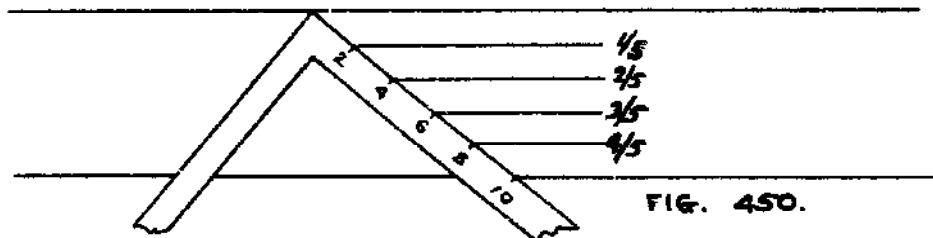


FIG. 450.

To divide a given line into a certain number of equal parts. Let AB be the given line. With the heel of the square on A make a mark along the square at the point which will correspond with the number of parts desired. Suppose that it is 25. Since we have not 25" on the square, we will use 1/2". Then we will make the mark at 12-1/2" which is twenty five half-inch divisions. Join the end of this line with the end of the given line. If the whole line is to be divided into twenty five parts, draw lines through each half inch mark parallel to the end line.

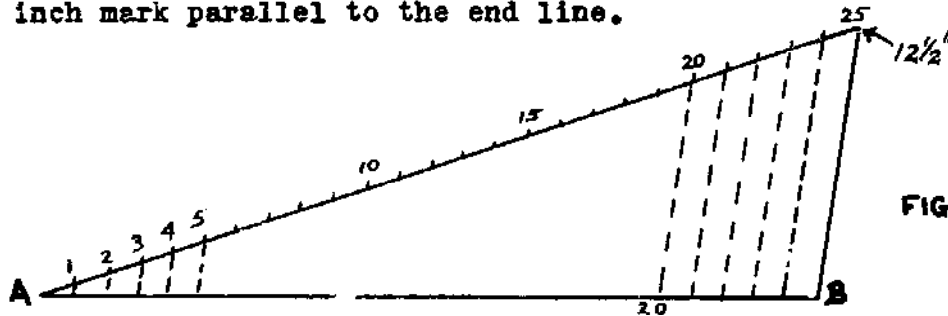


FIG. 451.

Making an octagon in a given square. Place the heel of the square on one line and the end of the square, (the 24" mark) on the other line bounding two opposite sides of the square. Pin point at 7" and 17" and draw lines through these points parallel to the first two lines. Where these two lines cross the sides of the square, draw lines at 45 degrees.

FIG. 452. OCTAGON LAYOUT.

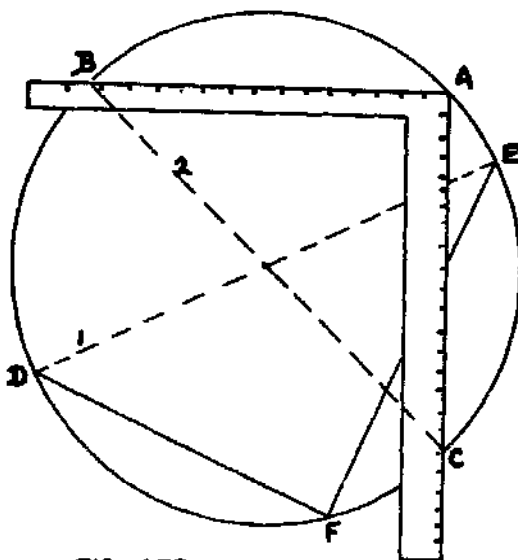
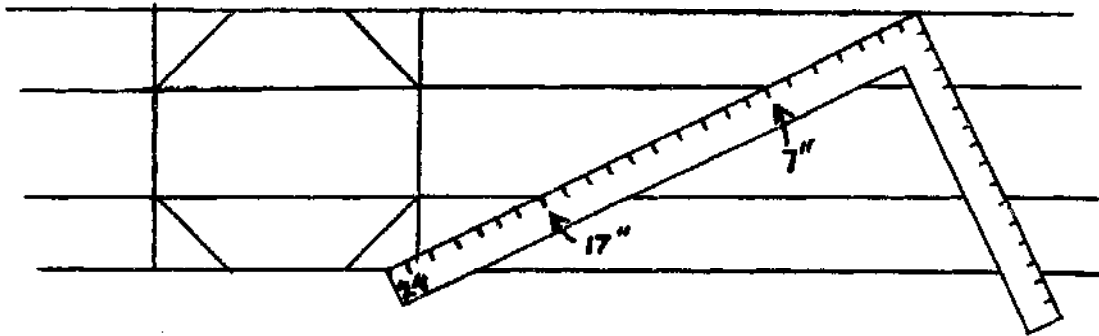


FIG. 453.

CENTRE FINDING

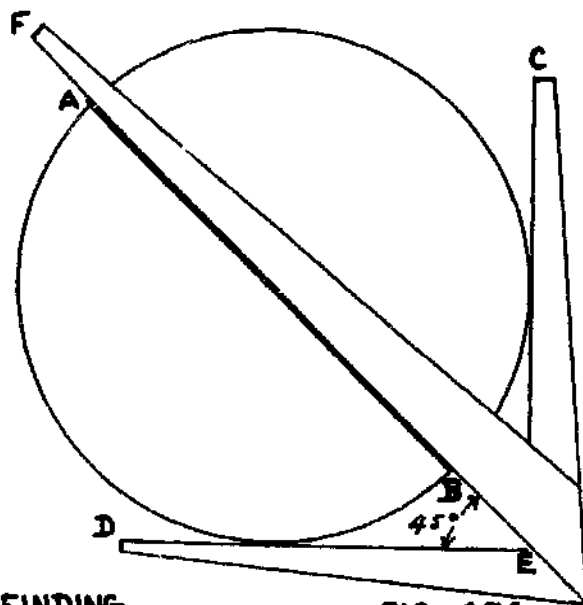
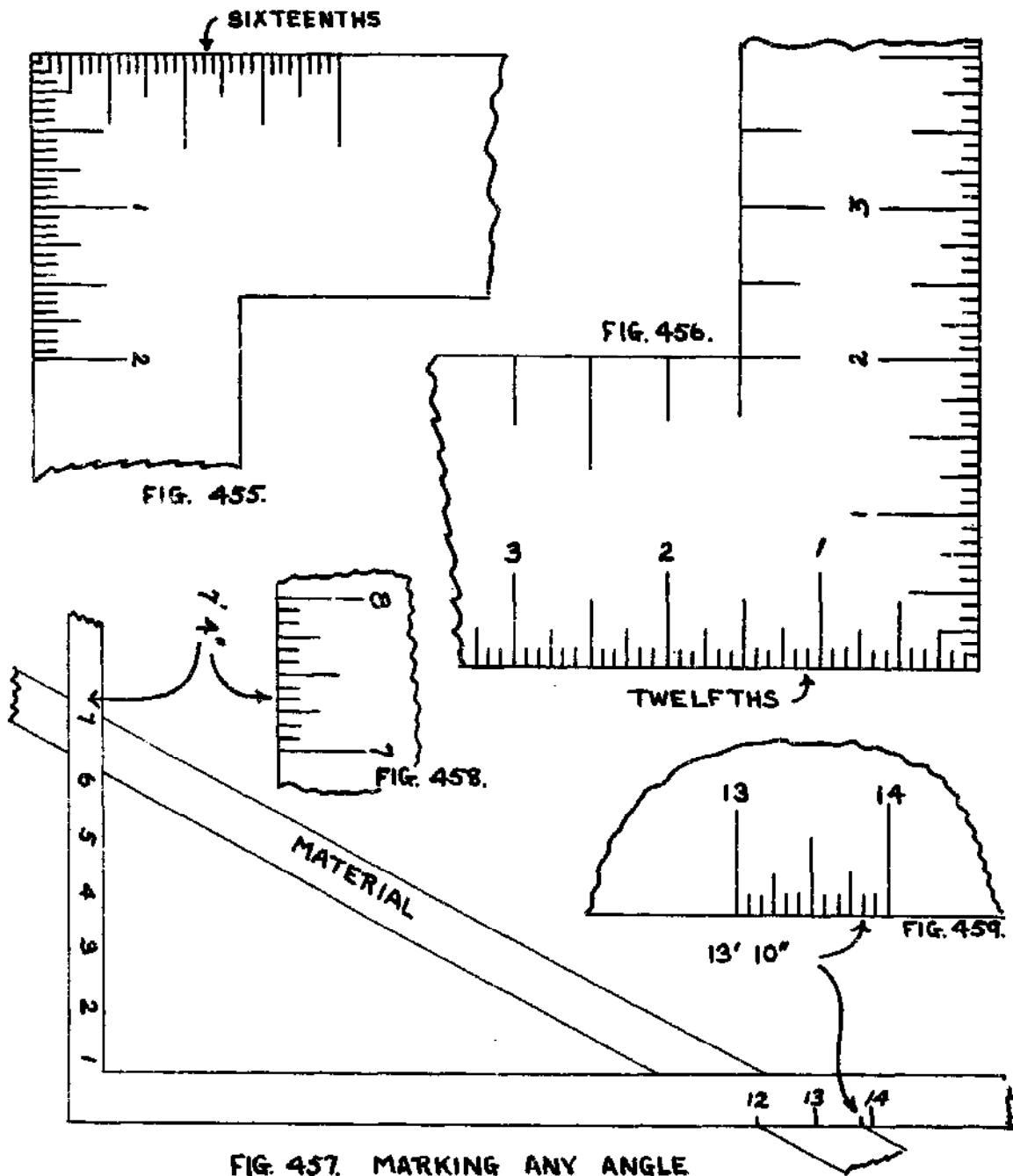


FIG. 454.

To find the centre of a circle with a steel square. Place the heel of the square against the circumference anywhere. At B and C where the square cuts the circumference make pin points. The line joining them is a diameter of the circle. Again place the heel against the circumference at some suitable point as at F. Again pin point the intersections of the square with the circumference and join the points. The intersection of the two diameters is the centre of the circle. In Fig. 454 a frame is made, DEC being a right angle, and blade KF with edge bisecting the angle DEC. The line AB is a diameter of the circle.

3. Scale. The common steel square has a body of 24" and a tongue of 12". But framing squares have a tongue of 16" or more. On this square, one side will have sixteen graduations to the inch and the other side 12 graduations to the inch. By use of the latter all roofs can be laid out. An angle involving two sides, 13'10" and 7'4" can be determined instantly.



II. ROOF PARTS, FUNCTIONS, TERMS.

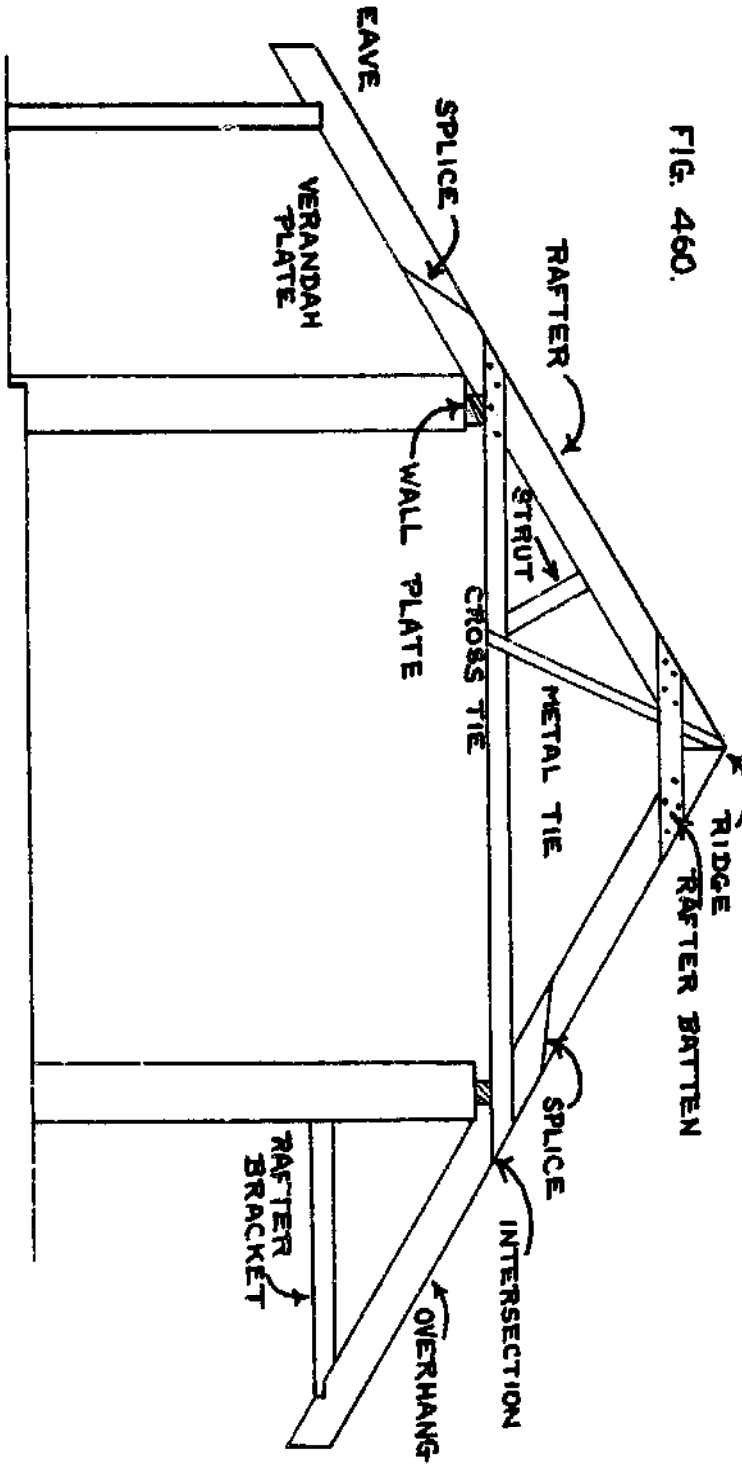
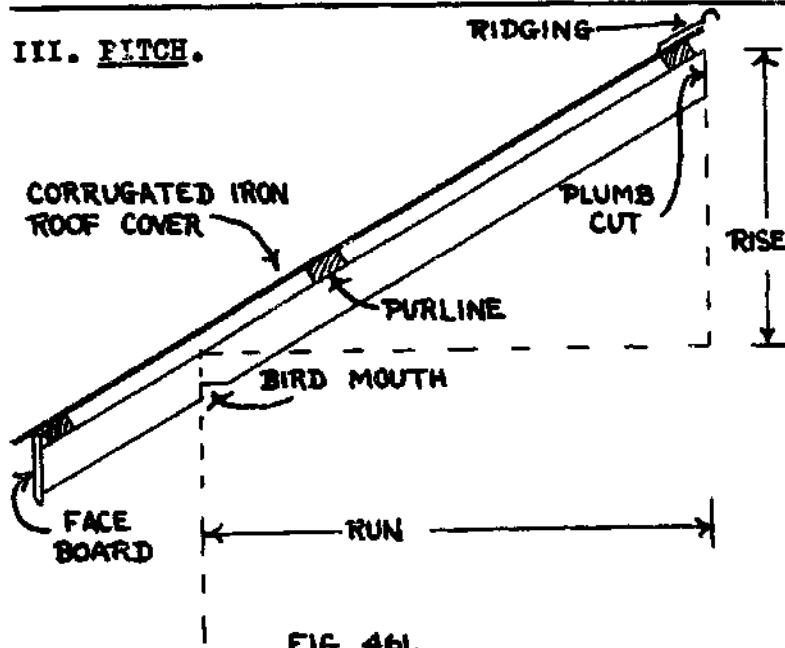


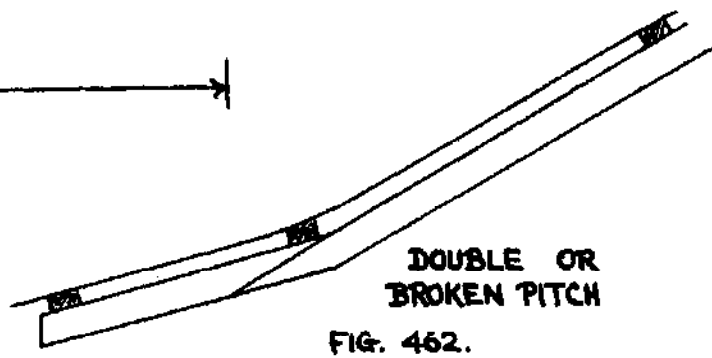
FIG. 460.

The rafter is a beam, supporting weight between two points of rest, the wall plate and the ridge. The cross tie is in tension and prevents the rafters from spreading at the wall plates. The cross tie may be of wood, wire, strap iron, steel rod, etc.; it is not a beam and need not be stiff or heavy. The strut supports a long-span rafter, and is in compression. The metal tie from the ridge, and the cross tie together support the strut. The strut must always have a metal tie from the ridge to its base, or, it may rest on the cross tie where the latter rests on a partition.

III. PITCH.



Pitch is the angle of the roof and is given a numerical value which is the result produced by dividing the rise by twice the run. In frame buildings and where the wall plate is flush with the face of a masonry wall, twice the run would equal the



width of the building; but where we place the wall plate in the centre of the wall to get better bearing as in mud walls, the width of the building is considered to be from the outer edge of the wall plate to the corresponding point on the other side.

Most roofs have standard pitch, and framing squares are figured to facilitate the measurement and angle cutting of all parts. But where corrugated iron is used, or similar sheeting, the pitch should be determined somewhat by the lengths of iron. This has been discussed in pages 22 ff. Arbitrarily we have adopted a minimum pitch of 30 degrees as standard for dwellings. This is a little steeper than 1/4 pitch. But we do not hold to the 30 degrees absolutely. If the width of house and the lengths of iron do not work out evenly, we raise or lower the pitch accordingly and so make use of every inch of iron and avoid waste in cutting.

The commonest pitches are given in the table on the next page. Steeper pitches are cooler, but of course cost more. Compare the pitch you intend to use with those on buildings you can observe. Hold your pitch plan in your hand as you look at the end of another building and decide whether yours ought to be higher or not.

Where a roof beyond the wall is supported by wall brackets rather than posts, we call it roof overhang. We have adopted the horizontal bracket because we can support the rafter at a lower point than with an upward pointing bracket. We found that even in three feet extension beyond the bracket there was sag in the rafter.

Fig. 464 shows a common rafter, pitched at 30degrees and measuring 16' run, 9'3" rise. Place the square on the rafter material as shown, with 16" mark at one end and the 9'3" mark along the same edge. Mark from the 16' point across the material. This is the bottom cut of the rafter. Every horizontal cut on the rafter anywhere is made in the same way.

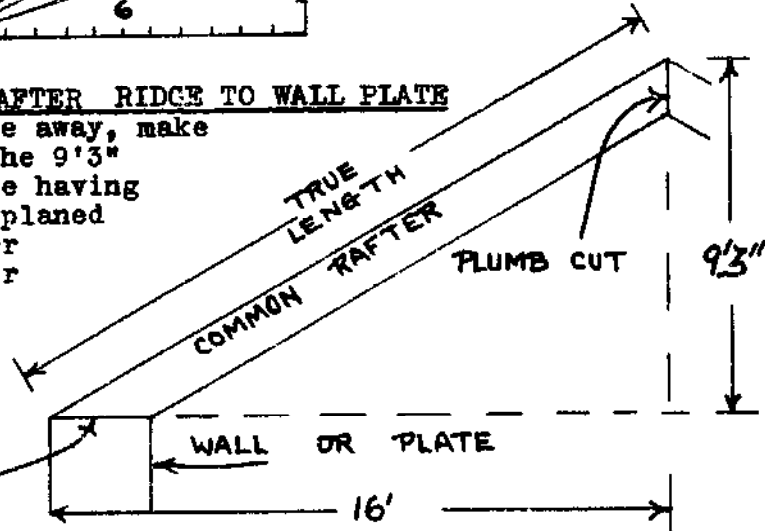


FIG. 463.

$\frac{2}{3}$ PITCH.	$\frac{16}{24} = \frac{2}{3}$
$\frac{1}{2}$ PITCH	$\frac{12}{24} = \frac{1}{2}$
$\frac{1}{3}$ PITCH	$\frac{8}{24} = \frac{1}{3}$
$\frac{1}{4}$ PITCH	$\frac{6}{24} = \frac{1}{4}$
$\frac{1}{6}$ PITCH	$\frac{4}{24} = \frac{1}{6}$

IV. THE COMMON RAFTER RIDGE TO WALL PLATE

Before taking the square away, make a fine pencil mark at the 9'3" point. It is worth while having the edge of the rafter planed both sides of the corner out to this distance for accurate measurement. The true length of the rafter is the distance between these marks converted into feet.



HORIZONTAL CUT

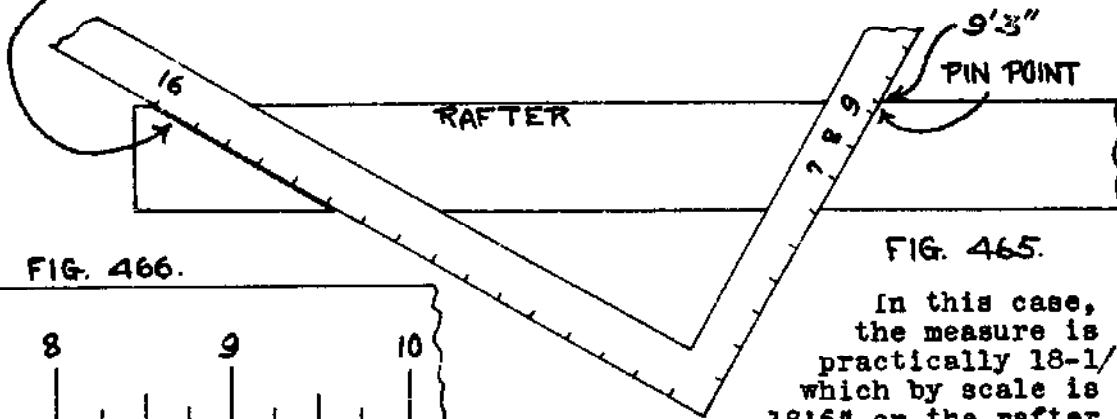


FIG. 466.

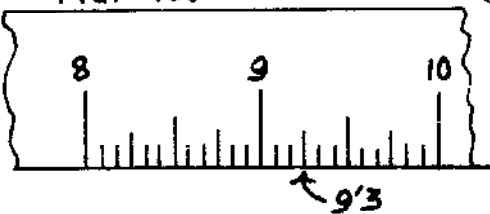
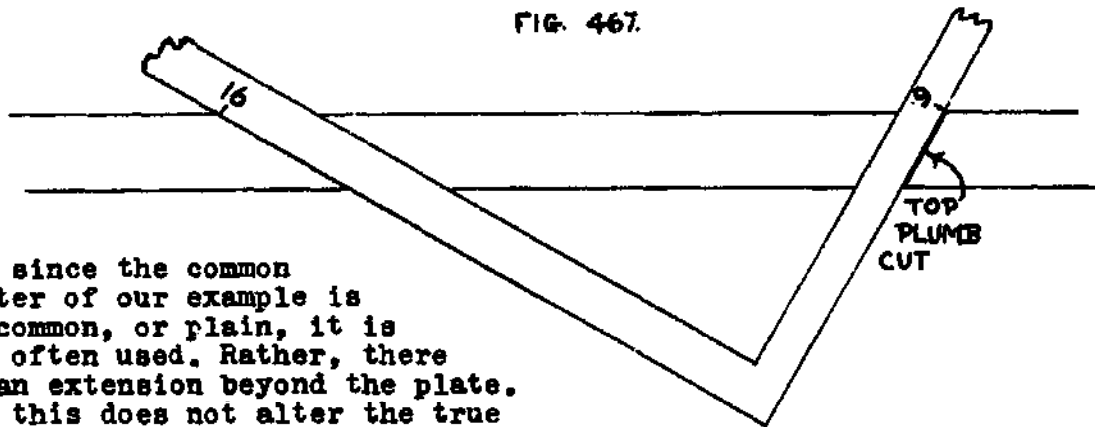


FIG. 465.

In this case, the measure is practically 18-1/2" which by scale is 18'6" on the rafter.

Measure off 18'6" on your material and place the square as at the first, except that the top mark coincides with the 9'3" on the square, and the 16' mark will be down the edge.



Now since the common rafter of our example is so common, or plain, it is not often used. Rather, there is an extension beyond the plate. But this does not alter the true length of the rafter or any of the angles or figures as is shown in Fig. 468. We have shown the common rafter used previously, by the dotted lines. By moving its upper edge straight up we have changed nothing essential. For convenience sake we use the upper edge of rafters for all measuring.

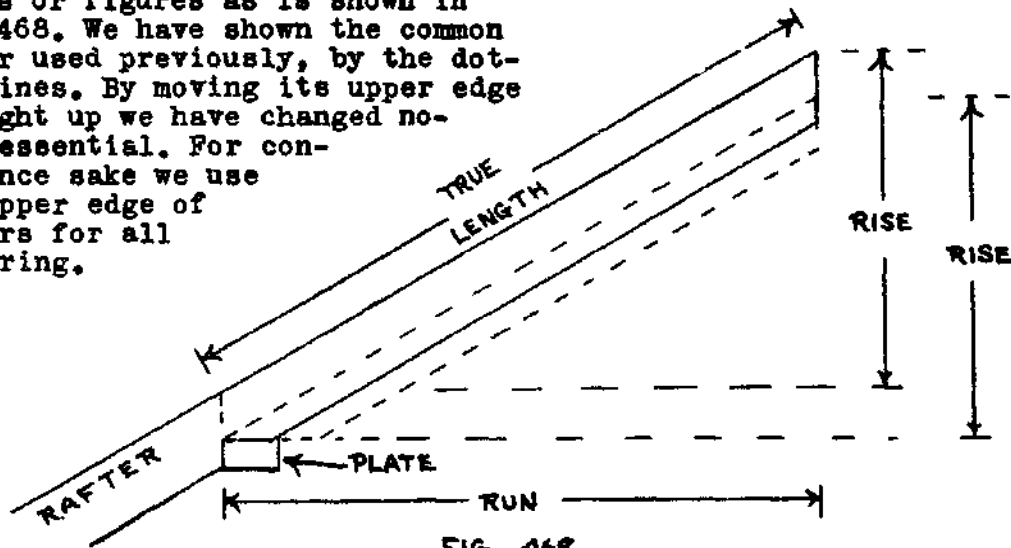


FIG. 468.

It is well therefore to see that edges of rafters are straight, reliable. A very slight crown, or slight curve upward is permissible in practically all beams, rafters, joists, etc., but very little. They should never have the curve downward.

In Fig. 461 we have called the small cut-out for the plate, the birdmouth. In all 2" X 6" rafter work we have set a distance for this from the upper edge. It is laid out as follows:

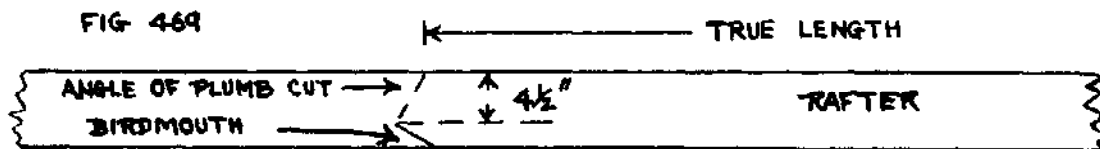


FIG. 469

2. The same principle is used for a rafter which touches wall plate and verandah plate, or a second wall plate. In these latter cases we will have an over-all length which will have nothing to do with the plates. We establish our pitch angle from the main wall plate.

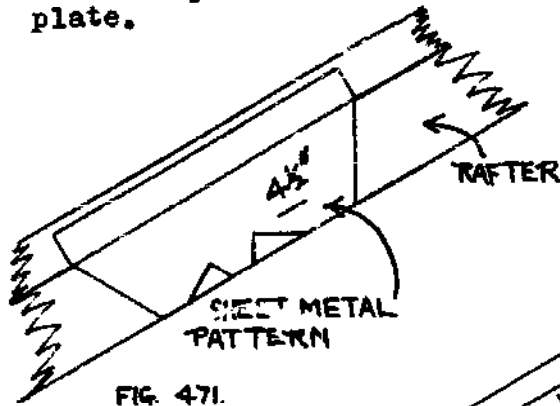


FIG. 471.

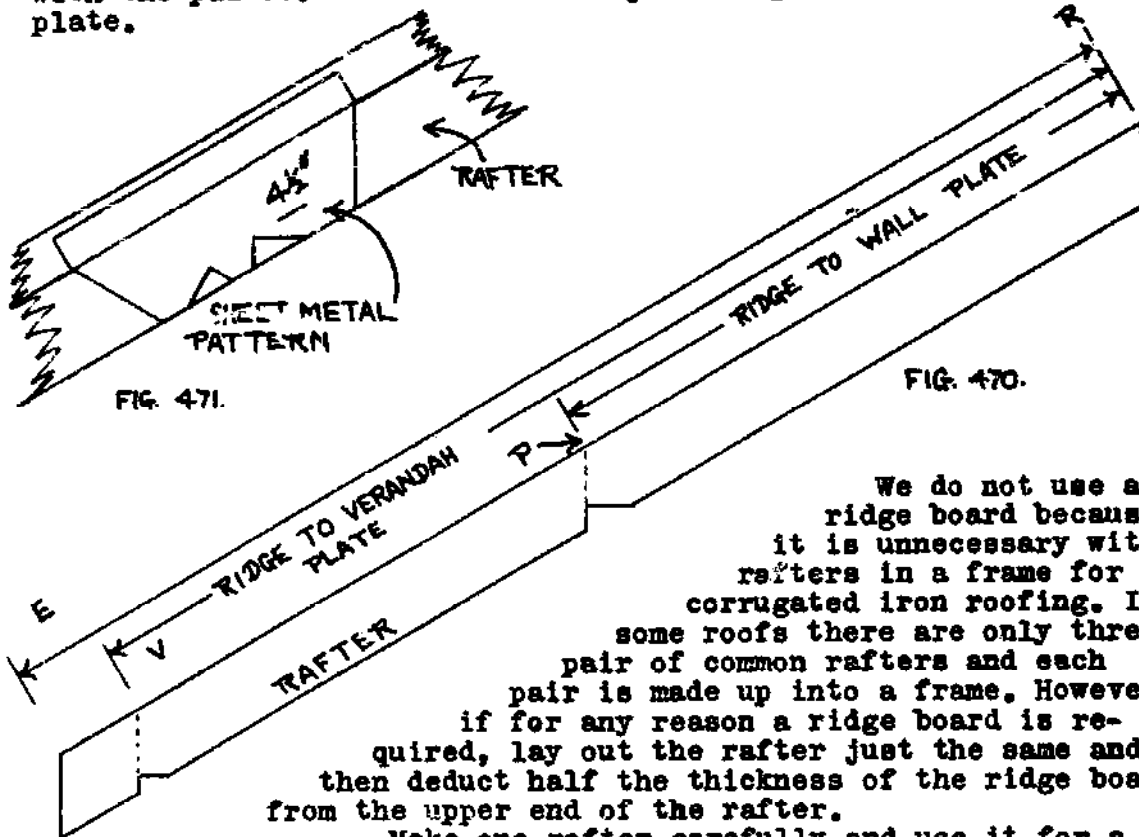


FIG. 470.

We do not use a ridge board because it is unnecessary with rafters in a frame for corrugated iron roofing. In some roofs there are only three pair of common rafters and each pair is made up into a frame. However, if for any reason a ridge board is required, lay out the rafter just the same and then deduct half the thickness of the ridge board from the upper end of the rafter.

Make one rafter carefully and use it for a pattern throughout. But also make a metal pattern as above; it will be useful for cutting birdmouth, and for any other cuts requiring rafter angles. One end of the pattern is for use on one side of the rafter. The other end is in case measurements are on the reverse side of some rafter.

The roof frame, or rather roof frames; that is, a pair of rafters made into a unit on the ground and erected complete on the building. The failure of many roofs, and sometimes of the walls supporting them is due to the lack of a cross tie, or lack of it at the right place. And the right place for the cross tie to join the rafter is the main bearing point of the rafter. If this triangle is made right the roof is essentially sound. Too many roofs have a beam across the walls, and from the beam a king post to hold up the roof. The truth is, that a roof properly built will support the king post, and a good deal else besides! It is only when the rafters are utterly incapable of being properly jointed and bearing any considerable stress that a king post might even be considered.

3. When we use the cross tie we abandon the wall plate point of measurement and pitch angle and use the point of intersection of the lower edge of the tie with the outer edge of the rafter.

2. The same principle is used for a rafter which touches wall plate and verandah plate, or a second wall plate. In these latter cases we will have an over-all length which will have nothing to do with the plates. We establish our pitch angle from the main wall plate.

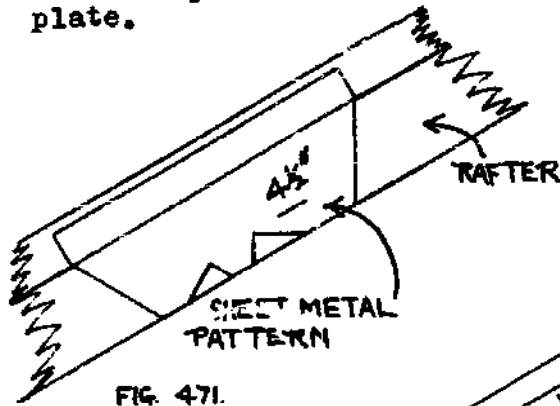


FIG. 471.

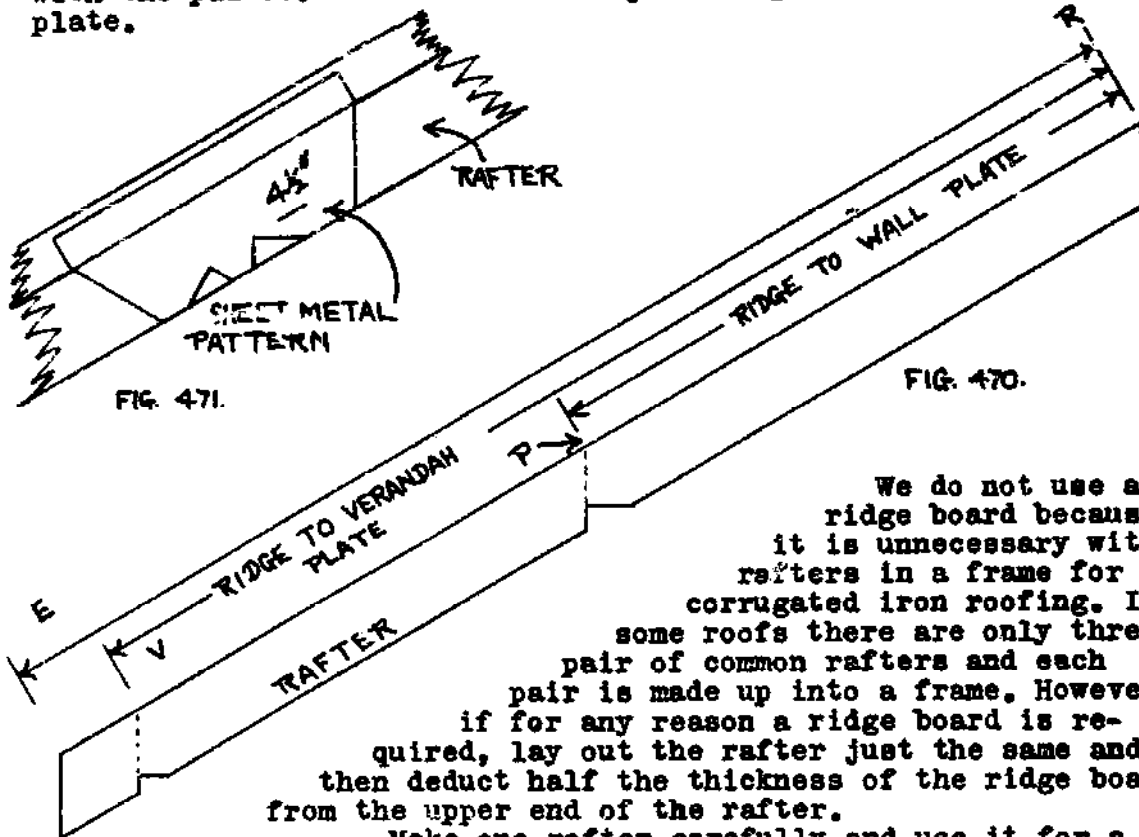


FIG. 470.

We do not use a ridge board because it is unnecessary with rafters in a frame for corrugated iron roofing. In some roofs there are only three pair of common rafters and each pair is made up into a frame. However, if for any reason a ridge board is required, lay out the rafter just the same and then deduct half the thickness of the ridge board from the upper end of the rafter.

Make one rafter carefully and use it for a pattern throughout. But also make a metal pattern as above; it will be useful for cutting birdmouth, and for any other cuts requiring rafter angles. One end of the pattern is for use on one side of the rafter. The other end is in case measurements are on the reverse side of some rafter.

The roof frame, or rather roof frames; that is, a pair of rafters made into a unit on the ground and erected complete on the building. The failure of many roofs, and sometimes of the walls supporting them is due to the lack of a cross tie, or lack of it at the right place. And the right place for the cross tie to join the rafter is the main bearing point of the rafter. If this triangle is made right the roof is essentially sound. Too many roofs have a beam across the walls, and from the beam a king post to hold up the roof. The truth is, that a roof properly built will support the king post, and a good deal else besides! It is only when the rafters are utterly incapable of being properly jointed and bearing any considerable stress that a king post might even be considered.

3. When we use the cross tie we abandon the wall plate point of measurement and pitch angle and use the point of intersection of the lower edge of the tie with the outer edge of the rafter.

2. The same principle is used for a rafter which touches wall plate and verandah plate, or a second wall plate. In these latter cases we will have an over-all length which will have nothing to do with the plates. We establish our pitch angle from the main wall plate.

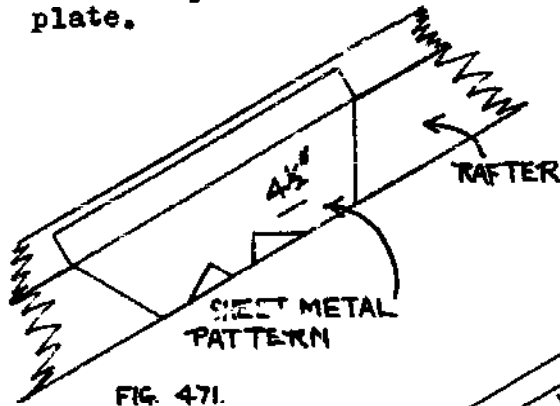


FIG. 471.

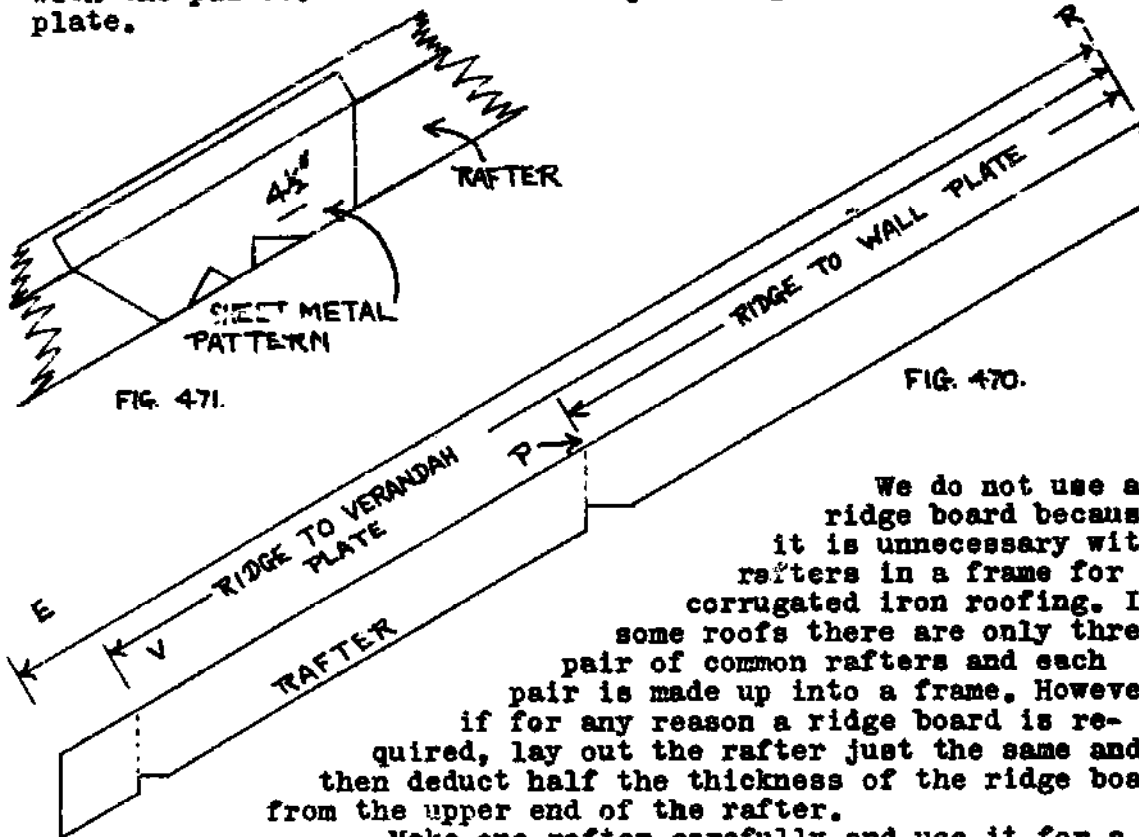


FIG. 470.

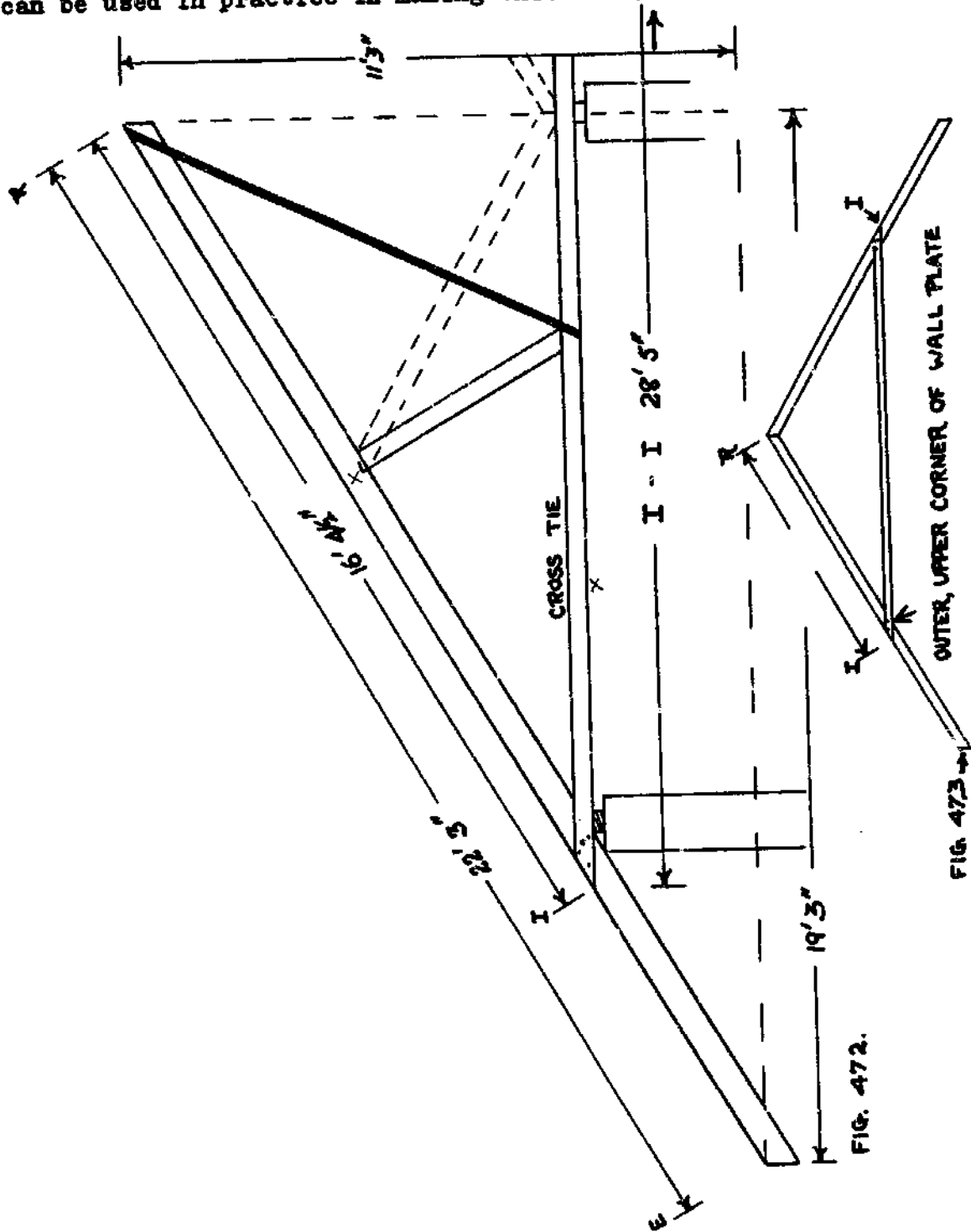
We do not use a ridge board because it is unnecessary with rafters in a frame for corrugated iron roofing. In some roofs there are only three pair of common rafters and each pair is made up into a frame. However, if for any reason a ridge board is required, lay out the rafter just the same and then deduct half the thickness of the ridge board from the upper end of the rafter.

Make one rafter carefully and use it for a pattern throughout. But also make a metal pattern as above; it will be useful for cutting birdmouth, and for any other cuts requiring rafter angles. One end of the pattern is for use on one side of the rafter. The other end is in case measurements are on the reverse side of some rafter.

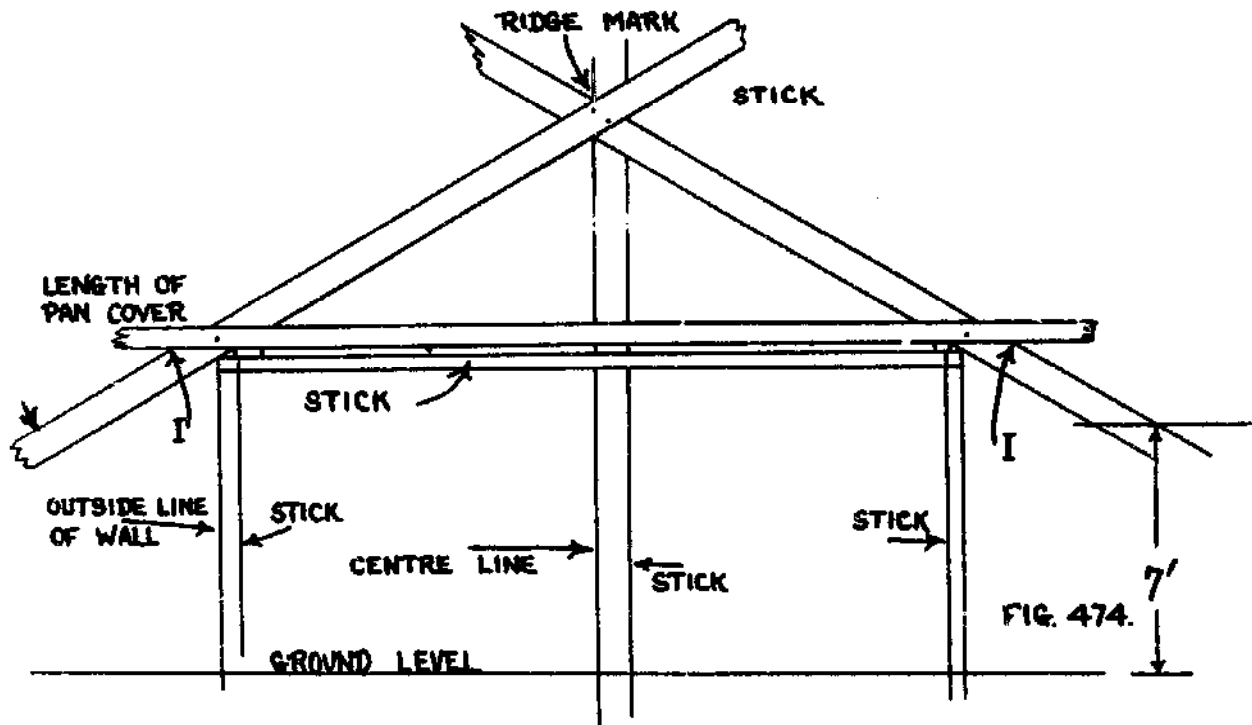
The roof frame, or rather roof frames; that is, a pair of rafters made into a unit on the ground and erected complete on the building. The failure of many roofs, and sometimes of the walls supporting them is due to the lack of a cross tie, or lack of it at the right place. And the right place for the cross tie to join the rafter is the main bearing point of the rafter. If this triangle is made right the roof is essentially sound. Too many roofs have a beam across the walls, and from the beam a king post to hold up the roof. The truth is, that a roof properly built will support the king post, and a good deal else besides! It is only when the rafters are utterly incapable of being properly jointed and bearing any considerable stress that a king post might even be considered.

3. When we use the cross tie we abandon the wall plate point of measurement and pitch angle and use the point of intersection of the lower edge of the tie with the outer edge of the rafter.

The example chosen to demonstrate the roof frame, in this case a real 'A' frame, is the Mission House Roof. The figures given here can be used in practice in making this roof.



There is a way of laying out a roof frame on the ground with the use of a tape. Have a quantity of lumber about, or else pegs, to make measuring points. Make an outline of the upper part of the wall and the ceiling line. Tack a couple of sticks together for a sample rafter; and another stick placed to represent the centre line of the roof.



On the rafter stick measure off the length of your pan surface. In the previous example, it was 22'6". Place the top mark of the two on the centre line, rest the under side of the rafter on the wall corner, then measure from the wall out to the other mark on the rafter. This particular mark is the rafter end, which is 3" inside the end of the pan. Hence, we want our eave mark to be just 5'9" from the wall. Keeping the rafter on the corner, move the other end up or down the centre line as is necessary to get the eave mark just 5'9" from the wall. When all measures have been checked and all the sticks are in position, tack them so that you may make permanent marks, copy angles, etc.

Mark the ridge point, the intersection I, the plumb cut at the top, and the point I on the cross tie. Also, mark out a sheet of metal for the pattern. Write all measurements on paper, or better still in a note book with all other data about the roof.

This trial method can be used for any roof and is just as accurate. But be sure that the eave point is accurately placed. It will be necessary in locating it to have the outline of the entire wall portrayed on the ground; also a cord drawn across to represent ground level.

VI. JOINTING ROOF MEMBERS.

All joints are made from top to bottom of the pieces. That is, the cut or splice commences at the top edge and finishes at the bottom edge.

There are a number of types and styles of splices, some with fish plates or extra pieces at the sides. Practically all of these splices or joints involve a good deal of time if made right and we are not satisfied that any one of them are better suited to our purpose than the wedge shaped splice shown first. If it is carefully made, it is one of the neatest, and is certainly the most economical of the lot. And we are persuaded it is as strong as any that do not use the fish plates.

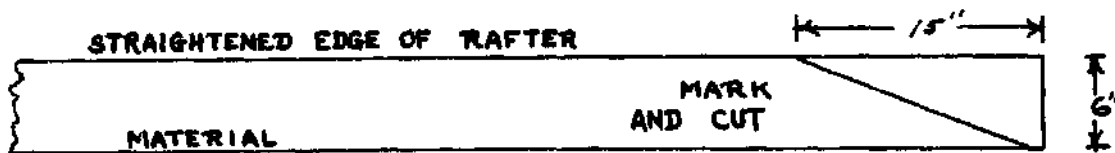


FIG. 475.

Choose the best material for the lower piece that overhangs, and the best end of it for the eave. Take the edge that has a slight upper curve for the top edge. In all rafters being prepared for frames or trusses, the edges are to be quite straight. But in any piece which with a slight upper curve there will be natural sag when in place, and the curve will sag to give the piece a straight line finish, make the curve continuous. If there is a slight curve in one piece, lay that on the second and make it the same. When joining, after cutting the wedge from the first, sight through and arrange both pieces in a continuous curve or arc before marking and cutting. Of course if one piece is straight the other must be and the two should be carefully lined up before marking. And again, when fitting the two pieces together, tack them and take a final sighting before nailing home and binding the joint. It might be a good rule to inspect all joints when they are supposed to be ready for final nailing. It is so much easier on everyone than to have to tear a joint to pieces and correct it.

The under edge never needs planing or straightening. The upper, good edge seldom needs planing all the way to give it a true line. There should be no bumps above what may be called the straight line. It should be so worked that when the complete rafter is in position on the roof it will present a straight appearance from top to bottom.

Search out the carpenter who has the best eye for sighting straight through for the marking. Block up the top piece which has been cut first so that it will lie in the same plane as the under piece. As stated before, when cutting to a mark, do not cut it out. Leave a little for evidence.

In the wedge splice, we have adopted the following set of figures. For 2" X 8" or 2" X 9" lumber an 18" wedge; for 2" X 6" a 15" wedge as above; for 2" X 4" a 12" wedge; for 2" X 3" a 10" wedge; and for 2" X 2" a 7" wedge.

Try to avoid making the wedge cut against the grain of the wood as in Fig. 476.



FIG. 476. BAD.

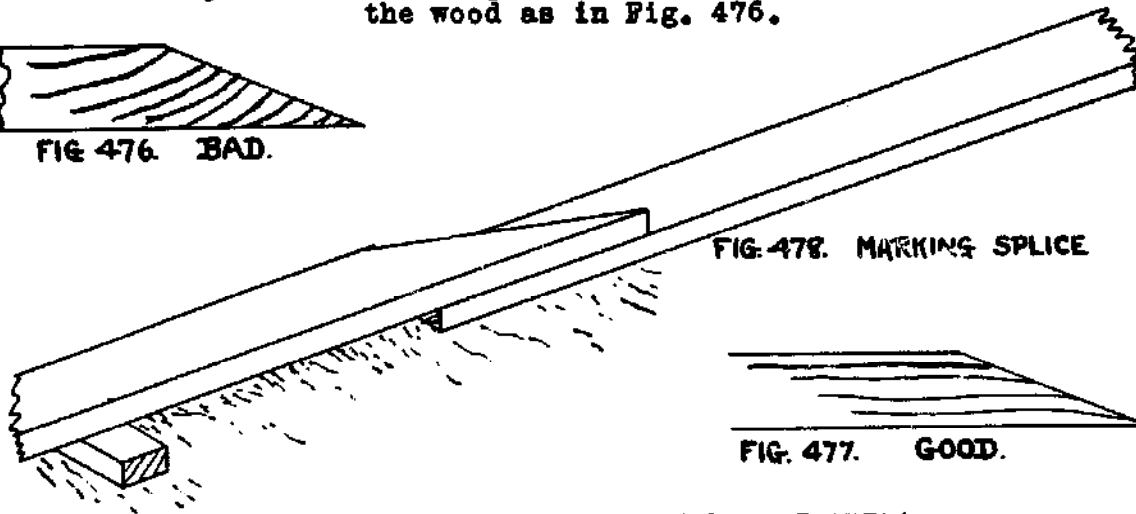


FIG. 478. MARKING SPLICE

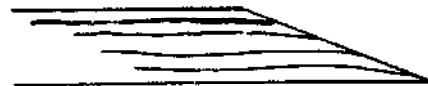


FIG. 477. GOOD.

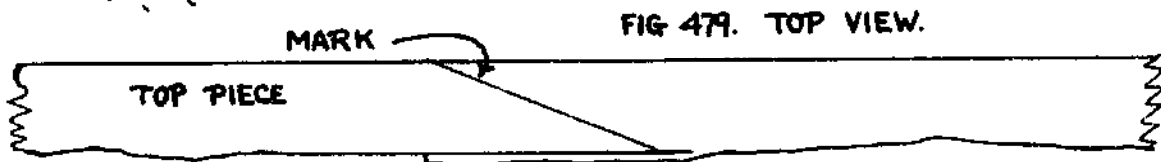


FIG. 479. TOP VIEW.

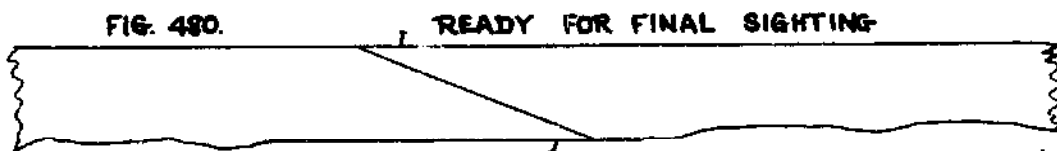


FIG. 480.

READY FOR FINAL SIGHTING

Trim the lower edges of each stick at and near the joint to facilitate binding.

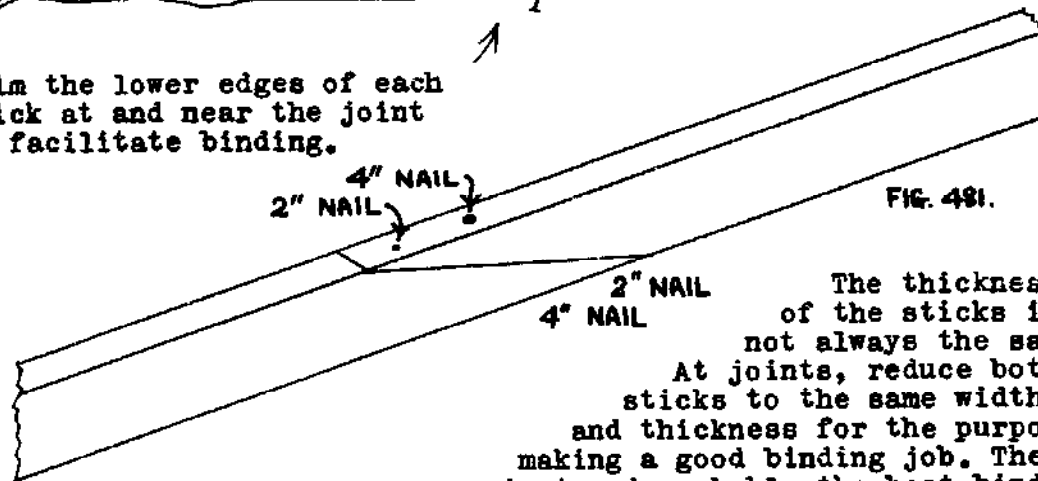
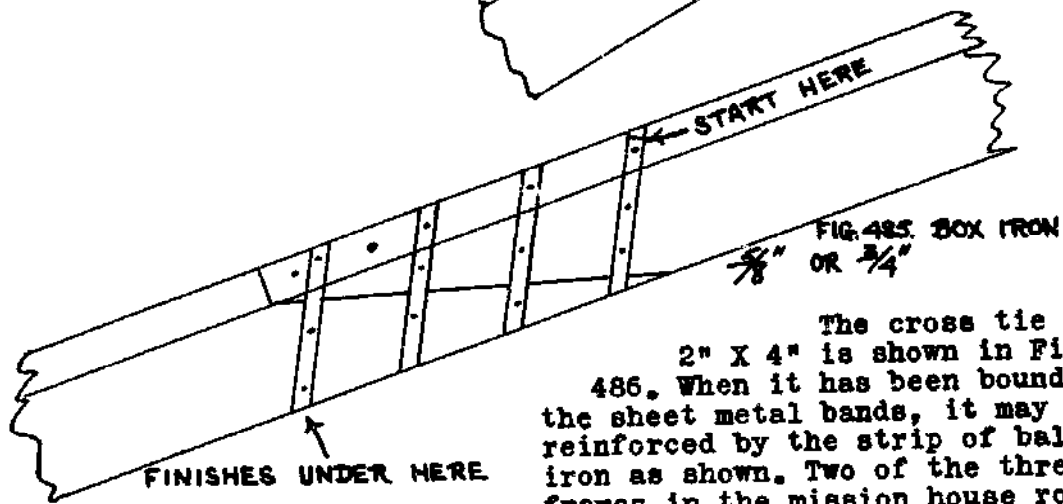
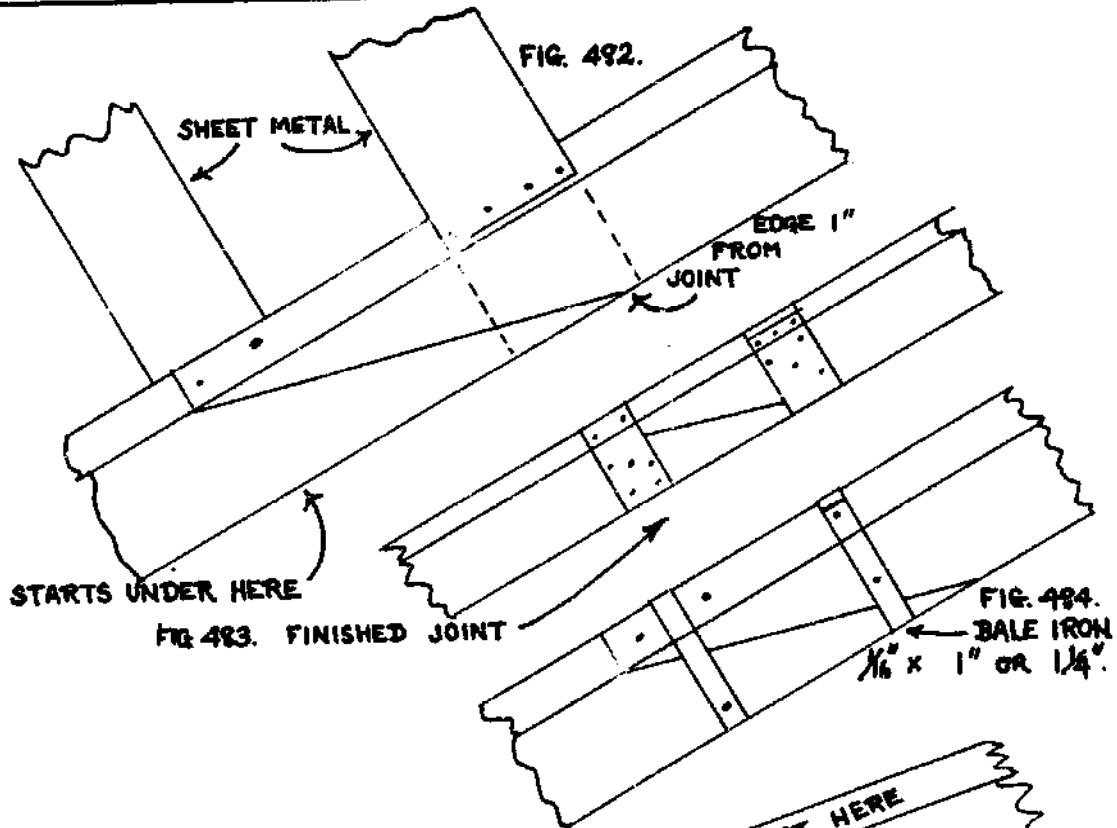


FIG. 481.

The thickness of the sticks is not always the same.

At joints, reduce both sticks to the same width and thickness for the purpose of making a good binding job. The easiest and probably the best binding

for the wedge joint is a piece of 26 gauge sheet metal at each end. For 2" X 6" the pieces should be at least 4" wide and the length is 15". Always in binding the wedge joint, start whatever kind of binding is used at the base of the wedge and finish up there. Drive as few nails as possible through the thin edge.



The cross tie of 2" X 4" is shown in Fig. 486. When it has been bound by the sheet metal bands, it may be reinforced by the strip of bale iron as shown. Two of the three frames in the mission house roof

carry the weight of the end of the roof and the ties should be adequate.

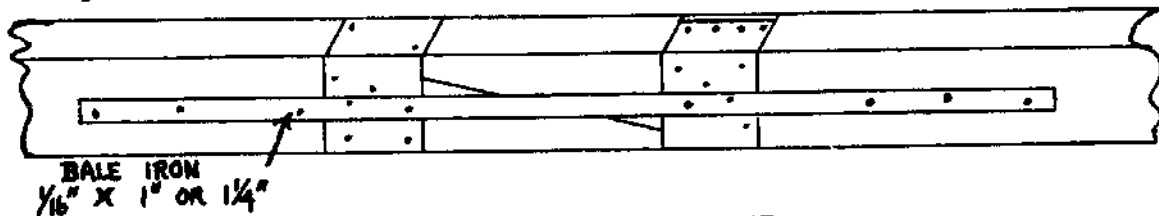


FIG. 486. CROSS TIE JOINT

Purline and wall plate joints also cut from top to bottom, but there is more work because the cut is across the width. If the wall plate is judged to be more weight carrying than thrust resisting, it has what we will call the flat joint. But if it has more thrust, (sideways) it may have the edge-to-edge joint which is easier to make.

FIG. 487. FLAT JOINT FOR PURLINES.

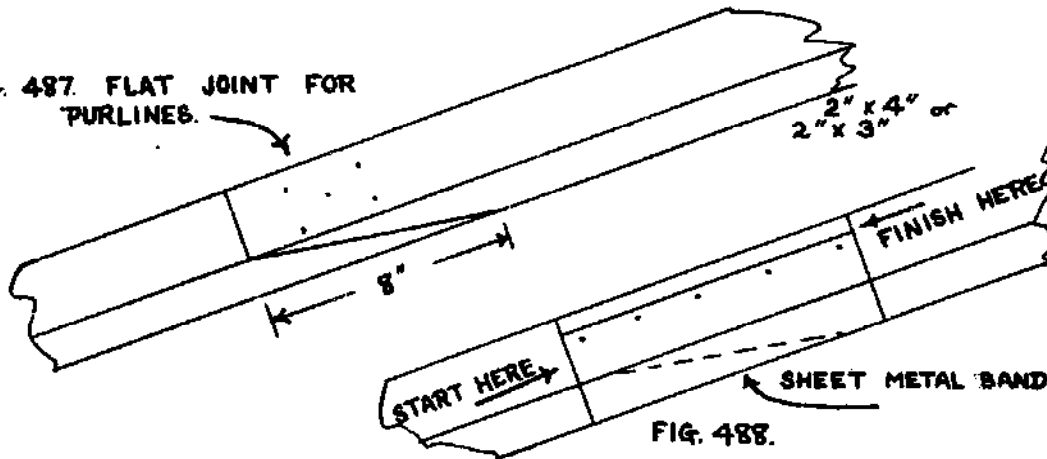


FIG. 488.

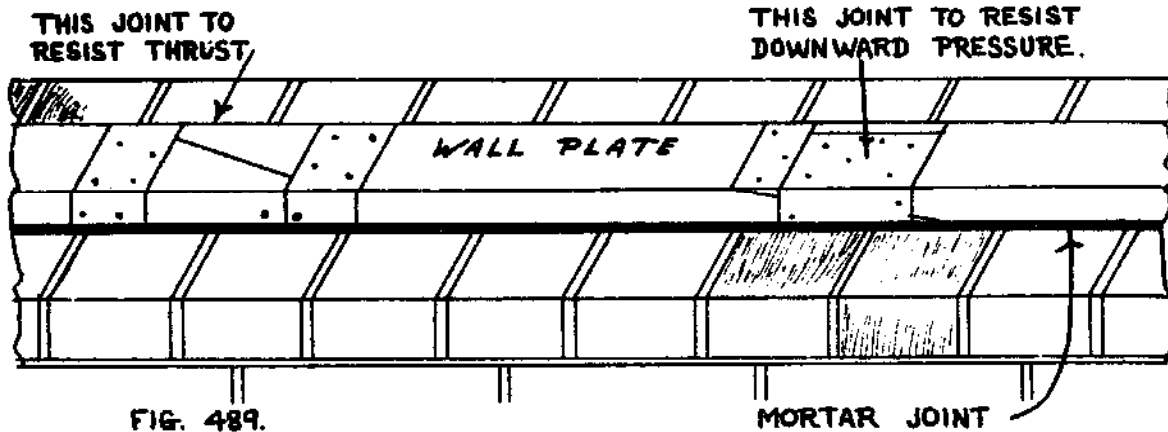


FIG. 489.

MORTAR JOINT

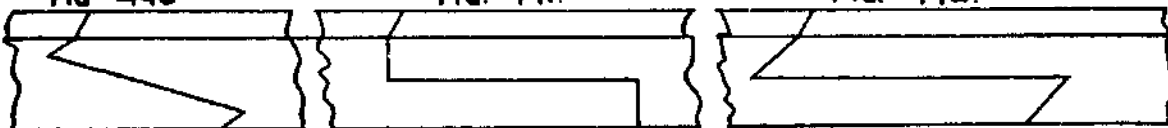
The flat joint for either 2" X 3" or 2" X 4" purlines should be at least 8" long. The whole joint should be covered by one piece of sheet metal band, 10" X 10", as in Fig. 488. It should not be necessary to say that the banding of all joints should be done with care so that there are no bulges in the metal.

Some other splices are shown to give an idea of the range of joints for various purposes.

FIG. 490

FIG. 491.

FIG. 492.



When well bound, this is a good tension joint.

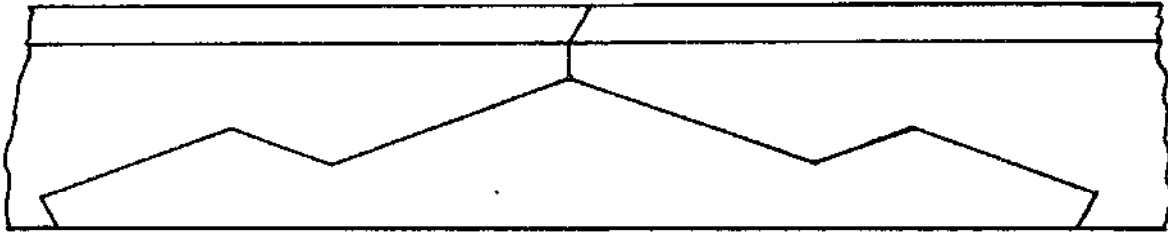


FIG. 493.

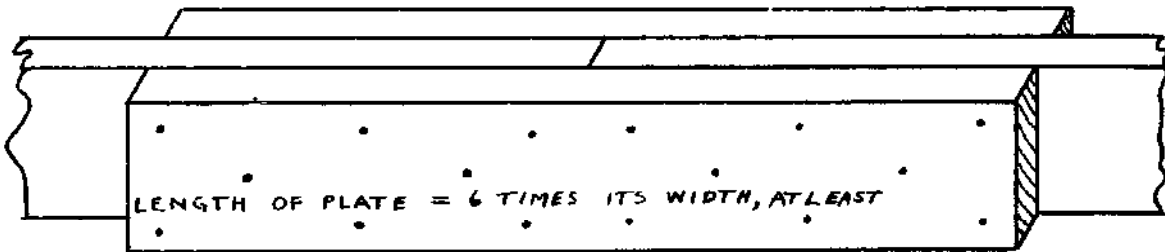


FIG 494 SINGLE TIE

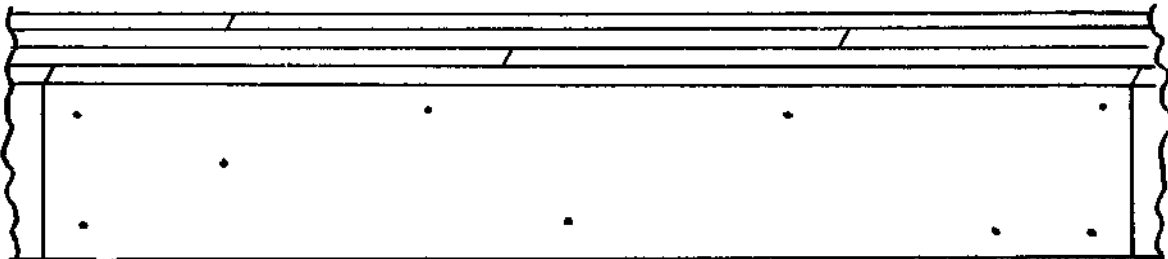
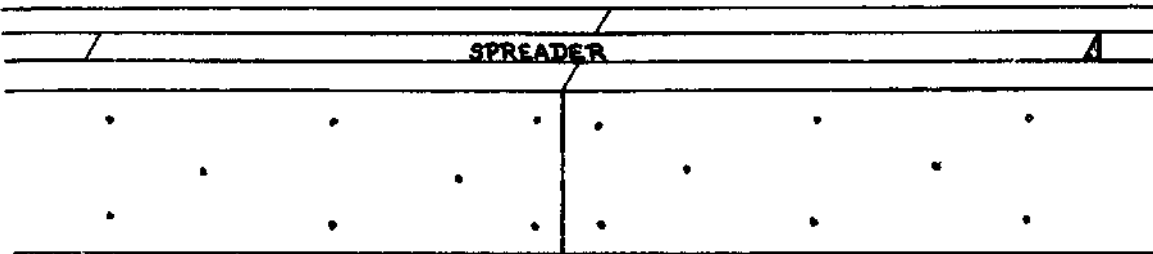


FIG. 495. BUILT UP BEAM

FIG. 496. DOUBLE TIE.



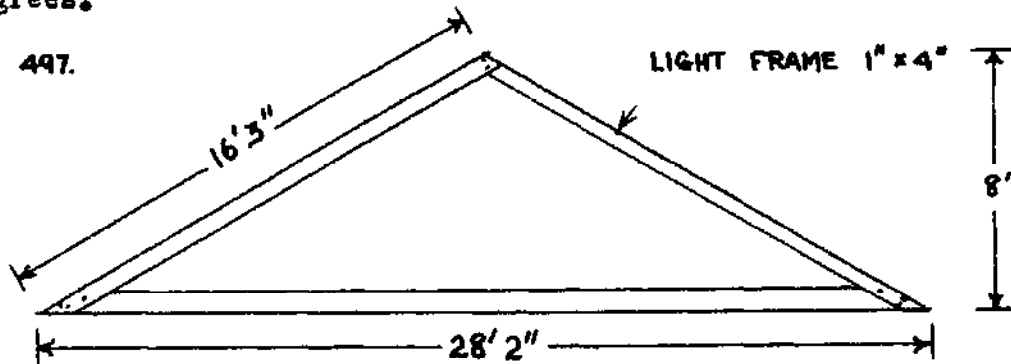
The length of the spreader is eight times its width. Fasten with nails or bolts. Use iron to further strengthen the joint if desired.

VII THE GABLE ROOF.

If wood is very scarce and the work of making a roof frame seems too great, gable walls at the end, and built-up partition walls in the interior may form the sole support for purlines. We prefer to have a frame inside each gable as well as intermediately. If partitions are built, see Fig. 498 and text.

Make a light framework the shape of the roof. This can be made by the use of a tape and some sticks on the ground. Determine the pan coverage as before. Let us suppose that three 6' pans are to be used on each side, and that the angle is to be 30 degrees.

FIG. 497.



Place this framework, called a template, on the side walls about 6" from the end wall. Build up the gable according to this form. The last course up the slope is to be of headers as shown on page 116. Long bale iron roof ties should be built in. The places for these can be marked on the template ahead of time. Also, a header can be left out where the purline is to set. If a ventilator window is to be built in to the gable, it should not be very large, and it can be centred by a plumb line dropped from the apex of the template.

Build the gable at the other end. The intermediate gables should have as little brick in them as possible, to save time and brick, and to allow for passage from one section to the other and for ventilation. Without cutting or disturbing the bond, build in dry brick in the shape of the door ways shown in the illustration. Leave the dry brick in place until the wall is baked dry. In fact one opening can be cleared and the rest left until the roof is complete and all movement ceases.

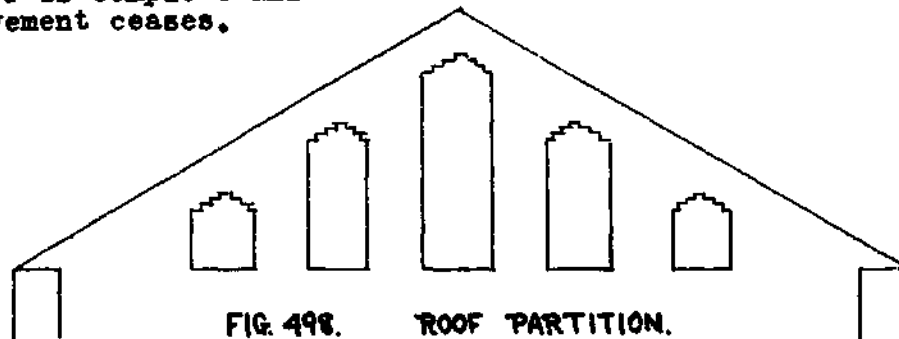


FIG. 498. ROOF PARTITION.

The purlines will project beyond the gable about 12". Make them the full length on the ground, all joined, ends squared, three for each side. We recommend that the ridge be one piece of 2" X 6" or 3" X 4" instead of two purlines almost touching. Between walls the purlines require support. There are several ways of accomplishing this. A rafter can be cut in, in fact a frame made inside after the purlines are in place. Preferably, the frame would be made on the ground by the use of the template, but the walls were built to avoid making frames!

The purlines can be supported by a light wood and wire truss. Or they can be individually supported by a single wire and a strut.

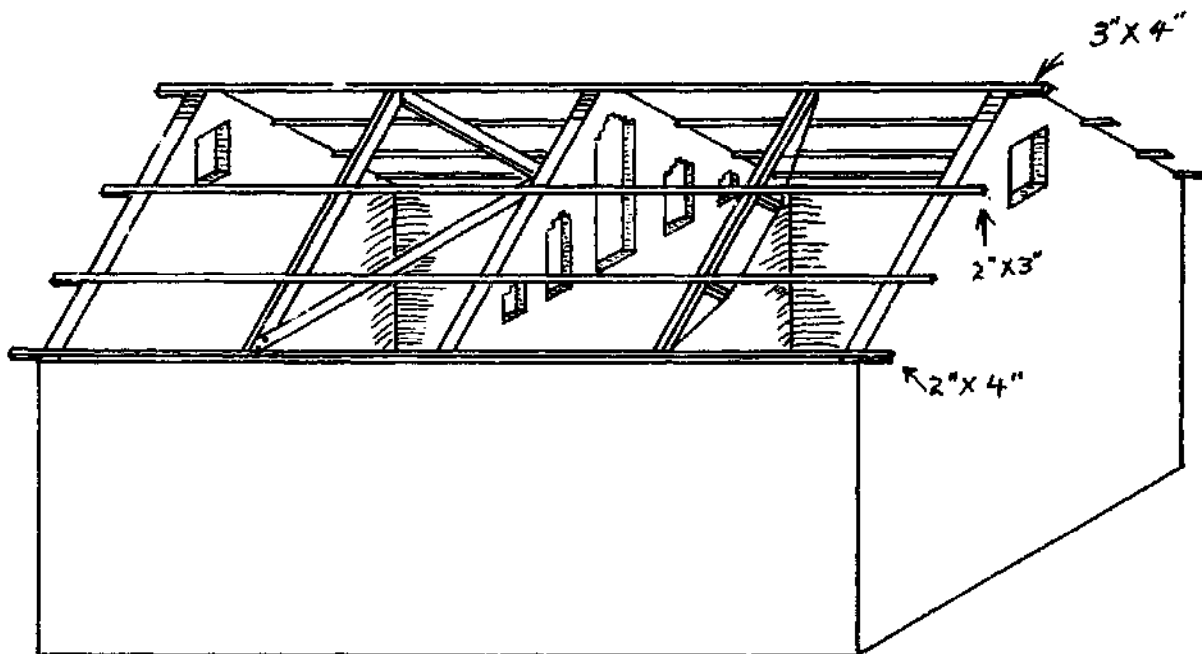


FIG. 500. GABLE FRAME.

FIG. 499. LIGHT TRUSS.

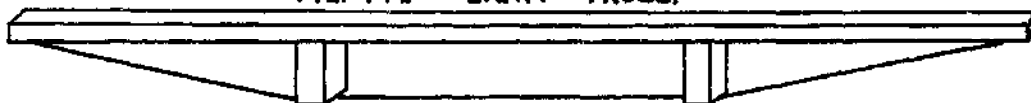
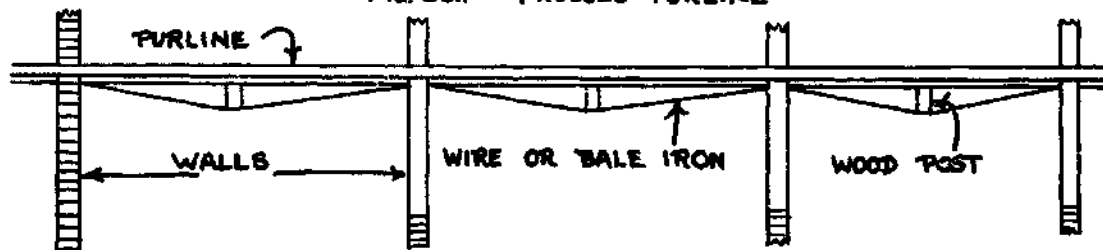
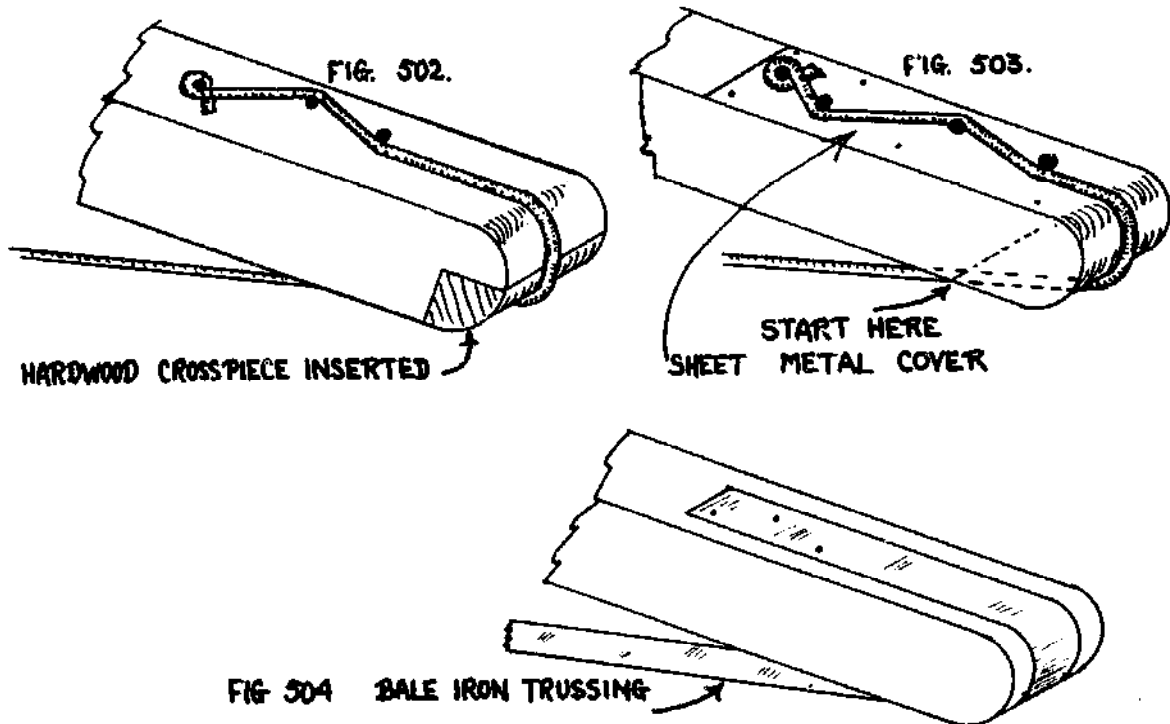


FIG. 501. TRUSSED PURLINE

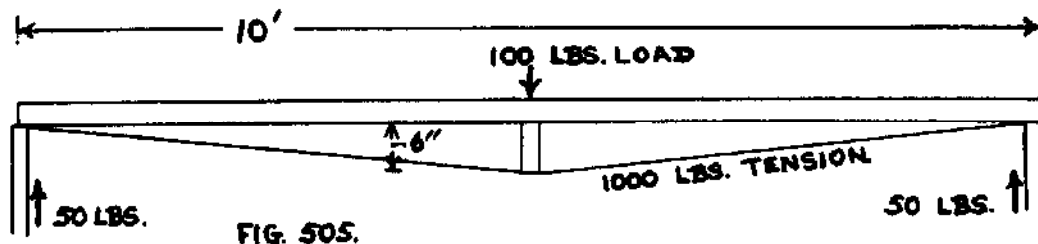


We admit some of this looks irregular, but it is better than nothing! And sometimes it is just right for repair jobs. But whether new or old work, prop up the purline, or rafter, as the case may be, secure the wire or bale iron, insert the short block, then let down the prop.

It is essential to the success of such devices that the wire or bale iron be perfectly anchored at each end. Never, if you can avoid it, fasten such ties to the under face of the truss piece; always wrap it around the end and so fasten it. Two simple arrangements are shown for securing the wire or bale iron.



Rule for trussing: The deeper the metal brace, the less tension stress there is on it. In other words, in a truss 10 feet long, with a post 6" long and 100 lbs weight to be supported, the tension on the wire is approximately 1000 lbs. But if the post be 2 feet long the tension on the wire is only 270 lbs.



Circumstances will guide in selecting the right length of post. A 2" X 6" hip rafter 23 feet long requiring support should have

a post at least three feet long, otherwise the tension on the bale iron may be too great. Further, a truss may be quite adequate after the roof is completed, but quite inadequate when as many as four to six men congregate over the truss during construction. Hence, if the truss require, prop it during the construction period. To make the post fit snug, secure the iron at each end of the truss, and then cut the post to fit. When securing the iron, a test can be made as to the approximate length of the post.

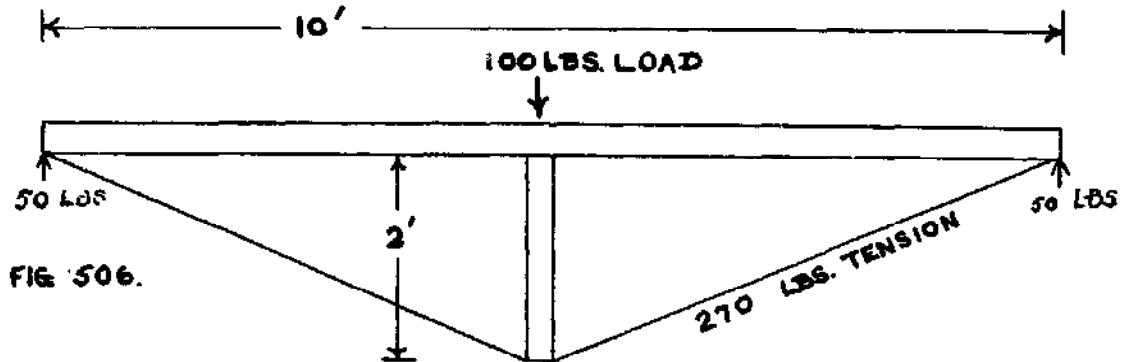


FIG. 506.

In Fig. 501 the iron or wire should be continuous from its anchorage on top of one end to its anchorage on top at the other end. At each point of rest it should be secured somewhat so that it will not shift if more tension is put on one span than on another. Of course the iron can be put on while the purline is on the ground; the posts can be put in when the remainder of the roof is complete and the final weight fixed.

If the truss is stressed at more than two points and it is not stiff enough in itself to have only two posts, it will be better to truss each half than to have three posts in series.

A three-post truss.

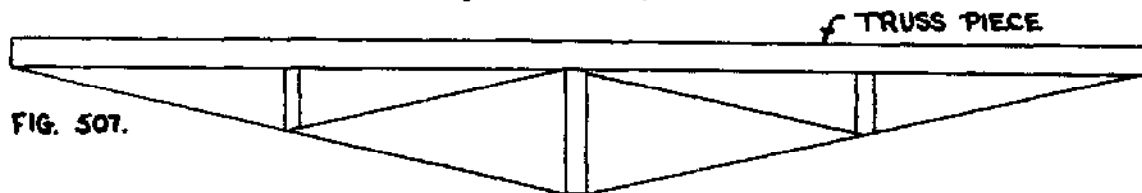


FIG. 507.

The advantage of the truss is that wire and bale iron are often cheaper and more plentiful than lumber. A properly trussed and stayed 2" X 2" will hold more than a 2" X 4", and will not sag at all. Truss pieces should be approximately square in cross section. The lighter the truss material, the more it needs staying. Fasten it securely to the various parts of the roof it supports. The wood of the truss is in compression as much as the metal is in tension. If it is not stayed, it will buckle.

Use trusses for long rafters that have no other means of support, as when they pass over large rooms.

VIII. THE HIP ROOF.

Given the same eave as the gable roof, there is the same area of cover on a hip roof as on a gable roof. That is, provided the pitch is the same on all four sides. But if the end pitch is steeper than the side, the roof will take more cover than if regular. There is more work to a hip roof, more lumber, more ridging, and a certain amount of waste in cutting the corners, even with the greatest ingenuity in using pieces.

To lay out a hip roof, think of it as a figure of nine lines; the four eaves, the four hips, and the ridge. See Fig. 510

The ridge length is the difference between the length of the side and the end. The mission house roof is 50 feet long, the width 39 feet. The ridge is the difference, eleven feet.

The length of the hip is the hypotenuse of a triangle whose two sides are the length of the common rafter and the half of the width of the roof.

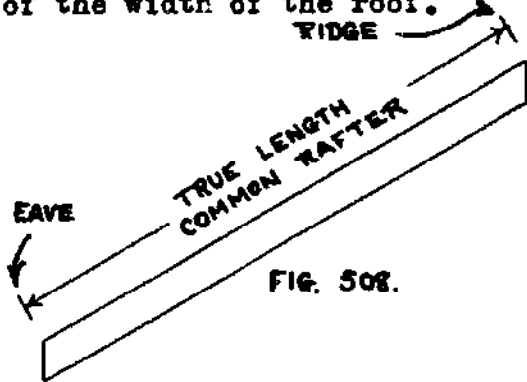


FIG. 508.

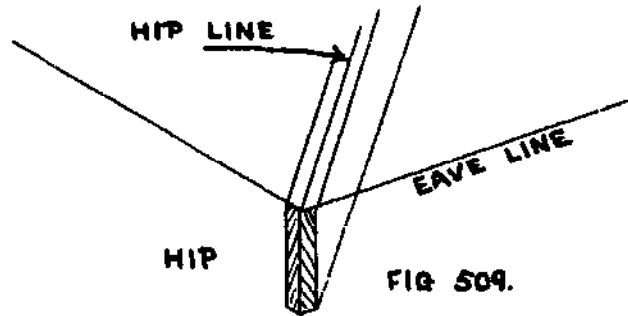


FIG. 509.

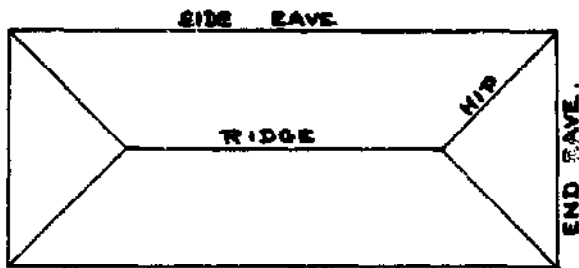
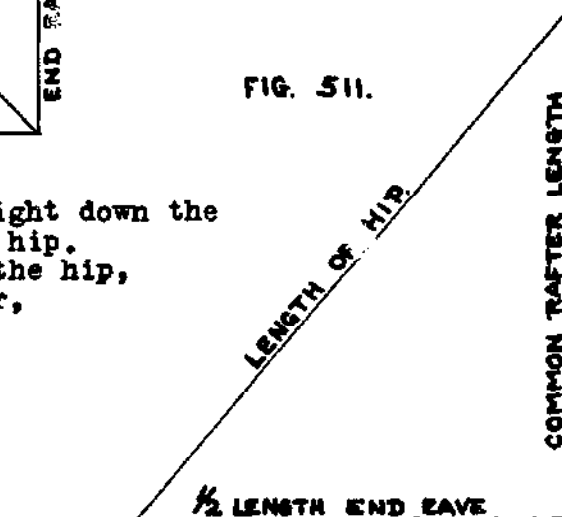


FIG. 510.

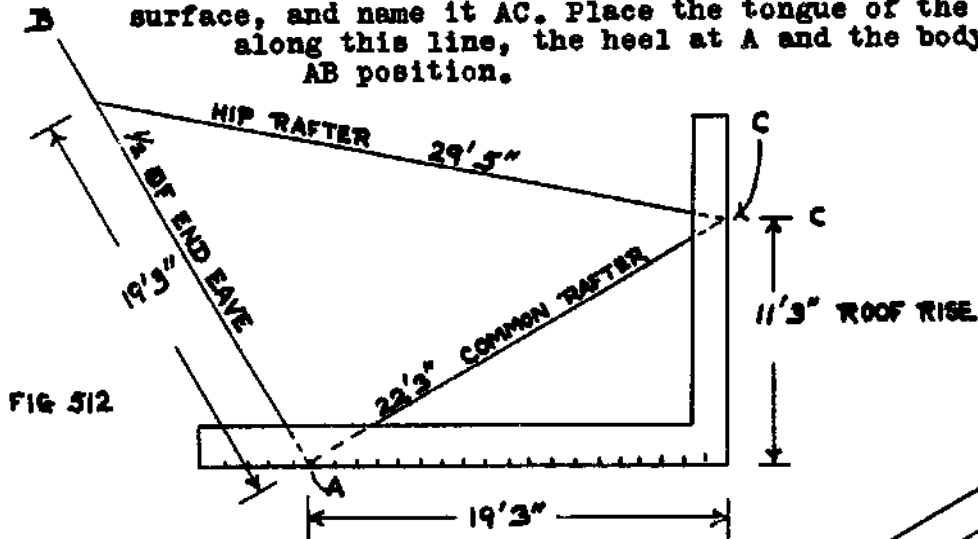
FIG. 511.

Note that the hip line runs right down the centre of the top edge of the hip. Fig. 511 shows the length of the hip, the top cut of the jack rafter, and the cut of the pans on the corner. The whole layout is now given on the framing square. See also Fig. 514



1. A study of page 22 ff. with the master plan on page 199 will show where we obtain the 19'3", (1/2 the width of the eaves) and 11'3", (the height of the ridge above the eave). These two figures on the square give 22'3" the length of the common rafter.

Transfer this line to a sheet of paper or other suitable surface, and name it AC. Place the tongue of the square along this line, the heel at A and the body in the AB position.



Draw a 19'3" scale line from A. Remove square, joint the end of this line to C. This is the hip length, and scales to 29'5".

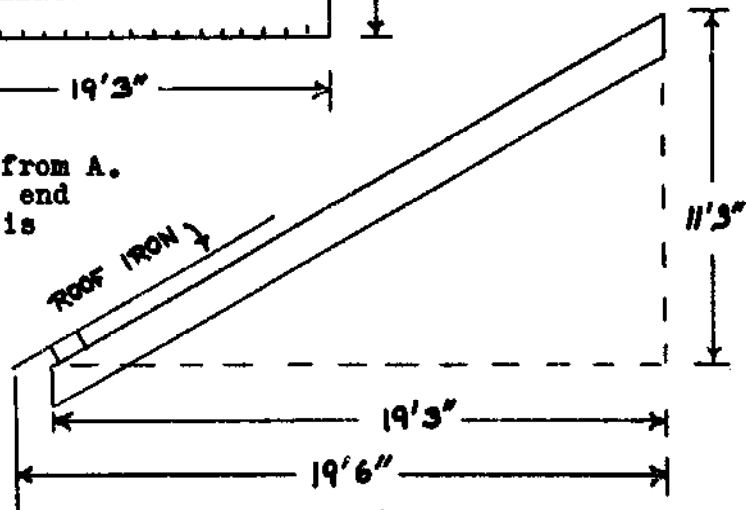


FIG. 513.

The hip rafter itself is a few inches longer than this on account of the angle of the toe which projects beyond the measured length.

For complete layout of hip rafter see page 220ff.

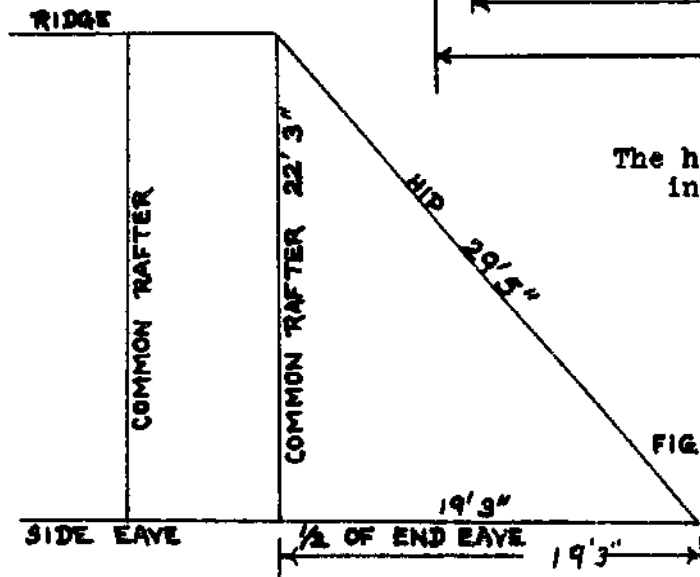


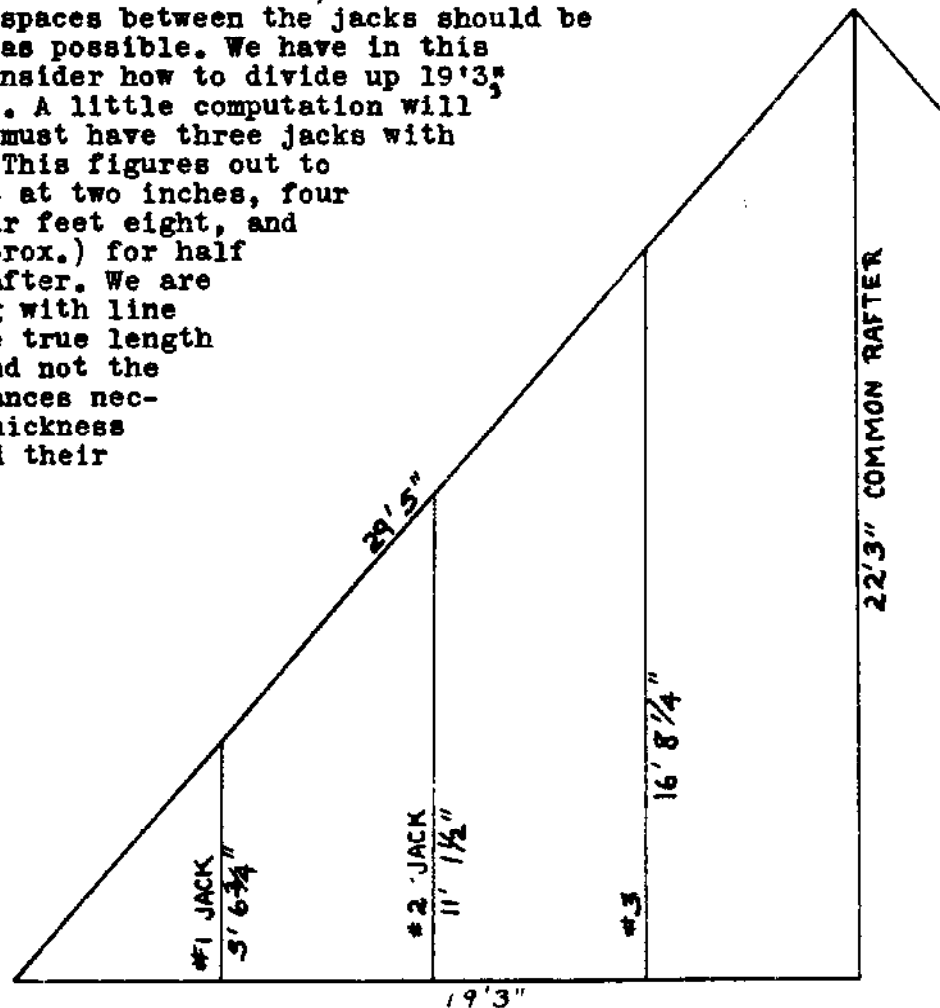
FIG. 514.

2. In Fig. 510 we have a plan or top view of the hip roof. This does not give the true length of the common rafter nor of the hip rafter. We now proceed to draw the end of the roof showing the true lengths of all members, the top cut angle for the jack rafters, the top cut for the purlines, the length of the jacks, etc. The whole end can be drawn on large paper, but half of the drawing will suffice here; it contains all essential information.

The first stage of the drawing will show the jack, or shortened rafters which meet the hip rafter. The number and spacing of these is determined by the number of common rafters along the side of the building. In this case, we have a ridge of 11' with a roof frame or pair of common rafters at each end. Obviously, 11' is too great a span, so we insert a frame, making three, with a spacing of 5'3" between each two. (11' less three rafters at two inches each leaves 10'6")

The spaces between the jacks should be as near 5'3" as possible. We have in this drawing to consider how to divide up 19'3" approximately. A little computation will show that we must have three jacks with four spaces. This figures out to three rafters at two inches, four spaces at four feet eight, and one inch, (approx.) for half of the hip rafter. We are still dealing with line measures, the true length of members and not the slight allowances necessary for thickness of sticks and their angles.

FIG 515



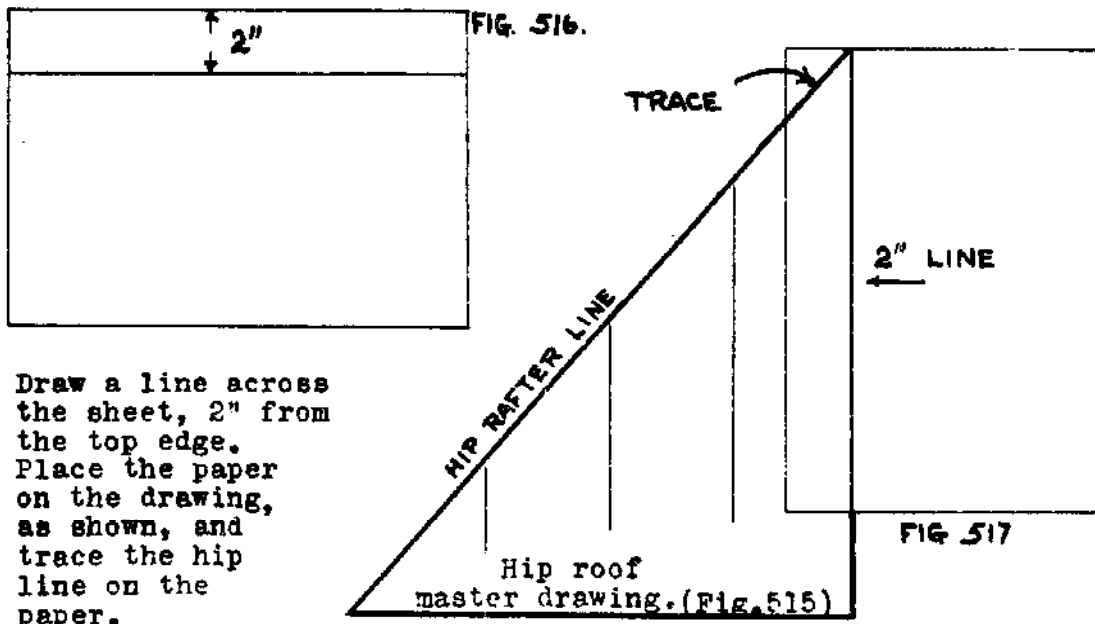
Hip roofmaster drawing; first stage showing jack rafters.

On the drawing, put in these three lines for jacks, spaced exactly at quarter distances from the common rafter.

A moment's consideration will show that these three jacks are respectively $1/4$, $2/4$, and $3/4$ the length of the common rafter which is 22'3". This makes them 5'6-3/4", 11'1-1/2", and 16'8-1/4" respectively. This happens to be a very economical arrangement when using 12' sticks of lumber for there is practically no waste. From one common rafter, (two 12' sticks spliced) the one quarter and the three quarter length jacks can be cut without waste; the half length can be cut from a 12' stick.

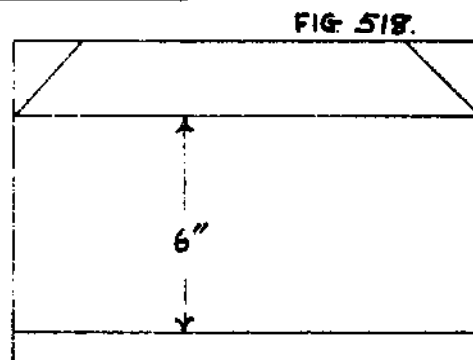
The jack rafter cut. This is a double angle, across the top as well as down the side, but is simplicity itself. The top mark may be transferred from the drawing by making a paper pattern. The side cut is the plumb cut of the common rafter, given on page 199.

Since there are 24 jack rafters to cut, it pays to make a metal pattern of this complicated-looking cut. We first make a paper pattern as follows:

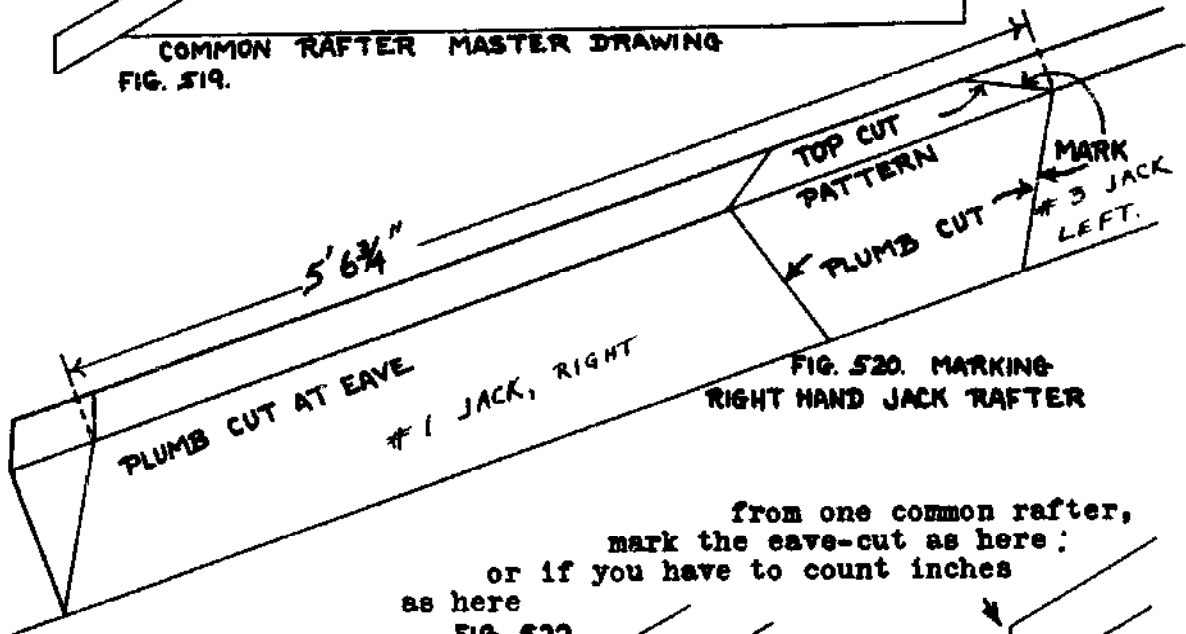
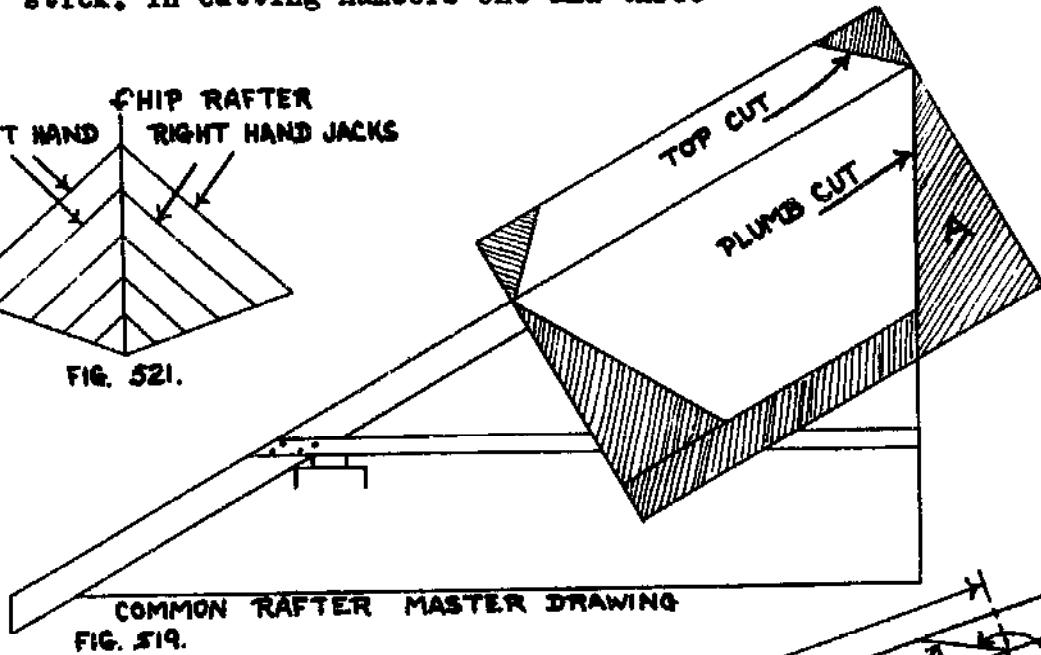
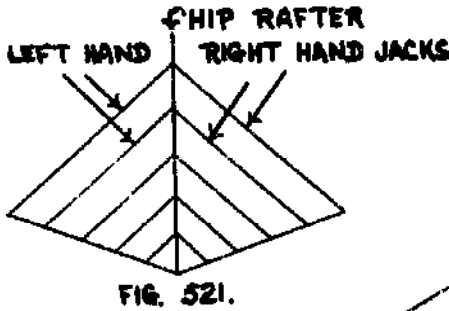


Draw a line across the sheet, 2" from the top edge. Place the paper on the drawing, as shown, and trace the hip line on the paper.

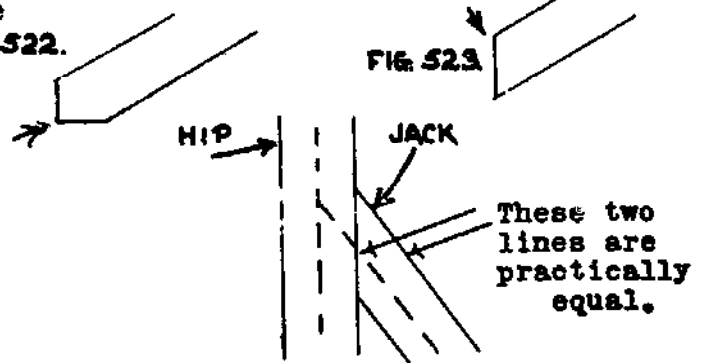
Reproduce this angle at the other end as shown in Fig. 518. Then draw a line 6" from the first line and place the paper on Master drawing on Page 199 as shown in Fig. 519. Cut off the shaded parts, transfer the shape to a piece of 26 gauge sheet metal. Bend the metal on the dotted line. The pattern is good for all jack and common rafters in the 'Mission House' roof.



Transfer the plumb cut to the other end by using the cut-off A. Number two jack presents no problem for it is cut from one whole 12' stick. In cutting numbers one and three

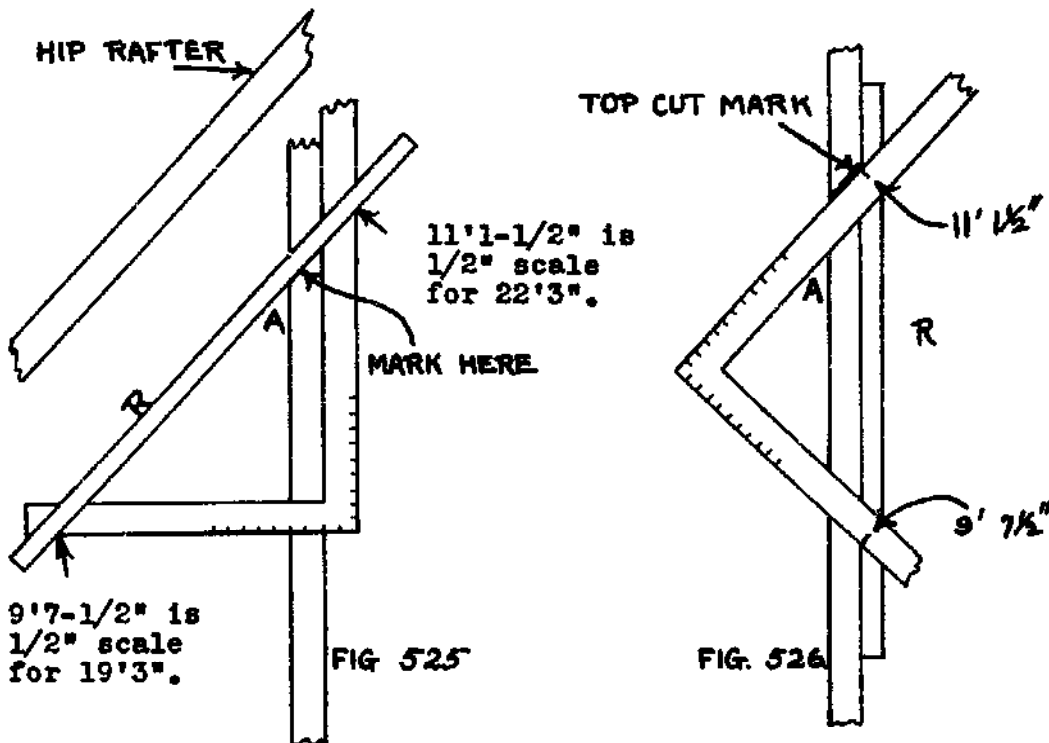


from one common rafter,
mark the eave-cut as here:
or if you have to count inches
as here
FIG. 522.



Measure from the eave point 5'6-3/4". Place pattern as shown in Fig. 520. Mark the top and side. This cut will make a right-hand, number one jack, and a left-hand, number three jack. Fig. 524 shows why the actual length of the jack is the same as the true or lay-out length.

The steel square lay-out for the jack rafter.



'R' is a $1/2$ " X 1" stick held on the square at the two figures, as shown in Fig. 525. It may be taken to represent the hip rafter, in a triangle with the common rafter and the eave line as the other two sides.

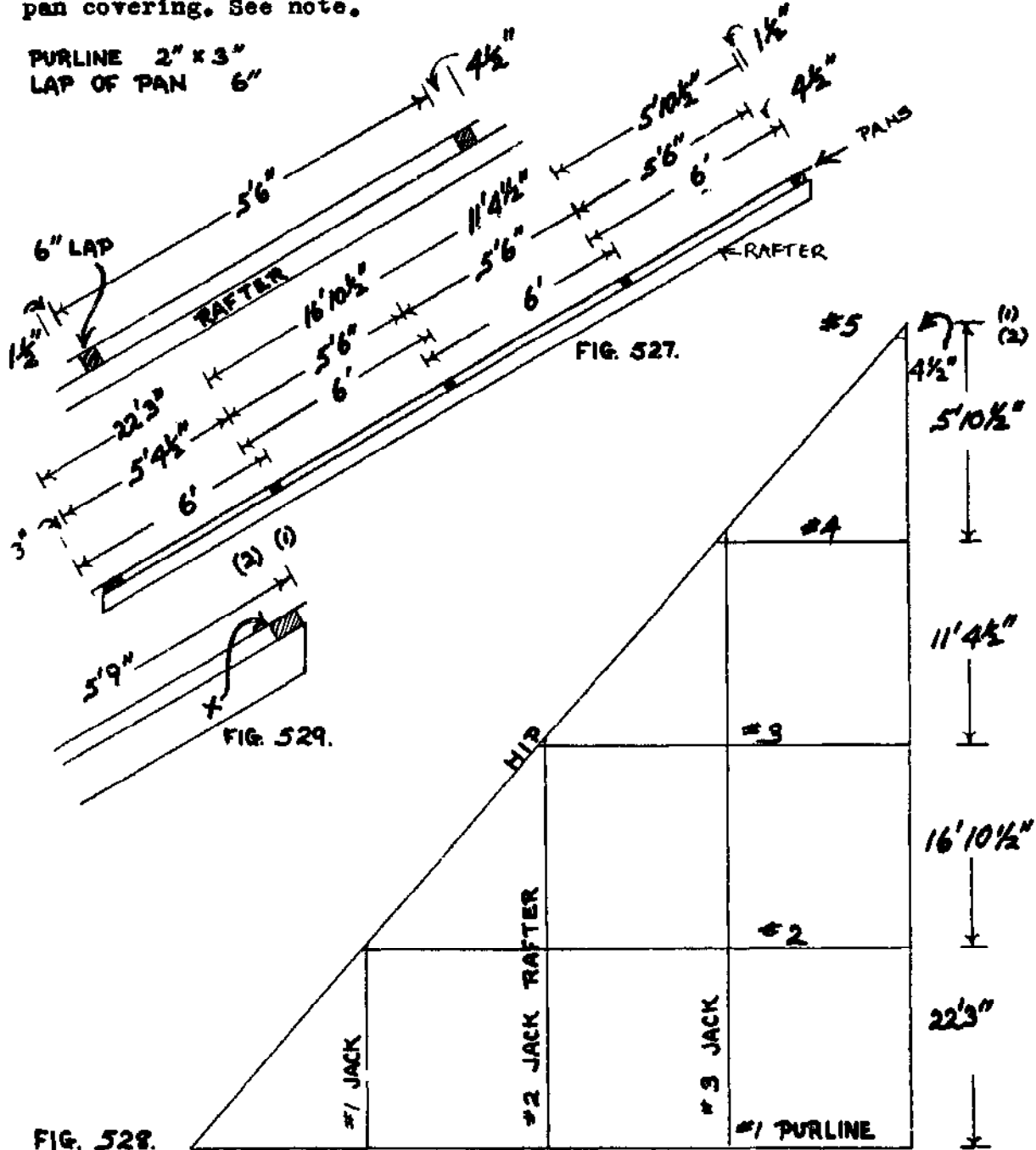
Holding it in the same position on the square, turn the square over and place it on the edge of the jack rafter as shown in Fig. 526, and with the stick along the edge of the jack rafter. In this case the mark on the rafter can be made along the edge of the square. The stick can be clamped to the square and used for all marking. Its main purpose here is to demonstrate that the angle is the one sought, and why. The largest figure, (that for the common rafter) is uppermost; in other words, the desired angle is that closest to the largest figure.

And, for emphasis, the plumb cut of the jack rafter is the same as for the common rafter.

We now consider the purlines whose measures we can get from the master plan of the hip roof. One word of explanation is necessary about the joint between the purlines and the hips. It is the custom in most places to have the top edge of the hip in the same plane with, or on the same line with the top edges of the common rafters. This means that the purlines rest on the top edge of the hip. Then, to accommodate the ends of the pans, a series of cut-in purlines, parallel to the hip must be built in. This takes considerable time as well as labour. We have eliminated this by raising the hip a vertical distance of approximately $2-3/8$ " so that the purlines nail to the side of the hip, their upper surfaces being even or flush.

Thus the actual end of the purline is about an inch and a half short of the true or lay-out length. Before we can space the lines on the lay-out, we must have a detail drawing of the pan covering. See note.

PURLINE 2" x 3"
LAP OF PAN 6"



Hip roof master drawing; second stage showing position of purlines.
Note: If various lengths of iron are used, the longest is against the eave, and the shortest is against the ridge.

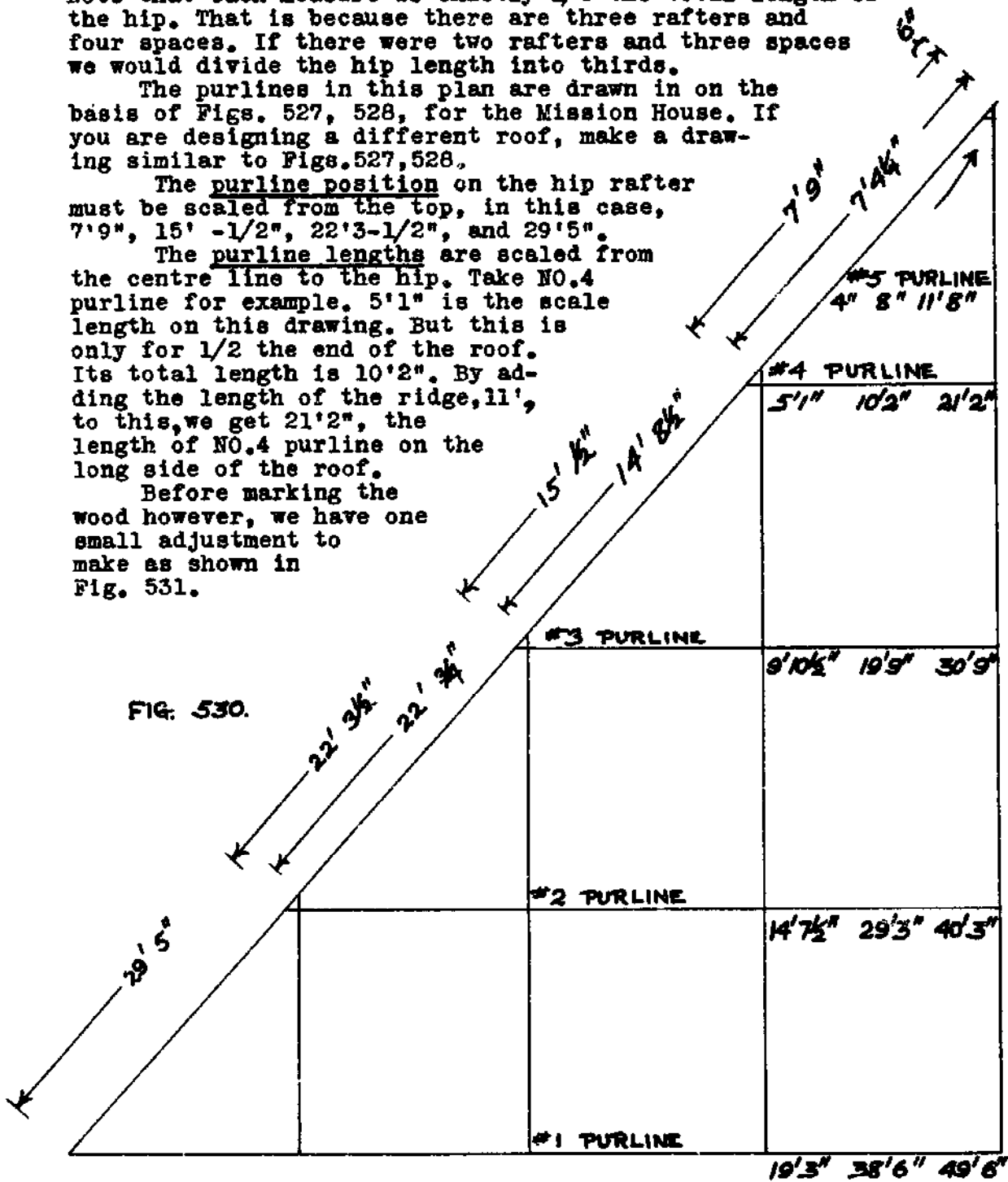
Key to Fig. 530. Marking the hip rafter for the jacks:
 Note that each measure is exactly 1/4 the total length of the hip. That is because there are three rafters and four spaces. If there were two rafters and three spaces we would divide the hip length into thirds.

The purlines in this plan are drawn in on the basis of Figs. 527, 528, for the Mission House. If you are designing a different roof, make a drawing similar to Figs. 527, 528.

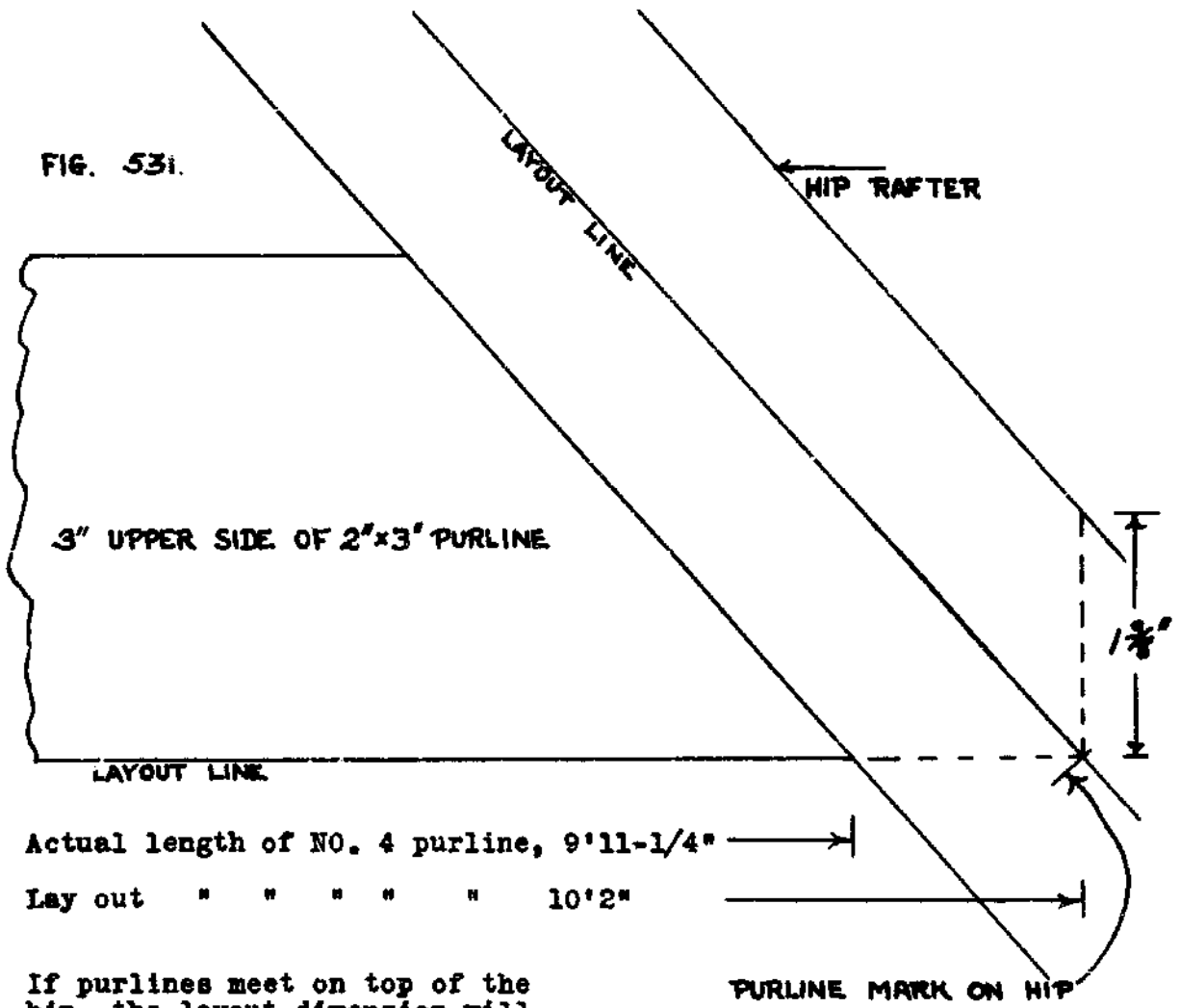
The purline position on the hip rafter must be scaled from the top, in this case, 7'9", 15' -1/2", 22'3-1/2", and 29'5".

The purline lengths are scaled from the centre line to the hip. Take NO.4 purline for example. 5'1" is the scale length on this drawing. But this is only for 1/2 the end of the roof. Its total length is 10'2". By adding the length of the ridge, 11', to this, we get 21'2", the length of NO.4 purline on the long side of the roof.

Before marking the wood however, we have one small adjustment to make as shown in Fig. 531.



Hip roof, Master Drawing, complete with angles and measurements.



Actual length of NO. 4 purline, 9'11-1/4" ———→
 Lay out " " " " " 10'2" ———→

If purlines meet on top of the hip, the layout dimension will be correct. But in this method the purline cuts in to the side and so we must deduct the distance from the centre line of the hip to the point of the purline, which in this case is 1-3/8", or a total for both ends of 2-3/4".

The purline pattern. Prepare a sheet of paper as shown in Fig. 532, making two marks, one at 4" and the other at 2" beyond it. Lay this paper on the master drawing as shown in Fig. 533, and trace as indicated. Cut off shaded parts. Then lay paper on Master drawing of Common rafter Fig. 472, page 199, as shown, and trace.

Transfer this double angle to the other end of the pattern

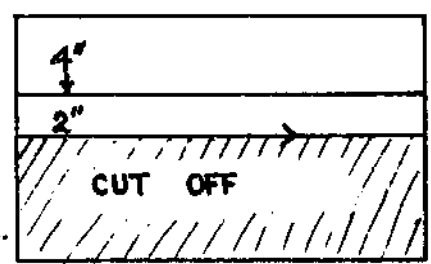


FIG. 532.

as in Fig. 535. Transfer this pattern to 26 gauge sheet metal. In-

clude the line from point to point. Bend the metal along this line, so that it will fit a purline as seen in Fig. 537. We recommend making 2 metal patterns if purlines are to be given final cut, at right end, up on the roof. Always mark and cut

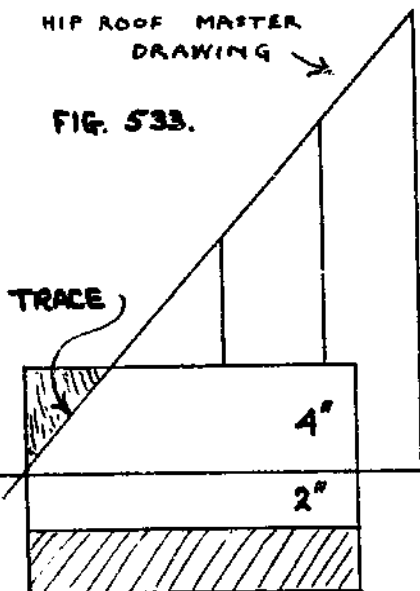


FIG. 533.

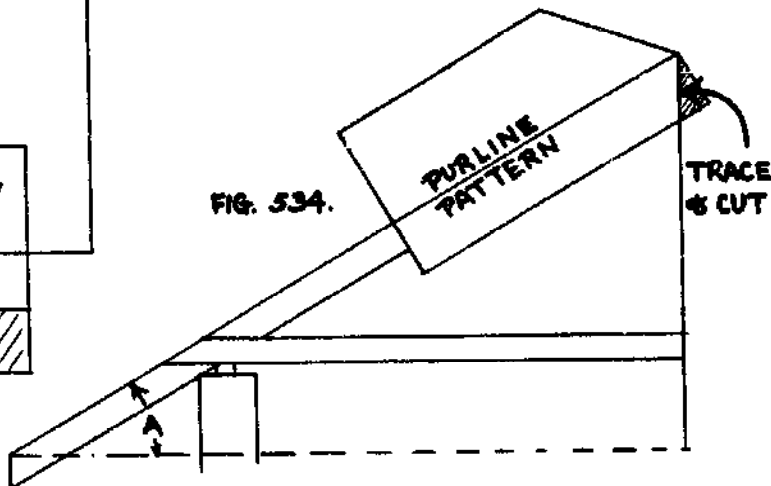


FIG. 534.

In Fig. 534 the angle cut from the pattern is the angle A.

the left hand one first, and on the ground, as it is the most awkward, especially up on the frame.

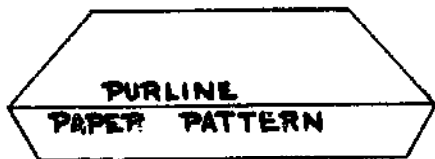


FIG. 535.

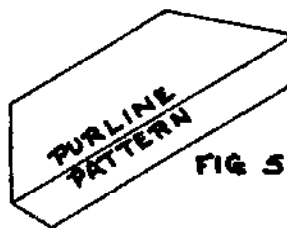


FIG. 536.

Marking for the left hand cut

Marking for the right hand cut.

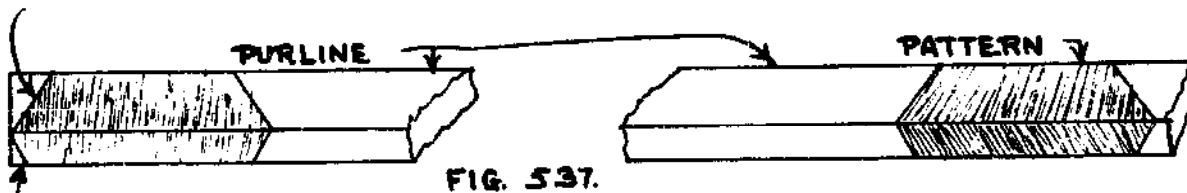
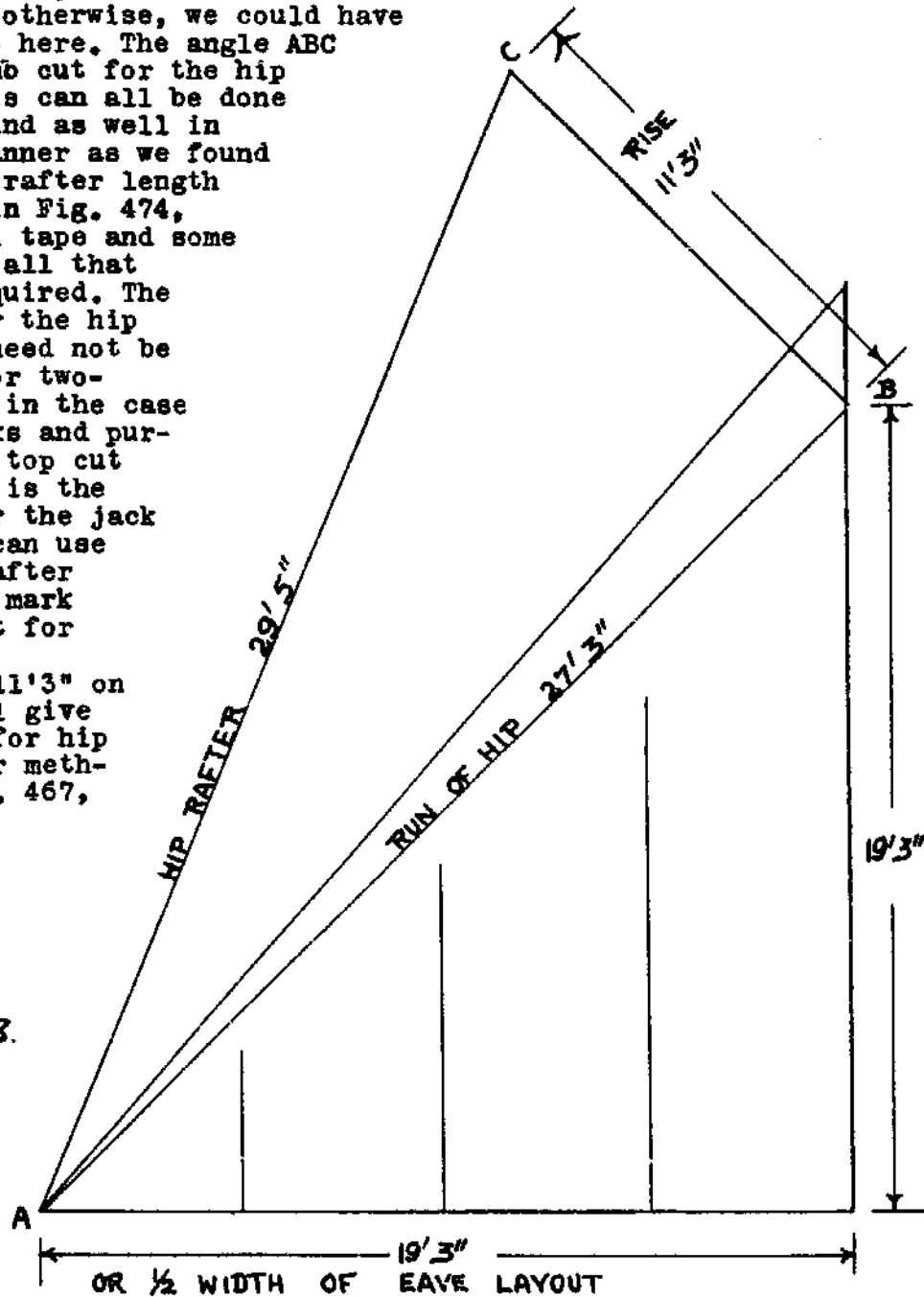


FIG. 537.

The method of cutting purline ends up on the roof is given in the chapter on roof erection. If your roof is laid out correctly, every piece can be cut on the ground and be ready for erection as soon as the walls are complete and the wall plate has been set.

3. Complete lay out for the hip rafter. (1.) The plumb cut. On your own copy of the hip roof master drawing, Fig. 515, page 212, mark off 19'3" on the common rafter line at B. Join A B. From B erect a perpendicular B C to represent the rise, which is 11'3". See Fig. 472, page 199. Join A C. This is the hip rafter line once more, and if we had not known its length otherwise, we could have obtained it here. The angle ABC is the plumb cut for the hip rafter. This can all be done on the ground as well in the same manner as we found the common rafter length and angle in Fig. 474, page 200. A tape and some sticks are all that will be required. The pattern for the hip plumb cut need not be compound, or two-flanged as in the case of the jacks and purlines. The top cut of the hip is the same as for the jack and so we can use the jack rafter pattern to mark the top cut for the hip. 27'3" and 11'3" on square will give plumb cut for hip rafter. For method see Fig. 467, Page 197.

FIG. 538.



The hip rafter plumb cut pattern. Since we propose to make a 2" X 9" hip rafter, we will make a paper pattern 9" wide. Place it on the previous drawing as indicated here, trace, cut off the shaded part, transfer to metal. This pattern is for eave as well as ridge on the hip rafter. (2) Making the 2" X 9" X 29'5" hip rafter.

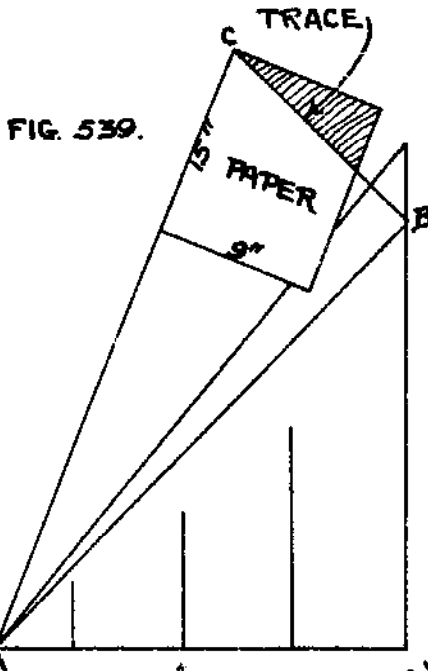


FIG. 539.

On top of a spliced, but unbound 2" X 6" X 33'6" rafter with a perfectly straight upper edge, nail a 2" X 3" strip, spliced as shown, perfectly straight, and breaking joints with the 2" X 6" approximately as shown. Bind as indicated in Fig. 541.

Three 12' sticks properly spliced will make a 33'6" length. Be careful in jointing the 2" X 3" at the upper end that it does not go beyond the 29' mark, otherwise it will interfere with the marks, cuts, at the end.

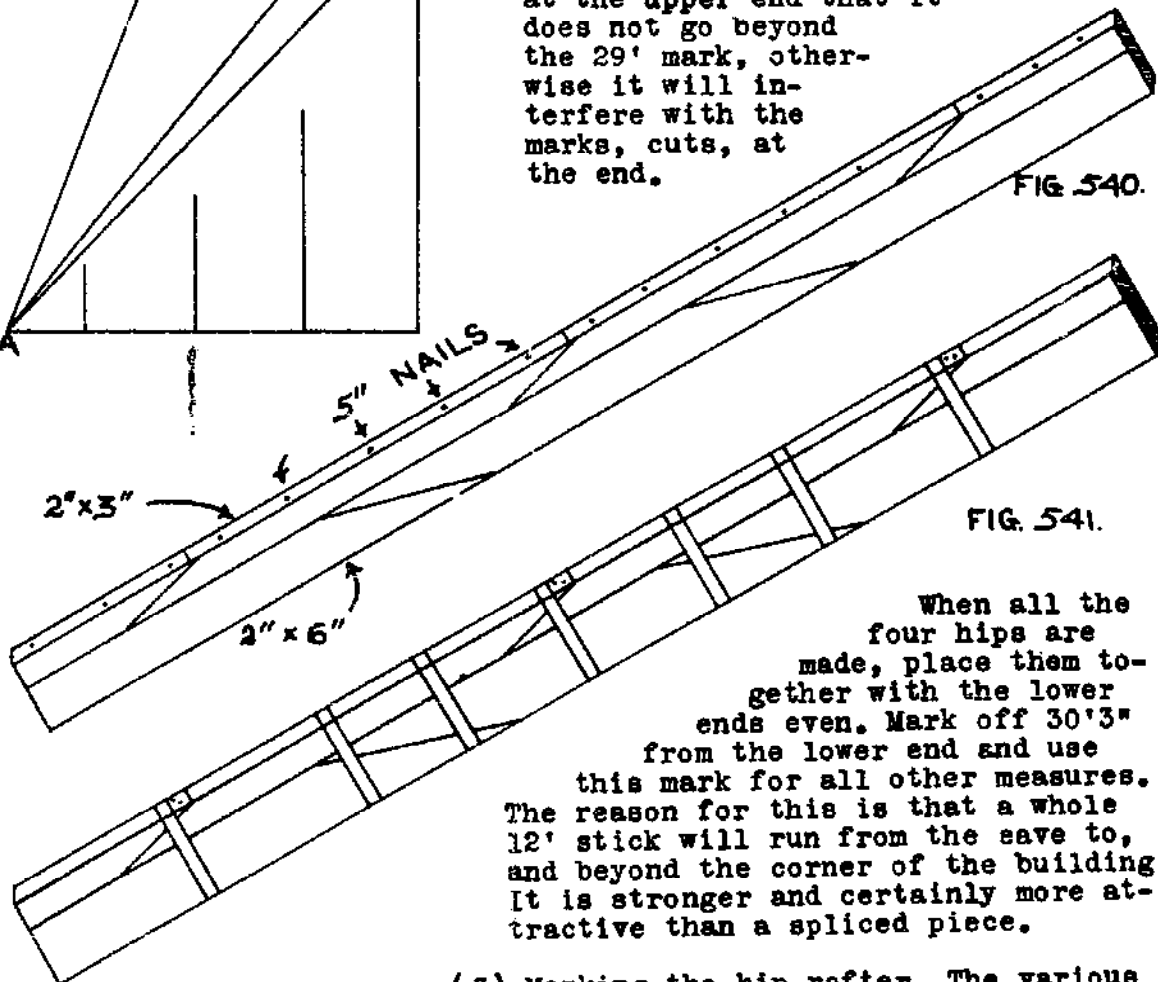


FIG. 540.

FIG. 541.

When all the four hips are made, place them together with the lower ends even. Mark off 30'3" from the lower end and use this mark for all other measures. The reason for this is that a whole 12' stick will run from the eave to, and beyond the corner of the building. It is stronger and certainly more attractive than a spliced piece.

(3) Marking the hip rafter. The various jack rafter and purline marks are taken from Fig. 530 on page 217 or from a drawing similar to it. The following table is for the Mission House roof. All markings from the top down.

Hip rafter marks for jack rafters and purlines.

Jack rafters
 7'4-1/4"
 14'8-1/2"
 22'-3/4"

Purlines
 6"
 7'9"
 15'-1/2"
 22'3-1/2"
 29'5"

Make a short cross-wise mark at each measure, but indicate whether it is for jack rafter or purline by the following arrow heads:

FIG. 542.

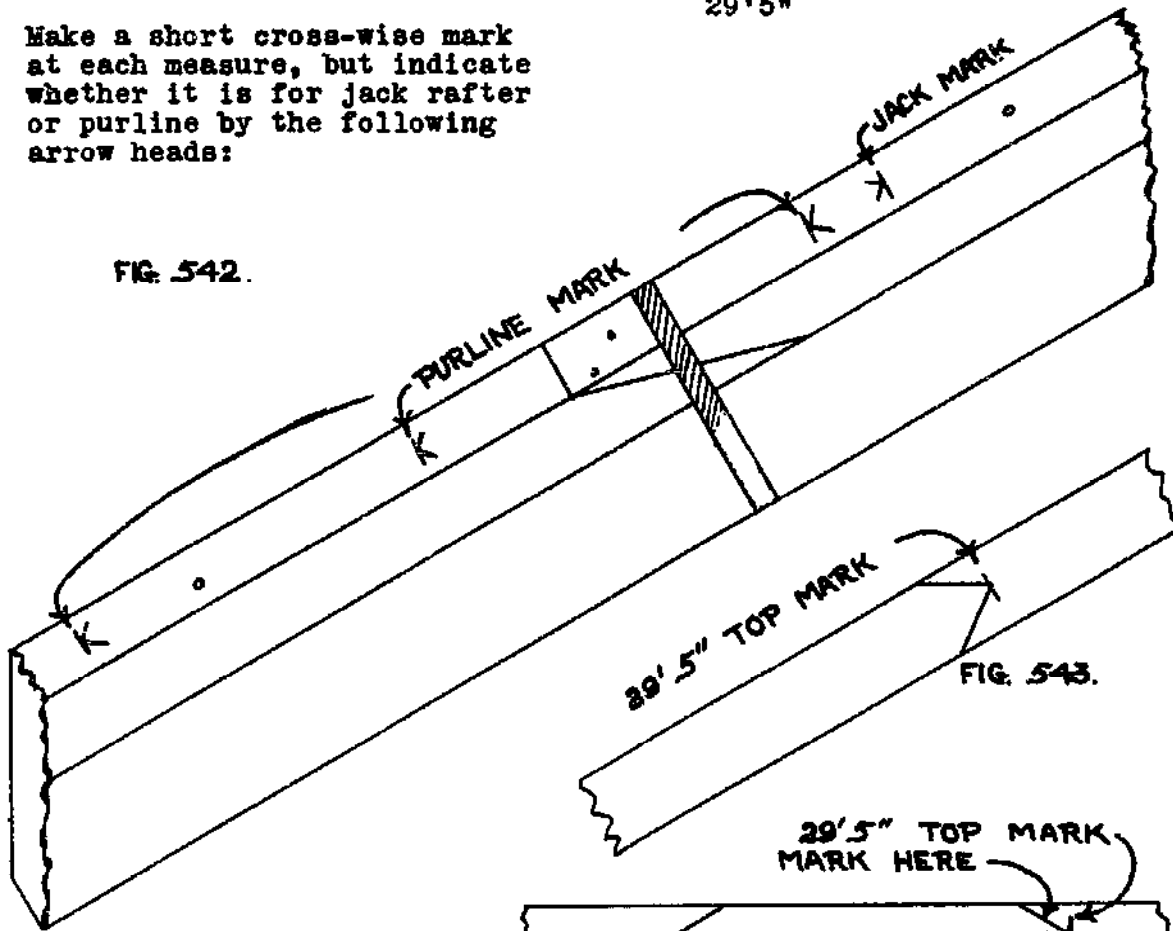


FIG. 543.

29'5" TOP MARK
 MARK HERE



FIG. 544.

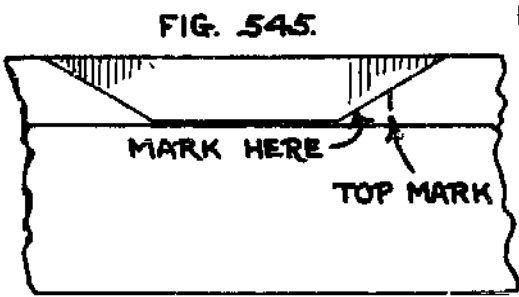


FIG. 545.

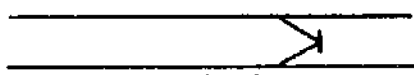
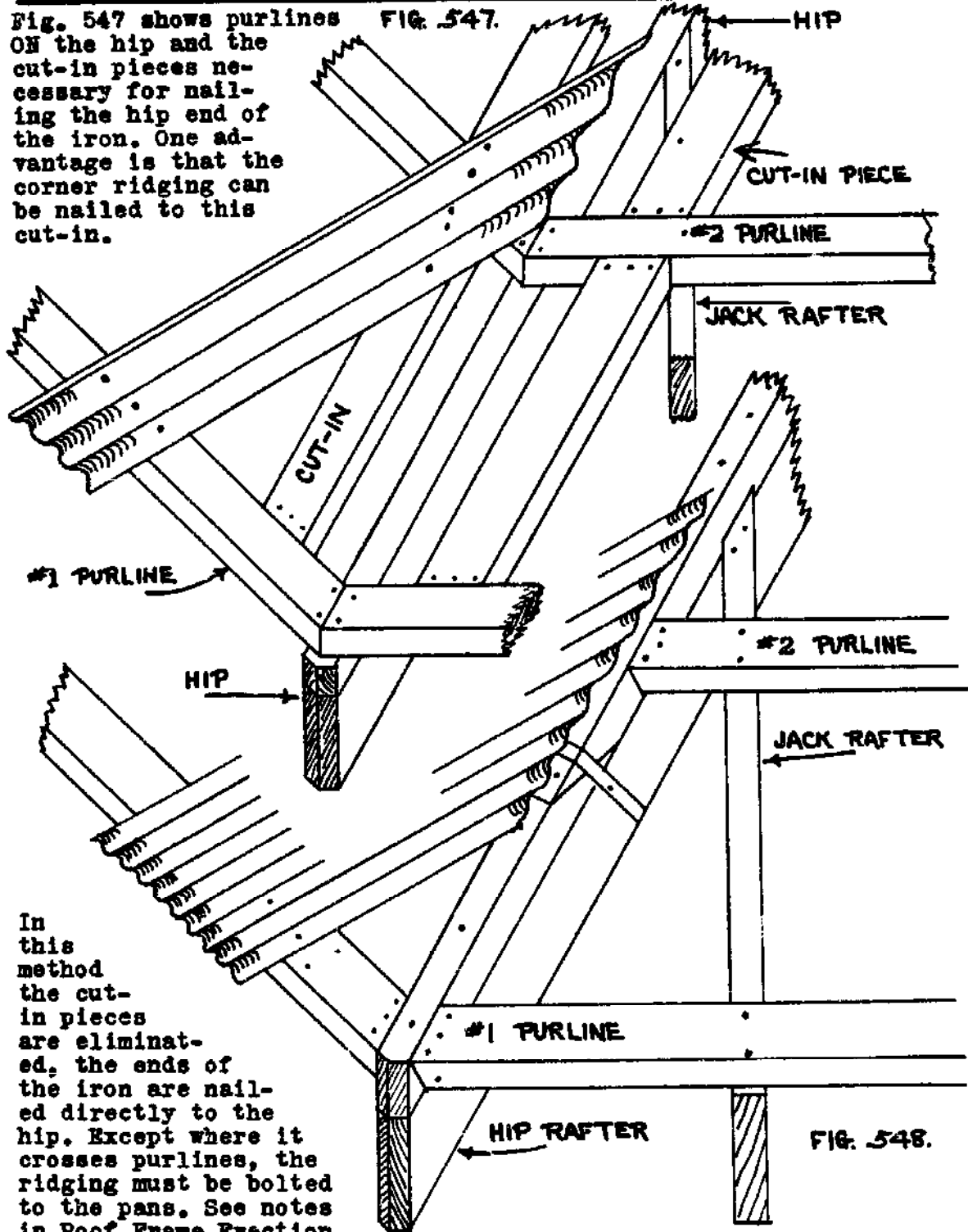


FIG. 546.

Fig. 547 shows purlines ON the hip and the cut-in pieces necessary for nailing the hip end of the iron. One advantage is that the corner ridging can be nailed to this cut-in.



In this method the cut-in pieces are eliminated, the ends of the iron are nailed directly to the hip. Except where it crosses purlines, the ridging must be bolted to the pans. See notes in Roof Frame Erection for tying bottom purlines at corners and nailing pans to the hip rafter.

FIG. 548.

Fig. 549 shows how the jack rafter and purline marks are developed and used.

In practice, a person with a good eye will make the purline mark without a pattern. Since it is not 45 degrees, and to get it right at first, hold the purline pattern against the edge of the hip rafter so that the folded edge of the pattern will be in line with the arrowhead.

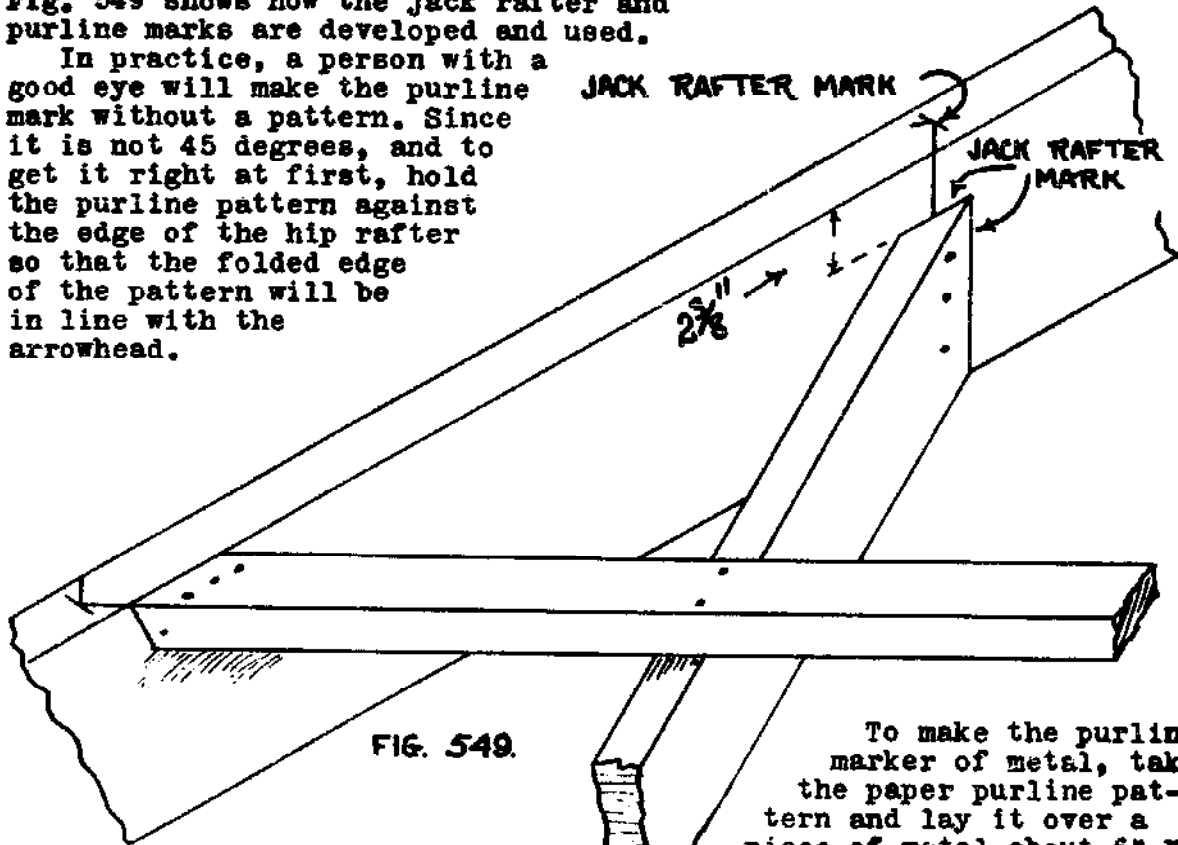


FIG. 549.

To make the purline marker of metal, take the paper purline pattern and lay it over a piece of metal about 6" X 6" as shown in Fig. 551.

Continue the dotted line of the pattern across the metal to 'P' which represents the arrowhead on the hip rafter. Remove the paper pattern, and complete the layout on the metal as shown in Fig. 552. Cut off the shaded parts and bend over at the dotted line.

Jack rafter marks. In this case, the least that an experienced man should do is to make a gauge for the 2-3/8" mark, which must be accurate. A simple pattern indicated by

'H' may do as shown in Figs. 553, and 555. The angle is the plumb cut of the common rafter. If the whole pattern is required,

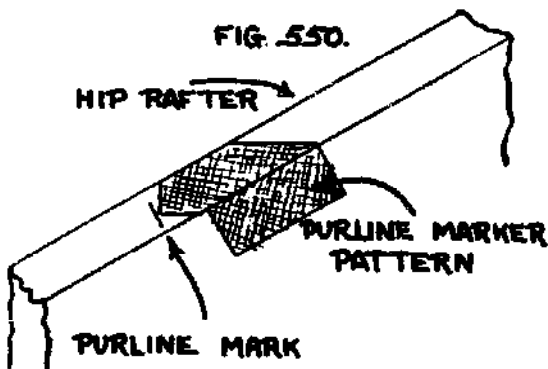
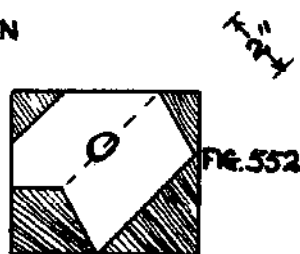
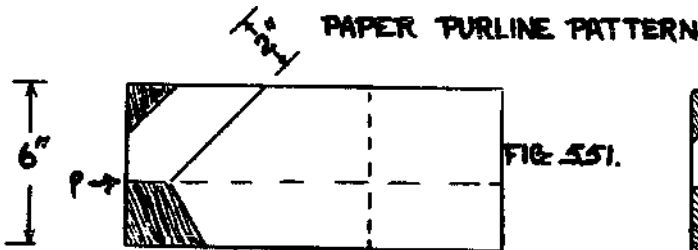


FIG. 550.



proceed as indicated in Fig. 553, 554. When completed, place the pattern as indicated in Fig. 555, and mark both sides of the hip in the manner indicated by the arrows.

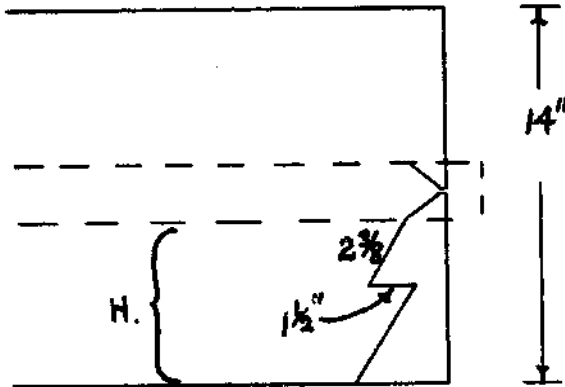


FIG. 553.

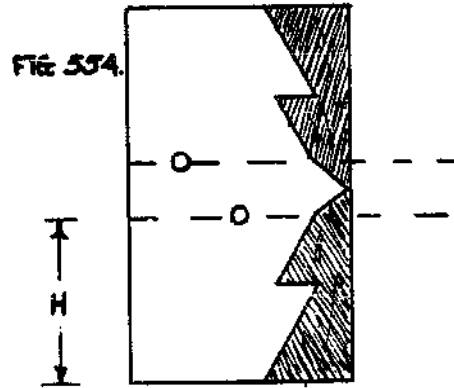


FIG. 554.

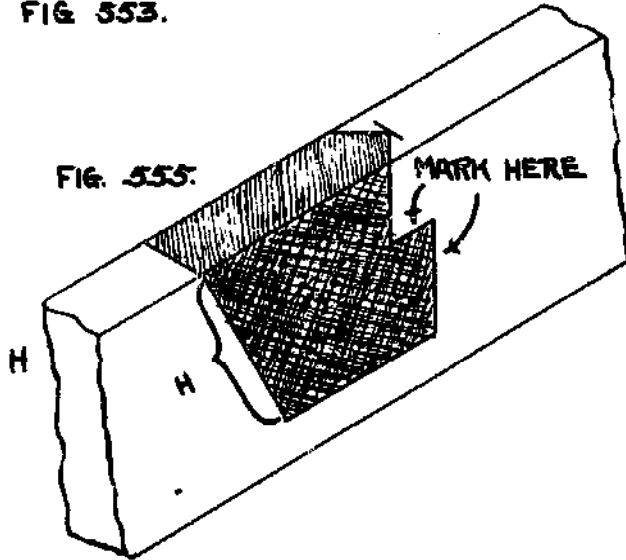


FIG. 555.

The arrow head is made with the top cut of the jack rafter pattern.

If the point at which the jack rafter is to fit is not of uniform surface, due to inequality of thicknesses of the 2" X 3" upper part of the hip rafter, dress it down before making the mark.

The junction of the ridge, and hip and common rafters. This is the most difficult layout in the entire roof, but taken step by step will not prove too complex.

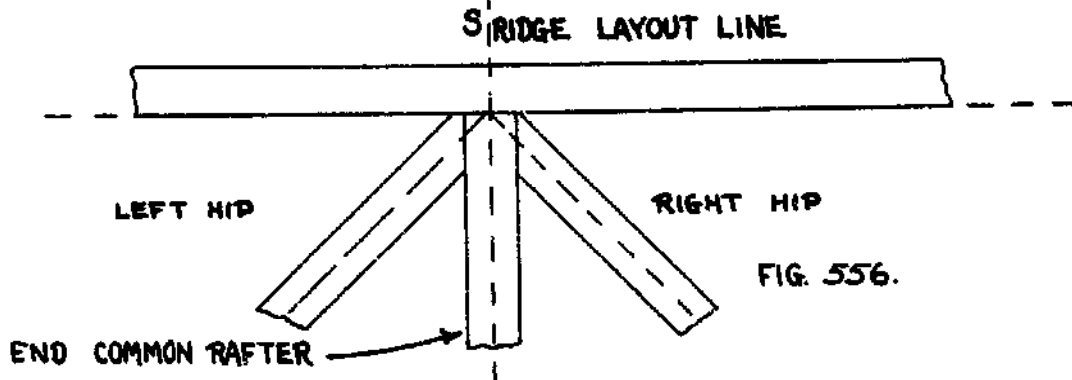


FIG. 556.

 Marking the ridge end of the hip rafter

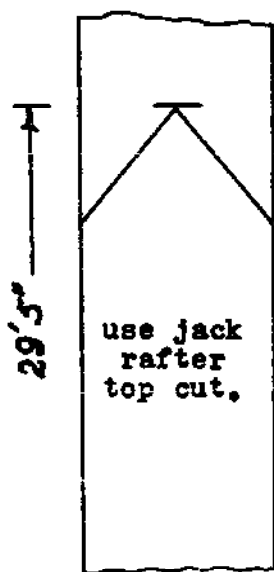


FIG. 557.



FIG. 558.



FIG. 559.

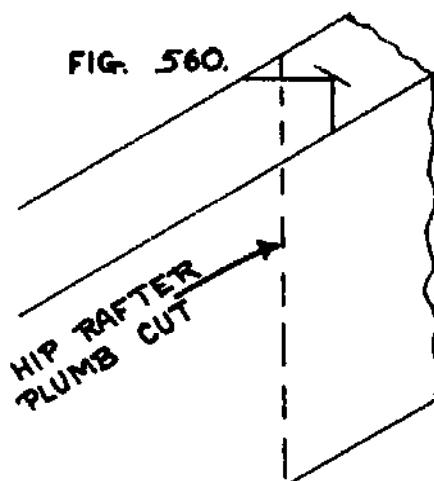


FIG. 560.

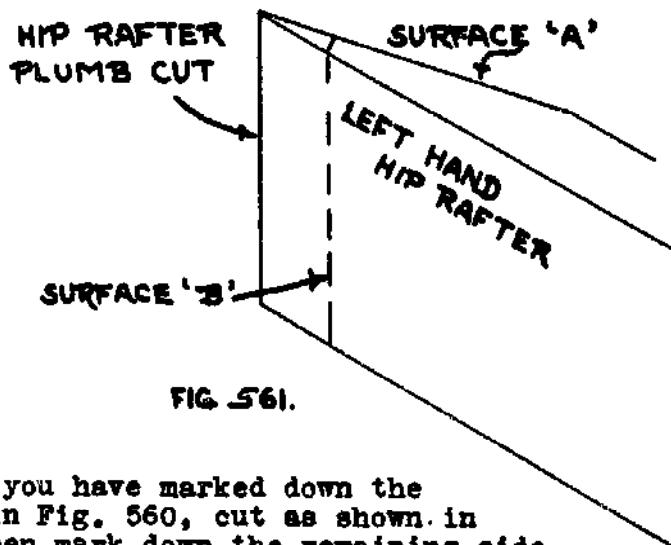


FIG. 561.

When you have marked down the side as in Fig. 560, cut as shown in Fig. 561. Then mark down the remaining side as shown also in Fig. 561. There only remains to get the right height for the seating upon the support batten shown in Fig. 562. In Fig. 563 we have shown a view of the hip rafter as seen from 'S' in Fig. 556, and looking through the common rafters as it were. It shows the end common rafter in section and the left hip rafter in position up against it. Fig. 564 shows a section or side view of the seating, which shows the surface of the cut 'A' on which the marks for the seating is laid out.

End view of end frame.

Fig. 562.

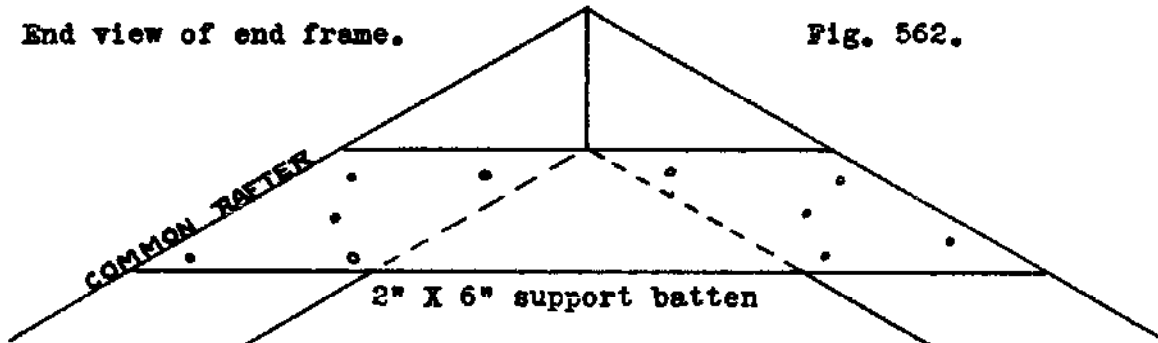
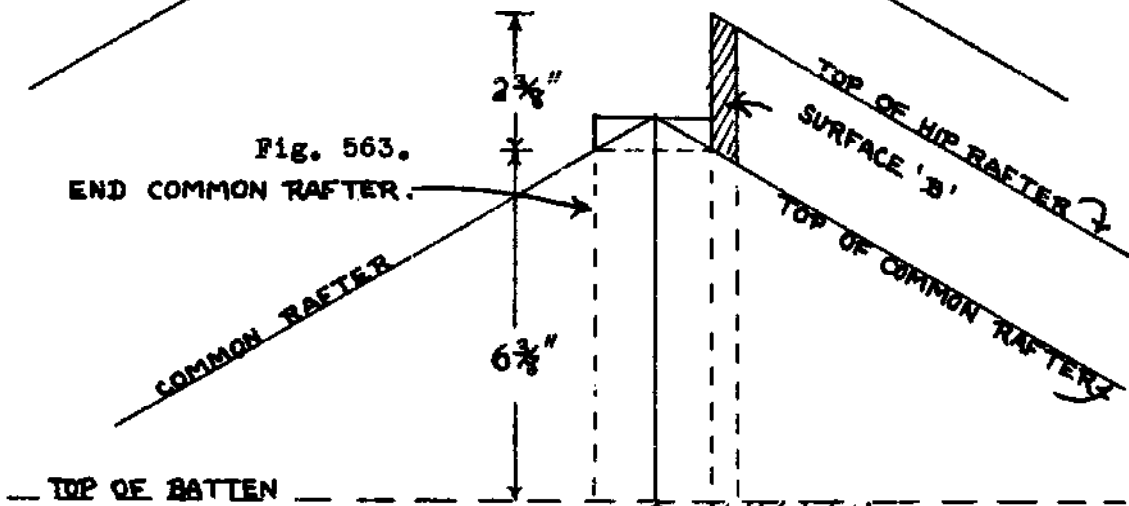
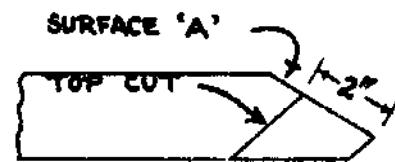
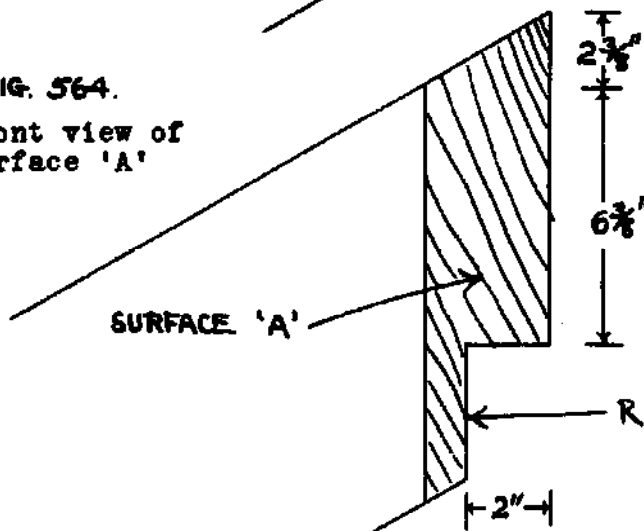


Fig. 563.
END COMMON RAFTER.



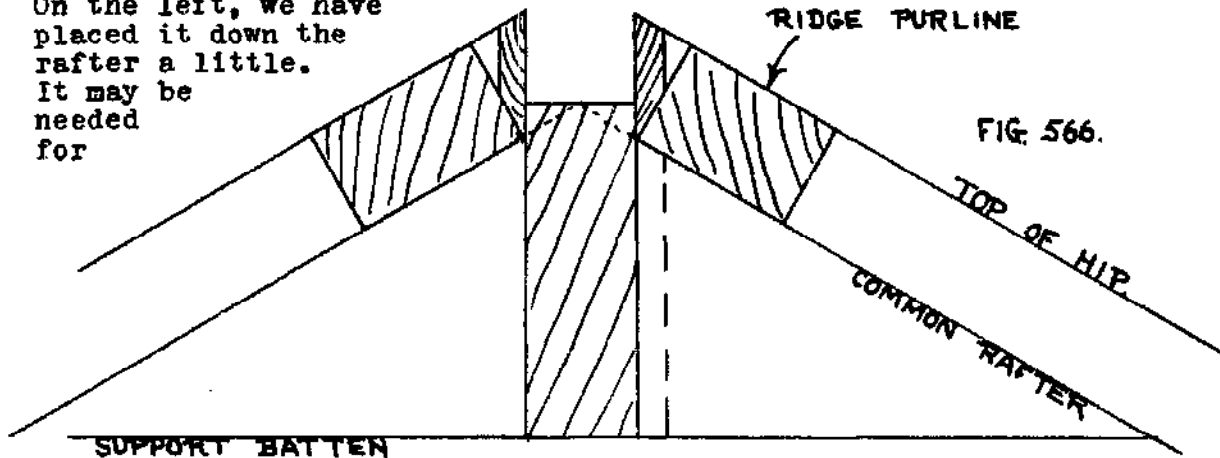
Surface 'R' rests against batten.

FIG. 564.
Front view of surface 'A'



View of under side of hip marked for the seating cut. Make mark with jack rafter pattern, top cut.

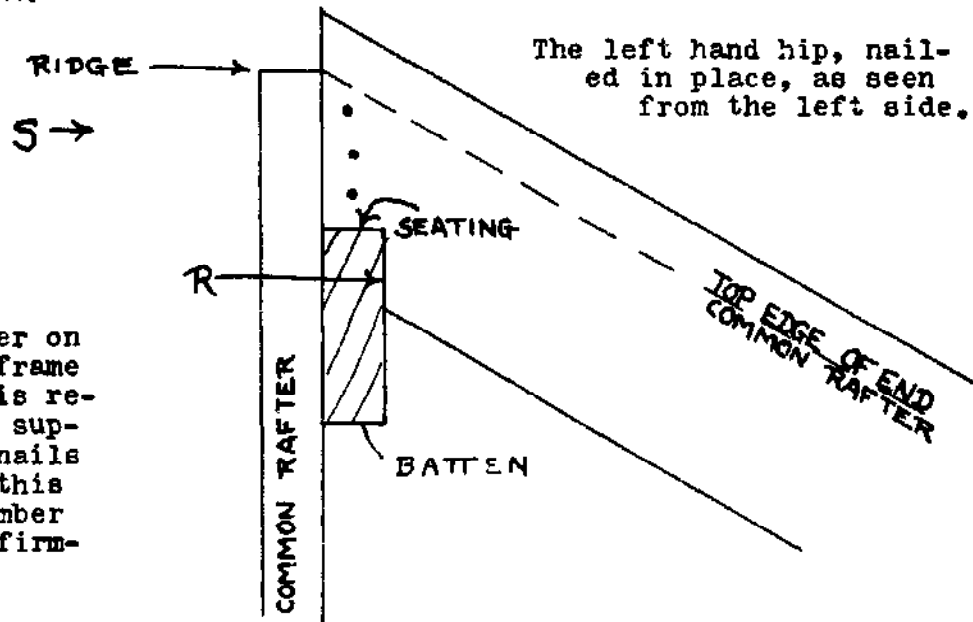
Fig. 566 shows how the two ridge purlines rest on the common rafters at the end, and how they fit perfectly into the hip rafter. On the right of the figure we have the purline which is measured in the former drawings. On the left, we have placed it down the rafter a little. It may be needed for



better nailing for wider ridging. Of course it would be a trifle longer than the measured purline. Just cut one end, the left, on the ground and cut the other on the roof when you have marked the correct length.

FIG. 567.

In the chapter on erection of frame a metal tie is recommended to supplement the nails for holding this important member of the roof firmly in place.



Except for the rafter brackets, this completes the preparation of the roof frame. They had better be cut to fit when the rafters are in place.

We add the following details of the quick joint for the end common rafter with the end frame because when it is done, the roof is entirely ready for erection.

The end common rafter has the common rafter plumb cut. From the point of this cut measure down 7" or whatever distance it is from the ridge point of the frame to the top of the support batten. Cut a square seating in the rafter as shown in Figs. 567, 568. The thickness of the batten may not be 2", in which case the seating should be regulated in depth. Drill a hole in the rafter and drive a 4" or 5" nail leaving the end to project 2-1/2" or 3". Drill a corresponding hole in the top of the batten, shown in the top view, Fig. 569. Do the same for both ends. This device has proved a time saver in erecting roof frames.

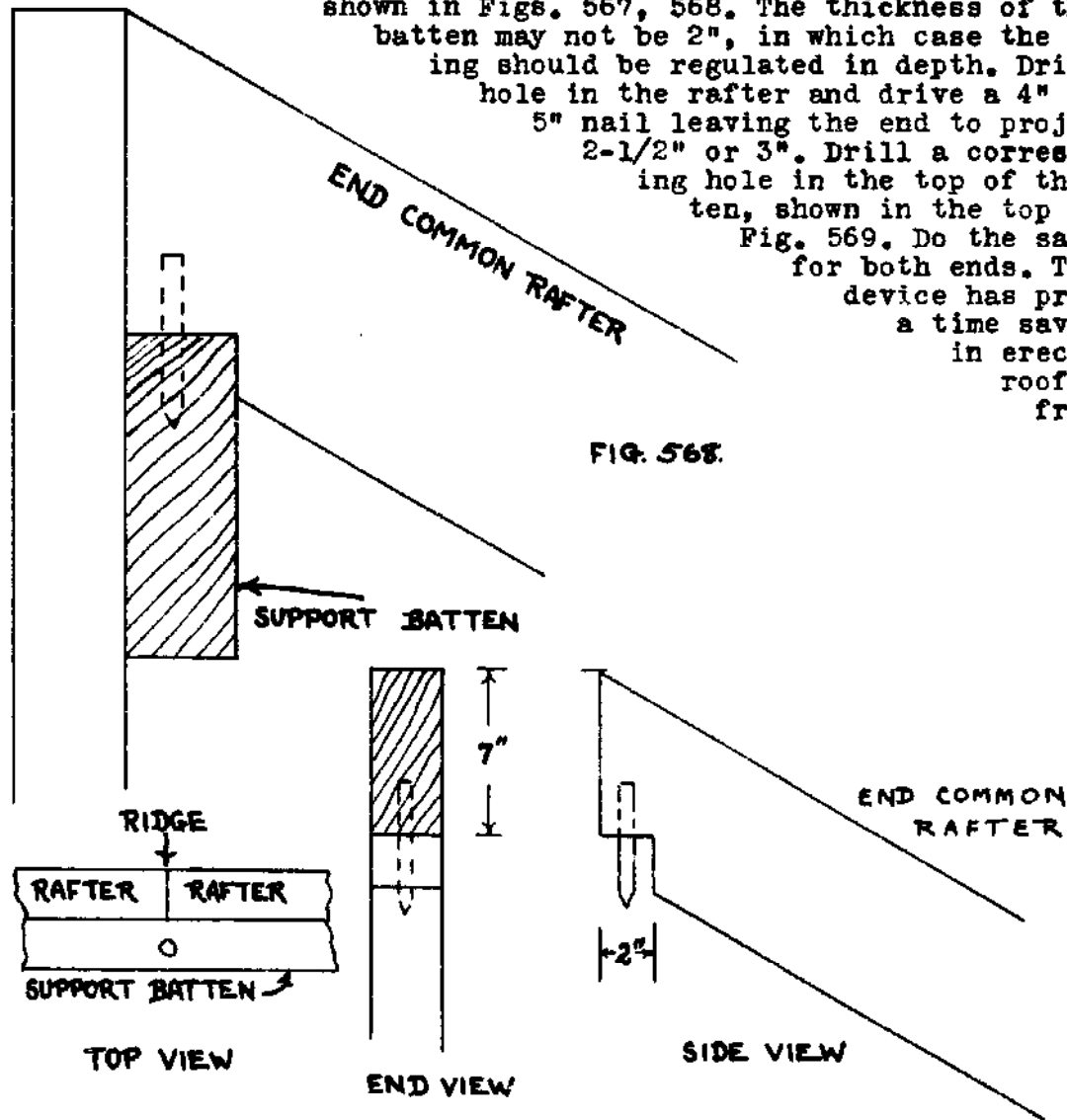


FIG. 568.

FIG. 569. END COMMON RAFTER.

 Complete carpenter's order for the Mission House Roof.

1. Wall plates. 2 - 2" X 4" X 37'4"
 2 - 2" X 4" X 25'8"
 1 - 2" X 4" X 10'2"
 1 - 2" X 4" X 7'6"
 1 - 2" X 4" X 6'4"
2. Common rafters. 10 - 2" X 6" X 22'9" over all, uncut.
3. Cross ties. 3 - 2" X 4" X 28'5" point to point.
4. Support battens. 3 - 2" X 6" X 4' point to point.
5. Frame struts. 6 - 2" X 4" X 4'4"
6. Hip rafters. 4 - 2" X 9" X 30'6" over all, uncut.
7. Jack rafters. 4 - left hand jacks, 2" X 6" X 6', 4 - 12',
 4 - right " " 6', 4 - 12', 4 - 18'
8. Rafter brackets. 21 - 2" X 3" X 4'3".
 3 - 2" X 4" X 9', uncut, for hip rafters.
9. Purlines.

	<u>Side of roof.</u>	<u>End of roof.</u>
Exact point to point measure.	1. 2-2" X 4" X 49'3-1/4"	2-2" X 4" X 38'3-1/4"
	2. 2 -2" X 3" X 40'-1/4"	2-2" X 3" X 29'-1/4"
	3. 2 -2" X 3" X 30'6-1/4"	2-2" X 3" X 19'6-1/4"
	4. 2 -2" X 3" X 20'11-1/4"	2-2" X 3" X 9'11-1/4"
	5. 2 -2" X 3" X 11'5-1/4"	2-2" X 3" X 5-1/4" (Better a 2" X 6" X 10 10-1/2")

IX. PORCHES. The covered porch at the front door of a Mission house is a very useful feature. The 6' overhang is not enough to give porch shelter. There are four main styles of porch roof.

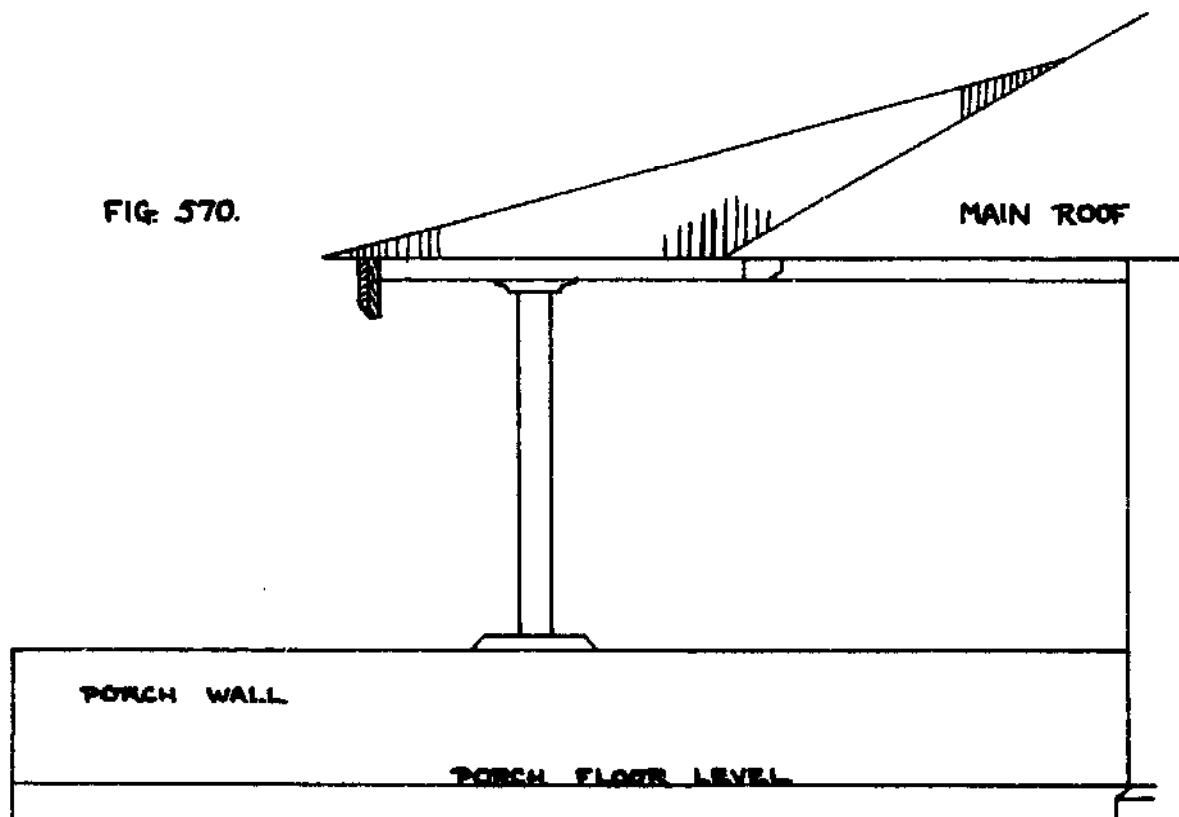
1. A partial flat roof. This gives adequate protection from the sun and the rain, but allows for an open part at the front which gives a sense of freedom from walls and roof, very acceptable in the evening after a hot day. Yet, with the freedom there is not the close contact with the ground and creeping things which goes with a sitting out in the open, away from the house.

2. A full roof. That is, the entire porch covered by roof. This too is useful and not too difficult to build. Like the partial shelter it can be added easily after the main roof has been completed.

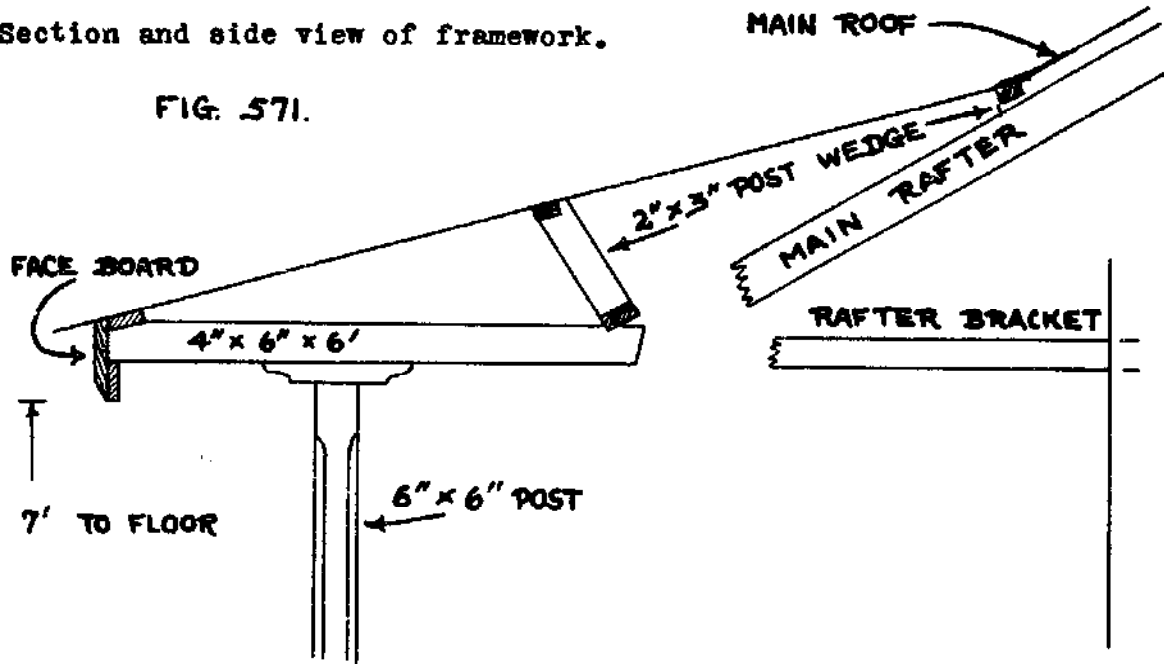
3. A gable roof. This is very acceptable under certain circumstances and although it does not give as much protection from the sun at the front, might conceivably be cooler than a hip roof. It is much easier to build than a hip roof.

4. A hip roof. This is undoubtedly the most attractive, whether a partial or full cover. The house in the Frontispiece has a partial cover, hip roof.

1. A partial flat roof. Draw a partial or whole section of the end of the house showing a side view of the porch. In the example we have chosen, there is an extension of two 6' pans, giving a new pitch with a length of 11'6".



Section and side view of framework.



Prepare two 4" X 6" X 6' beams of 2" X 6" wood. Plane the lower edge and the two sides; spike together.

Fit the one end under the main house purline. Tie temporarily, and support the outer end temporarily. By line or straight edge from the first joint up the roof, determine the pitch. Use a 2" X 4" block under this line to mark the top edge of the 4" X 6" beam where the purline will rest.

Two purlines will be required, 2" X 4" X width of porch plus 18" overhang at each side.

Prepare the face board, made of three pieces of 1" X 12". The length of the face board is the same as for the purlines. After planing the face of one board and as much of the second as is necessary to complete the full length, joint carefully, and lay face down. Fit the eave purline by dressing the outer edge to line with the roof and the face board. Back up the rest of the face board between the points where the 4" X 6" beams will butt the rear surface. Do not joint the face board in the middle of the span. Let one be full length. When backing up, let the full length of the backing board evenly straddle the joint in the face board, as shown.



FIG. 572.

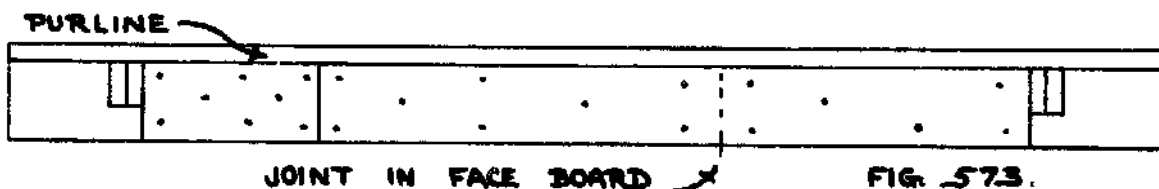


FIG. 573.

Nail, or better, screw the backing board to the face board. Erect this entire framework and support by temporary posts and by tying to the main roof purline. Adjust as is necessary to make the front purline level, and properly placed as to the width of the porch. If the rafter bracket to the wall is level with the lower trimmed edge of the main rafters, make the lower edge of the 4" X 6" beam level with the bracket. Otherwise, make the lower edge of the beam level with the lower trimmed edge of the rafter.

The main roof pans should be tacked in place first. If this porch is being added to the house after the completion of the main roof, the pans opposite to the porch will have to be loosed from the bottom purline. Raise the second purline to the main eave position, and, after lifting the eave pans of the main roof, insert this purline. Tack in place with a couple of one inch nails. Raise this purline and the pans to the new pitch line and prop temporarily.

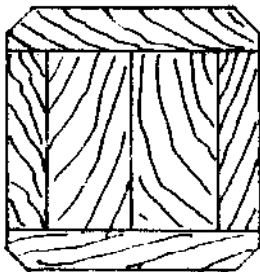
Now at each end of the porch roof, place the two corner pans, their upper end lapping under the pans from the main roof 6". The edge of the pan will be even with the face board, and the whole framework adjusted so that the lines of corrugations will harmonize with the main roof pans. When this is done, the remaining pans can be fitted in. Any piece will have to be within the two corner pans. Do not nail any pans home until the entire porch has been covered and a careful check up shows that all is correct.

The outer purline requires no further support than that of being securely nailed to the ends of the beams. The second purline is supported by short posts from the eave purline of the main roof. The posts should be over main house rafters, and of course one at each end over the 4" X 6" beam.

Prepare two post plates, one for the foot and one for the head of each post. If the curved end is too elaborate, saw and plane a chamfer as at base of post in Fig. 570.

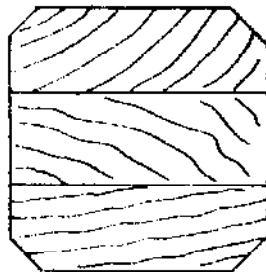
When the porch is in its final position, make the two posts. If there is a porch wall, they will be just about 6' long.

FIG. 574. FRONT



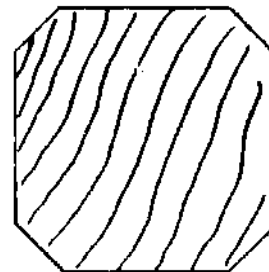
2 - 2" x 4"
2 - 1" x 4"
2 - 1" x 6"

FIG. 575 FRONT



3 - 2" x 6"

FIG. 576. POST SECTIONS.



Nail top and bottom plates to the post, erect, and nail the top plate to the beam. A metal tie should run from a stone anchorage in the porch wall, well below the porch floor, to the lower end of the post. Another tie, neatly made should connect the post and the 4" X 6" beam, fastened on the inner edge.

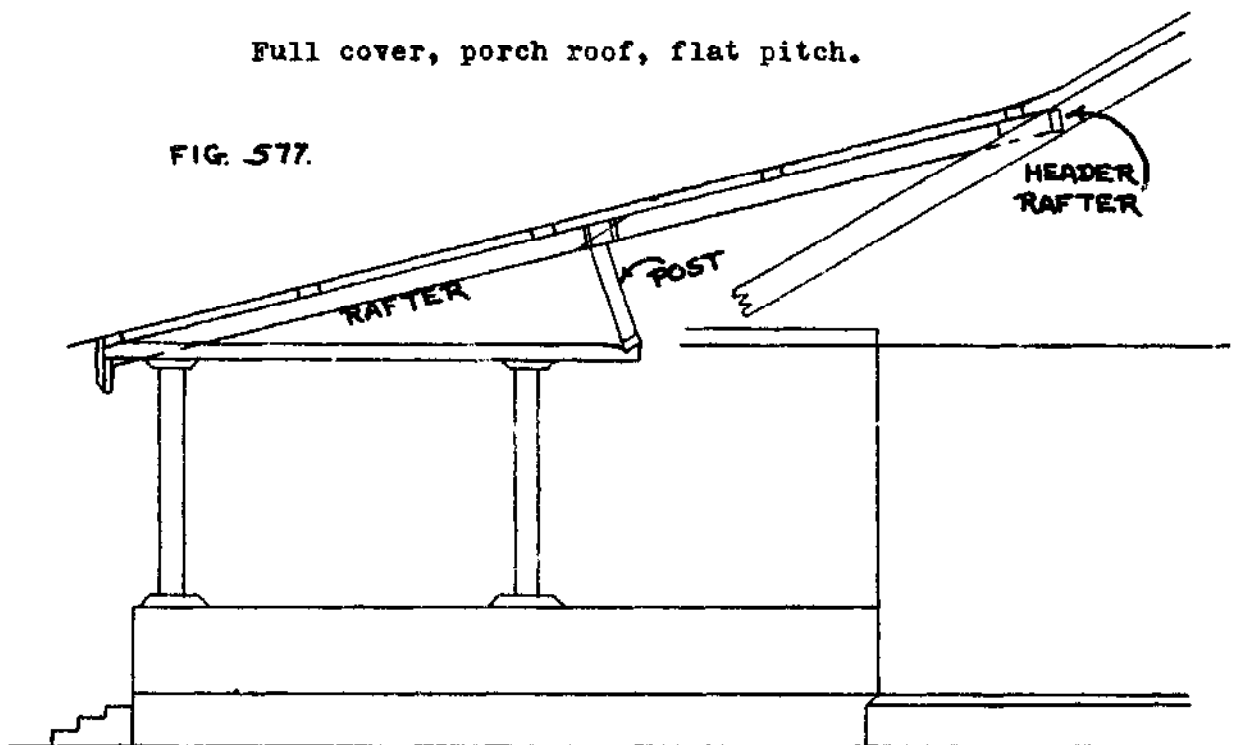
Also tie the beam to the main roof purline. Every precaution should be taken to prevent the wind from lifting the porch roof.

The space between the porch pans and the lower edge of the beam, at the ends, may be sheathed with corrugated iron in the vertical position; or with 1" boards, or with some arrangement of lattice.

2. A full porch roof, flat pitch. This is very much the same as the foregoing. The line is taken this time from the second joint in the main roof. Two main roof pans are raised, and two added, the total length of the flat pitch being 22'6".

The 4" X 6" beam is approximately 12' long. If you are using 12' lumber, try to get at least two pieces which are over the 12' a little, to make the beam as long as possible.

Full cover, porch roof, flat pitch.



At least three 2" X 6" rafters, 22'9" long are required to support the purlines, one over each beam and at least one in the span. The front end of the rafters are supported by nailing through the face board. The other end is nailed to a header rafter. Of course if the porch rafters can be made to rest conveniently on the main roof rafters, so much the better. Support the middle of each rafter by a post from the eave purline of the main roof. If the post comes midway between a wide span of rafters, the purline should be doubled.

As before, place the outer corner pans carefully and line up everything carefully before nailing the pans home. This roof needs four posts.

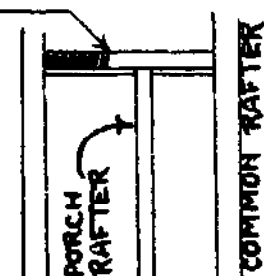


FIG. 578.

3. A gable roof front for the porch. This can be worked out right on the main roof frame, or drawn on paper. We will follow the latter method here, and the former may be used in practice.

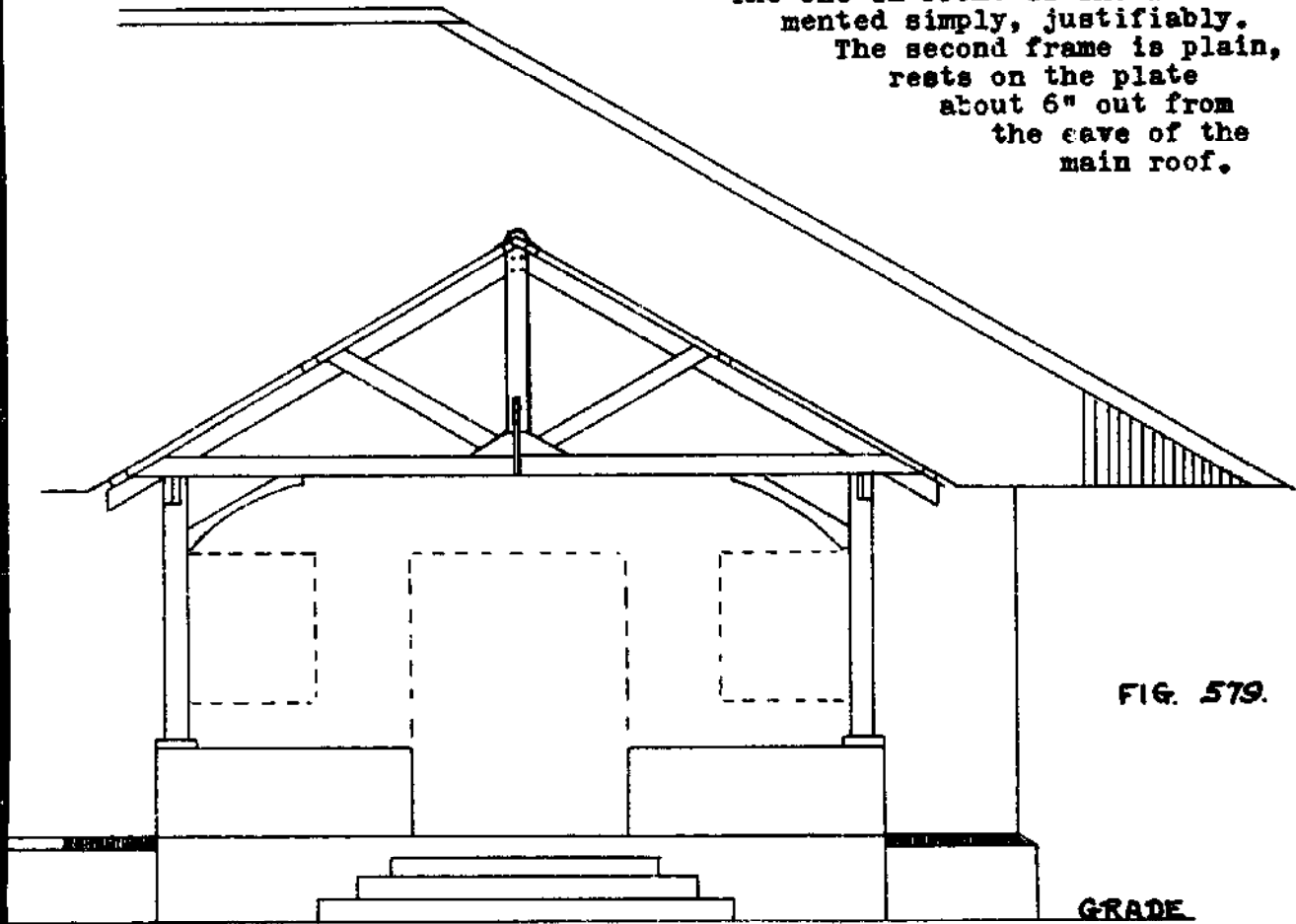
First draw an elevation of the two roofs, showing, first, the number and length of the pans to be used. Then, the out to out measure of the eaves, which in this case is 19'6".

Only two roof frames are required.

The one in front is shown ornamented simply, justifiably.

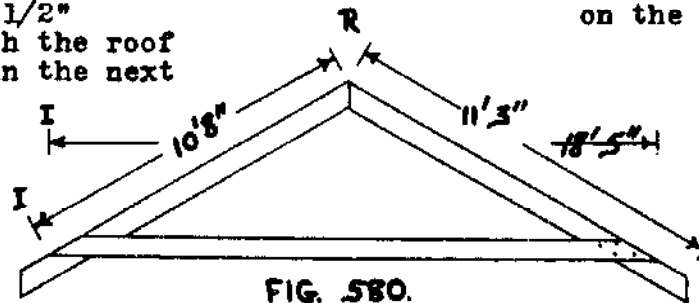
The second frame is plain, rests on the plate

about 6" out from the eave of the main roof.



The porch wall is 17' out to out. The posts and beams are 16'6" out to out. The angle of the plumb cut for the rafters is 30 degrees or 5'4" and 9'2-1/2" on the square.

The joint with the roof is taken up in the next section on roof junctions.



4. The porch hip roof. This side view shows why there can be no 'A' frame; and shows that the length of the hip and of the valley is the same.

Instead of the beam or plate all around, we use a truss because the 17' span across the front requires it. The truss along the side harmonizes with the truss in the front. Each diagonal in the frame should not be lighter than 3" X 4". 4" X 4" is good. The entire frame should be of uniform lumber. The foot of each diagonal should be made quite secure against outward thrust. The length of the hip and valley and other necessary detail can be secured from the drawing having to do with roof junctions, shown in the next section.

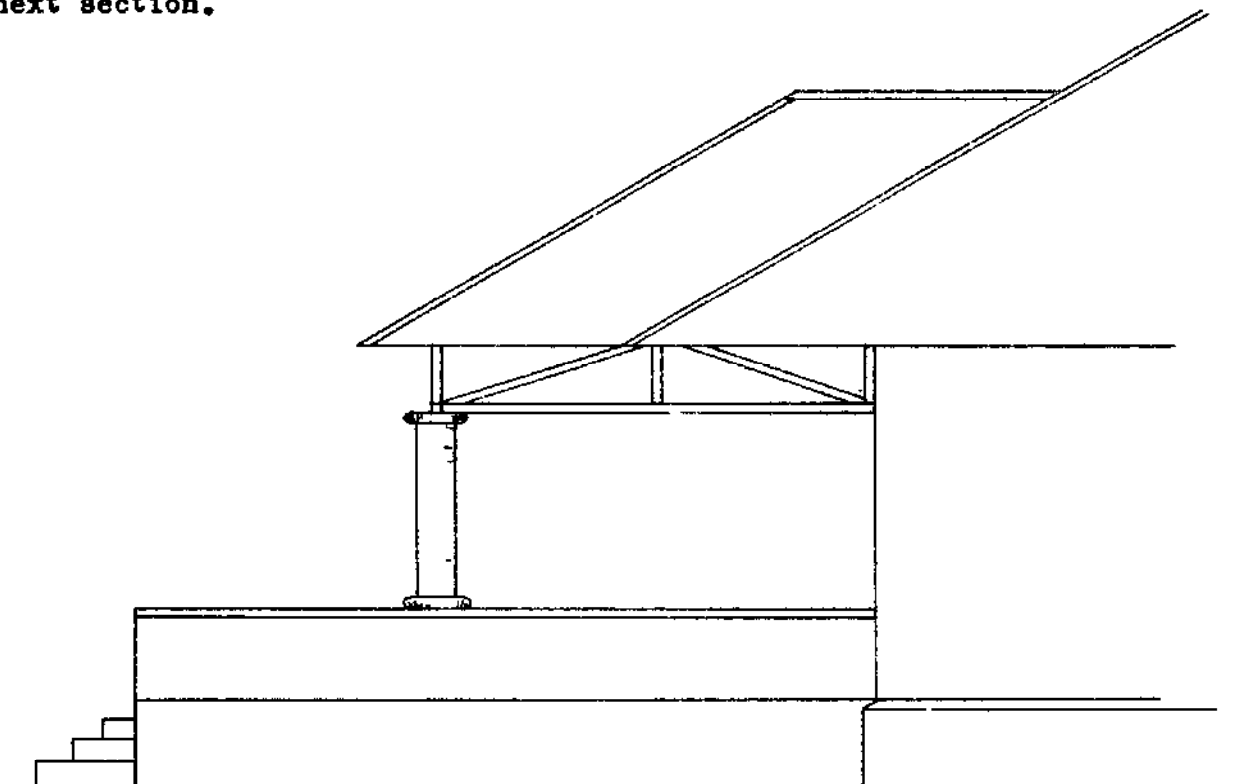


FIG. 581. SIDE VIEW OF PORCH

Be careful to keep the lowest point of the truss at least 6'6" above the floor. The truss shown here is 18" deep. The front truss is shown in the working drawing in the next section.

The two horizontal pieces of the side truss project into the main wall of the house at least 6" and should have a wood bearing plate, at least the lower one. The upper one should be tied by metal to a wood anchor on the inside of the main wall.

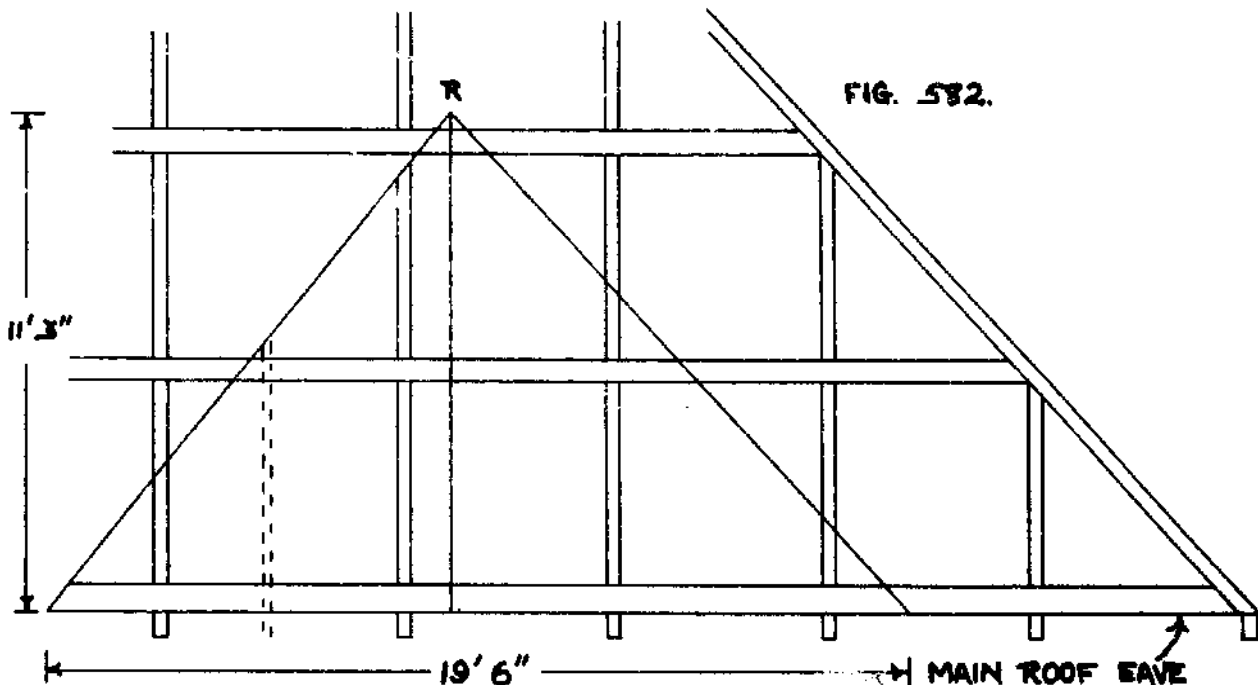
This drawing shows what might be termed a minimum projection for a hip roof. It is more worth while if it extends another three feet. That would make the porch 19' or 20' long. This is a most attractive and useful porch for a family; it makes an ideal shelter for children, especially on rainy days.

X ROOF JUNCTIONS.

Draw a plan of the main roof in the proximity of the porch as in Fig. 582.

Locate the eave points of the porch roof, 19'6" apart, on the eave of the main roof. (If working this out on the roof, drop a plumb line from the eave to the porch wall.) Make a mark at halfway, 9'9", and erect a perpendicular 11'3" long. Call the end of this line 'R'. Join R and the two porch eave points. These two lines are the centre lines of the valleys, and are, also, the true length of the hips.

A glance at the side view of the porch, Fig. 581, will show that the point of junction of the ridge with the main roof is the place to which the first two pans of the main roof come. In other words, if the pitch of the porch roof is the same as that of the main roof, the point at which the ridge of the porch contacts the main roof is the same distance up the main roof as from the eave to the ridge of the porch, learned from any cross section of the porch roof.



There is a problem with the intersection of the lower, main roof purline and the upper plate of the side truss which are on the same plane. Instead of intercepting either, which to us is objectionable, we may check out somewhat from the top of the purline as shown, and somewhat from the bottom of the plate as shown.

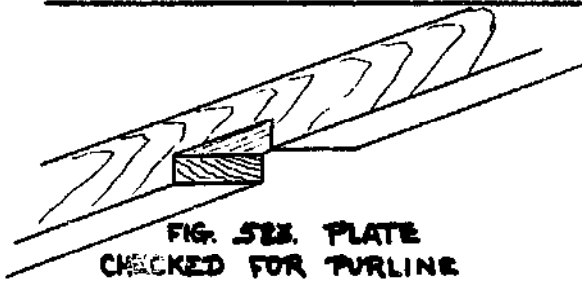


FIG. 583. PLATE
CHECKED FOR PURLINE

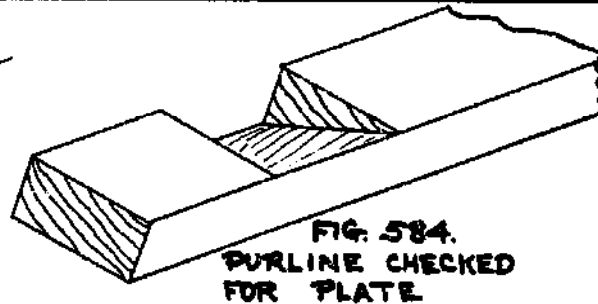


FIG. 584.
PURLINE CHECKED
FOR PLATE

The purline may be reinforced by a sheet metal tie across the top of the joint; and the truss plate may be strengthened the same way by a metal tie across the under side of the joint. This may be done more accurately when the main purline is in its final place and before the plate of the side truss has been fastened in its frame. It can easily be raised and marked for the check, and the checking done on the ground so much more quickly than when the truss is up in place.

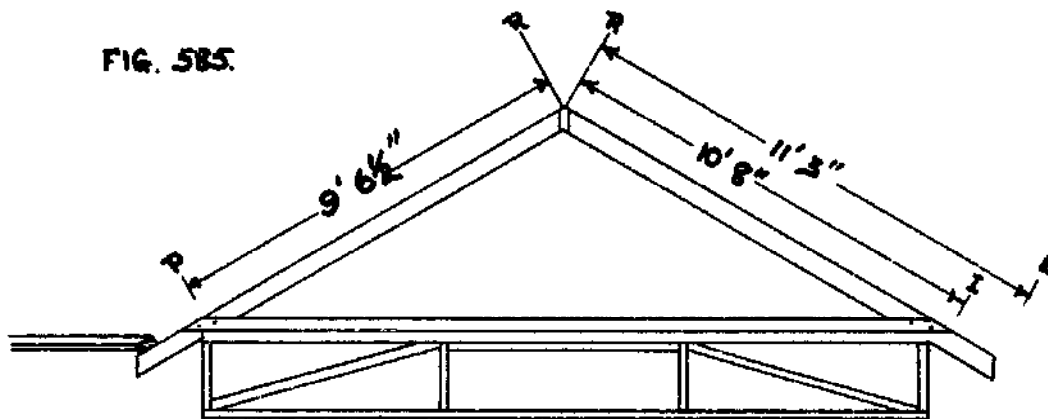
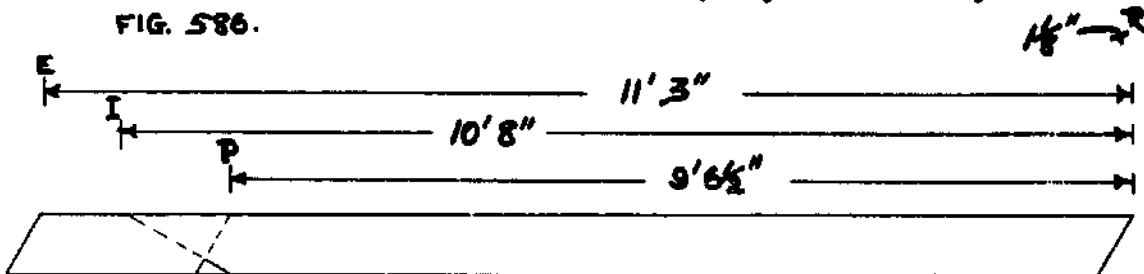


FIG. 585.

Make three common rafters as shown here. Lay out exactly as shown
FIG. 586.



but do not cut the plumb cut at the ridge until you have made the 1-1/8" deduction for one half the thickness of the ridge board. The 1-1/8" is measured along the face of the rafter.

Detail of birdmouth cut is given in Fig. 469, Page 197. The angle of the plumb cut is the same as for the main roof, or if you are using the square, 5'2" rise and 9' run.

Make the two hip rafters as follows. The length can be obtained by actual measure on the roof, see Fig. 582, or scaled from Fig. 582. There is no birdmouth for the hip because it is 2-3/8" above the common rafter. However, if a better seating is required, add a block as shown. The angle of the block is obtained quickly by placing a square on the point of the hip rafter and down the plumb cut. The intervening angle between the rafter and the square is the angle for the block. The wedge at the other end affords good nailing.

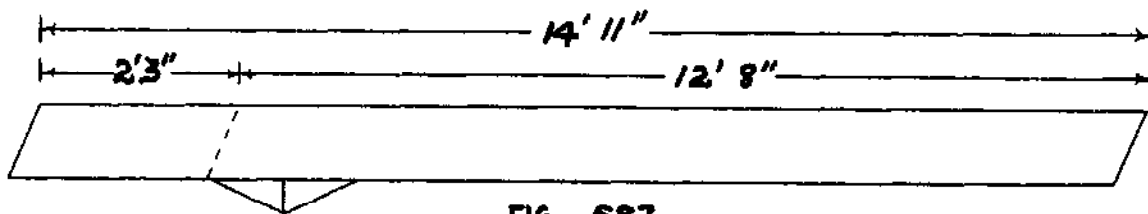


FIG. 587.

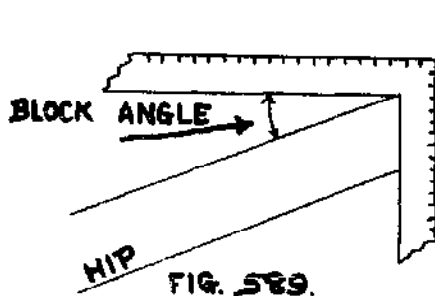


FIG. 589.

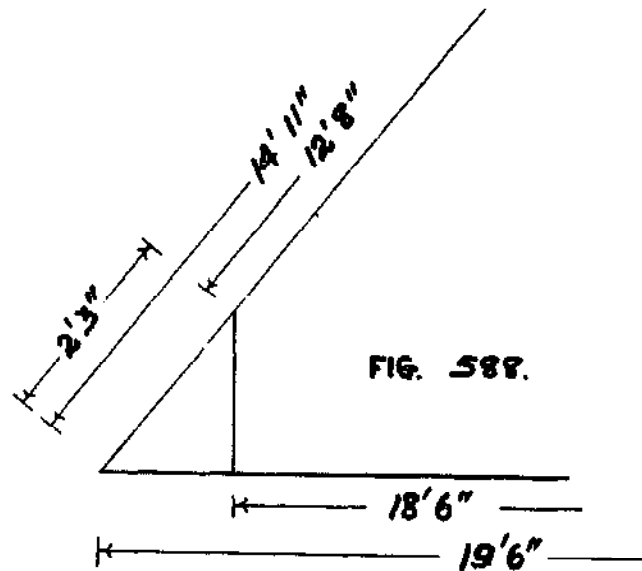


FIG. 588.

The distance on the hip from the eave cut to the plumb cut over the plate is secured by using the master drawing as in Fig. 538 on page 220, or in practice, the triangle

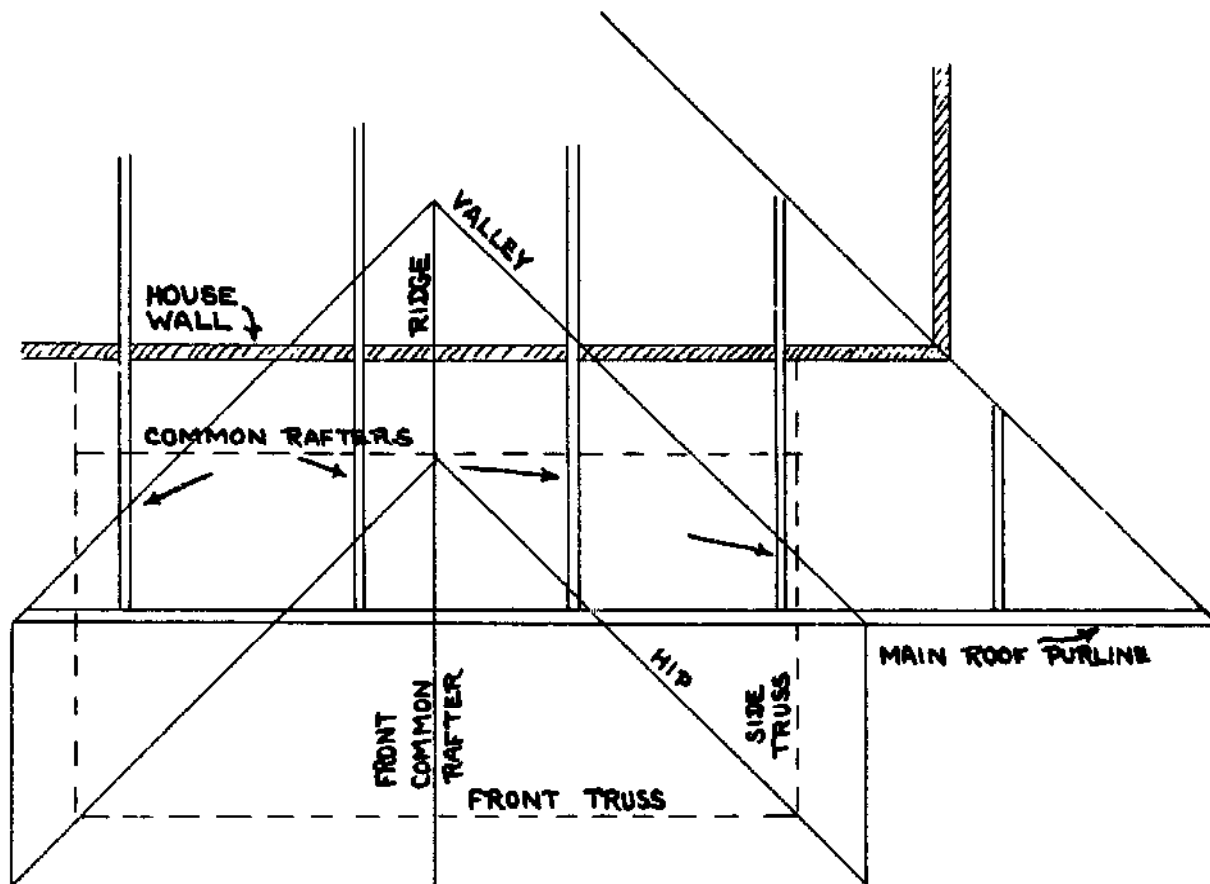
already made on the roof. In this case the 19'6" mark is for the eave, and the 18'6" mark is for the plate. Erect a perpendicular at this point to the hip line. This measures the distance from the eave of the hip to the plumb line over the corner of the plate. Measure the distance from the point of intersection to the eave on the hip. In this case it is 2'3".

The top cut of the hip rafter may be similar to that of the main roof, except that there is no need of a support batten and checking in the hip for it.

There are four jack rafters. One each side of the common rafter in front is sufficient. That means that there are two spaces, hence the jack rafter is just $1/2$ the length of the common rafter or $5'7-1/2"$. The jack rafter pattern for the main roof is correct for these. Make two left hand and two right hand jack rafters.

Make a ridge 6' long; the outer end square, the inner end bevel cut to rest on the purlines of the main roof. The angle is made by the use of a square as in Fig. 589, except that the square will be on the plumb cut of the common rafter this time. The pair of common rafters can be made up into a frame on the ground, but the cross ties should not be nailed home. The rafters straddle several main roof rafters and the cross tie is below those rafters. The following plan of the porch frame will help to show this.

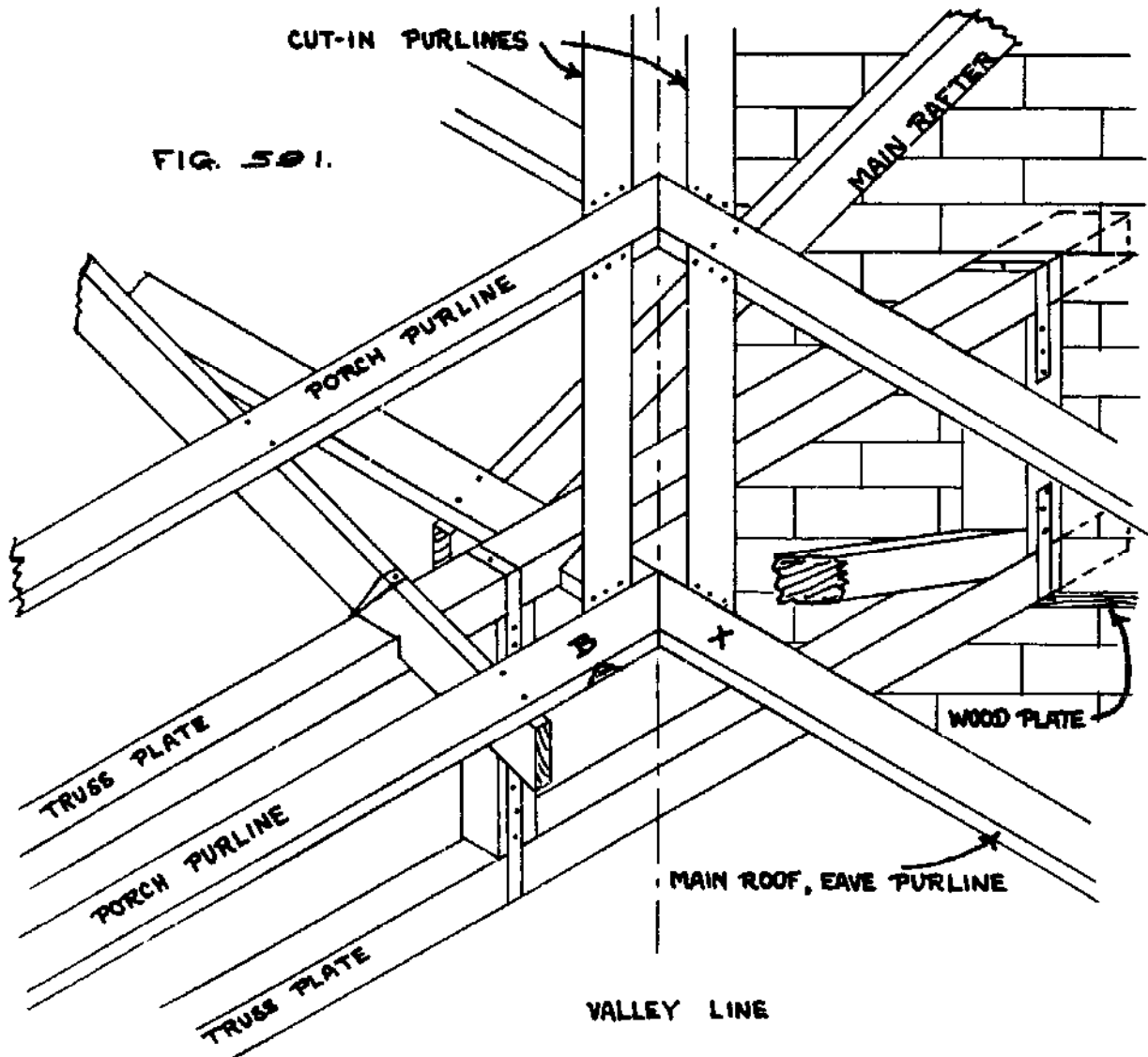
FIG. 590. PLAN OF PORCH TRUSS.

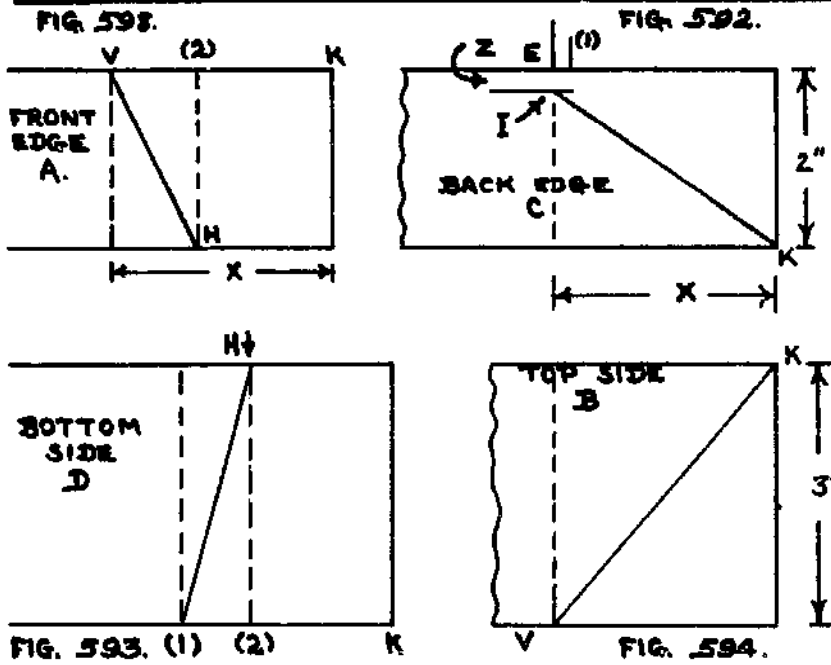


Erect the trusses, one at a time, tie together well, support well with temporary posts or props in such a way that it will be a sure scaffold from which to work. Erect the roof frame on this truss framework. Put in any additional, short, purlines on the main roof which may be necessary to make good joints for the porch frame.

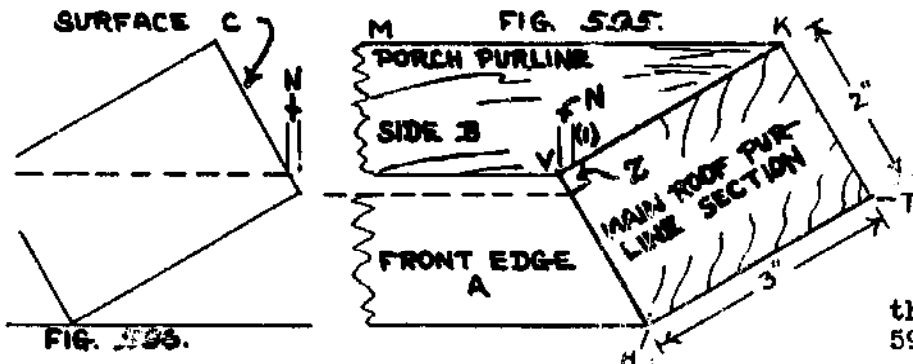
When the roof frame is complete, the purlines are run from the main roof purlines out to the hip rafters. The joint with the main roof purlines is admittedly complex, but if the following drawings is reproduced on paper and transferred to the wood, there should be no real difficulty. (Fig. 591 is not to be copied.)

We show the completed joint first, with the cut-in purlines up the valley. The centre line is the string of the triangle which has already been run from 'R' to the eave points of the porch. This string is the very centre of the valley.

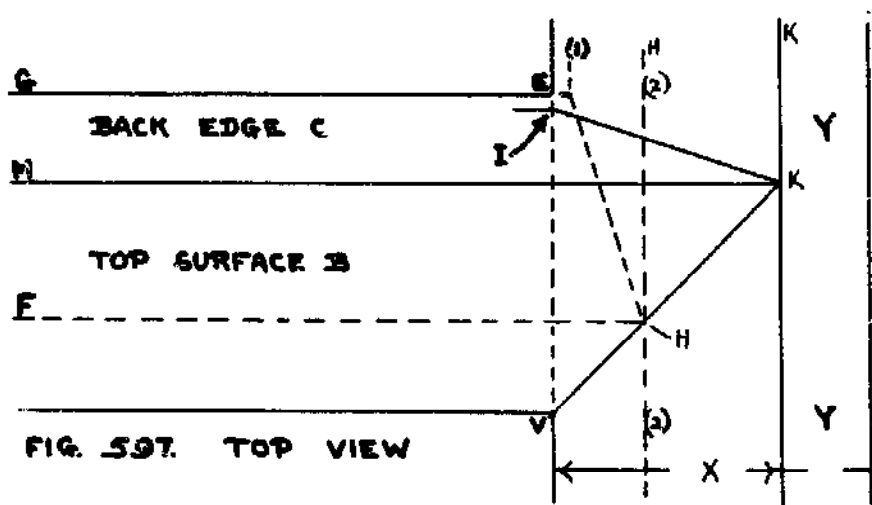




Joining purlines at roof junctions
 Draw Fig. 595 first, and full size. It is the section of a main roof purline, a 2" X 3" in this case, on the roof, as it were, having the same pitch as the common rafter. With it, show a front view of the porch purline meeting it. The dotted line is back corner of the porch purline, which, of course, is level with the back corner 'T' of the main purline.



Now draw Fig. 597, the top view of the joint, by bringing down from the four corners, lines V, H, K, T, from the four corners of the purline in Fig. 595. The dotted



lines EV and (2)(2) are the hidden corners of the main purline. To obtain the lines of the porch purline line, draw any line MK at right angles to the main purline. This will represent the top corner of the porch purline.

WV is the front corner of the porch purline and is the same distance from MK as EV is from K. GE is the back corner and is the same distance from MK as K is from T.

To get KI, measure down from E the distance N, obtained from Fig. 595. This is the distance from E to the point where the back corner of the porch purline meets the main purline. Connect KI and I(1).

The dotted line FH is the lower corner of the porch purline.

We may now transfer these dimensions to another drawing or to the wood itself, as seen in Fig. 594. It will be a full size drawing, whether on paper or on wood. V is located on the near corner by measuring back from the end of the stick distance X from the bottom of Fig. 597. Join VK. This is the cutting mark on the upper surface B.

To transfer KI and I(1) to the rear edge C, make another full size drawing as in Fig. 592. On the far corner at E, mark off from the end of the wood, the K line, the distance X. At distance Z from the far corner draw a line parallel with the corner. Z is secured from the section in Fig. 595. I is the intersection of this line with a square mark from E. Join KI and I(1).

If now you want to reduce the work to a minimum, transfer these marks to the stick if they are not already there, and start the saw at K, making it follow KV on the surface B and KI on surface C. Stop at V and I.

Square down from V across surface A, turn the stick upside down and square across the bottom surface D from this line. Cut straight across and square down to the diagonal cut just made from K. This cut at the main purline will have the appearance shown in Fig. 599. Bind the purline with box iron.

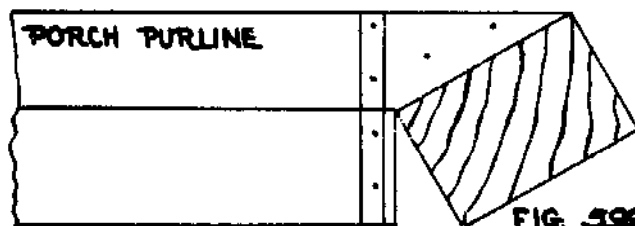
But if you wish to make the complete joint, make another drawing like Fig. 598, the front surface A of the porch purline. Distance VK on the far corner is the distance X. Distance V(2) is obtained from Fig. 597. Square across from (2) to H. Join VH.

To get the mark on the bottom surface D, turn the stick bottom side up as in Fig. 593. On the near corner mark off the horizontal distance K(1) obtained from Fig. 597. From the same Fig. obtain the distance (1)(2). Square across from (2) to H, (already marked on the side.) Join (1)H.

Now start the saw at H, making it follow HV on the surface A and H(1) on the surface D. This with the other cut from K completes the cut.

Fig. 596 is a partial section of the porch purline, showing its back edge and the point at which the front corner of the main purline cuts it.

In addition to the box iron binding, a stirrup of iron should undergird the porch purline the two ends of the iron being fastened at Y and Y on the back edge of the main purline.



When all the porch purlines have been joined up, cut in the diagonal purlines. Keep them about four inches apart, two inches from the valley line. These cut-ins support the metal valley iron, and also take the nailing at the ends of the corrugated iron cut about three inches back from the valley centre line.

XI DORMERS.

A dormer window is a vertical window set in a sloping roof. Its usual function is to light a living room under the roof but in a mission house it may be used for lighting the garret and providing plenty of ventilation.

A very simple and fairly common type of dormer roof is flat, being of less pitch than the main roof. Then there is the gable roof type, and finally the hip roof type.

All the angles for all dormers can be obtained from the roof drawings already made.

The dormer walls should be framed after the purlines of the main roof are in place. A wall plate at each side rests on the purlines, and a horizontal plate should be mounted on a purline if one happens to be there, or a special short purline if there is no regular one.

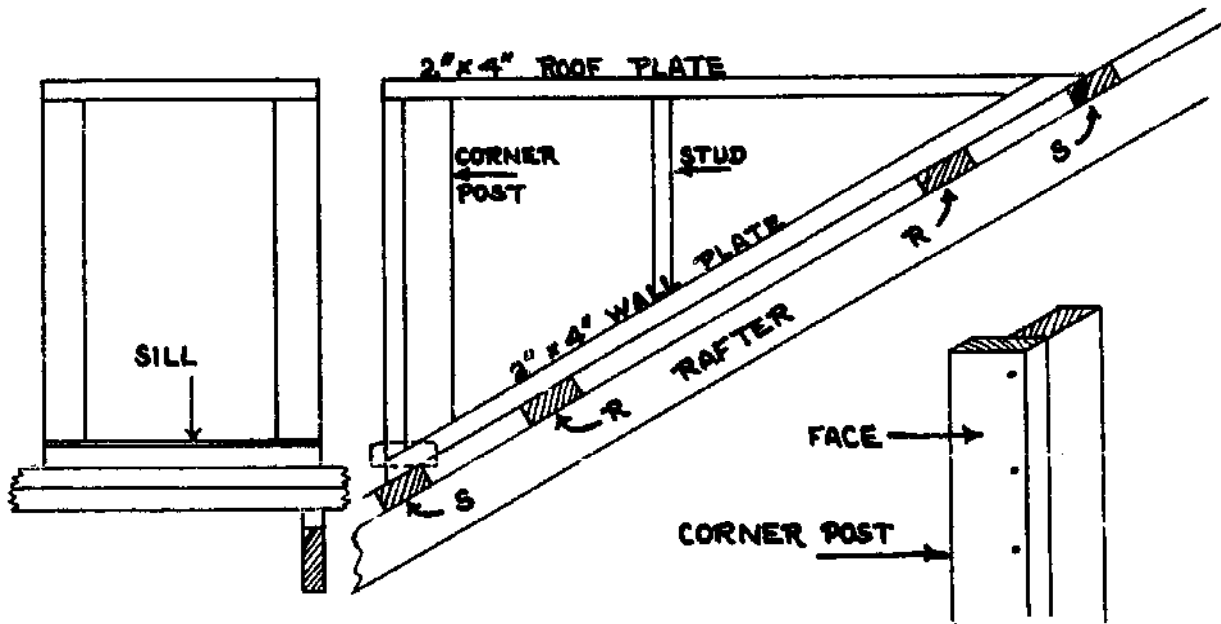


FIG. 601. FRONT VIEW OF DORMER

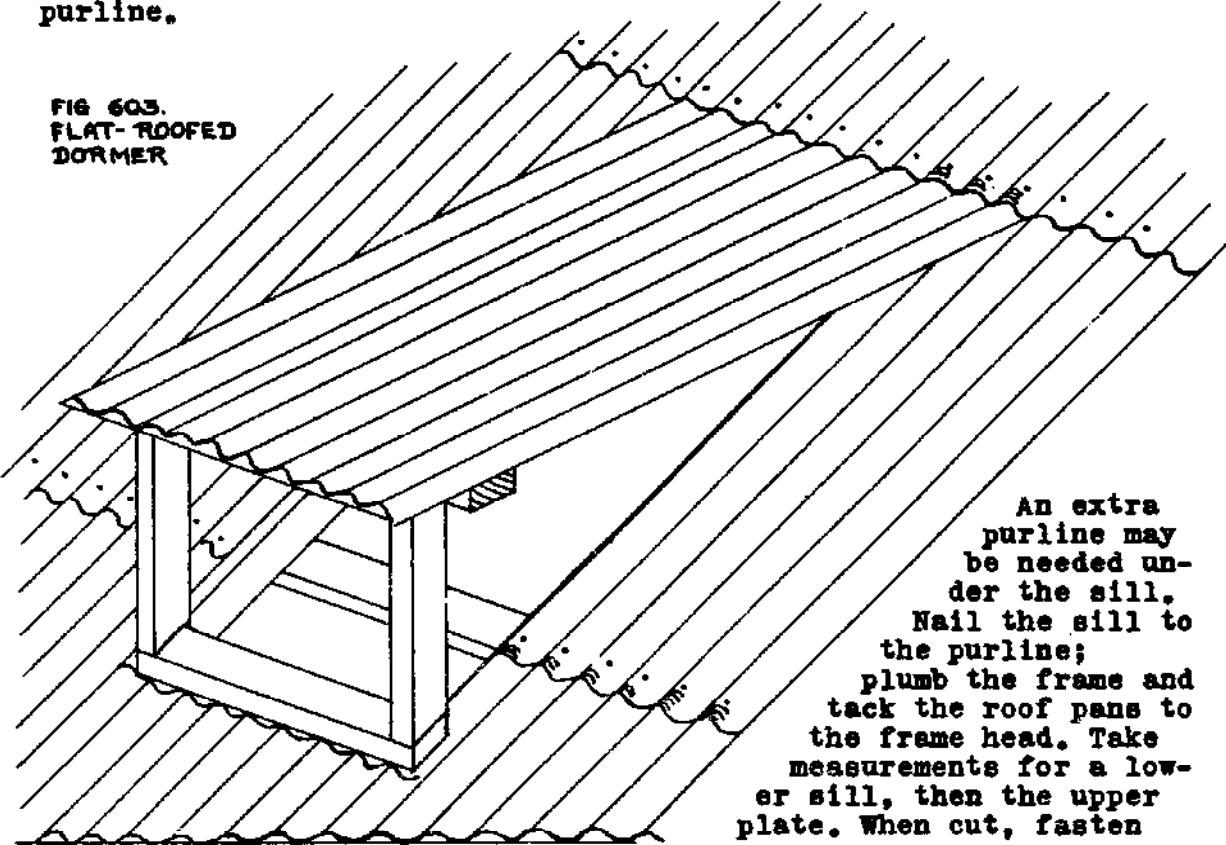
FIG. 600. SIDE VIEW OF DORMER, AND A SECTION OF PURLINES.

FIG. 602.

A small dormer can be made easily by raising one length of pans in the manner we made the flat porch roof, Fig. 570, page 231. In this case, however, we only propose a dormer which will be covered by a six foot pan, in length. It will be made more easily after the main roof has been completed, with the exception of nailing the pans home in the vicinity of the dormer.

In Fig. 603 is an example of a flat roof dormer; the window frame is made on the ground, the two or more pans are lifted and placed on the window head, which has been extended to form a purline.

FIG 603.
FLAT-ROOFED
DORMER



An extra purline may be needed under the sill. Nail the sill to the purline; plumb the frame and tack the roof pans to the frame head. Take measurements for a lower sill, then the upper plate. When cut, fasten

together, and slide up into place. Tack in place through the roof. Turn up the edge X before fastening the lower plate in place. This turn up is part of the water proofing device. Tack it to the lower plate. The two plates are all that is needed to which the iron wall pieces are nailed.

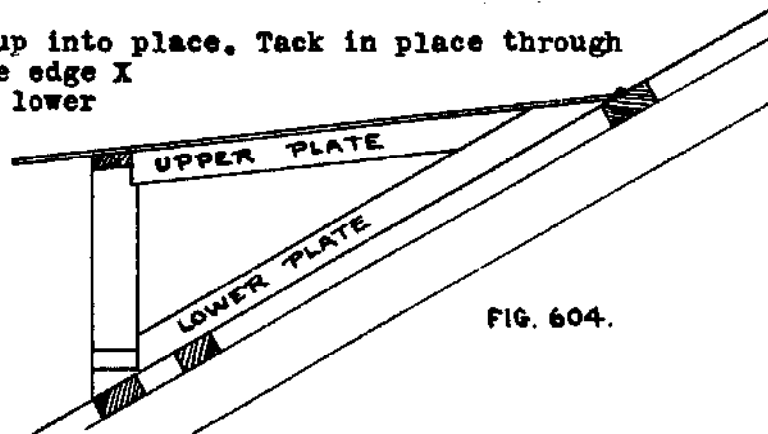


FIG. 604.

The gable and the hip type roofs join the main roof just as the porch roof joins it. The full waterproofing of the dormer is shown in sheet metal work, Book Five.

FIG. 606. DORMER HIP ROOF, T/P VIEW.

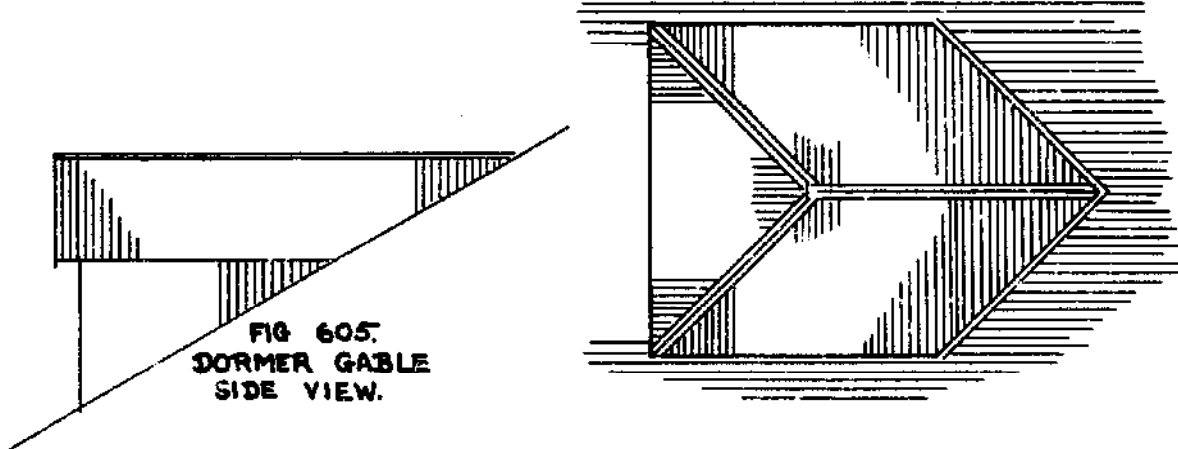


FIG 605.
DORMER GABLE
SIDE VIEW.

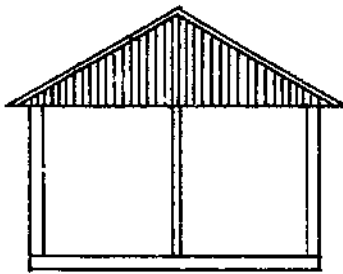


FIG. 608. FRONT VIEW.

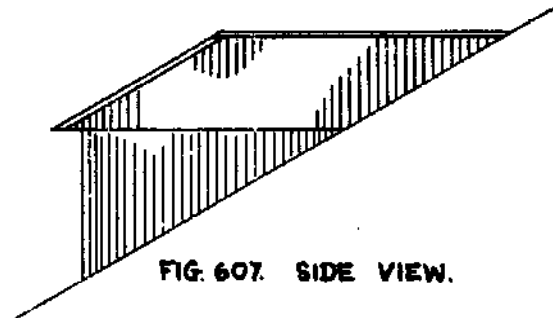


FIG. 607. SIDE VIEW.

XII GRASS ROOF FRAMES.

Many grass roofs built by indigenous peoples are quite satisfactory, and, many are not. The causes of failure are, termites which destroy the frame, the tying, and the grass; deterioration of grass; poor grade rafters, the poles used to make the conical frame; or no poles at all, in which case corn stalks are used.

In construction and design, the conical roof on the round house is the most perfect or shall we say the only perfect roof known. In construction, there is always a band or rope of various local materials, corn stalks, vines, which rests on the wall. This takes care of thrust, perfectly. It transfers the outward thrust of the roof to a vertical stress on the top of the wall. There is no weak point for wall or roof.

We are not a student of aero-dynamics but we presume to say that no roof offers less resistance to wind and storm than a conical grass roof. Experience shows that they seldom if ever are blown off, and that is what we would like to say about other roofs!

Some of their non-resistance to wind may be due to their very structure which allows air to pass through, without, however, allowing rain to enter.

It is very probable that the reason they are not blown off from the inside is that most huts have one very small door and only one or two, if any, windows. The door would be on the lee side of storm direction, and what air current would enter would be neutralized by the porosity of the grass which does not offer absolute resistance to the up-draught. We have seen a large hole blown in a grass roof, right over our heads, but this was due, probably, to two things: many large openings combined with a pocket at a partition, and second, faulty workmanship in tying on the grass.

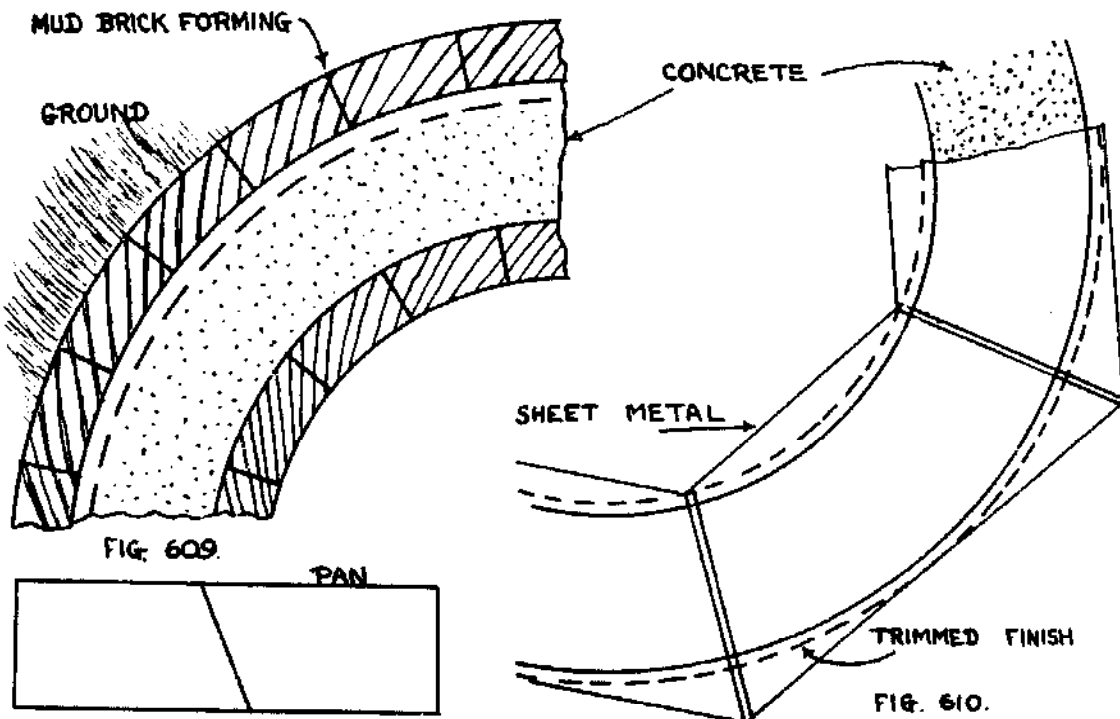
Ordinarily, grass roofs are not tied on. This is an important factor in preventing the spread of community fire. Immediately in the path of a conflagration, townspeople lift off roofs and carry them out of the path of fire.

A good grass roof will not have a pitch of less than 45 degrees. The best will have a steeper pitch than this.

1. Termite protection for grass roofs. This can be either one or both of the following.

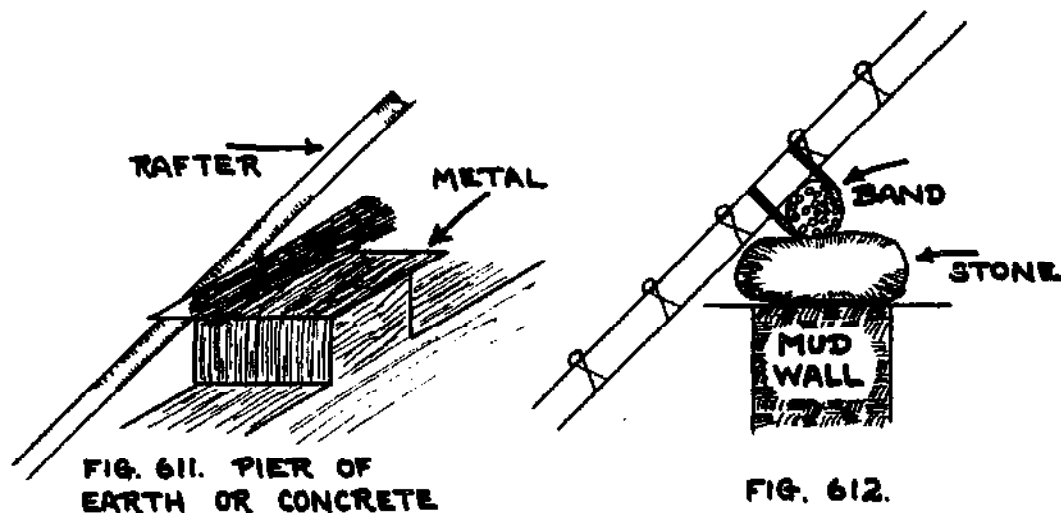
(1) Concrete and metal ant course at the base of the wall, opposite the floor height.

The concrete ant course can be formed by building a mud or mud brick wall around the outside of the main wall line, and another mud wall inside, on the floor. Between these two mud walls, pour concrete. Reinforce with a heavy wire or light steel rod band well jointed, laid near the outside edge and half way up in the concrete. Smooth the top of the concrete, giving it a slight outward slope.



In jointing the iron, it may be well to cut the pan in half. This will make more joints, but give more width if that is desirable. Note that the end of the iron on the inside is the finish line, but that on the outside, the middle part of the edge comes on the finish line. The finish line should not be cut until the entire circle of iron has been completed. Be careful that the finish line nowhere comes within 1-1/2" of the concrete. As with metal ant course in rectangular dwellings, lock, rivet, solder the joints and then paint the entire under surface of the metal with coal tar, to prevent deterioration of the zinc coating.

(2) A metal shield at each point where the rafters rest on the wall, or on piers, blocks, or stones.

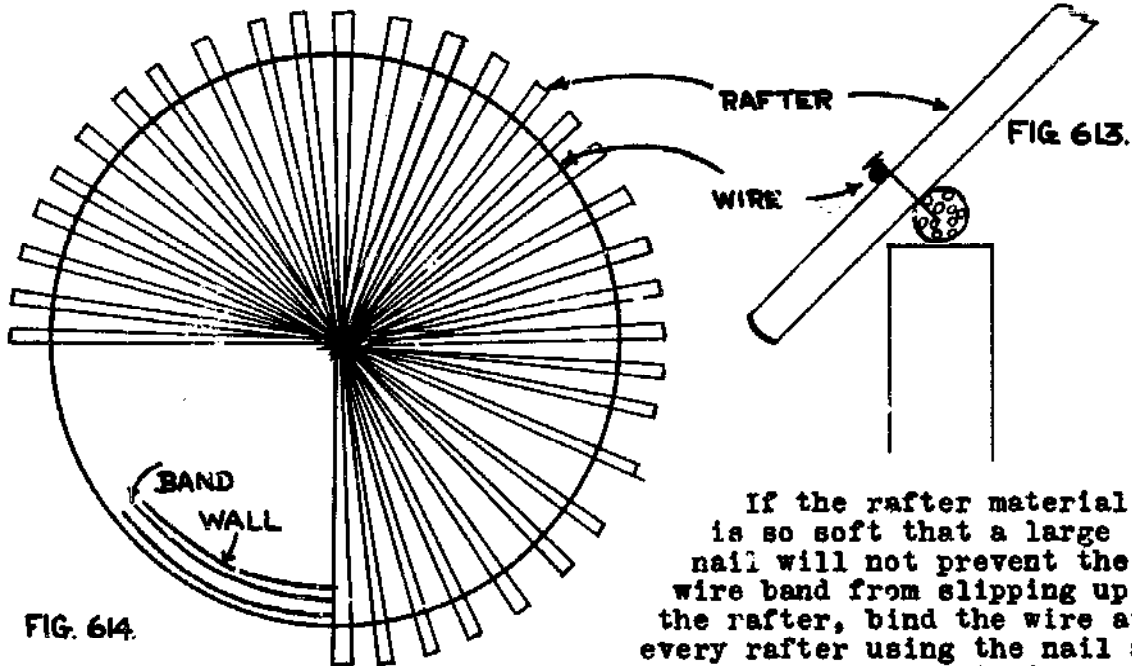


2. Attempts to overcome deterioration. The first, most obvious way is to get the best grass available. The second is to get plenty of it. Deterioration in a thinly covered roof will hasten the day of replacement, one of the greatest drawbacks to a grass roof.

The third way is to improve the method of putting grass on the roof. The usual way in many areas is to loosely weave parallel grass blades together in a long mat and then to roll this. When grass is being applied to the roof frame, the rolls are handed up and unrolled. The grass is tied to the framework. Another method is to make more or loose rolls of about four inches in diameter and place them side by side in the roof, lightly tapping them in place so that they will form a more or less homogeneous mass. These rolls are of course tied to the frame with the same material used for the other type of roof. We believe that this type of roof lasts for from ten to fifteen years, made of the same grass and other conditions being equal.

3. Rafter support. This means prevention of outward movement at the point of rest as well as stiffening midway and extra support at the top. To absolutely prevent outward movement, reinforce the locally made band with galvanized wire, secure at the joint. If the band circling the base of the rafters never gives,

the roof can never collapse, provided of course that the rafters do not buckle or warp.



If the rafter material is so soft that a large nail will not prevent the wire band from slipping up the rafter, bind the wire at every rafter using the nail as well. Bind with light wire, wrapping it around the nail head.

Even with the wire band some roofs will not stay put. This is because the rafters are so weak they bend or buckle. This can be remedied by the use of one or more light trusses which take all the weight of the upper part of the roof and provide an inflexible framework from which supports can run in any direction and in any number.

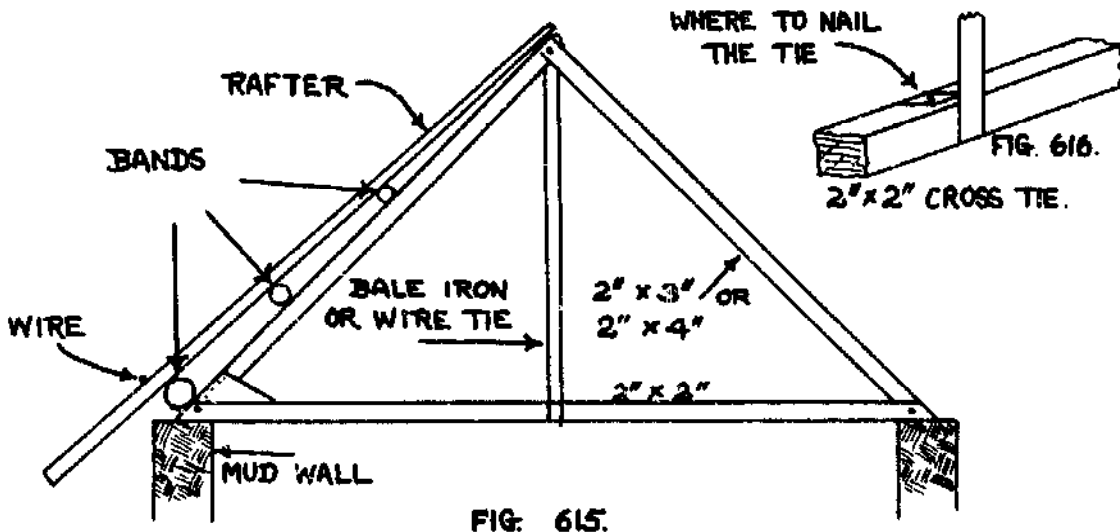


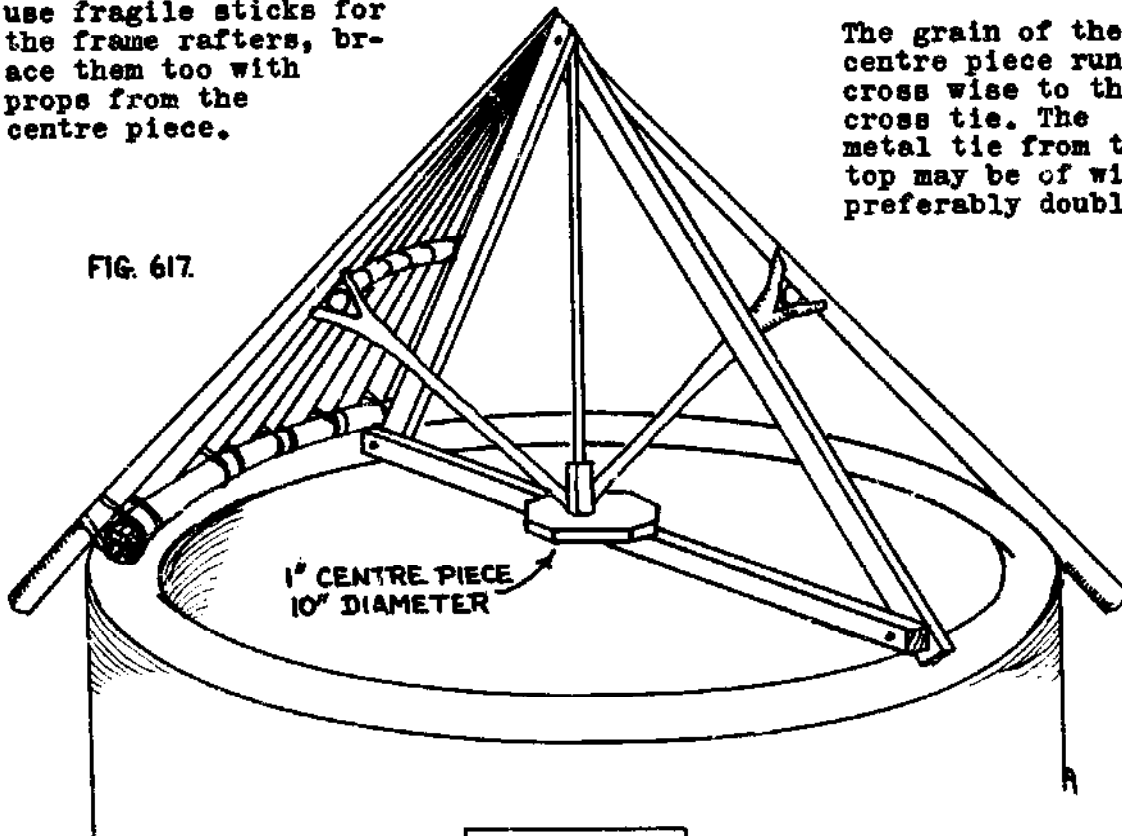
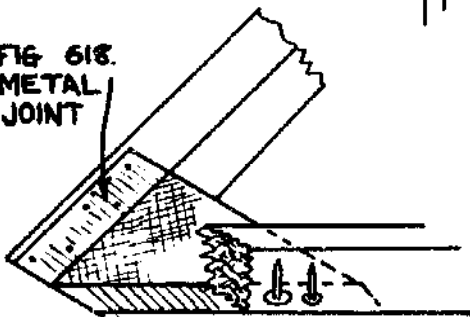
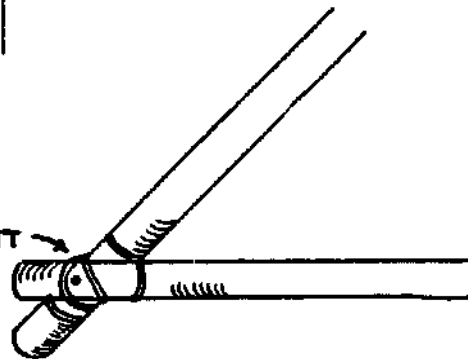
FIG. 615.

Note that the smaller end of the rafter is at the top. Bind every top end tightly to the apex of the truss. If necessary, use one or more bands midway as shown. These can be supported by a fan shaped arrangement of props which can be inserted after the framework is in place. The truss can be made of saplings or other local wood stiff enough to resist buckling under load. If you have no bolts for the ends of the truss pieces, use sheet metal for sawn wood and wire binding for unsawn sticks.

If you are compelled to use fragile sticks for the frame rafters, brace them too with props from the centre piece.

The grain of the centre piece runs cross wise to the cross tie. The metal tie from the top may be of wire, preferably doubled.

FIG. 617.

FIG 618.
METAL
JOINTFIG 619.
WIRE JOINT

A small block of wood beside the iron tie may be needed to catch the feet of the first pair of props. The remainder will fit in.

Very often churches are built in circular form, and, beyond a certain diameter, the support of the roof is a problem. The type of supporting frame is somewhat a question of what the missionary on the job is willing to undertake. A round house forty feet in diameter could be spanned by a single truss of the type shown in Fig. 617, except that two half trusses would be added to it to form a square cross in plan. Of course this can be extended so that three or four or five complete trusses would intersect at the centre and resemble, in plan, the spokes of a wheel.

Of course such a multiple truss would be made of reliable members, the first two cross ties being of a total cross section of 4" X 6" or metal of equal tensile strength, and the rafters would have to be not less than 2" X 6" and braced midway. The props too would be of sawn lumber of at least 2" X 4" cross section or saplings of not less than 4" diameter. We feel that this is the simplest form of support for a large round roof.

In erection, a ladder should be secured to the truss from the cross tie to one of the rafters, near, but not at the top. Two reliable ropes should be secured to each side at the top so that two sets of men on each side would be able to hold the truss when it has been erected until two braces or a pair of rafters have made it secure. The truss would first of all be hoisted to the top of the wall, where it would be laid flat while being prepared for the final lift. Two poles should be securely fastened to the apex on one side so that when the frame is to be lifted, men at the bottom of the poles could push up when the men on the walls had lifted the truss to the extent of their reach. The feet of the truss must be held securely during the lifting operation.

When the truss is in its final position, a man climbs up to the top and receives from others the upper end of one of the side rafters which he secures to its place up top. Then one opposite. Then a half cross tie from the foot of each is run to the centre of the first truss, and the two halves are securely bound together. We have now the strength of two trusses.

We admit that the criss-crossing of ties does not lend itself to a church interior. The best effect would be to make one truss sufficiently strong to do all the work, and run it from the front of the auditorium to the back, or from side to side at right angles to the aisles. If it is finished carefully it will not be objectionable. With only one truss, each rafter would have to be self supporting between ends. By means of a cut-in purline at one or two places, the rafter would be effectively stiffened. Fig. 621, 3.

Another arrangement for a large diameter round building is a ring of posts with suitable beams at the top. This lends dignity to an auditorium. It may be more difficult to erect, but it is a very satisfactory structural device. Figs. 625, 6.

The ring, or band of beams at the top might be considered as the top of a wall and above it, a truss may be erected as in the former arrangements. One of the advantages of a round roof of any size is the fact that the local builders and roofers are right at home on this form of roof. There are no hips and valleys, gables or corners. The posts used are straight trees, often palm tree trunks. There should be at least five to give the circular effect, but not any more than is necessary, otherwise they may

be obtrusive and will certainly be obstructive. The distance between them will depend very largely upon the beams which will span their tops. It might be argued that the more posts there are, the nearer the beams at the top will be to a full circle as contrasted with, for example, the pentagon. But it is comparatively easy to prop out the rafters from the main frame into a circular form. In Fig. 622 is shown the intersection of cross struts which may be used instead of the cut-in purlines as in Fig. 621. These are struts and not ties. The rafters are tied at the base.

Whether cut-in rafters or struts are used, all the rafters should be propped temporarily, and uniformly, in a straight line or slight upward curve until all the purlines or struts are in place. Rafters so braced will never sag or need further stiffening.

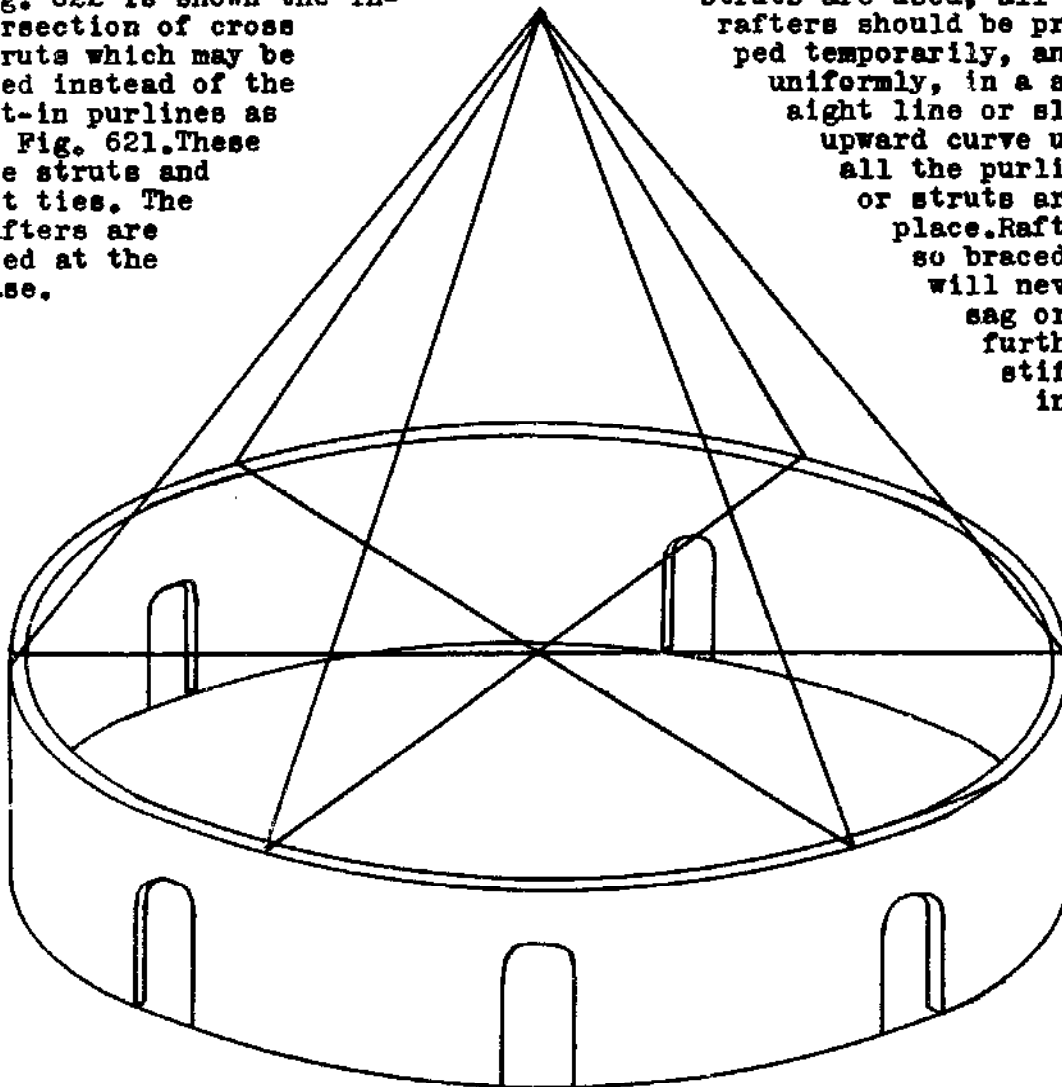


FIG. 620. MULTIPLE FRAME FOR LARGE ROOF

In Fig. 623 the curved cross tie may be preferable to a straight one. The curve may be effected by stakes driven into the ground on a curve made by a tape, and using a long radius. Place 2" X 4" on edge on the ground and conformed to the pegs. Place a rafter foot on each end of the first one. Nail a second stick to the first, breaking joints by as great a distance as possible. Make the cross tie and rafter joint quite secure with bolts and/or sheet metal plates with flanges.

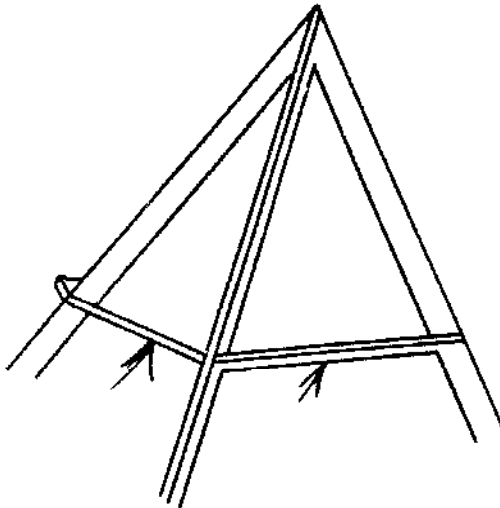


FIG. 621. CUT-IN BAND OR PURLINE

FIG. 622. CROSS STRUTS.

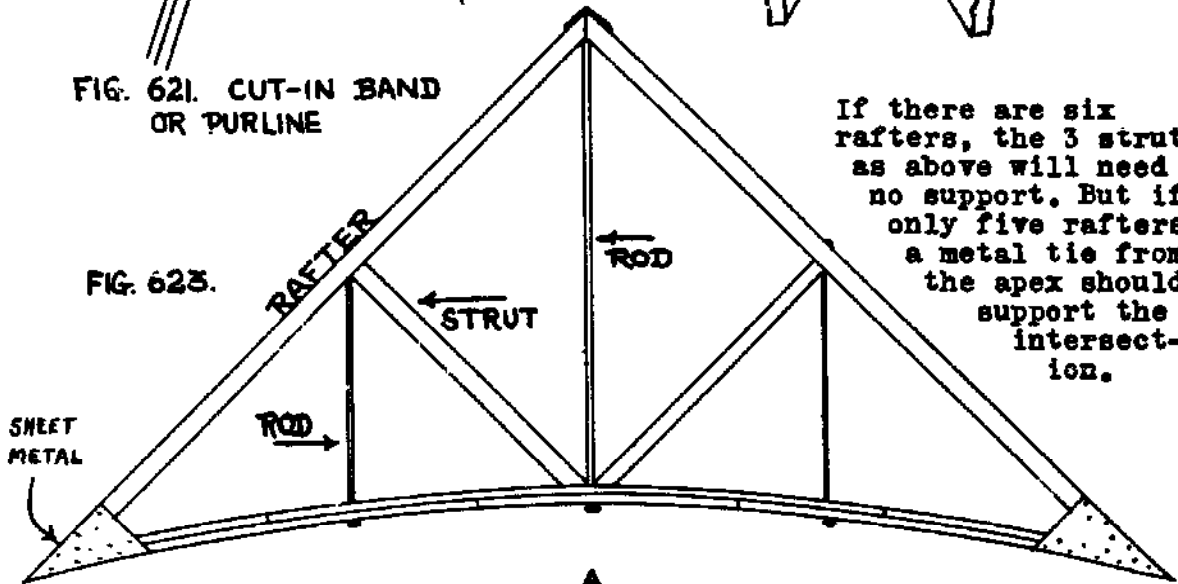
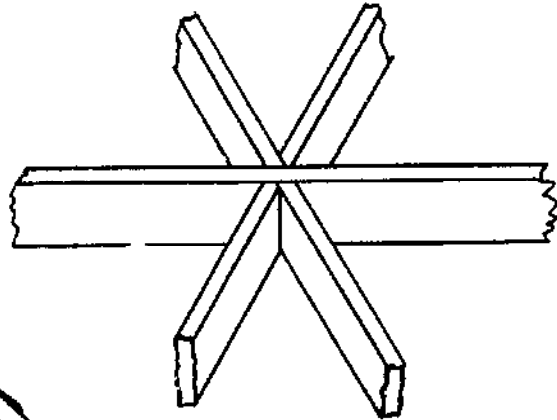


FIG. 623.

If there are six rafters, the 3 struts as above will need no support. But if only five rafters, a metal tie from the apex should support the intersection.

To lay out a pentagon. AB and CD are two righters at right angles. Bisect CP at E. With radius EA and centre E describe arc AF. With radius AF and centre A describe arc FG. AG is one side of the pentagon. With radius AG mark off the other points of the pentagon, J, H, I.

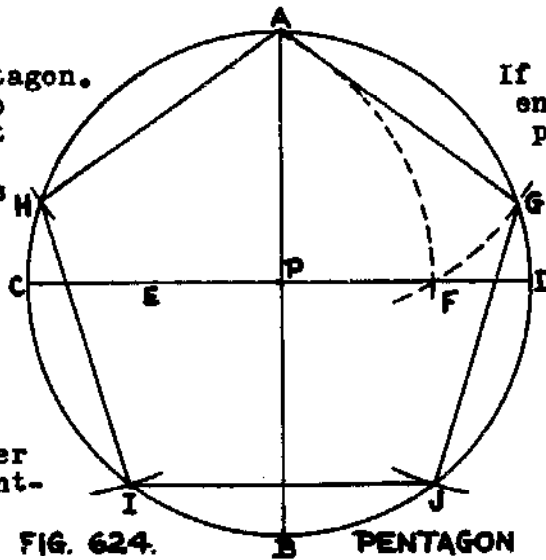


FIG. 624.

If the circle represents the circle of posts, the sides of the pentagon show the length of the beams up top. The rafters above these beams would rest on the points of the pentagon. The single frame erected on this circle of beams would have to rest on the centre post at the back or en-

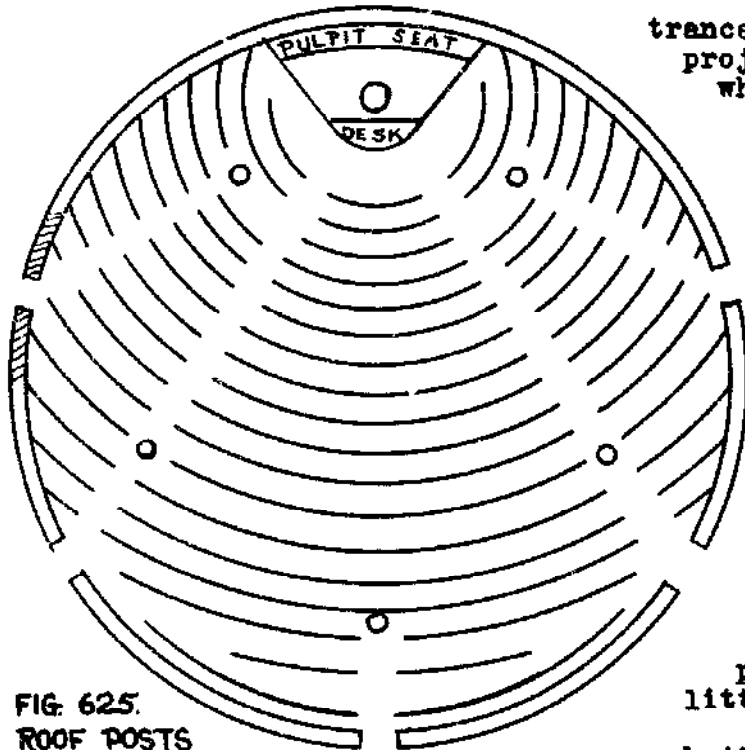


FIG. 625.
ROOF POSTS
AND SEATING PLAN.

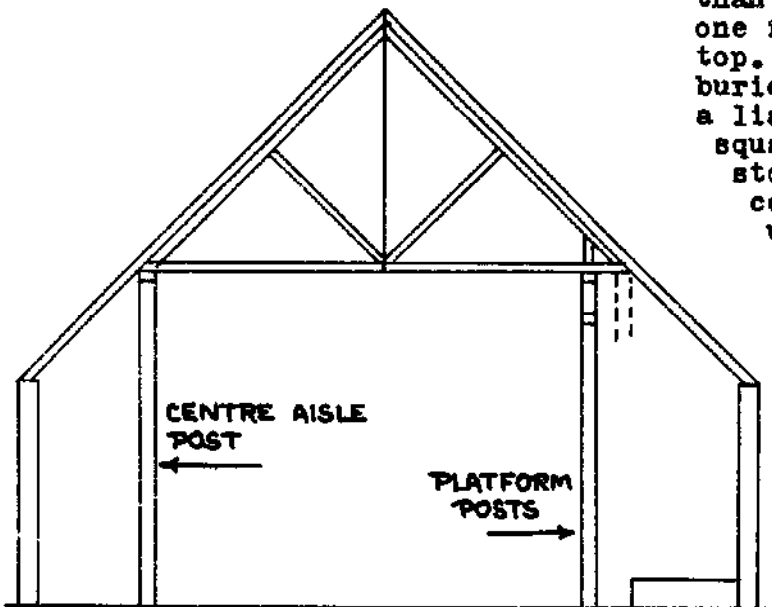


FIG. 626. CROSS-SECTION OF POSTS AND TRUSS.

trance side of the church, and project beyond the beam somewhat at the front end because in the pentagon there will be no post opposite. The projection is shown in Fig. 626. The beam is shown in Fig. 627. The exact projection is shown in detail in Fig. 628.

Circular seating, with the centre of lay-out where the speaker stands, is very effective, and the example given here is a suggestion of how it can be arranged so that no one sits behind a post, and yet there is little if any wasted space.

The walls of such a building should not be less than ten feet in height and one foot in thickness at the top. The posts need not be buried, in fact it would be a liability. Place each squarely upon a large, flat, stout stone, or slab of concrete. Brace the posts well during construction. Fig. 626 shows how the post construction can be arranged to divide the rafter support into three equal spaces.

The posts meet the rafters one third the way to the top; the struts or cut-in purlines would stiffen the rafters at the two thirds point. A great advantage of this is that the ring of

posts is as far away from the centre of the auditorium as possible. Finally, slope the floor of the auditorium from the centre to the back wall. The grade should not be less than 12" fall in every 15'.

FIG. 627.

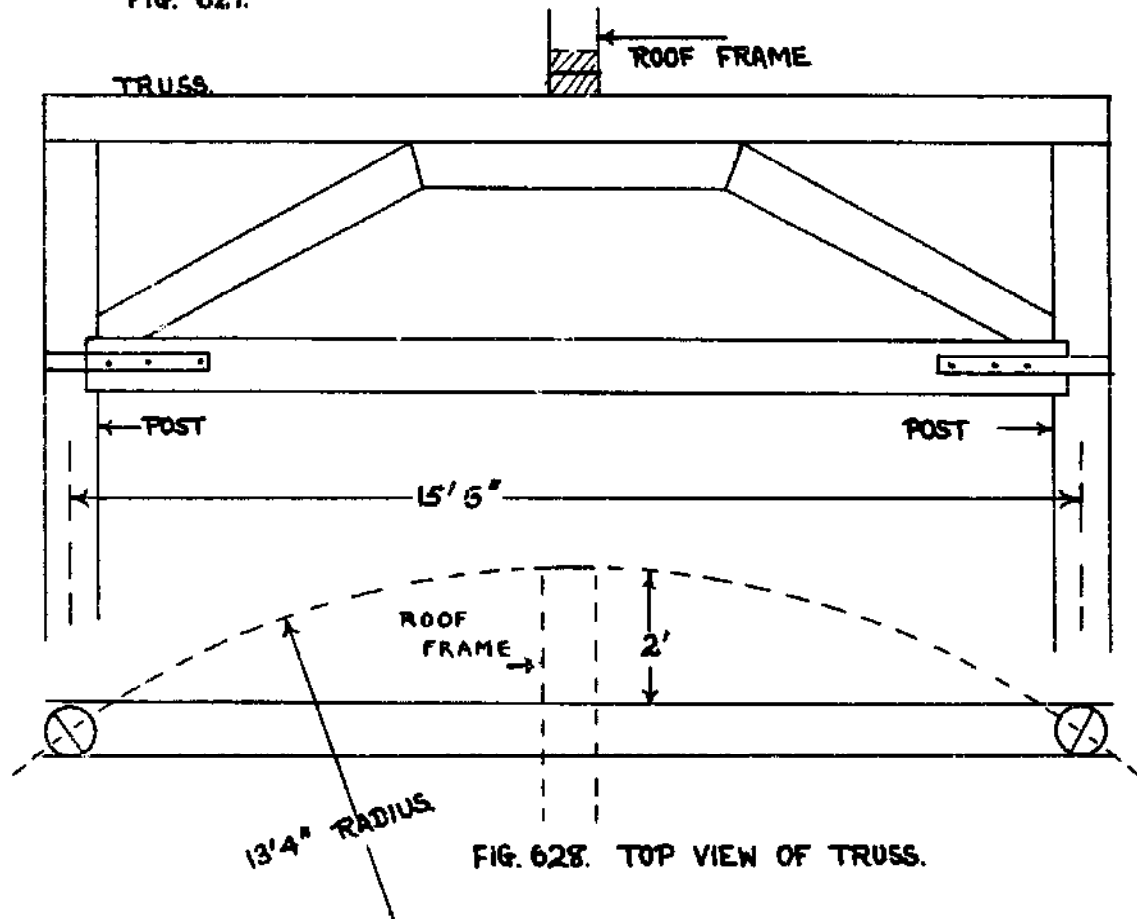


FIG. 628. TOP VIEW OF TRUSS.

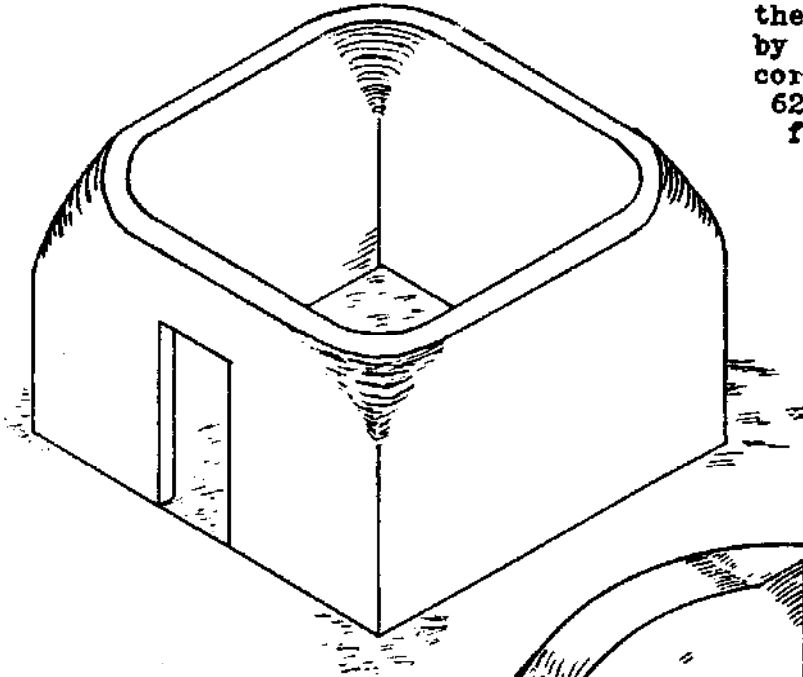
A round roof on a square building. Corners, and valleys, on grass roofs give trouble in making and are more likely to leak than what we may call the round type. Hence we recommend that no building have a square roof, or hip, corner. This can be arranged by using some or all of the following ideas.

If practicable, round the walls at the corners, by making a start two or three feet down from the top. When this does not seem suitable, then pare the square corner off and raise the level of the straight wall between corners. The raised part will hold the rafters out while the pared corner will let the corner rafters hug that part, and all together some approximation of a rounded corner, if not a round roof will be achieved. The third idea is to always have two or more corner rafters, none of which are prominent.

In a hip roof made of grass there must be some kind of special mat sewn on the corner to protect it. But in the round corner type of roof suggested here, no such device is required.

This round roof on a square house is made just the same as for a round house, but some care will have to be taken in getting the proper measures. In the case of the walls with the raised part, the diameter of the roof will have to be greater than that for the house with rounded corners.

FIG. 629. ROUNDED CORNERS.



It is possible to combine the three ideas somewhat by starting to round the corner inside as in Fig. 629, paring at least 6" from it on the outside, and, to raise the wall height between corners as in Fig. 630.

The diameter of the roof, on a square building should be the diagonal distance from corner to corner. Otherwise the roof will be too small. One

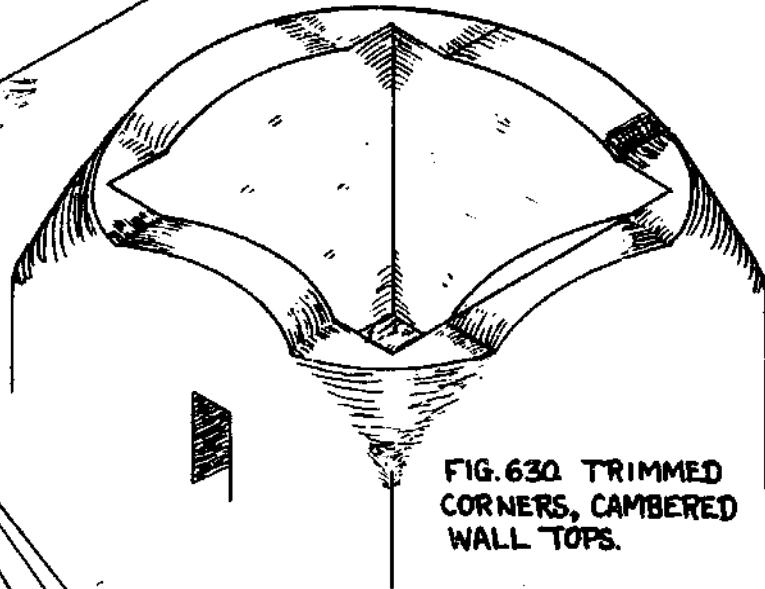


FIG. 630 TRIMMED CORNERS, CAMBERED WALL TOPS.

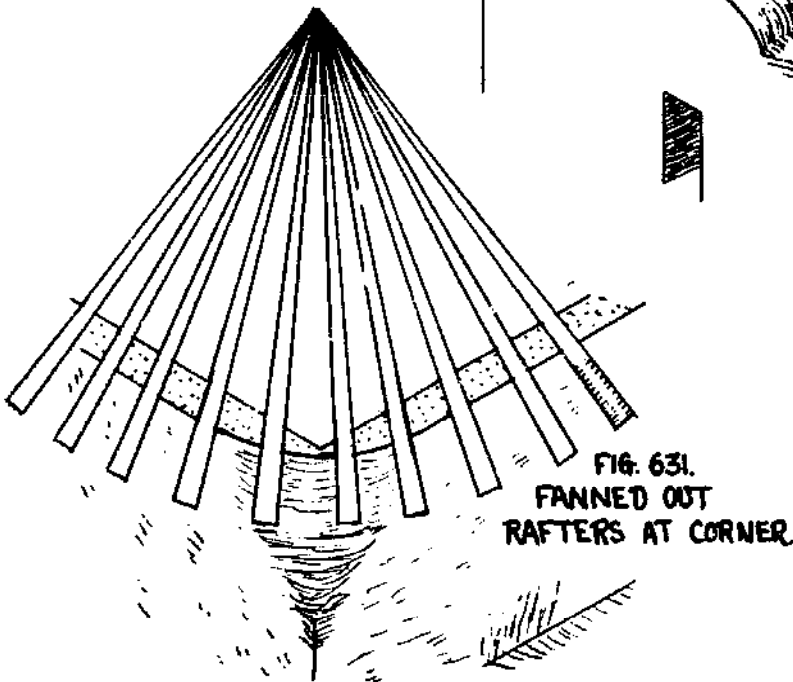


FIG. 631. FANNED OUT RAFTERS AT CORNER.

other development may be mentioned. The rounding of the corners taken up a little further than we have shown will produce a perfectly round wall top, and the rounded shoulders will form perfect support for corn-stalk and similar very weak rafters. But do not close in the dome! It is too hot and stuffy.

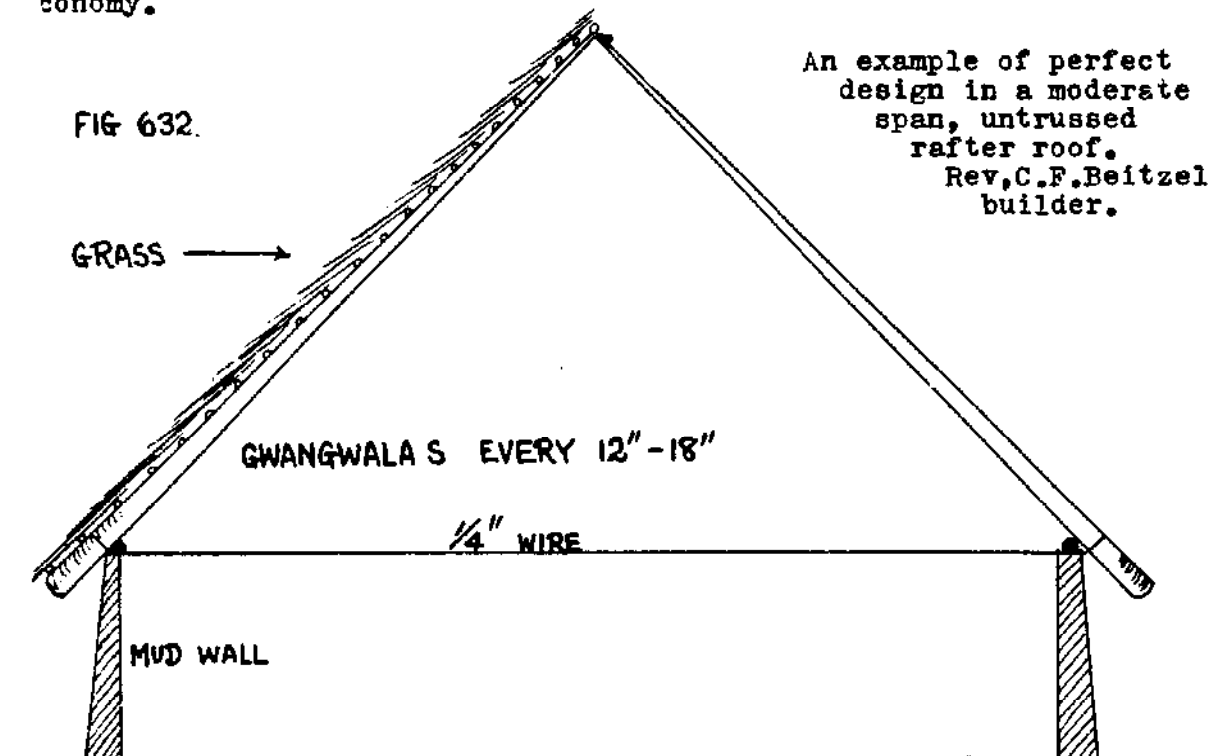
(2) Rectangular grass roofs. We have been dealing with grass roofs that are conical. Now we discuss those that have a ridge. The common means of supporting these is by posts and/or beams. Neither of these should be used if at all possible to dispense with them. Posts have to be used to carry frames and beams in very large structures, but a beam with a post resting upon it is unnecessary.

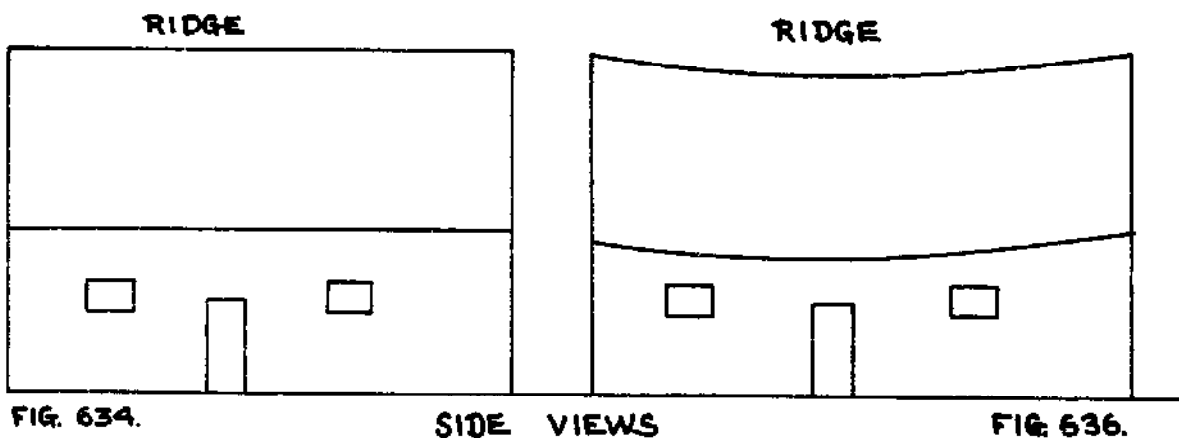
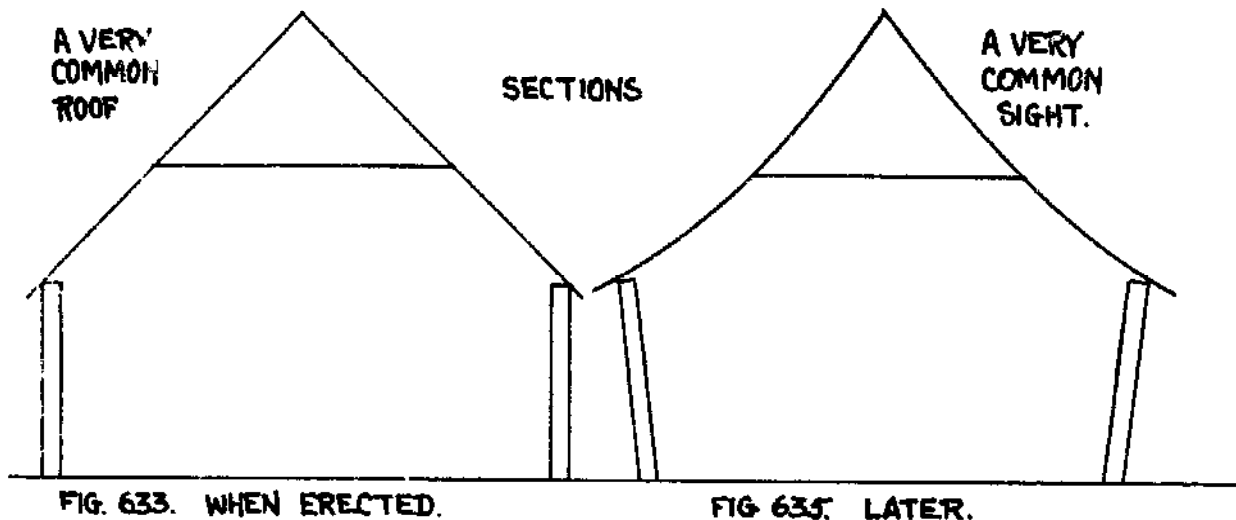
The very best example of what we mean in a moderate size church building is, or was, in a church at Kukar Gadu, near Potiskum, northern Nigeria, and built by Rev. C.F. Beitzel of the Sudan Interior Mission.

The interior width was at least 25', and the rafters were the trunk or stem of a swamp-side tree called out there, Gwangwala. Its diameter is from an inch at the small end to 4" in the common sizes at the butt. The bark or skin is smooth, the structure, very light and porous. They are naturally curved and this curve is turned up when the rafter is in position. They are placed about 6" to 9" apart.

The only support these rafters had was a 1/4" wire across the building every three feet or so.

If this principle was used universally, roof building would be simplified tremendously. (Say these last two sentences over again.) I venture to say that the principle is the most important in roof design. It is, in other words, that providing the rafters are strong enough for their purpose, if they are tied together or connected by a tie fastened where the main weight of the rafter is supported, the roof will have perfect design in strength and in economy.

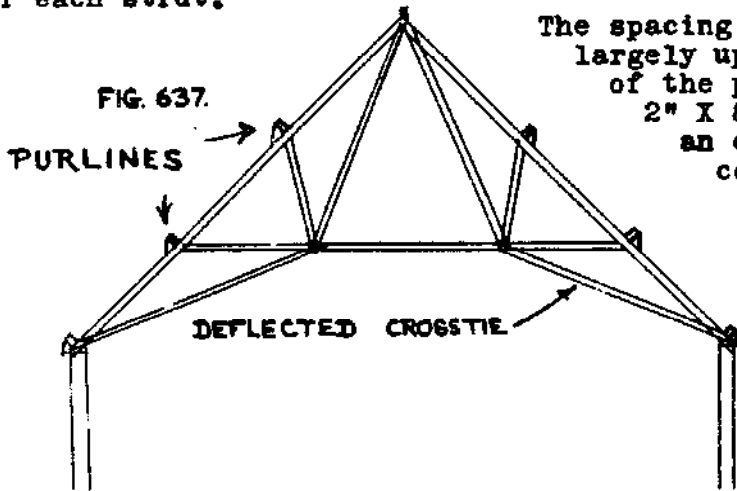




Figures 635 and 636 are hardly necessary for they merely repeat what is seen all over the world. The sagged ridge of Fig. 636 is sometimes caused by subsidence of the main wall, but more often than not it is due to the unsupported 'A' frame. The supported 'A' frame is that in the cross section of the Mission House roof. In that case, the main weight is taken at the point of junction of the cross tie and the rafter. The remainder of the rafter is merely a tail piece. But in Fig. 635, the rafter is actually a beam. But it is seldom strong enough to be a beam, hence it is deformed. The 'A' frame unsupported should never be used in ordinary buildings. If it must be used as in an ornate church, secure the services of an engineer or architect to check stresses, strength of materials, suitability of design, etc. The unsupported 'A' frame is always more expensive because it requires stiffened walls and specially constructed or heavy weight rafter members. Not the least of the damage caused by 'A' frames is the pushing out of the walls.

When we move to a building so wide that rafters require stiffening, we have several solutions. This of course is only applicable to grass roofs where the rafters are some unsawn saplings or other natural wood forms. At certain intervals these have to be supported, and since individual support is impracticable, we use the true purline, a horizontal beam supported by walls, posts or roof frames, and on which all rafters rest.

The first type of support is the triangular frame shown already in Fig. 623. It will seldom be as elaborate, but it is the same in principle. The rafter members are in compression, hence they need to be stiff enough to resist buckling. This can be greatly reduced by having one or more struts for each rafter and by tying the rafter securely to all purlines. The cross tie is usually made of wood, but strong enough metal band or rod or cable will do. There must be a metal tie from the apex of the frame to the foot of each strut.



The spacing of the trusses depends largely upon the type and strength of the purlines to be used. A 2" X 8" might be alright for an eight foot span under certain conditions. A purline to span 12' may be made from two 1" X 12" boards with 2" X 6" spreader blocks every two feet. The purline is to be at right angles to the pitch of the roof as in Fig. 639.

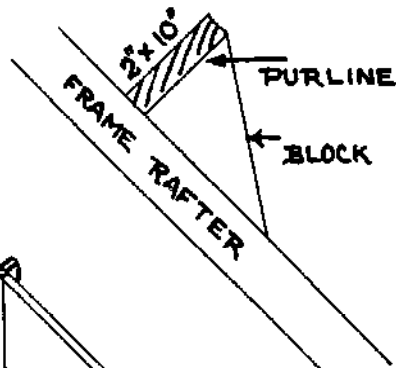
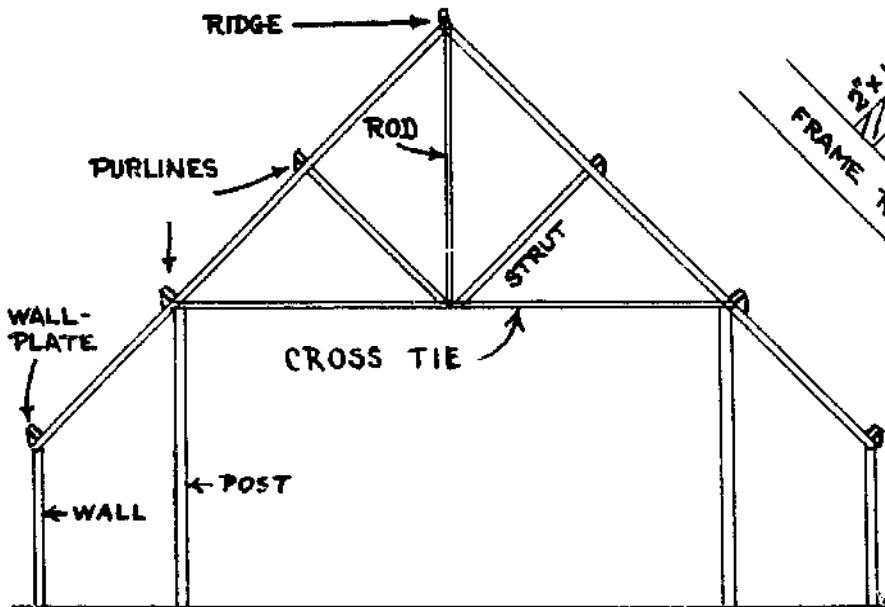


FIG. 639.

FIG. 638.

The post-down-the-middle type of support is somewhat unsatisfactory, but at least everyone may see the speaker if the post nearest to the pulpit is not too close. This can be obviated by a truss from one post to the wall, the truss carrying a post which would otherwise be right in the front of the church.

As it appears in Fig. 640, the single post support looks and is unstable, but with temporary support poles, shown by dotted lines, and with permanent, horizontal braces shown in Fig. 641, it is satisfactory. If the foot of each post can be buried safely and put deep enough to make it secure, it will also help the stability of this type of roof. The dotted lines in-

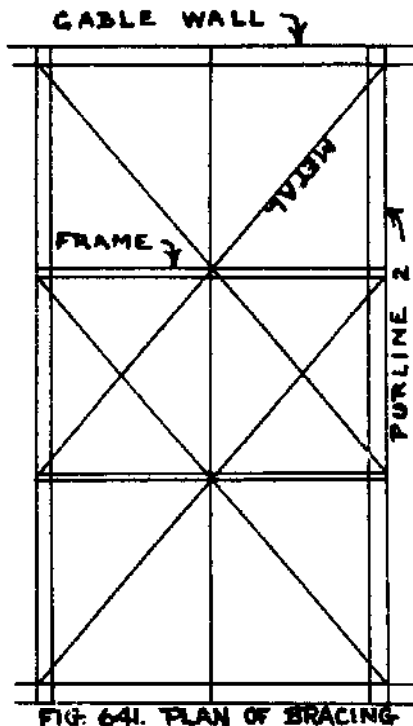


FIG. 641. PLAN OF BRACING

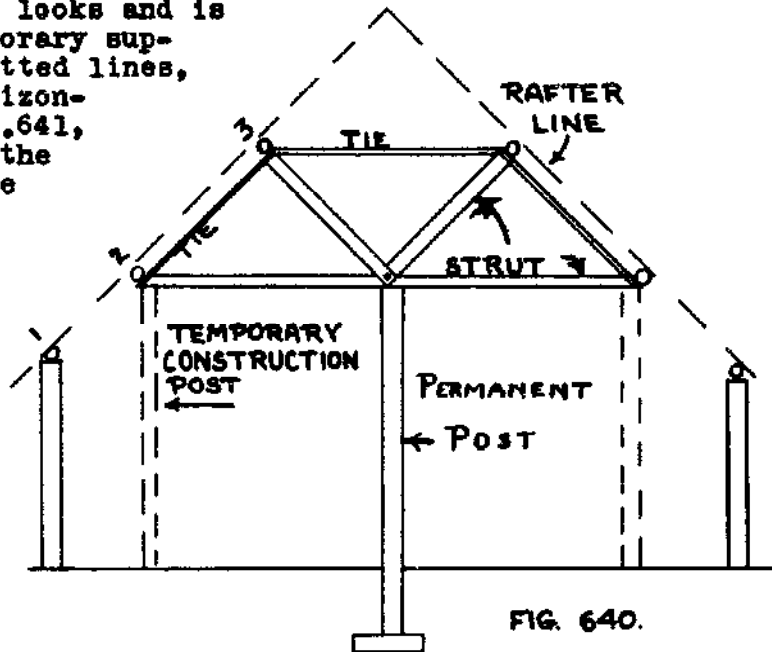


FIG. 640.

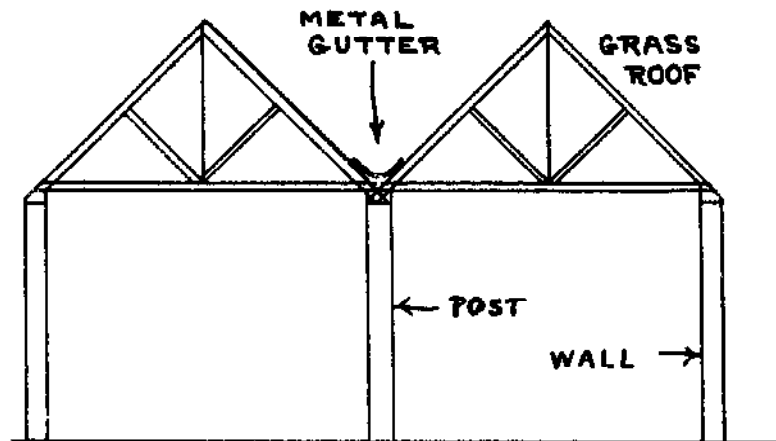


FIG. 642. TWIN GABLE

dicating rafters resting on purlines. The purlines are $1/3$ and $2/3$ the way up the roof. In Fig. 642 is shown the double gable arrangement for a church roof, built by Rev. H. L. Ogilvie. The only problem of this type of roof is the long gutter between the roofs. This gutter was made of properly jointed and soldered roof pans, flattened somewhat and then formed into a large gutter as shown. By the use of trusses, only one or two posts need be used in the whole length.

XIII FLAT ROOFS.

We recommend that flat roofs have at least the pitch shown here, which is 12" in six feet, which is about 9-1/2 degrees. In a flat roof, it does not pay to have a very low pitch when a higher and better one costs practically the same. A little experimenting will demonstrate this.

A six foot pan on the level covers six feet, raised 12" covers 5'11",
 24" " 5'8",
 36" " 5'2-1/2".

It is hardly worth while risking leaks and having such a flat looking roof for the sake of one or two inches of increased width in the building. Somewhere between 12" and 24" rise per 6' would seem to be best.

Fig. 643 is the simplest type of flat roof, where one stick will carry the roof. Where the span is so great that stiffening is required, use a bale iron truss tie as in Fig. 644. Another form of support is shown in Fig. 645, page 262.

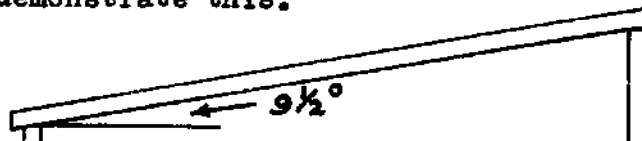


FIG. 643. UNSUPPORTED RAFTER

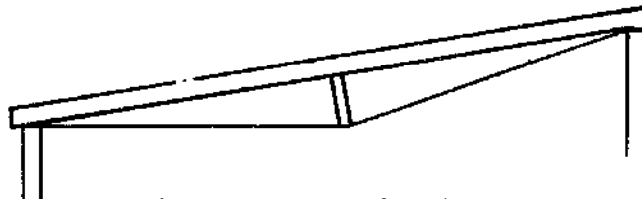


FIG. 644. STIFFENED RAFTER

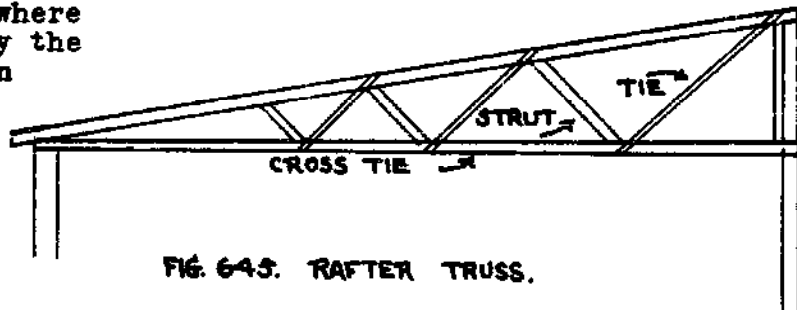


FIG. 645. RAFTER TRUSS.

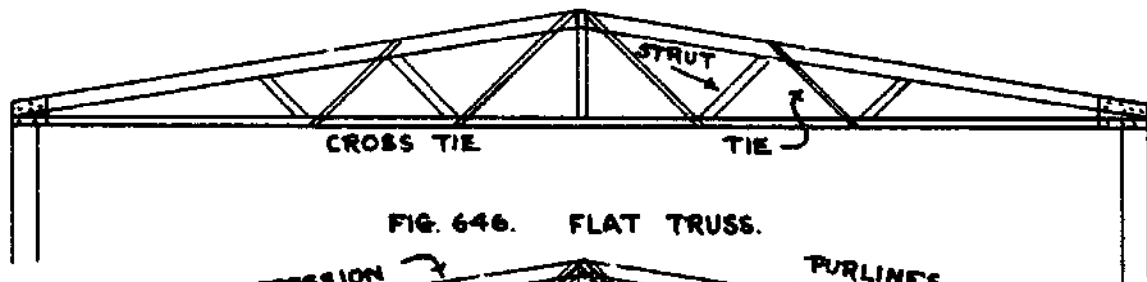


FIG. 646. FLAT TRUSS.

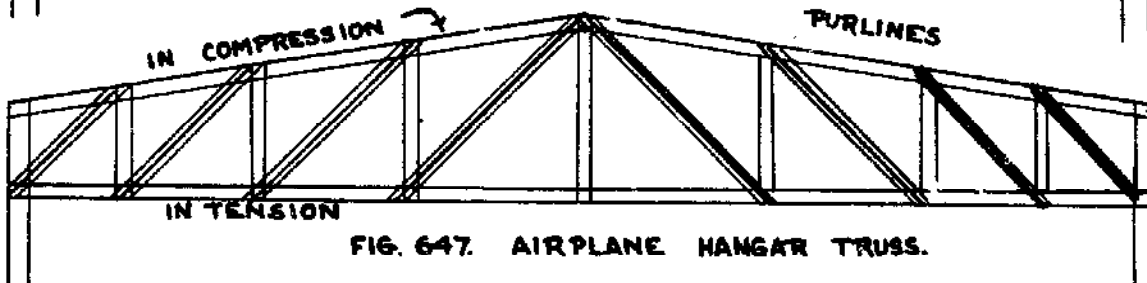


FIG. 647. AIRPLANE HANGAR TRUSS.

Figs. 645, 646 show the way to care for greater spans. 645 may be extended considerably, but it might be wise to increase the pitch to at least 18" rise per six foot run.

Fig. 648 and 649 show two ways of carrying a flat roof. The rafters and the truss pieces should not be less than 2" X 4". Fig. 647 is designed as an airplane hangar roof.

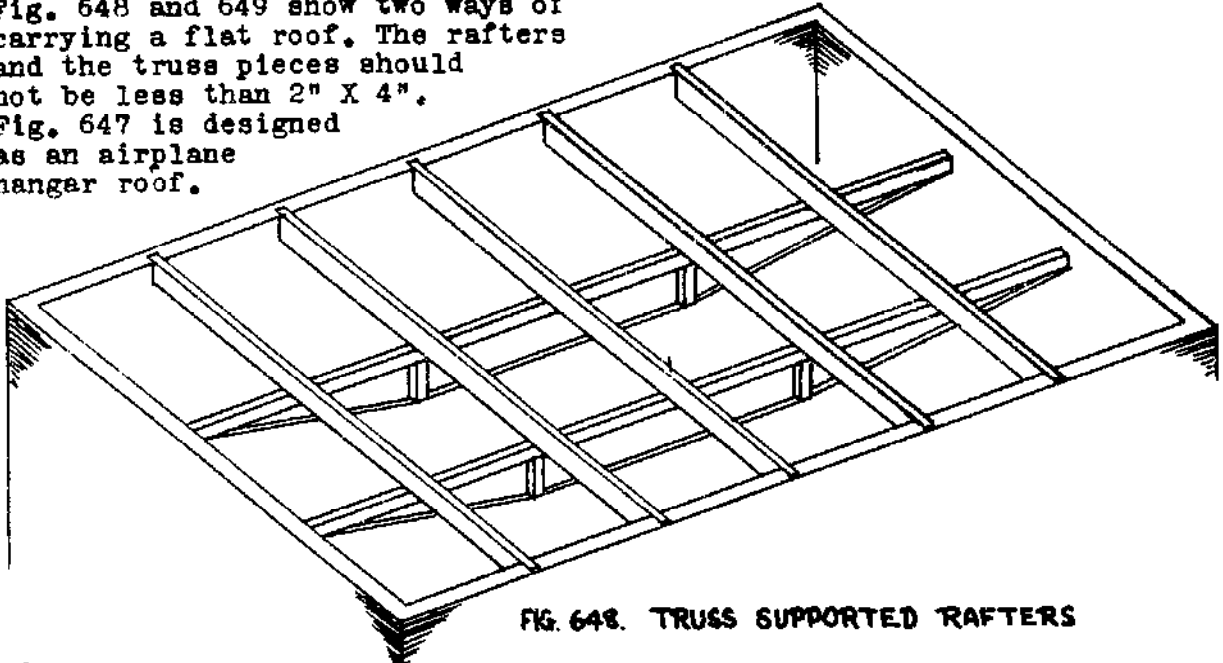


FIG. 648. TRUSS SUPPORTED RAFTERS

Of the vertical and diagonal pieces, all two-line parts are in tension, and may be one thickness of material; the three line parts are in compression and must be the equivalent of two thicknesses.

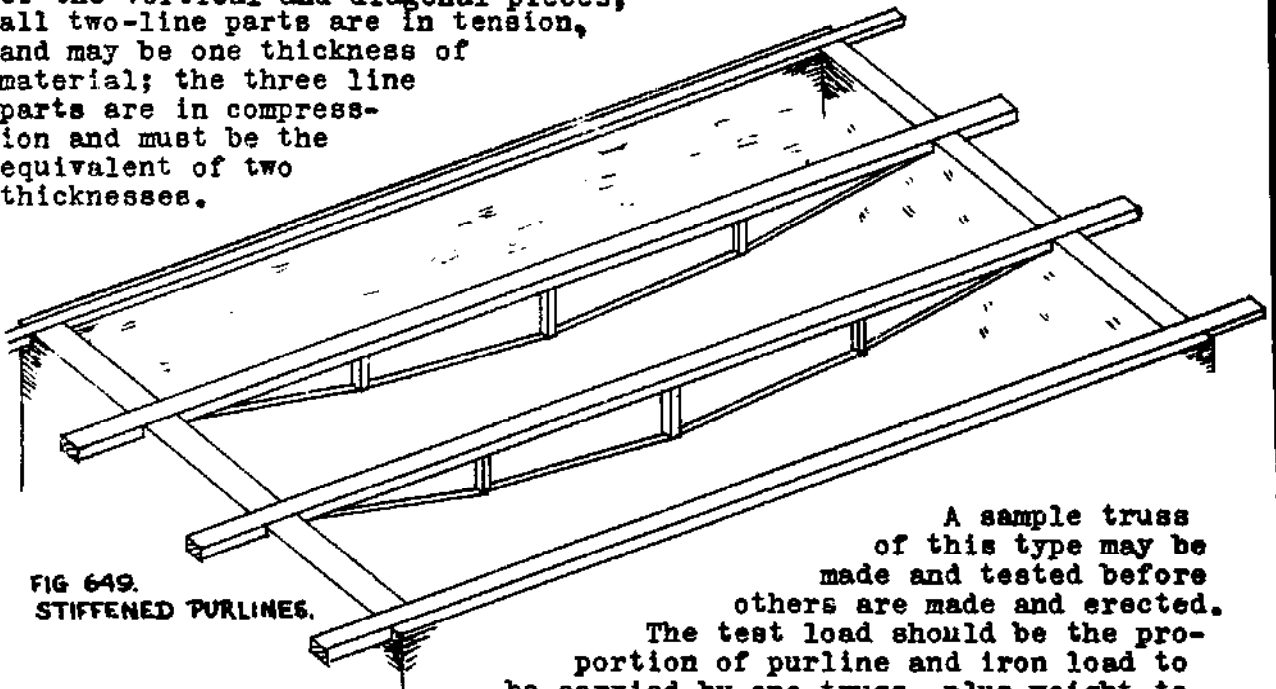


FIG 649.
STIFFENED PURLINES.

A sample truss of this type may be made and tested before others are made and erected.

The test load should be the proportion of purline and iron load to be carried by one truss, plus weight to be carried by the front door track, plus allowance for track to carry an engine, plus allowance for holding plane parts, the whole multiplied by four. Build a platform over the truss and load it with weighed stone, cement blocks, etc. The truss will be supported at each end on a block, and will have pairs of posts to hold it in erect position without interfering with the loading test. There must be play enough to allow the truss to buckle.

buckle. The pairs of posts should be placed where the purlines are to be, for the purlines being fastened to the truss will stiffen it against side movement. The depth of the truss at the end, gives some stability; the end wall should be diagonally braced in itself to give maximum stability to the whole rear of the structure. But the front requires an outside brace or tie. According to the height, this should be from three to six or eight feet from the base of the wall. It should be anchored in at least a ton of concrete several feet below the surface of the ground. If wood is used as a brace, it should have a metal tie at the top and a metal tie in the concrete at the bottom.

The other great stress on the hangar is the pocketing of a strong wind. It will tend to distort the side walls, blow out the end wall, or tear a hole in the roof. To meet this, diagonally brace the side walls, and provide the end wall with long shallow shutters, hung at the top, and left unlocked so that in a sudden emergency, a strong wind will push them open and escape rather than destroy the roof or end wall. Twisting of the roof can be met by corner to corner, horizontal braces of wood or metal, secured to the cross ties of the trusses.

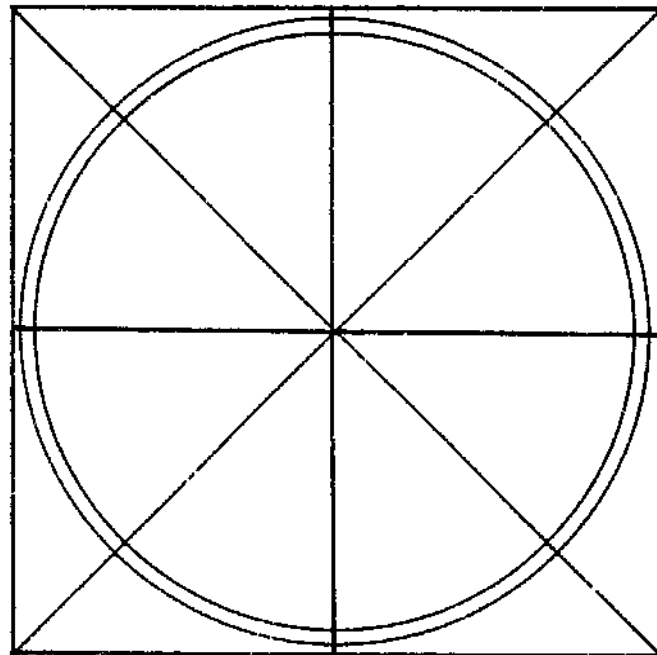


FIG. 650. SQUARE ROOF ON ROUND HOUSE.

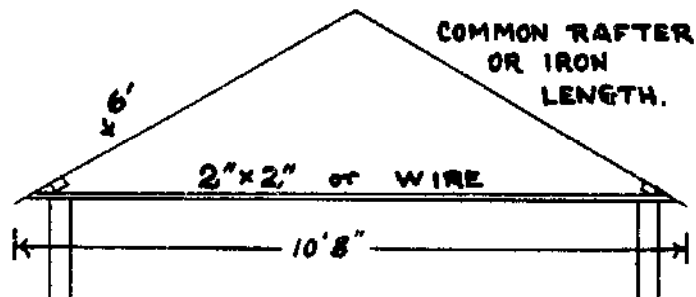


FIG. 651. ROOF CROSS-SECTION.

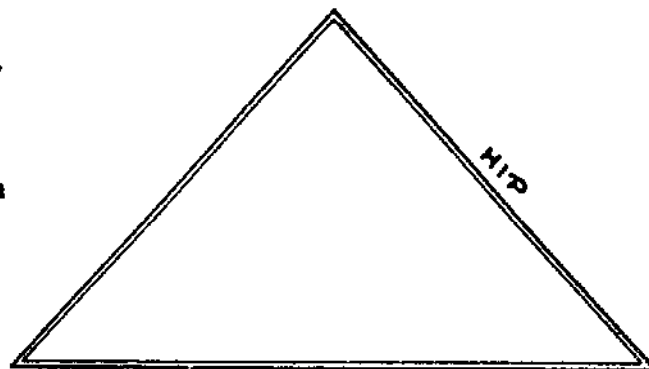


FIG. 652.

A square roof on a round house may be dealt with here. Make a drawing as in Figs. 650, 651, or lay out on the ground. From the cross section get the length of the iron, then draw the master as in Fig. 652, the height of the triangle being the length of the iron. The true length of the hip will be the diagonal lines. Make four frames just like this, using as light as 2" X 2" wood for the hip. Use 2" X 4" for the eave purline. Nail together on the ground. Erect two opposite sides, prop up in the middle, tie the feet with a temporary wire tie for cross tie. Erect the other two sides. Tie all together at the hips, including the ends where the eave purlines meet. Adjust the cross tie, make permanent. This roof can be dismantled and moved to another place.

Regular ridging or hand made can be used to cover the joint at the hips, and would be bolted in place.

XIV MUD ROOFS.

Under certain circumstances, mud roofs are a necessity. We wish that it might be otherwise.

Problems and drawbacks are: great weight, cracking and leaking, heating of interior, and, usually, unattractive appearance.

To support the great weight, thick walls and wide footings are required. For a mud roof on a 14' X 14' room, with wa'ls 14' high, 18" thick walls would be a minimum. The footing for this wall, depending on the earth base of course, would be not less than four feet. Settlement of the wall means cracking in the roof.

Waterproofing the mud is a real problem. Leakage is due to three main causes, settlement of the walls causing structural cracks; expansion and contraction cracks due to change in temperatures; and the lack of waterproofing mixture or application for the mud itself.

There are at least two waterproofing products on the market and they should be tried by anyone who must waterproof a mud roof and to the present has not found anything satisfactory.

'HYDROZO' is made by HYDROZO PRODUCTS, Inc., at Lincoln, Nebraska. During the first of the war, Army Engineers at Gering, Nebraska, ran many tests of Hydrozo on adobe buildings and found it very effective for keeping water and moisture out of this type of wall.

Hydrozo mixes well with all oil paints. A light coloured oil paint on a roof coated with Hydrozo ought to be a worth while experiment for all who are in real need of a waterproofing job. Water washes cannot be used over a Hydrozo treated wall. Oil paint must first be applied, preferably stippled. (Tapped with the end of the bristles on a square end brush to produce a dotted surface.)

Another experiment should be made with whitewash boiled together with tallow. This has been recommended by a painter who has used it on masonry surfaces. We cannot guarantee many of these suggestions, but think they are worth a try.

In another place we recommend cotton seed tar for mud walls. Put on hot, it penetrates, dries, and then has the property of holding cement wash. Sometimes the cement wash has powdered off, but that

may have been due to applying it before the tar was properly dried in, or applying it when the wall was hot, or it may have been due to poor cement, or other conditions. We have seen this cotton seed tar, with the cement wash applied later, prove satisfactory in so many places that we urge its use as the cheapest most satisfactory waterproofing for mud walls, mud roofs and other masonry of this type.

Figs. 653,654 Show mud wall supporting saplings.

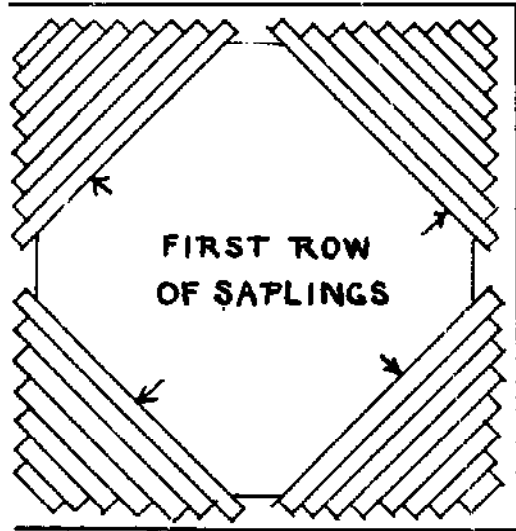


FIG. 653. FIRST ROW OF SAPLINGS.

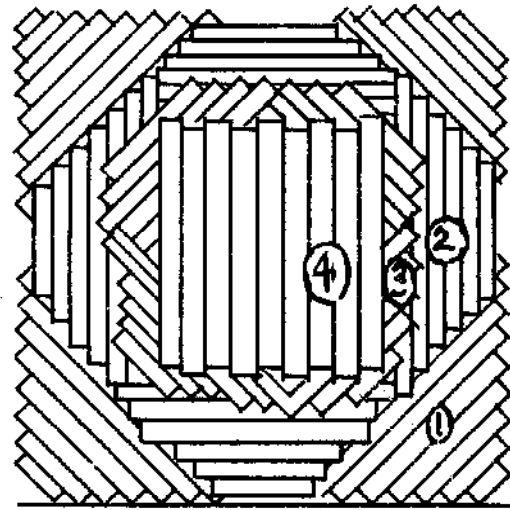


FIG. 654. COMPLETE

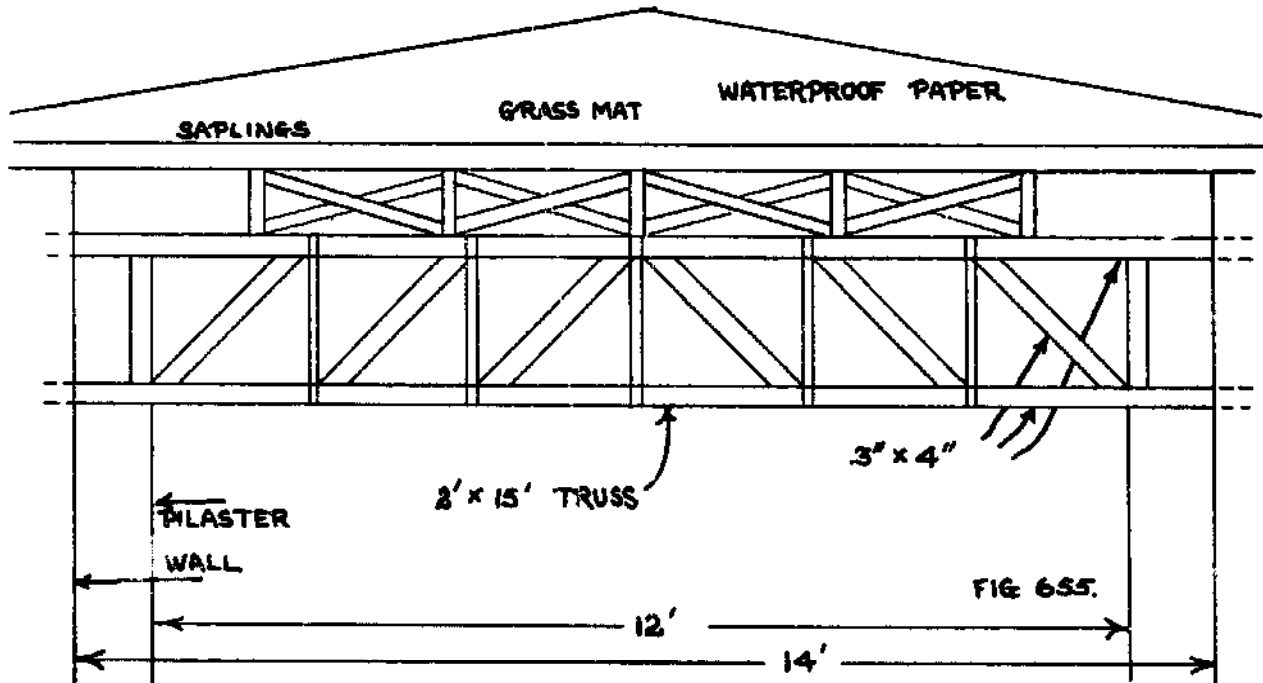
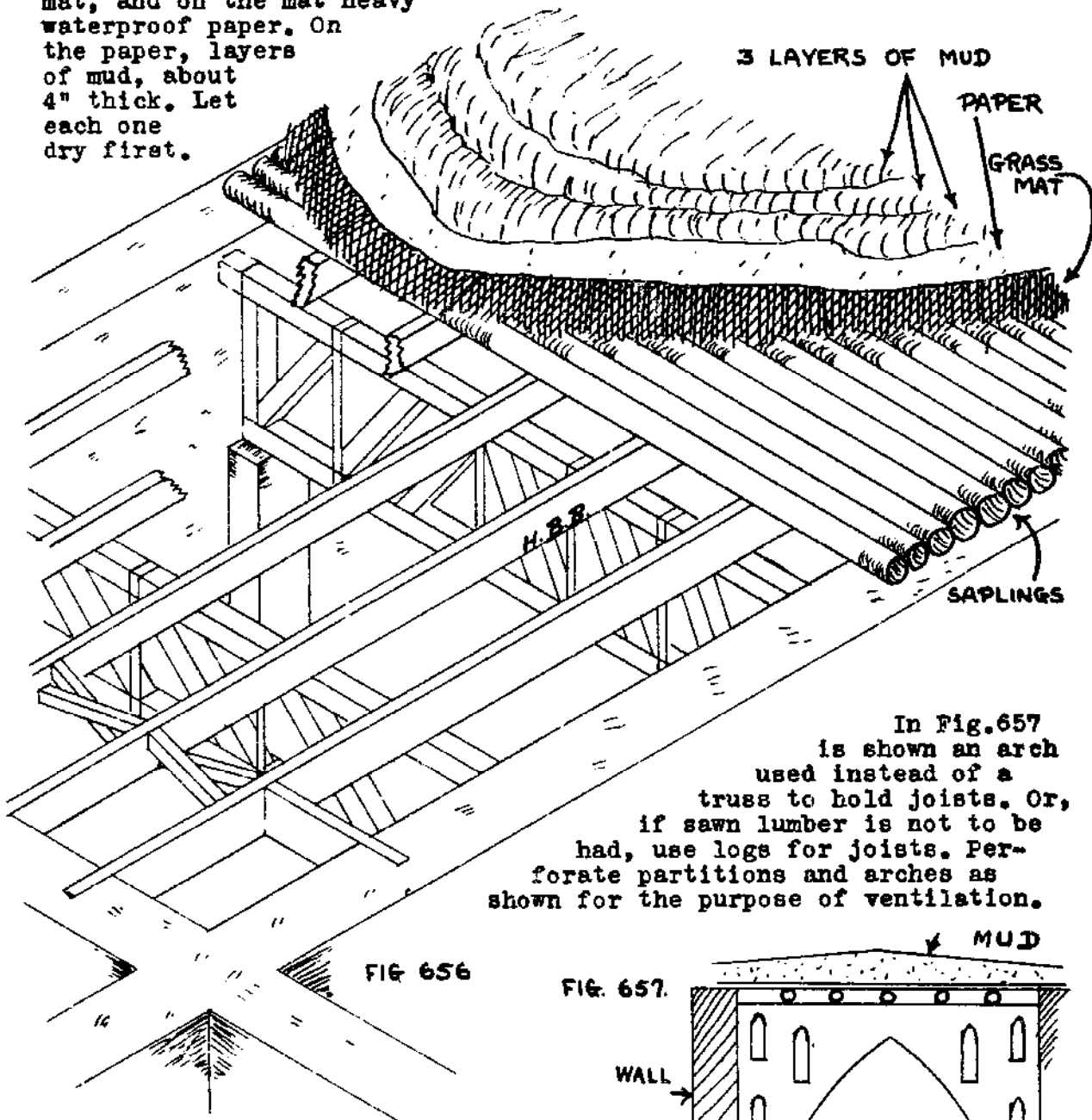
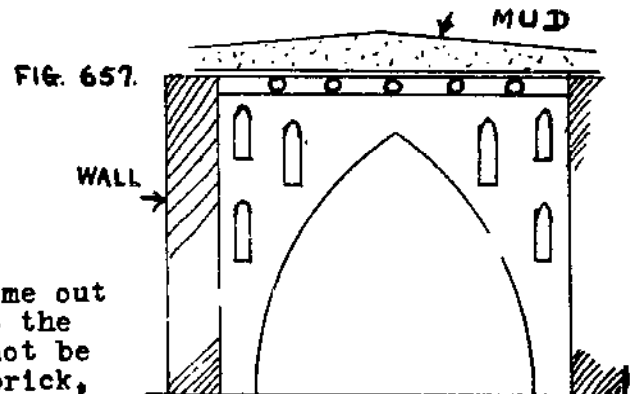


Fig. 655 shows an inflexible truss supporting 2" X 8" joists. The trusses should not be more than about seven feet apart.

The joists have to be spaced according to the strength of the saplings, and/or their own strength. On the saplings, lay a stiff grass mat, and on the mat heavy waterproof paper. On the paper, layers of mud, about 4" thick. Let each one dry first.

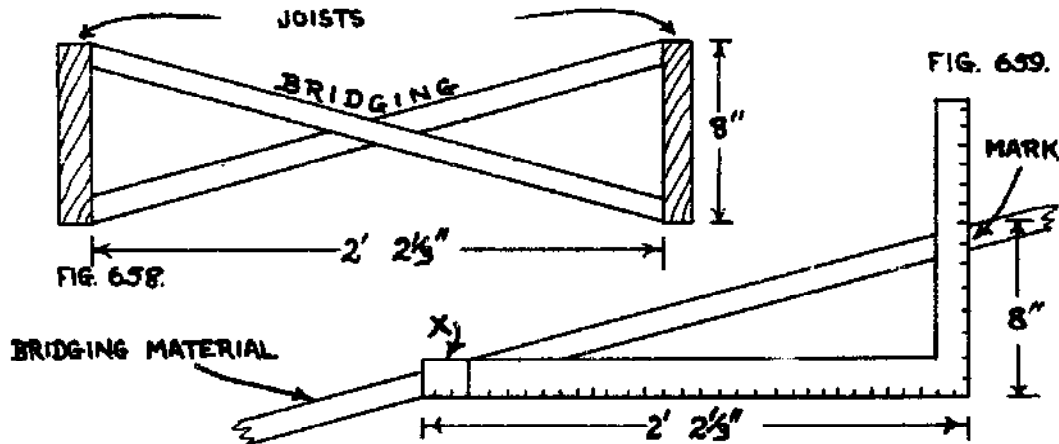


In Fig. 657 is shown an arch used instead of a truss to hold joists. Or, if sawn lumber is not to be had, use logs for joists. Perforate partitions and arches as shown for the purpose of ventilation.



The foot of this arch ought to come out from the wall about two feet. But the thickness of the arch wall need not be more than 12" if it is built of brick, and if a split log, or sawn plank in mortar is laid along the top.

Bridging. In Figs. 655 and 656 we have shown what is called 'herring bone bridging.' To stiffen and render more efficient and steady the joists that are being used, short braces are used in the manner shown. Sometimes there is one row and sometimes two rows of bridging between spans. At the end of the row, because there is no joist, we have inserted a short length of joist at right angles to the joist. Besides being nailed through the joist, there should be a metal tie from the bottom edge of the joist to the bottom edge of the short piece.



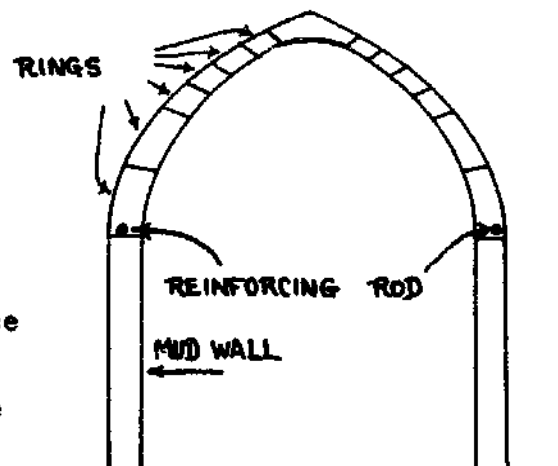
The large room shown in Fig. 656 is 14' wide, has five joists with six spaces, 2'2-1/3" each. We have taken this example to show how to cut a sample bridging. If necessary, as here, to extend the square, do so with wood or metal as indicated by 'X'. Place the square so that the horizontal distance between joists, transferred to the square, is on the under side of the material to be cut. The height of the joists, 8" in this case, is held even with the top edge of the material to be cut. Before finally nailing home all the bridging, see that each joist is plumb and in its exact position.

FIG. 660.

IV. MUD DOMES.

It may be practicable to construct a mud hut with a mud-dome roof. If to be without a grass roof cover, special attention must be given to waterproofing, light-refracting decoration, and, perhaps, extra shade from the sun. Without plenty of high up vents, the room would be hot.

Make a light frame of the general shape of this dome, and place it in the building to guide the builder. Joint the rings as shown. At the base of the first ring, place a metal band, perfectly jointed, to encircle the building and prevent outward thrust of the dome.



XVI. TILE ROOFS.

Wherever there is clay to make pottery which is waterproof, roof tile may be made. We present the essential details of a tile made by a missionary acquaintance.

The adoption of this type of roof should only be decided upon after experiments have been made through at least one full year. Presumably if the tile weathers a full dry season and a full wet season without deterioration or other defect, it may be expected to weather many seasons. Try the manufacture and framework and placement of the tile for one building a year in advance of the main building for which tile is required. We merely offer suggestions about the form and manufacture of roof tile. For instance our tile example is a half round. Experiment may show that less than a half circle but with a longer radius will do. It is cheaper, but it would not keep out spray as well as the half round.

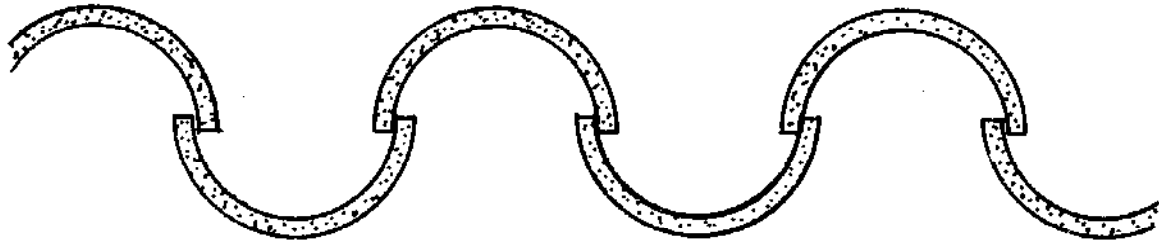


FIG. 661. CROSS-SECTION OF HALF ROUND TILE

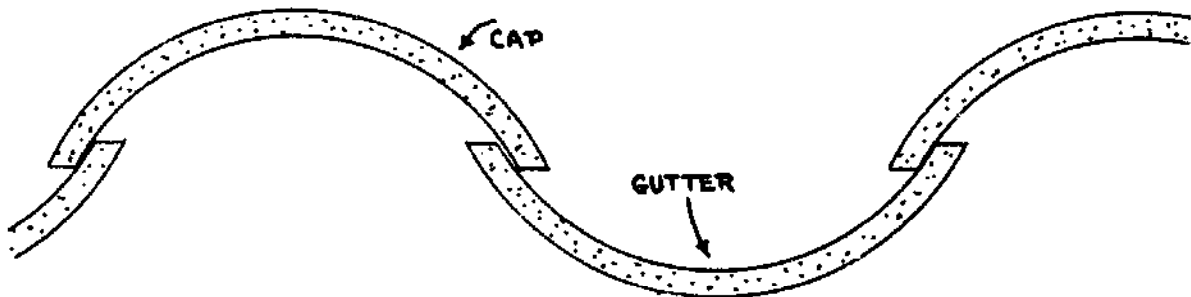


FIG. 662. SEGMENT TILE



FIG. 663. FLAT TILE.

FIG. 664. TOP VIEW OF SINGLE GUTTER.



FIG. 665. SIDE VIEW - LONG SECTION

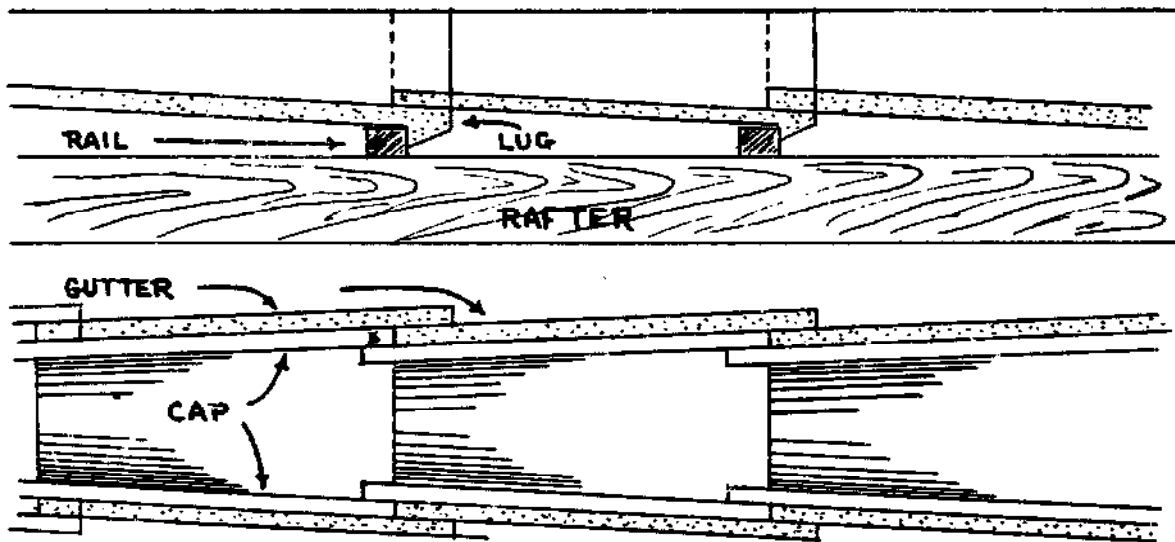


FIG. 666. PLAN OF CAP AND GUTTER JOINT

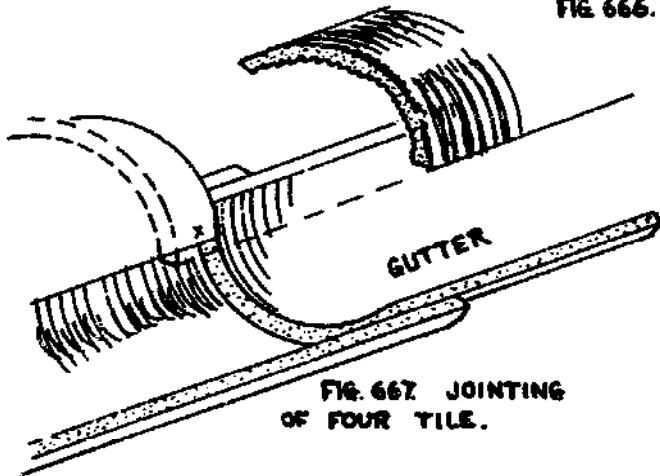
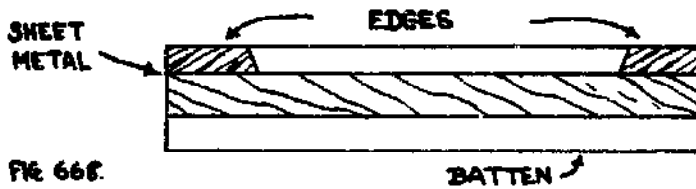


FIG. 667. JOINTING OF FOUR TILE.

In Fig. 665 the lug is part of the tile, moulded that way. It is the only device used to keep the tile from slipping down the roof. The cap does not slide because it grips the wedge shape of the gutter tile. Figs. 666 and 667 show the arrangement of the tile where the joints of all come together. 1-1/2" to 2" ought to be enough for lap. These drawings will do for the other tile in Figs. 662, 663.



Longer tile means that fewer rails for holding them will be required on the roof. We recommend that 18" tile be tried. If the tile are too large they will give trouble in the manufacture, and later, on the roof may break.

Thick rails mean fewer rafters. We recommend 1-1/2" X 1-1/2" rails and 2" X 6" rafters. These latter should not be more than 4' apart.

We have shown cross sections of three tile, the half round, Fig. 661; the segment, Fig. 662; and the camber, Fig. 663. The half round is the strongest and the most waterproof. The camber is the weakest. But of course the camber covers the greatest area for the amount of weight per tile.

We describe the manufacture of the half round tile. Quite arbitrarily we choose one with a 6" diameter at one end. This means a 7-1/4" diameter at the other end to allow for the lapping at the other end, as shown in Fig. 664. These tile are 5/8" thick. (You may be able to make them even thinner to reduce the weight of the roof. There are two dangers, one, that of breakage on the roof due to handling; the other is heavy hail. Hail has been known to mutilate corrugated iron. Admittedly this is rare, but heavy hail is occasionally experienced in the tropics. If the tile were too light they would not resist such hail.)

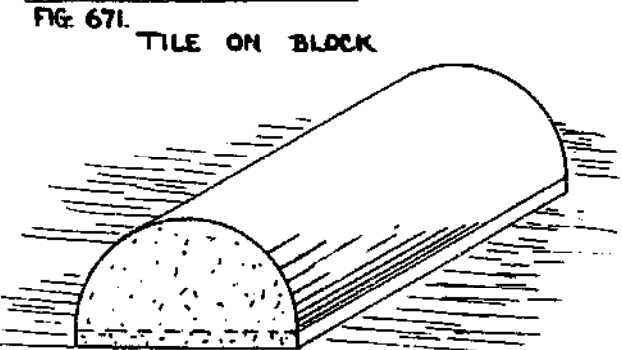
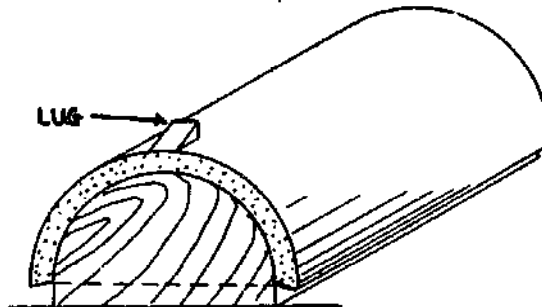
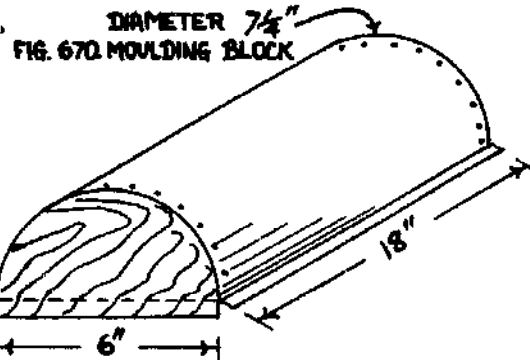
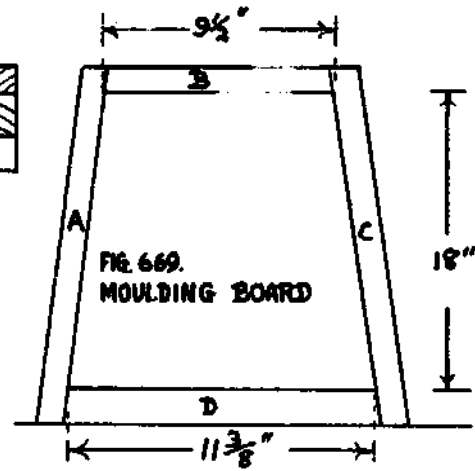


FIG. 672. CLAY PALLET

Equipment. After the clay has been rolled flat to a thickness of $\frac{5}{8}$ " , there are two methods of making a piece the required size. In the first a pattern board is made, see Fig. 669. Use a piece of seasoned wood, 1" X 15" X 22". Fix two stout battens to the under side to prevent warping. Make the upper surface perfectly true and cover with a piece of smooth sheet metal. Make three fixed edges, ABC and bevel A and C as shown in Fig. 668. The bevel edge on the clay will produce a sharp edge on the tile and contribute considerably to the prevention of various little drip leaks.

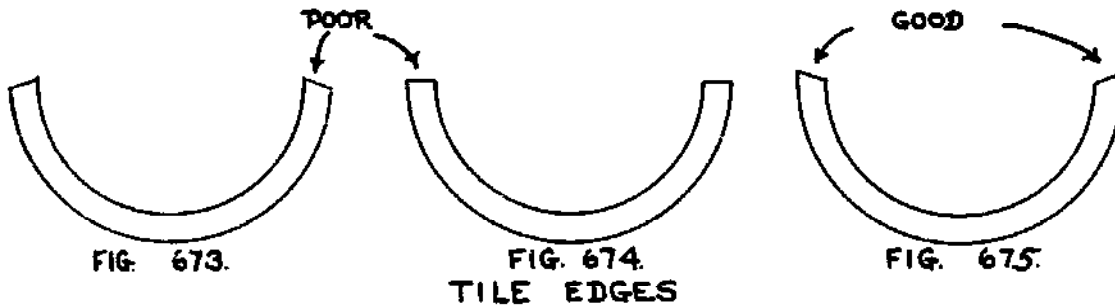


FIG. 673.

FIG. 674.

FIG. 675.

TILE EDGES

Make a removeable edge D to allow for picking up the clay when it has been properly sized. All the edges are to be $\frac{5}{8}$ " thick. The measures we have given are purely mathematical. Make a few tile with this board, sun dry them and try them for size and fitting at joints. A little adjustment will be enough to produce perfect fitting tile.

The second method of preparing the right size of clay sheet might be called the 'cookie-cutter' way. The 1" wood is cut to the exact size of the clay and a metal edge is nailed to it and projecting beyond it at least $\frac{3}{4}$ ". It is fitted with two strong handles. The metal should be 1- $\frac{1}{2}$ " wide bale iron, or a strip of 22 gauge sheet metal. Keep it oiled so that, in cutting, the clay will not stick to it.

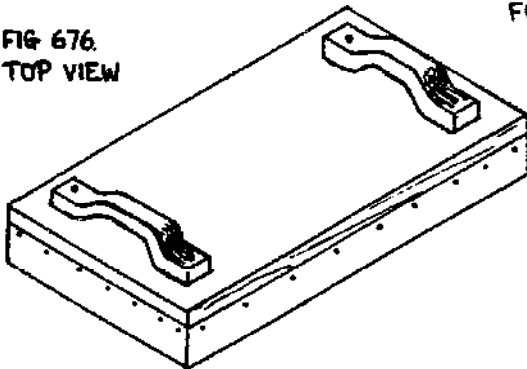
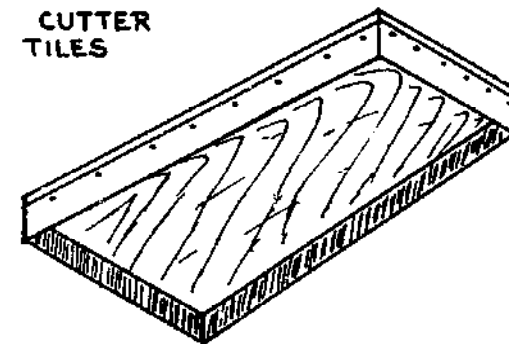
FIG 676.
TOP VIEWCOOKIE CUTTER
FOR TILES

FIG. 677. UNDERNEATH VIEW.

Provide a spatula for lifting the clay from the table or board.

Make a moulding block as in Fig. 670. The block at the one end has a 3" radius, the one at the other end a 3- $\frac{5}{8}$ " radius. A sheet of metal is fastened to these wood ends. The metal measures 10- $\frac{3}{4}$ " at one end and 12- $\frac{5}{8}$ " at the other end, and is 18"

long. Allowance is made for a $5/8$ " flange at each side, bent down a little so that the clay may be moulded into a bevelled edge as seen in Fig. 675.

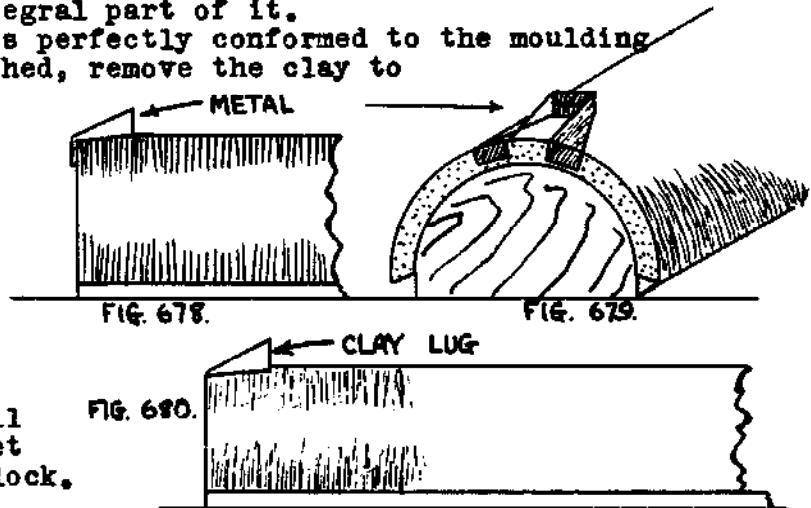
While the clay is on the moulding block the lug is added. Pallets for holding the clay while it is being dried will be required. On one station a board with converging battens was used. The moulded clay was placed on the board and left to dry. The space enclosed by the battens was the exact size of the outer edges of the finished tile. In the example we are using the battens would be $7-1/4$ " apart at one end, and $8-1/2$ " apart at the other end. If this type of pallet is to be used, a great number would have to be prepared. If each was used three times a day, it would require 100 of them to do the job in 12 days. That is to make 3500 tile for a roof the size of the Mission House roof. The coverage of each tile is about 6 " X 16 ".

If the newly moulded tile becomes misshapen on this flat wood pallet, use a round mud pallet. Make bricks the exact shape of the moulding block, with the exception of the flanges. Make them smooth on the upper rounded side, and just before placing the clay tile on them, smear them with a little grease. The only disadvantage to the brick pallet is that the inner surface of the tile will not dry so quickly. But that is not so important because being cheap we can make more of them.

Tile clay. Get the best advice from local potters. Building sand in the clay will give some hardness and glaze to the burned tile. Sand also tends to prevent cracks in the clay.

The clay should be thoroughly mixed, but at the time of moulding, it should be as stiff as possible. Roll out the clay to a thickness of $5/8$ ", cut with the 'cookie cutter, lift with the spatula and place on the moulding block. This also should be smeared with grease. When the clay is in place, affix the lug. A metal pattern would be best to make sure that the lug is correctly placed and shaped. It is at the large end and two inches from the end. Roughen the surface of the clay, press in the new clay, somewhat moister than the other, and smear the three sides. The face of the lug should be straight, square with the tile and full size, not less than $3/4$ " X $1-1/4$ ". Be sure that the lug is not merely stuck on the tile, but is made an integral part of it.

When the clay is perfectly conformed to the moulding block, and the lug attached, remove the clay to the mud pallet. If the drying ground is very hard, the mud pallet would need to be raised a little from the surface to allow the sharp edges of the clay to hang free. Otherwise they will strike the ground when deposited and be marred. The best way to overcome this will be to make the mud pallet $1/2$ " thicker than the block.



As soon as the clay has become hardened enough to be handled without distortion, remove it from the mud pallet and place flat on the ground until it is thoroughly dried.

When all the tile are made and thoroughly dried, place them in the kiln. Here again, ask for advice from the local potters.

Laying the tile on the roof. The greatest care should be taken to have the rails perfectly spaced, in this case, 14" from upper edge to upper edge.

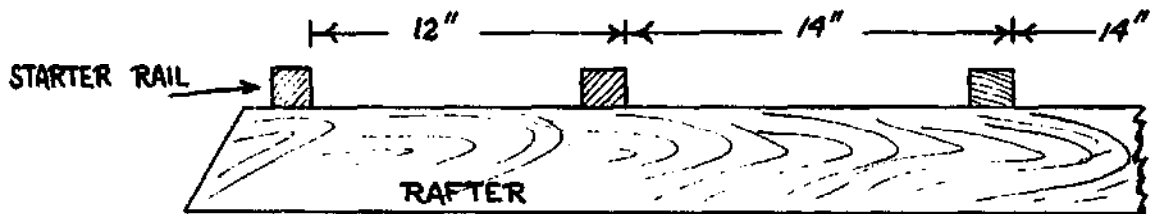


FIG 681

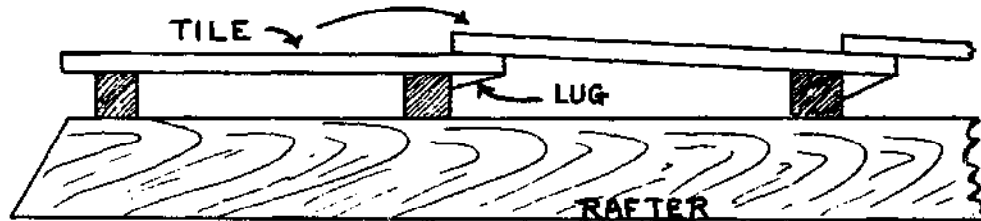


FIG. 682.

Experience will show whether the tile should be laid a row at a time, horizontally, or, vertically, that is from eave to ridge. We recommend the vertical because the workmen do not have to be on the tile. Start at the eave and lay two complete gutters to the ridge. Then cap them with a row. The nearest gutter will need a little adjustment so that the joint will be snug. We recommend that a mortar of the clay, and moist enough to be sticky, be used to make tight joints, both at sides and ends.

On a hip roof, some cutting will have to be done. Score the tile and break carefully. A 2" X 4" should be nailed on top of the hip rafter to take up the slack and give the edges support. Bed the cut tile with clay mortar, and fill all voids. Fig. 683 shows 2" X 4".

The ridge and hip corners are finished with a row of tile bedded and jointed in cement-lime mortar. 1 cement, 1 lime, and ten of sand. Or cement mortar, 1 cement, six of sand. Wet the roof tile before spreading the mortar and wet the ridge tile before laying on the mortar. Prevent this mortar from drying out rapidly. Do the job in the late afternoon, wet it when it is set enough to withstand water, wet it the next day, cover it with grass or other mat, and keep wet for another day.

Workmen should not move over a tile roof without proper

plank walks supported by cross pieces and they in turn resting on fillers.

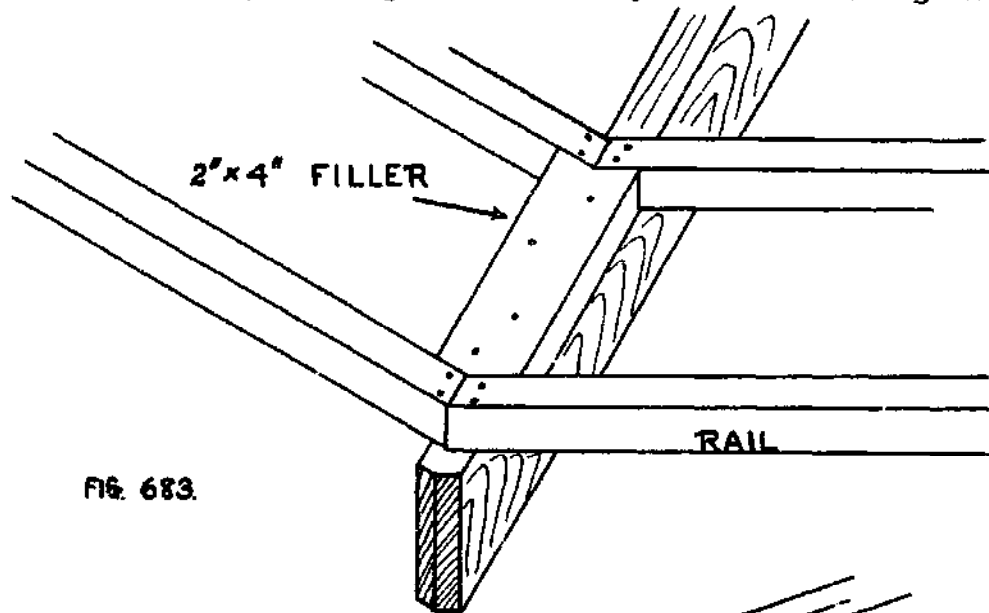


FIG. 683.

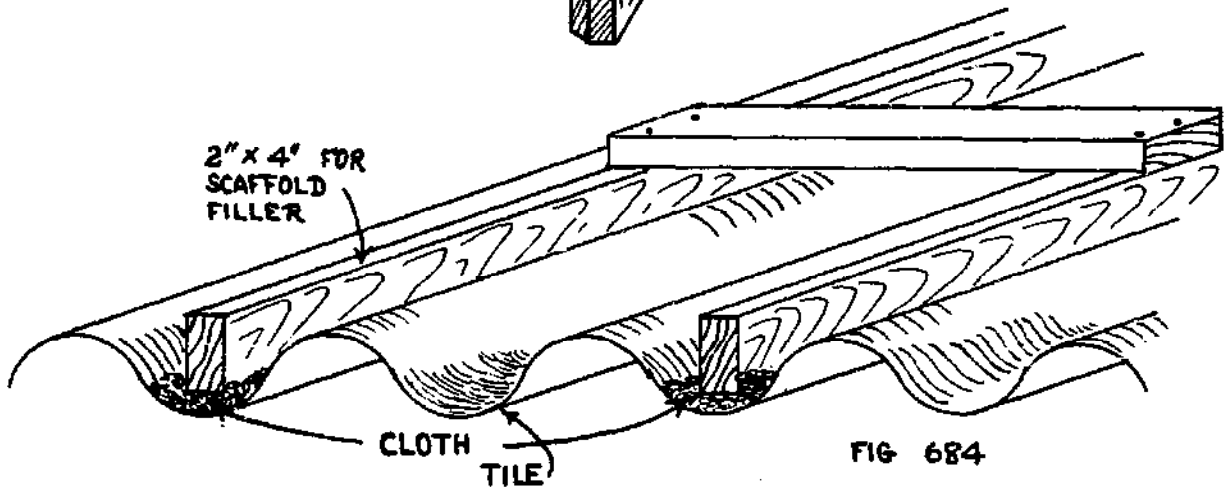


FIG. 684

CHAPTER EIGHT ROOF FRAME ERECTION.

I WALL PLATES.

When there is a 9" corner rafter, it rests upon the wall plate, and in this case the corner joint of the two wall plates should be reinforced by a diagonal brace.

If there is only a 6" hip rafter, use an extra plate at the corner to make a lap joint.

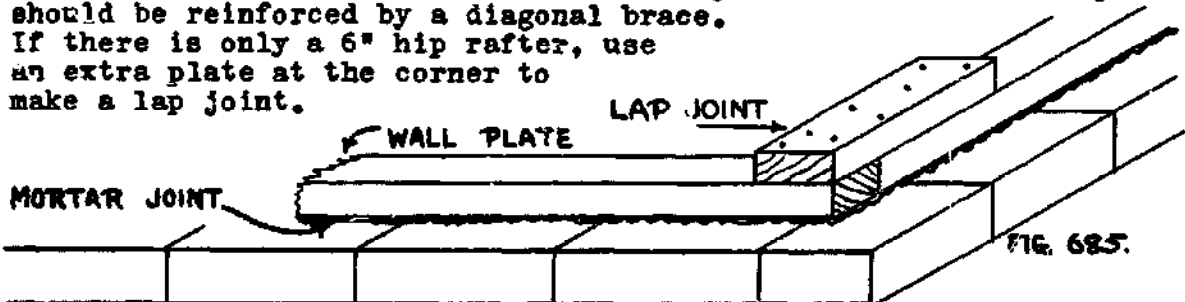
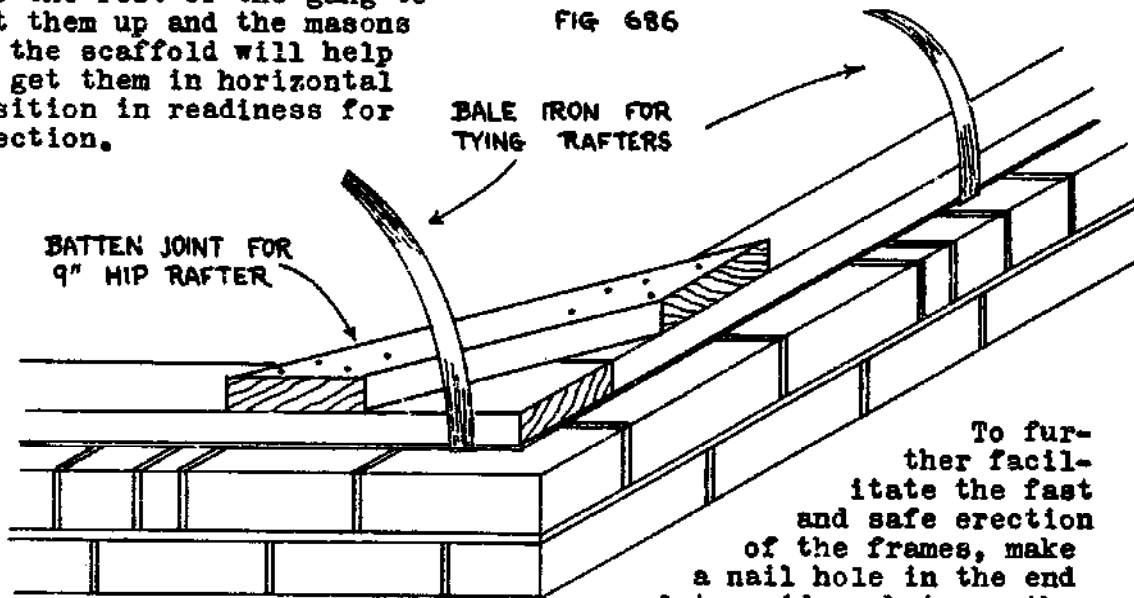


FIG. 685.

Whether the rest of the roof frame is ready or not, have the wall plates all ready to put up when walls are completed, before the masons get down from the scaffold. Let them spread mortar on the wall, lift up the plate and put it in its final position, as to wall line and as to level. They must also lead out the bale iron beside the plate so that there will be hacking to clear it, and no lifting of the plate to disentangle it.

If the roof frames are ready get the rest of the gang to put them up and the masons on the scaffold will help to get them in horizontal position in readiness for erection.

FIG 686

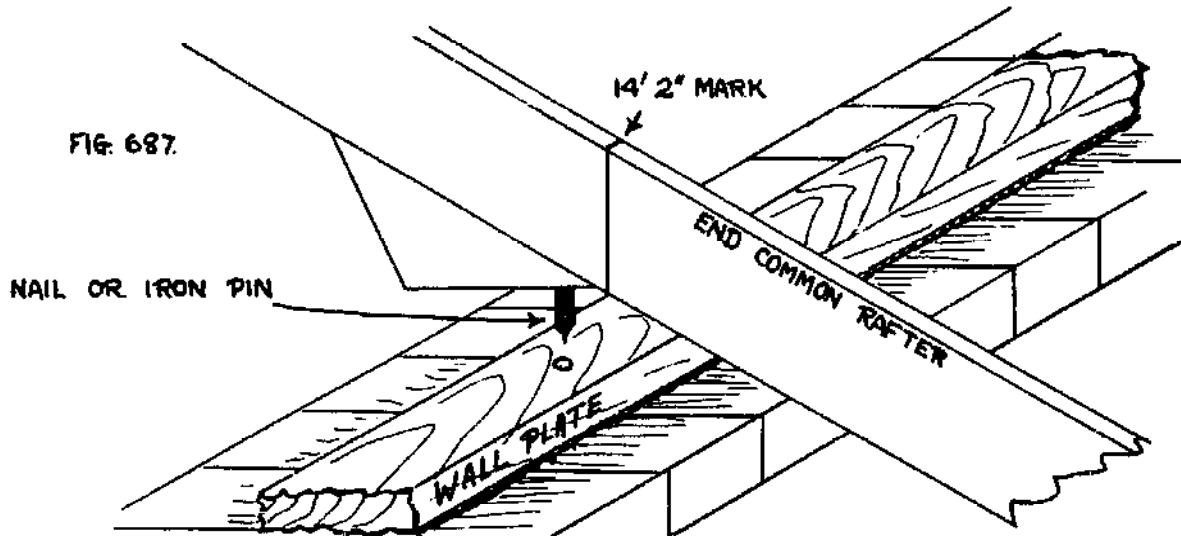


To further facilitate the fast and safe erection of the frames, make a nail hole in the end plate, midway between the front and rear walls, at each end. From drawing 472, page 199

II. END RAFTER HOOK UP.

it can be learned that the wall plate plumb mark is 14'1" from the ridge mark. Make a common rafter plumb mark at the 14'1" and attach a block as shown. Drive a nail into the block and on into the rafter so that it will correspond with the hole in the plate.

FIG. 687.



At each end wall provide two 2" X 3", one inside and one outside, with a 4" nail started in each, ready to nail to the end common rafter when it has been placed in position. They will have the responsibility of keeping the frames upright while men are working aloft until hip and jack rafters at least are in place.

Have one of the ridge purlines marked for the roof frames and a 4" nail started for each. When the first frame is ready for erection, nail the ridge purline to it quite near the top, and lay the ridge purline along the edge of the frame. When the frame has been raised to its position, swing the ridge purline around and it will help to steady the frame while the carpenter goes aloft to hammer the end purline into place. While he is

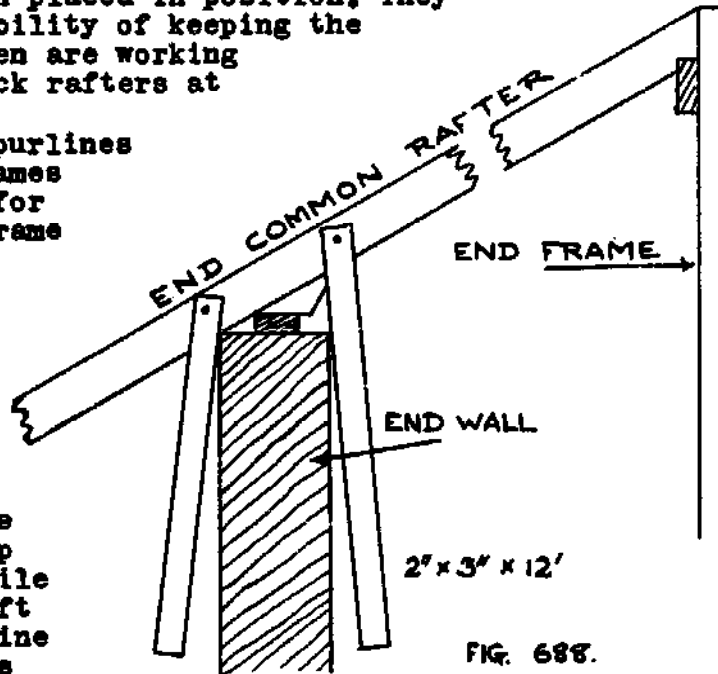
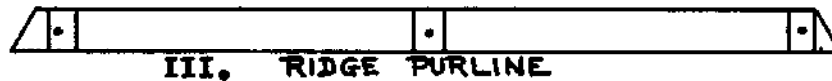


FIG. 688.



still up there, raise the second frame and he can reach over and drive the nail into it. Raise the third frame and attach its end rafter as the one at the other end was attended to. Some little adjustment may have to be made before the last frame erected lines up with the marks on the ridge purline. Make the adjustment and go ahead with the hip rafters.

Lay plenty of planks on the cross ties of the frames for good scaffold. If necessary, nail a short, temporary cross tie to each end frame to enable the carpenter to make scaffold and stand safely while he is putting the hip rafters in place.

With enough men up top, start the hip rafter up along the line of the end frame. When the man at the top has a hold on the rafter, the men on the wall carry the rafter toward the corner, assisted by the men on the ground. The hip rafter should be secured with bale iron as well as with nails.

IV. If there are two jack rafters, put in the longest pair for each hip rafter. If there are three, put in the middle length one. This will serve to support the bottom purline which goes in next. If a purline seems too long, pull the hip rafters away from each other, or push up the end with a prop to the ground. Join up the four bottom purlines and secure them with iron to prevent the corner joint being pulled to pieces as the rest of the frame goes up.

As soon as the bottom purlines are in place and secured, check on the position of the three roof frames and tack them temporarily; then straighten the purlines from end to end, and tack them to the rafters of the main frames. Now straighten the hip rafters and brace them; then fix all the jack rafters in place. Space the jacks from the main frame rafters and tack purlines to them. When the bottom pur-

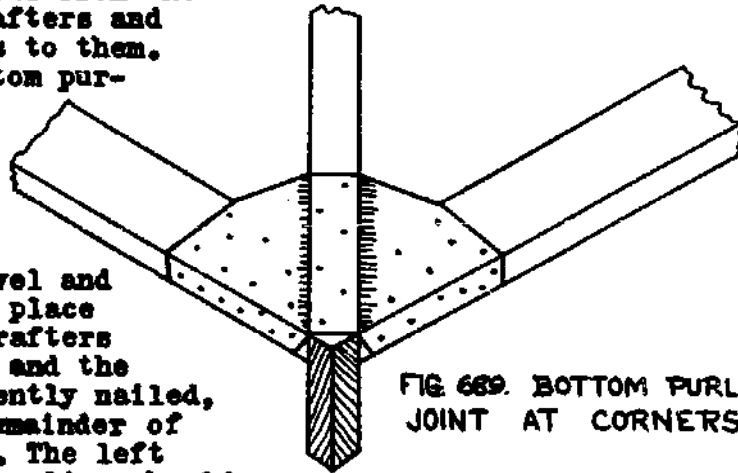


FIG. 689. BOTTOM PURLINE JOINT AT CORNERS

lines are level and in permanent place and the hip rafters are straight and the jacks permanently nailed, put up the remainder of the purlines. The left end of each purline should be cut already; fasten the

left end in its place and leave the rest unfastened. Repeat this all the way to the top. Then check to see that the left end hip rafter is straight; if it is, commence nailing the purline from the left to the right, being sure that each rafter is straight from the top to the bottom. If the purlines have been cut at the right end as well as the left end, they should fit into place and the right hip rafter should be straight when they are all in place. If the purlines have not been cut on the ground and need to be cut without the help of a mark, proceed as follows: place the purline flat on the hip rafter and with the edge right over the purline mark. Indicate the place on the edge of the purline, and with the square make a mark across the edge. Place the purline pattern on the purline with the point of the pattern on the square line as in the illustration.

Mark and cut.

FIG. 690.

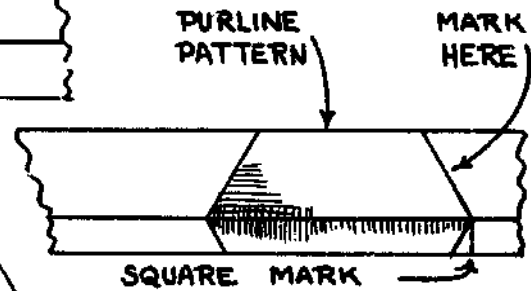
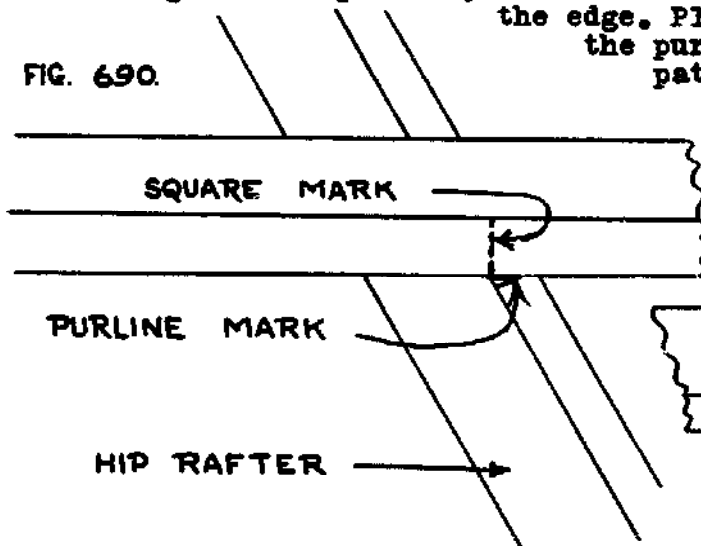


FIG. 691.

V. TYING. Not until all roof members are in place should purline nailing, rafter tying, and purline tying be done.

When tying rafters with the bale iron anchored in the wall draw the iron tightly with nippers or pincers and nail on top, never on the side on the way up. When the top is nailed, a nail may be driven on the off side. Rafter tying should be quite solid. A gust of wind will tear loose a tying which is not tight.

Tie each purline to the hip rafter and to each common and jack rafter.

FIG. 692. RAFTER
TIED BY BALE IRON

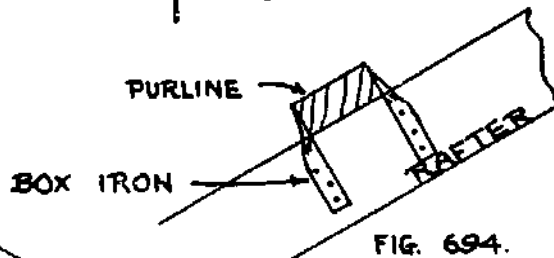
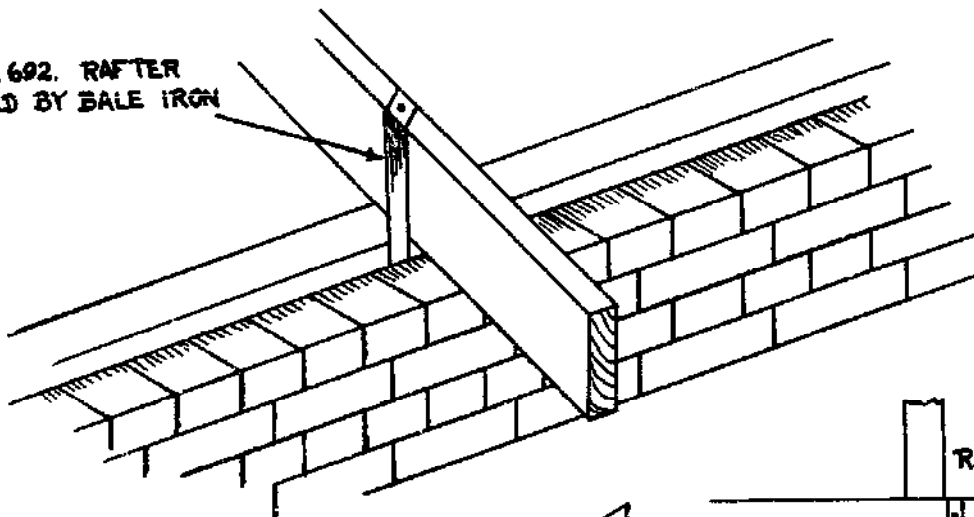


FIG. 694.

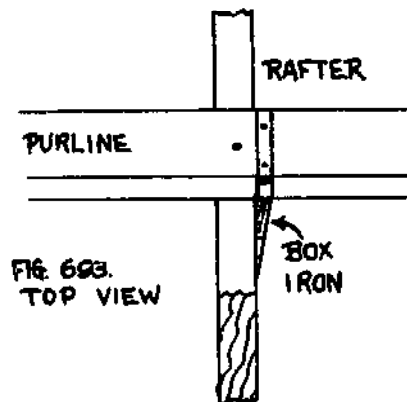
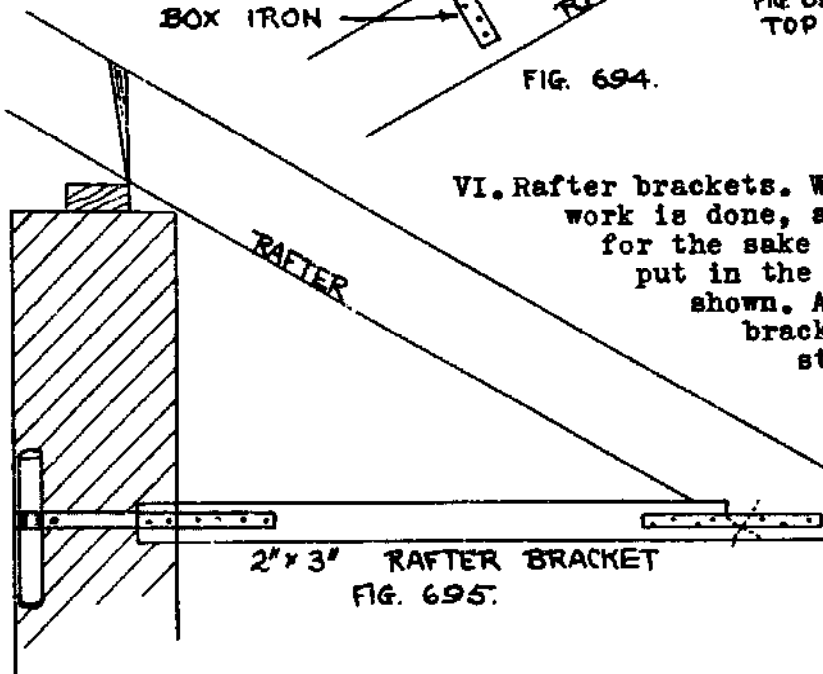


FIG. 693.
TOP VIEW



2" x 3" RAFTER BRACKET
FIG. 695.

VI. Rafter brackets. When all other roof work is done, as soon as possible for the sake of the plasterers, put in the rafter brackets as shown. A metal tie from the bracket is rivetted to a strong wood pin at the inside surface of the wall. The iron is pushed through a hole and fastened to the bracket.

CHAPTER NINEROOF COVERING.I. CORRUGATED IRON.

Correct side and end lapping are essential to a weatherproof job and require particular supervision. There will be little chance of making the end joints longer after the roof frame has been designed and erected, but they can still be bungled enough to make a leaky roof.

For appearance as well as jointing accurately, measure off roof sections. With ring of the tape at the apex of the hip rafter measure to the point of the hip rafter; with ring at the same place swing the tape until the same measure is on the outer edge of the bottom purline. A mark here is the end of a line from the apex of the hip rafter which is at right angles to the bottom purline. At 10' intervals at the ridge and at the eave make marks. Do this on both sides of the roof. At the ends, measure half way between the hip rafter points. A line from here to the junction of the hip rafters ought to be square to the bottom purline.

On the front side, start laying the pans by placing one at the eave, one above it, and so on until the ridge is reached. At the ridge, the upper edge of the pan should be exactly in the centre and not something short of it. If you want to be sure, you must climb up there yourself, place the pan where it belongs and drive a nail in it to hold it there. Then place the bottom pan where it ought to be. Now measure the amount of lap of the others. If it is right, (we recommend a minimum of 6") go ahead with sighting the pans for line. If it is not right, give all the joints over the house proper the full six inches if you can. If there is a joint over the outer wall and another on the overhang or over a verandah, they may be skimped as necessary. You may even have to shorten the drip overhang at the eave.

Two lines have to be observed in laying pans: the line of ends at the eave and the line of corrugations from the eave to the ridge. The eave line is not always right because there is a square line to the ridge. Occasionally the end cut of the pans from the factory is not square. Take a good look at the eave overhang before tacking the pan. However, if the pans are square with the eave, a little divergence in one pan must be ignored. Take care that the general line of the eave is straight and uniformly projecting.

When the bottom pan is tacked, through the middle corrugation, the top pan being already tacked at the ridge, line up all the pans. The carpenters should be to the left of the pans so that they may reach over and nail conveniently. To maintain the right end-lap they should seize the edge of the two pans between the fingers of the left hand, and with the right hand hold the head of the hammer, the handle being in a valley at the middle of the pan so that the person sighting from the ground may see clearly all the way from the bottom pan to the ridge.

When all the pans are perfectly lined and end-lap is correct, the bottom man, or the one at the first joint up, holds the two pans where they are as he tacks his joint. Then the next man tacks his, and so on up to the top. If more than one man nails at a time, the pans will shift and the sighting will have to be done

over again. When all joints have been tacked, sight once more, and if all is right, give the order to nail home. The nail should be driven until it begins to exert pressure upon the pan. Put in all the nails the pans will require, except of course at the near edge.

Making the side joint correct. Regardless of the number of corrugations in a side lap, the greatest care must be taken that the lap is exact. Almost invariably, if the lap is correct at the end of the pan, it will not be right at the middle, or midway between ends. This is because the corrugation is distorted, flattened. And so when we place the second pan at the eave we look to the lap at the middle; when that is right, we will find that the second pan overlaps the first too much at the end. This can be corrected. Again, nail the ridge pan in its right place, nail the eave pan, and then sight through. Nail the middle corrugation first, always. If the men try to nail through the joint they will disarrange the pans. Do not nail any joint until the centre of the pan has been nailed home. Then the awkward distorted end can be drawn into its proper place and nailed.

For the third row of pans, measure over to the next ten foot guide line and see if top and bottom pans of the row are equally distant from the line. If not, make suitable adjustment. There is no need to have a row of pans out of square.

Occasionally climb up and see that end joints and ridge line are being maintained.

FIG. 696. SIDE VIEW OF MARKED ROOF

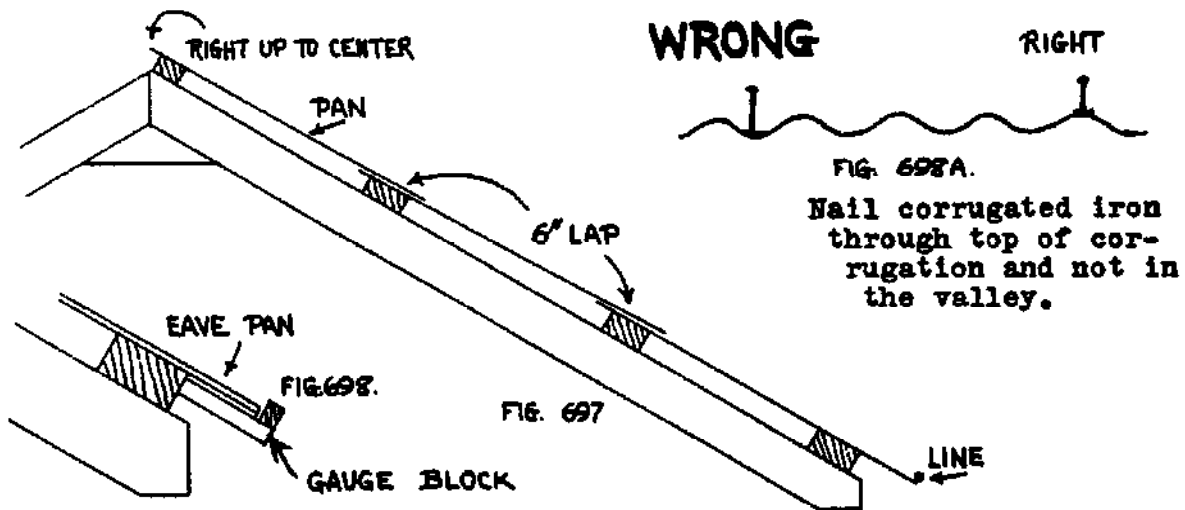
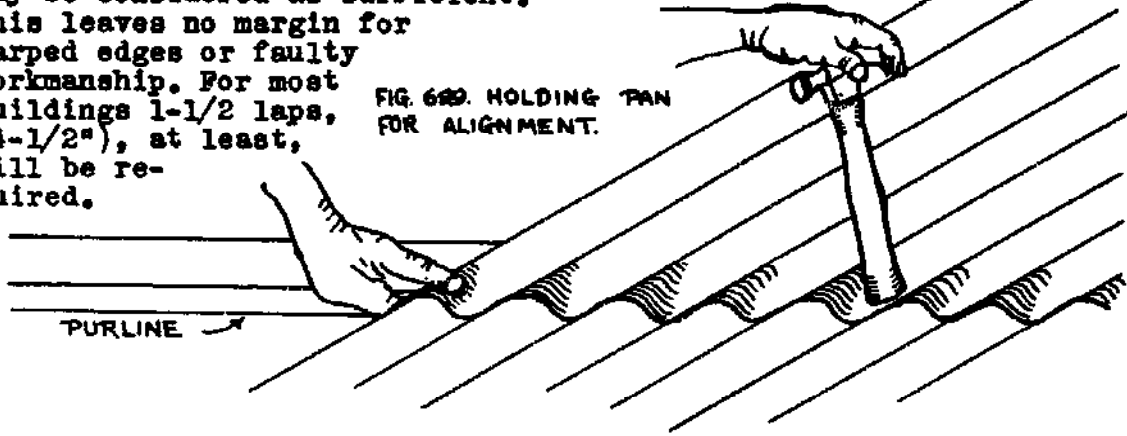
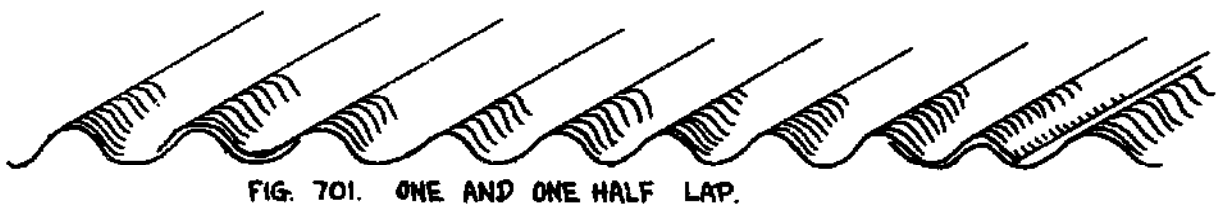
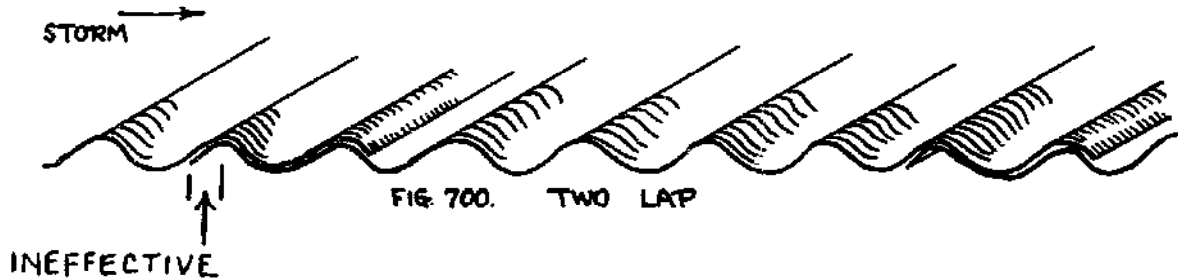


FIG. 698A.
Nail corrugated iron through top of corrugation and not in the valley.

Side lapping. Temporary shelters may have only a 1/2 corrugation, (1-1/2"), lap, the edge of the upper pan pointing downward. For some buildings, 1 lap, (3"), may be considered as sufficient. This leaves no margin for warped edges or faulty workmanship. For most buildings 1-1/2 laps, (4-1/2"), at least, will be required.



This saves 1-1/2" of metal per pan, or 5-1/2 % on the cost of the pans for the roof. We believe that 1-1/2 lap is as efficient weather protection as two laps because, in practice, the upturned edge



seems to hug the upper pan more closely than the whole corrugation in one or two lap joints. On the under pan, the last 1-1/2" is not effective in preventing drift or leakage. When the last 1/2 corrugation of a lot of pans is full size, the 1-1/2 lap is as effective as two laps. But when the last 1/2 corrugation is not full size, then two laps are required.



In one or two lap work, work toward the storm side, so that the lap gives protection, as indicated in Fig. 700.

In the 1-1/2 lap work, every other pan is right side up, so to speak, and every other is up side down. Admittedly the appearance of the pattern is not so common, but it is regular, uniform, and perfectly admissible.

The strongest arrangement for corrugated iron is a broken joint; in which one row of pans covers the joints of the row beneath.

FIG 704 ONE AND ONE HALF LAP

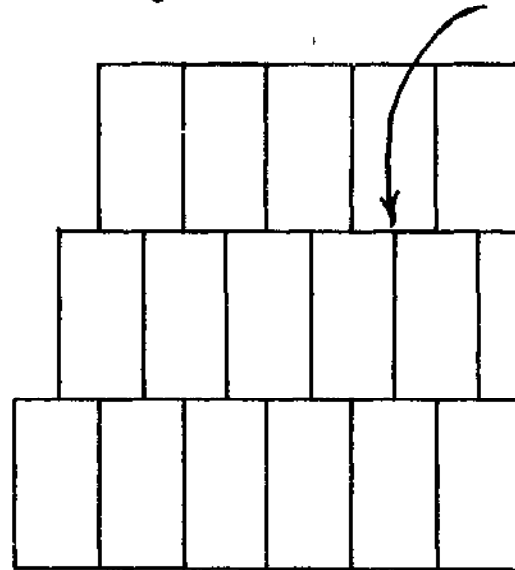
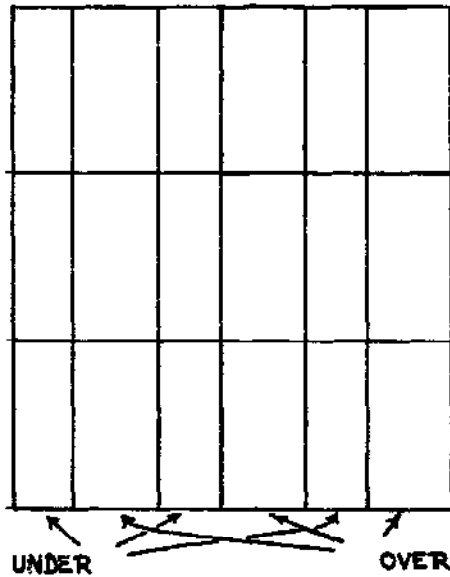
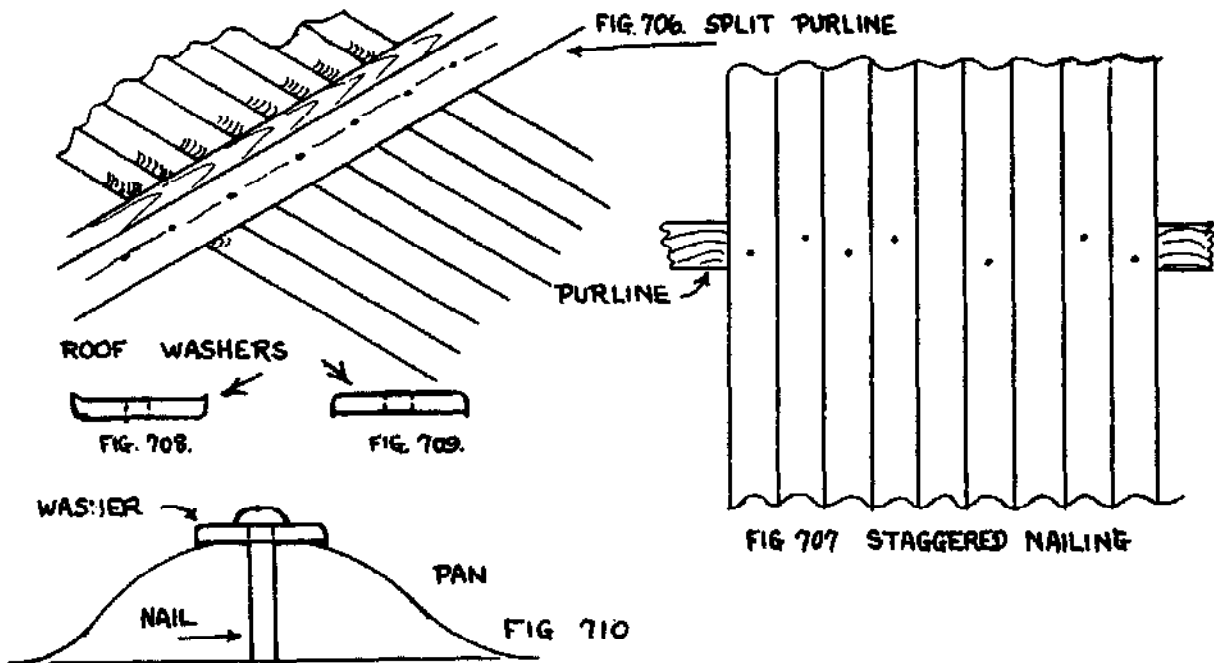


FIG 705 BROKEN JOINT LAY UP



Miscellaneous helps.

If using a line at the eave, sight it through and support it as often as may be necessary to make it effective. The eave gauge block may also be used with the line to keep a uniform overhang. See Fig. 697, 698.

Very often the line of nails is so straight that the purline is split. This may be avoided by staggering the line of nails as shown in Fig. 707.

Before putting a pan in place, the carpenter should make a mark to show him just where the purline is. The mark will have to be just beyond the place where the edge of the new pan will come.

Have one carpenter at each purline.

Let the labourers put all the nails in washers before the carpenters go up on the roof. There are two ways of placing the washer. The wrong way is to have the feather edges turned up; the right way is to have the edges turn down.

Labourers should be ready to hand a pan to the carpenter just as soon as he can take it. If 1-1/2 lap work is being done, take care that all pans with trade labels and other markings are turned the right way. Usually the markings are on the 'under' side. These pans will have to be the 'over' pans in 1-1/2 lap work.

The carpenters should have long, slim taper punches to start nail holes. Especially at joints, where the nail must pierce 4 thicknesses of pan, the punch is most profitable. A sharp light tap of the hammer, especially for light metal will help to prevent depressing the iron at nail holes.

If a nail has begun to bend, and should be pulled out, use a block as shown in Fig. 711. Grease or soap nails for hardwood.

The best weatherproofing of nail holes is done with the use of washers made of roofing paper, which take up the slack between the iron washer and the roof metal. Tar oozed out of some that were used. The washers are cut out of a sheet of roofing by the use of a sharp end on a piece of bicycle metal tubing.

Where there is need of hurry in placing the roof pans, and the bulk of the nailing done subsequently, drive one nail home in each pan. If the carpenter has difficulty in 'finding' the purline for nailing, make a 'purline finder'. See Fig. 713.

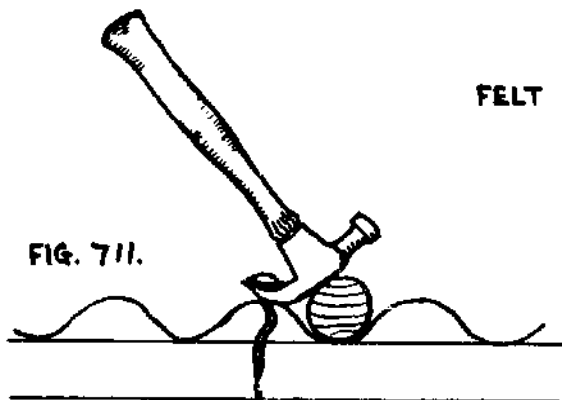


FIG. 711.

FELT WASHER

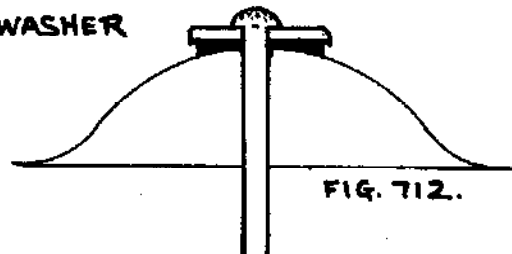
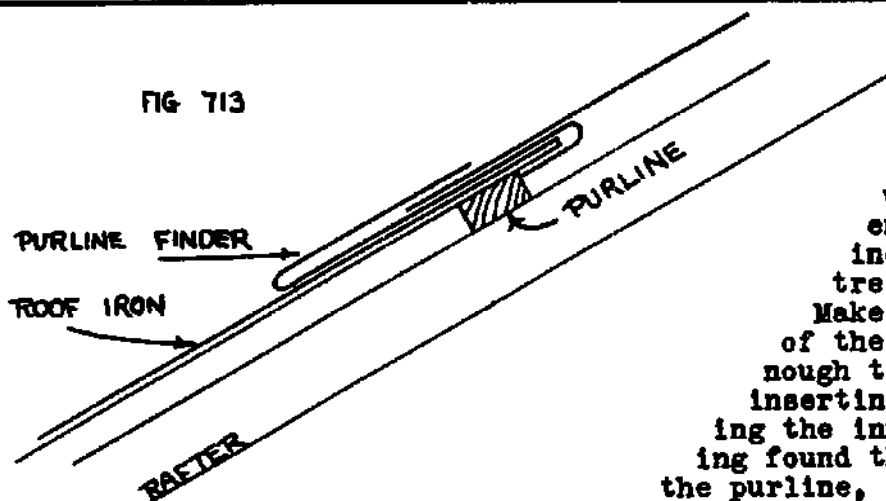


FIG. 712.

The felt washer should be slightly smaller in diameter than the metal washer. Use two ply felt.



Make the purline finder of bale iron, $\frac{3}{16}$ " thick, 1" to 1-1/2" wide. As shown, end on the roof indicates the centre of the purline. Make the outer part of the finder long enough to slide up for inserting and withdrawing the inner hook. Having found the centre of the purline, do not follow it; Nail each side of it to avoid splitting it down the middle.

When a horizontal row of pans reaches the hip rafter, stop. Leave all the triangular holes at the hip rafter for one job of cutting when all the whole pans have been put in place.

When the second row of ridge pans has been put in place, fold the projecting one over. We recommend that the roof be as weatherproof as possible. Hence, on the storm side of the ridge, the pans should be at least one full inch above the ridge line. Similarly, on the hip rafter, put the pans on the lee side first, the edges being cut to just beyond half way. When the storm side pans are cut, make them about two inches longer; the extra being a lap which can be hammered down after the nailing has been done. Fig. 714, 5.

Since the nailing along the hip rafter is covered, it may be in the valleys. This gives maximum strength. The nails should be roof nails, and with their washers. Terrific tropical storms put heavy stresses on roofs, and reasonable strengthening, like roof nails along the hip and at the ridge, is all to the good. The nails at the ridge may also be in the valleys of the corrugations.

The first nail in the pan at the ridge, for the purpose of holding it in position, should be a 1-1/2" nail in the valley. They are easy to carry, drive, and finally pull out or drive home.

When the carpenter at the eave purline has nailed his pan home, he should call for the next pan and have it ready to put in place as soon as the next man up the roof is through his nailing and can receive it. And so on up the roof. When the man at the ridge is ready, the whole crew will be ready for the adjustment of another row of pans. As in brickwork, speed in the unit means speed in the whole roof. Adopt a technique for each row of pans so that the men will know every move. Amongst other blessings, shouting will be reduced to a bearable minimum.

If a corrugation has been badly mangled through bending of, and pulling a nail, try to restore the original shape, and also insert a scrap of metal between the upper and lower pans to bring the area around the nail hole to normal as nearly as possible.

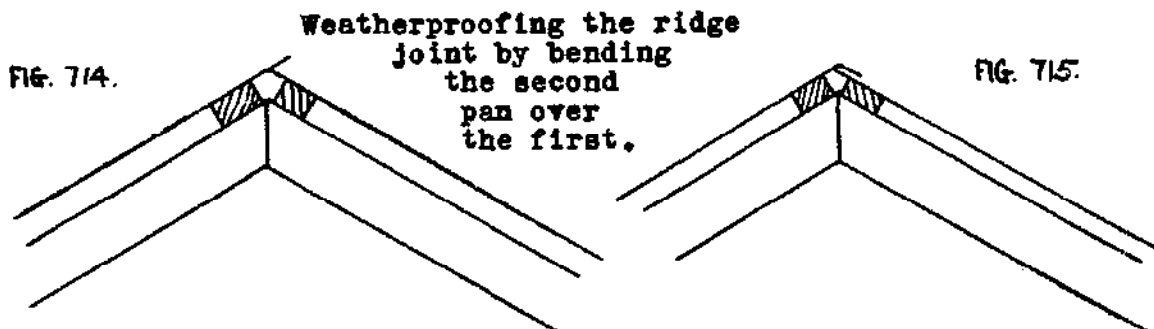
Corners. We recommend marking every pan before cutting it for a corner. And, sighting it before marking it. Here again, work out a system so that when the carpenter holds the pan to be marked he will be doing what you want: a proper side lap; proper end lap; mark half way on the hip rafter, each side of the pan, or, the pre-determined distance of lap beyond the pan already there. The pan is then passed down to the ground where you place a straight edge on the two marks, draw a line and cut.

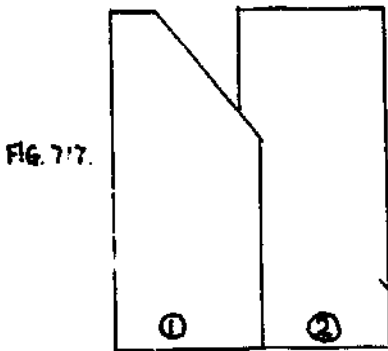
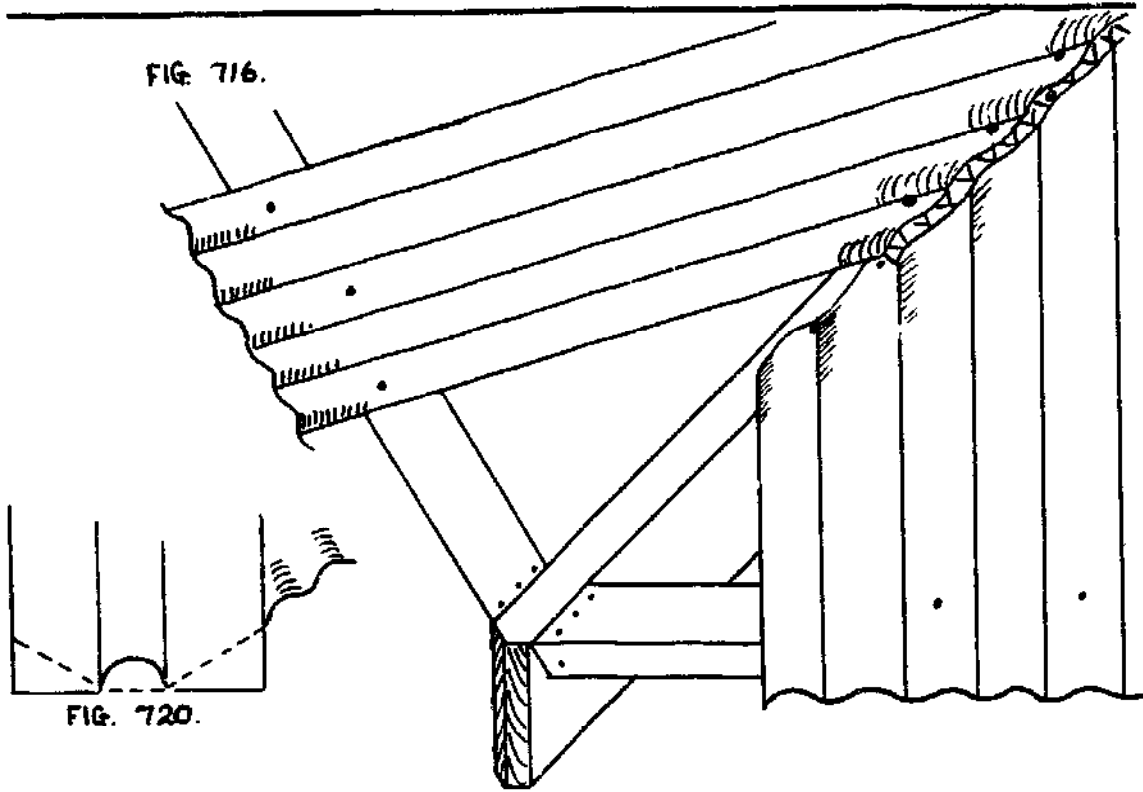
Before sending the first pan up the roof, make a mark on a second. When the first is found to be satisfactory, the second can be cut and before going up, another is marked from it. The second may be found to be a little off. In which case the third can be remarked. Do not cut until you are sure.

In nailing corner pans, the carpenter should hold the base, and the centre of the top edge. If alright, he nails the middle corrugation of the base. Then when the top is in position, he drives a 1-1/2" nail in a valley to hold it. If all is right, he may complete the nailing with roof nails in the valleys.

As the cutting job progresses, a stock of left over pans will accumulate. Classify them so that when an order comes down from the roof, you can tell in a moment whether a piece is ready for it, whether with a very little trimming one can be used, or whether a new pan has to be cut. Never cut a whole pan unless you have to. One person on the ground with a helper can look after several carpenters on the roof. When you get down to the last little triangle of a corner at the end of a row, and there is no piece just right for it, leave it a little. One may turn up. Be sure that before the corner is to have the ridging, every little corner is filled in. Let the roof be weatherproof without the ridging.

When a corner pan is cut, there is a sharp corner at the top. Nip it off. It may cause a flesh wound. When a pan is cut, it often has needle like slivers along the edge. This is caused by allowing the tin snips to move backward when they are being opened for another cut. To prevent slivers, push the snips forward as they open. If the blades begin to cut just where the first cut finished there will be no slivers. Handle all pans carefully. Especially when handing them to someone. Do not leave pans lying about where careless people will step on them and distort the pattern. All pan cuttings are useful. Keep them all. Be sure that in storm time no pans are left loosely nailed on the roof, nor left on the ground without being weighted down. A pan picked up by the wind can give a fatal wound. In some areas, it will be necessary to place all loose pans in a safe place every night.





At the base of the hip rafter, let the ridging roll come right to the eave line of the pans, the corners protruding. Bend them under, neatly, on the dotted line.

In Fig. 718, the piece is just too large for number two on the corner. Cut from the

bottom to make it right. Sometimes

the hip rafter

line is not

perfectly

straight. To

make a true

line with the

ridging, fasten the top end of the

top piece and the bottom end of

the bottom piece and sight the

others. Some will have to

be moved sideways, some

depressed, and others

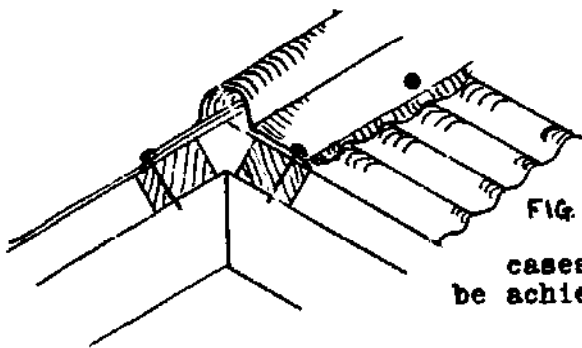
perhaps pulled up into

a sharper angle. In most

cases a straight looking hip rafter can

be achieved by manipulation of the ridging.

FIG. 718.



II. GRASS COVERINGS.

To lessen the heat of iron roofs, grass covering is sometimes put on. Before doing this, make sure that all other helps to coolness in the house have been taken advantage of. Ventilators near the floor and near the ceiling; a well ventilated space under the roof; verandah ceilings at vital spots; proper arrangements of shutters during the day; roof paint to refract light and heat; trees; proper insulation of all ceilings in the house proper; There is one special drawback to the grass cover and that is the contamination of any water supply from the roof.

But if the covering is to be put on, determine that no nails will be driven in the iron roof. Whatever the framework for the grass, wire the up and down pieces at the top to support them and at the bottom a wire can be led around to the purline, to prevent the wind lifting the grass and frame. The most effective grass cover will be as far from the roof as is practicable, and as thick as you can afford.

CHAPTER TEN.**CEILINGS.**

With a strong roof frame, the cost of ceilings can be greatly reduced by using very light ceiling joists and tying them up to the roof. The cost is further reduced because, being above the ceiling covering, they are unseen and are left rough. Also, they can be made up of two pieces whereas if they were seen, one long piece would seem to be required.

Whatever the nature of covering, 2" X 2" joists, or 2" X 3" at the most are satisfactory.

Ceiling joists are invariably put across the narrowest dimension of a room so that the corrugations and/or long joints of the ceiling surface run long ways with the room.

I. BUILDING BOARD CEILINGS.

In main rooms endeavour to make a balanced lay out. Herewith a suggestion.

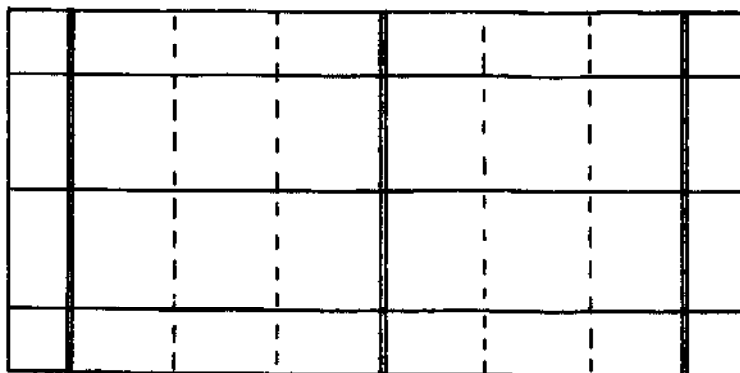


FIG. 721.

When sheets of building board do not fit evenly in a ceiling, put one or more in the centre and divide the remainder of the space for margins. All the cross lines are joists, but no joints will show where the dotted lines are. A 2" X 4" can be run from end to end down the centre and all the joists tied to it. The 2" X 4" is tied to the roof.

II. CORRUGATED IRON CEILINGS.

These do not have the domestic appearance of some other types of ceiling covering. But for cleanliness, durability, insulation, and quiet, they excel. They do not warp or shrink, no dust filters through, they harbour the least, if any, vermin, are more or less indestructible and fireproof, carry insulating earth, are not affected by spray or leaks from the roof and prevent them from getting below, and, being earth covered prevent the noise made by lizards and rodents from disturbing occupants of the house.

Other types of ceilings have one or more of the nuisances avoided when iron ceilings are used.

Iron as light as 36 gauge has been used effectively. The joists of 2" X 2" material are spaced at 2' centres and supported by box iron from the roof or a roof supported beam. These ceilings can be made in sections on the floor and raised to their place in the ceiling with the minimum of trouble and scaffold.

Ceiling iron is always laid with the side edge turned up.

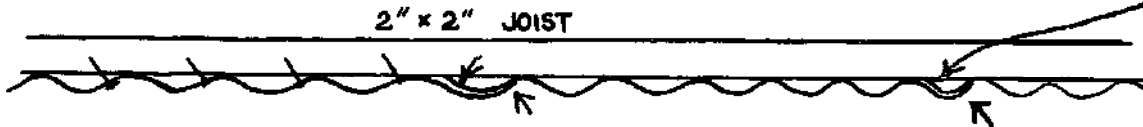
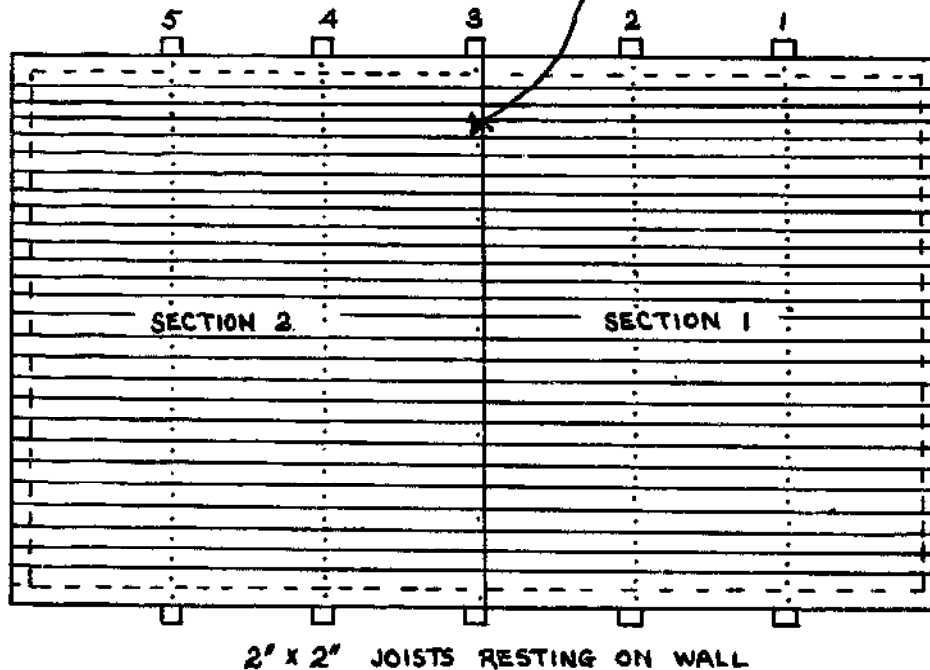


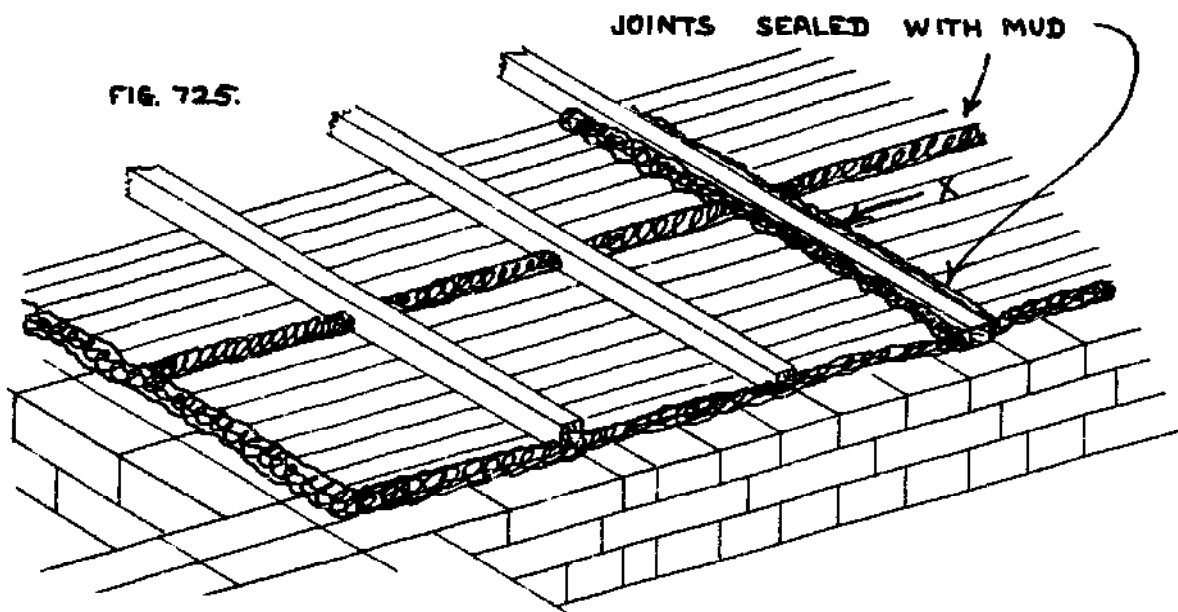
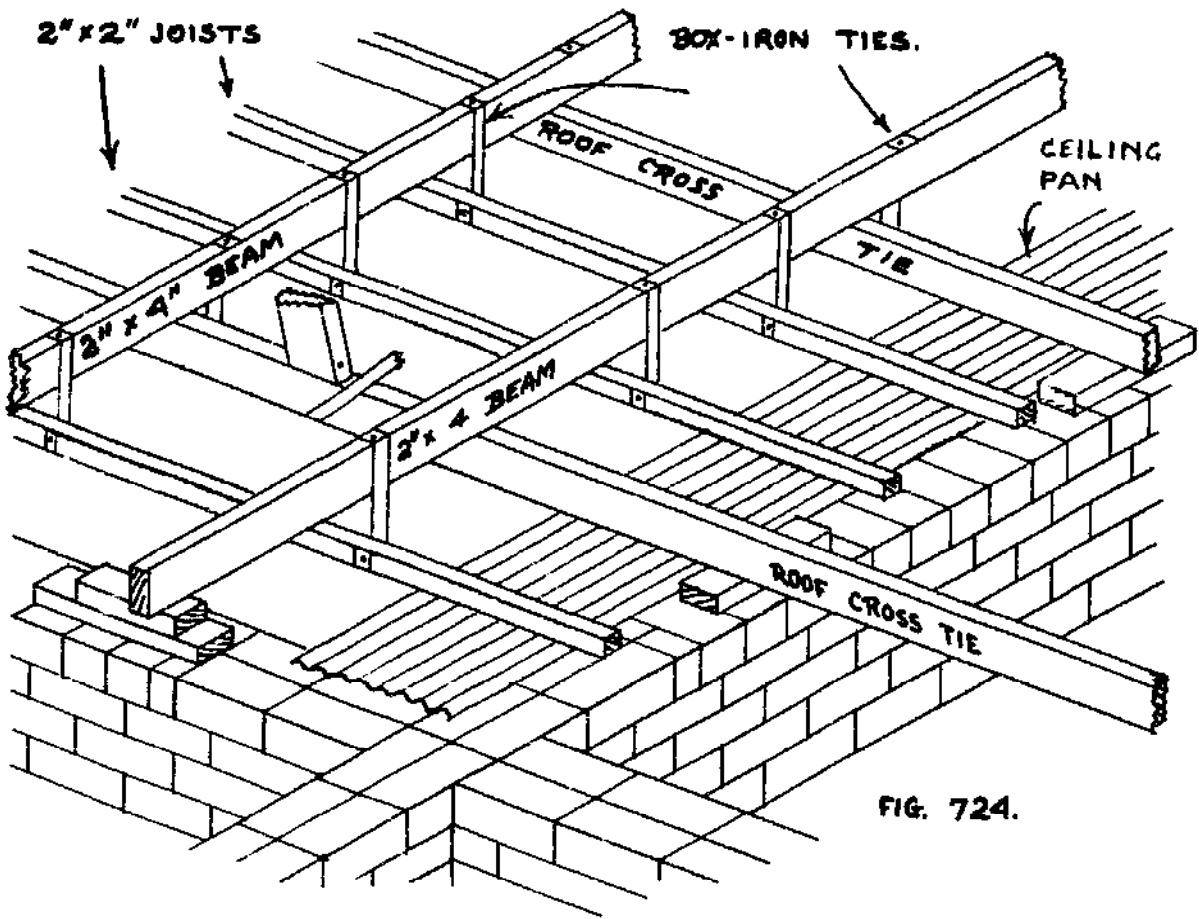
FIG. 722.

On the ground, do not nail pans home on this line, just tack them.

FIG. 723.



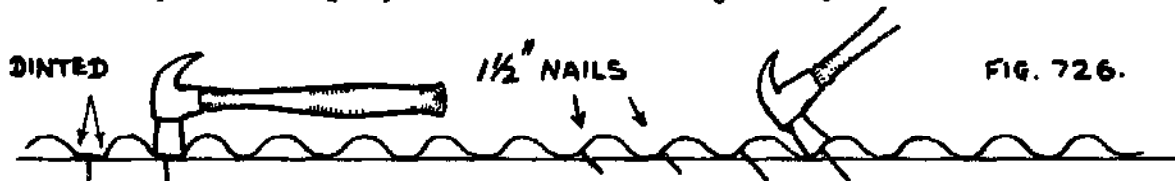
2" X 2" JOISTS RESTING ON WALL



Making the ceiling on the ground. Usually the sections will be made outside the house so that they can be fitted together as one ceiling before any one section is erected.

The 2" X 2" joists should have 3" bearing at each end. In Fig. 723 the dotted line represents the inner edge of the wall on which the ceiling rests. Otherwise the illustration shows what two sections look like on the ground, ready for erection.

Joists 1, 2, 3, are laid out as shown and the iron nailed to them. Drive the nails through the slope of the corrugation so that the hammer in giving the final blows will not mar the iron. Drive the nail until it just pinches the iron. Use 1-1/2" nails. Arrange your ceiling lay out so that the light will not strike the open part of the joint; and so that a person standing in the front entrance, for example, will not see the joints.



To get a good ceiling job, make the pans parallel when you place them by measuring from the centre of the crown in one pan to the centre of the corresponding crown in the next pan. Pans out of parallel will show up against the wall plaster line.



FIG. 727. FROM FRONT DOOR JOINT IS INVISIBLE.



FIG 728. END JOINT.

On joist 3 bring the end of the pan to the edge of the joist. When section 1 is complete, set out joists 4, 5, and start the pans. There is a 2" end lap on section 1 but be careful not to nail this home; just tack it to hold it in place until the section is complete. The carpenters must not kneel or in any other way rest on the ceiling iron. If they cannot reach their nailing properly, place a pan of heavier gauge on the ceiling pans and rest on it.

When all the sections are complete erect section 1, then two and so on. Move them about up top until, having proper bearing on all walls, proper end lap etc., they are also lined up with the wall surfaces.

To nail the end lap more easily, have a labourer up top with a block or heavy hammer to hold over the joist where you are nailing.

When the entire ceiling has been hooked up, arrange beams over the main rooms especially, to which the short box iron ties can be fastened. Then prop up the ceiling in the middle until it is about two inches higher than at the walls. The top of the prop should be rounded so that it will not mar the ceiling iron. The prop should be raised with a lever and blocked up while an iron tie secures the joist in its final position. The ceiling should curve almost imperceptibly from this middle point to the four walls. Always place the prop directly under a joist. Leave the prop under

this central place and use another prop for the second nearby lift, otherwise the box iron tie might have too great a load. Tie up the entire ceiling. When it has a perfect appearance from underneath, seal all the joints with brown paper covered with mud ridges to prevent dust sifting down into the room below. See Fig. 725.

When completed, including the end joints, see 'X' in the same figure, fill all these little compartments with 2" of earth. Some persons prefer mud insulation, contending that it is cleaner. We have never known it to be lifted by wind, and it has this feature that it is not as good an insulator as loose earth.

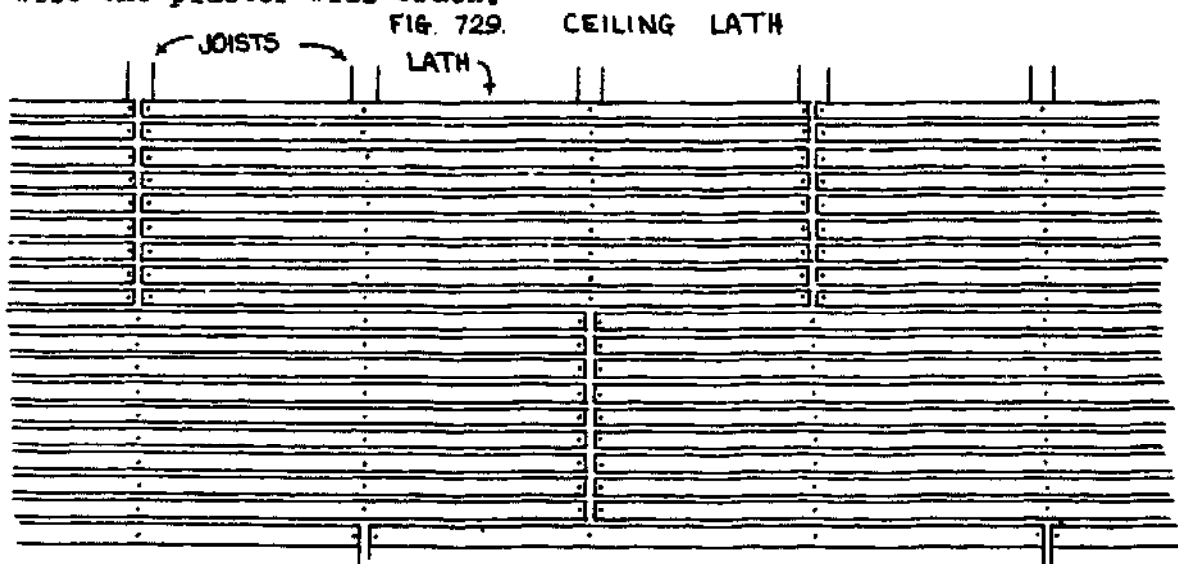
It is possible that ceiling sections cannot be manoeuvred into place in some small rooms, from underneath. This has to be studied out before the roof frame is complete, otherwise the ceiling pans will have to be nailed from underneath to joists already in place. This is a strenuous job and should be avoided.

Some building superintendents prefer to have the ceiling sections put up before the roof frame is erected. We cannot recommend this method because workmen erecting the roof invariably step on the ceiling iron, drop wood and tools on it, and it does impede transfer of materials and passage of men who are working on the roof.

III. PLASTER CEILINGS.

We recommend their use if the materials necessary to their proper construction are available. True, plaster is not quite so indestructible as iron, but it has very many good features.

To avoid movement which would result in cracks, it may be well to use 2" X 3" joists and at 2' centres. The lath should be about 1-1/4" wide and 5/8" thick. 1" wide lath is perfectly alright and may be made more handily if cut from 1" boards. When using wood lath, end joints must not be in line for over two feet, otherwise the plaster will crack.



When the joists with lath attached have been adequately tied up with metal supports, place a labourer up top for every mason below. Both men will be supplied with plaster; the labourer places large lumps of the plaster on the lath and presses it down through the cracks while the mason spreads it underneath. The mason will need to take some of his own plaster and form a suitable thickness to serve as a base for the final coat.

The plaster should be of the very best clay and sand mixture, previously tested for strength, cracking, etc. Mixed with it there must be ample quantities of hair, or shredded vine, hemp, sisal or similar fine strands to make the plaster cohere.

When this first coat of plaster is at just the right point in setting, score it with small rake with nail points, to form a key for the second and final coat. You will find that the first coat must be fairly tacky and not be applied too thick. But it must be even on the surface, so that the second coat will not vary appreciably in thickness. The second coat should be as thin as possible and only applied when the first coat is perfectly dry. It should not be necessary to warn that the greatest care must be exercised by any persons employed up top to avoid stepping on or otherwise touching the plastered ceiling. If the plastered ceiling does not give adequate insulation from roof heat, spread an inch or two of loose earth upon it.

The plaster ceiling does not need to be raised as much as 2" in the centre, but a little above level will be acceptable. The amount of lift or camber is proportionate to the size of the room.

Expanded metal lath might be secured which would be more economical than wood lath. It is more difficult to plaster on, but with thicker mud and a little experimenting it will be found satisfactory. It is easily shaped and for main rooms, a cove is quite admissible, adds practically no expense, and when finished gives a cozy and finished appearance to the room.

If staples are not available, use 1-1/2" nails to fasten the metal lath to the joists. Drive the nail in about 2/3 the way and bend the head over the lath.

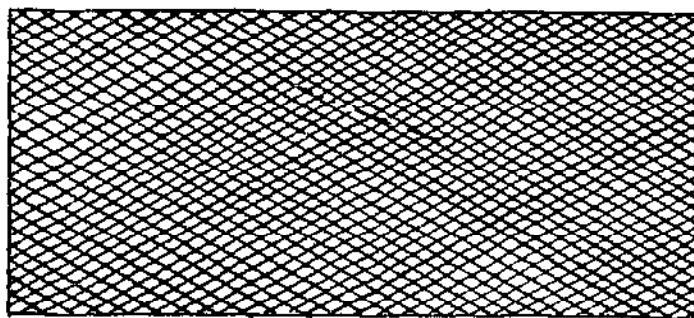
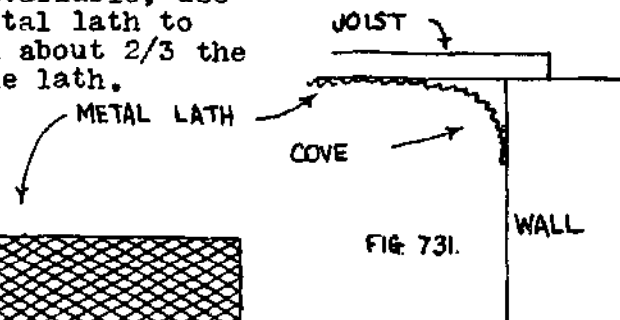


FIG. 730.



A perfect lock or key is provided ceiling plaster when it is applied from both sides.

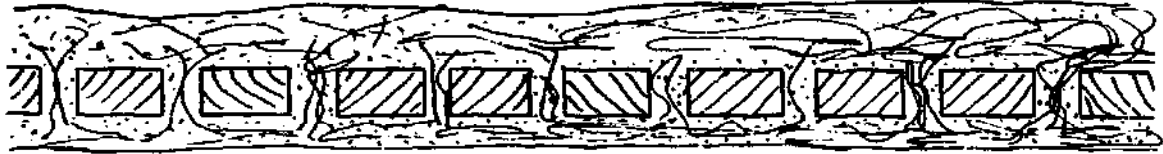


FIG. 732.

MUD CEILING ↗

CHAPTER ELEVEN DOOR AND WINDOW HANGING.

If the hinge jamb of a door or window is not plumb both ways, the fixture will not hang properly. A door or window should remain in any position without the aid of a stay. And not because of rusty hinges either.

If the jamb leans toward the door, cut the hinge check more deeply into the jamb at the top and more deeply into the door at the bottom. Similarly, if the jamb overhangs into the room, set the hinge well back into the jamb at the top and well out at the bottom.

In the accompanying illustration, the dotted line represents the pivotal point; in hanging any fixture, endeavour to have this line coincide in all hinges. Then there will be no binding due to bad alignment.

We know that the custom is to check both the jamb and the door

equally, to 'house' (pronounced houze) the flange of the hinge. We do not practice this. First because the work on the jamb tends to loosen it in the mud brick wall; second because so often adjustments have to be made; third because sometimes a door is taken away and the check has to be filled; and fourth because it is cheaper to cut just one check. It may be added that because in the tropics there is so much expansion and contraction that a greater allowance is made between door and jamb, and there is not the need to house the hinge in the jamb that there is where snug fits are permissible.

When checks for hinges are not at the right angle, for one reason or another, loosen the hinge and pack it on one side or the other with cardboard until the desired results are achieved. When doors bind on the hinge jamb, a little cardboard inserted at the

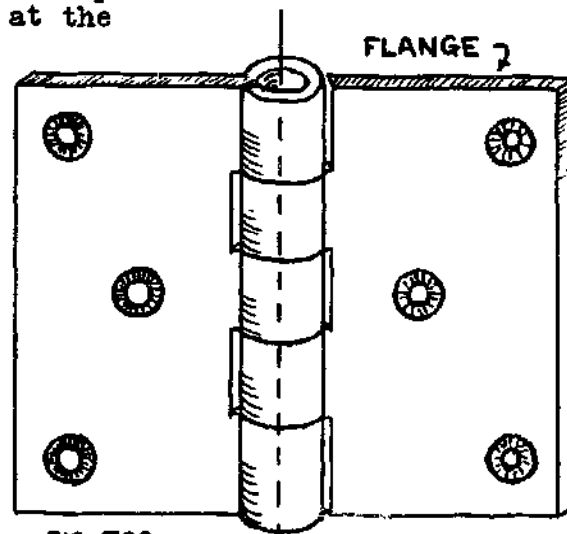


FIG. 733.

face edge of the hinge will often relieve the condition. Loosen the screws a little, push in a strip of cardboard about 1/2" wide and the length of the hinge. Tighten the screws. This will force the hinge and the door away from the jamb at the pivot point.

Conversely, when the door binds on the lock jamb, and a little adjustment can be made without having the door bind on the hinge side, loosen the screws sufficiently to insert a piece of cardboard at the back edge of the hinge so that the pivot point will be drawn away from the lock side of the door. If cardboard will not relieve the situation enough, or at all, you will have to remove the door and trim it, and/or alter the check in the door or the jamb.

Window fasteners.

The Mission Window requires a special fastener.

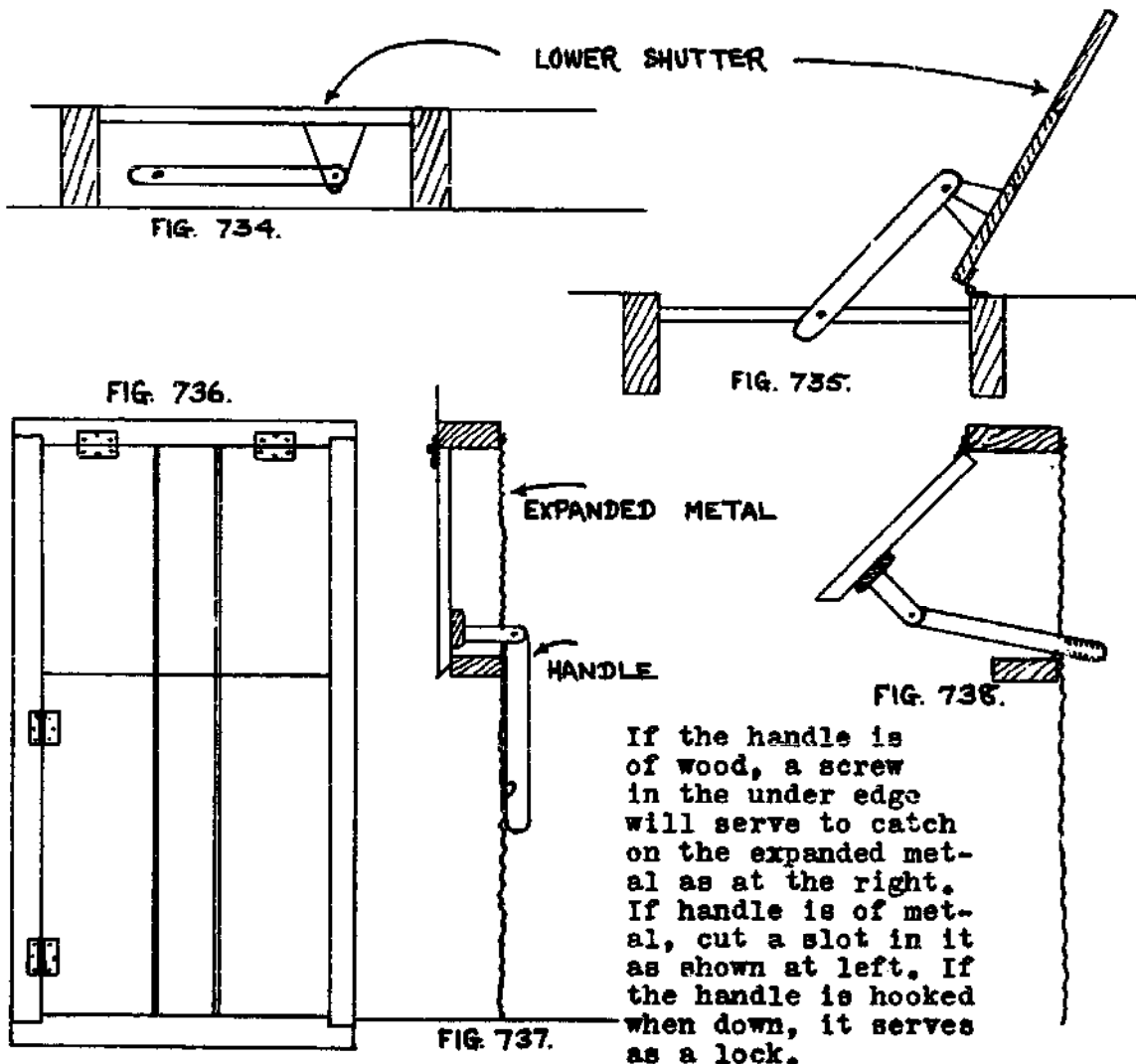


FIG. 740. SAFETY STRIKE PLATE.

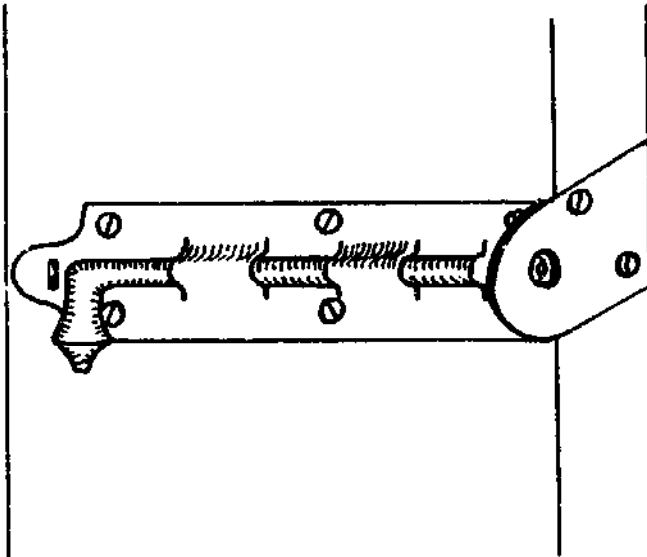
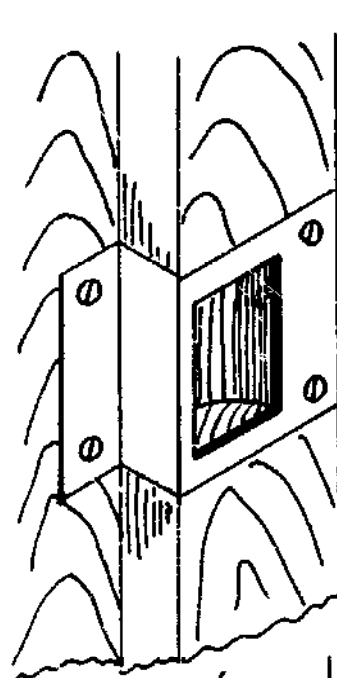


FIG. 739. BARREL BOLT AND PLATE

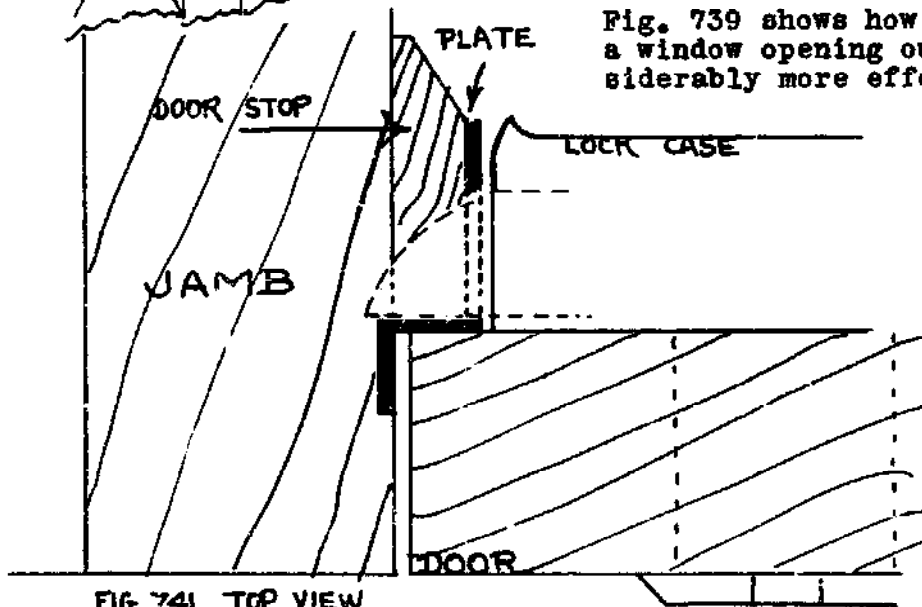


FIG. 741. TOP VIEW

Fig. 739 shows how a window bolt on a window opening out can be made considerably more effective than if held by the two small screws near the edge.

Fig. 740 and 741 show how to fasten a night latch to a door opening outward to prevent as far as possible tampering with the catch. The metal strike plate should not be less than $1/16$ " thick, and should be let in to the jamb and

to the edge and side of the door stop. To make the job complete, put a metal strap over the box and with heavy screws fasten the iron to the door. This will greatly increase the natural strength of the lock if the door is being pried.

If the night latch is on a door opening inwards, the metal strap should be over the strike plate box fastened to the jamb. The door stop opposite the night latch should be reinforced with metal and well fastened to the jamb to hinder tampering with the latch.

An effective, made-at-home, padlock holder plate. The metal should be about two inches wide and $1/16$ " or $3/32$ " thick. Make two identical plates like the one shown on the door. Let each one in to the wood so that its outer surface will be flush with the surface of the wood. One is fastened to the door and one to the door jamb.

Have two keys at least for every lock. If you lose a key, change the lock. You may be able to trade with someone else, unknown of course to anyone who might have your lost key. The cylinders of night latches can be changed when a key for that type of lock is lost. Use night latches wherever possible. They discourage burglary. Unless of course the directions given above are ignored, and the catch of the lock is visible; in which case, it invites predatory characters.

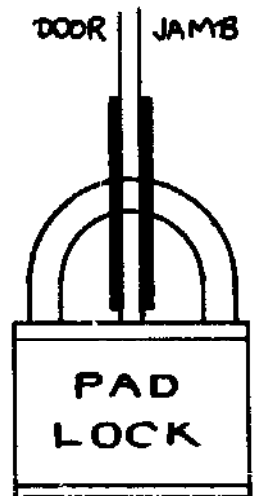


FIG. 743.

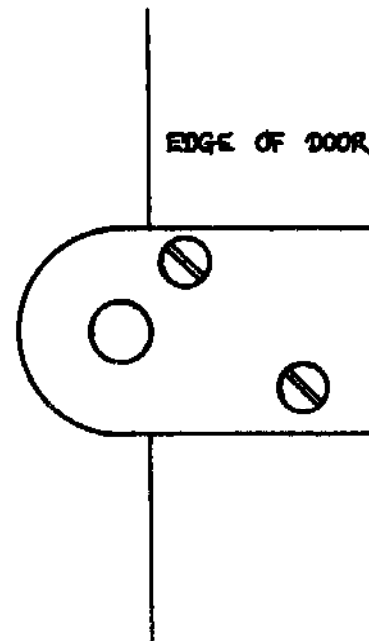


FIG. 742.

CHAPTER TWELVE STEPS AND STAIRS

Human muscles and nerves used in step climbing, or descending, are remarkably swift in becoming adjusted to the height of a set of steps to which they are complete strangers. This accounts for some serious accidents in which one or more steps of a flight are a different height from the starters; The slight variation causes a stumble, which might develop into a serious fall. In other words, the person mounting your steps unconsciously trusts that the designer has made each step equal in height. Also, if at all possible, make step heights uniform in flights which are more or less continuous or are near to each other.

If possible, approximate a step with a six inch rise and a twelve inch tread. This can be obtained, invariably, when leading from a verandah or porch to the grade level.

How to lay out a simple set of steps or stairs. Measure the exact distance from the lower level to the upper level. More often than not it will be difficult to divide this equally by mathematics. So measure it off on a smooth 12" board. Set a pair of dividers at the desired height of each step and mark off from one end with the dividers to find how many steps there will be. Probably,

the distance being measured will not come out even. If you wish to increase the height of the step widen the points of the dividers a little and work over the measured distance until you get it divided equally.

The number of treads is one less than the number of risers. If there is no set point for the flight, you may choose the width of your tread. But if the space is limited, then you must divide the 'go' or horizontal distance by the number of treads.

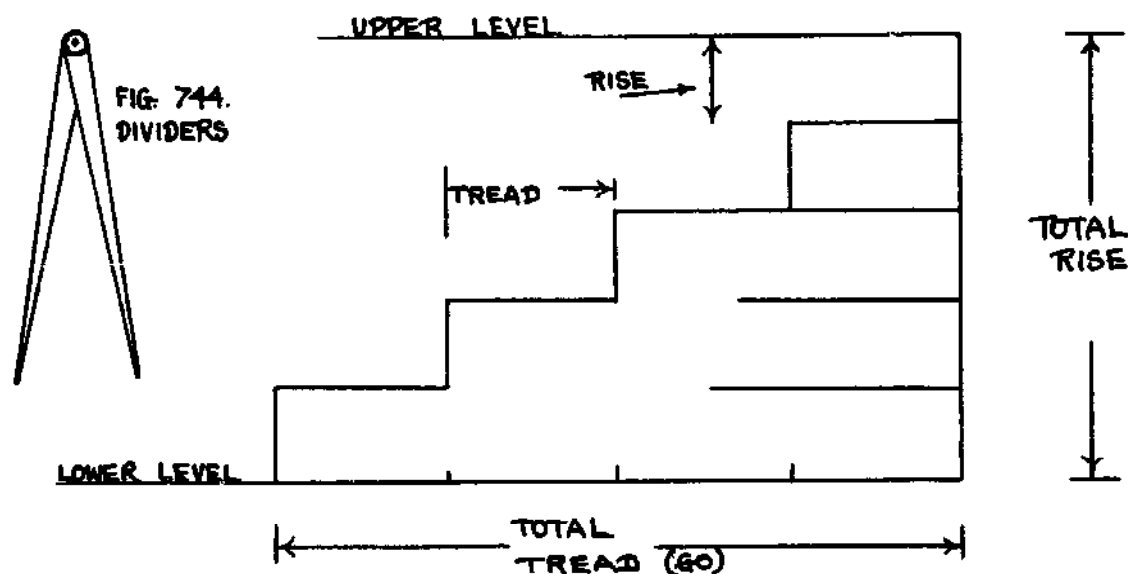


FIG. 745.

If the number of risers you have marked out conflicts with the width of treads you want, calculate the combination of riser and tread you want as in the following example:

If the rise is 10' 9-3/4" and the go 14'6" what are the practical combinations of risers and treads we may choose from?

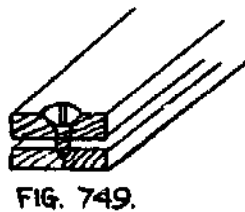
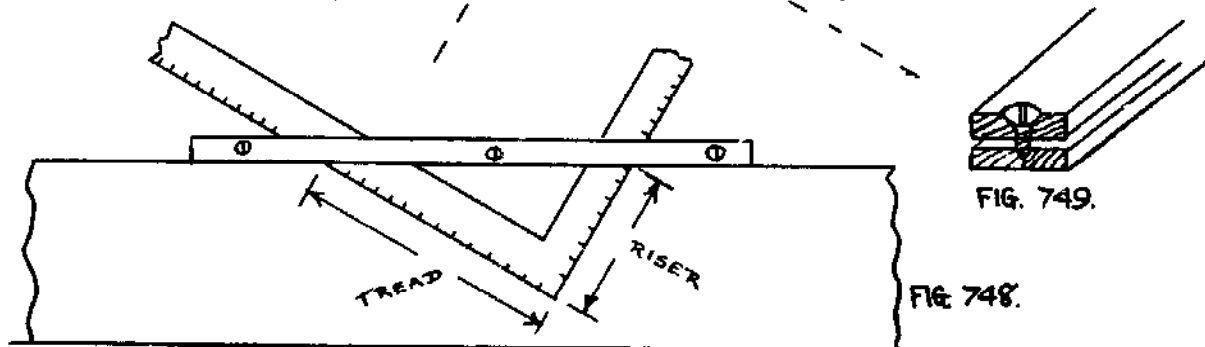
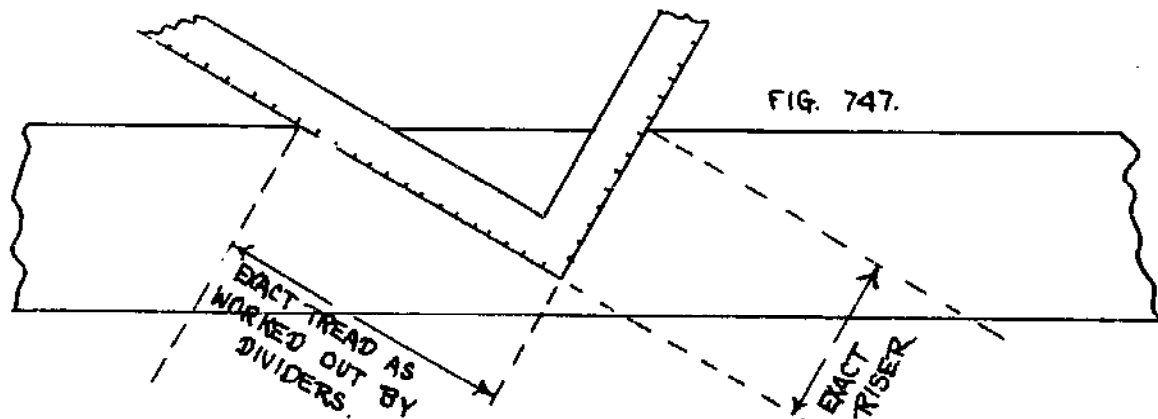
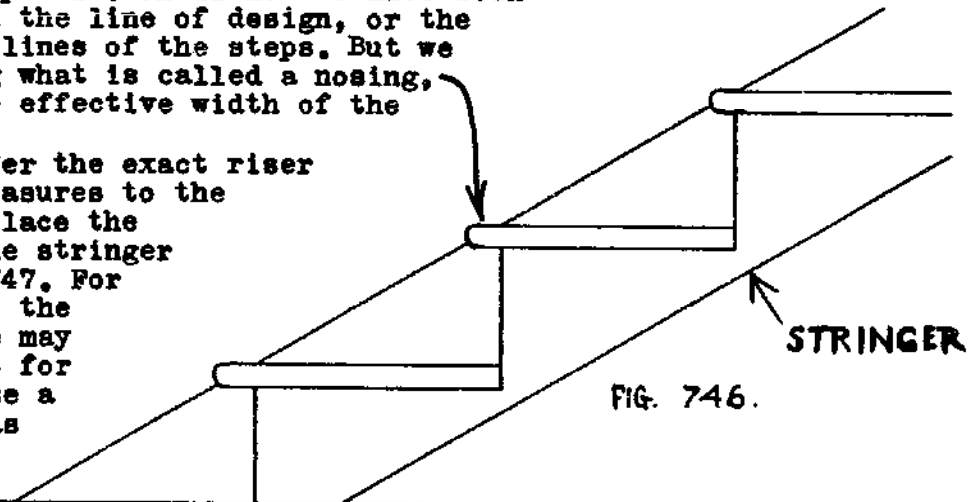
- Combination (a). Choose a riser of 6". The number in 10'9" is about 21-1/2. This means 20-1/2 treads and by dividing 14'6" by this number we get 8 (inches) approximately. This seems a little short for a tread, and 6" is a little low when there is not much room. So we will try again.
- Combination (b). This time we will choose an 8" riser. By the same process as above we get 16 risers, and 15 treads at approx. 11" each. This time we have an extravagant tread and a steep riser, so we will try a
- Combination (c). middle course and choose 7" for our rise. This time we get 18-1/2 risers and 17-1/2 treads which work out to about 9-1/2" or better. This seems the most practicable set of figures and so we work them out

more closely. Since we cannot have $18\frac{1}{2}$ steps we divide the rise, $10'9\frac{3}{4}"$ by 18 and get $7\frac{3}{16}"$ approximately; and by dividing the $14'6"$ go by 17 we arrive at $10\frac{3}{16}"$, approx.

Using these figures we again take the dividers and discover the exact working distance for risers and treads.

Before going further we will see that a tread of $10\frac{3}{16}"$ is very acceptable. Until now we have been working with the line of design, or the theoretical lines of the steps. But we may, by using what is called a nosing, increase the effective width of the tread.

Transfer the exact riser and tread measures to the square and place the square on the stringer as in Fig. 747. For a few steps, the square alone may be used, but for a number, use a wood guide as shown in Fig. 748, 749.



With the square, mark out the required number of steps. From these marks lay out for the actual tread, and for the cuts at the top and bottom of the stringer. The marks must not be altered for the one is always the top of the tread and the other is always the face of the riser, regardless of whether there are riser boards, nosings on the treads, and regardless of the thickness of the materials used.

If you wish to set the steps back from the edge of the stringer, measure from the angle at the back of the step to the back edge of the stringer. Then make a line parallel to the front edge of the stringer and as far from it as the angle was from the back. Set the square on this line and then attach the guide.

FIG. 750. STEPS OUT TO EDGE

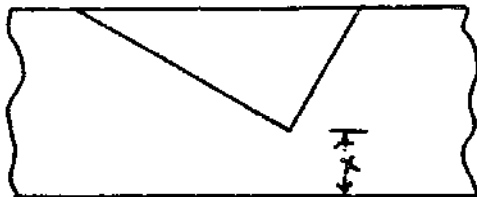


FIG. 751. STEPS BACK

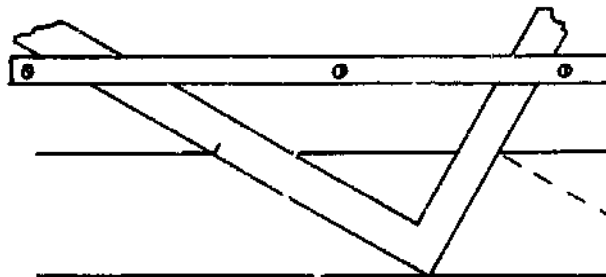
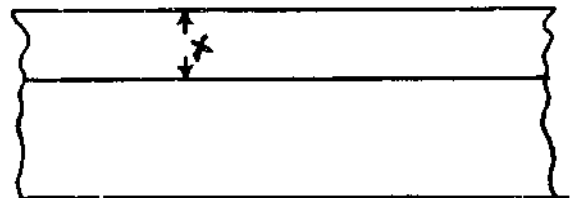


FIG. 752. STEPS BACK

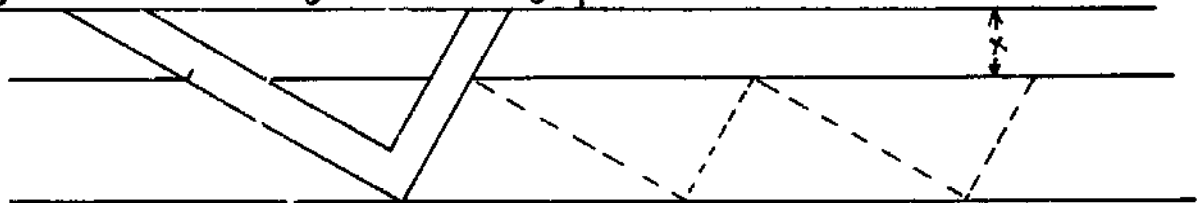


FIG. 753. FULLY HOUSED STRINGER

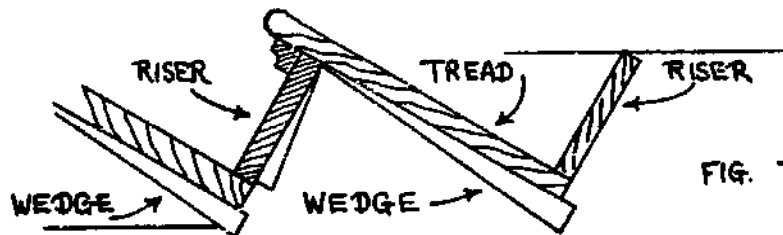
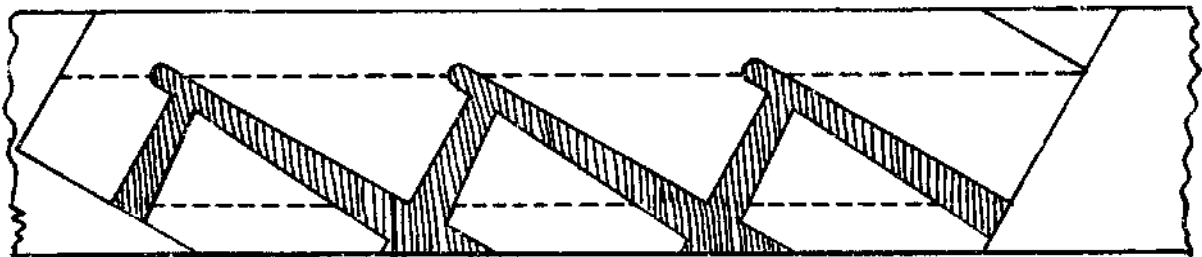
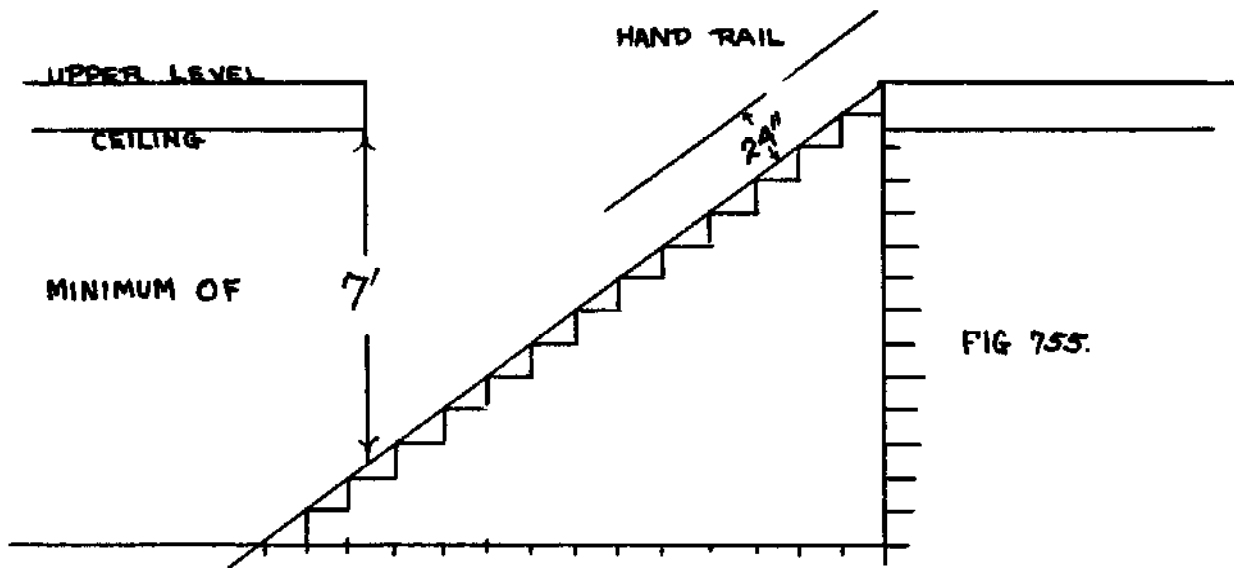


FIG. 754.

To make a housed stringer for a finished job, mark and cut out as in Fig. 753. Make the rabbett at least $5/8$ " deep, $3/4$ " is better, safer.

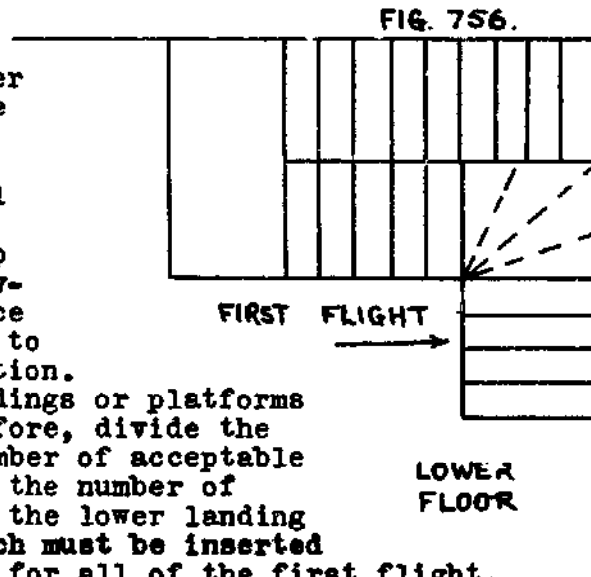
If there is a top riser it is fitted into its place first. Then the first or top tread is pushed into its place and wedged up as shown. Then the second riser goes into place and wedged. Make sure that the stringers will not be able to spread either during fitting of treads and risers nor at any subsequent time.

If there is a stair well with limited boundaries, the angle of the stair must be conformed to it.



Draw a 7' line from the lower corner as shown. Draw a line from the upper point of the stair line to the bottom of the 7' line and extend until it meets the floor line. Join this point with the top point of the stair line. Divide off the vertical distance and the horizontal distance to determine your step combination.

In Fig. 756 the landings or platforms are treated as steps. As before, divide the total rise into an equal number of acceptable risers; this will determine the number of treads. The dotted lines on the lower landing indicate 'winder' steps which must be inserted if there is not enough room for all of the first flight.



CHAPTER THIRTEEN FURNITURE AND EQUIPMENT

There are plenty of books and booklets dealing with furniture of the conventional type. We will deal only with special problems met by the missionary.

We have no confidence in glue to hold anything together in the tropics. We use it, but do not depend upon it for holding a rail to a post. Wherever possible we use sheet metal to hold rails to posts in chairs and tables and cupboards.

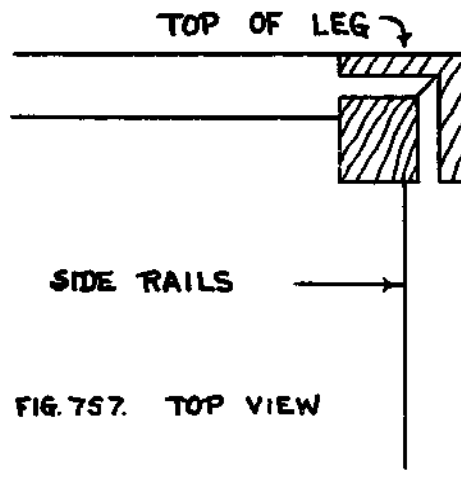


FIG. 757. TOP VIEW

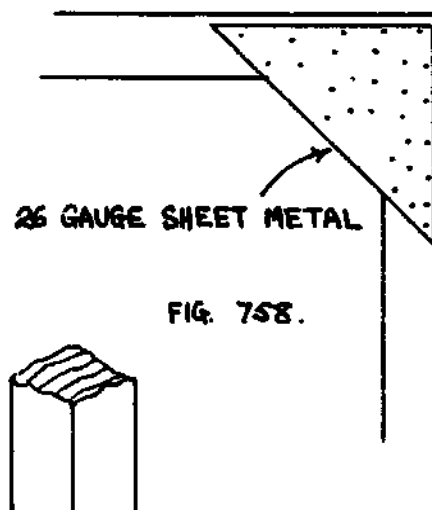


FIG. 758.

Two shoulder tenons are better than those with only one. Clamp the two posts and one rail tightly and pin the tenon from the back of the post as shown. When the entire framework is fastened together like this, apply the sheet metal plates top and bottom as shown. For both of them, the best job requires that a little chamfer or even rabbeting be done to house the metal. This is particularly necessary on the top side

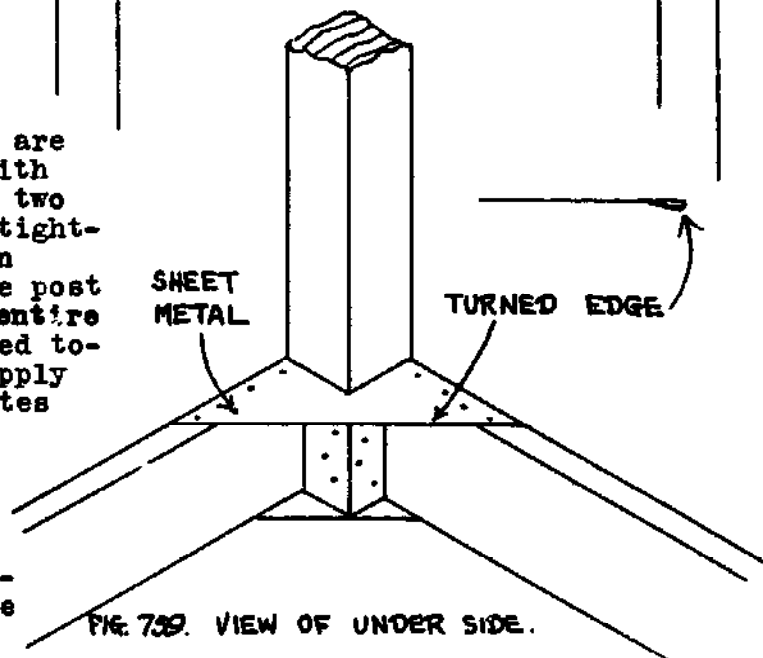


FIG. 759. VIEW OF UNDER SIDE.

where the thickness of the metal, and perhaps of the nail heads would make the table top 'ride'. We repeat, if you can hold the shoulders of a tenon against a post, nothing but the worst abuse, including accidents, will ever cause the joint to come apart.

Since we have to make our own tables we may as well do away with the unsightly and most inconvenient corner legs of dining tables, whether of the small one-family size or the larger ones necessary where there is a large staff.

The smaller table may be square or round. The construction is practically the same. This top is about four feet in diameter and will require at least four battens to keep it in shape. The two cross bars fastened to the top of the pedestal, Fig. 762, should be long enough to support the two outer battens. Before the

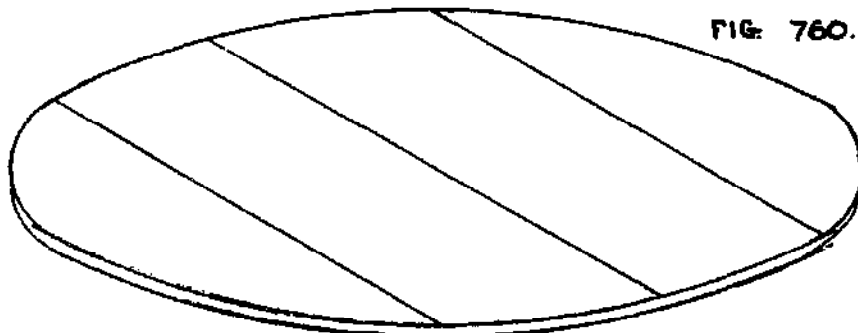


FIG. 760.

pedestal is finally fastened together, the bolt for anchoring it to the base should be put in a block and the block thoroughly secured to one of the sides which is parallel to the cross bars. The base may be made of 2" X 8" material and be given the plain round finish shown here, or moulded somewhat. Note in Fig. 763 that a strap of metal reinforces the under side of the base piece which has been halved. The spread of the base as shown here may not in a particular case be sufficient. If so, enlarge it.

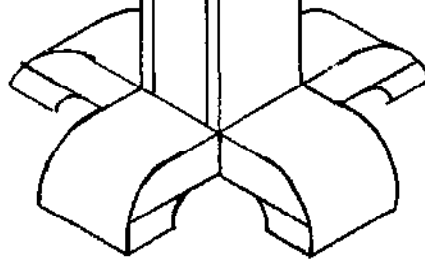


FIG. 761.

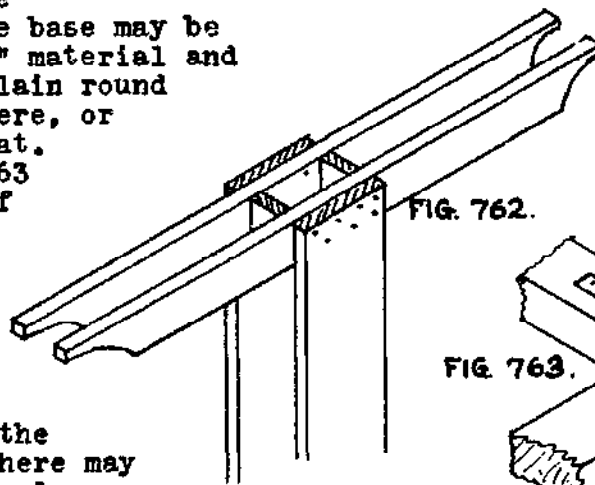
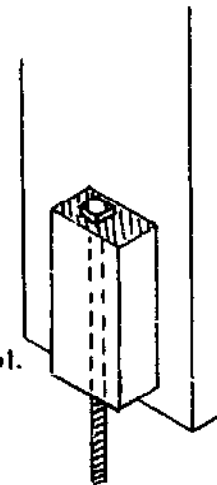


FIG. 762.

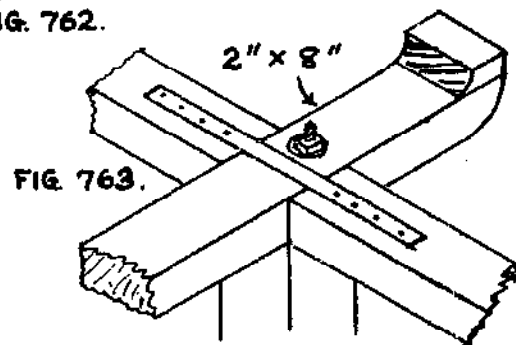


FIG. 763.

Long dining table with pedestal support.
 Note in Fig. 765 that the
 long bar has a shoulder
 against the leg.
 If this proves
 inadequate

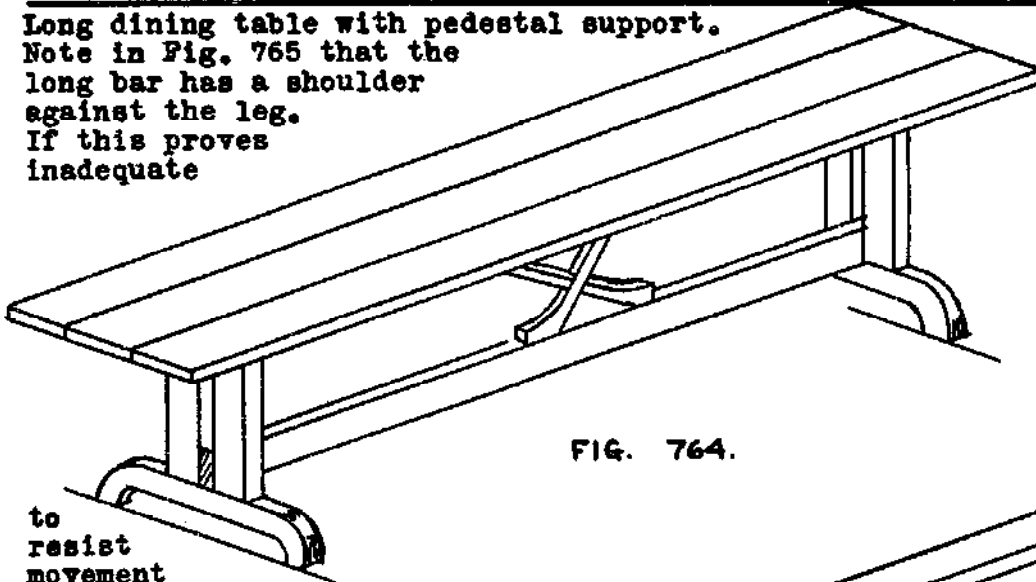


FIG. 764.

to
 resist
 movement
 of the table,
 brace it. One
 suggestion is
 the cross shown
 in Fig. 764.

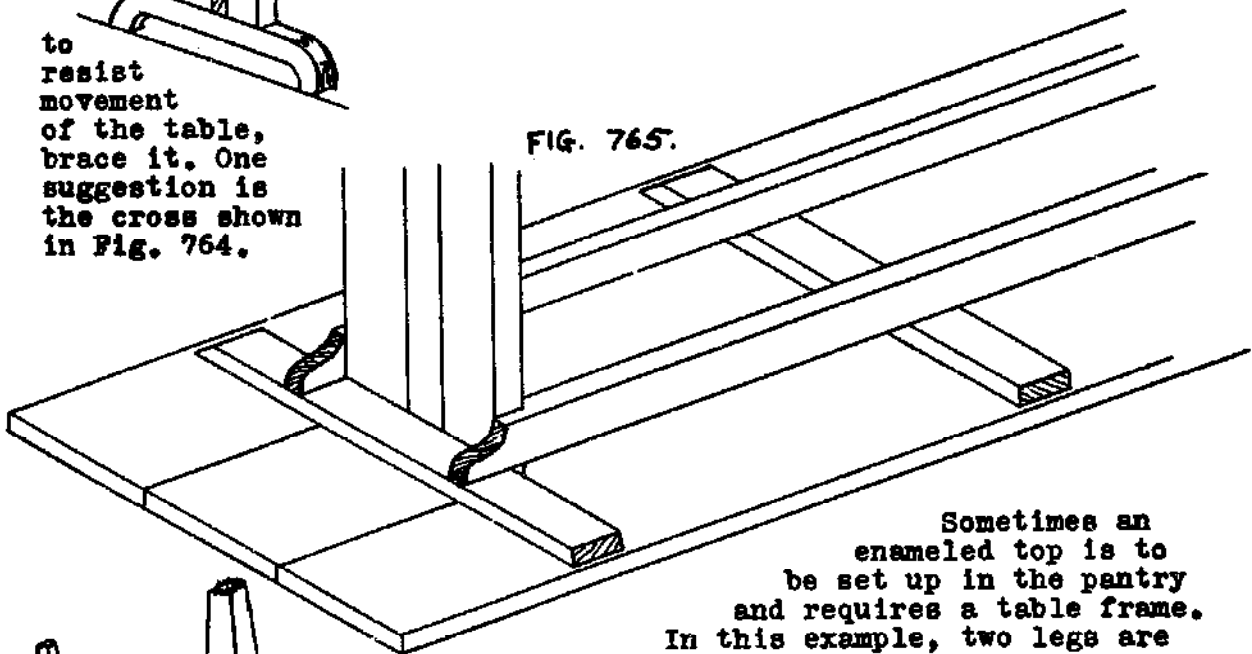


FIG. 765.

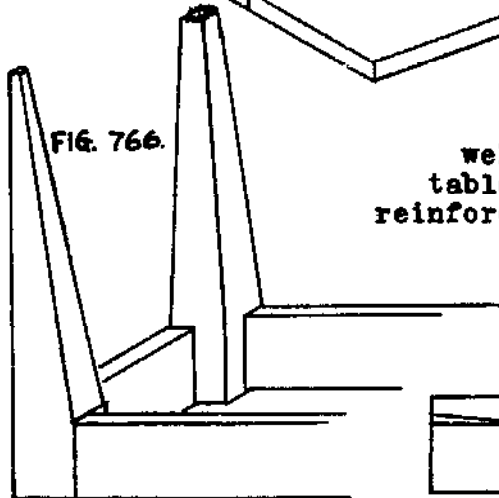


FIG. 766.

Sometimes an
 enameled top is to
 be set up in the pantry
 and requires a table frame.
 In this example, two legs are
 cut from one piece of 4" X 4".
 This will be found to be a strong,
 well balanced and sufficiently attractive
 table. The joints of rails and posts need
 reinforcing with sheet metal as in Fig. 757,8,9.

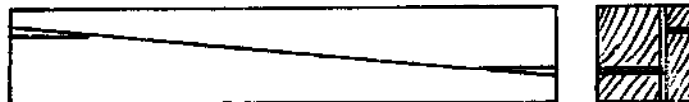


FIG. 767.

Securing a built in cupboard to the masonry. To literally build it in may result in the ruination of the wood and the appearance. If there is danger of this, build in two posts as in this illustration. They should be longer than the cupboard so that the top and bottom may be better anchored.

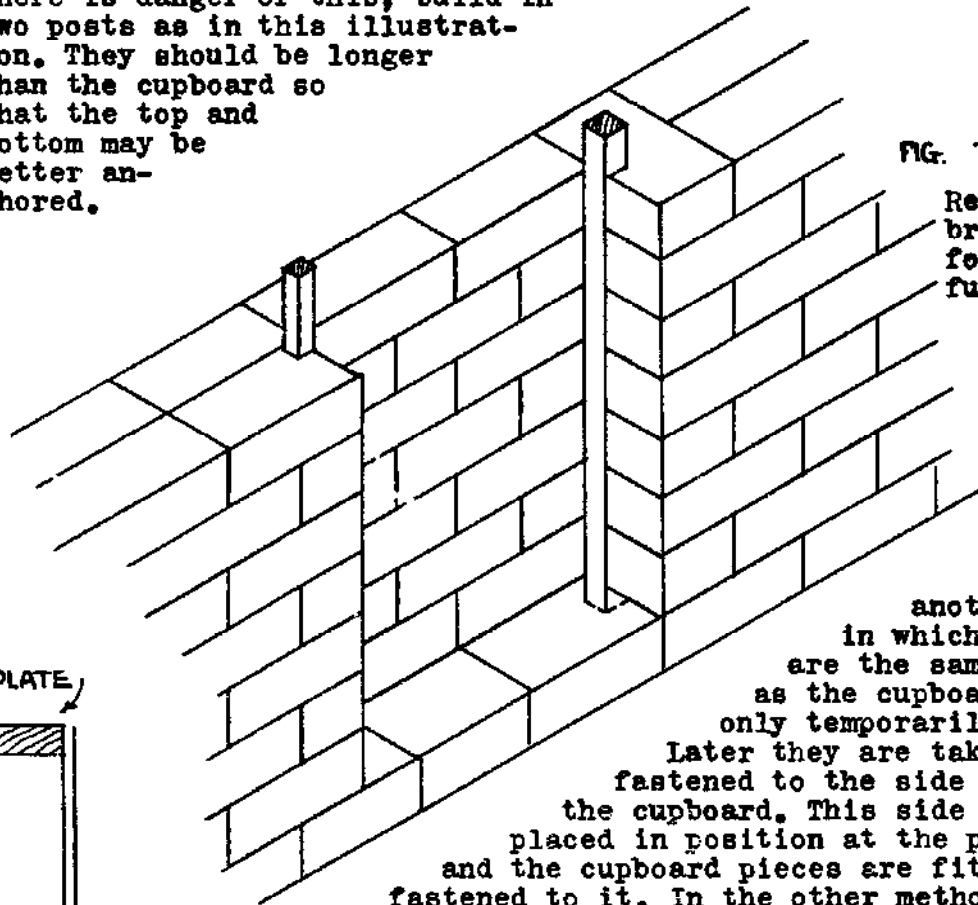


FIG. 768.

Recess in brick wall for built-in furniture.

There is another method in which the posts are the same length as the cupboard and are only temporarily built in. Later they are taken out and fastened to the side piece of the cupboard. This side piece is placed in position at the proper time and the cupboard pieces are fitted and fastened to it. In the other method the cupboard is built completely and set in place at the proper time, and fastened to the posts which have been built in.

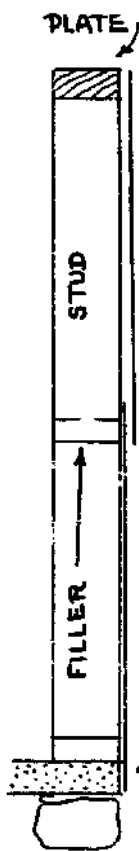


FIG. 769.

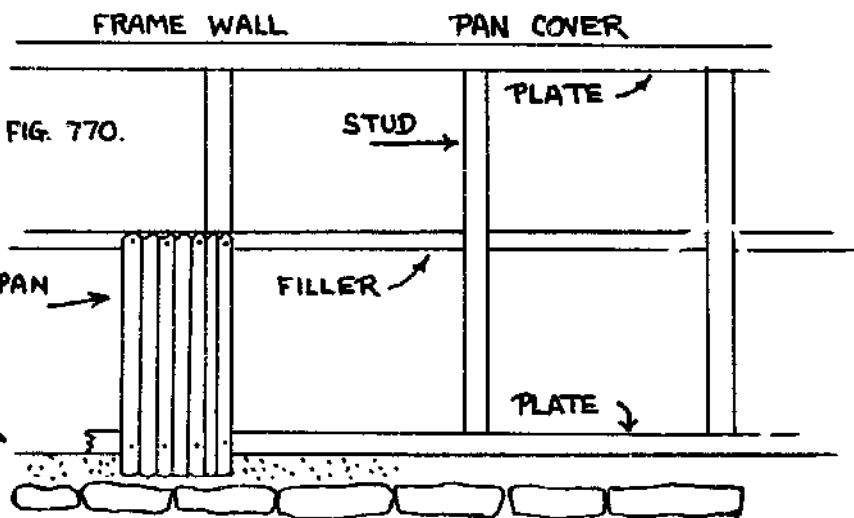


FIG. 770.

BOOK FOUR CONCRETECHAPTER ONESPECIFICATIONS.

There are seven essential factors in a permanently satisfactory concrete job. They are:

I. DESIGN OF THE STRUCTURE.

1. Proper support. The best concrete in the world will become unsatisfactory if it has not proper support, - if the earth, beams or columns on which it rests are not adequate.

2. Mass. If the thickness, bulk, mass, of the concrete is not sufficient to withstand the use, vibration, or abuse it will receive, it will not be satisfactory.

3. Quality. Various purposes require various consistencies, qualities of materials, finishes, ingredients, etc.

4. Reinforcement. Some concrete structures require steel reinforcement which must be in accordance with building and engineering standards and principles as to size, quantity, position, etc.

II. QUALITY OF THE INGREDIENTS.

1. Cement. All that looks like cement is not necessarily good cement. There are many grades. But the most serious damage is done to cement by moisture, either by direct contact with water or by humid air. The latter is obviously the most difficult to combat because, as a rule, the damage is done before safeguards are taken or seem to be needed. When it is not smooth and flour-like, but is granulated, or caked, it is spoiled to some extent, if not altogether ruined.

If we are placed in the annoying position of having to use cement that has been damaged, or do without, grade it as best you can and use the best for the top coat. Use the next best for the slab and use more of it than otherwise.

Buy good cement and then protect it from dampness. Some paper bags have been quite satisfactory and some metal drums have been found to be defective, allowing the contents to be spoiled.

ONCE MOISTURE REACHES CEMENT, CHEMICAL ACTION BEGINS.
ON THE JOB, MAKE IT A PRACTICE TO MIX, PLACE, AND FINISH ALL CONCRETE WITHIN AN HOUR OF THE TIME THAT THE CEMENT HAS FIRST BEEN WETTED.

2 Sand. By definition, sand is fine rock particles, and in concrete is called, 'fine aggregate.' It is found in gravel pits, and on the shores of rivers and lakes.

Use only clean sand which is free of silt, loam, vegetable matter and other alien substances to which cement will not adhere. Sand is graded as, Coarse, the texture of which is about the same as common granulated sugar.

Medium, which is like fine granulated sugar;

Fine, which is like shaker salt;

Dust, sand which is like dust in size as well as in other ways. Dust sand should never be used. If it occurs in any appreciable

quantity in the sand you must use, take it out, either by tossing it in the wind as in winnowing, or else wash it out.

To determine the amount of silt or loam, etc., in sand, take a fair sample and place in a pint jar; about 3/4 of a jar will do. Now fill up the jar with clean water, shake thoroughly and allow to settle until the water is clear again. A fair idea of the impurity contained may be judged by the colour of the water immediately after shaking.

If there is much impurity, the contents will be graded as follows: on the top layer, slime, then silt, then the finest of the sand, medium, coarse and small pebbles at the bottom.

For mass concrete and slab work the presence of one sixteenth of an inch of silt may not be serious, but if there is more in the sample, look for better sand or wash what you have.

This test should be made in plenty of time to look for good sand, or to wash what you have. This is a tedious process and must be done well ahead of the concrete job or there will be bad delays.

If water is scarce, wash the sand over a barrel and use the dirty water for mortar, mud plaster, etc.

For the top coat of a floor, use only good medium and fine grade sand.

3. Rock or gravel. This is called 'coarse aggregate.' This is added to sand and cement to increase its hardness and wearing qualities and also to increase its bulk. This latter reduces the cost per cubic foot because stone is cheaper than cement. Concrete strength depends upon the ratio of sand to cement and also upon the coarse aggregate. The concrete can be no stronger than the coarse aggregate in it. The stone or gravel must be clean and hard. Stones with oily or glassy surfaces to which cement will not adhere are to be avoided.

4. Water. Water must be clean. It must not contain salt, oil, grease, appreciable quantities of vegetable matter, strong acid, or alkali.

III. PROPORTIONS OF INGREDIENTS.

The ratio of cement to sand is the greatest determining factor for strength, other things being normal.

A concrete floor made of 1:5:6 concrete is vastly stronger than one made from 1 part cement and 11 parts sand. (The proportions are written cement, sand, stone.)

Beyond a certain point there is no economy in making a weak mixture. By experiment you may be able to economize beyond the table given here.

First class concrete for heavy duty floors, tanks, baths, basins, etc.

the slab: one cement, three sand, three to six of stone.

the top coat: one cement, two of fine and medium sand.

Second grade concrete for ant coursing, cisterns, steps, reinforced floors, etc.

Slab: one cement, four sand, four to seven of stone.

Top coat: one cement, three parts medium and fine sand.

Weakest grade concrete for walls, light duty floors, (dwellings).

The slab: one cement, five or six of sand, six to ten stone.

Top coat: one cement, four parts medium and fine sand.

Determine by experiment with the stone you are to use how much stone you may put in. As long as the cement and sand mortar fills all the voids, you are alright, but if there are voids which the mortar cannot fill, then you have too much stone.

Too much water will weaken concrete. Here again, experiment to discover just how little water you can use. Make the consistency just soft enough to work in place and no more. Use approximately $\frac{4}{5}$ as much water as cement for a start.

IV. MIXING.

Thorough mixing is essential to good concrete. And this includes preserving the homogeneity of the mass once it has been mixed. The addition of too much water, excessive vibration on the way to the placement, and other bad practices will cause the sand and cement to separate to such an extent that a great deal of the available strength of the concrete will be lost.

When water is added to the dry mix, add it carefully to prevent as much as possible the separation of the cement and the sand. Supervise the addition of the water. Sloppy concrete is weak concrete. The mixing operation is described in Chapter Two.

V. PLACING CONCRETE.

Concrete bases and forms and all reinforcement should be in perfect readiness before the concrete is mixed so that there will be no delay in placing and no disarrangement after placing.

All earth bases and forms should be wetted just enough to prevent the absorption of water from the concrete and not so much that there will be excess water which will increase the water content of the mixture.

All carrying receptacles should be ready and wetted.

All equipment and tools necessary for the handling and finishing of the concrete should be ready.

All scaffold, passages, and other items pertaining to the safe and prompt handling of the concrete should be in readiness.

WE REPEAT, ALL CONCRETE SHOULD BE IN PLACE AND FINISHED WITHIN ONE HOUR OF THE TIME THE WATER IS ADDED TO THE CEMENT.

VI. CURING.

By curing we mean the process of so controlling the moisture in new concrete that the maximum strength will be obtained.

When concrete first turns white, it has set, and does not increase in strength appreciably if at all, if wetted again. The purpose of curing is to retain the moisture of the new concrete for as long a period as is practicable. Concrete kept damp for the first ten days is 72% stronger than if left to cure in dry air. Twenty one days dampness increases the strength 124%; four months, - 207%.

Warmth is conducive to strength of concrete during the curing period. But protect from frost, vibration, movement, or any work which will involve scraping, cutting, bruising of the surface.

Concrete supported by posts, beams, and forming must be kept supported throughout the curing period. Otherwise the concrete will probably bend, and may easily fracture. This applies almost entirely to reinforced concrete floors and beams.

VII. PROTECTION.

When the floor has been made available to common use, keep it free of grit. It should not be subjected to greater loads and conditions than that for which it was designed. Raw linseed oil disintegrates cement.

CHAPTER TWO CONCRETE FLOORS.

I. GENERAL NOTES ON PREPARATION.

1. Supplies. Start early to get good hard sand. If you must have two grades separated, do that. Have some medium and fine sand ready, by sifting if necessary. If the sand needs water washing, do that too. And when you have all the sand you will need, and all ready for the work, handy to the mixing area, then protect it. Children love to play in it, and when they do, they scatter it all over and the work must be done twice.

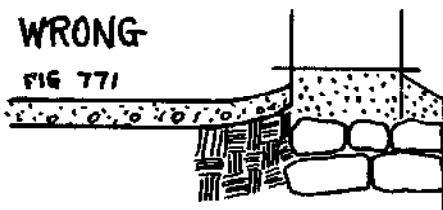
Get all the rock you will need. Get the hardest you can, wash it if necessary, and reduce it to the size you will need. Gravel is ideal for concrete work; graded sizes in stone is to be sought. No stone is to be larger than one half the thickness of the concrete it is to be used in.

2. Base. If you have evidence that ballast, that is crushed stone, gravel, cinders, etc., under a floor make it a better floor under the conditions where you build, then use it. Its primary purpose is to keep a concrete floor dry, when otherwise, resting on moist earth, the concrete would absorb moisture. Our opinion is that in very dry places especially, the floor becomes too dry and brittle, and has not the resistance to loads and heavy duty that an earth-based floor has. That concrete needs to be not too far away from a very little moisture to combat the excessive dryness. Ballasted floors sound hollow when struck. The ballast costs money in itself and tends to absorb some of the concrete laid upon it. If ballast is used, give it a thorough, uniform pounding.

Prepare earth bases the day before concrete is laid on them. Pound the earth uniformly, make the surface level and clear all earth away from the ant course. The earth base should run down at the wall rather than up.

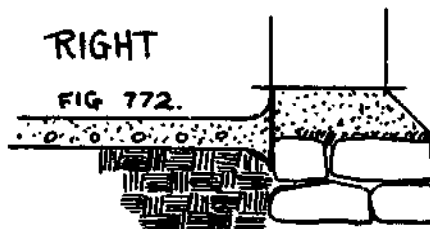
WRONG

FIG 771



RIGHT

FIG 772



Plan to do a small or medium sized floor the first day to get used to the various demands of the concreting process. Have a small room ready for concrete also, so that if there is some left-over of concrete from a batch, it can be put down at once without delay.

Plan to start the concrete job first thing every day. It is very strenuous and the finishing of the floor surface is a most exacting job. Too often it is done in poor light at the close of a long day. According to the size of the gang, do one or two floors a day, and if there is any time left over, have the men do something less strenuous.

The most economical floor has a designed uniform thickness. Check the earth base to see that it has a perfectly level surface at the right height so that no unnecessary concrete will be required to fill depressions.

3. Equipment. If a concrete platform at the base of a set of steps, or in front of the kitchen is to be made eventually, make it first of all and use it as a mixing platform for all concrete. It is probable that even if a mixing platform is made for that purpose alone that it is an economy. It should be at least 4' X 6', and with a strong mixture top coat. Make it a couple of weeks before you will be using it.

Have at least two square mouth shovels for the concrete mixing job. Get the measuring receptacles ready. There should be a large barrel near the mixing platform so that there will never be a shortage of water during operations.

Warn the masons as to the time you will be starting the concrete work so that they will have all the necessary tools on the job.

II. MIXING CONCRETE.

Machine mixed concrete, properly attended to makes the best job. The hand job is heavy and we therefore suggest a somewhat new technique. Ordinarily the stone is measured out on the platform, then on it the sand, and on that again the cement. Everything is turned over at least four times; then a pool is formed, water mixed with the mass, and finally the whole is turned over again at least four times.

We suggest that the sand be measured on the platform, and then the cement and the whole turned over at least four times. The correct method for turning over is for the shovel to slide along the floor, pick up a load and spill the load over the top of the new pile. The two men work turn about so that as one is picking up the other is emptying. The main point is that each shovelful is turned over the top of the new pile and runs down the sides of the cone evenly. This is the easiest and best way of mixing dry or wet concrete and all other motions should be eliminated.

When the dry mix has a uniform colour it may be considered to be well mixed, but to be sure, turn it over again. If there is a strong wind which will blow poured cement away, damp the sand just a little, place the mouth of the bag right on the sand, and empty carefully. Carefully cover the dry cement with the moist sand and mull it a little until when the turning operation starts the cement

will not be carried away by the breeze.

The cement poured on the sand, ready for mixing.

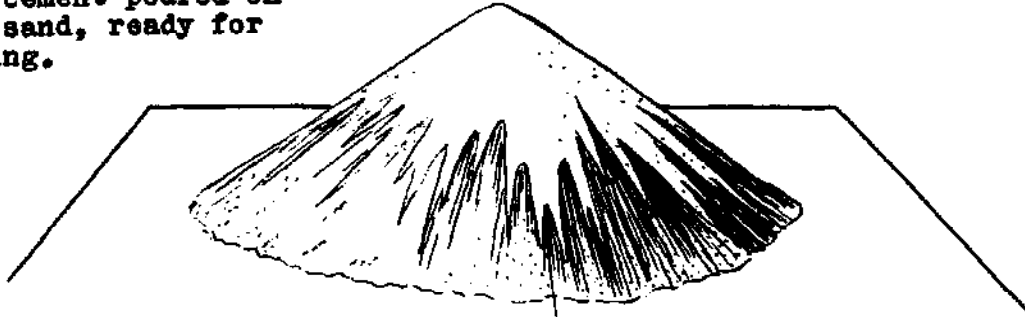
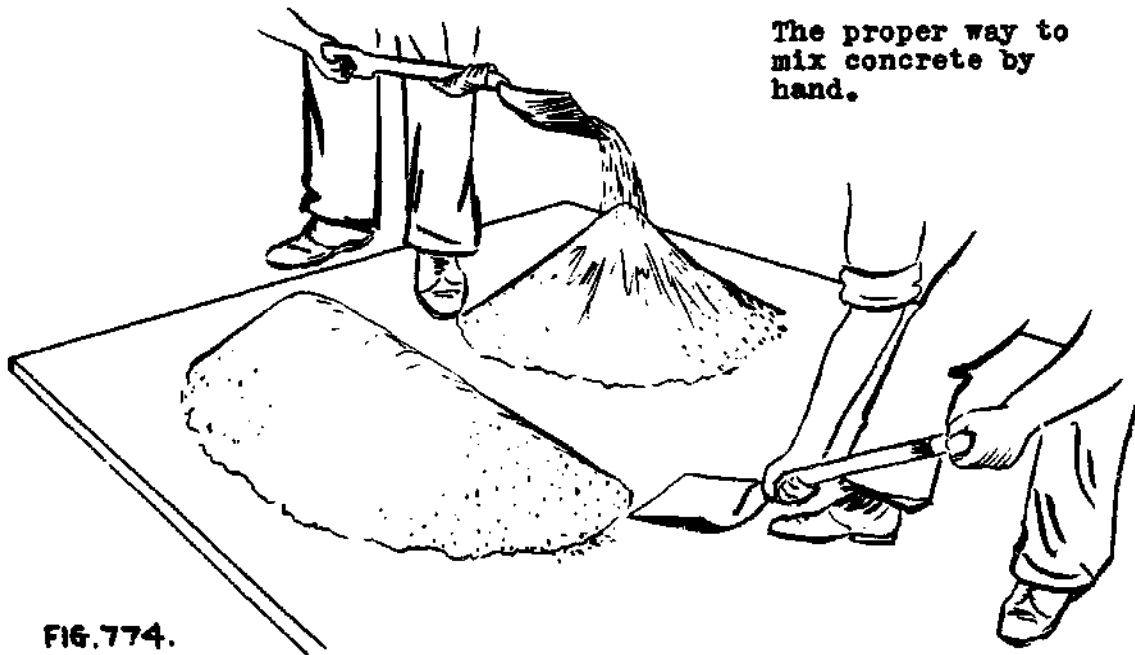


FIG 773



The proper way to mix concrete by hand.

FIG. 774.

It cannot be too strongly emphasized that too much water will weaken concrete. Hence, measure out the water very carefully. Use what you are sure will be insufficient and mix thoroughly. If a little more is required, measure that too. Follow the batch to the place of deposit and observe whether there is too much or too little moisture in the concrete. It should shake, or spade, or pound into a solid mass without any voids and without free water lying on the top. Mix the second batch accordingly.

When the batch has been thoroughly mixed, dry, form a crater or pool, the sides being drawn out toward the edges of the mixing platform. There should be no mixture in the middle of the pool. Now pour in, gently, the amount of water you want for the first stage of the mixing. Turn the shovel over and with the square edge scraping along the floor, push some of the dry mix out into the

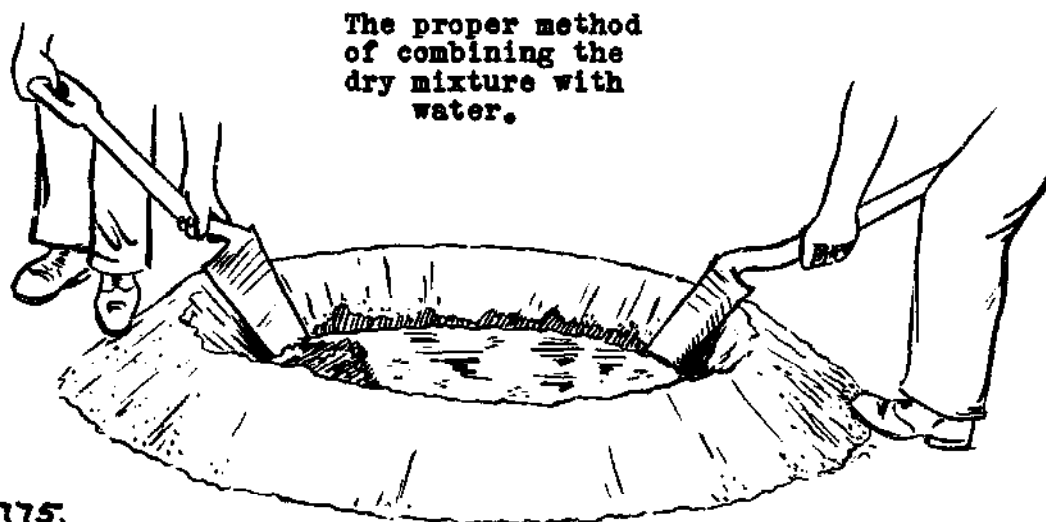


FIG. 775.

pool in such a way that it spreads out, the water under and over it, becoming saturated with the least possible of a washing action which would separate the cement and the sand. When the entire dry mix has been heaped up in the centre of the pool it should have taken up all the free water. As in the beginning, turn this mass over and back at least four times. Thorough mixing is essential to good concrete.

Now add the measured quantity of stone. You must judge whether the stone should be slightly damped before it is added. The important thing is that the already mixed cement mortar will not be adversely affected by the addition of stone too wet, too dry.

If, after the first batch, you think more stone may be added, you may add it. The rule is that all interstices between the stones must be filled with mortar when the concrete is finally in place. You do not weaken concrete by having all the stone in it that it will take when following the rule.

III. LAYING THE FLOOR.

1. Slab. Start the slab in that part of the room most difficult to get at and arrange to complete it at the door which will give the easiest access, the most light, and if possible, the point of commencing the next day's work. Arrange to have the joint between one day's work and the next at a door way, preferably in line with one side of the door. The joint when completed should be perfectly straight and even.

The surface of the slab should be almost smooth. It should be true and even so that the top coat, which is very thin, will be uniformly thin and even. Try to achieve the good finish before the first pounding operation is complete. In other words, do not leave projections all over the floor and have to hammer them down just before the top coat is put on, when the slab has begun to harden and

all pounding on the slab will dislocate much of the mass which has been hardening for some time.

Provide foot-walk planks for the carriers of concrete so that they will not track earth and dust over the slab as they bring the top coat.

When the slab is half done, mix a batch of the top coat and get it started. Two masons can be working on it while others are busy with the rest of the slab. It will speed up the completion of the job.

The top coat costs money. It should be rich. But it does not have to be more than 1/2" thick. The obvious method would be to lay a 1/2" strip over the slab, pour on the top coat and then smooth it down to the level of the strip. In practice the thickness of the top coat will be found to be well over 1/2". Use whatever method seems most practicable to draw out the top coat to your desired one half inch thickness.

If the slab has dried out so much by the time the top coat is put on that it will absorb moisture from the top mix, sprinkle just enough water on the slab to enable the top mix to retain its moisture consistency.

Finishing the top coat. The first operation is to reduce the mass to just a little above its finish level because it settles and compacts a little in the various operations. It should be worked just as soon as it is brought in because it is understood to have only enough water to work it.

After screeding or drawing out with a long straight edge, it is evened up with a wood trowel, called a float. Many masons have a square float. This will allow an uneven surface because it can smooth out little depressions without levelling them. Try to get the men to use the rectangular float, approximately 4" X 12".

If possible restrict its use to one or two sweeps over the surface at a time. It brings water to the top and whenever this happens, CEMENT GOES DOWN, leaving the surface mixture weakest where it should be strongest. Do not work over the top coat when the water is more or less free on the surface.

The finish is made with a rectangular iron trowel. Very few of the masons, at least in some countries, use these, but here again, try to introduce them. As with the wood trowel, water is brought to the surface by the movement of the trowel. Make a sweep or two and pass on. If the surface were left this way, it would have a final appearance of being porous. The last strokes of the iron trowel are to compact the surface to a glass-like smoothness and iron-like hardness.

Dusting cement. Some skill is required to make a dusting of cement effectual. So often it leaves dark patches on the surface, and sometimes it pulls away from the rest of the floor. When done properly it makes an extremely smooth and hard surface. Provide yourself with a small can with a perforated bottom. After floating the top coat once, dust on the cement from the can evenly; work over this with the float until the dusted cement has been incorporated with the top coat mixture. Smooth and iron with the iron trowel. Experience will show that the final sweeps with the iron trowel are made pretty much with the edge of the metal. One edge is turned by wrist action a little up from the surface and the other edge finally compacts the pores into a smooth, more or less impenetrable surface.

IV. CURING AND PROTECTION.

We recommend having all the doors and windows in a house when the concrete floors are laid so that when each floor is laid, the doors and windows of that room may be closed to keep out people and animals and to keep in the moisture of the concrete and the water put on it to complete the curing.

It is not fair to a floor to have men all over it a day or two after it has been finished. If there are no doors and windows, take the utmost precautions to keep people as well as animals from the floor, until at least the surface will bear them. And when men have to walk around, put down some kind of walk or mat which will not stain the floor. For the floor must be kept wet for at least four days, better ten. Mahogany planks and boards should not be used for they will leave a dark red stain.

Porch and verandah floors which cannot be closed off, need a low mud dike around the edges as well as a layer of earth. The earth is kept soaked. Some kinds of earth will stain the floor. Use the cleanest you can find.

Clean building sand may be spread on the floor to retain water, but it is not well to walk over or place equipment on the sand because it is abrasive and the movement of men and materials and equipment over it will spoil the cement surface.

V. CONCRETE TILE FLOORS.

Under certain circumstances cement tiles may be the most practicable way to make a floor. Shapes may be squares or hexagons or rectangles. Different colours will make a very attractive pattern. The border of the room would ordinarily be a strip of solid concrete, and it may be wise to merely indicate its place at first and lay the tiles in the centre of the room. When they are all in place, the border would be laid and there would be no cutting or trimming.

Tile should not be larger than 12" square, and for this size the thickness should not be less than 1".

The mixture should be 1:3:3 of cement, fine and medium sand and coarse sand and very small gravel. A very thin top dressing of 1:1, cement and fine sand is added. The greatest difficulty in making tile is the absolutely true surface which must be made in a mould. There is a tendency to have more or less than the exact amount of concrete in the mould. In either case, the surface will not be even with the edge of the mould.

The tile may be laid in mud. Take care that the mud used is of uniform consistency throughout each single room. A 1/8" metal strip may be used to separate the tile as they are laid, and then before the mud has dried, pour in the 1/8" joint a thick mixture of cement, fine sand, and water. Take care that new tile are not walked on for a day or two. To do the work of filling the joints, place cross boards to support the plank you work from. If the tile are made in one place and require transportation, they need the most careful packing in straw for the journey. One of the advantages of their use is that they can be used in temporary buildings and removed as may be necessary. Another advantage is that they may be made during the wet season, and in one place which is

most convenient for equipment, labour, materials and transportation. We recommend that if a 12" tile is adopted, an 11" square band of jointed wire be used as a reinforcement in each tile. Approximately one quarter of inch of concrete would be placed in the mould, then the wire placed centrally, and then the remainder of the concrete.

In laying the tile, a straight line of tile should be laid down each side of the room first. Then starting at the top, so to speak, lay the tile across from one side to the other, lining them by means of a straight edge which rests on the two strips.

CHAPTER THREE CONCRETE UNITS AND EQUIPMENT.

I. LINTELS, SMALL, LARGE, AND FOR FIREPLACES.

A concrete lintel is a beam, and every beam bearing weight has two main internal stresses, compression in the upper half and tension in the lower half. The upper half must be constructed to resist the compression and the lower to resist being pulled apart due to the tension. Hence in a concrete lintel, we place steel rods in the lower part of the lower half where there is the greatest amount of tension. Ordinary door and window lintels require very little of such steel. The ends of the steel are to be hooked.

For ordinary wall loads, the following table may be used.

Concrete lintel sizes and quantities of steel reinforcement.

Lintel Height	Thick- ness	Span	Quan- tity	Steel	Rods	or	equivalent.
6"	6"	2'	2	1/4"	"	"	"
8"	6"-8"	- 3'6"	2	3/8"	"	"	"
10"	8"-10"	- 5'	3	3/8"	"	"	"
12"	8"-12"	- 7'	2	1/2"	"	"	"

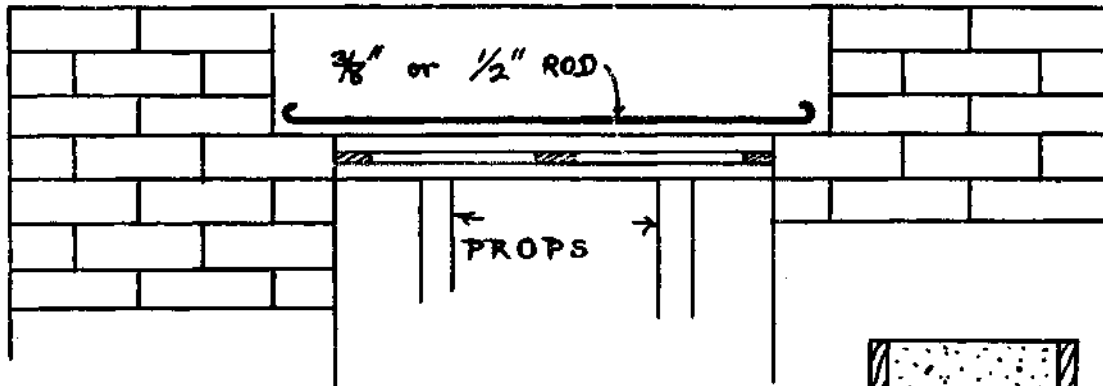
The smaller lintels may be pre-cast to speed wall erection; if so, make a mark to identify the position of the steel rods so that they will be on the bottom when the lintel is finally in position.

If lintels are moulded on the wall, the under side of the form must be left in place for at least ten days. It will be well if the sides too can be left for that period to conserve the moisture of the concrete for curing purposes.

Build up the masonry wall at each side of the opening and as far back as you want the lintel to rest. Then make a bottom form to hold concrete, either supplementing the wood lintel or a complete but temporary board support. A post should support this in the middle. If you wish to ornament the lintel somewhat, make markings on the face board to represent joints as in stonework.

The concrete need not be stronger than 1:4:4. Take care that the lintel is free from vibration until it has taken its initial set. Do not lay masonry on it until it has hardened a little on top.

FIG. 776.



REINFORCING RODS

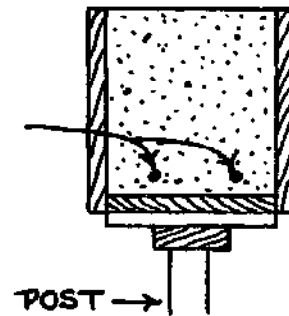


FIG. 777.

Fireplace lintels.

By a study of the following drawings and of the drawings of the fireplace in Book Two, it will be seen that the central section of the fireplace lintel has a sloping side at the rear. This can be shaped by masonry as in Fig. 243, page 119.



FIG. 778.



FIG. 781.

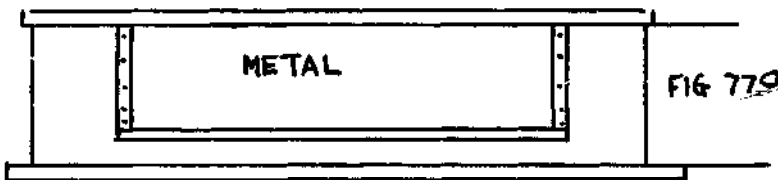


FIG. 779

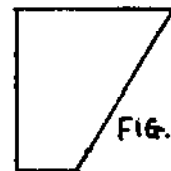


FIG. 782.

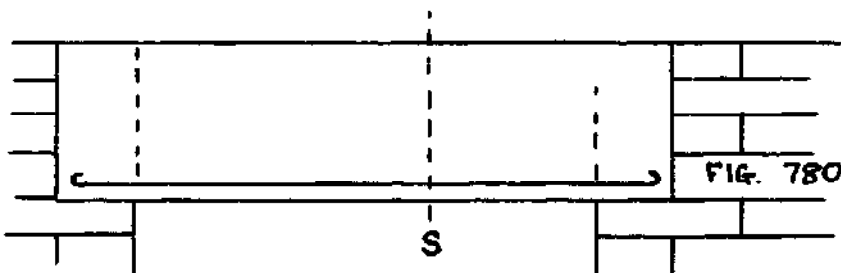


FIG. 780.

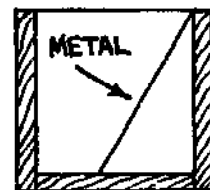


FIG. 783.

Or the sloping back can be moulded by a sheet of metal from the floor of the mould to the top rear edge. The ends of the metal may be nailed to a shaped block placed over the wall or jamb of the fireplace itself. The metal itself is the span of the fireplace opening.

Fig. 779 is a top view of the box all ready for the concrete. An inch of concrete would be poured into the long narrow part, and then the steel reinforcement, a $\frac{3}{8}$ " rod, would be laid in place. After that, the rest of the concrete would be poured in.

II STEPS AND STAIRS.

Steps need to be well made for several reasons. They do not need to be expensive, but they need to be massive. They should have a well founded and solid masonry base. The stone may be laid in mud mortar. A wood form is made to hold the concrete in place at the risers. Leave at least two and a half inches space between the wood and the stone for concrete. Tack the wood form together lightly so that it may be taken apart easily about six hours after the concrete is poured. This is to have a soft, green surface to which the top dressing may be plastered. The step top may be finished when the concrete is poured, or it may be done when the face of the riser is done.

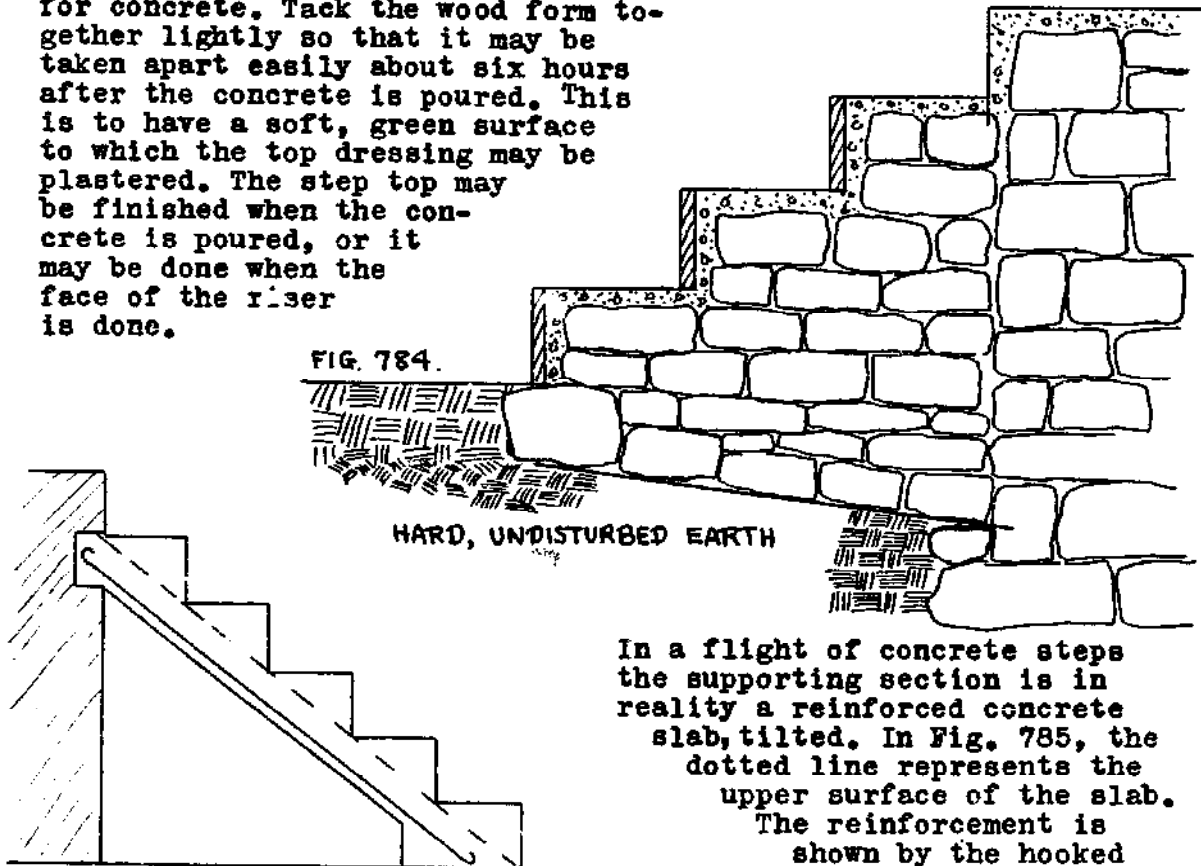


FIG. 784.

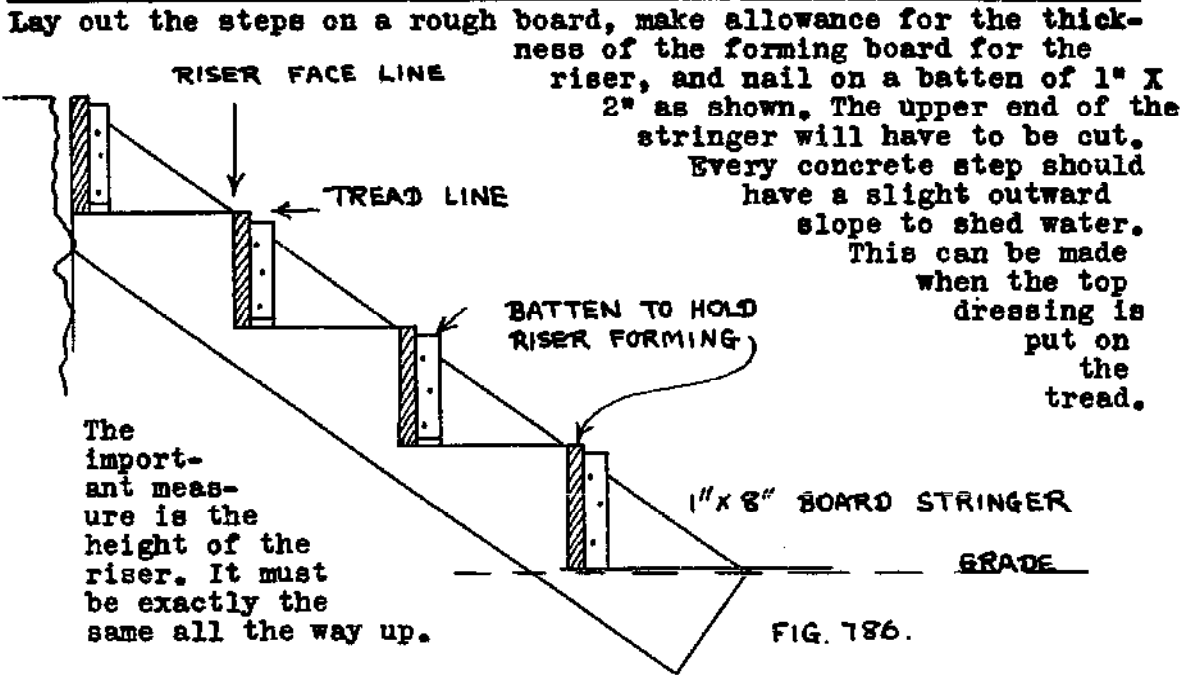
HARD, UNDISTURBED EARTH

FIG. 785.

In a flight of concrete steps the supporting section is in reality a reinforced concrete slab, tilted. In Fig. 785, the dotted line represents the upper surface of the slab.

The reinforcement is shown by the hooked line. If the slab can be supported every eight feet, it need

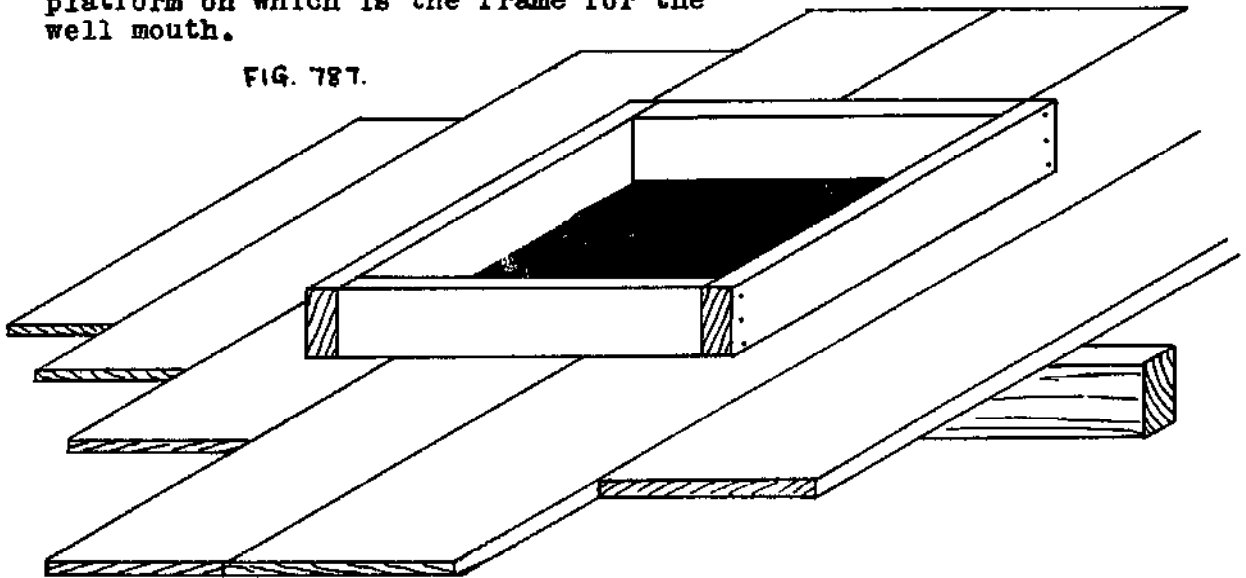
not be more than 4" thick. For that distance, three $\frac{1}{2}$ " rods, evenly spaced across the slab will be sufficient. Leave the forming of such a slab in place to support it for at least ten days.



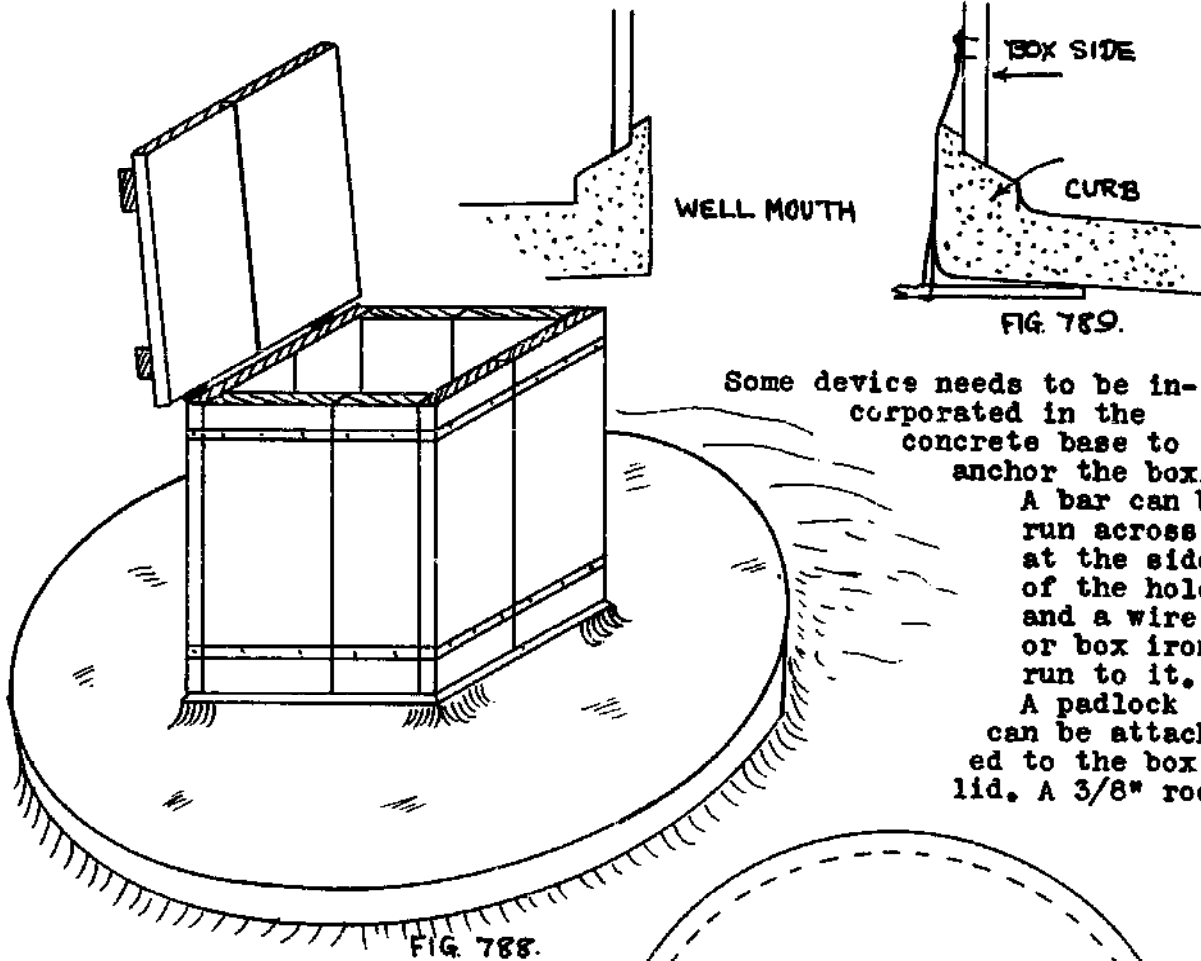
III. WELL TOPS AND LININGS.

A properly constructed well top on a good well may be an economy. It is safer than a wood top, and it will shed surface water and keep it from trickling in the well. With some ingenuity, a wood frame may be constructed which will support the concrete and then when the concrete is self supporting, be taken out. We have shown only a common plank platform on which is the frame for the well mouth.

FIG. 787.



A curb of concrete at the well's mouth will prevent surface water from running back in, and a box top on the curb will go a long way to prevent mishaps, especially as a safeguard for children.



Some device needs to be incorporated in the concrete base to anchor the box. A bar can be run across at the side of the hole and a wire or box iron run to it. A padlock can be attached to the box lid lid. A 3/8" rod

should girdle the base as shown by the dotted line. Another reinforcement is required across the base. One rod is run each side of the opening. The base is slightly crowned, on top, but flat on the bottom. All the steel reinforcement lies near the bottom. In the rod which girdles the base, there must be a non-slipping joint. Hook the straight rods.

FIG. 790.

The following is a suggestion for a concrete lining for the well which has begun to fall in or threatens to fall in. Sections of concrete are lowered into place, held together by a metal band, and then earth is dug from the bottom of the well

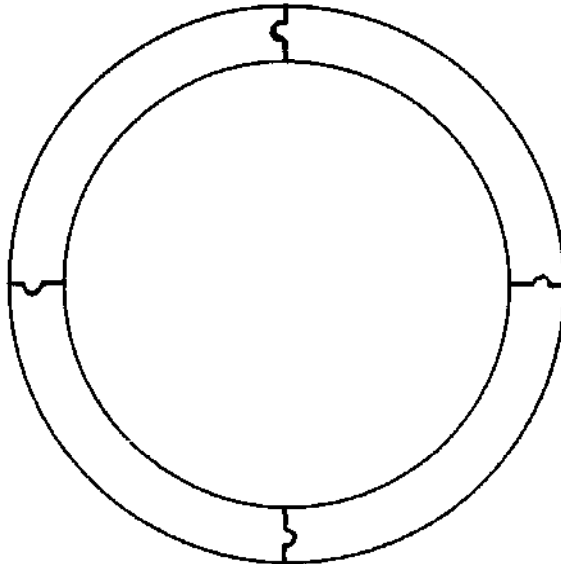


FIG. 791. TOP VIEW OF LINING

in such a way that the concrete lining will settle by its own weight. Its lower edge is adapted for this by a bevel. Two sections or lifts may be put down before the digging operations begin. If this type of lining were used at the commencement of the excavation of the well, or when the sides showed need of support, the task of digging would be made much safer, and a well conserved for use which might otherwise be lost because the cave-in ruined the general form of the well.

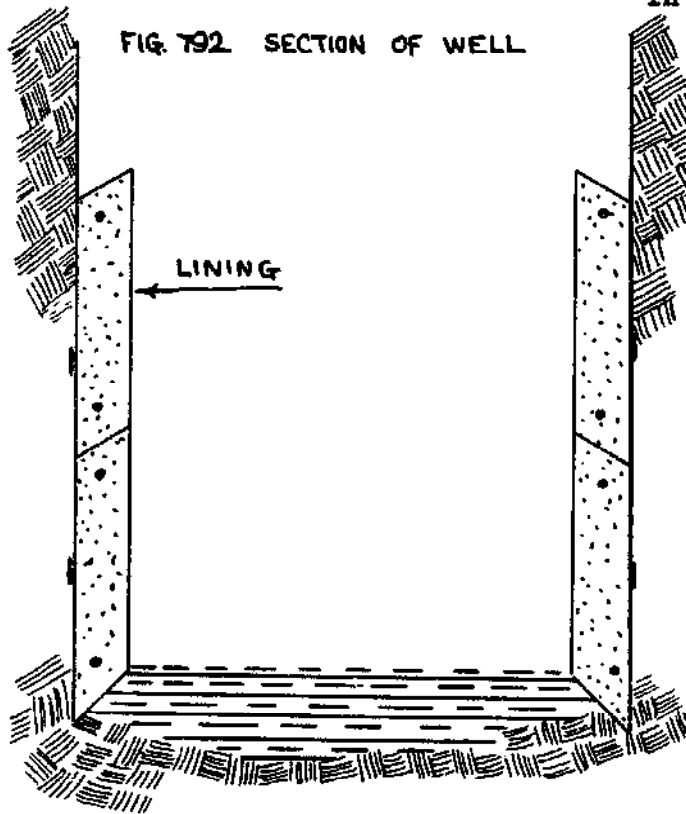


FIG. 792. SECTION OF WELL

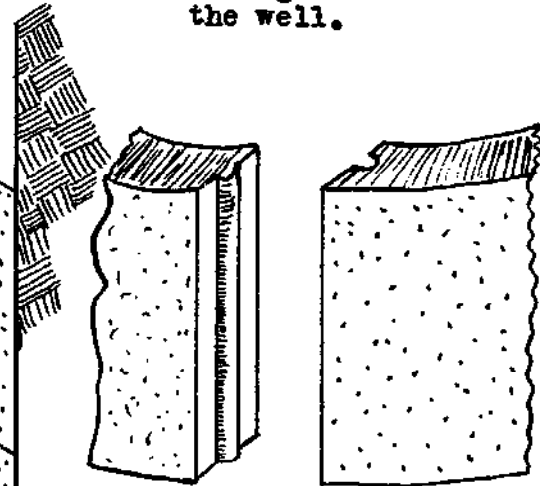
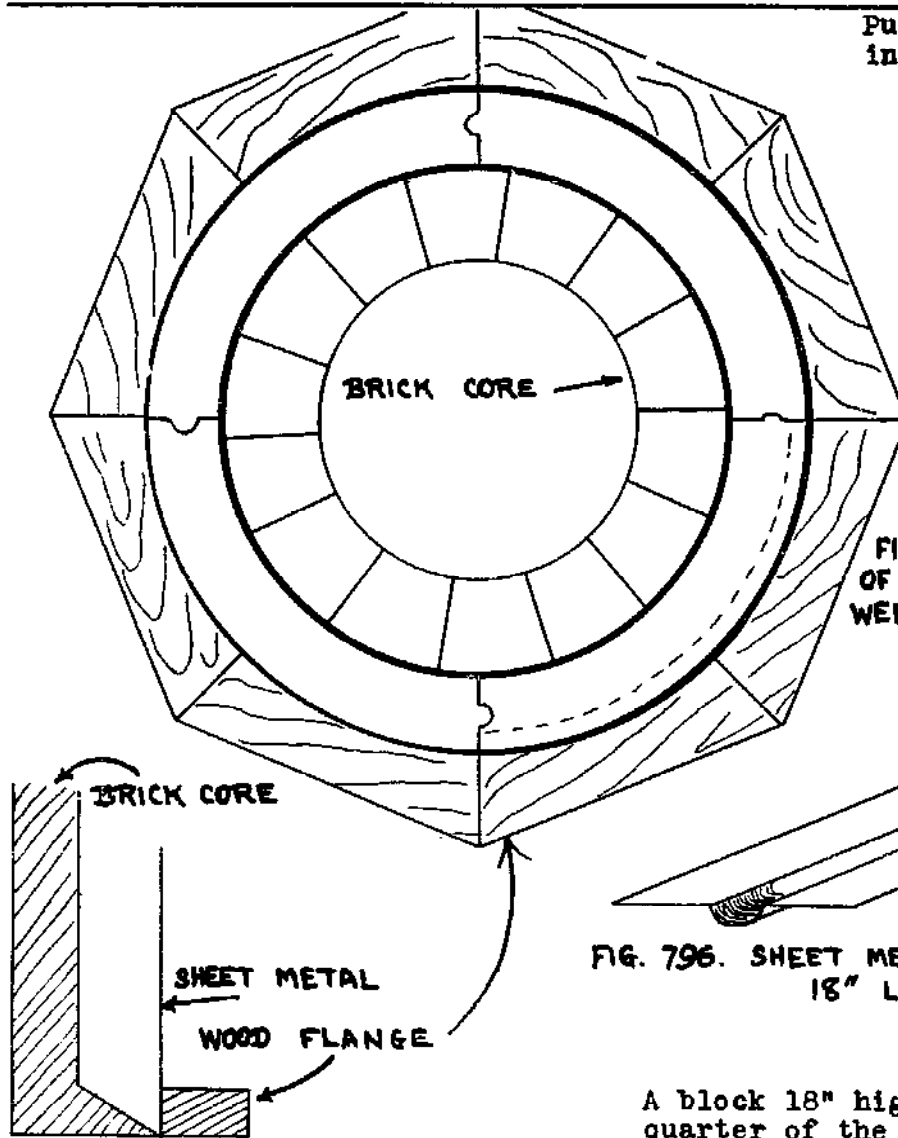


FIG. 793.

The metal band would be made up top, and adjusted there so that when it was lowered it would encircle the new lift of blocks without trouble.



Put two $\frac{3}{8}$ " rods in each quarter section; the dotted line in Fig. 794 shows how they are placed and Fig. 792 shows when they are placed.

FIG. 794. TOP VIEW OF MOULD FOR WELL LININGS.

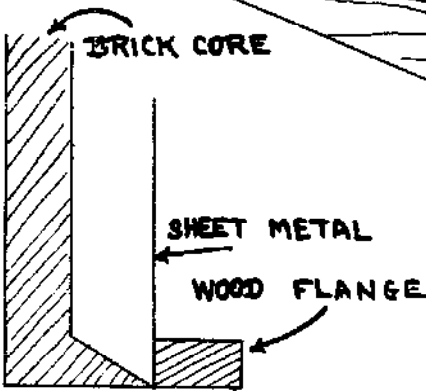


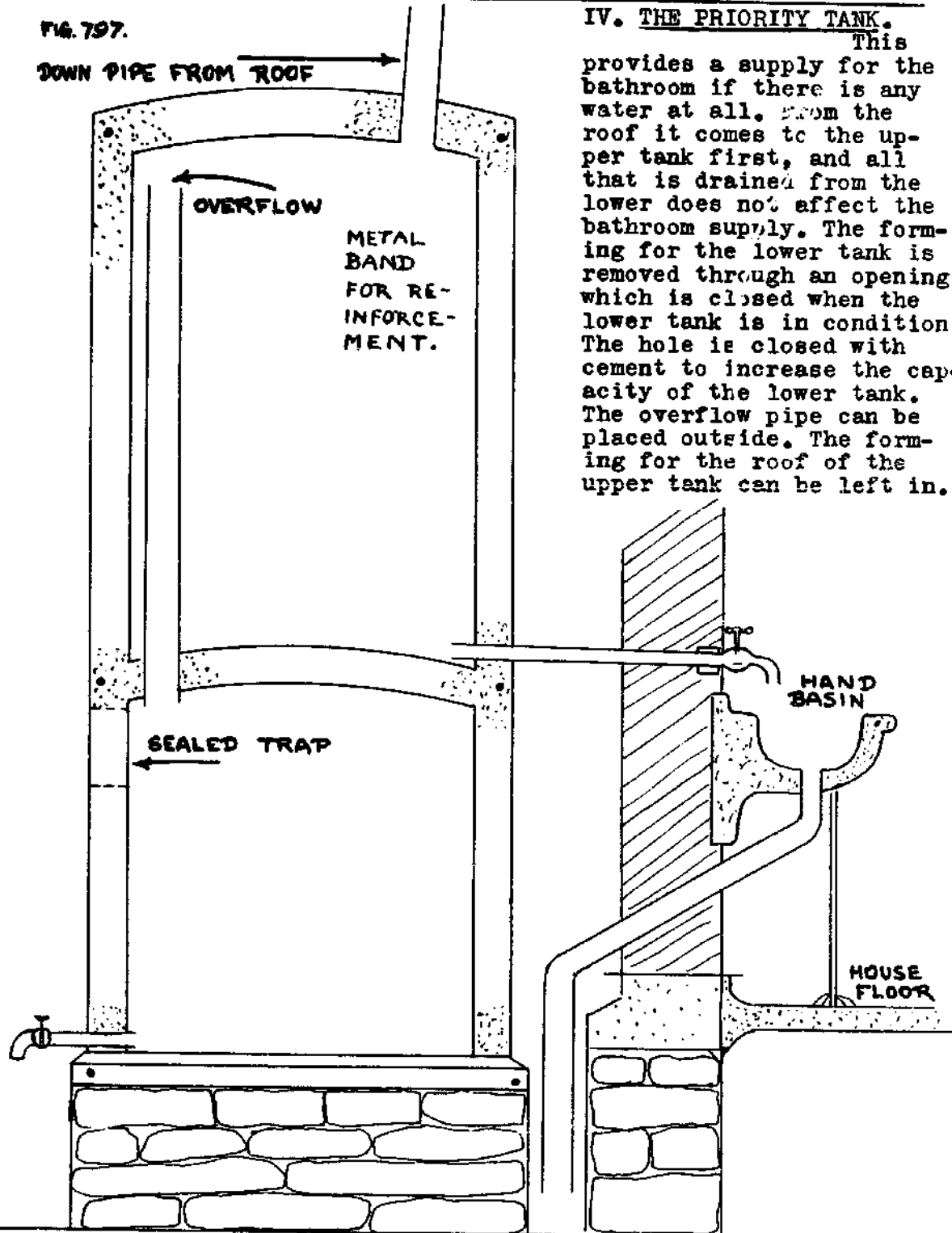
FIG. 795. SECTION OF MOULD.

FIG. 796. SHEET METAL PARTITION 18" LONG.

A block 18" high, 4" thick, one quarter of the circumference of a 4' diameter lining weighs about 175 lbs. This is not too heavy to handle. Cut out a 4'

diameter circle of cardboard and build to that shape a mud brick core. Keep the brick just enough inside the pattern to allow for a little plaster. Slope the bottom as shown in Fig. 795. Lay out a wood circle at 4'8" diameter as shown in Fig. 794. To this fasten a sheet of metal. Make the form in two halves. Make four metal partitions as in Fig. 796. This may seem an elaborate block machine, but if it were made at district headquarters it would serve a wide area. Grease the mud plaster before each set of blocks are made. Grease the metal sides. The blocks may be made of wet concrete or of the so-called dry mix as for regular cement blocks. Make the blocks well ahead of time and cure them at least four weeks. If the form must be used at different places, make an inside core of metal and wood to correspond with the outside form.

FIG. 797.



IV. THE PRIORITY TANK.

This provides a supply for the bathroom if there is any water at all. From the roof it comes to the upper tank first, and all that is drained from the lower does not affect the bathroom supply. The forming for the lower tank is removed through an opening which is closed when the lower tank is in condition. The hole is closed with cement to increase the capacity of the lower tank. The overflow pipe can be placed outside. The forming for the roof of the upper tank can be left in.

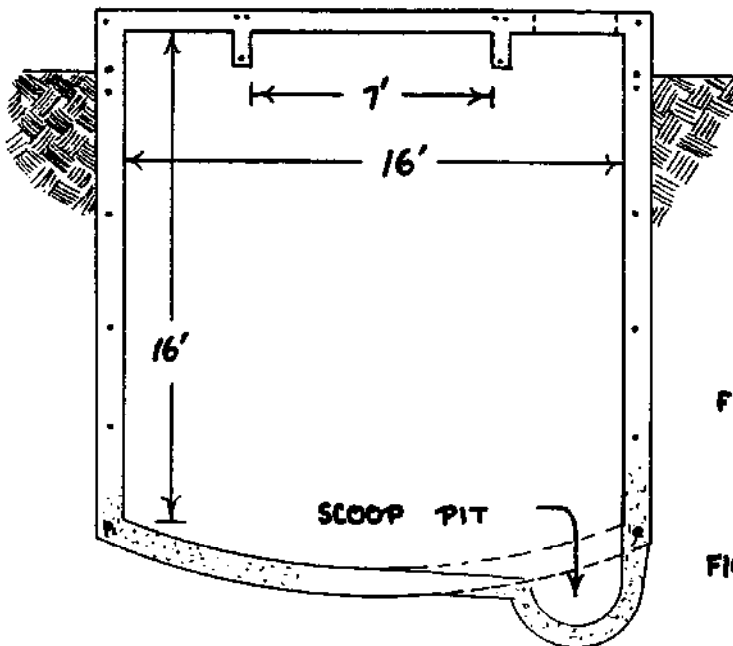
An inside diameter of 4' gives a capacity of 78 gallons per foot depth.

V. CISTERNS. A Mission House roof has 1950 square feet effective for catching rain water. Making no allowance for loss from all causes, this gives about 12,000 gallons of water per foot of rainfall. Ordinarily, this supply is ample for all the needs of one family throughout a normal dry season: 18,000 gallons, 100 gallons a day for 180 days, - half a year.

There should be an auxiliary 400-800 gallon tank above ground for use while the large tank is being cleaned out, and for the very end of the rainy season so that after the last rain, the cistern will be filled to capacity.

The cylindrical cistern with depth equal to diameter is the cheapest and best container made of concrete. To contain 18,000 gallons we require a diameter of 16' and an equal depth. If possible have a reinforced concrete floor over it, supported by a central post, or a beam, and then use the top for the kitchen floor. The protected opening of the tank is just outside the kitchen wall.

FIG. 798. SECTION OF CONCRETE CISTERN



Scrape the surface of ground carefully and describe a 16'8" circle so that the excavation will be as accurate as possible. Make the wall as true as possible. Dish the floor as shown, and then shape a scoop pit directly under the trap through which water will be drawn by pail or by pump. Prepare a 3/8" or 1/2" steel rod

FLOOR REINFORCEMENT

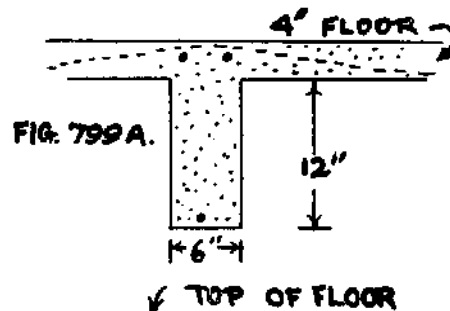
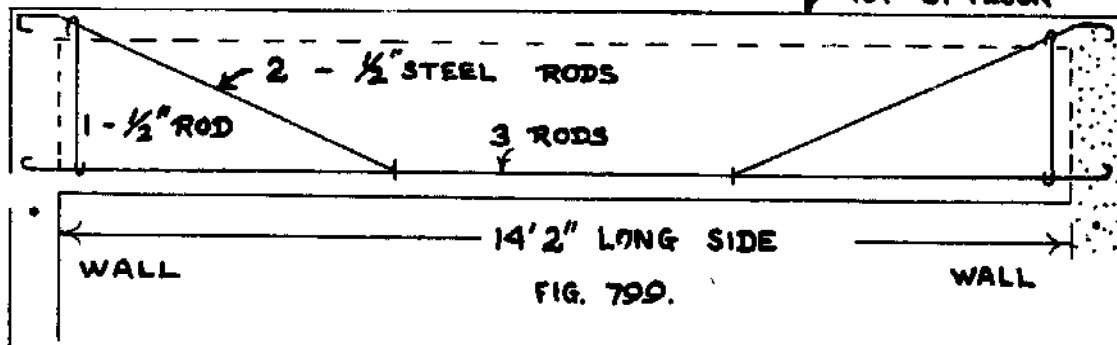


FIG. 799. CISTERN ROOF BEAM



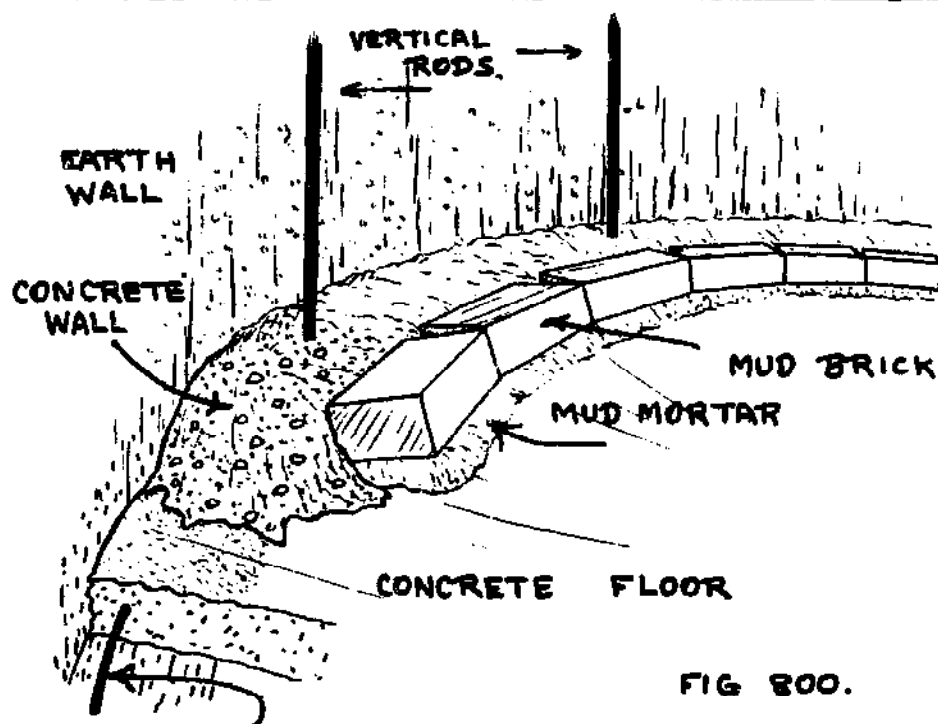


FIG 200.

band like this to girdle the circumference of the floor. It must be understood that in all concrete reinforcement like this the steel joint must be made secure. To make the best job, hook vertical $\frac{3}{8}$ " rods around the rod at the base and stand them up against the wall while the floor is being poured. Leave the outer six inches rough to make a better bond for the joint at the base of the wall.

When the floor is hard enough to work on, (keep hob nails off please) lay a course of brick around the circle, about six inches from the earth wall, and tilted toward the wall as shown. Fill the cross joints, and clean out any mud which may have fallen between the brick and the earth wall. The concrete may now be poured in the space between the brick and the wall. Let the next course of brick incline a little toward the earth wall and so bring the space between the bricks and the wall to 4". Use the very best concrete for this job, and follow the specifications carefully. The less water you use, the more waterproof your concrete will be, other conditions being normal.

Build this circular wall as rapidly as possible so that there will be the least chance of structural cracks forming. The top of each batch should be left rough, and at night leave the top of the concrete well roughened for the next day's concrete.

At the top, thicken the wall, outwards, just a little, before laying an outside circle of bricks to retain the concrete which will be above ground. One foot above ground may be considered a minimum.

It will be much easier work if the inside brick walls are removed before the top concrete floor is put on the cistern. When the tank has been cleaned out and plastered, make the box forms for the reinforced concrete beams. They are built as one piece with the wall beside and under their ends. Support the beam boxes with posts and

leave them in for at least ten days. As soon as possible, make the support for the floor, lay the expanded metal over it and pour the floor concrete. At the beams, raise the expanded metal as near to the floor surface as possible. Mid spans, the expanded metal is to be near the bottom surface of the floor. The trap for withdrawing water is made almost identically as the well top. If water is to be withdrawn by pail, make a safety box at least two feet high over the trap.

If a pan top is preferred over the tank, make stiffened rafters or joists and on them lay purlines for the metal. To get extra water supply, drain the pans into the tank, but screen all openings to prevent mosquitoes entering and laying eggs.

CHAPTER FOUR CONCRETE BLOCKS.

I. SIZE.

Size of concrete blocks depends, more or less, upon five factors.

1. Building by-laws and regulations. Make certain about these before investing in machinery and other equipment.
2. The machine sizes available, if a machine must be used.
3. Whether the wall is solid or veneer block, whether the wall is one or two storey, the weight the wall must carry, etc.
4. The bond or block sizes which are most practicable.

If possible make your own moulding machine. It will make blocks good enough for most work. They are comparatively inexpensive to make, can be transported without difficulty anywhere, and require no outlay at all on pallets like the regular machines do. And there is little if any transport cost from the home land if they are made there. The regular machines with their pallets are very heavy.

It may be well to adjust the building plan to the machine if bought, or make the machine to suit your requirements. The cutting of concrete blocks is an expense which should and can be avoided.

Blocks are of two main types and sizes. Solid blocks from 4-1/2" to 6" in thickness, approximately 9" to 12" in height, and from 14" to 28" in length.

Hollow blocks, that is with air chambers for insulation, dryness, lightness and economy, - from 9" to 14" in thickness, 9" high, and 14" to 18" in length.

Whatever size of block is used, lay up as in Fig. 801, one block laid evenly over two, with small pieces used at the corner to make the bond come right. The small piece should be made in the mould by the use of partitions. When designing your blocks and pieces be sure to allow for joints. Work out your bonding problems on paper or with 1" blocks of wood on a table.

Do not allow the intersection and bonding of partitions to interfere with the appearance and bond of the main wall. One course must run through without a break from corner to corner. If blocks do not come out evenly, use just one piece or fraction of a block in every course.

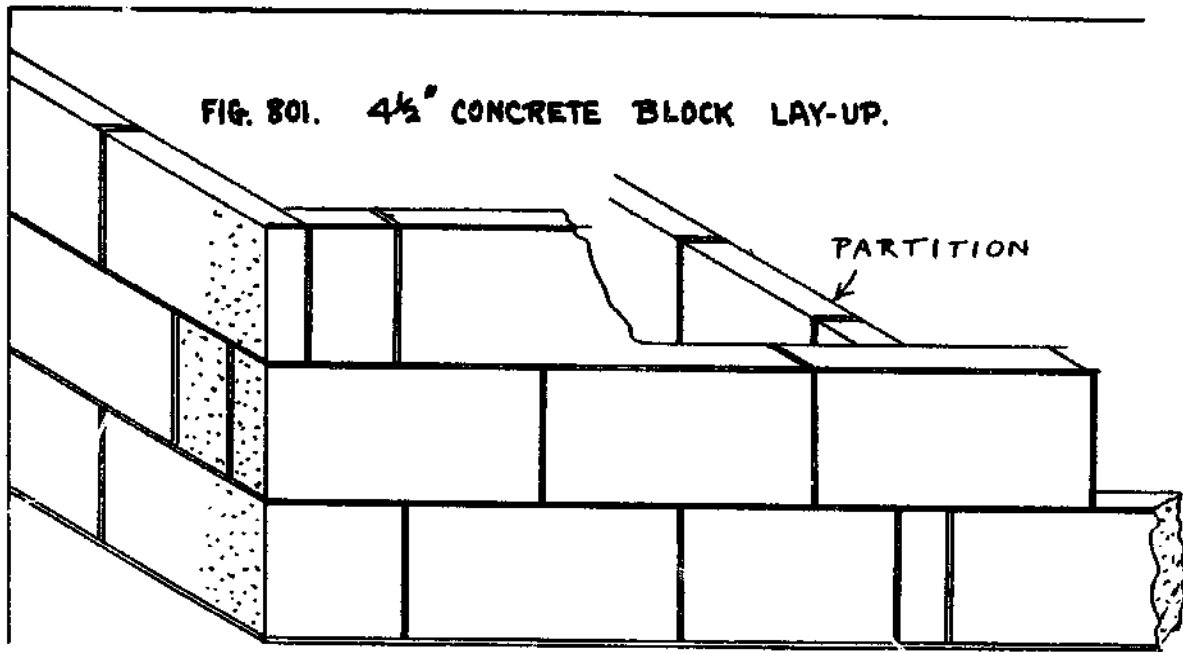


FIG. 801. 4 1/2" CONCRETE BLOCK LAY-UP.

II. SHOP MADE BLOCK MACHINE.

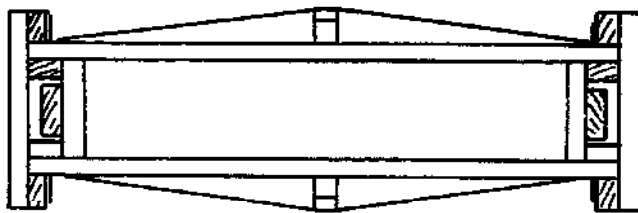


FIG. 802. TOP VIEW OF MOULD.

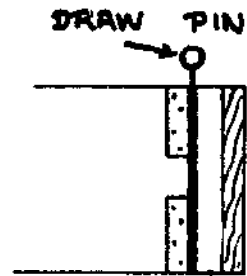


FIG 804.

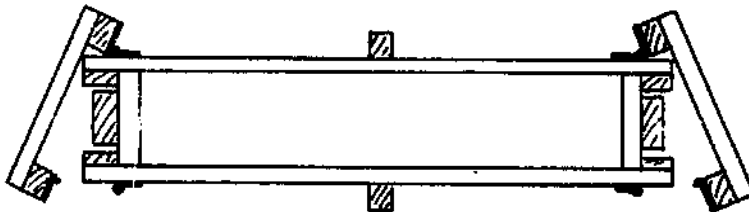


FIG. 803.

When the entire mould has been put together, the inside measures should be 4-1/2" X 11-1/4" X 23-1/4", or, of course whatever you have designed. The mould may have a sheet metal lining. Select the most seasoned wood; that

which is least likely to swell and warp. We have indicated how the grain is to run in the various pieces. Unless the side of the mould is of 1-3/4" lumber, an iron strap will be required to prevent bulging of the side when the cement is being tamped into the mould.

FIG. 805. SIDE OF MOULD

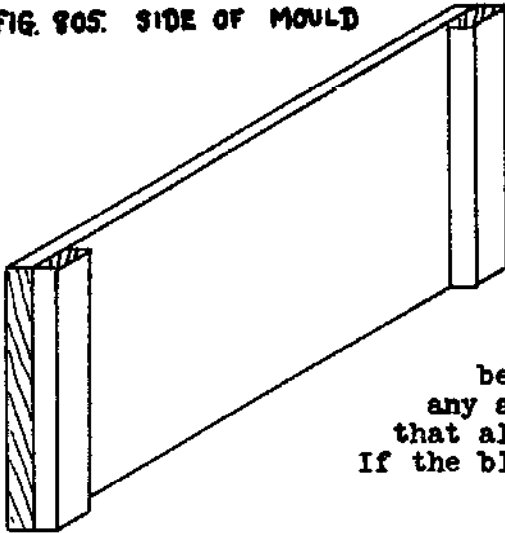


FIG. 806.

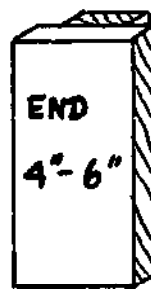
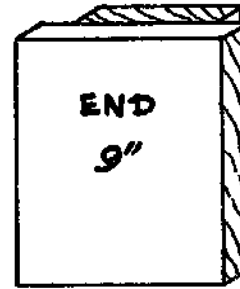


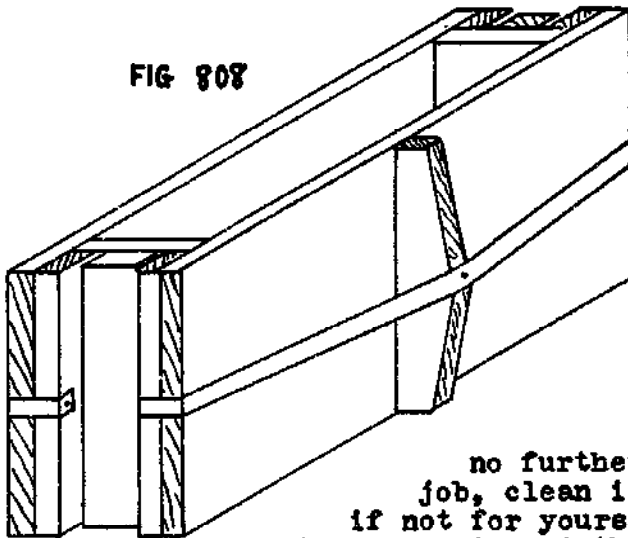
FIG. 807.



When the first block or two have been moulded, measure them and make any adjustments needed in the mould so that all further blocks will be accurate. If the block is bulged even a little along

the side, the iron strap must be tightened. To do this, insert a metal wedge between the strap and the vertical batten holding it out from the side. If perchance the block is thinner in the middle than at the ends, the strap is too tight and a shaving or two must be removed from the batten. Keep the mould clean and oiled. Kerosene is probably the best treatment to prevent rust and clinging of cement to the metal or wood. When you have

FIG. 808



no further use for the mould on one job, clean it carefully and put it away, if not for yourself, then someone else. Keep the draw pin and the hinges well oiled. The bottom corners will be much sharper and accurate if the

lower edges of the mould are bevelled a little away from the block. This will make it possible for the moulding edge to rest more directly on the ground than if a square edge were on the ground. The ground itself should be as smooth, even and hard as possible. If you desire to have accurately made blocks, make a floor of mud and finish it as you would a concrete floor. The blocks are moulded in rows. To save space, arrange the mould so that when it is being unfastened from one block, the end which swings will swing away from the last block made.

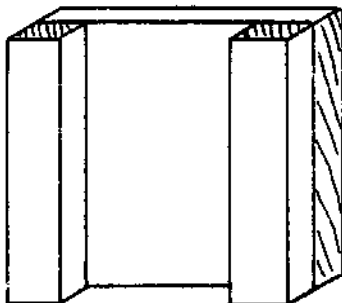


FIG. 809 CLAMP

Parts order for the concrete block mould illustrated herein.

	Thickness		Height		Length
2 sides.....	1-1/8"	X	11-1/4"	X	30-1/2"
2 ends	7/8"	X	11-1/4"	X	4-1/2"
2 ends	7/8"	X	11-1/4"	X	9"
2 clamps.....	7/8"	X	11-1/4"	X	12-1/4"
2 clamps.....	7/8"	X	11-1/4"	X	16-3/4"
4 battens for sides.....	7/8"	X	2-3/4"	X	11-1/4"
2 battens for 4-1/2" ends.....	1-1/4"	X	2-1/4"	X	11-1/4"
2 battens for 9" ends.....	1-1/4"	X	6-3/4"	X	11-1/4"
4 battens for 4-1/2" clamps...	1-1/4"	X	2-3/4"	X	11-1/4"
4 battens for 9" clamps.....	1-1/4"	X	2-3/4"	X	11-1/4"
2 brace battens.....	1-1/2"	X	2-1/2"	X	11-1/4"

The bulk order for the lumber dealer:

1 - 1-1/8"	X	11-1/4"	X	12'4"	dressed, sound, seasoned lumber.
1 - 7/8"	X	2-3/4"	X	4'	" " " "
1 - 1-1/4"	X	2-1/4"	X	2'	" " " "
1 - 1-1/4"	X	6-3/4"	X	2'	" " " "
1 - 1-1/4"	X	2-3/4"	X	8'	" " " "
1 - 1-1/2"	X	2-1/2"	X	2'	" " " "

The hardware order:

- 12 - 4" loose pin butt hinges, steel, as for ordinary doors.
- 2 - 20" steel rods for inserting in the hinges.
- 2 - 1/16" iron straps for side braces

A few nails for the assembly of the parts, but 3/16" flat head stove or carriage bolts for permanent fastening all parts and hinges.

III. MANUFACTURE OF CONCRETE BLOCKS.

Mixture. For ordinary walls, 1:6 is considered satisfactory. That is one part of cement to six parts of fine, medium and coarse sand. There is no objection to small gravel being added, but the cement-sand ratio must be maintained.

Since it takes some time to dispose of a mixture of concrete for blocks, only what you can handle in an hour should be mixed at one time. The common practice of mixing a large batch of cement and sand and taking from it little by little to dampen and use, cannot be too strongly condemned.

As in other types of concrete work, the less water the better. As long as each particle of cement has been moistened, and the tamped block will stand intact after the mould has been removed, there is enough water in the mixture. On perfectly dry sand sprinkle a very little water. Mix thoroughly until the sand has the feel and appearance of sand which has been rained on the night before and has somewhat dried out.

Spread about 3" of the mixture in the mould and tamp with a 3" X 3" pounder; continue in layers until the mould is full. The mould is gently unfastened and removed. Keep the hot sun from the blocks. Wet them when they can withstand disintegration by water.

CHAPTER FIVE. CONCRETE WALLS, COLUMNS, JOISTS, BEAMS, AND FLOORS.
I. WALLS.

Wherever possible use excavation walls for the outside forming of concrete. Wherever possible use mud brick walls for concrete forming. If lumber must be used, have plenty of 2" X 4" or 2" X 6" uprights, in pairs, and have good joints in the wood

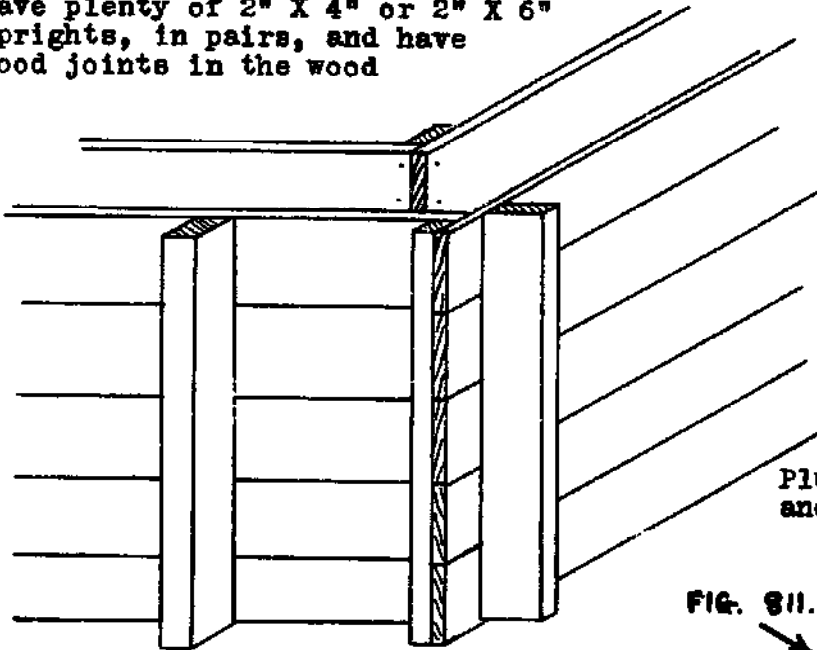
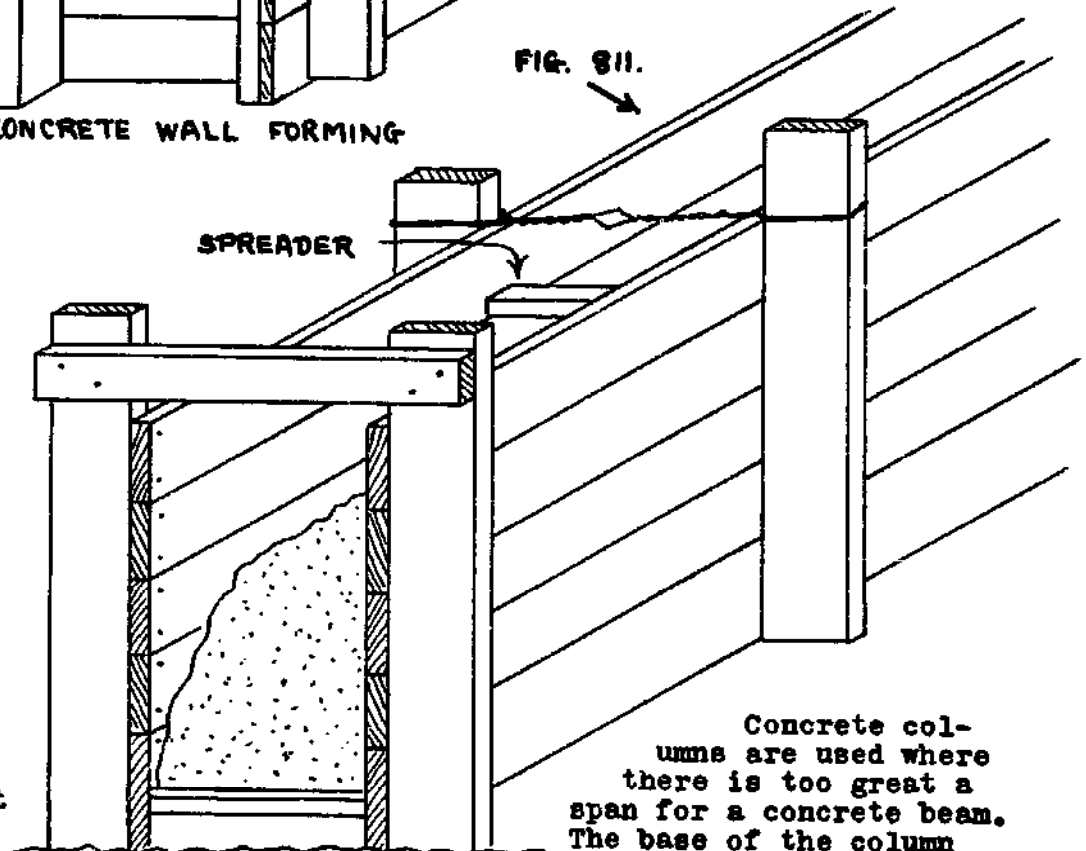


FIG 810 CONCRETE WALL FORMING

forming to retain all the water which would emerge from the new concrete. Each pair of uprights must be bound together by wire, twisted until the boards of the forming press on the wood spreader, which is the thickness of the wall. For ordinary buildings, 6" to 8" is plenty of thickness for a concrete wall. Plumb up the wall forms and brace them securely.

FIG. 811.



Use a hoe or long spade to compact the concrete in the form. In a long stretch of thin concrete wall use a pilaster to stiffen it. Short walls receive stiffening from cross walls. Leave forming up for at least 4 days.

Concrete columns are used where there is too great a span for a concrete beam. The base of the column

II. COLUMNS.

Column forming.

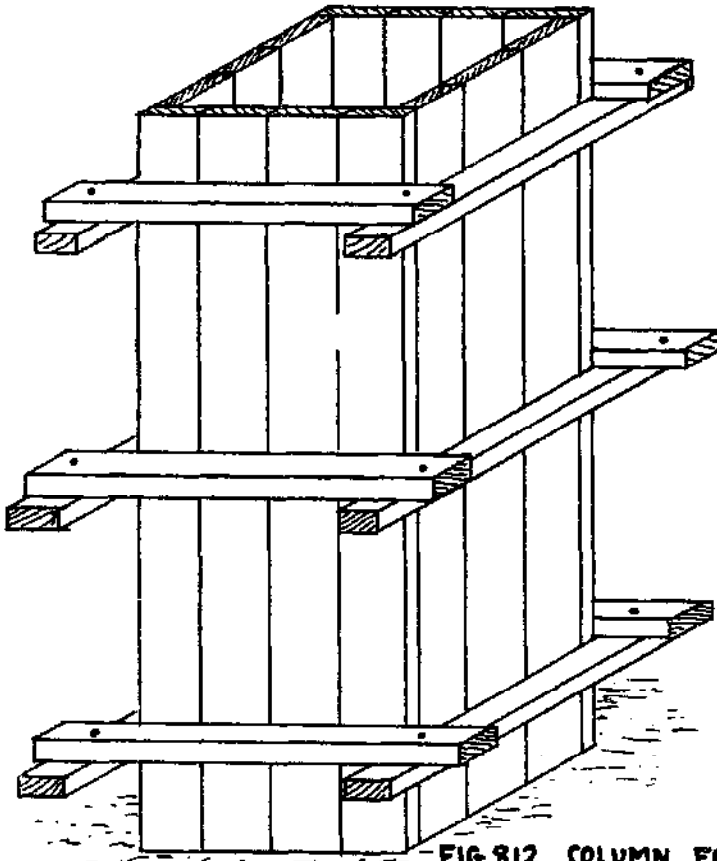


FIG. 812. COLUMN FORMING.

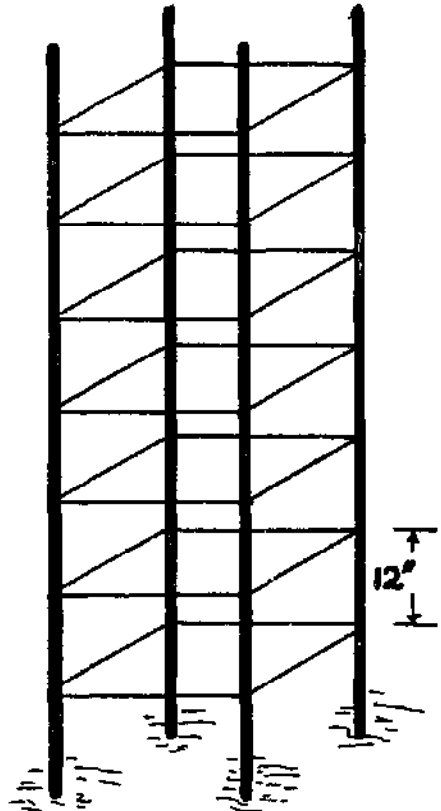


FIG 813 COLUMN REINFORCEMENT

should rest on the hardest earth level which is practicable, and should be at least four times the area of the cross section of the column. It must bear the column always without the least subsidence.

BEAM 8" WIDE 12" DEEP

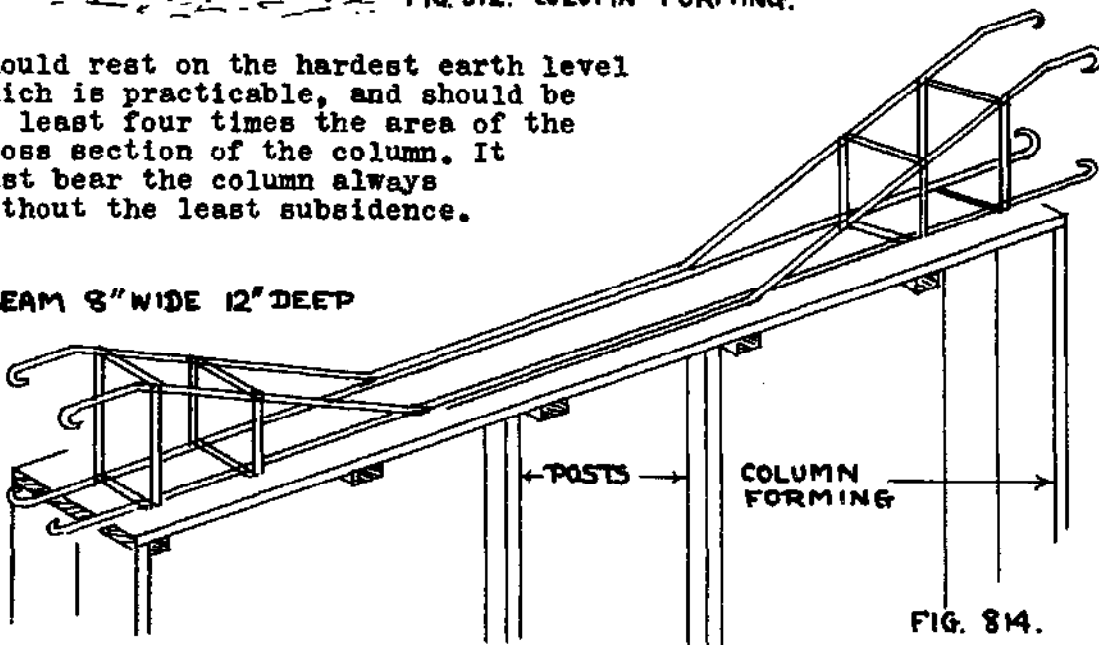


FIG. 814.

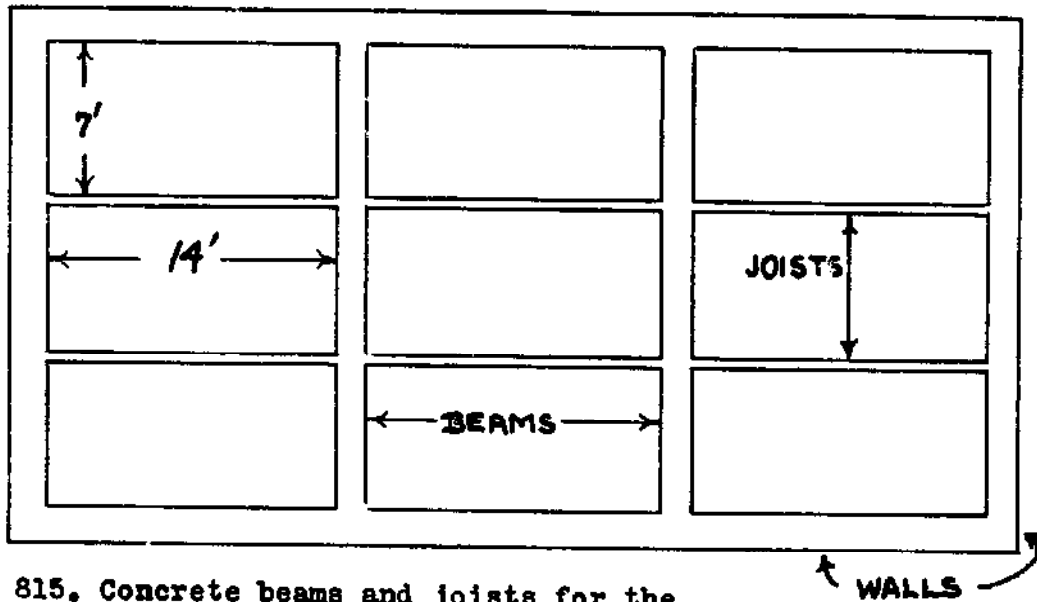


Fig. 815. Concrete beams and joists for the support of a large reinforced concrete floor.

FIG. 816. SECTION OF FLOOR AND JOISTS 3" EXPANDED METAL

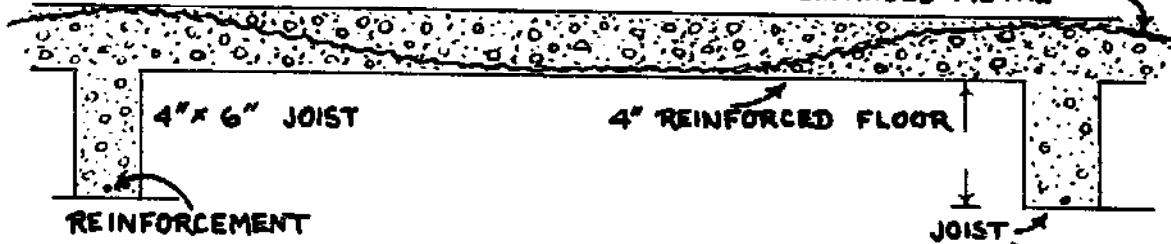
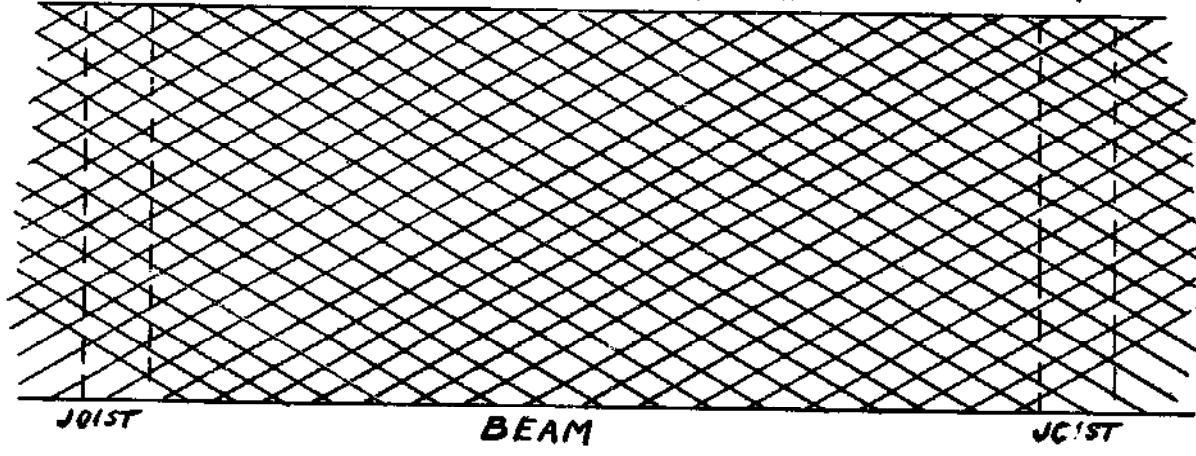


FIG. 817. TOP VIEW OF EXPANDED METAL



The base should be a pyramid rather than a flat slab. The usual reinforcement is a square frame with hoops of iron every 9". The vertical posts should be 1-1/2" back from the face of the concrete. For columns up to 8" square use 3/8" vertical rods with 3/16" wire hoops; columns up to 12" square, 1/2" vertical rods and 1/4" hoops; and up to 18" square, 5/8" or 3/4" vertical rods and 3/8" hoops. The column forming is left up until the beams and the floor have been in place for about ten days.

III. BEAMS.

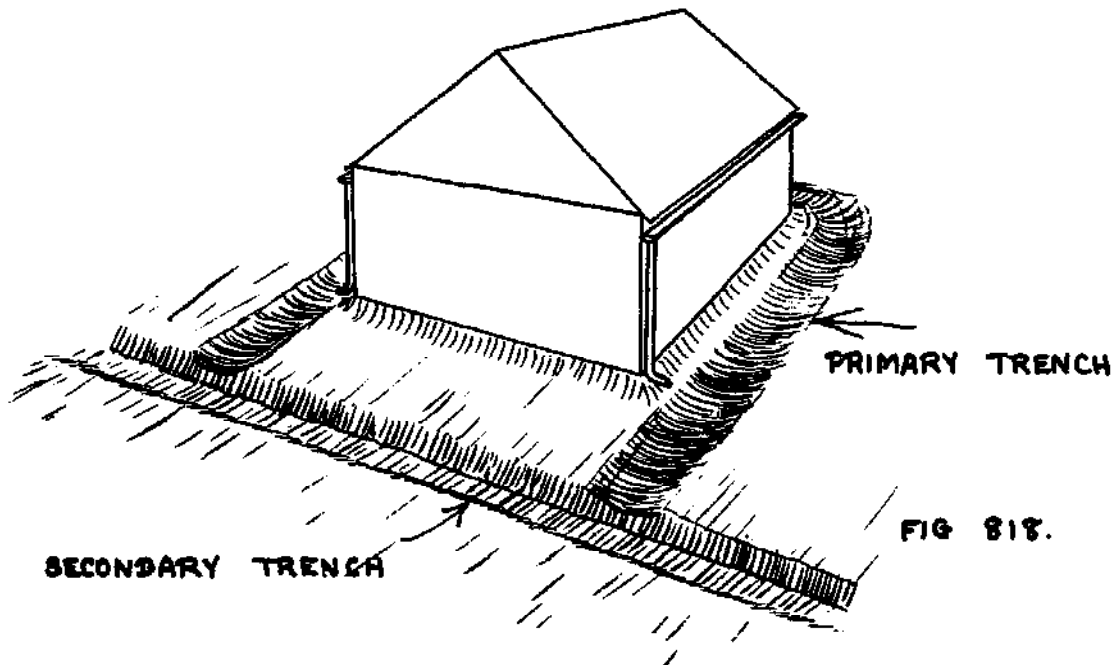
Fig. 815 shows why beams are used and how. The floor has support at short intervals, on concrete joists, and these in turn require support. In the example, we suppose a room about 22' wide and 44' long. The joists are about 14' long. The entire boxing of the beams and the joists and the forming of the floor are put in before any concrete is poured. The beams, joists and floor are one piece. Fig. 814 shows the general layout for the steel reinforcement for an ordinary beam. The one shown here with four 3/4" steel rods as arranged would be sufficient for a 15' span provided there was no special load above. The beam in this case would be about 12" deep not counting the floor thickness. Where possible, an engineer or architect should be consulted about the exact dimensions of the whole layout, but what we give here is the general scheme and proportion of such work. Since each job is different, this presentation is more of an idea what is required in concrete floor construction than it is a working drawing for any job.

IV. FLOORS.

The space between joists and beams is called a bay. The distance from joist to joist is the span of the floor in the bay. But the expanded metal must be crosswise, from joist to joist, and not along the length of the bay. In Fig. 817 the metal is lengthwise with the beams. It must never be the other way. Do not allow metal to joint midway between joists. Let it meet over a joist. It may have a lap of two complete apertures or diamonds. We prefer to lap it once and bind it with wire at the joint. The side lap is just one diamond. Note in Fig. 816 that the expanded metal is near the floor surface over joists, and near the lower face of the floor between joists. Lay the expanded metal over the entire floor, pour about an inch of concrete, then lift the metal so that it rests upon this one inch of material. Then pour all but the very top of the floor and lift the expanded metal so that it will have the desired elevation along the line of the joist.

Apply the top coat of the floor at once as for an ordinary earth supported floor. There should not be any movement upon the floor for four days. The forming should not be removed for at least ten days, and even then it is well to support the floor and joists with posts for another six days. If the support is taken away from concrete floors before they have acquired sufficient set, they will sag. The floors and joists outlined herein are satisfactory for domestic use. Avoid concentrations of people, jumping, or any other stress for which the floor is not designed.

CHAPTER ONE. GRADING AND DRAINAGE.



For preserving the foundation of the building, as well as for health purposes, the area around the house should be well drained of surface water.

If possible, have gutters and down pipes to take roof water and lead it away from the immediate vicinity of the walls.

Bushes and flower beds right against the house may have to be sacrificed to safety for the building. The earth at the wall should shed water readily and slope toward a shallow trench, which if necessary should girdle the house. This leads directly or indirectly to a secondary trench or ditch which carries off the water to some distance.

If the house is on a slope, cut across the slope at some distance from the house, and more than once if necessary, to carry off water coming down the slope, to prevent the house area becoming saturated.

CHAPTER TWO WATER SUPPLY. PLUMBING

I. CITY SUPPLY.

Even though the water piped to the house has been chlorinated, it may be wise to boil all which is used for human consumption, cooking water included. There are several chances of contamination.

II. ARTESIAN WELLS.

Usually these are expensive because of the drilling machinery required to bore a deep well for the pipe. In home

countries there is a sand point which can be driven through sand and loam for twenty or thirty feet to reach water levels, but it is doubtful if this type of well can be driven in the soil of those tropical countries where there is no rain for six months at a time, or where there is very hard earth or shale to be pierced before water is reached. A pipe, up to 2" in diameter has a screened point attached to it, and this is pounded into the earth where there is believed to be water. A hand or electric pump at the top makes the delivery to a pail; or, further up the pipe to an outlet.

Locating water. We have never seen water located by the divining rod, but we are satisfied through reliable witnesses that it has been done. When you wish to search for a suitable location for a well, cut a green stick about 1/2" or 3/4" in diameter and about three feet long. Hold it at each end, with the curve upwards. Where there is water, the stick turns downwards. It is possible that with some persons this phenomena will not occur. So take several persons along on the expedition.

Water piped from a distant stream. If there is water above the level of the Mission station, it only needs a simple pipe line to deliver it. In one instance, the outlet of a spring was in a dark cavern high up in the hills where the local inhabitants were afraid to venture. A small dam was built and a one inch, screened pipe led from it. The overflow was ample for the needs of the village people. The pipe was laid on the surface of the earth and it was exposed to the tropical sun so that at almost any time during the day, the water was literally 'piping' hot.

Where the stream is below the level of the outlets, build a dam and instal an automatic pump. Some are called 'Hydrants'. This pump receives all the water you can lead to it, is motivated by that force and sends between one fourteenth and one seventh of that water up the pipe to your compound level. The water used for the Hydrant should be well screened at the dam. Do not construct a dam for this purpose until you have contacted the manufacturers and received instructions.

Common wells are used extensively, by necessity. Take care to have all drainage, especially of septic tank variety, strictly isolated. Build up a mound for shedding water in the immediate vicinity of the well mouth. Cover the well mouth with a concrete top with a safety box opening.

When the well is being sunk, at the first sign of collapse of the walls, make well linings and protect yourself as well as the well. The well linings, described in Book Four, Concrete, are placed in position. Earth is dug in such a way that the lining settles. If the well goes dry, dig further down, and keep adding sections of lining to prevent cave in at the point where the linings were first required.

Rain water. This is collected from the roof and stored in what may be called temporary cisterns which hold between four hundred and a thousand gallons. They serve fairly well in the rainy season, but will not serve more than a few days after the last rain. Below-the-ground cisterns are being used more and more, the chief objection to them is that so many have failed. The water has leaked, considerable trouble is experienced getting water elsewhere, and, the investment is lost. We have described the construction of a cylindrical-

al cistern, the cheapest type, in Book Four.

Drinking water. This comes under the heading of equipment rather than buildings, but it is so important an item, and is so frequently a problem, that we give the following from our experience.

It has to do with adequate supply, cooling, and, freedom from ants, vermin and other sources of contamination.

For an ordinary family, boil four gallons of water each day for drinking water and the washing of fresh vegetables. Have two four gallon cans so that one can stand and cool while the other is still being used.

Always at night, the last thing, and sometimes at noon after the noon meal, empty the water from the filters into the cooling jar which is a spherical, four gallon jar of burned earthenware, slightly porous. The filters are refilled from the four gallon heating can. By morning, the filters will be full of filtered water, about four gallons; the jar will be full of cool drinking water, and there will yet be the water heated the previous afternoon. This system has never failed us.

The heating can should have only a very small opening so that the water will not be smoked. The water cans are used for nothing but drinking water. If the water you are compelled to use is very muddy, have as many as four or even six cans, and keep them in order. What is boiled, (and be sure it does boil for at least five minutes) today, can stand and cool and settle for as many days as you have cans for. Provide a large, clean cloth cover for each can.

To settle muddy water add alum, five grains per gallon. Where there is muddy water you may require more than the the two filters, which under ordinary conditions are sufficient for a small family.

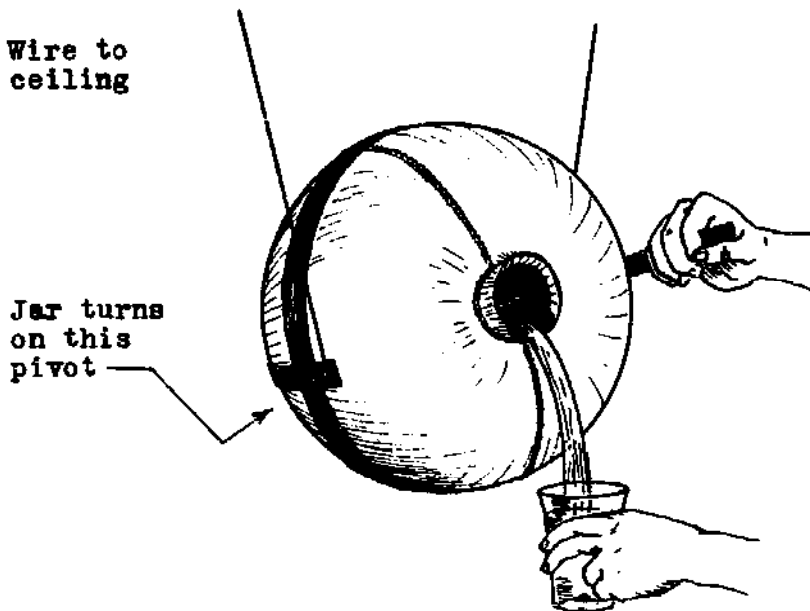
When the filter candles clog too quickly, scrub them with a special brush kept only for that purpose. The candles need not be removed at every cleaning, if a brush is attached to a long handle.

When buying filters, get at least two candle capacity type. If you have facilities, make your own filter and have as many as four candles in the upper chamber.

The earth jar container when we were first introduced to it was accessible to ants, and susceptible to frequent breakage. To eliminate both, we made a metal basket for it and suspended it from the ceiling. A handle at the right side enables a person to turn the jar with one hand, and with the other hold the glass or jug receptacle. The mouth of the jar is about three inches in diameter; large enough to permit cleaning from time to time, and small enough to cover with a can which rests upon the surface of the jar.

The cooling is accomplished by the evaporation from the jar. It works much better in the dry season of course. There may be enough evaporation to require no drip pan below the jar, but if evaporation does not take care of all that exudes, a drip pan will be required.

The metal basket for the jar is made of bale iron, about 1/16" thick and 1-1/2" wide. One band passes completely around the horizontal circumference and the other, fastened securely to it, starts just above the first band, passes underneath and projects far enough above the band on this side to make, or be fastened to a handle. The basket should hold the jar so that when full, the jar will be just a little bottom-heavy. The horizontal band will be just



above the equatorial circumference for best results, but not so far that the turning of the jar is inconveniently difficult. When you are buying the jar, and since they are so inexpensive, get at least two the same size so that if replacement is necessary the basket will not have to be altered. The bottom of the jar should be about 3'6" from the floor. If you need to order the jar from the potter, it is about 15" in diameter, and the material

Fig. 819. Four gallon water cooler and reservoir.

is about 3/8" thick average. It is burned enough to hold water, but not enough to prevent a slight transpiration, which with evaporation cools the jar and its contents. Never hang the jar in the sun. Try to allow it some circulation of air.

CHAPTER THREE HOT WATER SYSTEMS.

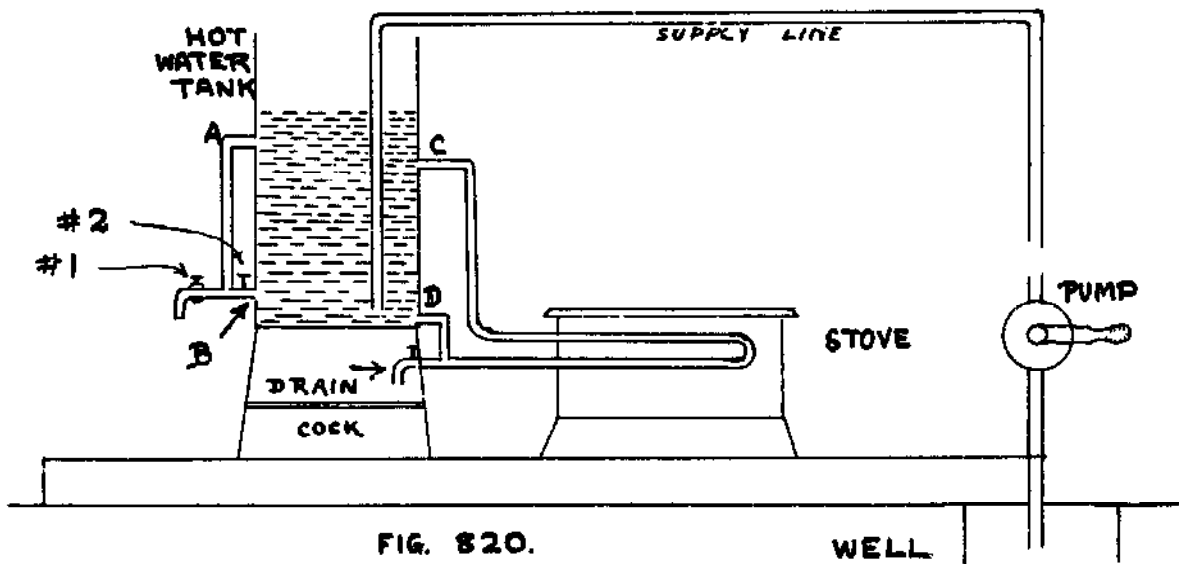


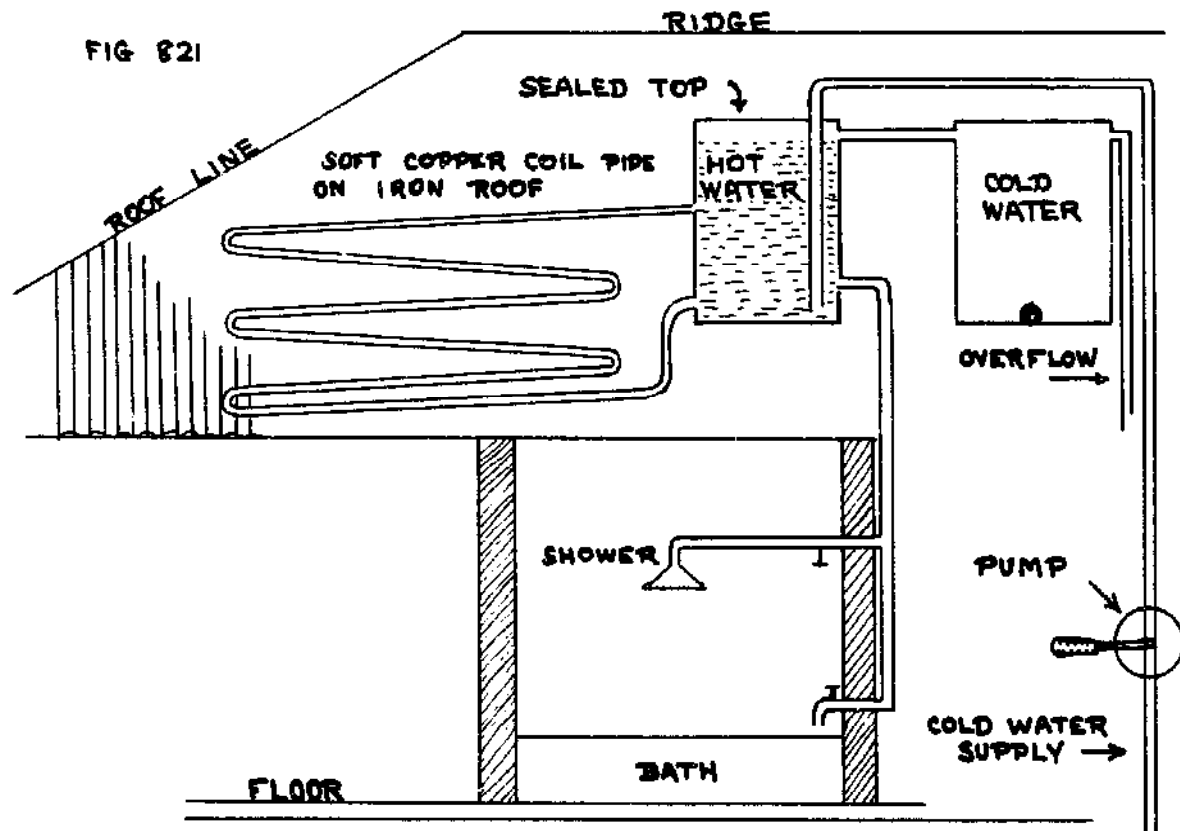
FIG. 820.

In Fig. 820, water is pumped from the well to the reservoir. The latter should be full before there is fire in the stove. Keep the pipes from the tank to the coil and back to the tank in the same relative position as shown here. The outlet A can be used entirely when there is only a small demand daily, or, it can be used to draw off hot water before the tank is full. By closing valve NO.2, outlet A from the tank operates. By opening NO.2, water is drawn off from B. A is a little above C so that when it fails, it will be warning to fill the tank again in order to keep up circulation of the coil. When water from B and NO. 1 fails, it is warning to fill the tank so that there will be no possibility of the coil going dry. B is placed above D so that there will still be water in the coil even though all the hot water is drawn from the tank.

The cold water supply pipe is run to the bottom of the tank so that at any time there is hot water it will not be chilled by cold being poured in on top of it.

Another type of water heater is a small firebox built for water heating only. It may have a coil from the tank, or may be built right under the tank. If the tank is high enough to give gravity supply to the house fixtures, it will save trouble.

We offer the following copper coil heater with the approval of a plumber. It has often been talked about, but we have never seen it in operation. It is well worth while where firewood is scarce.



Use $3/4$ " soft copper tubing; make the bends over a 4" diameter circle of wood or metal. Run the pipes under the end lap of the roof pan. Tanks over the ceiling should have sealed tops and overflow pipe.

CHAPTER FOUR WASTE WATER FROM BATHROOM AND KITCHEN.

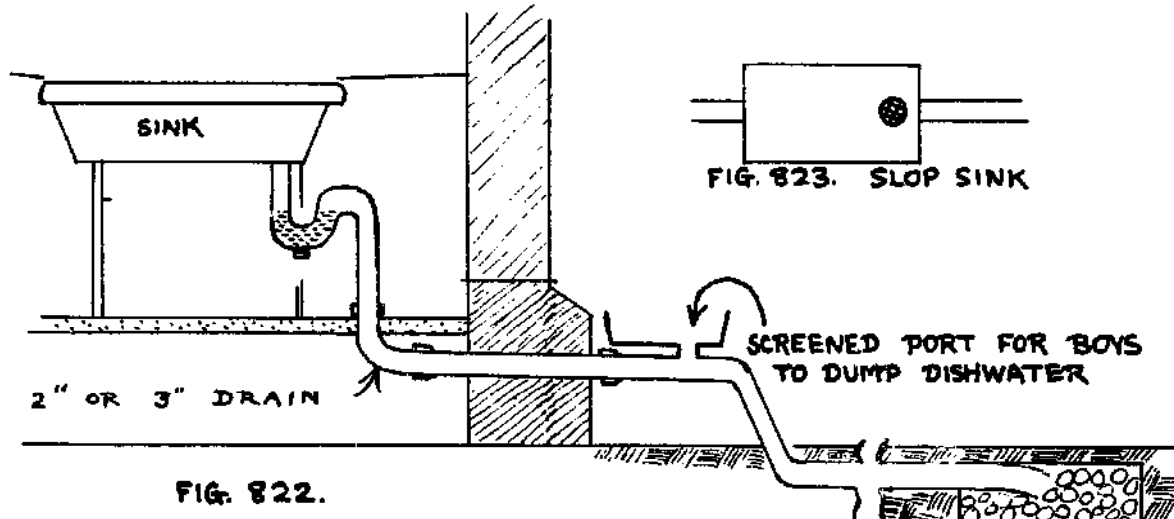


FIG. 822.

Whether there is a septic tank or not, all wash and kitchen water should be disposed of in a separate system. Trap the sink pipe to prevent odour from entering the room; outside, a screened port with a screened lid may be used for those outside the house. The screen should be removable so that accumulations of grease and other undissolved matter may be removed periodically.

The disposal pit is filled with stone, broken (burned) brick, gravel or cinders. The top is of loose boards and covered with a little earth. The top may have to be removed sometime to clear away excess grease.

CHAPTER FIVE. FLUSH TOILETS. SEPTIC TANKS.

Flush toilets require as much as 18 gallons per day for each person using them. Where there is running water, there is no question of keeping the equipment in a sanitary condition, but if there is any doubt about adequate supply, think twice about putting it in. There is a question of disposal for each toilet used. In restricted residential areas, there will be by-laws about the use of septic tanks and you should consult the authorities before going to any expense. Also, when permission has been given for such installation, have your drawings made, or at least approved by a competent plumber or someone who has had experience with these facilities. And, further, do not try to instal the system until all essential parts have come to hand.

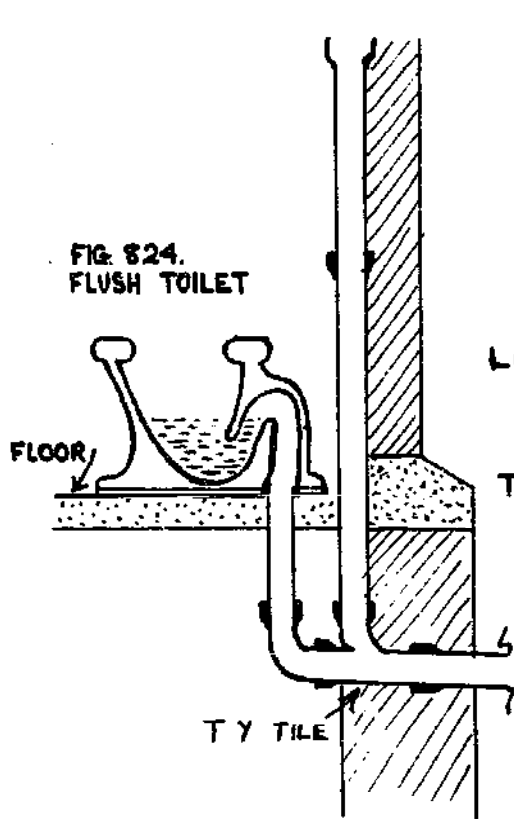


FIG. 824.
FLUSH TOILET

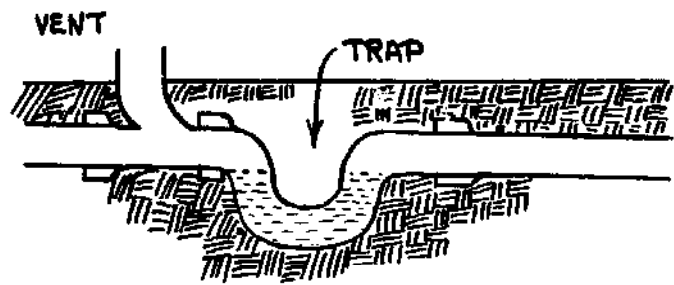


FIG. 825.

LOCATION
OF
TRAP

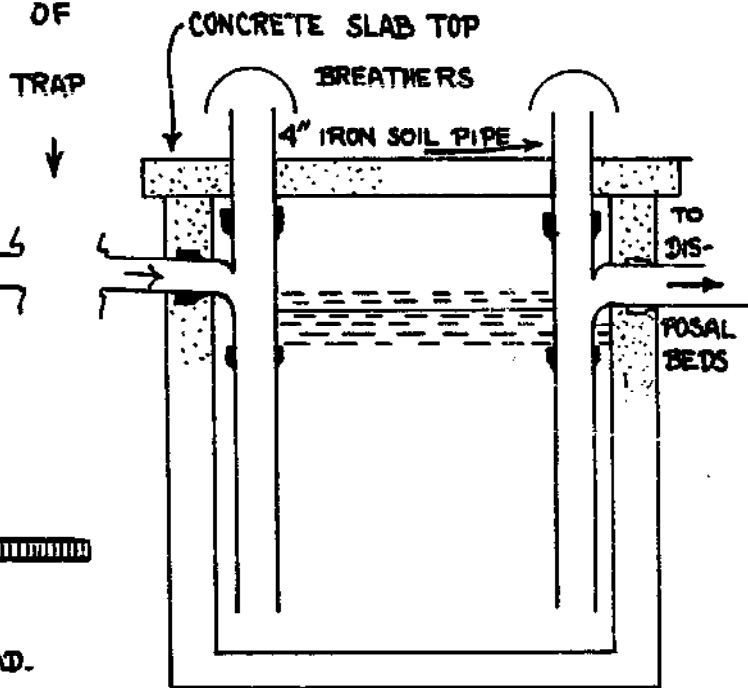


FIG. 826. SEPTIC TANK.

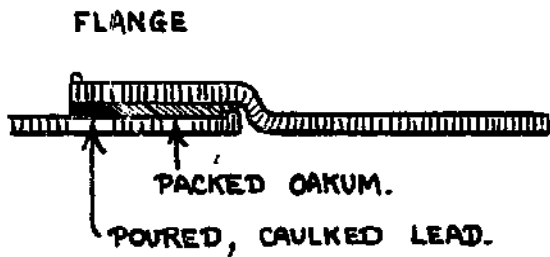
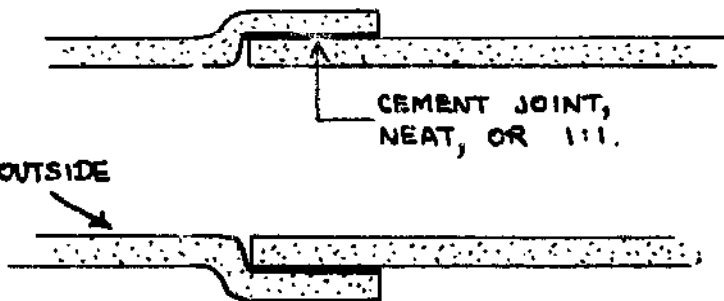
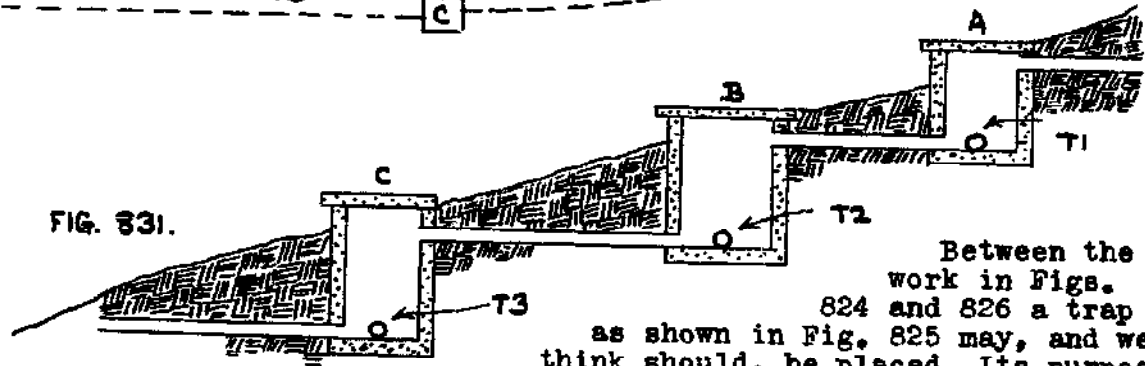
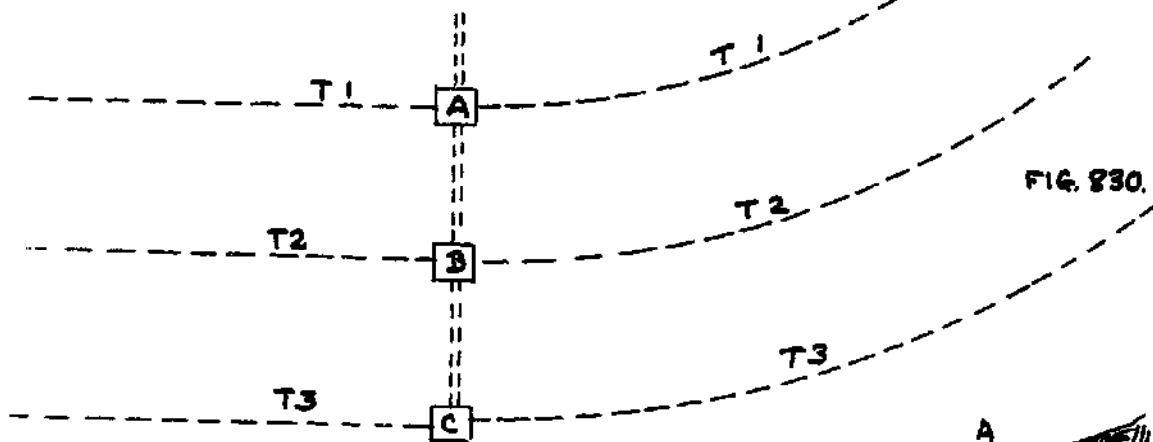
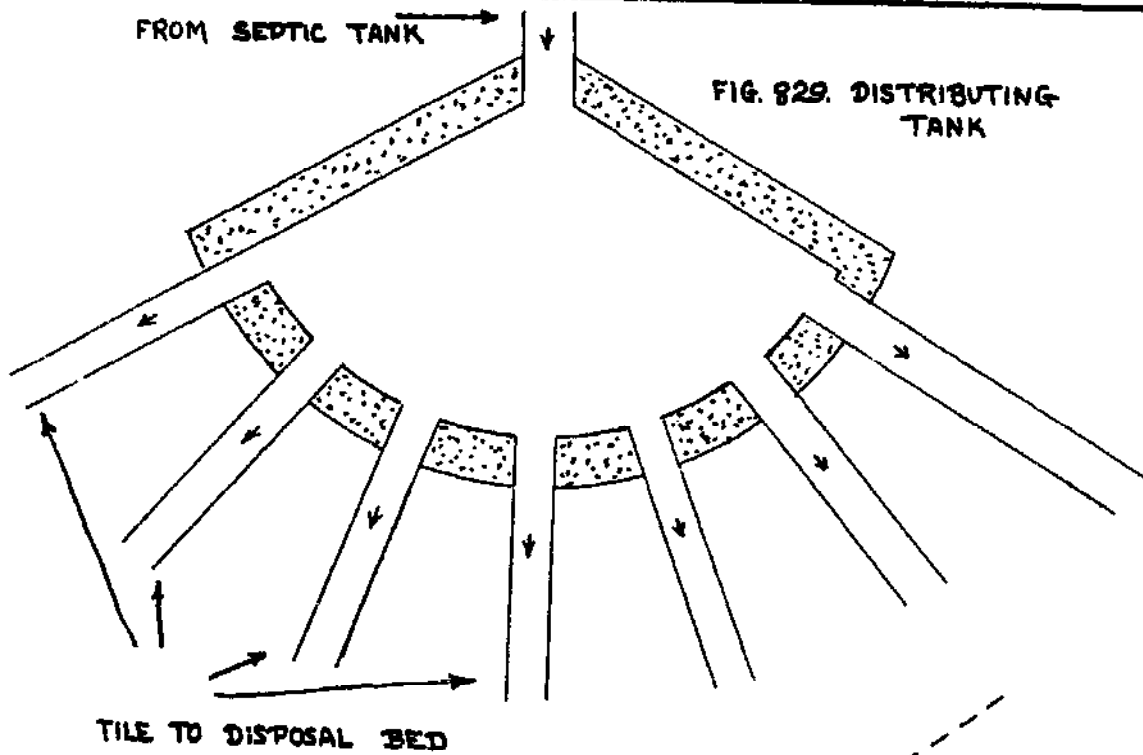


FIG. 827.
METAL PIPE FOR
INSIDE BUILDING

GLAZED SEWER TILE FOR OUTSIDE
FIG. 828.





Between the work in Figs. 824 and 826 a trap as shown in Fig. 825 may, and we think should, be placed. Its purpose is to prevent sewer gas entering the

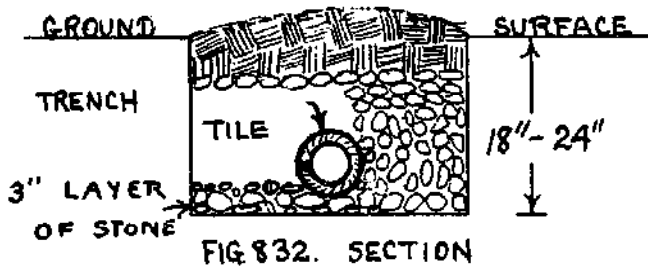


FIG. 832. SECTION

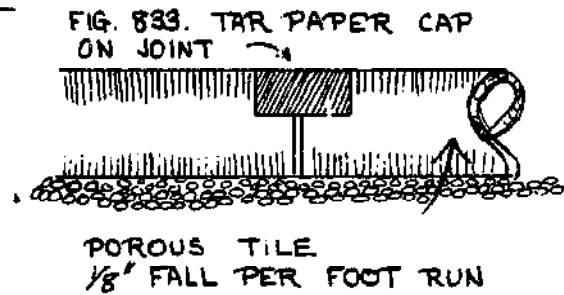
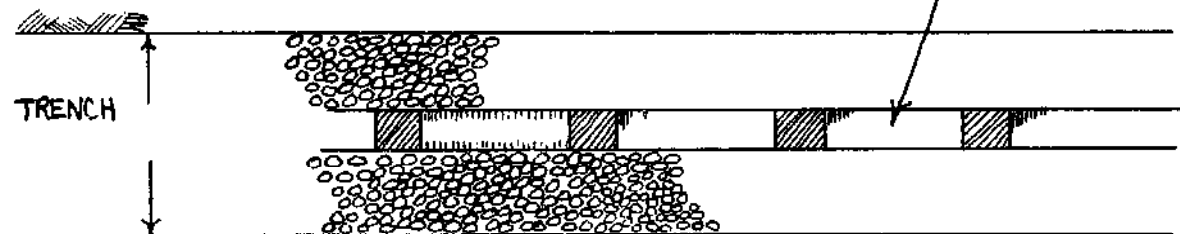
FIG. 833. TAR PAPER CAP
ON JOINT

FIG. 834. Top view of trench showing line of tile laid on a 3" layer of stone.

house. Some authorities insist upon it, others forbid it. Since we recommend the breathers for the septic tank, see Fig. 826, we also recommend the trap, because there is no pocket in which gas can become pressurized. The breather arrangement for the septic tank is also a simple method of cleaning the pipes.

All pipes within the walls of the house are to be 3" or 4" soil pipe, the joints to be arranged as shown, and caulked as in Fig. 827, first with oakum, well set to within one inch of the end of the flange; on this is poured melted lead, 4 lbs for a 4" pipe, and the surface of the lead also caulked. Outside of the house glazed sewer tile may be used, but the joints are to be filled with neat cement or cement and sand, 1:1. See Fig. 828. No pipes will be laid level, but have at least $\frac{1}{8}$ " fall per foot, away from the house. The vent pipe behind the toilet bowl may not be required by law, but put it in. Take the pipe from the septic tank a reasonable distance from the house, and away from the well. There are various ways of distributing the flow; we illustrate a fan arrangement which with mud brick forming will not be much trouble, and will eliminate a number of T Y tile. There is a trench for the tile beyond the distributing box; the water from the septic tank should soak away into the ground and also should be drawn by sun heat to the surface, hence do not make the disposal trenches deeper than about 24". The trench floor should not be less than 18" wide. It is covered by stone or other ballast to a depth of at least two inches, and then porous tile, sometimes called weeping tile, are laid from the distributing box outward for not more than 100'. The joints are capped with a piece of tar paper so that earth will not sift through and clog the tile. See Fig. 832,3,4.

Fig. 830 shows how to arrange a disposal bed on a slope, and Fig. 831 shows how to lead the sewage to each level for distribution. In the left hand part of Fig. 830, the slope is regular, without contour, and so the lines are straight, but in the right hand side there is a contour as well as a slope, and so the lines follow the contour. As before, the tile has a fall of at least 1/8" per foot run.

CHAPTER SIX DRY CLOSETS.

There is much difference of opinion about dry closets. Like other types of sanitary installation, it depends very much for its value upon proper operation. This again depends a great deal upon whether it is strictly for family use, or is semi-private. In the former case it may be located under the main house roof, but cut off from the living rooms by a bathroom, or be entered from a screened porch. It can be as inoffensive, almost, as a flush toilet, when ashes or dry sand or other dry cover can be kept on the surface in the bucket. It is practically impossible to ensure this condition when other persons, not immediately connected with the family, use the closet. A semi-public closet should be completely removed from all living rooms by dead walls, or be in a separate building.

Fig. 45, page 27 shows the long section of a satisfactory dry closet furniture. The seat is hinged and has a hinged cover. The side of the box fits into the trap door opening made for it. There is no access for rodents, reptiles, etc.

When the bucket of heavy metal has been bought, coat it well with tar, inside. This will preserve the bucket for a very long time, and make the task of emptying and cleaning it very much easier and less offensive. The bucket should stand in a little depression in the cement floor. Fastened to the under side of the seat there is a shield, the lower edge of which is just above the edge of the bucket. The edges of the shield are just within the rim of the bucket when the latter is in position. The least bit of attention will show whether the bucket is in its right position, and then the set up should give no trouble. The box can be fastened to the wall, and when no one is in the house, the lid of the furniture, or the toilet door itself can be locked in such a way as to make entrance to the house by way of the toilet practically impossible.

The bucket is emptied at least once a day and the contents placed in a prepared trench at a good distance from the house. Every deposit is covered by enough earth to prevent flies from settling on it.

Garbage also should have a special trench for disposal, but there should be some arrangement to prevent dogs and other animals from scattering it about.

Sanitation for servants. Provide a servants latrine, properly constructed, regularly attended to and inspected. Ask your local government officer for details. The latest approved latrine we have seen is a raised concrete floor with an opening just a little smaller than the large bucket used. The bucket is attended to through an opening in the lower level. The whole building is water washed each day, and, if roofless as many are, are further cleansed by the sun.

CHAPTER ONE. FLATTENING CORRUGATED METAL

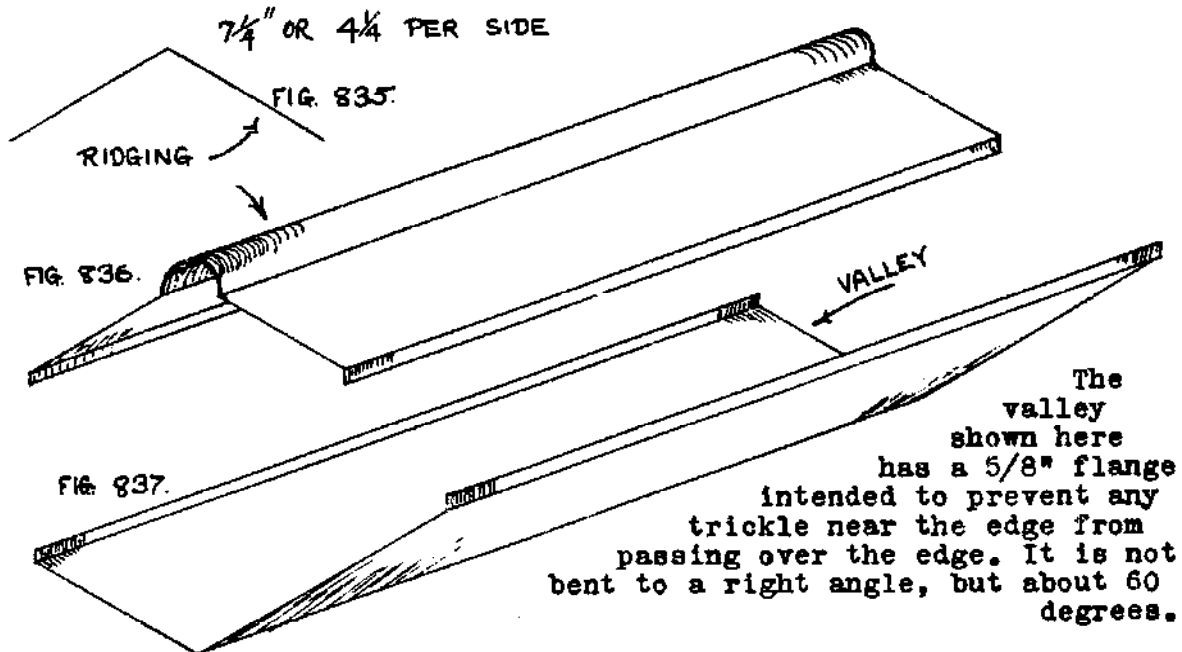
Many sheet metal articles are not available unless we take the corrugated iron, flatten it, and make what we want.

For hand work use 26 guage iron. Do not roll it at first. Lay the sheet on smooth earth or grass, without pebbles or bumps, and tramp out one corrugation at a time, starting with the outside one. Do not use heeled shoes, and do not press the iron with what heels you have. Use the ball of the foot. Press out the two outside ridges, one each edge of the pan, turn it over and do the next two, and so on until the whole pan is as flat as you can make it by that process. Now if you have a roller, roll each corrugation, again starting at the outside. This time it will not be necessary to turn the sheet each time. Next, cut the sheet in the general shape you want. If for ant coursing, split it down the middle. If you have no clothes wringers or any other kind of roller, make a 3" X 4" rounded bar and support it so that you can pass the iron over it and back again, gradually ironing out the remaining irregularities. Turn the iron over several times. The first time it is passed over the wood, it should not be drawn down very much, but as it smooths out, increase the angle of the bend.

If a small piece is required to be very smooth and true, work it over the bar front and back from end to end, then from side to side. Never strike sheet metal with a hammer to flatten it if you want a good job. Blows stretch the iron in one place.

CHAPTER TWO. RIDGES, VALLEYS, FACING, AND GUTTER.

The ridging may be patterned after the factory style, or it may be made plain. Valleys should be made plain. Valleys need to be much wider than ridging; pay attention to the measurements given.



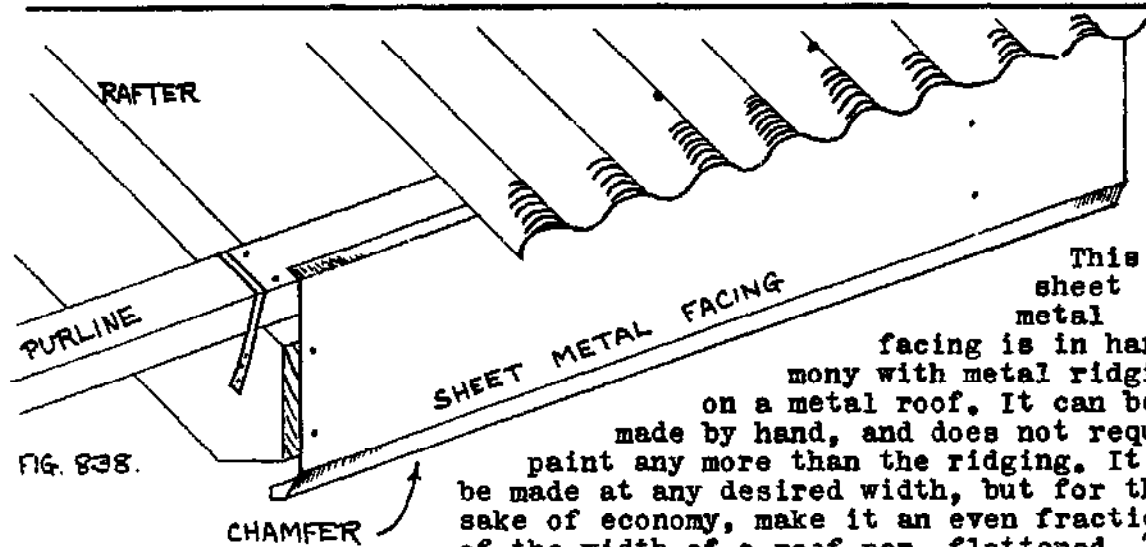


FIG. 838.

This sheet metal facing is in harmony with metal ridging on a metal roof. It can be made by hand, and does not require paint any more than the ridging. It can be made at any desired width, but for the sake of economy, make it an even fraction of the width of a roof pan, flattened. The usual pan gives 29" of width; this divided

by four gives an effective width to the facing of about 5-1/2". One third will give approximately 8-1/4" which would look like that in Fig. 838. Where joints do not come at rafter ends, make a wood block of suitable shape to which the lapped ends of the facing can be nailed.

In Fig. 839 one method of bending sheet metal is shown. Use your fingers in the preliminary stages of the bend,

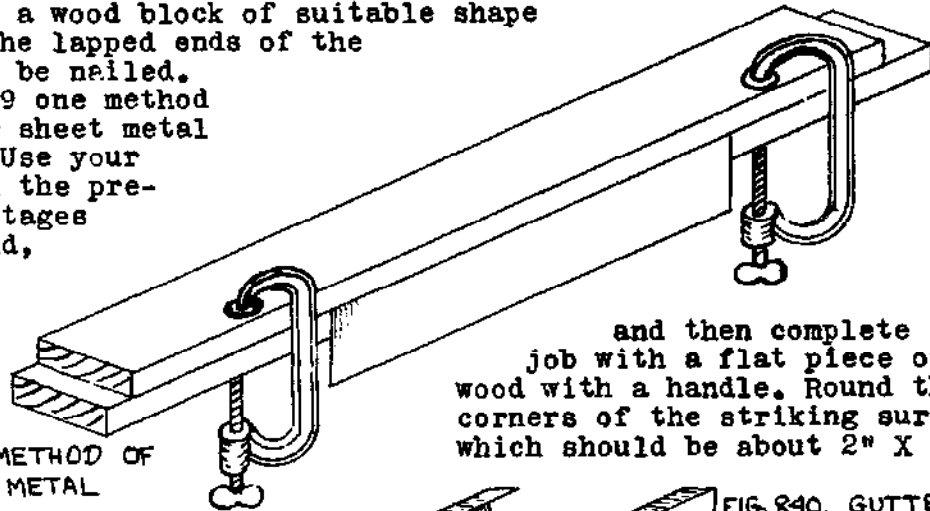


FIG. 839. A METHOD OF BENDING METAL

and then complete the job with a flat piece of wood with a handle. Round the corners of the striking surface which should be about 2" X 6".

When making gutters avoid waste by splitting the roof pan into

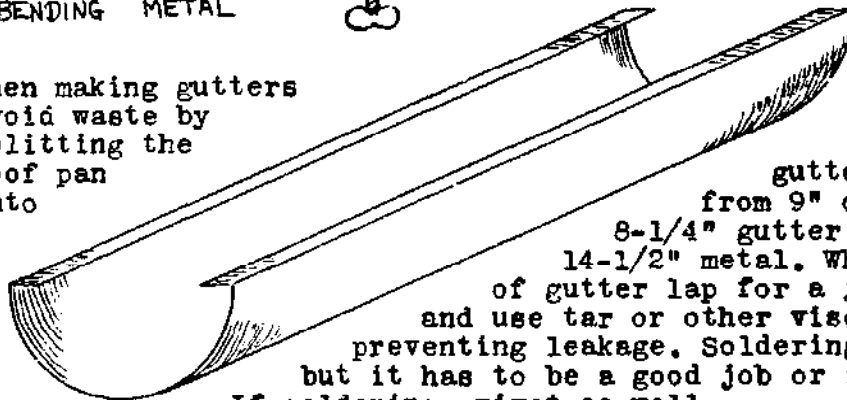


FIG. 840. GUTTER.

fractions. With 3/4" flanges a 4-3/4" diameter gutter can be made from 9" of metal, and an 8-1/4" gutter can be made from 14-1/2" metal. Where the lengths of gutter lap for a joint, rivet them and use tar or other viscous caulking for preventing leakage. Soldering is conventional, but it has to be a good job or it will crack open. If soldering, rivet as well.

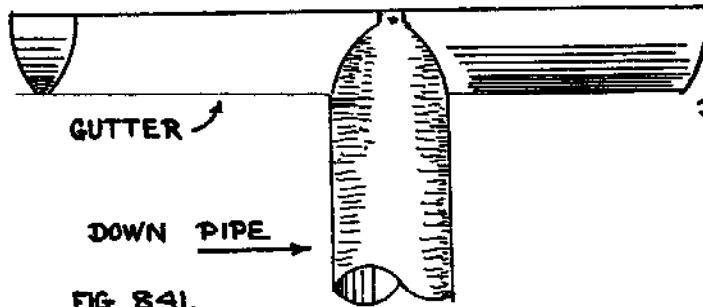


FIG. 841.

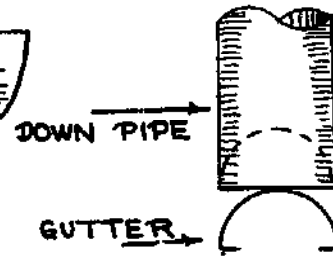


FIG. 842.

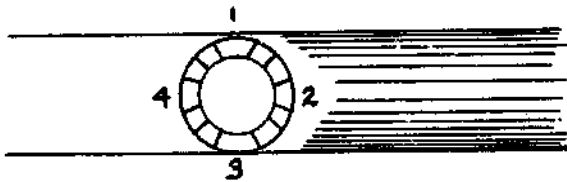


FIG. 843.



FIG. 844.

We have shown a straight down pipe connected with the gutter, the two being of equal diameter. The trade name for this part of a gutter is a spout. It is well to have the downpipe the same size as the gutter at the spout, but the pipe may diminish in diameter at once because the flow diminishes. Turn the gutter upside down as in Fig. 842 and place the downpipe on it as shown and mark the downpipe so that when cut it will fit the gutter. When it does, mark the gutter as in Fig. 843, outer circle, and then make an inner circle about 1" away from it. Cut out the inner circle and then cut it as shown by the straight lines. There should be wide pieces at 1 and 3 and narrow pieces at 2 and 4. Turn all these pieces so that they will fit up into the downpipe. Bolt or rivet the flanges to the downpipe at 1 and 3 always, and at 2 and 4 for the best job. When the two pipes are so fastened, gently hammer the flanges and other edges into a snug fit. More or less the same process is used for ends and corners. If the spout comes in the middle of a long line of gutter which slopes toward it from each end of the building, bend the gutter up at each end before rivetting it together.

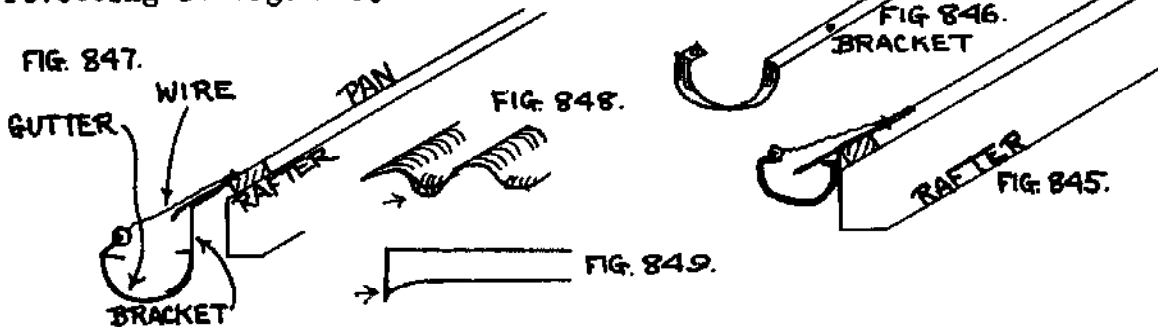


FIG. 847.



FIG. 848.

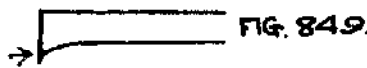


FIG. 849.

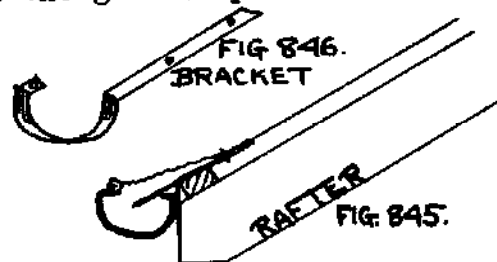


FIG. 846.

BRACKET

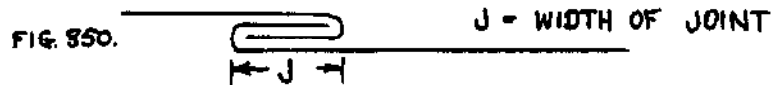
FIG. 845.

In Fig. 845 the gutter is pressed up as far as it will go at the high end, or that furthest from the spout. Fig. 847 shows the gutter at its lowest point near the spout. Strap iron 1/8" thick is ideal for the brackets, but thinner metal will do if strengthened by the wire from the end of the bracket to the bolt up the roof.

CHAPTER THREE STOVE PIPES, ELBOWS, CAPS.

It is worth while to make proper stove pipes by hand. A six inch pipe is average for stoves. This requires exactly 18-27/32" plus the metal required for the joint. Every joint requires three times the width of the joint. If one inch is needed to make a flange for a joint, then one and a half inches more iron will be required than the exact circumference of the pipe being made. The following table gives all exact circumferences for diameters from 1" to 12".

Diameter of pipe	Circumference of pipe.	Diameter of pipe	Circumference of pipe.	
1"	6-5/8"	7"	22"	To each of these measures add three times the width of the joint.
2"	9-27/64"	8"	25-1/8"	
3"	9-27/64"	9"	28-17/64"	
4"	12-9/16"	10"	31-13/32"	
5"	15-45/64"	11"	34-35/64"	
6"	18-27/32"	12"	37-45/64"	



To make a series of pipes fit together, one end must be a little larger than the other end of each length. The difference between the large end and the small end is made by adding seven thicknesses of the metal to the exact measure. Take seven small pieces of the metal, press them together tightly and make a record of their combined thickness. This is the difference between the large and small end of pipes which are to be joined.

Cutting stove pipe from a roof pan with minimum waste:

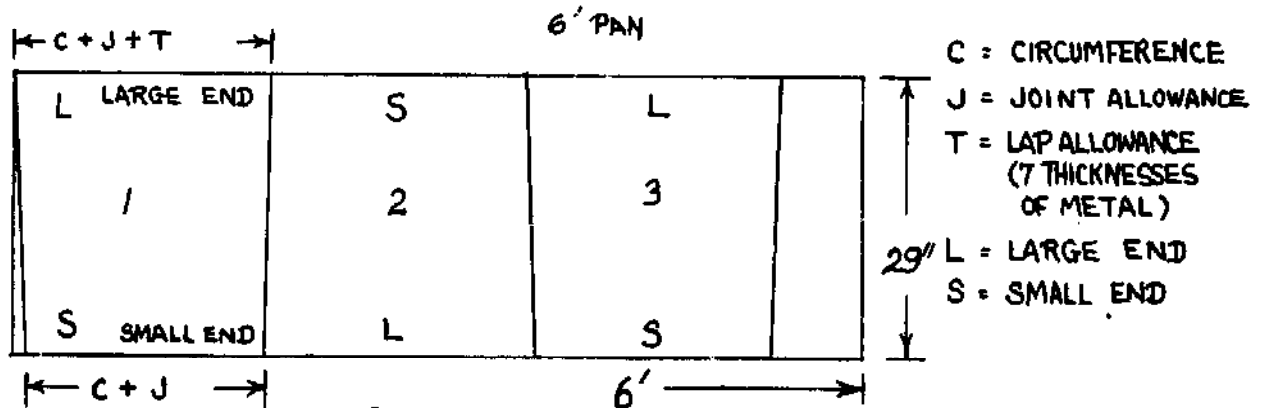


FIG. 851.

Without an elbow turning machine, it is hardly worth while trying to make elbows from round pipe. But the round pipe may be used as far as the elbow and then shaped into a square which is easily marked and cut. Since a column of smoke is circular in cross section, the square pipe which carries smoke from a 6" diameter pipe should accommodate a 6" circle; that is, the side of the square should be 6".

Since 45 degree elbows are better for draughts than 90 degree elbows, we will illustrate one such. If a 90 degree change in direction is required, make upper end of section 2 square also, and section 3 will be square at lower end and round at upper end.

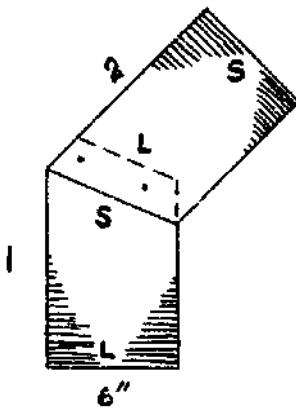
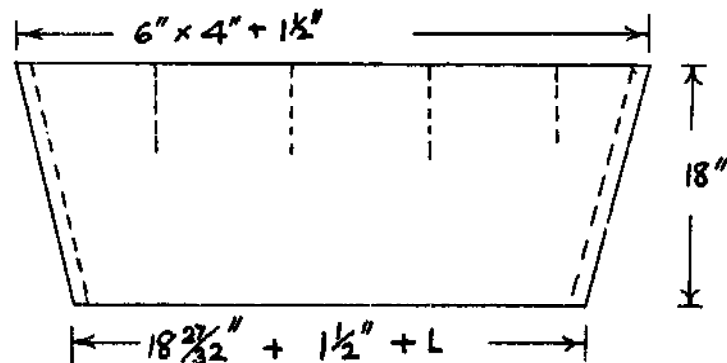


FIG. 852.

FIG. 853. SQUARE SECTION ELBOW WITH ROUND ENDS.



All smoke conducting pipes fit up into the pipe above; all water conducting pipes like down pipes from the roof, fit down into the pipe below. In Fig. 852, the flanges of the lower pipe are shown by the dotted line to be fitting up into the next section of pipe. They may be rivetted or bolted. Section 2 should be large enough to accommodate section 1, and on the upper end, small enough to enter the circular pipe just above it. The dotted lines in Fig. 853 indicate how to form corners and sides on a pipe which is square at one end; also how to avoid having the joint at a corner.

Metal chimney caps. We recommend a flat ceiling, half the diameter of the chimney pipe above the top of the chimney, and its diameter twice that of the chimney. In our illustration we give dimensions and directions for a cap for a 6" chimney stack.

Make a drawing like Fig. 854, to scale. The length of the slope will be found to be 7". On a 14" square sheet of metal lay out a 14" diameter circle. On another sheet of metal, lay out a 12" diameter circle, and cut it out. This is the ceiling. Now place the ceiling piece on the 14" diameter circle as shown in Fig. 856, and mark off on the larger circumference the length of the ceiling circumference. Join the starting mark and the finishing mark to the centre of the 14" circle. Make allowance for a flange on one of these lines as shown in Fig. 857. Also, make another circle outside of the 14" diameter circle to allow for a flange to turn in to hold the ceiling. Cut out the shaded part and then cut out the whole piece.

Shape it into a cone, turning the flange inside. When the cone is regular and the joint straight and tight, rivet it. Now mark out a 6" circle on the ceiling and

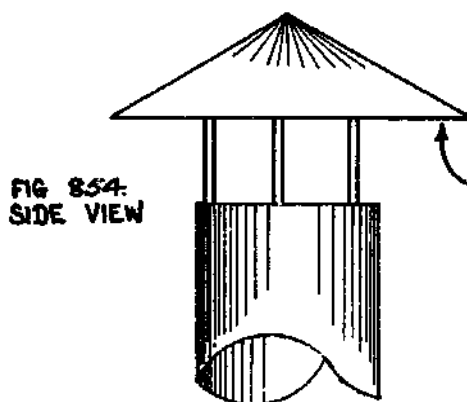


FIG. 854.
SIDE VIEW

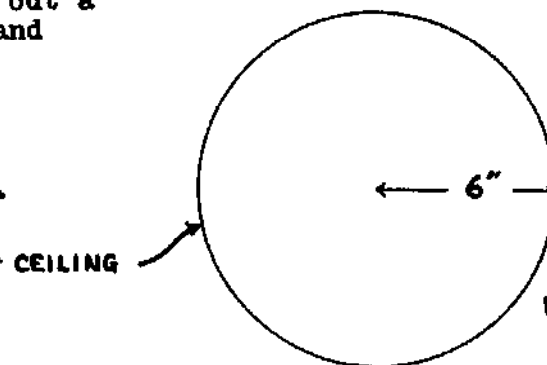


FIG. 855.

place the three posts. To determine their position, mark off on the 6" circumference, 3 points just 6" apart,

by placing the centre of the compass on the circle and making two arcs with 3" radius.

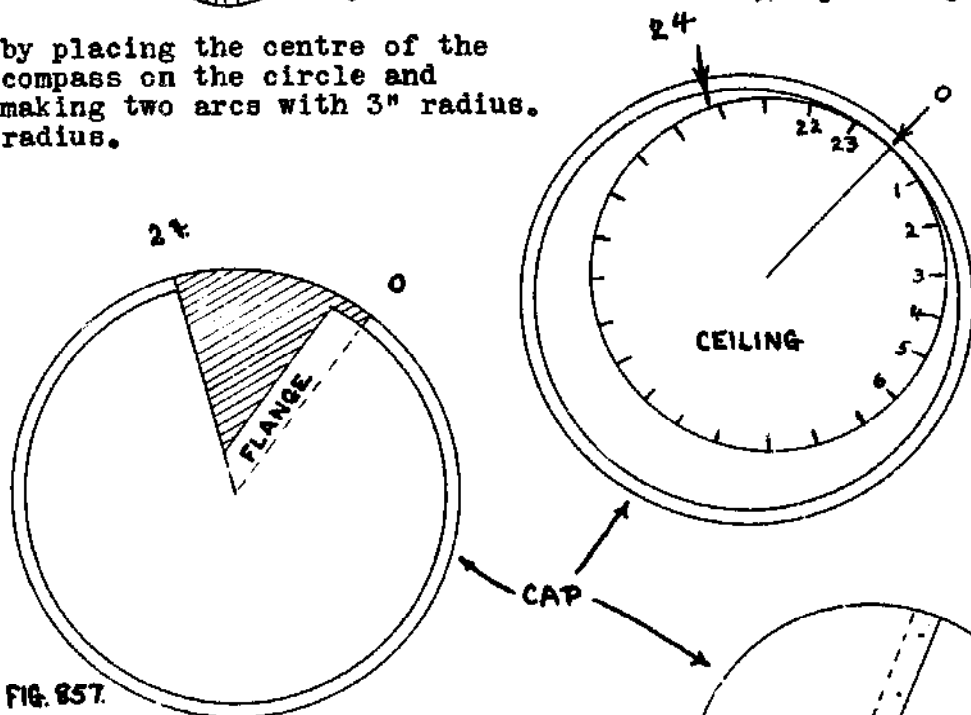


FIG. 856.

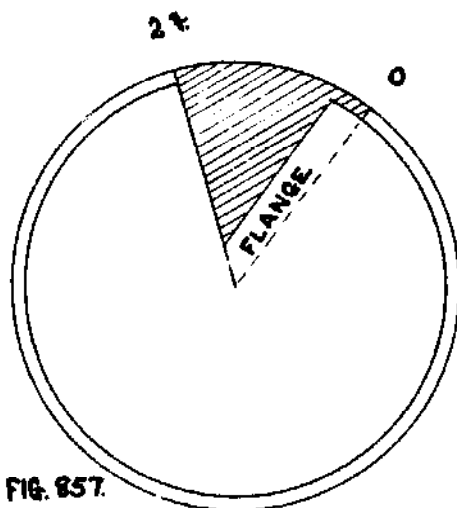


FIG. 857.

Turn a flange at the top of each post and fasten to the ceiling so that the posts when fastened will all fit inside the stack as shown in Fig. 854. When the posts have been fastened to the ceiling, place the ceiling in the cone and bend the 1/2" flange over it, and hammer into place.

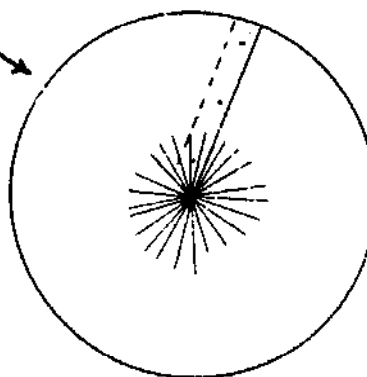


FIG. 858. TOP VIEW -
RIVETTED TOGETHER.

CHAPTER FOUR FLASHING.

Flashing is waterproofing the joint between a roof and other parts of a building by the use of sheet metal or other material. The simplest form of flashing is the lapping of the wall material over a turned up edge of the roofing material as in Fig. 859. With masonry, small pieces of metal are laid out as A in Fig. 861 or with a little variation as C in Fig. 860. Starting at the bottom, A is placed as shown with the flange penetrating into the joint of the masonry. The flange should slope up a little to throw rain, and, it may be necessary to drive a nail through the flange further into the joint to secure the flange against later movement. When A has been placed, put B in place, making sure that it laps A enough to keep water from running down behind either A or the roof flange. The raked edge of C is better weather protection than the vertical edges of A and B. This flashing should be put on after the wall has been plastered up to this point, but before plaster has been put on above this point. Only when the flashing is permanently in place should the upper plaster be applied and finished at the line of the flashing.

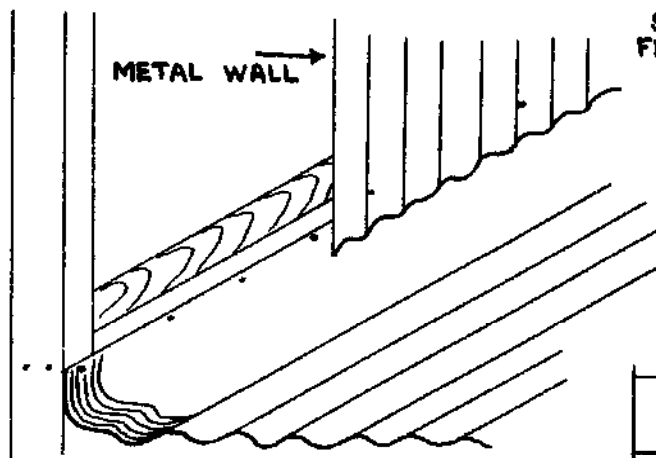


FIG. 859.

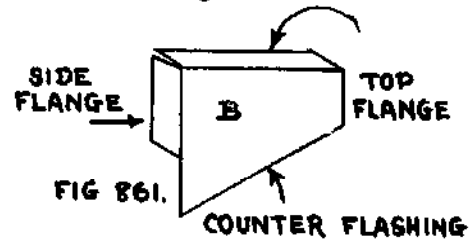


FIG. 861.

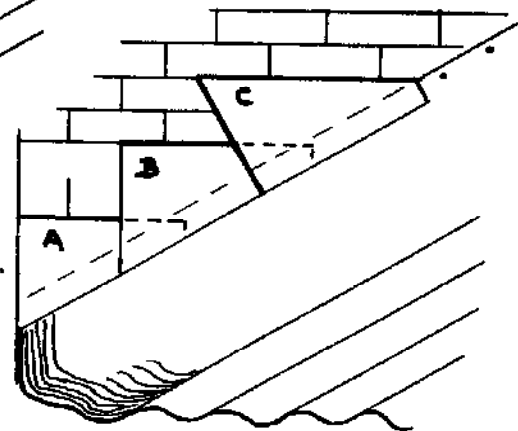


FIG. 860.

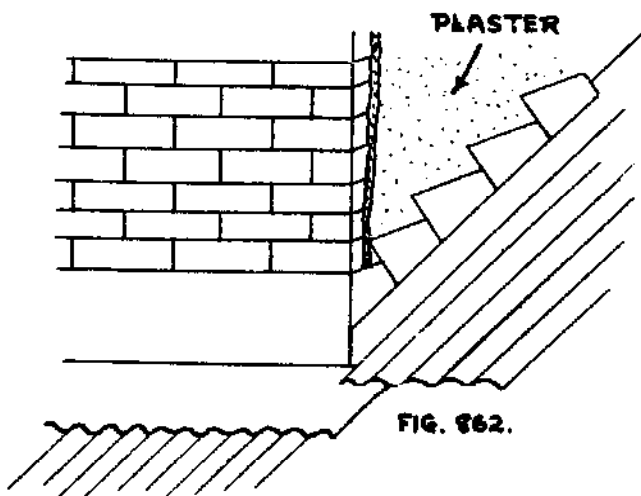


FIG. 862.

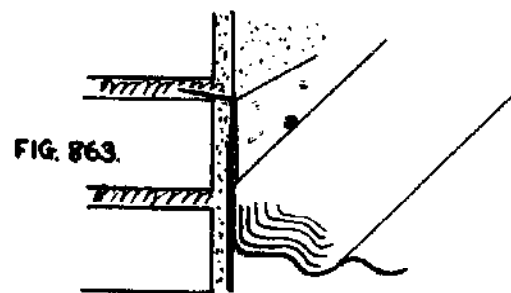
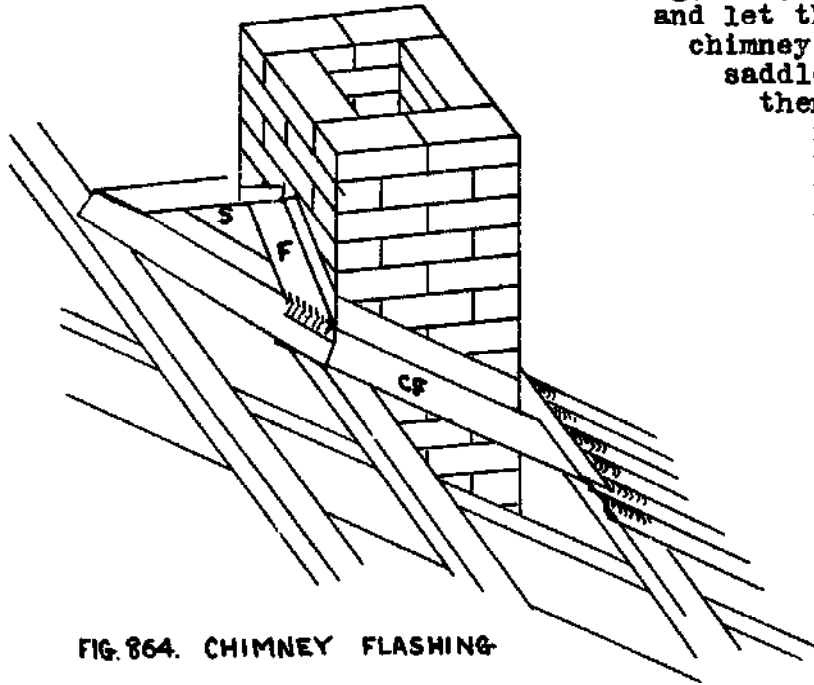


FIG. 863.

Chimney flashing. Between the chimney and the roof construct a small gable roof, called a saddle, see S Fig. 864. Make valley flashings V and let them run on top of the chimney flashings CF. Make saddle flashings F and let them run on top of V. Put



flat or roof iron on the saddle roof. From the bottom of the main roof bring the pans up to and around the chimney, and cut up to fit the valley of the saddle. Flashing CF is now covered with the counter flashings as in Fig. 860. Then flashing F is covered the same way. A much simpler flashing is shown in Fig. 246, p. 121, but it is not always suitable for a major building chimney.

FIG. 864. CHIMNEY FLASHING

CHAPTER FIVE VENTILATORS.

These are more or less gigantic chimney caps, but they require baffles to prevent the wind from driving the rain into the stack.

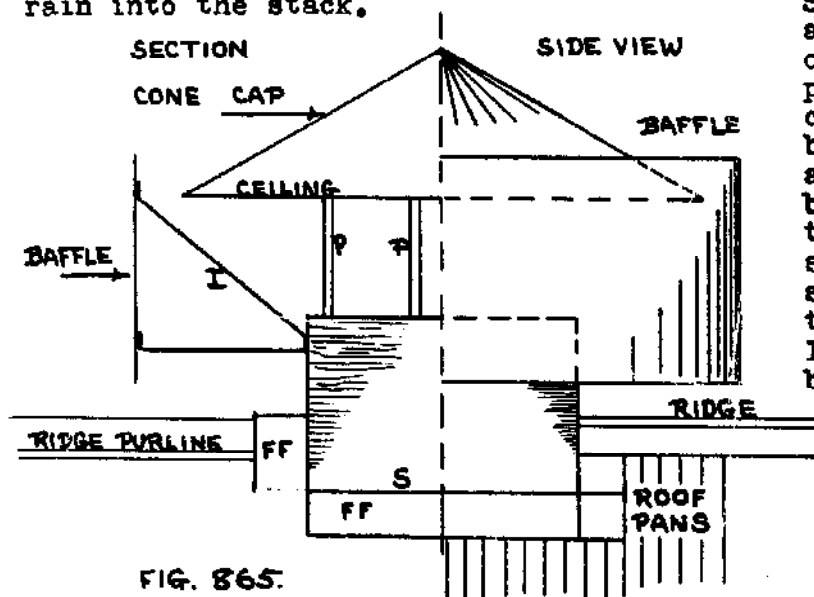


FIG. 865.

S is the square base and R is the round top of the stack. P is a post to support the ceiling; there should be six of these. I is a 1/4" X 1" iron bar bracket for the baffle; there should be at least six of these. The stack straddles the ridge; there should be a purline to catch the base of the outer wall of the stack.

The base of the stack walls have 6" flanges, FF. Fill in the corner as at X. Bolt all flanges to the roof, and tie the

stack to the roof frame with at least three strong metal ties.

 CHAPTER SIX SOLDERING.

EQUIPMENT.

The soldering iron. This is sometimes called the copper because its main part is a lump of copper, generally square in section and weighing between a few ounces and six pounds.

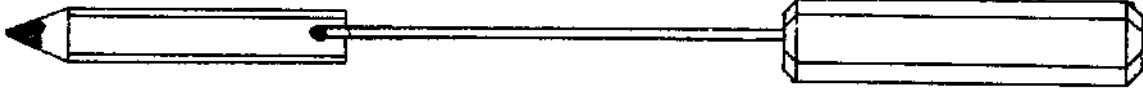


Fig. 866. Soldering Iron.

Solder. For tinsmiths, this is usually tin and lead. Strong, hard solder is about 60% tin and 40% lead; medium solder 50-50; and soft solder about 20% tin and 80% lead. Use hard solder where the work has to withstand the most heat and stress, but where it cannot bend. Use medium solder for common jobs; and soft solder where movement is present and the solder must not be brittle.

Flux. Flux is a medium, liquid, powder, or solid, which promotes the fusing of metals. Wire solder, sold on spools, contains acid for soldering; the acid being in small, regularly spaced globules so that as the solder is melted by the iron, the acid is released frequently to flux the joint.

The work. The work is the metal being soldered.

Tinning. Tinning anything is to coat it with a thin coat of solder preparatory to soldering it, or, as in the case of the soldering iron, before it is usable.

SOLDERING.

There are four main operations in soldering: Cleaning, Fluxing, Heating, and Fusing.

1. Cleaning. The metal surface to which solder attaches itself must be absolutely clean. This is effected by filing, scraping, scouring with emery cloth, or by suitable acid treatment, which removes all oxidization, grease, or other foreign substance including the film left by drawing the finger across clean metal.

2. Fluxing. Apply flux with a small brush, like a mucilage brush.

Table of fluxes.

For lead, tinned metals,
copper, brass, tin.
Brass, iron, copper,
Iron, steel, copper, brass,
Dirty zinc,
Clean zinc, copper, brass,
tin, and tinned metals,

Resin.
Sal Ammoniac.
Borax.
Muriatic Acid.

Chloride of Zinc. Killed
Muriatic acid. This is reg-

ular muriatic, (Hydrochloric) into which zinc, or zinc-coated metal is thrown until the acid ceases to boil. Try this first on all zinc-coated metal, (galvanized iron). If it does not work, try a little dilute muriatic acid; if this does not work, use the neat acid. But take care that the acid does not eat off all the zinc, in which case the bare iron will have to be tinned, Commercial fluxes are made in the form of paste, also as liquid in cans. The beginner should have a fair assortment of fluxes at hand so that if he cannot get the one to work, perhaps the other will. Try to get all materials which would hinder the fusing of the solder cleaned away; do not trust entirely to the acid to do this. Unsalted tallow may be used as a flux if you cannot get other more suitable varieties.

3. Heat. Solder melts at about 370 degrees. Adequate heat is indispensable to a regular soldering job. The work, the metal to be soldered must be brought to the right heat before the solder will adhere properly. Two thin pieces of metal will heat sufficiently almost at the touch of an ordinary soldering iron, but thick sheets of metal or blocks will require some heating before the solder will adhere. This extra heat draws so much from the iron that unless it is a large iron of four to six pounds, it will have to be reheated every moment or so. So, for light work use a light iron, for heavy work, a heavy iron. If you have extensive work, use two irons, one to be heating while you use the other. The irons should not be allowed to get red hot. If they do, allow them to cool a little, and then re-tin them.

4. Fusing. This includes tinning. When an iron has been heated enough to melt solder, plunge it into the flux and simultaneously touch it with solder. If the solder at once flows over the face of the point of the iron, you have properly tinned that face, or the whole point if it is done right. But if the iron does not tin, then you must clean it by filing it. Perhaps you will have to re-heat it. If it is very hot, you will observe that a coloured film covers it almost at once. This is oxidization and interferes with the tinning. Therefore, as soon as you draw the iron from the fire, plunge it into the flux and tin it. If you still have trouble, it is probable that your iron is not hot enough. Coal, charcoal, coke, or a gasoline fire will give the necessary heat.

When your iron is tinned, smear the clean surface of your work with flux, lay the iron on the place to be soldered, and touch the point of the iron with your stick of solder. The solder should flow to the work and adhere to it. If it does not, the work is not clean, or properly fluxed, or the iron is not hot enough. In soldering a single edge of metal to anything, it may need some spots of soldering at intervals, while it is held in place for the spot to cool; when the entire edge has been secured by spots of solder, the intervening spaces can be sealed. If you want to solder a lap joint, tin the under side of the upper piece first; then press the two together, apply the iron and solder, hold all solid while you remove the iron and let the solder harden. The joint should be solid between the metal surfaces as well as at the edge.

After some jobs, dip the hot iron into cold water; this tends to keep the iron soft whereas otherwise it tends to become hard and crystalline. To prevent solder from running freely and adhering where it ought not, smear clean metal with grease or oil. Put acid in a shallow glass or porcelain dish while it is in use, but to store it place it in a glass-stoppered bottle and put away from steel, tools, etc. The fumes are very pervasive, and rust steel quickly and badly.

Have all work cleaned and in position for soldering before putting the iron into the fire; have a common piece of metal to set the iron on when it is not in use and not in the fire. Have a cloth handy on which to lightly clean the iron when it is drawn from the fire. To solder inaccessible points, put in the suitable flux, drop in a little melted solder, then hold the iron to the outside surface of the work, and when it has heated the whole sufficiently, the solder will melt and run and fill all interstices. Hold the work firmly, withdraw the iron, and when the solder has hardened, release your hold.

BOOK FIVE, PART THREE, ELECTRICITY AND LIGHTNING

CHAPTER ONE HANDLING.

Because of the peculiar and potent danger to life and damage to property and equipment through accidents and improper handling of electricity, only those who understand it should handle it. But it is sometimes necessary for those not in the trade to attend to things electrical perforce. Hence, for the safety of ourselves and others, let us observe the following:

Never touch a wire or piece of electrical equipment or even a person being electrocuted until the power has been turned off. The only exception which may be made is when the power cannot be turned off by reason of inaccessibility and a person is held to an electric wire; in which case it may be possible to lever the person away by the use of a wood beam, some stick not less than 2" X 4", and then only when you can do so by not touching the person except with the stick. If you can don rubbers or rubber boots, (without holes) it is safer than otherwise.

There is only one safe rule in electrical work, and that is to be absolutely, personally, sure, that everything you do is safe. Do not send anyone to shut off the power, do it yourself, and make quite sure that no one will turn it on while you are working with it. A simple testing device can be made from a porcelain socket which has two insulated wires about 10" long attached to it. Bare the wires for an inch, screw a bulb into the socket and then apply the two ends to any pair of wires or outlet apertures, or equipment posts when you wish to discover whether there is current or not.

When a fuse blows, do not put in another until you find out what piece of equipment is defective. When the wires in a piece of equipment break, or the insulation fails and they can touch each other or touch metal, the fuse will burn out. It is a safety valve. do not put in a strong fuse when a weak one fails. Stronger fuses, or substitutes of any kind may cause serious damage to buildings or loss of expensive equipment.

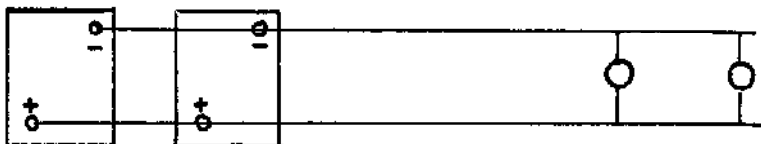
Check all equipment occasionally in an effort to anticipate break-down; insulate or replace worn parts, tighten terminal screws, see that light bulbs are screwed in tightly, worn posts on irons and toasters are replaced, and that insulated wires are not allowed to chafe on each other or on other things.

All joints of wire should be soldered. If you are unable for any reason to solder a joint, tie a reef knot in the wire and wrap the ends; or make a Western Union splice as follows: bare 1-1/2" of each wire, cross them 1/2" from the insulation, wrap each end around the other wire to cover the remaining 1/2". Wrap all types of joints with electricians' tape, called friction tape.

CHAPTER TWO COMMON INSTALLATIONS.

The common installation consists of, 1. A power line from the street; 2. A main switch. 3. A meter, if any. 4. Main fuses. 5. Branch circuits begun, each with a pair of fuses. 5. The branch circuit with a pair of wires leading to outlets for lamps, fixtures and other equipment. The branch circuits should have balanced loads; if you are unable to make sure what a balanced load is with your equipment

FIG. 869.



The 12 volt system may have one or more 12 volt batteries, lined up as shown here, the voltage remains at 12, but the power of the line is increased by each battery added. That is, 12 volt lamps will still be used, but more of them can be used at a time, and for longer periods.

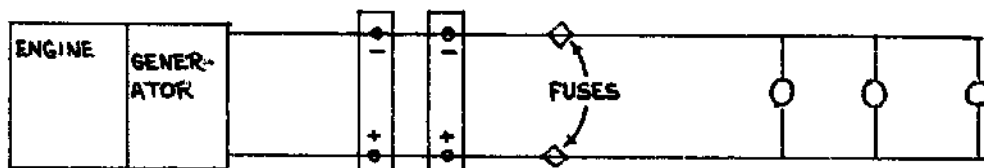


FIG. 870.

Fig. 870 shows the line up of the engine-driven, 32 volt circuit, with batteries. A 1000 watt capacity plant like this will handle radio and loud speaker, lamps, irons, toasters, etc. And, when the engine is running, will transmit power for thousands of feet. When the engine is shut off, the batteries will carry a few lamps for a few hours.

When buying the engine, get a spare if you can afford it; or at least get spare spark plugs, valves, bearings, pistons, and piston rings, brushes for generator, etc.

A 32 volt battery system can be set up with 16 two volt batteries in series, (like the two batteries in Fig. 868.) But the greatest care must be taken in shipment that the acid be separate, and that the glass jars be well packed. These batteries require a 32 volt generator, presumably a wind charger. This requires a regular and strong wind.

Water power. If you have a stream which apparently has enough flow and fall to drive a generator-turbine, and you know that you may have permission to harness it, get in touch with an electrical engineer, or a manufacturer of turbines, and get instructions relating to survey for such installation before investing any money on equipment.

Batteries. Get a standard product like Willard, Exide, or similar dependable makes; get heavy duty, 120 ampere hour. Have them sent out empty, with the acid in separate containers.

Wind chargers. These are made to charge a certain voltage, 6 volt, or 12 v., or 32 v., as the case may be.

A car generator will charge a 6 volt battery. In an emergency, for car starting, take out the generator, connect it to the battery, and drive the generator by a belt from the rear wheel of a supported bicycle. Unless the battery is too far gone, it will be charged enough to supply ignition to an engine which is started by cranking or pushing.

Battery condition depends upon care. Do not use more current than you have to; keep all connections tight and clean. Have

two hydrometers, one for a spare. Test the batteries regularly; do not let the batteries run down or get dry.

General supplies. A D.C. Voltmeter will be useful.

1. Wire for 6 volt circuit, NO. 4 or NO. 6, rubber covered.
2. Wire for 12 volt circuit, same.
3. Wire for 32 volt circuit, No. 6 or 8.
4. Wire for drop cords to lamps, NO. 10.
5. Guy wires for chargers, poles, etc. Galvanized wire NO. 9.
6. Staples for house wire.
7. Outlet boxes with terminals for the wire you use.
8. Switches. 9. Hot plugs. 10. Sockets. 11. Fuses.
12. Lamps and shades. Plenty of 25 to 40 watt lamps.
13. Insulators for outside wiring. 14. Soldering requisites.
15. Electricians tape.

Buy these supplies in your home country.

CHAPTER FIVE. LIGHTNING.

Lightning is the discharge of electricity between two masses of clouds, or between clouds and the earth. On the approach of a storm, electricity seeks escape from the earth, usually concentrating in the highest object, whether tree or structure. The drier the object the more confined the earth charge becomes. Unless there is proper lightning protection there may be a strike. But proper lightning installation is practically 100% protection according to one government bulletin.

First because it provides escape from the earth into the air of the earth charge before the storm strikes.

Second because if there is some remaining charge it will not have nearly the drawing power of a full charge and so the possibility of a strike is much more remote.

Third because when a strike does come, it follows the line of least resistance, which is a metallic conductor installed according to standard specifications.

Lightning conductors must be thoroughly grounded, that is, they will penetrate to more or less moist and solid earth. The bottom end should have tentacles.

Conductors consist of copper cable an inch thick, without insulation, or, a copper bar, 1/4" X 1" or 1/8" X 1". The bar follows a streamlined course from the earthing point to the roof corner and thence to the ridge. There must be no sharp or short corners, bends. The rod must be insulated from wood and masonry. On the roof it runs the length of the ridge and is continuous down the building to a second earthing point. The two earthing points should be at diagonally opposite corners of the building. From the ridge rod, several vertical rods are erected, approximately two feet high, and again having tentacle ends. The joints must all be by secure wrapping or bolting. On grass roofs, use a 2" X 2" wood post to keep the rod away from the grass at least a foot. An iron roof may be grounded by two rods at opposite corners and without ridge installation. No clothesline, wire fence, or other metallic conductor should be fastened directly to any building. If it has to be supported by a structure, use insulators. Ground all wiring, piping, metallic systems.

BOOK FIVE PART FOUR PAINTING AND DECORATING

CHAPTER ONEVALUES

A good paint job preserves building materials from rot, rust, and general decay, prevents swelling and warping of woods, and always enhances the value of the property.

The proper selection of colours, inside and outside, affects the temperature, appreciably, in the desired direction; greatly influences the lighting effects, with good results for the eyes, for general movement about the house, and toward greater safety.

Care in the use of colours adds tremendously to the general morale, satisfaction, and reduction of fatigue, etc., and has been proven to be a favourable factor in the dining room.

A correct finish is cleaner, facilitates cleaning, and adds to the sense of cleanliness. Painted surfaces resist vermin, germs and odours.

And, not the least value of a good paint job on Mission buildings is that it commends, to some people at least, the Gospel which we preach.

CHAPTER TWOPREPARATION OF SURFACES

Do not waste good paint on a poor surface. Scrape off all dirt, scale, rust, grease, oil, old paint, etc. Brush down to remove all dust. To remove old paint, apply a coat of paint and varnish remover, and let stand 10 minutes. Scrape off all you can. Repeat the process as many times as may be necessary.

All work on or near the surface to be painted is to be completed before painting begins. Everything to be painted should be permanently fastened, sound, clean, suitably smoothed down. There must be no dampness in the material, paint is not to be applied on a wet day, or when the moisture in and around the building makes the air humid. Nail holes and similar blemishes in the surface are filled after the first coat of paint. All new work requires three coats.

New galvanized iron does not take paint. One preparation of the iron is merely to let it stand for a year by which time the air will have neutralized the surface of the zinc coating so that it will retain paint.

New iron may be shellacked. Or it may be washed with a dilute solution (10-15%) of muriatic acid and water. Wash this off with clean water, and then be sure that the iron is thoroughly dried before it is painted.

If it is impossible to get all scale and rust from metal surfaces, paint them with aluminum first. And there are aluminum paints which will adhere to rusty surfaces and retard further rusting.

CHAPTER THREECOLOURS

White or light creams will not stand the weather like spruce, yellow ochre, Venetian red, or lamp black which lengthen the life of paint as much as 150%. Dark and medium greens do not stand the weather well as a rule for they do not contain lead, zinc, or titanium.

But for the small amount of woodwork exposed on a masonry building, we may build up prepared paint with the addition of pure white lead and raw linseed oil to make them wear reasonably well.

Presumably the masonry will be given a light-refracting treatment which will also have to be waterproof. This is dealt with in the last chapter. Lighter shades are cool, and if right will reduce the temperature in and around the house as much as 10 degrees, sometimes more. Red is warm, and makes the room seem smaller. Use white for the kitchen; it is cleaner and cooler. Tints of yellow and other suitable colours for the dining room giving the sense of space and being lighter. Hospitable colours for the living room; shades of blue and purple for the bedroom for they are not lively colours, but on the contrary, according to some advice, are sleep inducing. In the bathroom, warmth in the colours, tints of pink, deep ivory, yellow, etc.

Window sash to be white, inside and out, to reflect light. If woodwork has an attractive grain and a suitable finish, varnish it. Inside woodwork may be shellacked.

For maximum cleanliness, have smooth, glossy finishes as they catch the least dust and wear best.

The primary colours are Red, Yellow, Blue. In the right proportions they produce black. With white and black and the primary colours, any shade, tint, or colour can be produced. Tints are made by adding white to any colour; a shade of a colour is made by adding black to it.

Some secondary colours are: green from yellow and blue. Orange from red and yellow. Purple from red and blue.

Some tertiary colours are: citrine from orange and green; olive from purple and green; russet from purple and orange; peach from orange and yellow.

With a white base the following can be made: Cream from raw Sienna and a few drops of raw umber; Ivory with French ochre and a few drops of raw umber; Canary, a tint of yellow; pink with American vermillion; Gray with lamp black; blue with Prussian blue; Modern blue with Prussian blue and lamp black; Brown with raw Sienna and Venetian red.

To produce warmer tones use burnt Sienna, vermillion, or Venetian red. To produce colder tones, use a little green, blue, black, raw umber, Grays from white shaded with black, blue-green, blue-red, burnt Sienna and blue.

Colours come in oil, very concentrated, or in powder form. like ochre, burnt umber, etc.

To commence mixing colour, take a very little of the colour and mix it with linseed oil and turpentine until the colour has been entirely broken down in the thin paste. Then add some of the paint stock you want to colour and again thoroughly mix the colour paste with the paint stock. If you are sure that your colour is not too deep, add it to the stock of paint you will use for the two finish coats. Be sure that it will completely cover your work twice. Mix thoroughly. If the colour is not deep enough, remember, before you add more, that paint darkens with age, always, even within the first hour after application. Paints should be made 48 hours before use, particularly the admixing of the colours. Thorough mixing and stirring are essential to a good paint.

CHAPTER FOUR QUANTITIES, ECONOMY, ESTIMATING.

Order sufficient quantities of all supplies. Left over painting supplies are always useful. Be sure that you have sufficient of any one colour for two complete coats before you start the first coat. It is practically impossible to match a previous mixture with a new one.

It is economy to put on three coats of paint, to use good paint, to use good ingredients for thinning it out to its proper consistency so that it may be applied and brushed out to the right thickness, to put it on soon. Good paint costs money. So do the substitutes, afterwards. Usually they come in cans which never bore a name but the colour of the paint; and are marked with the selling price which is about half way between the cost to the maker and the ultimate cost to the buyer.

Enamels and glossy finishes wear better than flat finishes. New work, inside and out, requires three coats for the best, most enduring work. The first, or primer coat makes a base for the succeeding coats. A large percentage of turpentine enables the mixture to penetrate the pores.

100 pounds of lead will make about 7-1/2 gallons of paint; and one gallon covers about 100 square feet.

List all the labour for cleaning the work down, mixing the paint, applying it all coats for every purpose; for scaffold, and for cleaning up afterward; and for all requisites:

Paint and varnish remover.	Brushes of all types, putty knife.
Pure white lead.	Putty.
Pure, raw linseed oil.	Prepared paint.
" boiled "	Lime.
Pure turpentine.	Glue for size.
Driers,	
All colours.	
Enamels.	
Varnish and shellac.	

CHAPTER FIVE EXTERIOR PAINT.

Ready mixed paint. For the priming coat add about one quart of turpentine to one gallon of paint from the can. For the second coat, add about one pint to each gallon from the can. For the third coat use straight from the can unless it is too thick, in which case add raw linseed oil until the right consistency is obtained. Use only raw linseed oil outside, boiled linseed oil for interior work. Let each coat of paint dry thoroughly before applying a second or third. If the third coat seems too oily, add a little driers.

Old work requires only two coats of paint. Thoroughly clean the surface.

Your own mixed paints. Prepare them at least 48 hours before you want to use them. The night before you start to mix, open the white lead and add some raw linseed oil. The next day stir and mix thoroughly until all the lead is broken down and you have a smooth uniform paste. The next day stir in turpentine and raw oil to make enough paint for the whole primer coat. The proportions for this mixture are turpentine three parts, raw oil one part. They are to be added in this proportion until the paint is the right consistency to

brush on smoothly and just cover the surface.

When this is practically dry, putty all holes, shellac all knots and resinous areas in the wood.

For the second coat, add turpentine and oil in the reverse proportions to the primer coat, that is three parts of oil and one part of turpentine. Care should be taken that if the third coat is to be glossy, that is oily, the second coat should not be oily. Hence, if the third coat is to be glossy, make the second coat flat with the use of more turpentine or driers. Cover thoroughly with the second coat. And remember that all the second coat and the third coat are to be of the same colour mixture.

Give roofs two coats, the first flat, the second with plenty of oil. But do not apply the paint itself heavily; draw it out evenly. Aluminum paint is about the most satisfactory for roof work, being the most durable light-refracting product on the market.

CHAPTER SIX INSIDE WORK

Use gloss or enamel finishes in the dining, pantry, kitchen, bath, and toilet rooms at least. Apply enamel and gloss coats on flat coats. For inside work use boiled linseed oil. Make sure that all resinous wood surfaces have a flat coat and that it is well dried before applying any further paint. Have all the work well smoothed and otherwise worthy of a good paint job.

If masonry is to be painted, apply a coat of glue size first. There are many distemper and other masonry decorations on the market. Any masonry must be thoroughly dry before paint is applied. This is especially true of floors. Some say six months of drying.

CHAPTER SEVEN BRUSHES

Buy good brushes; with care they will last for years. Break them in on a priming coat. Bore a hole in the handle and hang them up each night in turpentine, do not allow the brush to stand on the bristles. Turpentine tends to retain stiffness in the bristles; linseed oil tends to softness. The latter is good for enamel work, the former for sash trim. For extended preservation of the brush, hang in 50-50 turpentine and oil. Or, rinse out thoroughly in turpentine, being sure that all the paint has been removed from the base of the bristles, and then washing out with soap and warm water. There must be no caustic in the soap. When the brush has dried out, lay flat in a dry, cool place, not exposed to the open air. Never use kerosene to wash paint brushes, or thin paint. Never use a paint brush as a duster or for lime wash work.

CHAPTER EIGHT CARE OF PAINTS

Try to prevent the skin forming on the paint in the can. The material in the coating is a necessary part of the mixture. Do not keep a little paint in a large can; have as little air space as is practicable. Smear a little paint around the edge of the can just before you put the lid on each time. Press the lid right down into place each time. At night, or when you will not be using the paint for a little time, pour a little driers on the surface. Strain out all lumps, scum, and other matter which would mar a fine finish.

CHAPTER NINE GENERAL HINTS

Wear gloves, or use vaseline on the hands when working with paint. Take care of all surfaces not being painted; sand on the floor is not sufficient protection. Both sides of a piece of lumber should be painted if possible to prevent warp. Have a good cloth handy for last minute or emergency clean off. Never leave oily rags in a heap; spread them out where there is air.

Clean off paint with paint remover. Clean paint from glass with hot vinegar, or a razor blade. Clean off shellac with alcohol. Clean off tar with kerosene. Lift fresh paint from clothing or upholstery with clean turpentine.

Take ample precaution to keep unauthorized persons, generally children, from the paint stores; and give ample warning that fresh paint is being applied, and give that warning before you start, not after someone has brushed against your work.

CHAPTER TEN GLAZING

Glaze sash when they can stand unhandled for a few days. Prime sash before puttying. Cut glass with a 1/16" free margin on all sides. Lay on the ledge where the glass is to rest a ribbon of soft putty and press the glass gently into it. Do not use more putty than is needed. Make all the puttying uniform. Before doing any puttying, empty the whole container and mix thoroughly. As a rule, there is enough linseed oil in it to make the correct consistency. When you have mixed it all, put the bulk of it back. When you are not holding the putty in your hand, place it on a piece of glass or metal so that it will not lose oil.

CHAPTER ELEVEN FURNITURE.

When your furniture is freshly finished, apply any transparent coating you desire before the wood discolours. White shellac, varnish, crude oil or wax may be applied. Even brown shoe polish has been used. In using enamel, apply three coats. Linseed oil darkens a natural finish, but with daily, hard rubbing, it has produced a very fine polish finish.

CHAPTER TWELVE WATERPROOFING MASONRY

This includes mud plaster and mud brick and pise construction. The most durable, economical and practicable treatment of which we know is the application of hot cotton-seed tar to the mud plaster. When this has soaked in and dried pretty well, taking possibly two months or more, it is coated with a cement wash, (cement and water). This must be done when the wall is cool and will remain so for some hours. The cement wash must dry as slowly as possible. Experiment to discover how best you can get the cement wash to really hold. Try wetting the wall just before it is applied. Keep the sun off it as long as possible. Try some lime in one experimental patch. In any case, apply lime wash after the cement is set enough to take it. Experiment also with lime wash with tallow boiled into it. Also whitewash with glue size in it. Apply these two last to the mud wall when you cannot get cotton-seed tar for the preliminary coating.

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8. Kenyan Building Contractors; Practices, Problems and Needs.	£1
9. A Management Handbook for the Nigerian Building Contractor.	£2