Cyclopedia
of
Architecture, Carpentry, and Building

A General Reference Work

ON ARCHITECTURE, CARPENTRY, BUILDING, SUPERINTENDENCE, CONTRACTS, SPECIFICATIONS, BUILDING LAW, STAIR-BUILDING, ESTIMATING, MASONRY, REINFORCED CONCRETE, STRUCTURAL ENGINEERING, ARCHITECTURAL DRAWING, SHEET METAL WORK, HEATING, VENTILATING, ETC.

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HE editors have freely consulted the standard technical literature of America and Europe in the preparation of these volumes. They desire to express their indebtedness particularly to the following eminent authorities whose well-known works should be in the library of everyone connected with building.

Grateful acknowledgment is here made also for the invaluable co-operation of the foremost architects, engineers, and builders in making these volumes thoroughly representative of the very best and latest practice in the design and construction of buildings; also for the valuable drawings and data, suggestions, criticisms, and other courtesies.

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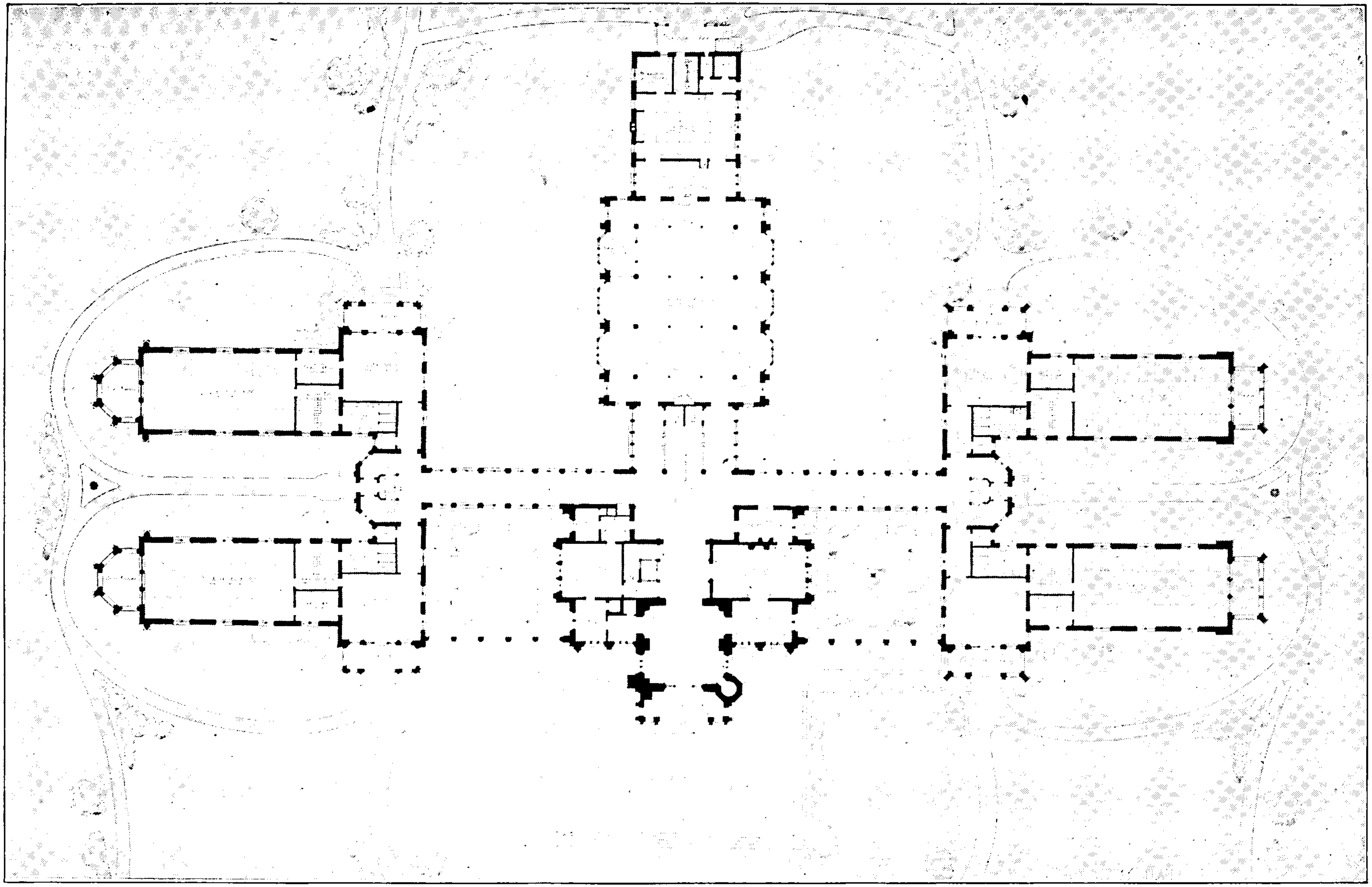
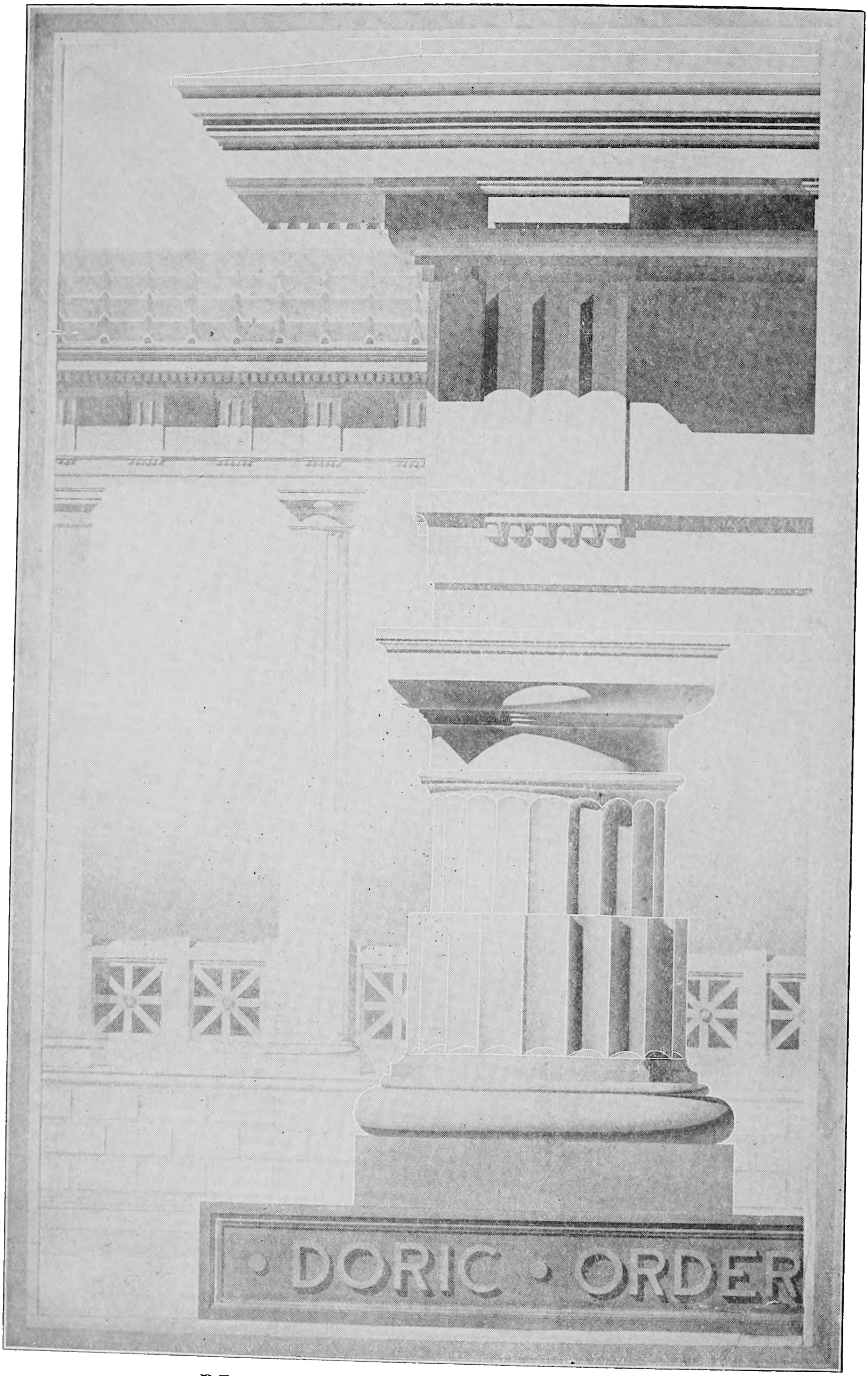


PLAN FOR HOME OF THE KNIGHTS OF PYTHIAS AT DECATUR, ILL.

H. V. von Holst and Lorin A. Rawson, Architects, Chicago, Ill.

Reproduced from Competition Drawing. The Central Front Building is for Administration Purposes, the Two Dormitories to the Left are for Girls; the Two to the Right, for Boys. The Building in the Rear Contains the Dining Room, with Auditorium Above. For Exterior View, Reproduced in Color, See Frontispiece in this Volume.



DETAIL OF ROMAN DORIC ORDER.

An example of conventional shadows and rendering in wash. Note the French Method of rendering the quarter round moulding under cornice, and the reflected shadows. See Section on "Rendering in Wash" Page 227.

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THE rapid evolution of constructive methods in recent years, as illustrated in the use of steel and concrete, and the increased size and complexity of buildings, has created the necessity for an authority which shall embody accumulated experience and approved practice along a variety of correlated lines. The Cyclopedia of Architecture, Carpentry, and Building is designed to fill this acknowledged need.

¶ There is no industry that compares with Building in the close interdependence of its subsidiary trades. The Architect, for example, who knows nothing of Steel or Concrete construction is today as much out of place on important work as the Contractor who cannot make intelligent estimates, or who understands nothing of his legal rights and responsibilities. A carpenter must now know something of Masonry, Electric Wiring, and, in fact, all other trades employed in the erection of a building; and the same is true of all the craftsmen whose handiwork will enter into the completed structure.

¶ Neither pains nor expense have been spared to make the present work the most comprehensive and authoritative on the subject of Building and its allied industries. The aim has been, not merely to create a work which will appeal to the trained expert, but one that will commend itself also to the beginner and the self-taught, practical man by giving him a working knowledge of the principles and methods, not only of his own particular trade, but of all other branches of the Building Industry as well. The various sections have been prepared especially for home study, each written by an acknowledged authority on the subject. The arrangement of matter is such as to carry the student forward by easy stages. Series of review questions are inserted in each volume, enabling the reader to test his knowledge and make it a permanent possession. The illustrations have been selected with unusual care to elucidate the text.

The work will be found to cover many important topics on which little information has heretofore been available. This is especially apparent in such sections as those on Steel, Concrete, and Reinforced Concrete Construction; Building Superintendence; Estimating; Contracts and Specifications, including the principles and methods of awarding and executing Government contracts; and Building Law.

The Cyclopedia is a compilation of many of the most valuable Instruction Papers of the American School of Correspondence, and the method adopted in its preparation is that which this School has developed and employed so successfully for many years. This method is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best yet devised for the education of the busy working man.

In conclusion, grateful acknowledgment is due the staff of authors and collaborators, without whose hearty co-operation this work would have been impossible.

VOLUME VI

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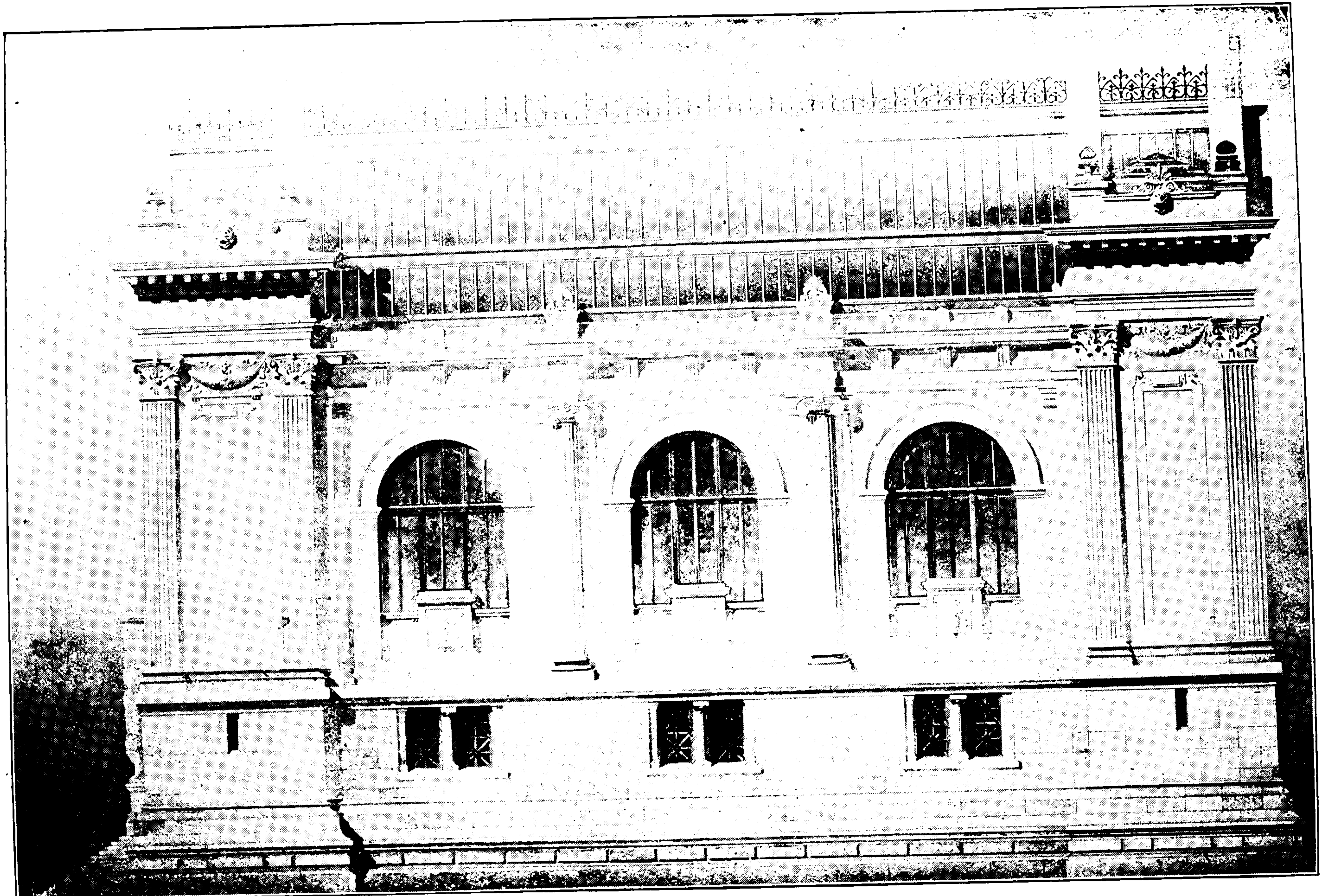
* For page numbers, see foot of pages.

† For professional standing of authors, see list of Authors and Collaborators at front of volume.



AN EXAMPLE OF WELL RENDERED DRAWING.

Note the treatment of the roof and the windows. See Section on

or when ink or colors are used; should neither repel nor absorb liquids; and should allow considerable erasing without spoiling the surface. It is, of course, impossible to find all of these qualities in any one paper, as great strength cannot be combined with fine surface. However, a kind should be chosen which combines the greatest number of these qualities for the given work. Of the higher grades of papers, Whatman's are considered by far the best. This paper, either side of which may be used, is made in three grades: the *hot pressed,* which has a smooth surface and is especially adapted for pencil and very fine line drawing; the *cold pressed,* which is rougher than the hot pressed, has a finely grained surface, and is more suitable for water color drawing; and the *rough,* which is used for tinting. For general work, the cold pressed is the best as erasures do not show as plainly on it, but it does not take ink as well as the hot pressed.

Whatman's paper comes in sheets of standard sizes as follows:

Cap	13×17 inches	Imperial	22×30 inches
Demy	15×20 "	Atlas	26×34 "
Medium	17×11 "	Double Elephant . .	27×40 "
Royal	19×24 "	Antiquarian . . .	31×53 "
Super-Royal . . .	19×27 "		

The usual method of fastening paper to a drawing board is by means of thumb tacks or small one-ounce copper or iron tacks First fasten the upper left-hand corner and then the lower right, pulling the paper taut. The other two corners are then fastened, and a sufficient number of tacks placed along the edges to make the paper lie smoothly. For very fine work, however, it is better to stretch the paper and glue it to the board. Turn up the edges of the paper all the way round—the margin being at least one inch—then moisten the surface of the paper by means of a sponge or soft cloth, and spread paste or glue on the turned-up edges. After removing all the surplus water on the paper, press the edges down on the board, commencing at one corner and stretching the paper *slightly*—if stretched too much it is liable to split in drying. Place the drawing board in a horizontal position until the paper is dry, when it will be found to be as smooth and tight as a drum head.

Drawing Board. The drawing board, Fig. 1, is usually made of well-seasoned and straight-grained soft pine, the grain running lengthwise of the board. Each end of the board is protected by a side strip—$1\frac{3}{4}$ to 2 inches in width—whose edge is made perfectly straight for accuracy in using the T-square. Frequently the end

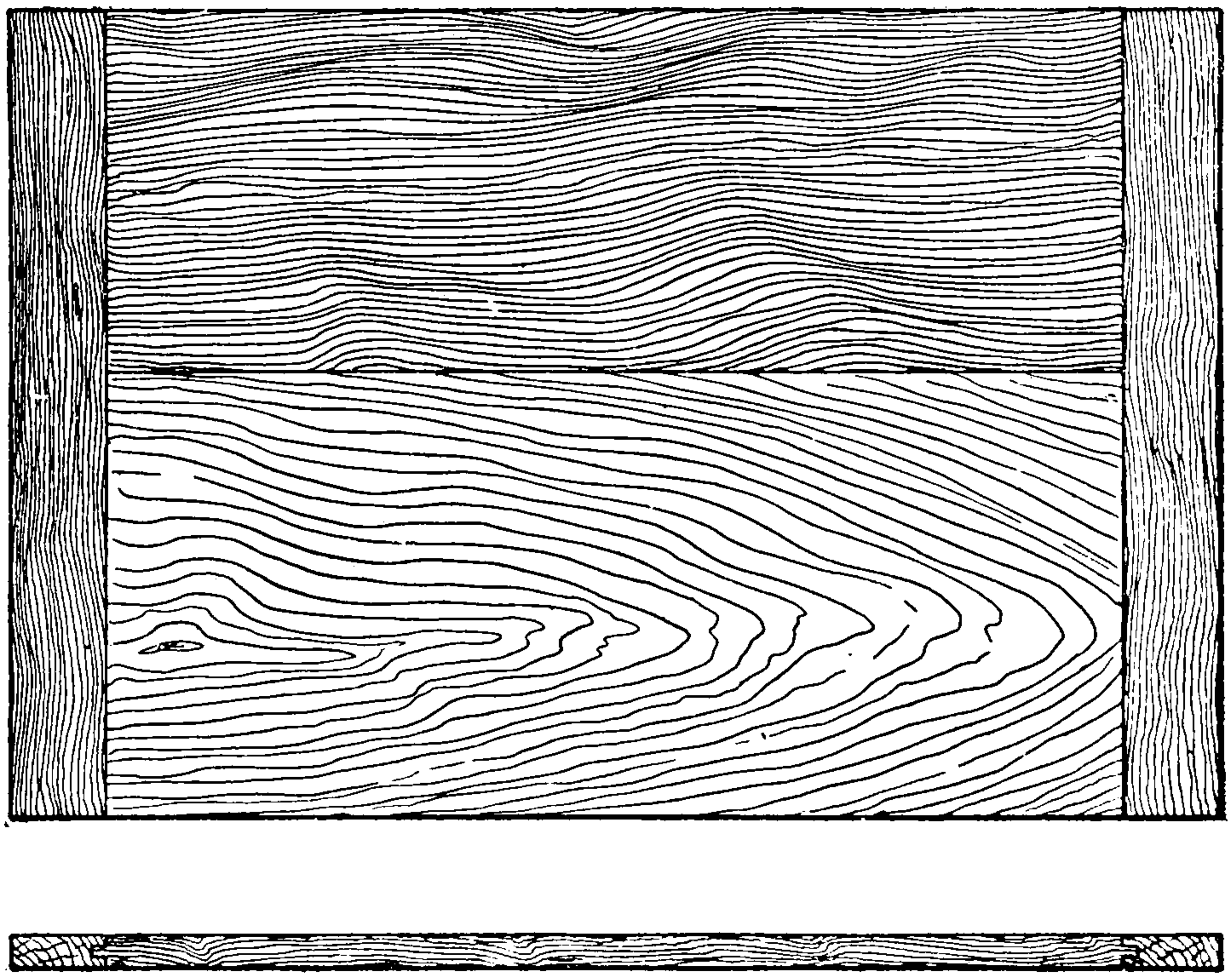


Fig. 1. Drawing Board

pieces are fastened by a glued matched joint, nails or screws. Two cleats on the bottom, extending the whole width of the board, will reduce the tendency to warp. Drawing boards are made in sizes to accommodate the sizes of paper in general use.

Thumb Tacks. Thumb tacks are used to fasten the paper to the drawing board. They are usually made of steel, pressed into shape—as in the cheaper grades—or with heads of German silver, the points being screwed and riveted to them. For most work, draftsmen use small one-ounce copper or iron tacks, as they are cheap and can be forced flush with the drawing-paper, thus offering no obstruction to the T-square.

Pencils. Lead pencils are graded according to their hardness, the degree of which is indicated by the letter H—as HH, 4H, 6H, etc. For general use a lead pencil of 5H or 6H should be used, although a softer 4H pencil is better for making letters, figures, and points. The hard lead pencil should be sharpened as shown in Fig. 2 so that in penciling a drawing the lines may be made very fine and light. The wood is cut away so that about $\frac{1}{4}$ or $\frac{1}{2}$ inch of lead projects. The lead can then be sharpened to a chisel edge by rubbing it against a bit of sand paper or a fine file, and the corners slightly rounded. In drawing the lines the draftsman should place the chisel edge against the T-square or triangle, thus enabling him to draw a fine line exactly through a given point. If the drawing is not to be inked, but is made for tracing or for rough usage in the shop, a softer pencil, 3H or 4H, may be used, so as to make the lines somewhat thicker and heavier. The lead for compasses may also be sharpened to a point although some draftsmen prefer to use a chisel edge for the compasses as well as the pencil.

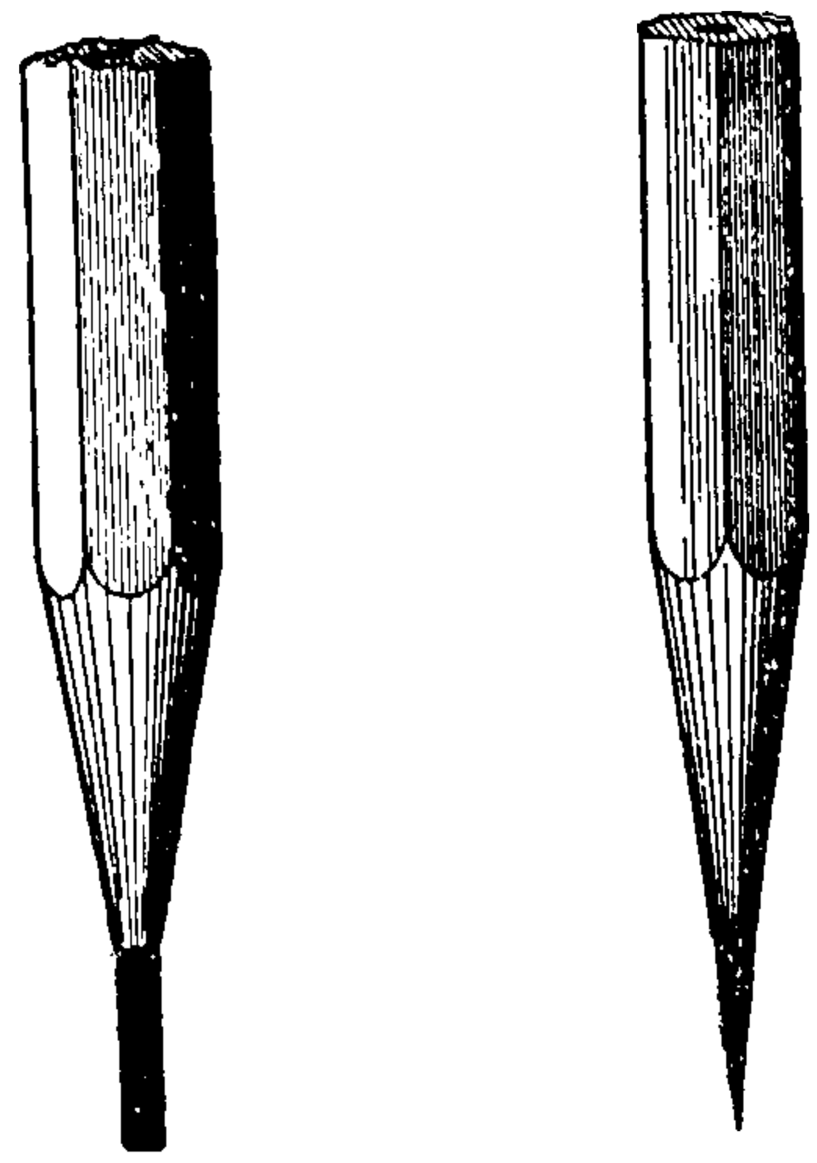


Fig 2 Pencil Sharpened to a Chisel Point

In using a very hard lead pencil a light pressure should be used as otherwise the chisel edge will make a deep impression in the paper which cannot be erased.

Erasers. What little erasing is necessary in making drawings, should be done with a soft rubber. To avoid erasing the surrounding work some draftsmen use a card in which a slit is cut about 3 inches

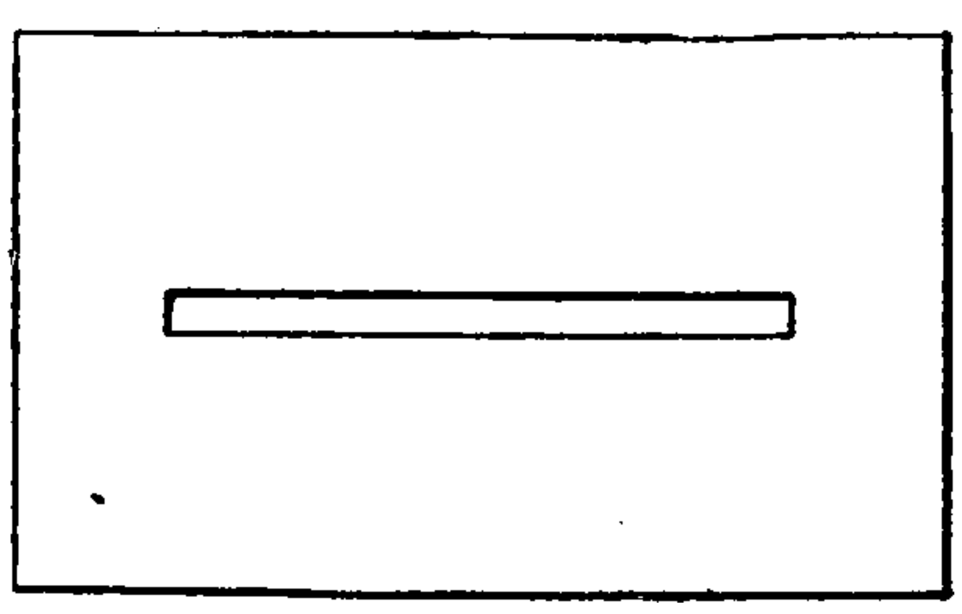


Fig. 3. Erasing Shield

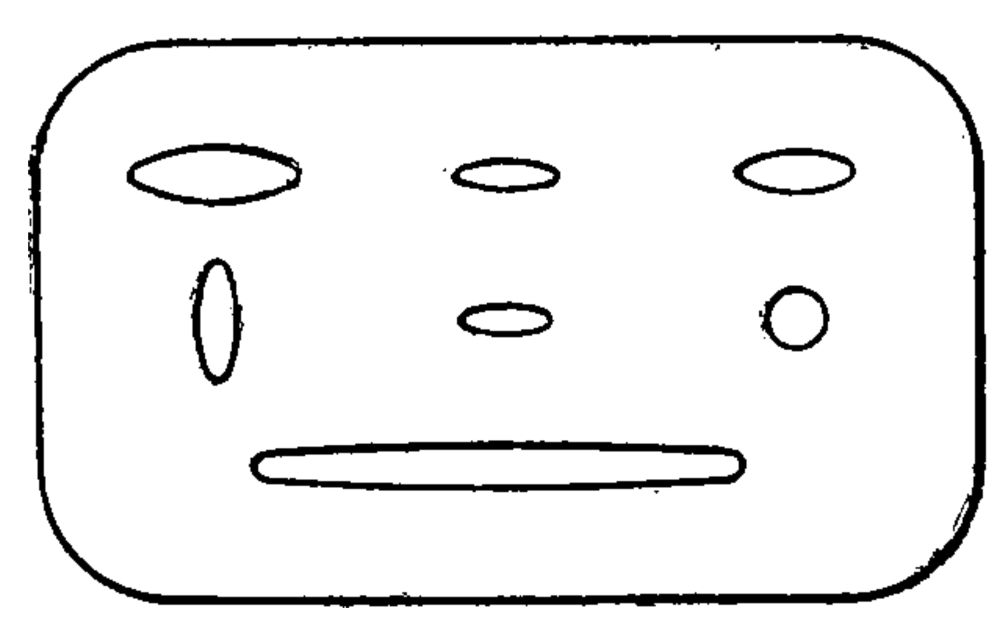


Fig. 4. Metal Erasing Shield

long and $\frac{1}{8}$ to $\frac{1}{4}$ inch wide, Fig. 3. An erasing shield of thin metal, Fig. 4, is also very convenient, especially in erasing letters. For cleaning drawings, a sponge rubber or bread crumbs may be used. To clean the drawing scatter *dry* bread crumbs over it and rub them on the surface with the hand.

T=Square. The T-square, which gets its name from its general shape, consists of a thin straight-edge, the *blade,* with a short piece, the *head,* fastened at right angles to it, Fig. 5. T-squares are usually made of wood, the pear and maple woods being used in the cheaper grades, and the harder woods, like mahogany, with protecting edges of ebony or celluloid, Fig. 6, in the more expensive instruments. The head is designed to fit against the edge of the drawing board, allowing the blade to extend across the surface of the board. It is

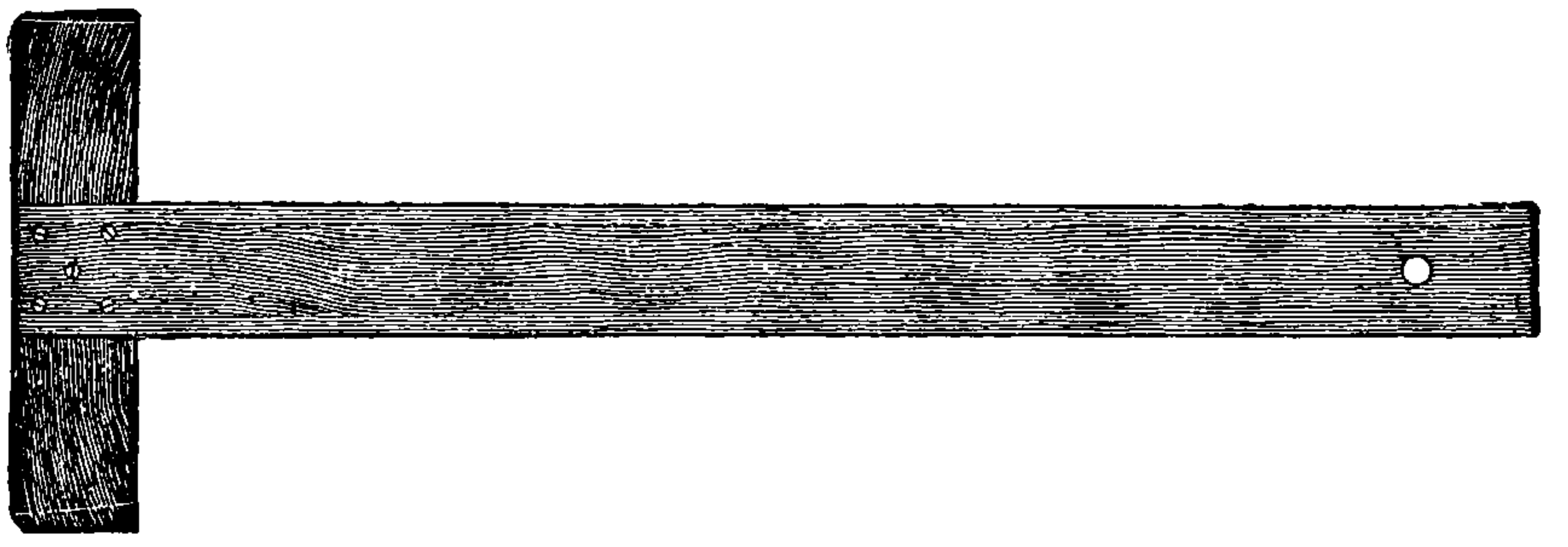


Fig 5 Common T-Square

desirable to have the blade of the T-square make a right angle with the head, but this is not absolutely necessary, if the head is always placed against the left-hand edge of the board, for the lines drawn

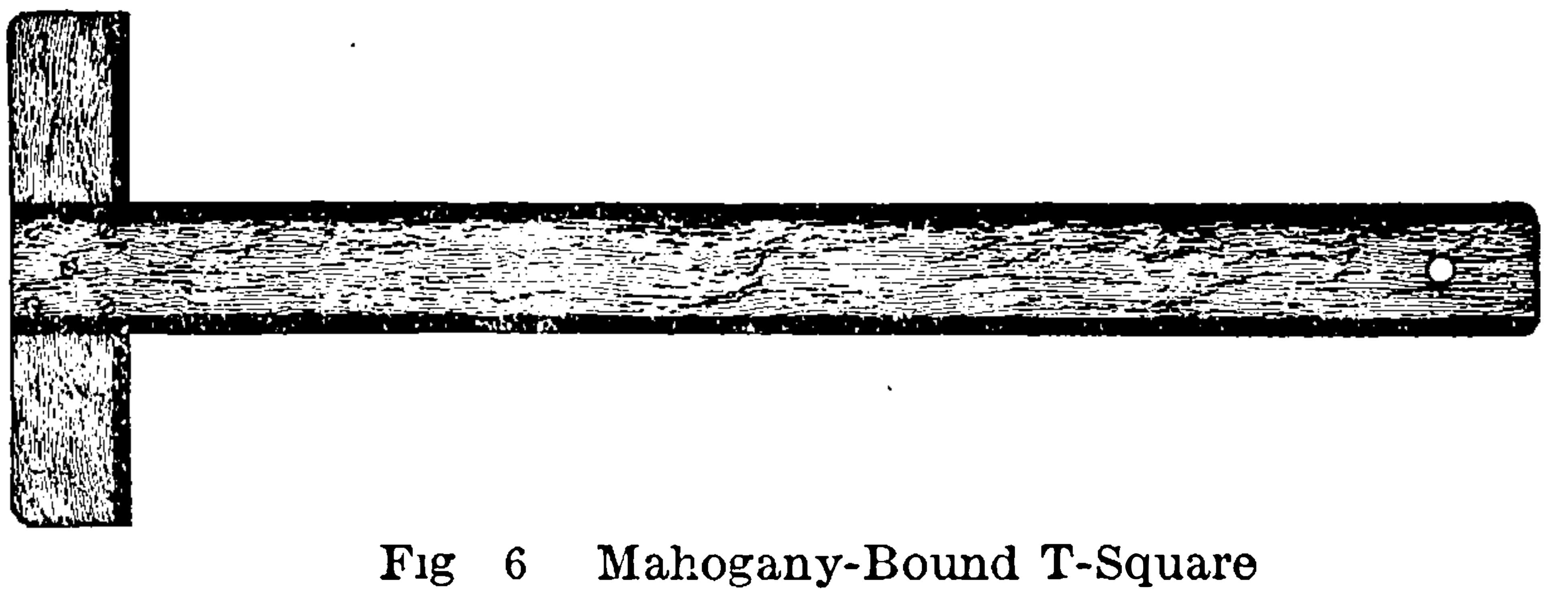


Fig 6 Mahogany-Bound T-Square

with the T-square will then be referred to one edge of the board only, and if this edge of the board is straight, the lines will be parallel to each other.

T-squares are sometimes provided with swiveled heads as it is frequently very convenient to draw lines parallel to each other which are not at right angles to the left-hand edge of the board. To use the T-square in drawing parallel horizontal lines, place the head of the T-square in contact with the left-hand edge of the board, Fig. 7, and draw the pencil along the *upper edge* of the blade at each new position of the T-square. Only the upper edge should be used as the

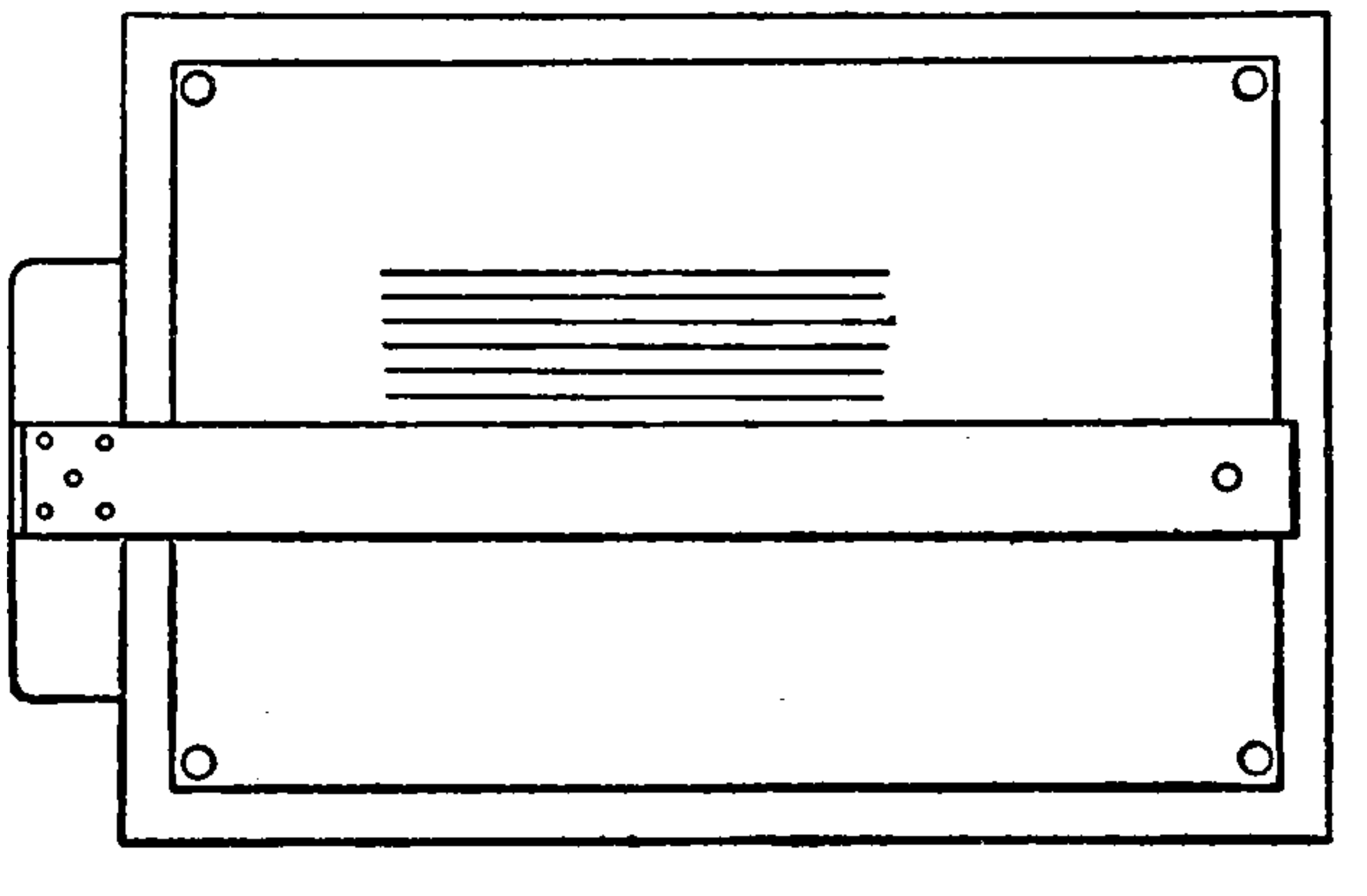


Fig. 7. Drawing Parallel Lines

two edges may not be exactly parallel and straight. In trimming drawings or cutting the paper from the board, always use the *lower edge* of the T-square so that the upper edge may not be made untrue.

For accurate work it is absolutely necessary that the upper edge of the T-square be exactly straight. To test the straightness of the edge two T-squares may be placed together as shown in Fig. 8. However, a lack of contact such as shown in the figure does not prove which edge is crooked, and for this determination a third blade must be used and tried with the two given T-squares successively.

Fig 8. Testing the Edge of T-Square

Triangles. Triangles are made of various substances such as wood, rubber, celluloid, and steel. Wooden triangles are cheap but are likely to warp out of shape; rubber triangles are frequently used, and are, in general, satisfactory; celluloid triangles are extensively used on account of their transparency, which enables the draftsmen to see the work already done even when covered with the triangle.

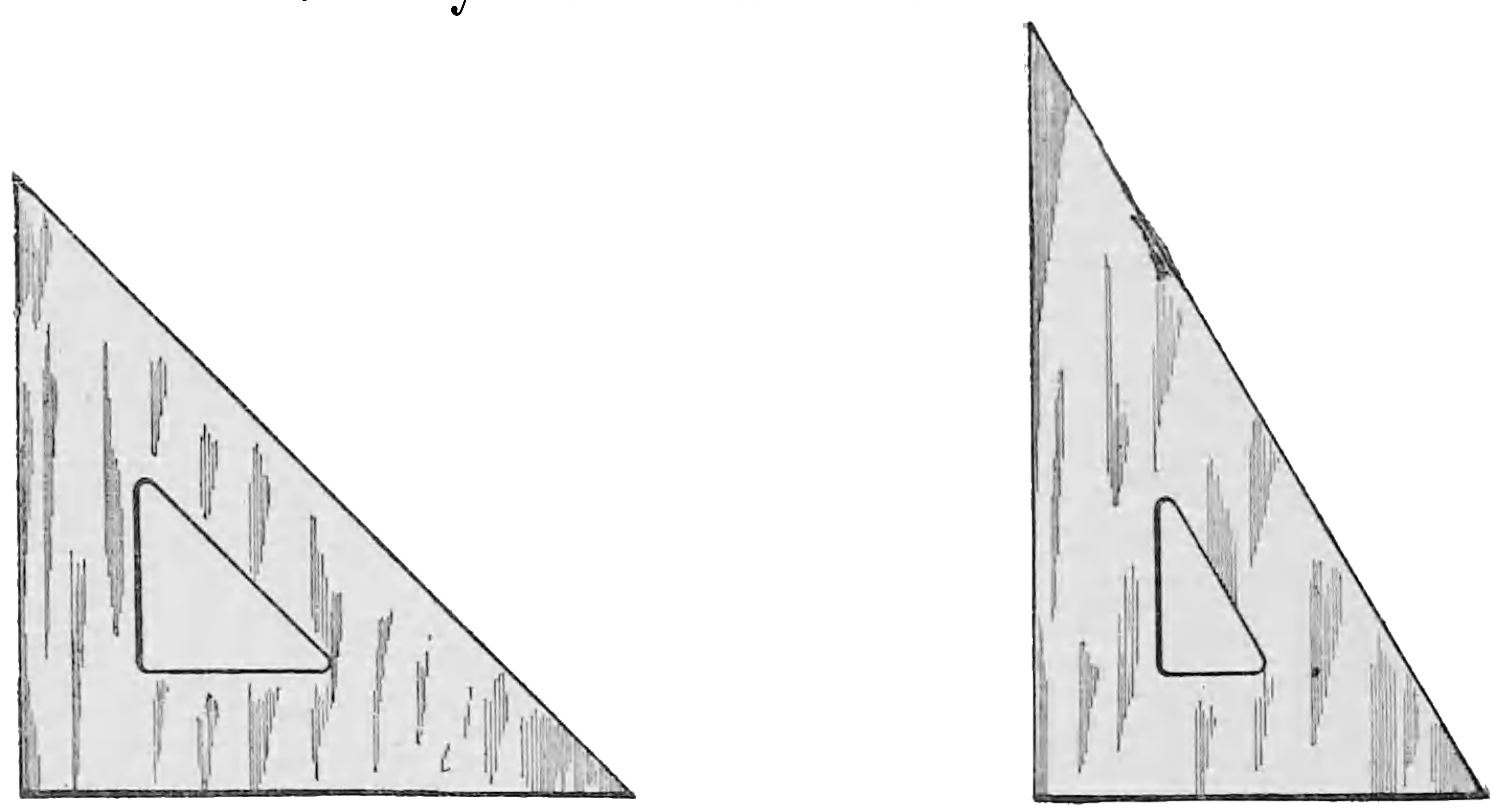


Fig. 9. 45° and 30° – 60° Triangles

In using a rubber or celluloid triangle take care that it lies perfectly flat and is hung up when not in use; when allowed to lie on the drawing board with a pencil or an eraser under one corner it will become warped in a short time, especially if the room is hot or the sun happens to strike the triangle.

Triangles from 6 to 8 inches on a side will be found convenient for most work, although there are many cases where a small triangle measuring about 4 inches on a side will be found useful. Every draftsman should have at least two triangles, one having two angles of 45 degrees and one right angle; and the other having angles of 30, 60, and 90 degrees, respectively, Fig. 9.

The value of the triangle depends upon the accuracy of the angles and the straightness of the edges. To test the accuracy of

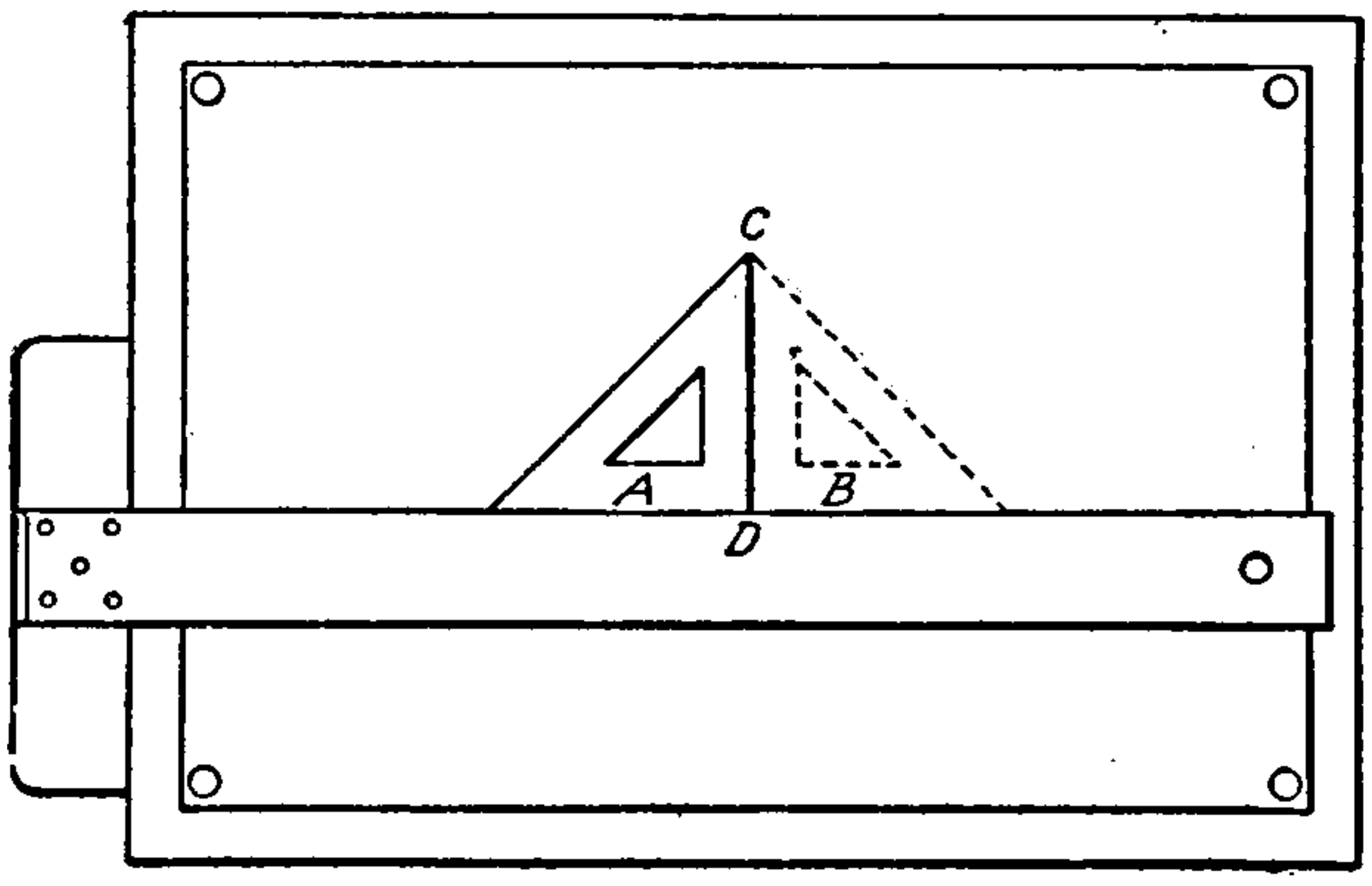


Fig. 10. Testing a Right Angle (45° Triangle)

the right angle of a triangle, place the triangle with the lower edge resting on the T-square in position *A*, Fig. 10. Now draw the line *C D*, which, if the triangle be true, will be perpendicular to the edge of the T-square. Transfer the triangle to position *B*, and if the right angle of the triangle is exactly 90 degrees the left-hand edge of the triangle will exactly coincide with the line *C D*.

To test the accuracy of the 45-degree angles place the triangle with the lower edge resting on the working edge of the T-square,

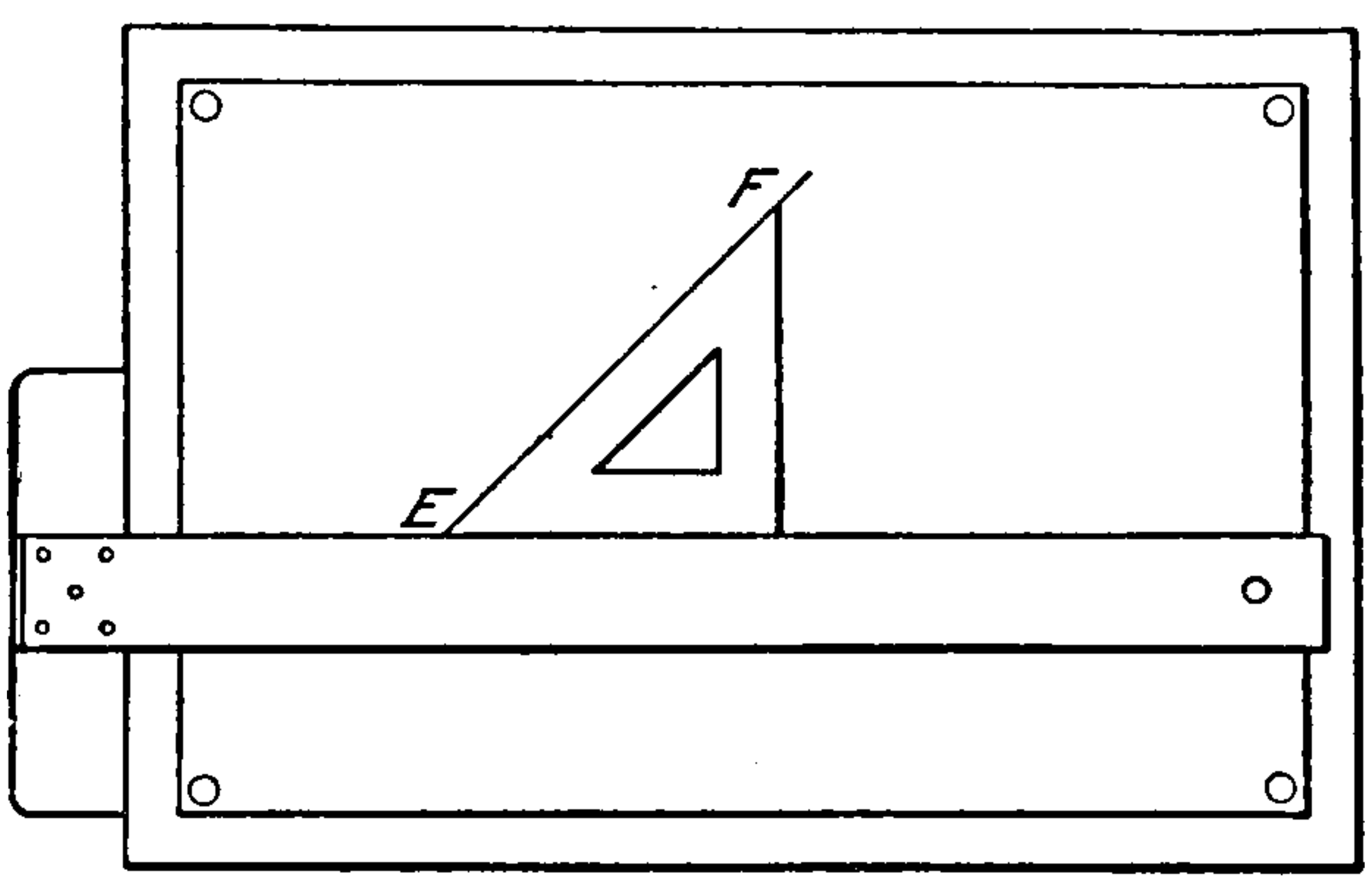


Fig 11. Testing 45° Angle (45° Triangle)

and draw the line *E F*, Fig. 11. Now without moving the T-square place the triangle so that the other 45-degree angle is in the position occupied by the first. If the two 45-degree angles coincide they are accurate.

Triangles are used in drawing lines at right angles to the T-square, Fig. 12, and at an angle with the horizontal, Fig. 13. If it is desired to draw a line through the point *P*, Fig. 14, parallel to a given

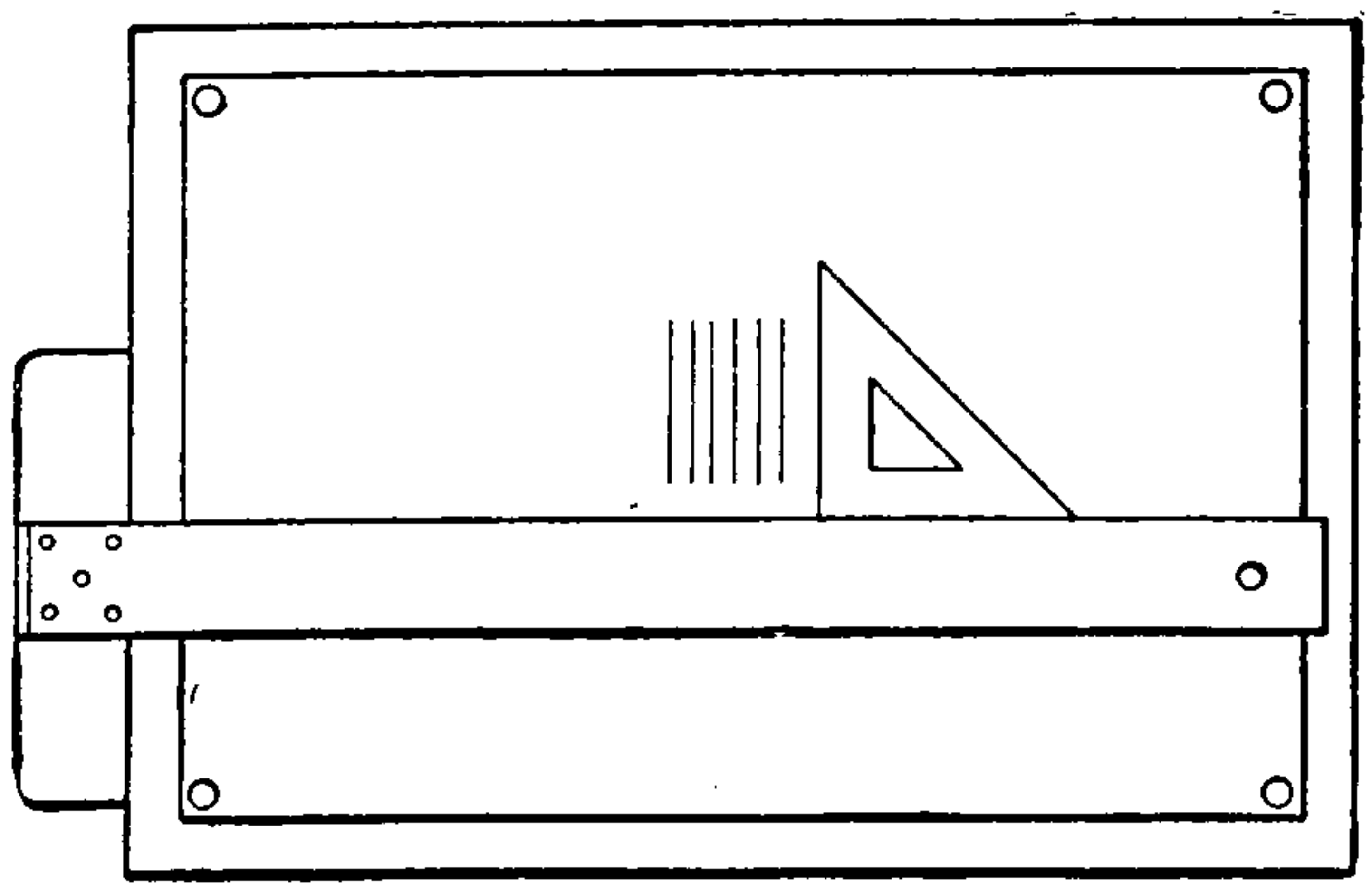


Fig. 12. Drawing Vertical Parallel Lines

line *E F*, two triangles should be used. First, place triangle *A* with one edge coinciding with the given line. Now take triangle *B* and place one of its edges in contact with the bottom edge of triangle *A*. Holding triangle *B* firmly with the left hand, slide triangle *A* to the right or to the left until its edge reaches the point *P*. The line *M N* may then be drawn passing through the point *P*. In place of the triangle *B* any straight-edge such as a T-square may be used.

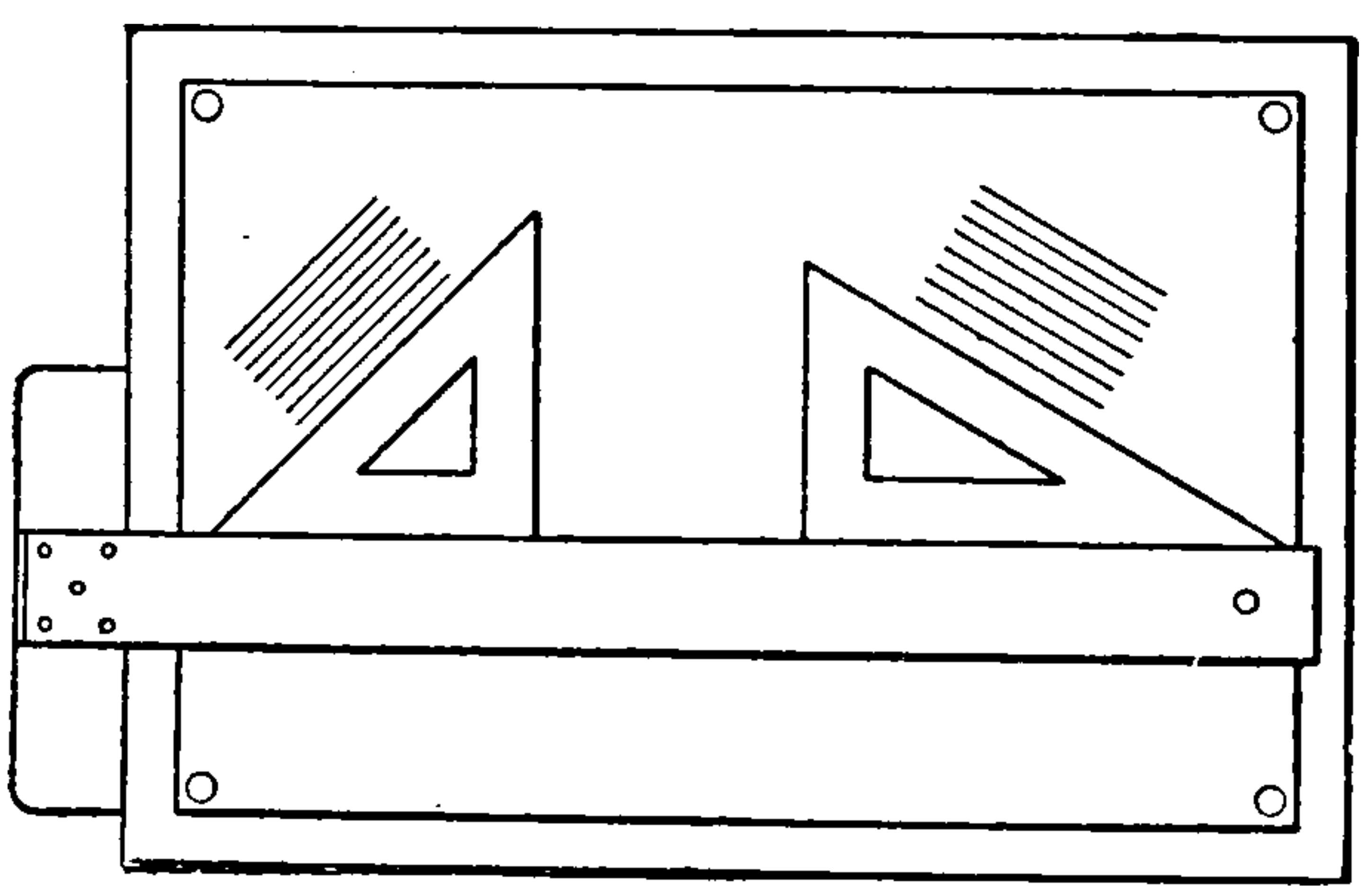


Fig. 13. Drawing Parallel Lines at an Angle with the Horizontal

A line may be drawn through a point, perpendicular to a given line by means of triangles as follows: Let *E F*, Fig. 15, be the given line, and let the point be *D*. Place the longest side of triangle *A* so that it coincides with the line *E F*. Place the other triangle (or any straight-edge) in the position of the triangle *B;* then holding *B* with the left hand, place the triangle *A* in the position *C*, so that the longest side passes through the point *D*. A line may then be drawn through the point *D* perpendicular to *E F*.

triangles on the T-square and in positions *E* and *F* draw the vertical lines *D A* and *B C*.

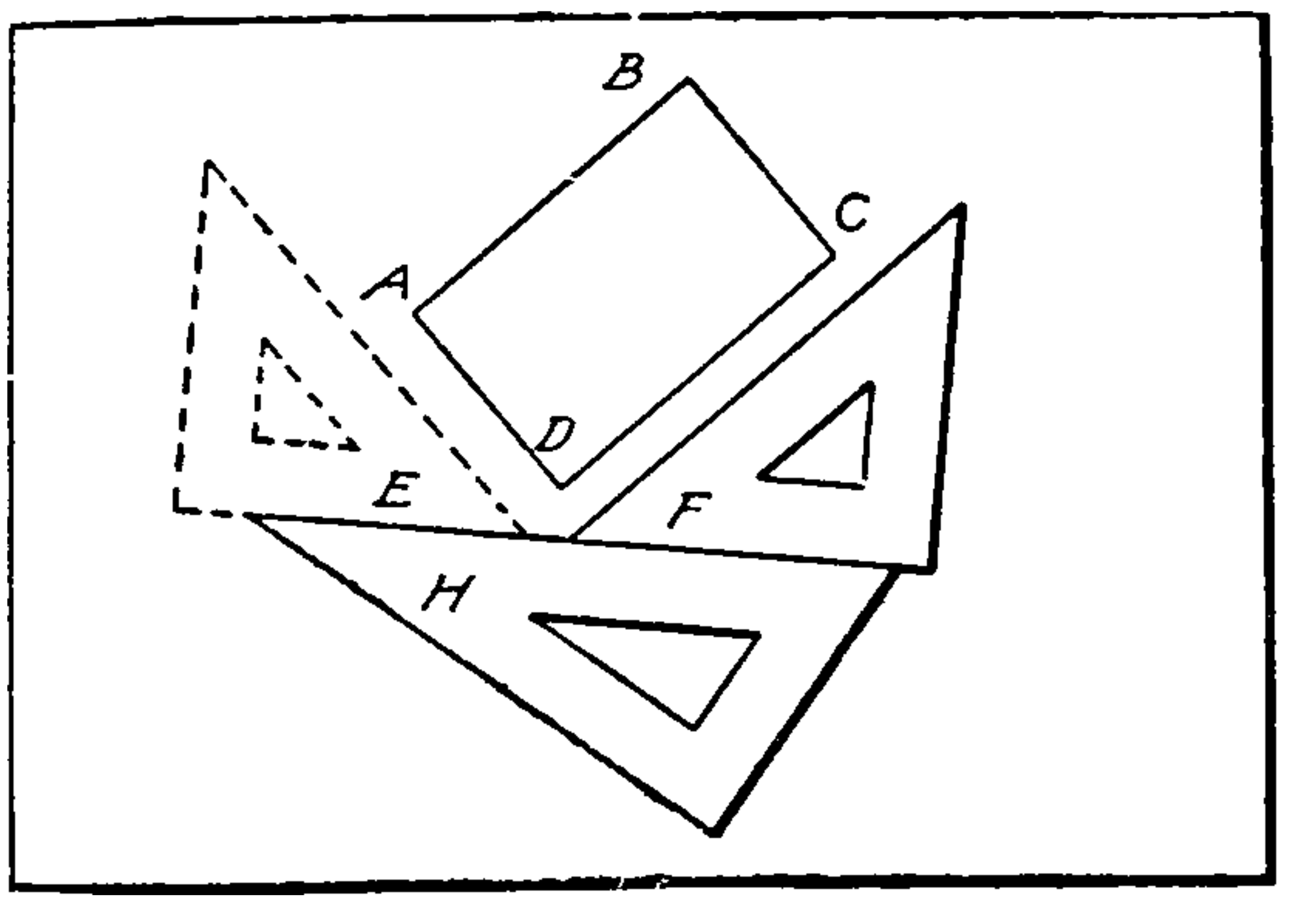


Fig 18 Rectangle Drawn with Triangles

If the rectangle is to be drawn in some other position on the board, as shown in Fig. 18, place the 45-degree triangle *F* so that the longest edge is in the required direction of the side *D C*. Now, hold the triangle *F* in position and place another triangle in position *H*. By holding *H* in position and sliding triangle *F*, the sides *A B* and *D C* may be drawn. To draw the sides *A D* and *B C* change triangle *A* to position *E* and repeat the process.

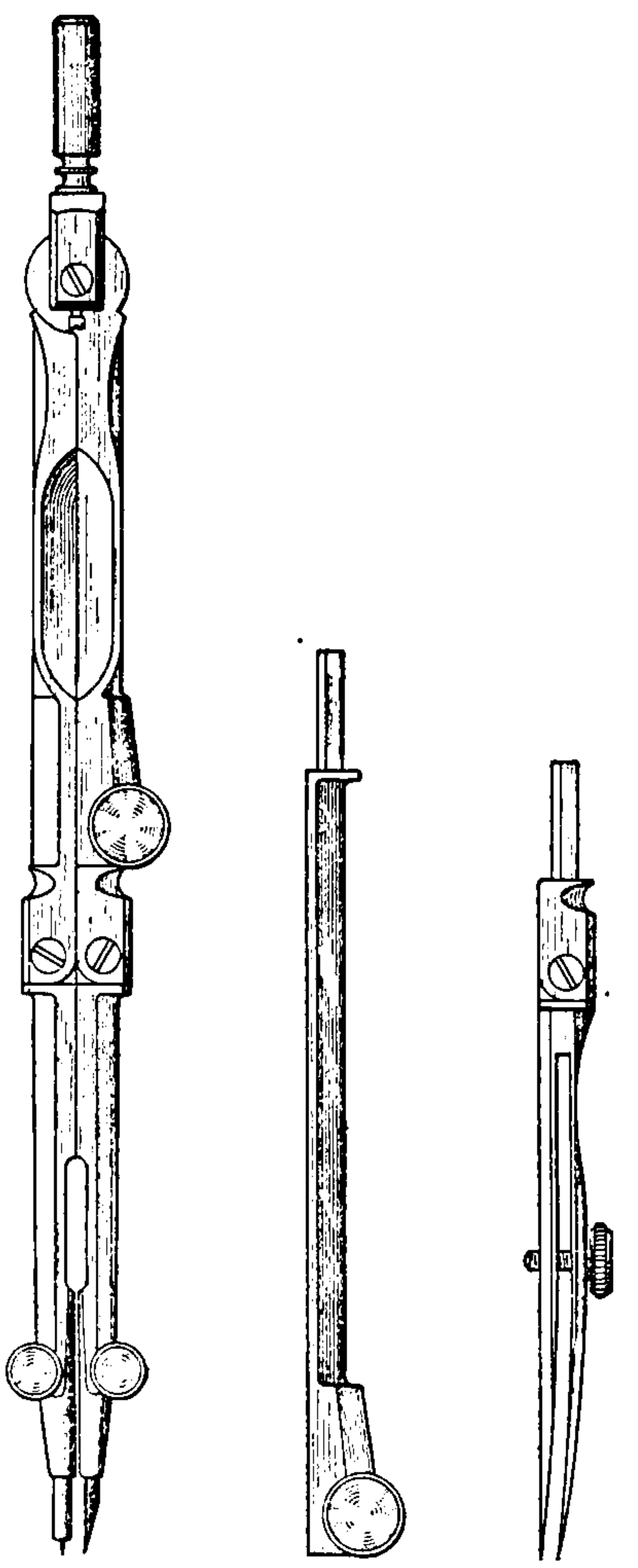


Fig 19 Compasses and Attachments

Compasses. Compasses are used for drawing circles and arcs of circles. The cheaper class of instruments are made of brass, but they are unsatisfactory on account of the odor and the tendency to tarnish. The best material is German silver, as it does not soil the hands, has no odor, and is easy to keep clean. Aluminum instruments possess the advantage of lightness, but on account of the softness of the metal they do not wear well.

The compasses are made in the form shown in Fig. 19 and are provided with pencil and pen points. Fig. 20 shows the compass in position for drawing circles. One leg has a socket into which the shank of the pencil or pen mounting may be inserted. The other leg is fitted with a needle point which is placed at the center of the circle. In most instruments the needle point projects through a piece of round steel wire with a square shoulder at one or both ends.

In some instruments the joints are held in position by lock nuts, made of thin disks of steel, with notches for using a wrench or forked key. Fig. 21 shows the detail of the joint of a high grade instrument. Both legs are alike at the joint, and two pivoted screws are inserted in the yoke. This permits ample movement of the legs, yet gives the proper stiffness. The flat surface of one leg is faced with steel, the other with German silver, so that the rubbing parts may be of different metals. Small set screws are used to prevent the pivoted screws from turning in the yoke. The contact surfaces of this joint are made circular to exclude dirt and to prevent rusting of the steel face.

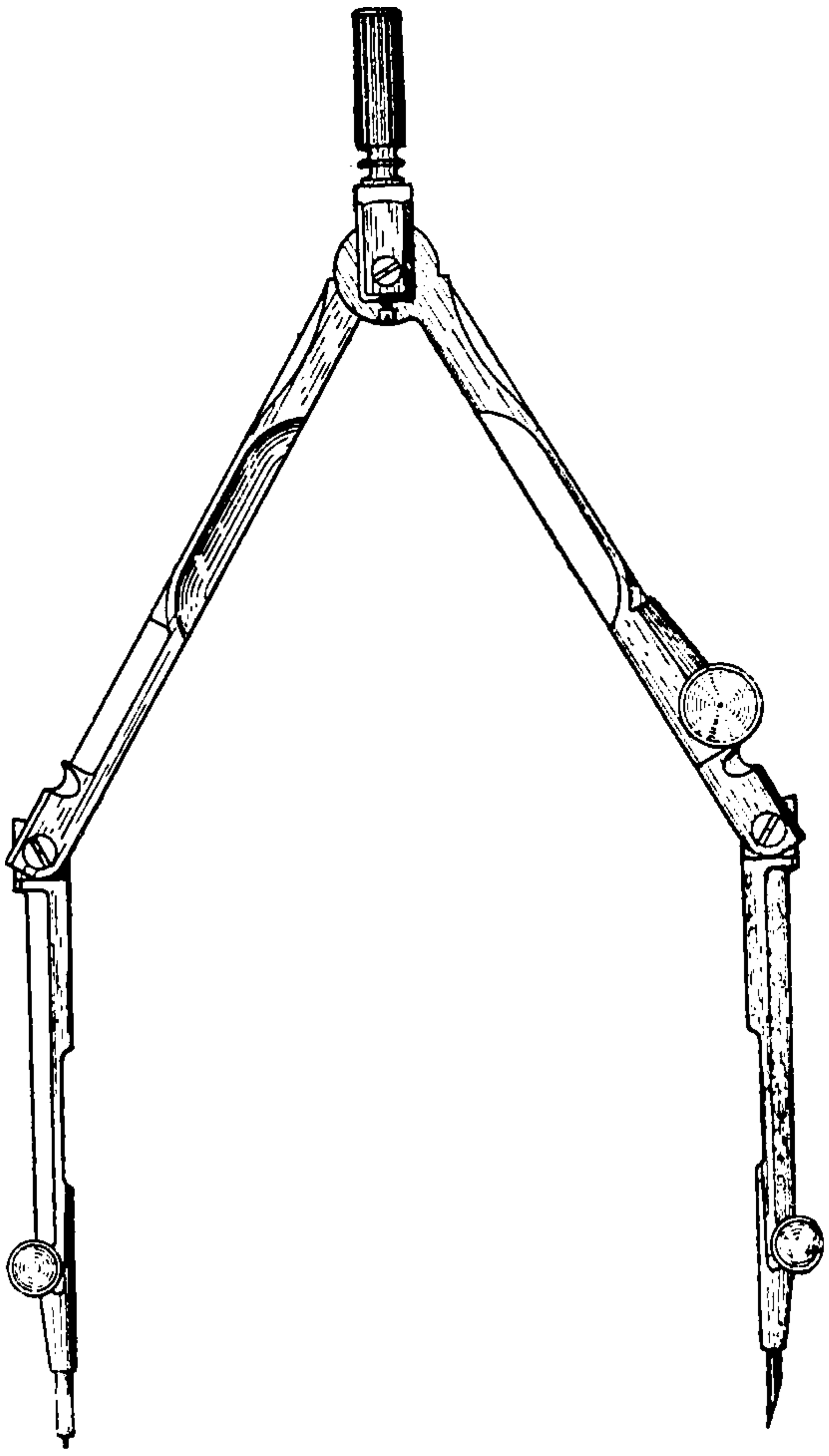


Fig 20 Compasses Set for Drawing Circles

The details of the socket are shown in Fig. 22, Fig. 23, and Fig. 24; in some instruments the shank and socket are pentagonal, Fig. 22, the shank entering the socket loosely, and being held in place by means of the screw. Unless used very carefully this arrangement is not durable because the sharp corners soon wear, and the pressure on the set screw is not sufficient to hold the shank firmly in place.

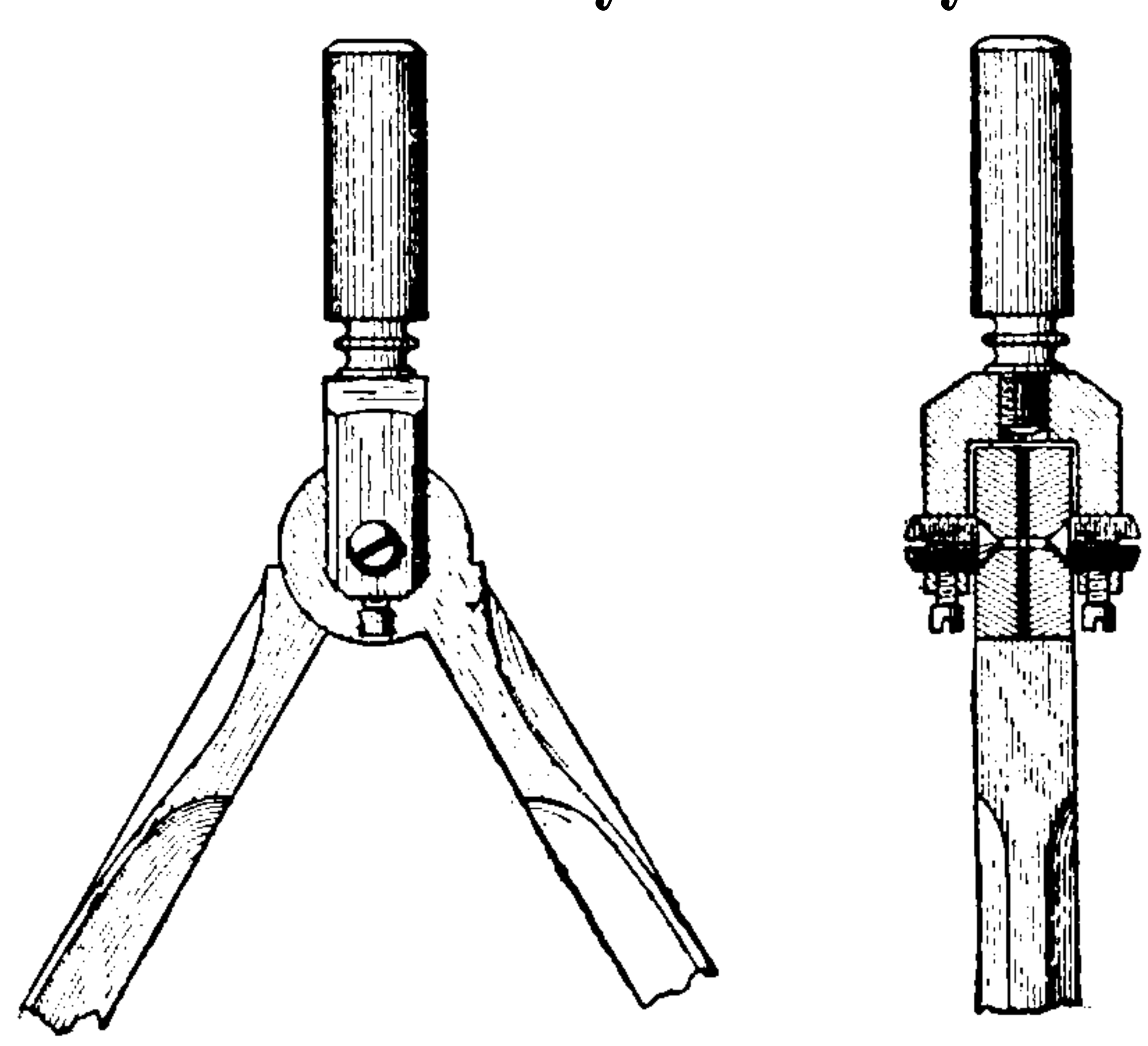


Fig. 21 Details of Compass Joint

In Fig. 23 is shown a round shank, the shank having a flat top, with a set screw to hold the shank in position. A still better form of socket is shown in Fig. 24, the hole being circular and tapered. The shank fits accurately into the split socket and is clamped by a screw on the side; it is held in perfect alignment by a small steel key.

Both legs of the compass are jointed in order that the lower part of the legs may be perpendicular to the paper while drawing circles. In this way the needle point makes but a small hole in the paper, and both nibs of the pen will press equally on the paper. In penciling circles it is not as necessary that the pencil should be kept vertical;

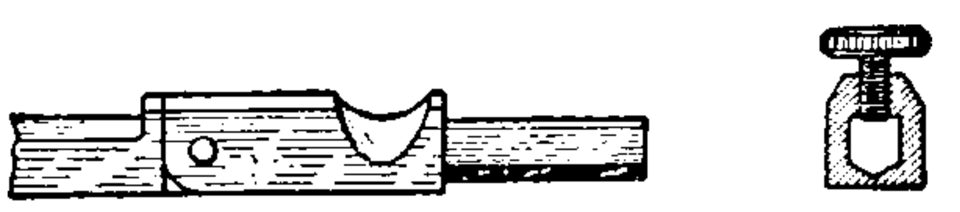


Fig. 22 Pentagonal Shank and Socket

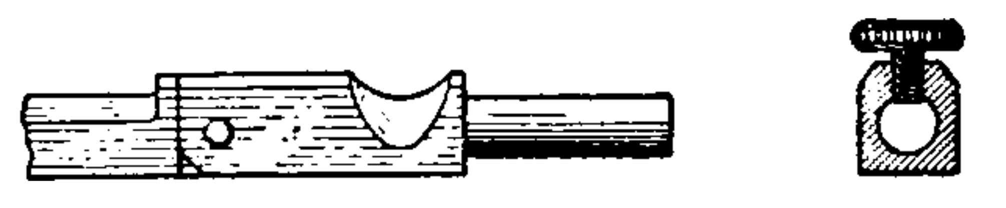


Fig 23 Circular Shank and Socket

it is a good plan, however, to learn to use them in this way both in penciling and inking. The compasses should be held loosely between the thumb and forefinger. If the needle point is sharp, as it should be, only a slight pressure will be required to keep it in place. While drawing the circle, incline the compasses slightly in the direction of revolution and press lightly on the pencil or pen.

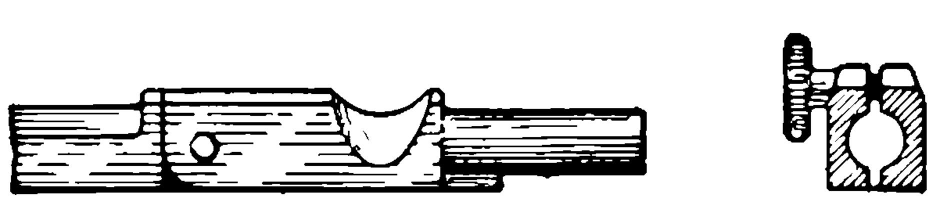


Fig 24 Circular Socket with Set Screw

In removing the pencil or pen attachment from the compass it should be pulled out straight in order to avoid enlarging the socket, and thus rendering the instrument inaccurate. For drawing large circles use the lengthening bar, Fig. 19, steadying the needle point with one hand and describing the circle with the other.

Fig. 25 Dividers

Dividers. Dividers, which are similar to compasses, are used to lay off distances on the drawing, either from a scale or from other parts of the drawing, Fig. 25. They are also used for dividing a line into equal parts. To do this turn the dividers in the opposite direction each time, *i. e.*, move the point alternately to the right and to the left. The points of the dividers should be very sharp so that the holes made in the paper will be small, thus assuring accurate spacing. Compasses may be used as dividers by substituting for the pencil or pen point an extra steel point, usually furnished with the instrument. In place of dividers many draftsmen use a *needle point*. The needle, with the eye-end broken off, is forced into a handle of soft pine, making a convenient instrument for marking line intersections and distances.

Bow Pen and Bow Pencil. Ordinary large compasses are too heavy and the leverage of the long leg is too great to allow small circles to be drawn accurately. For this reason the bow compasses, Figs. 26 and 27, should be used on all arcs and circles having a radius of less than $\frac{3}{4}$ inch, such as those which represent boiler tubes and bolt

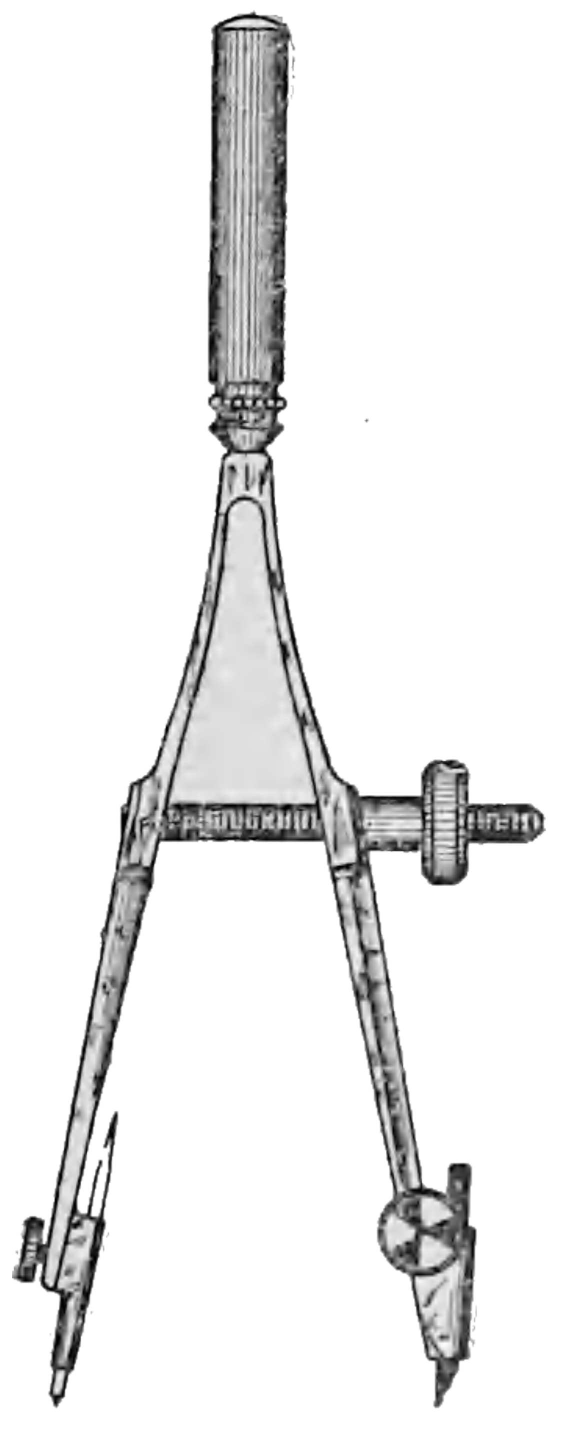


Fig. 26 Bow Pencil

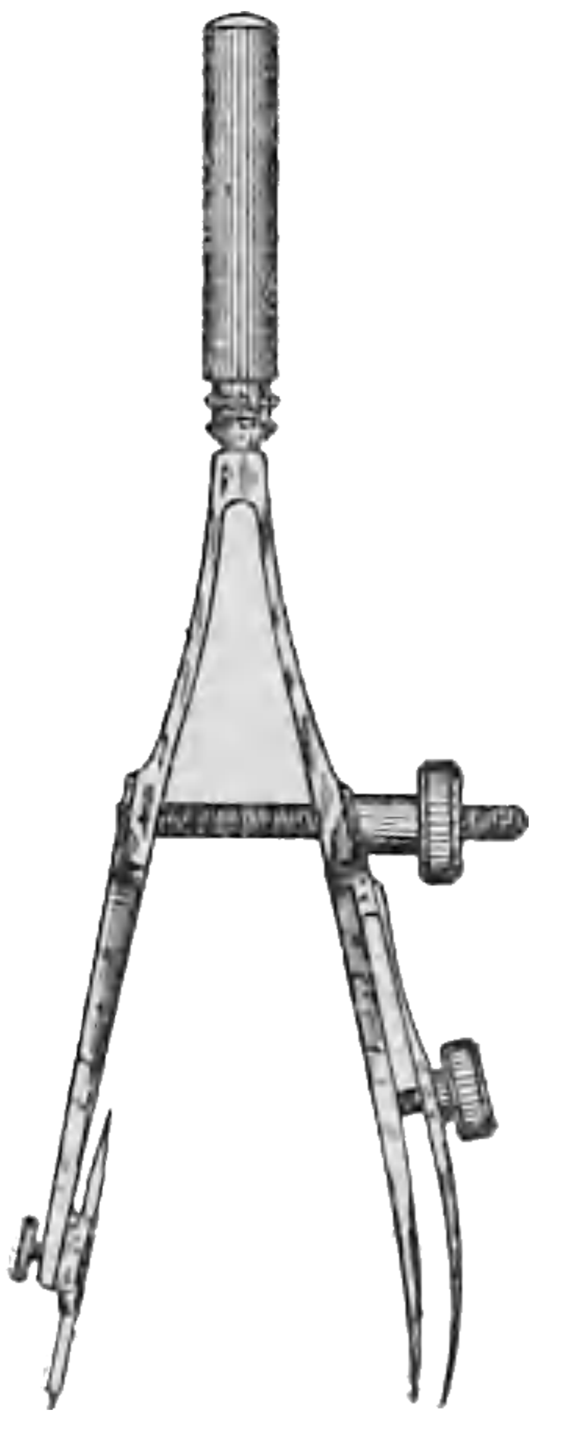


Fig 27 Bow Pen

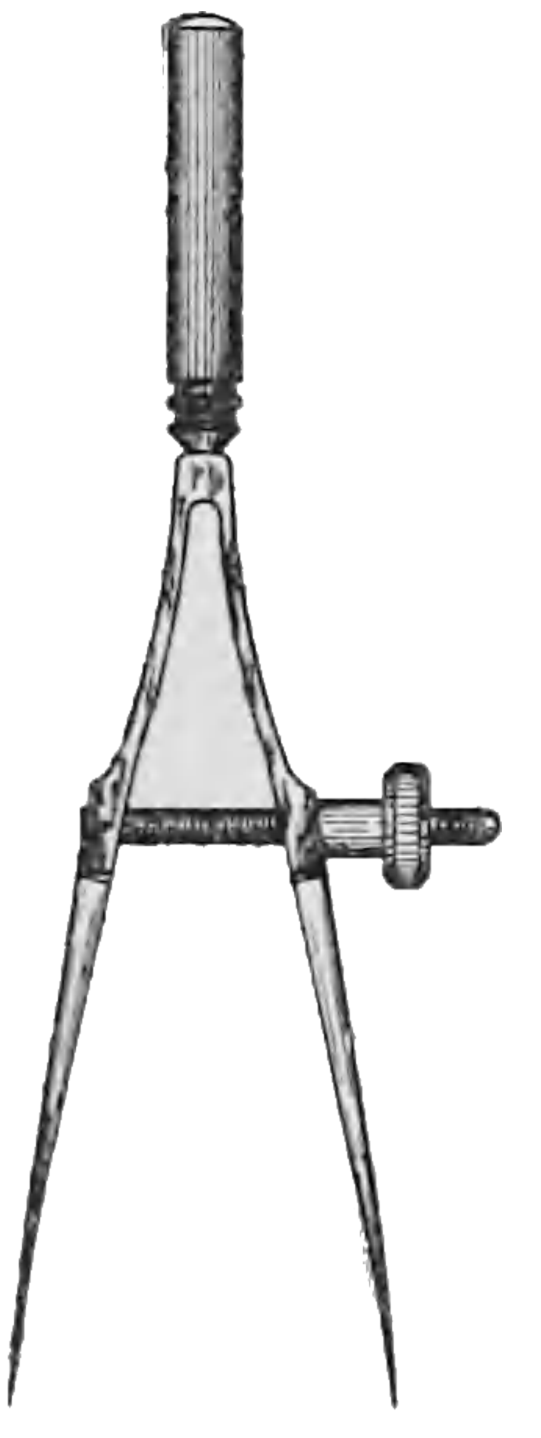


Fig. 28. Bow Dividers

holes. When small circles are drawn, the needle point must be adjusted to the same length as the pen or pencil point. If a considerable change in radius is made, press the points together before turning the nut so as to prevent wear in the screw threads. The bow dividers, Fig. 28, replace the ordinary dividers in small work and have the advantage of a fixed adjustment.

Drawing Pen. For drawing straight lines and curves that are not arcs of circles, the line pen—sometimes called the *ruling pen*—is

Fig 29 Drawing Pen

used, Fig. 29. The distance between the pen points, which regulates the width of line to be drawn, is adjusted by the thumb screw, and the blades are given a slight curvature so that there will be a cavity for ink when the points are close together.

The pen should not be dipped in the ink but should be filled by means of a common steel pen or quill, to a height of about $\frac{1}{4}$ or $\frac{3}{8}$ inch; if too much ink is placed in the pen it is likely to drop out and spoil the drawing. Upon finishing the work wipe the pen with chamois or a soft cloth, because most liquid inks corrode the steel.

In using the pen, care should be taken that both blades bear equally on the paper, in order that the line may be smooth. The pen is usually inclined slightly in the direction in which the line is drawn and should touch the triangle or T-square lightly so as not to press the blades together and thereby change the width of the line; the pen must not be tipped outward, however, as the danger of blotting is greatly increased when the line is drawn so close to the guide.

Sharpening the Drawing Pen. When it is impossible to make a smooth line with the drawing pen, it should be sharpened. Screw the blades together and grind them to a parabolic shape by drawing the pen back and forth over a small, flat, close-grained oilstone. This process, of course, makes the blades dull but insures their being of the same length. Now separate the points slightly and rub one of them on the oilstone, keeping the pen at an angle of from 10° to 15° with the face of the stone, and giving it a slight twisting movement. This part of the operation requires great care as the shape of the ends must not be altered. After one point has become fairly sharp, grind the other in a similar manner, grinding always on the *outside* of the blades and removing the burr from the inside with leather or pine wood. Test the pen by filling with ink and drawing several lines. Unless the lines are smooth, the grinding must be continued.

Ink. India ink is always used for drawing as it makes a permanent black line; it is obtainable in solid stick or liquid form. The liquid form is much more convenient but contains acid which corrodes steel and makes it necessary to keep the pen perfectly clean.

To prepare the ink in stick form for use, put a little water in a saucer and place one end of the stick in it; then by a twisting motion grind enough ink to make the water black and slightly thickened. Now draw a heavy line on a sheet of paper and if after drying the line has a grayish appearance, more grinding is necessary. Wipe the stick dry after using to prevent crumbling. It is well to grind the ink in small quantities as it does not dissolve readily a second time; however, if covered it will keep for two or three days.

Scales. The scales used for obtaining measurements on drawings are made in several forms, the most convenient being the *flat*, with beveled edges, and the *triangular*. The scale is usually graduated for a distance of 12 inches. The triangular scale, Fig. 30, has six

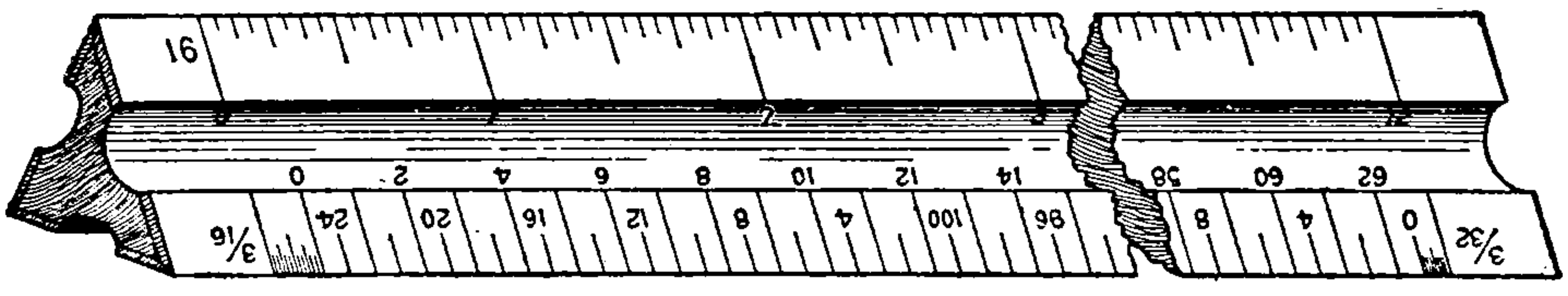


Fig. 30. Triangular Scale

surfaces for different graduations, and the scales are arranged so that the drawings may be made in any proportion to the actual size. For mechanical work, the common divisions are multiples of two; thus drawings are made full size, $\frac{1}{2}$ size, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$, etc. If a drawing is $\frac{1}{4}$ size, 3 inches equals 1 foot, hence 3 inches is divided into 12 equal parts and each division represents one inch. If the smallest division on a scale represents $\frac{1}{16}$ inch, the scale is said to read to $\frac{1}{16}$ inch.

Scales are often divided into $\frac{1}{10}$, $\frac{1}{20}$, $\frac{1}{30}$, $\frac{1}{40}$, etc., for architects and civil engineers, and for measuring indicator cards.

The scale should never be used as a substitute for the triangle or T-square in drawing lines.

Protractor. The protractor, an instrument used for laying off

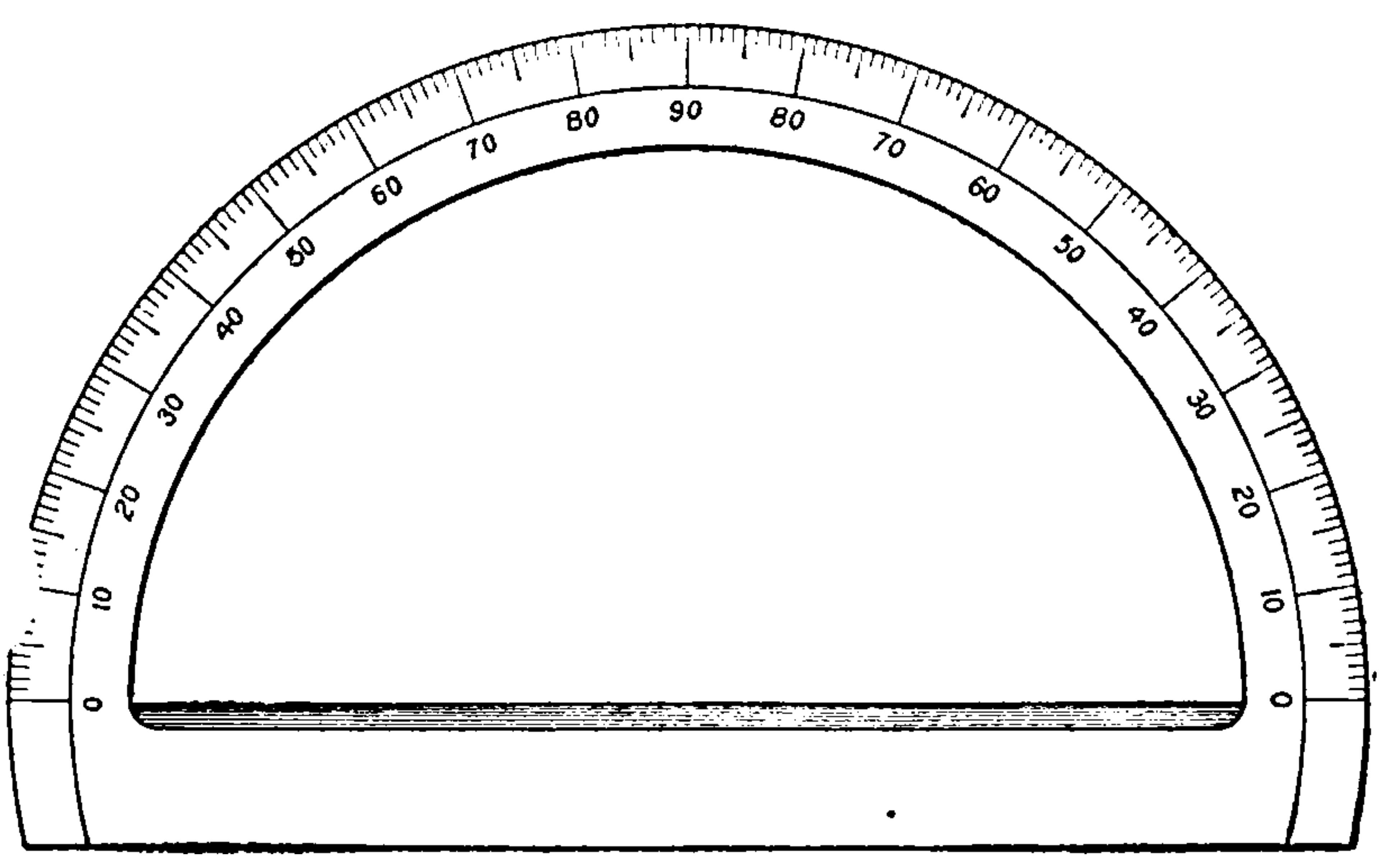


Fig. 31. Protractor

and measuring angles, is made of steel, brass, horn, or paper. When made of metal the central portion is cut out, Fig. 31, so that the draftsman may see the drawing. The outer edge is divided into degrees and tenths of degrees. To lay off the required angle—use a very sharp, hard pencil in order that the measurements may be accurate—place the protractor so that the two zero marks are on the given line, produced if necessary, and the center of the circle is at the point through which the desired line is to be drawn.

Irregular Curve. One of the conveniences of a draftsman's outfit is the *French* or *irregular curve,* which is used for drawing curves other than arcs of circles, with either pencil or line pen. This instrument, which is made of wood, hard rubber, or celluloid—celluloid being the best—is made in various shapes, three of the most common being shown in Fig. 32.

To draw a curve through a series of located points find that position of the irregular curve that passes through several points and

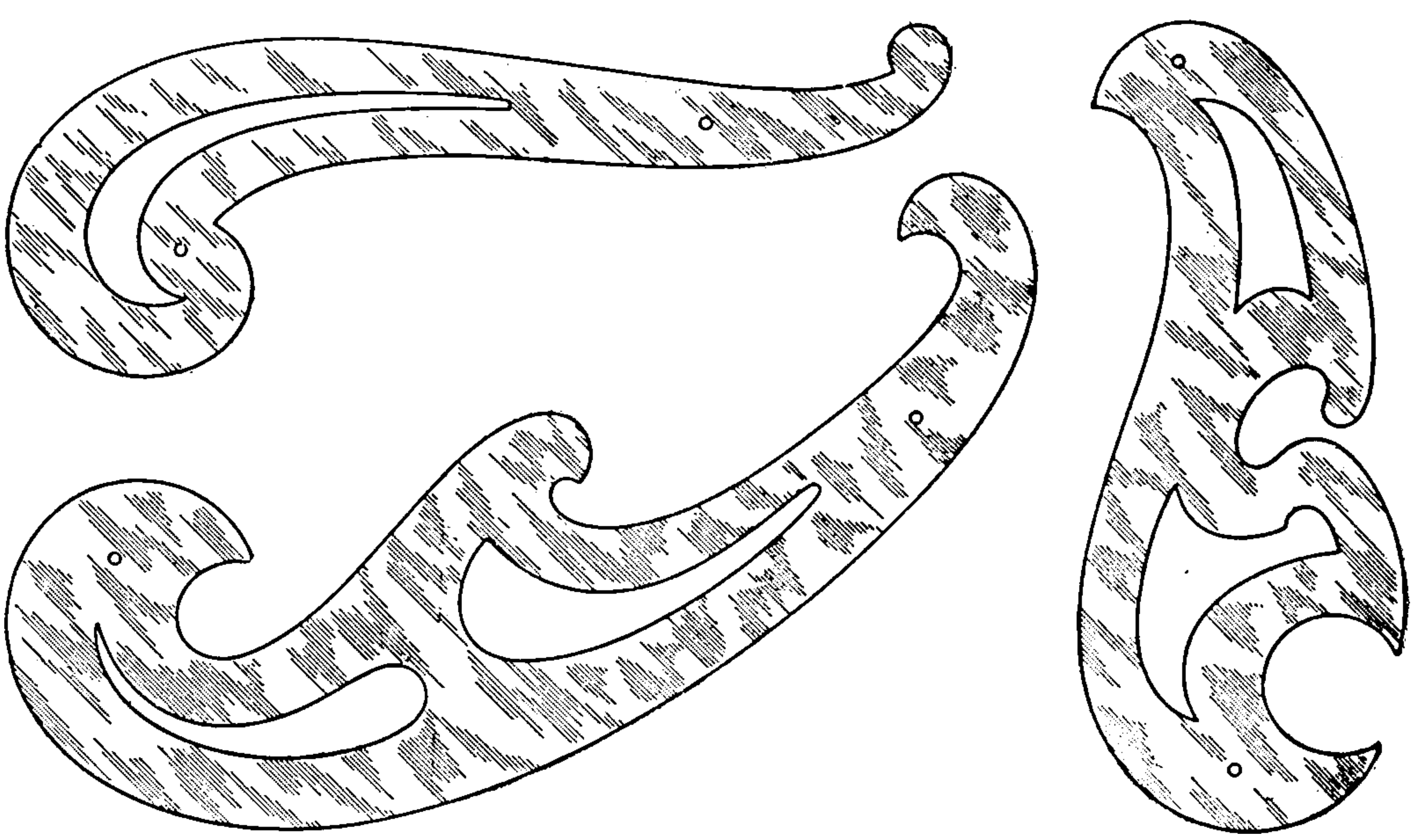


Fig. 32. Irregular Curves

draw the line through them. Now shift the curve so as to include a few more points and so on until the curve is completed. It frequently facilitates the work and improves its appearance to draw a free hand pencil curve through the points and then use the irregular curve, taking care that it always fits at least *three* points. In inking the curve, the blades of the pen must be kept tangent to the curve.

Beam Compasses. The ordinary compasses are suitable for drawing circles up to 8 or 10 inches diameter. For larger circles beam compasses, Fig. 33, are provided. The two parts called *channels*

which carry the pen or pencil and the needle point are clamped to a wooden beam at a distance equal to the radius of the circle. The

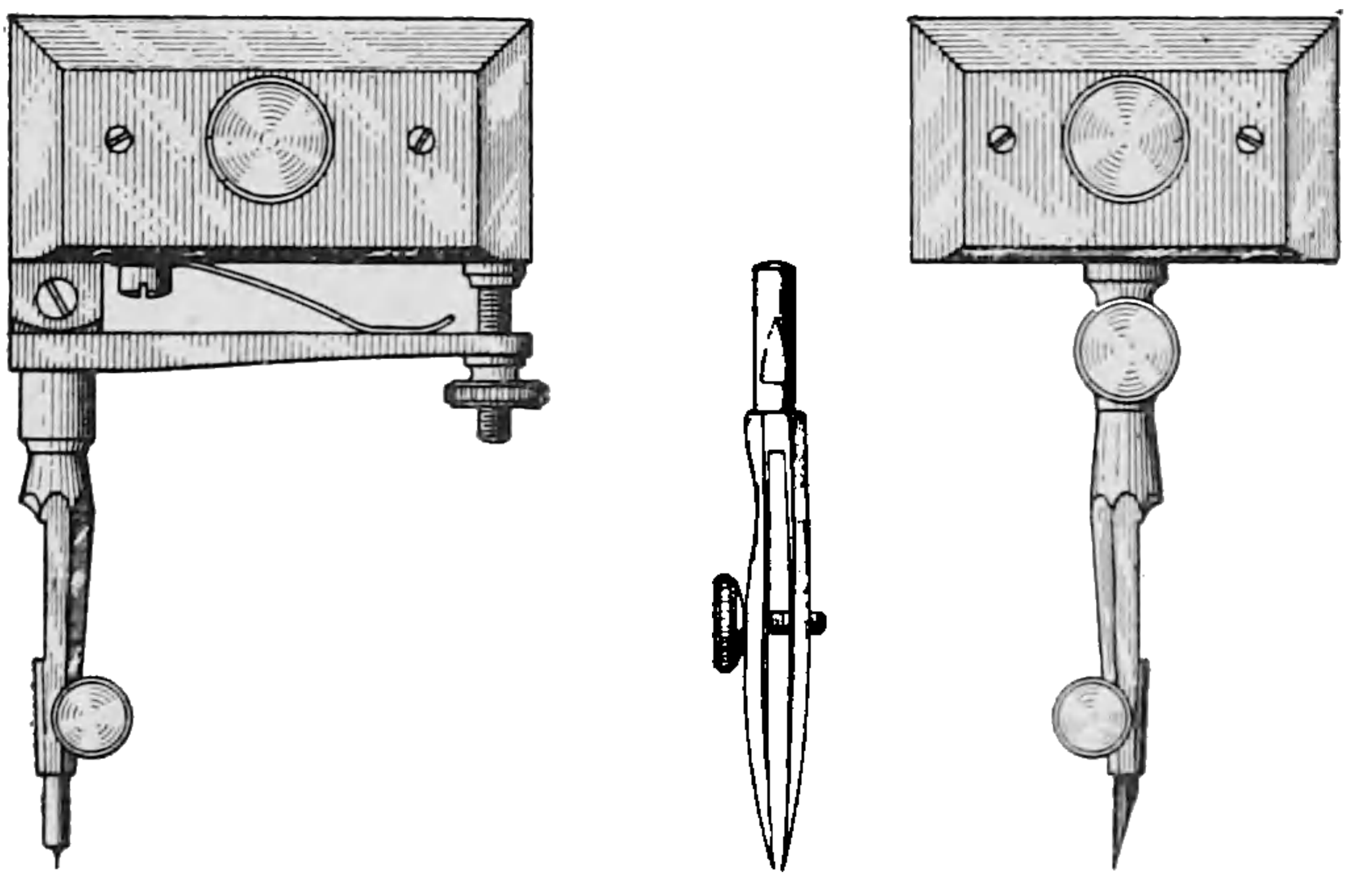


Fig 33 Channels of a Beam Compass

thumb nut underneath one of the channel pieces makes accurate adjustment possible.

LETTERING

No mechanical drawing is finished unless all headings, titles, and dimensions are lettered in plain, neat type. Many drawings are accurate, well-planned, and finely executed but do not present a good appearance because the draftsman did not think it worth while to letter carefully. Lettering requires time and patience especially for the beginner; and many think it a good plan to practice lettering before commencing drawing. Poor writing need not necessarily mean poor lettering, for good writers do not always letter well.

In making large letters for titles and headings it is often necessary to use drawing instruments and mechanical aids, but small letters, such as those used for dimensions, names of materials, dates, etc., **should be made free-hand.**

Forming. The student is apt to think that lettering is a form of mechanical drawing, that the use of the straight-edge is the principal operation, and that letters, forms, and the spaces between are to be figured out by measurement. On the contrary, lettering is design, and the draftsman so distributes the letters in the spaces arranged for them as to make a combination that will be pleasing to the eye. The requirements for a good design are simplicity and uniformity. These are acquired by accuracy in detail and by good judgment and taste, as no practical rules can be followed which will invariably produce the same result. Letter forms are, to a certain extent, standard. The lettering for a title is usually done very carefully and accurately, while practically all of the other lettering on a drawing is done rapidly and in a simple style. To develop a letter use the same method of procedure as in drawing a straight line between two points. First, draw the guide lines rather carefully and then block out the general form of the letter by a series of short strokes of the pencil. Continue this method, straightening the lines and rounding the curves of the latter until its form is satisfactory.

Spacing. The spacing of the letters is very important and is best obtained by the unaided eye just as are the proportions of the letters. Care must be taken to allow a clear distance between letters, the space varying according to the combination. For instance, such letters as *A*, *V*, and *W* spread more at one part than at another and therefore do not fill the space completely. Of course, when the distance between letters is large any such irregularities will not be noticeable. The best method for obtaining good space values is by sketching in the letters roughly and then bringing them to a good appearance by correction and adjustment The first results are, of course, unsatisfactory, but after the eye and hand have become trained, great improvement will be noticed. A simple aid to this development will be found in the use of a piece of cardboard with the widths of the enclosing rectangles or parallelograms of the different letters marked on its edge, by which the spacing made by the eye may be checked.

Inking. In practical work most of the lettering is penciled in and then finished in ink. As faults in letters which may not be noticed in the penciled work stand out clearly after inking, it is not advisable to ink in the penciled letter accurately, but rather to improve upon it.

For lettering free-hand, use a pen that will make the full weight of line desired without much pressure, holding it squarely on the paper and directly in front. A new pen, which is apt to give too fine a line, may be remedied by scratching a little on a rough surface. If a pen is kept clean and all hardened ink removed so that the nibs are not spread, the pen will last a long time. A coarser pen must be used on rough than on smooth paper.

To remove a faulty line or a blot, let the ink dry thoroughly, then with a sand rubber, erase the spot carefully, rubbing around it, as well. Clean the sand out of the surface with a pencil eraser and finally polish down with a piece of ivory or smooth wood. Pencil in the parts erased as if doing the work for the first time and again ink in, using special care, as the ink is more likely to spread on an erased surface than anywhere else.

Style. There are many styles of letters used by draftsmen, but almost any neat letter free from ornamentation is acceptable in regular practice. For titles, large Roman capitals are preferred, although Gothic and black letters also look well and are much easier to make. The vertical and inclined or italicized Gothic capitals shown in Fig. 34 and Fig. 35, are neat, plain, and easily made. This

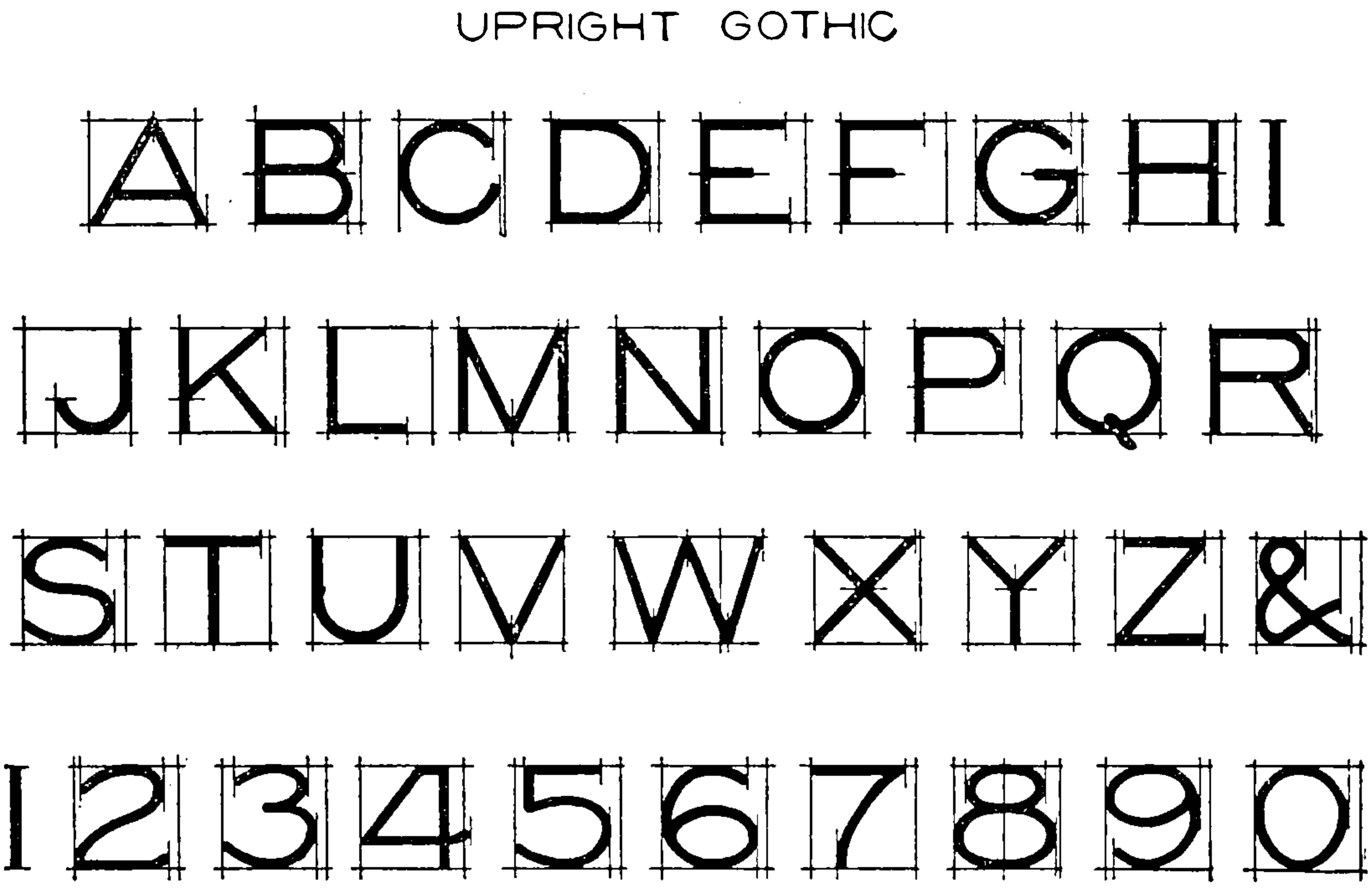


Fig. 34 Upright Gothic Capitals

latter style possesses the advantage over the vertical type in that a slight difference in inclination is not apparent.

The curves of the inclined Gothic letters such as those in *B*, *C*, *G*, *J*, etc., are somewhat difficult to make free-hand, especially if the letters are about one-half inch high. In the alphabet, Fig. 36, the letters are made almost wholly of straight lines, the corners only being curved.

The first few plates of this work will require no titles, the only lettering being the student's name, the date, and the plate number which will be done in inclined Gothic capitals. Later the subject of lettering will again be taken up in connection with titles and headings for drawings which show the details of machines.

To make the inclined Gothic letters, first draw two parallel lines $\frac{5}{32}$ inch apart to mark the height for the letters of the date, name,

Fig. 35 Inclined Gothic Capitals

and plate number. This is the height to be used on all plates throughout this work, unless other directions are given. When two sizes of letters are used, the smaller should be about two-thirds as high as the larger. The inclination of the letters should be the same for all,

Fig 36 Inclined Gothic Capitals— Straight Lines with Curved Corners

and as an aid to the beginner, light pencil lines may be drawn about $\frac{1}{4}$ inch apart, forming the proper angle with the parallel lines already drawn; this angle is usually about 70°, but if a 60° triangle is at hand, it may be used in connection with the T-square as shown in Fig. 38.

Capital letters such as *D, E, F, L, Z,* etc., should have their top and bottom lines coincide with the horizontal guide lines, as otherwise the work will look uneven. Letters, of which *C, G, O,* and *Q* are types, may be formed of curved or straight lines. If made of curved lines, their height should be a little greater than the guide lines to prevent their appearing smaller than the other letters. In this work they may be made of straight lines with rounded corners as such letters are easily constructed and may be made of standard height.

To construct the letter *A*, use one of the 60° lines as a center line. Then from its intersection with the upper horizontal line drop a perpendicular to the lower guide line. Draw another line from the vertex meeting the lower guide line at the same distance on the other side of the center line. The cross line of the *A* should be a little below the center. The *V* is an inverted *A* without the cross line. For the letter *M*, the side lines should be parallel and about the same distance apart as the guide lines. The side lines of the *W* are *not* parallel but are farther apart at the top. The *J* is not quite as wide as such letters as *H*, *E*, *N*, *R*, etc. To make a *Y*, use the same spread as in making a *V* but let the diverging lines meet the center line a little below the middle.

The lower-case letters are shown in Fig. 37. In such letters

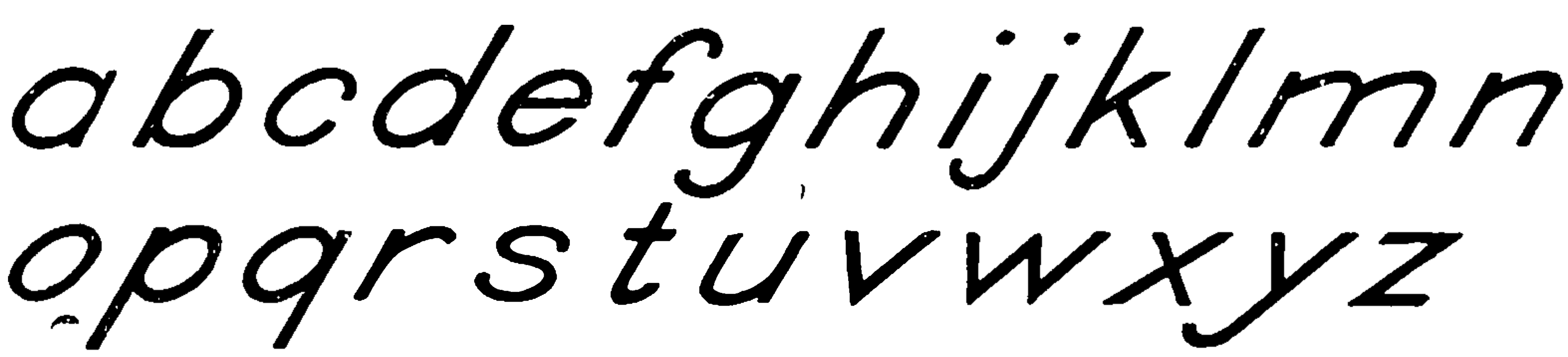


Fig. 37 Inclined Gothic Lower-Case Letters

as *m*, *n*, *r*, etc., make the corners slightly rounding. The letters *a*, *b*, *c*, *e*, *g*, *o*, *p*, *q*, should be full and rounding.

The style of the Arabic numerals is given in Fig. 36; Roman numerals are made of straight lines.

At first the copy should be followed closely and the letters drawn in pencil; the inclined guide lines may be used until the proper inclination becomes firmly fixed in mind when they should be abandoned. The horizontal lines, however, are used at all times by most draftsmen. After considerable practice has been had the letters may be constructed in ink without first using the pencil. When proficiency has been attained in the simple inclined Gothic capitals, the vertical, block and Roman alphabets should be studied.

PRELIMINARY LINE PROBLEMS

To lay out the paper for the plates of this work, place a sheet, *A B G F*, Fig. 38, on the drawing board 2 or 3 inches from the left-hand edge, called the *working edge*. If placed near the left-hand edge, the T-square and triangles can be used with greater firmness and the horizontal lines drawn with greater accuracy. In fastening the paper on the board, always true it up with the T-square according to the long edge of the sheet and use at least 4 thumb tacks —one at each corner. If the paper has a tendency to curl, 6 or 8

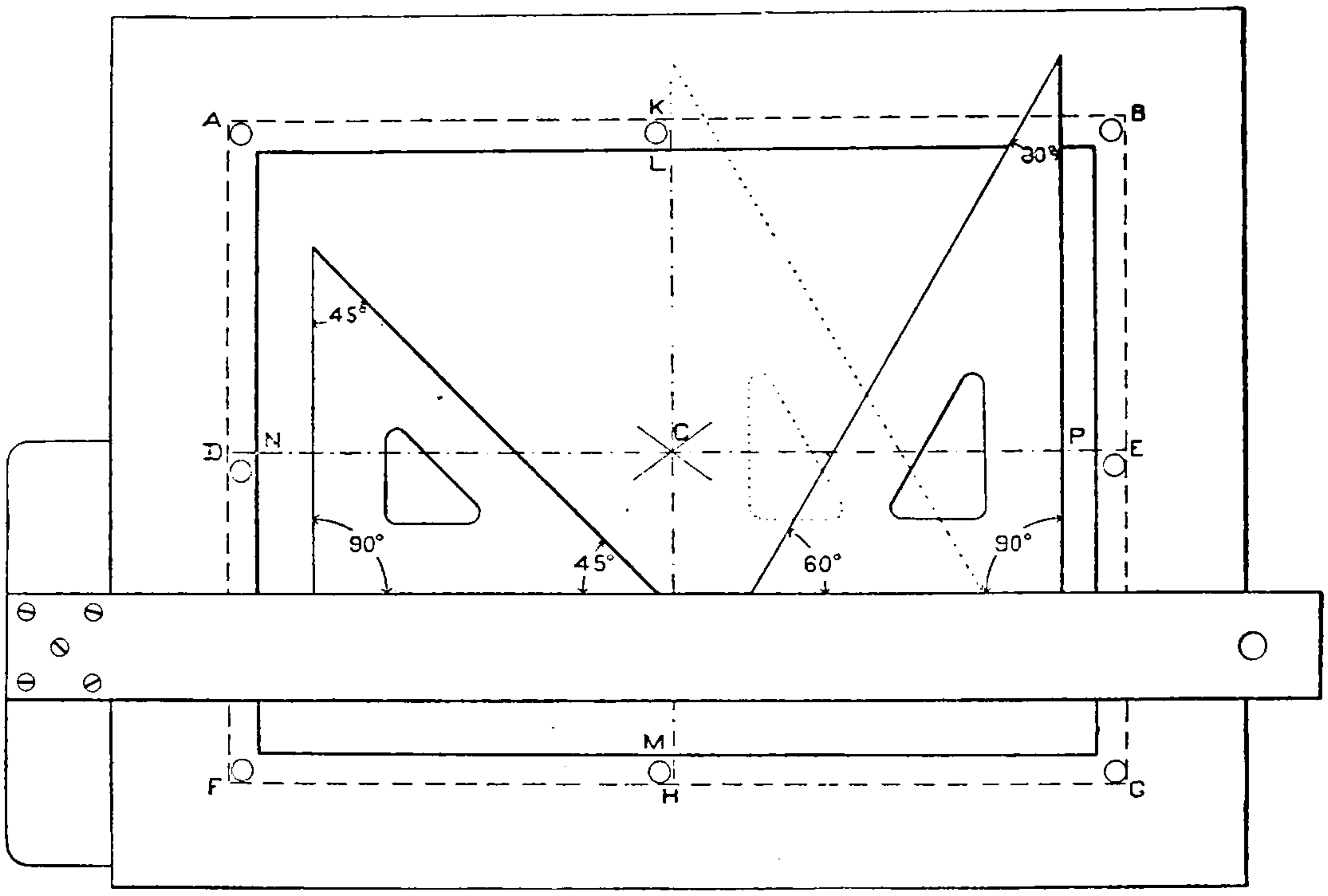


Fig 38 Standard Lay-Out for Plates

tacks may be used placing them as shown in Fig. 38; many draftsmen prefer one-ounce tacks as they offer less obstruction to the T-square and triangles.

To find the center of the sheet place the T-square so that its upper edge coincides with the diagonal corners *A* and *G* and with the corners *F* and *B*, and draw short pencil lines intersecting at *C*. Now with the T-square draw through the point *C* the dot and dash line *D E*, and with the T-square and one of the triangles—shown dotted in Fig. 38—draw the dot and dash line *H C K*. It will probably be necessary to draw *C K* first and then by means of the T-square or triangle, produce (extend) *C K* to *H*. In this work always move

be used. Keep the pressure of the pen on the paper uniformly light, remembering that different weights of lines are not obtained by pressure as with the ordinary writing pen but only by adjusting the nibs of the pen. If the lines are ragged the pen should be put in order, according to the instructions already given. Sometimes when the ink does not flow regularly, moisten the end of the finger and touch the point of the pen. Care should be taken not to put too much ink in the pen, but on the other hand there must be enough to draw the next line as it is difficult to continue a line after re-filling the pen. The only way to draw fine lines well is to frequently clean and re-fill the pen. If the amount of ink in the pen is small it is quite likely to thicken in the point and cause clogging. When this occurs, draw a small strip of paper between the nibs to clean out the clogged ink.

When drawing, the pen should be held with the thumb screw out and should be inclined slightly in the direction in which it is moved. Be careful, however, not to incline it too much, as the best of pens when incorrectly held will produce poor lines. It is therefore advisable at the start to acquire the correct method of holding the pen. Do not press the sides of the pen point too heavily against the ruling edge as this will vary the width of the line; after a little practice the pen can be lightly and firmly brought in contact with the paper and ruling edge at the same time. The pen should be drawn from left to right, the hand being steadied by sliding it on the end of the little finger.

Always try to get into the easiest position when inking a line, even if it becomes necessary to walk around the drawing. The average draftsman prefers the standing position while inking as he can usually obtain much better results. Keep the ruling edge between the line and the body so that the pen will be drawn against the ruling edge, for if this is not done, the pen is liable to be pulled off at an angle, making a crooked line. Be careful after inking a line to draw the ruling edge toward the body away from the line in order to avoid blotting. Where lines meet at a point, always ink towards the point, being sure to allow one line to dry before inking another. Always ink in the top and left-hand lines first, gradually working down to the right, thus saving time that otherwise would be lost in waiting for the lines to dry. When the pen is set at the proper width, draw all the lines of that width before making a change. Never push the pen backward over a line. If a good line is not drawn the first time, it is better to go over it again in the same direction, taking great care not to widen the original line.

Ink dries very quickly and should not be left in the pen on account of its corrosive effects. The celluloid triangles should be washed frequently in water and all ink spots removed.

In using the compass, bend both legs so that each will be perpendicular to the paper or cloth when the arc or circle is drawn. When the pen attachment is used special care must be exercised on this point for in no other way can the nibs of the pen be made to bear evenly on the surface. In drawing arcs, hold the cylindrical handle at the top of the compass loosely between the thumb and the forefinger and let it roll between the two during rotation; allow the compass to lean slightly in the direction of rotation, pressing down the pen point slightly but not the needle point. Be sure to fix the needle point firmly in its proper place on the paper before touching the pen to the paper, as otherwise a slip is likely to occur. In setting the needle down on any particular center, guide it to its place with a finger of the left hand. Try to avoid making a noticeable hole with the needle point.

Ink in the circumference of a circle with one continuous motion, giving an even pressure to the pen throughout the operation and stopping it sharply at the end of one revolution. Since straight lines can be more easily drawn tangent to curves than the reverse, it is always advisable to ink in all arcs or circles first. When a number of circles are to be drawn from one center, the smaller should be inked first while the center is in the best possible condition.

PLATE I

Penciling. To draw *Plate I*, take a sheet of drawing paper at least 11 inches by 15 inches and fasten it to the drawing board as already explained. Find the center of the sheet and draw fine pencil lines to represent the lines *D E* and *H K* of Fig. 38. Also draw the border lines *L*, *M*, *N*, and *P*.

Now measure $\frac{3}{8}$ inch above and below the horizontal center line and, with the T-square, draw lines through these points. These lines will form the lower lines *D C* of Fig. 1 and Fig. 2 and the top lines *A B* of Fig. 3 and Fig. 4. Measure $\frac{3}{8}$ inch to the right and left of the vertical center line; and through these points, draw lines parallel to the center line. These lines should be drawn by placing the triangle on the T-square as shown in Fig. 38. The lines thus drawn, form the sides *B C* of Fig. 1 and Fig. 3 and the sides *A D* of Fig. 2 and Fig.4. Next draw, with the T-square, the line *A B A B* $4\frac{5}{8}$ inches above the horizontal center line, and the line *D C D C* $4\frac{5}{8}$ inches below the horizontal center line. The rectangles of the four figures may now be completed by drawing vertical lines $6\frac{5}{8}$ inches on each side of the vertical center line; these rectangles are each $6\frac{1}{4}$ inches long and $4\frac{1}{4}$ inches wide.

Fig. 1. *Exercise with Line Pen and T-square.* Divide the line *A D* into divisions each $\frac{1}{4}$ inch long, making a fine pencil point or *slight* puncture at each division such as *E, F, G, H, I,* etc. Now place the T-square with its head at the left-hand edge of the drawing board and through these points draw light pencil lines extending to the line *B C.* In drawing these lines the pencil point must pass *exactly* through the division marks so that the lines will be the same distance apart. Start each line in the line *A D* and do not fall short of the line *B C* or run over it. Accuracy and neatness in penciling insure an accurate drawing. Some beginners think that they can correct inaccuracies while inking; but experience soon teaches them that they cannot do so.

Fig. 2. *Exercise with Line Pen, T-square and Triangle.* Divide the lower line *D C* of the rectangle into divisions each $\frac{1}{4}$ inch long and mark the points *E, F, G, H, I, J, K,* etc., as in Fig. 1. Place the T-square about as shown in Fig. 38, and either triangle in position with its 90-degree angle at the left. Now draw fine pencil lines from the line *D C* to the line *A B* passing through the points *E, F, G, H, I, J, K,* etc., keeping the T-square rigid and sliding the triangle toward the right.

Fig. 3. *Exercise with Line Pen T-square and 45-degree Triangle.* Lay off the distances *A E, B L,* etc., each $\frac{1}{4}$ inch long on *A B* and *B C,* respectively. Place the T-square so that the upper edge will be below the line *D C,* and, with the 45-degree triangle, draw the diagonal lines through the points laid off. In drawing these lines move the pencil away from the body, *i. e.,* from *A D* to *A B* and from *D C* to *B C.*

Fig. 4. *Exercise in Free-Hand Lettering.* Draw the center line *E F,* Fig. 39, and light pencil lines *Y Z* and *T X,* $\frac{3}{8}$ inch from the

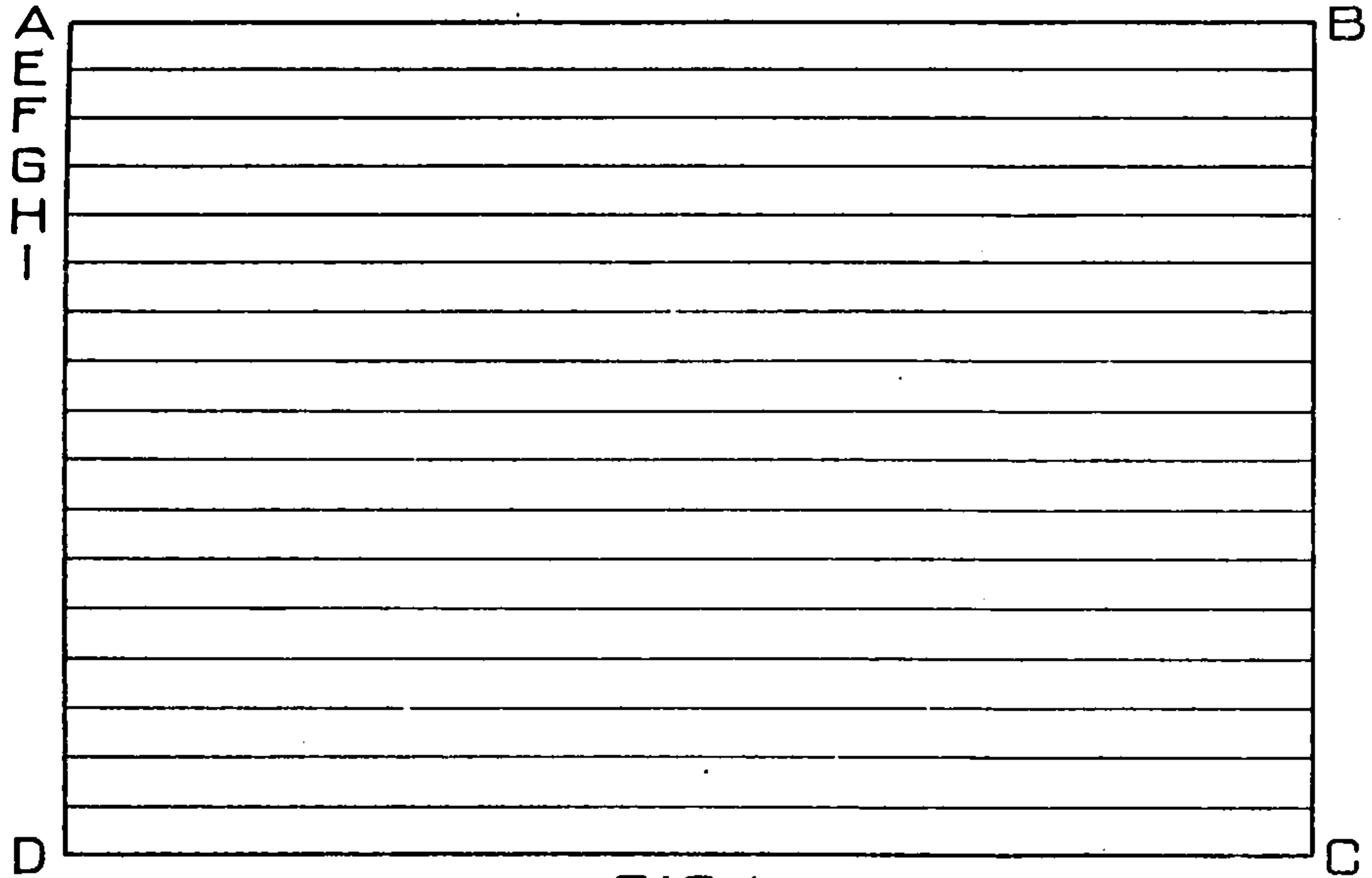


FIG. 1

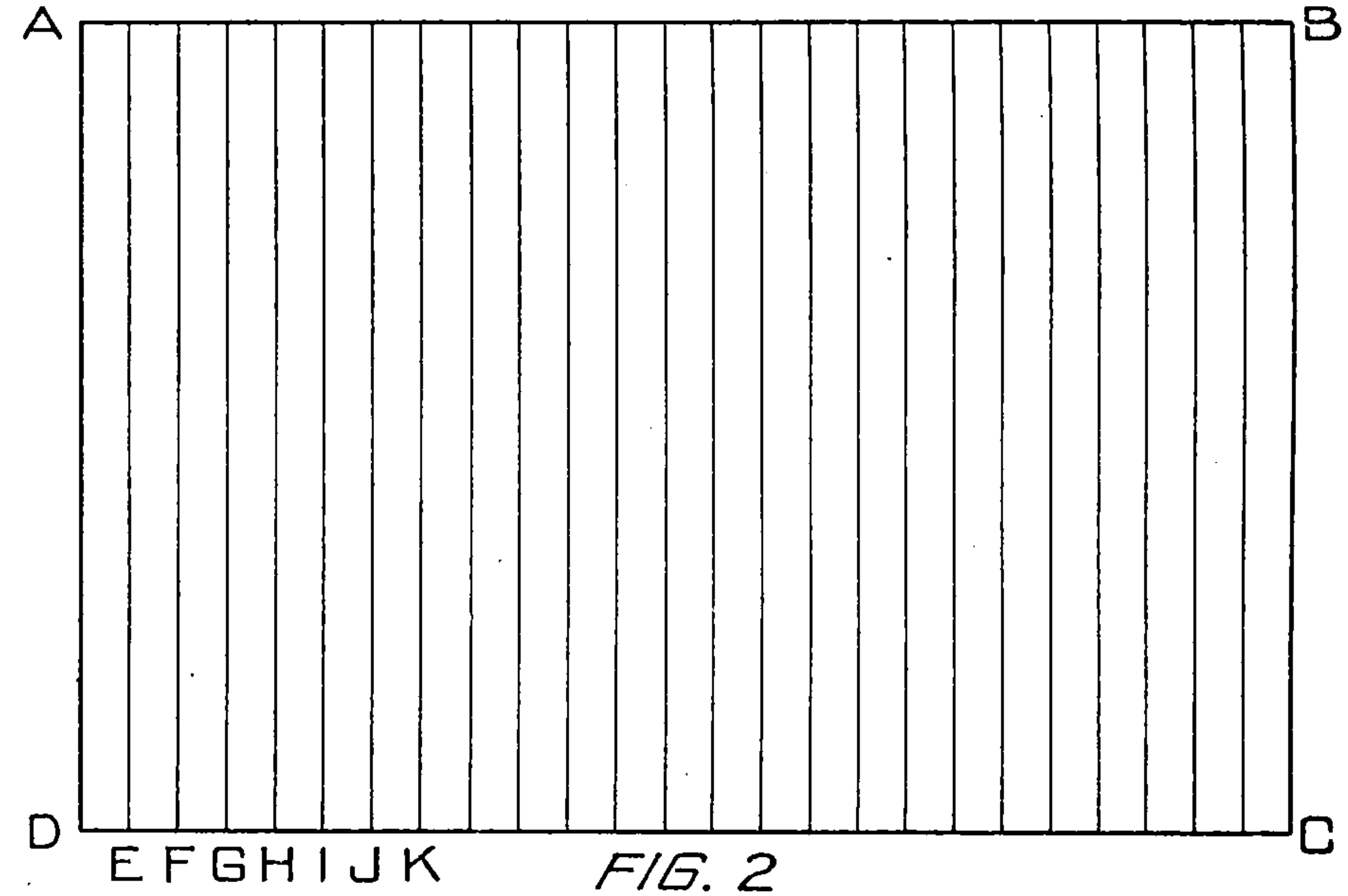


FIG. 2

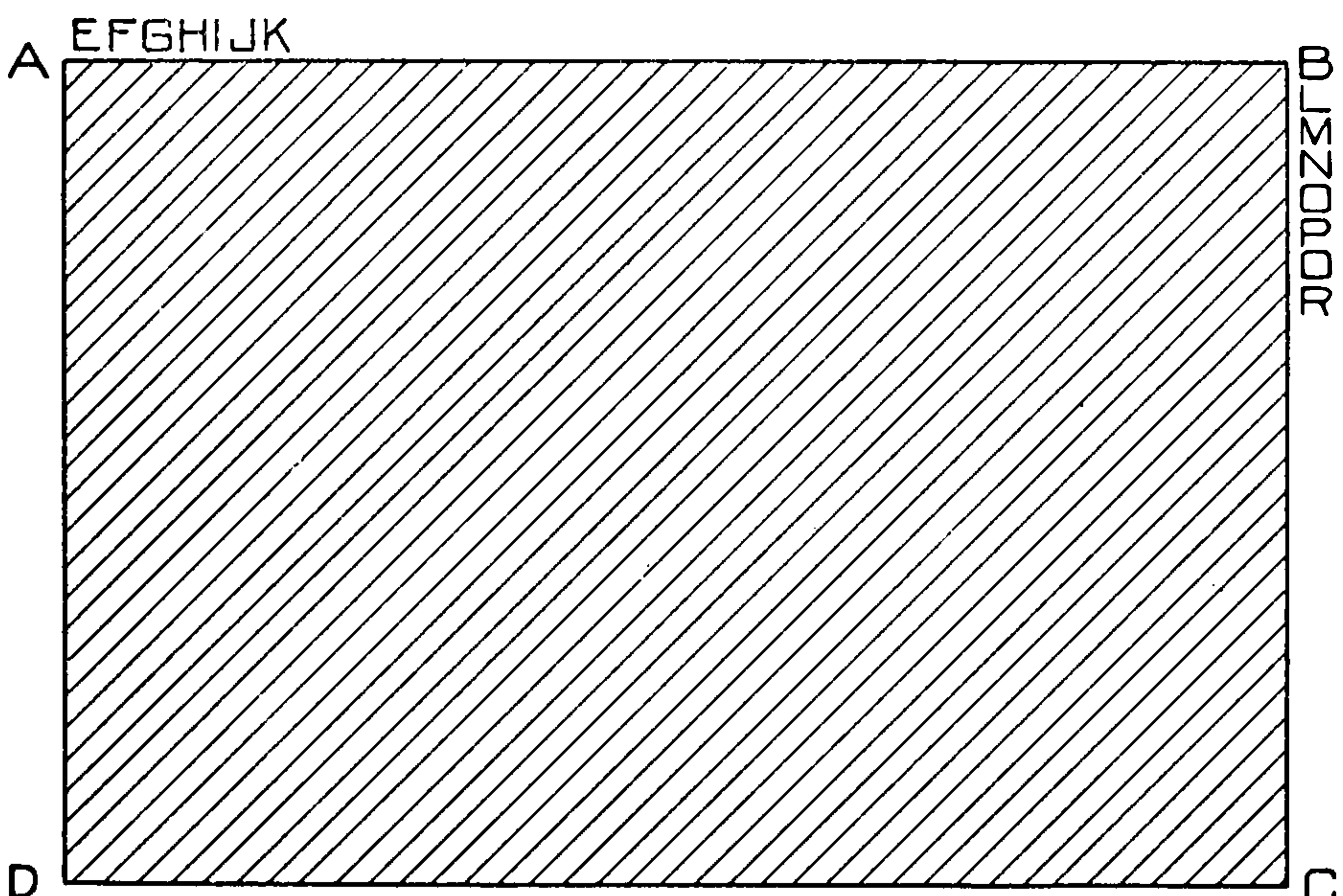


FIG. 3

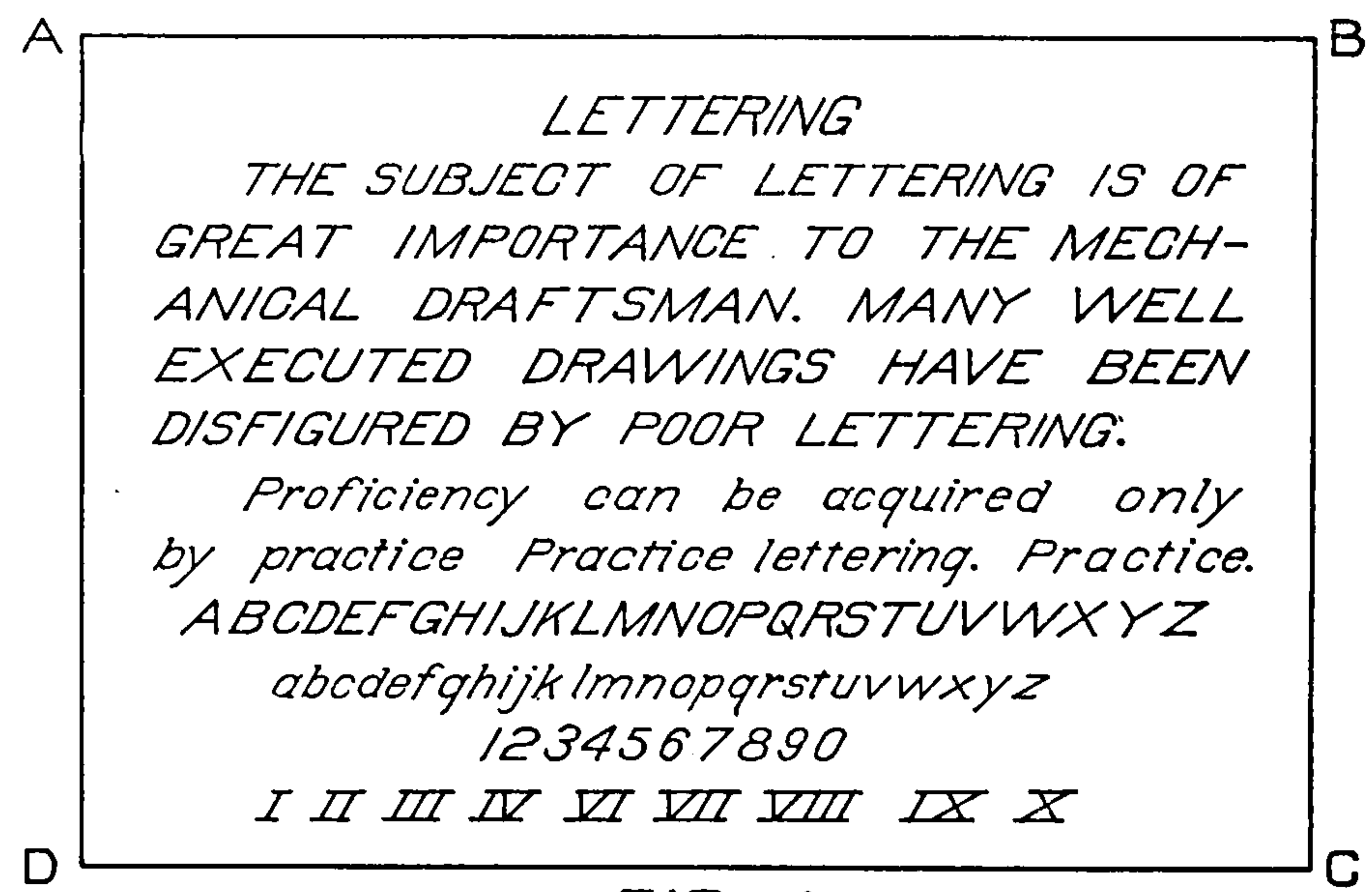


FIG. 4

JANUARY 1, 1910

HERBERT CHANDLER, CHICAGO, ILL.

PLATE II

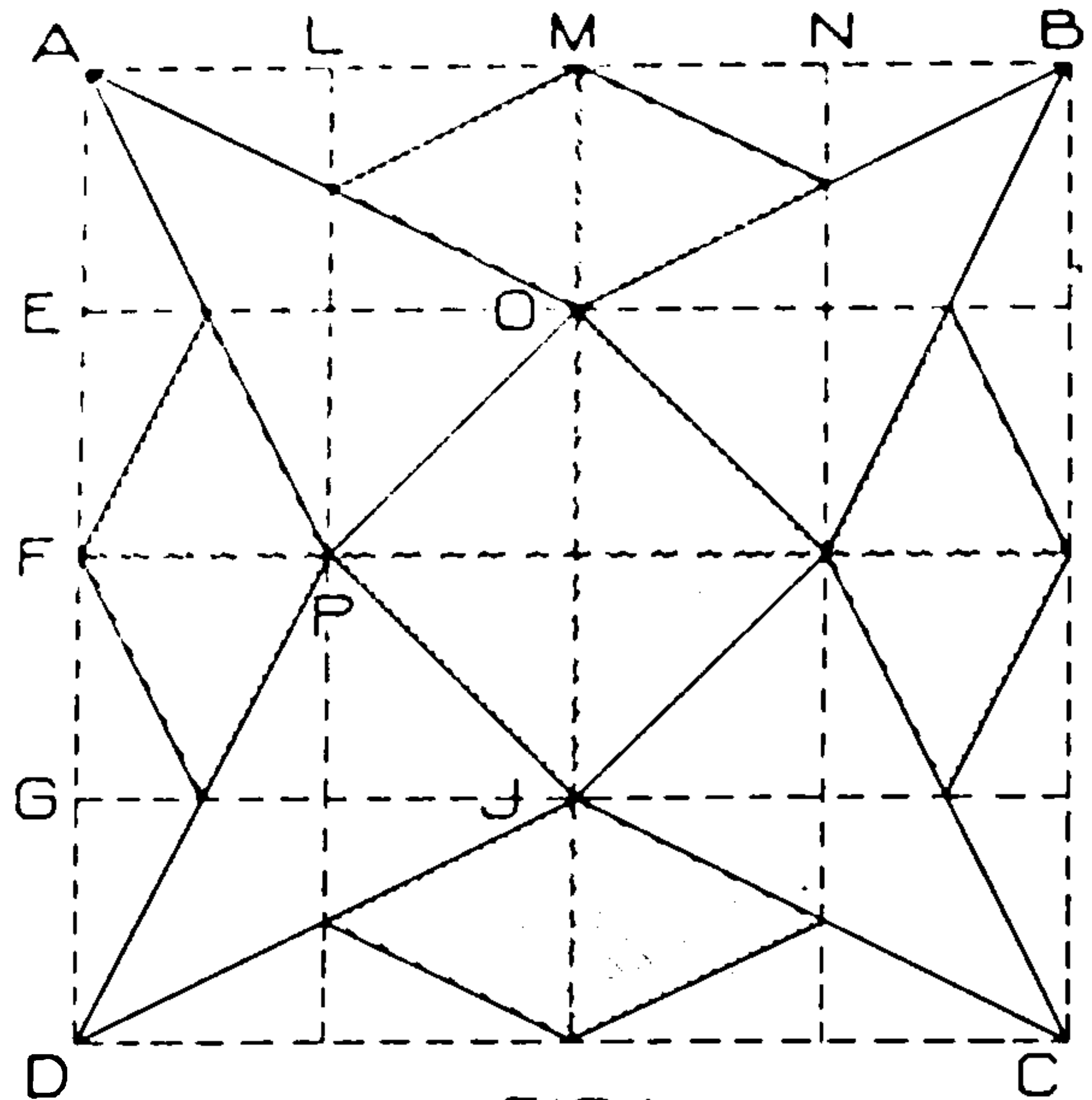


FIG. 1

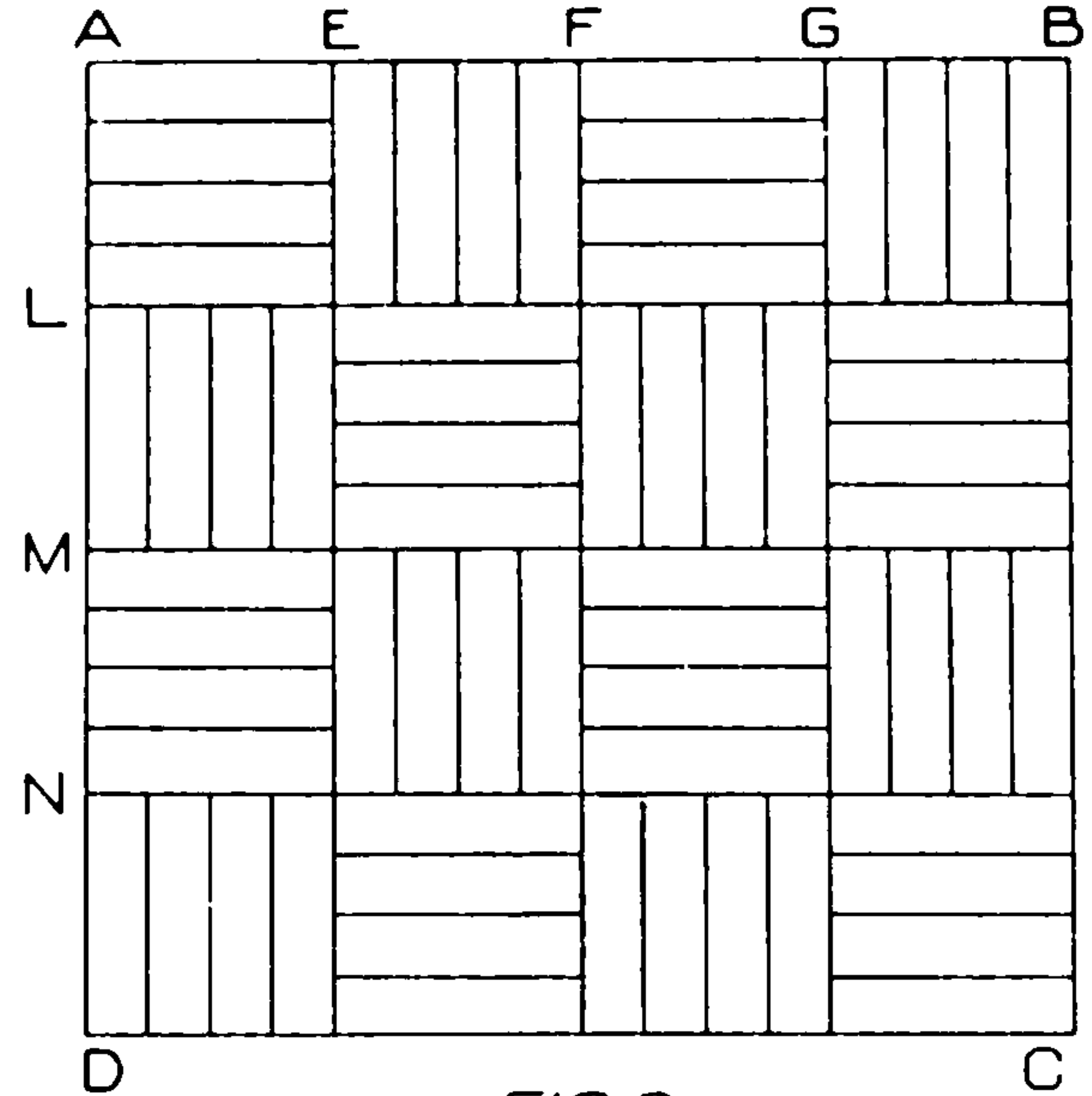


FIG. 2

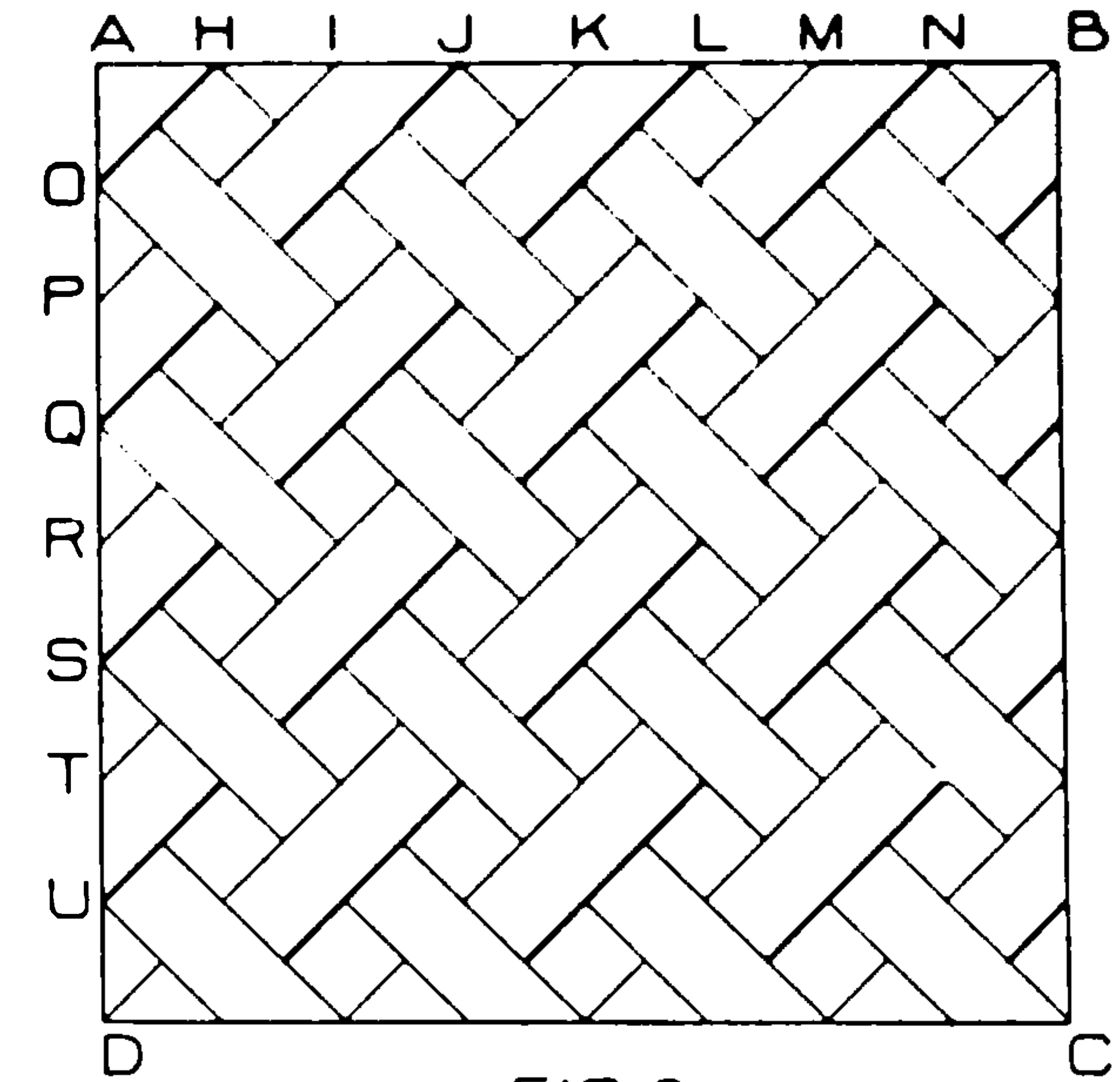
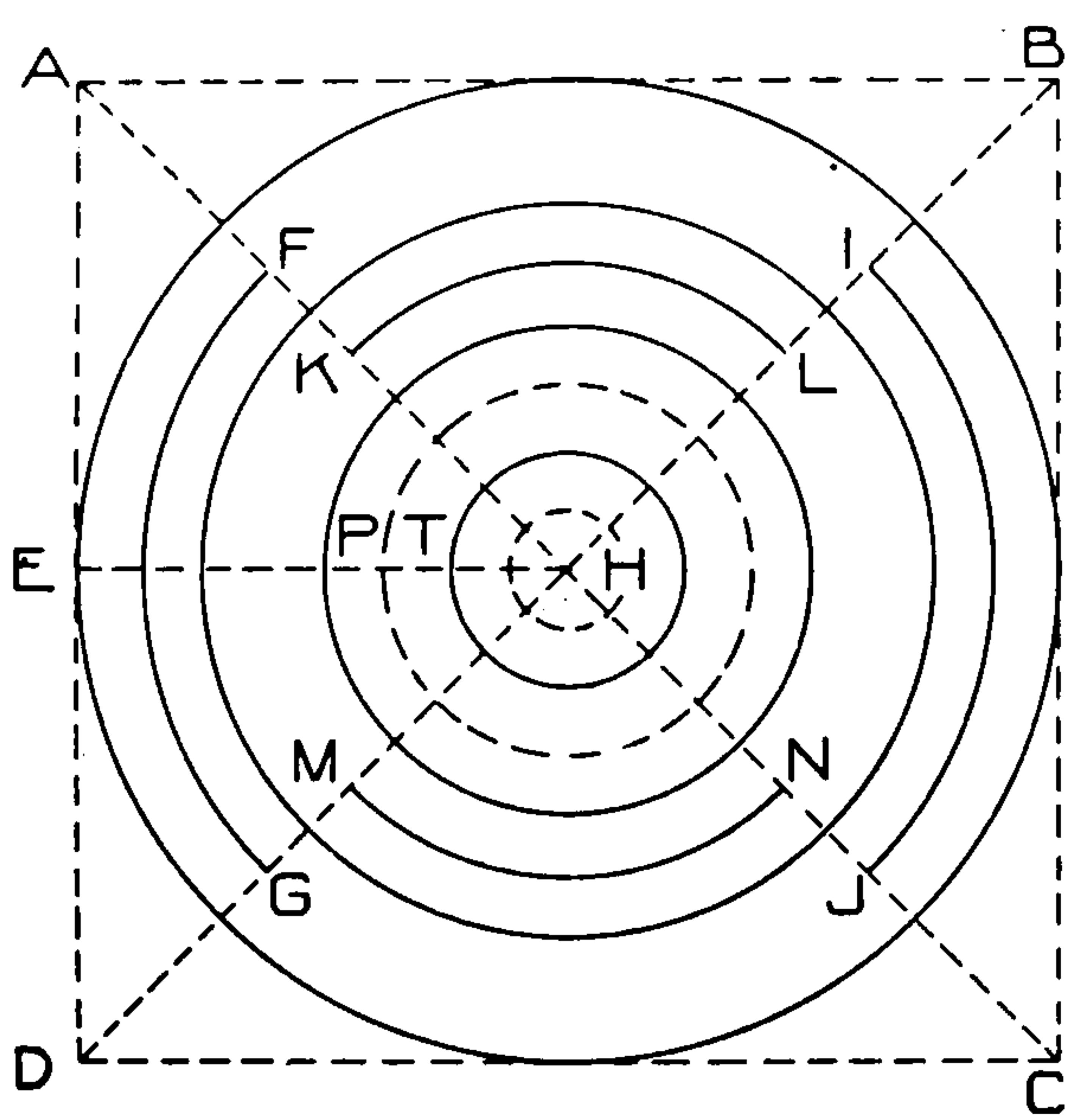
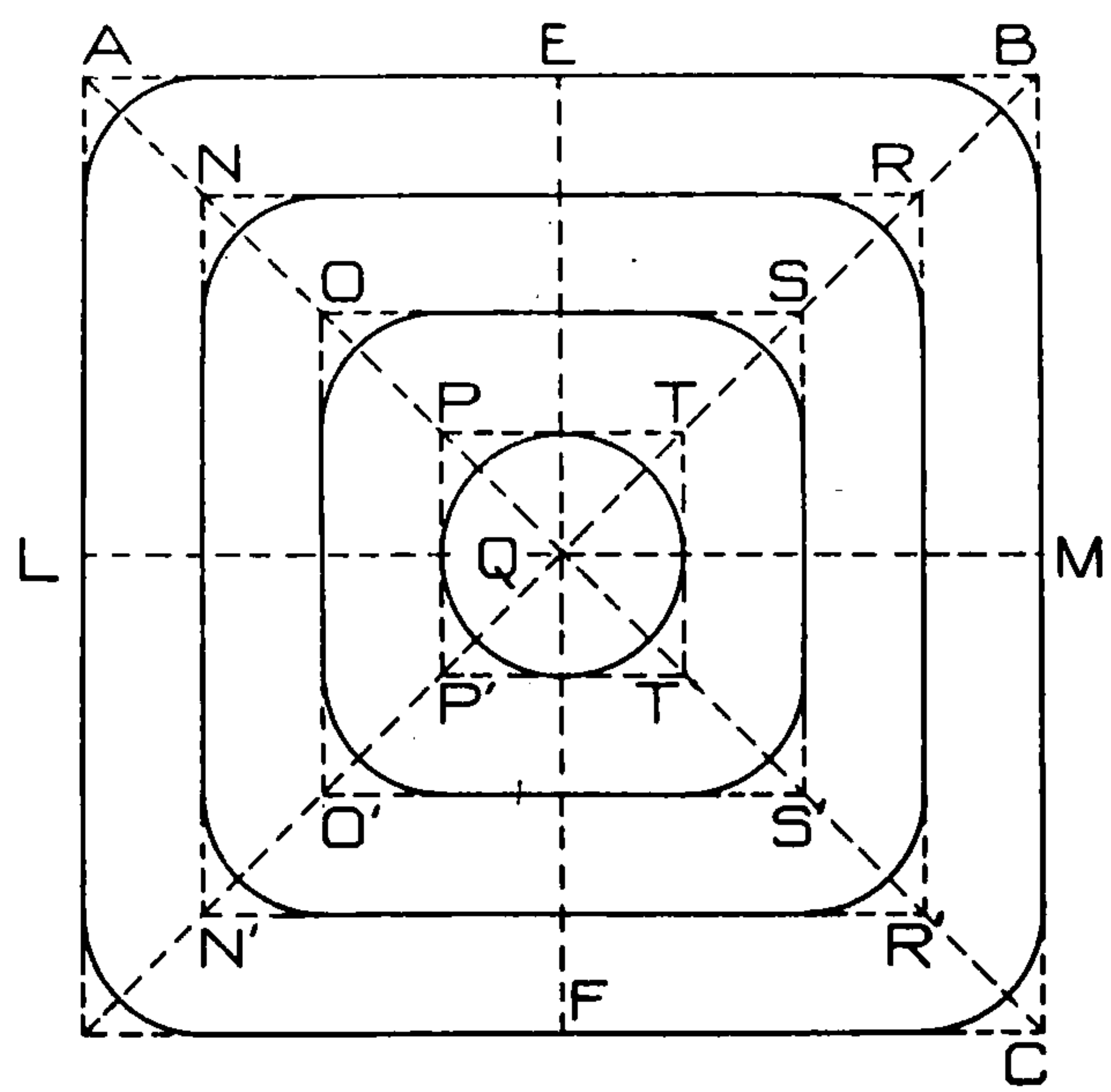
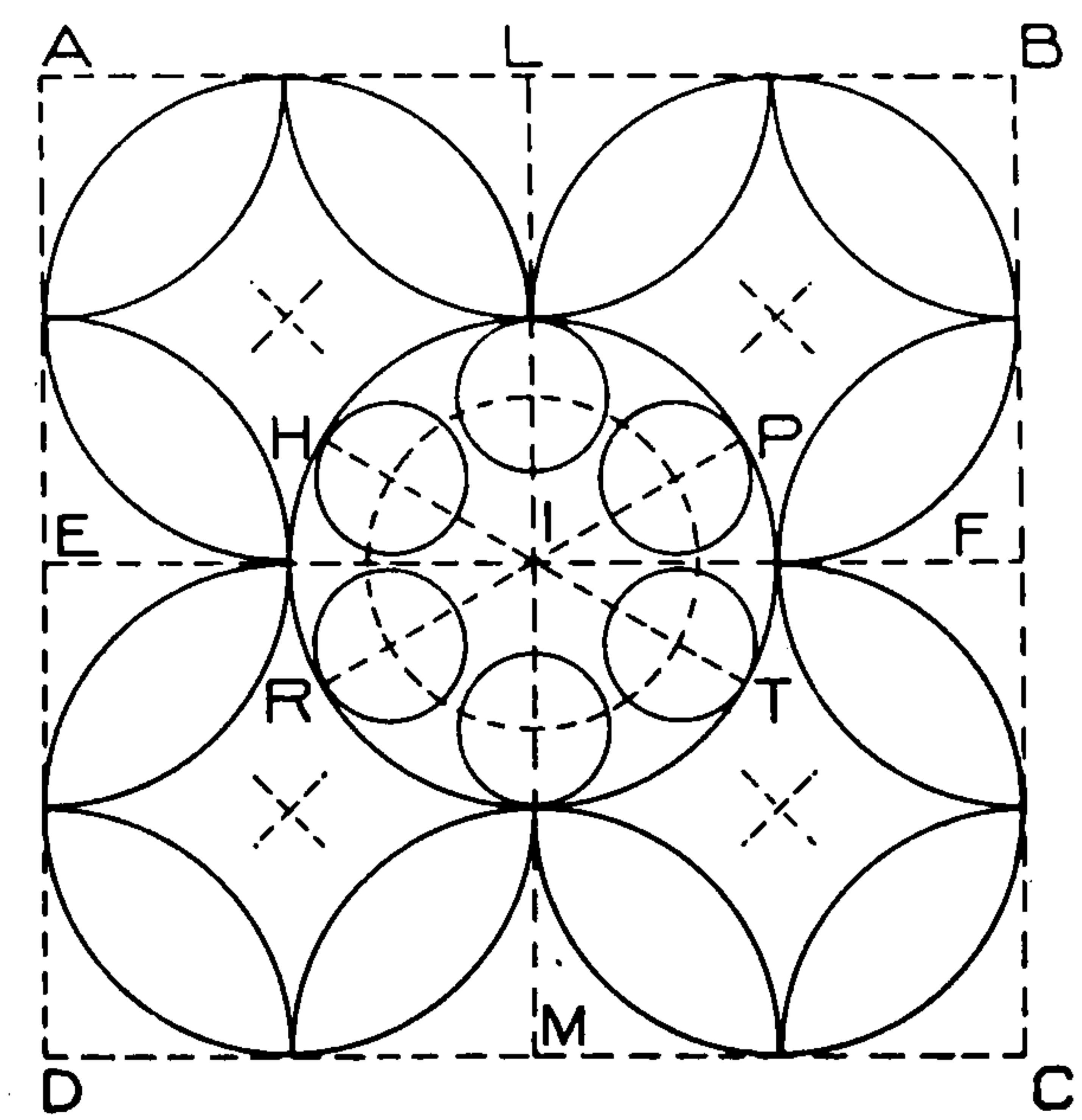


FIG. 3







border lines. With the T-square, draw the line *G*, $\frac{1}{4}$ inch from the top line and the line *H*, $\frac{5}{32}$ inch below *G*. The word "*LETTERING*" is to be placed between these two lines. Draw the line *I*, $\frac{3}{8}$ inch below *H*, and space the lines included between *I* and *K*, $\frac{5}{32}$ inch apart.

The next style of letters to be discussed is lower-case letters. Draw the line *L* $\frac{3}{16}$ inch below *K* and to limit the height of the small letters draw a light line $\frac{1}{8}$ inch above *L*.

Make the space between *L* and *M*, $\frac{5}{32}$ inch and draw *M* and *N* in the same manner as *K* and L. Now draw *O*, $\frac{1}{2}$ inch below *N*,

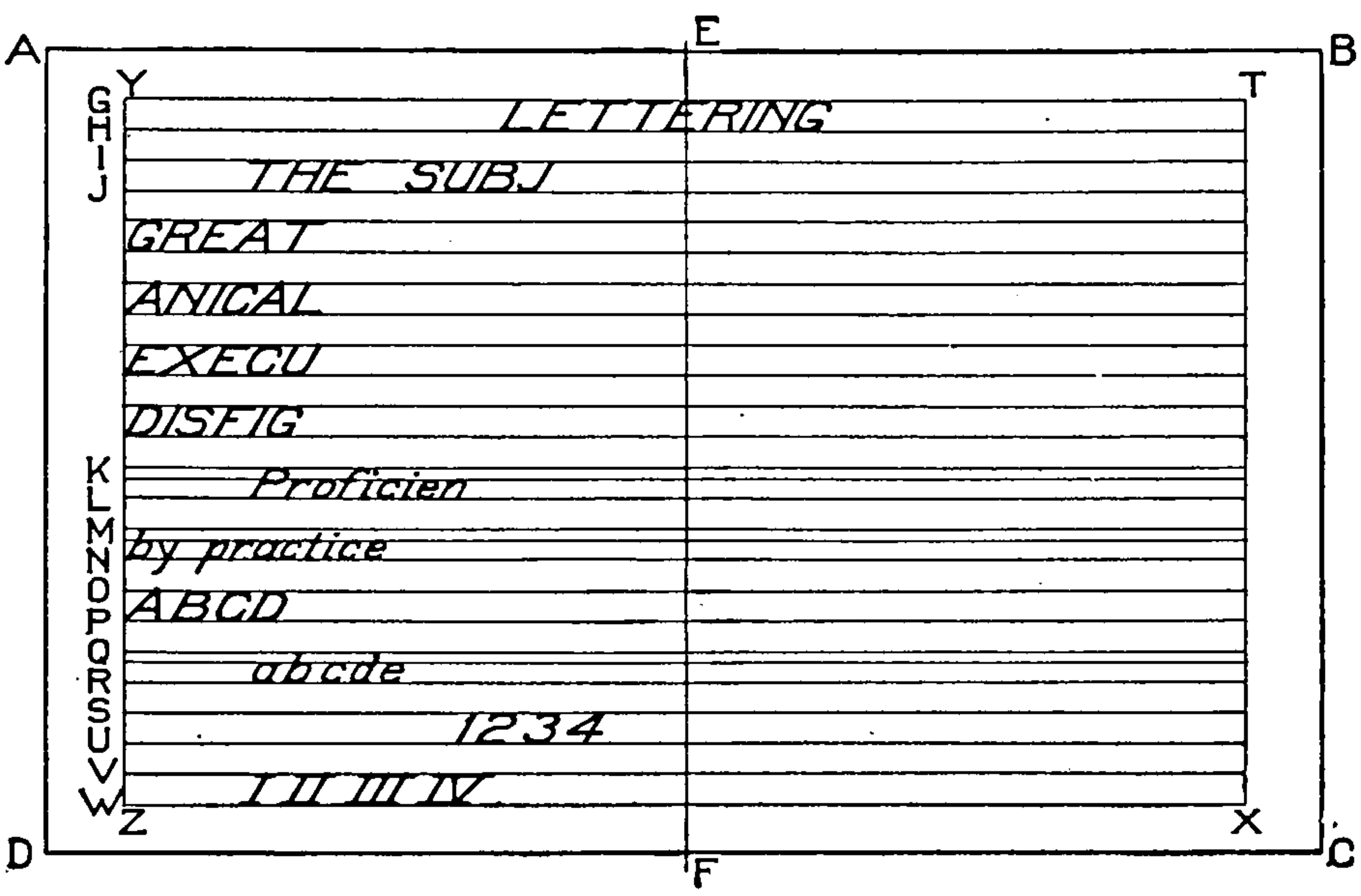


Fig. 39. Sample Lettering Plate—Fig. 4, Plate I

P, $\frac{5}{32}$ inch below *O*, and *Q*, $\frac{5}{32}$ inch below *P*. Space *Q* and *R* as *K* and *L*, and draw *S*, *U*, *V*, and *W*, $\frac{5}{32}$ inch apart.

The center line is a great aid in centering the word "*LETTERING*," the alphabets, numerals, etc. Indent the words "*THE*" and "*Proficiency*" about $\frac{3}{8}$ inch, as they are the first words of paragraphs. To draw the guide lines, mark off distances of $\frac{1}{4}$ inch on any line such as *J* and with the 60-degree triangle draw light pencil lines cutting the parallel lines. Sketch the letters in pencil making the width of the ordinary letters such as *E*, *F*, *H*, *N*, *R*, etc., about $\frac{3}{4}$ their height. Letters like *A*, *M*, and *W*, are wider. The space between the letters depends upon the draftsman's taste, but the beginner should remember that letters next to an *A* or an *L* should be placed nearer to them than to letters whose sides are parallel; for instance there should be more space between an *N* and *E* than between an *E* and *H*. Similarly a greater space should be left on either side of an *I*. On account of the space above the lower line of the *L*, a letter following an *L* should be close to it. If a *T* follows a *T* or an *L* follows an *L* place them near together. In all lettering place the letters so that the general effect is pleasing. After the four figures are completed, pencil in the lettering for name, address, and date. With the T-square draw a pencil line $\frac{5}{32}$ inch above the top border line at the right-hand end, and about 3 inches long. At a distance of $\frac{5}{32}$ inch above this line draw another line of about the same length. These are the guide lines for the word *Plate I*. Pencil the letters free-hand using the 60-degree guide lines if desired.

Draw in a similar manner the guide lines of the date, name, and address in the lower margin, the date of completing the drawing placed under Fig. 3, and the name and address at the right, under Fig. 4. The street address is unnecessary. It is a good plan to draw lines $\frac{5}{32}$ inch apart on a separate sheet of paper and pencil the letters in order to know just how much space each word will require. The insertion of the words "Fig. 1," "Fig. 2," etc., is optional with the student, but it is advised that he do this extra lettering for the practice as well as for convenience in reference. First draw with the T-square two parallel lines $\frac{5}{32}$ inch apart under each exercise, the lower line being $\frac{1}{16}$ inch above the horizontal center line or above the lower border line.

Inking. After all of the penciling of *Plate I* has been completed the exercises should be inked. Before doing this, however, see that the pen is in proper condition, and after filling try it on a separate piece of paper in order that the proper width of line may be drawn. In the first work where no shading is done, use a firm, distinct line. The beginner should avoid the extremes; a very light line makes the drawing appear weak and indistinct, while a very heavy line detracts from its artistic appearance.

Ink in all the horizontal lines of Fig. 1 first, moving the T-square from *A* to *D*, and take great care to start and stop the lines exactly on the vertical boundary lines. It is necessary to use both triangle and T-square for inking *A D* and *B C*. In inking Fig. 2 and Fig. 3, follow the same directions as for penciling, inking in the vertical and oblique lines first and then the border lines. Ink the border lines

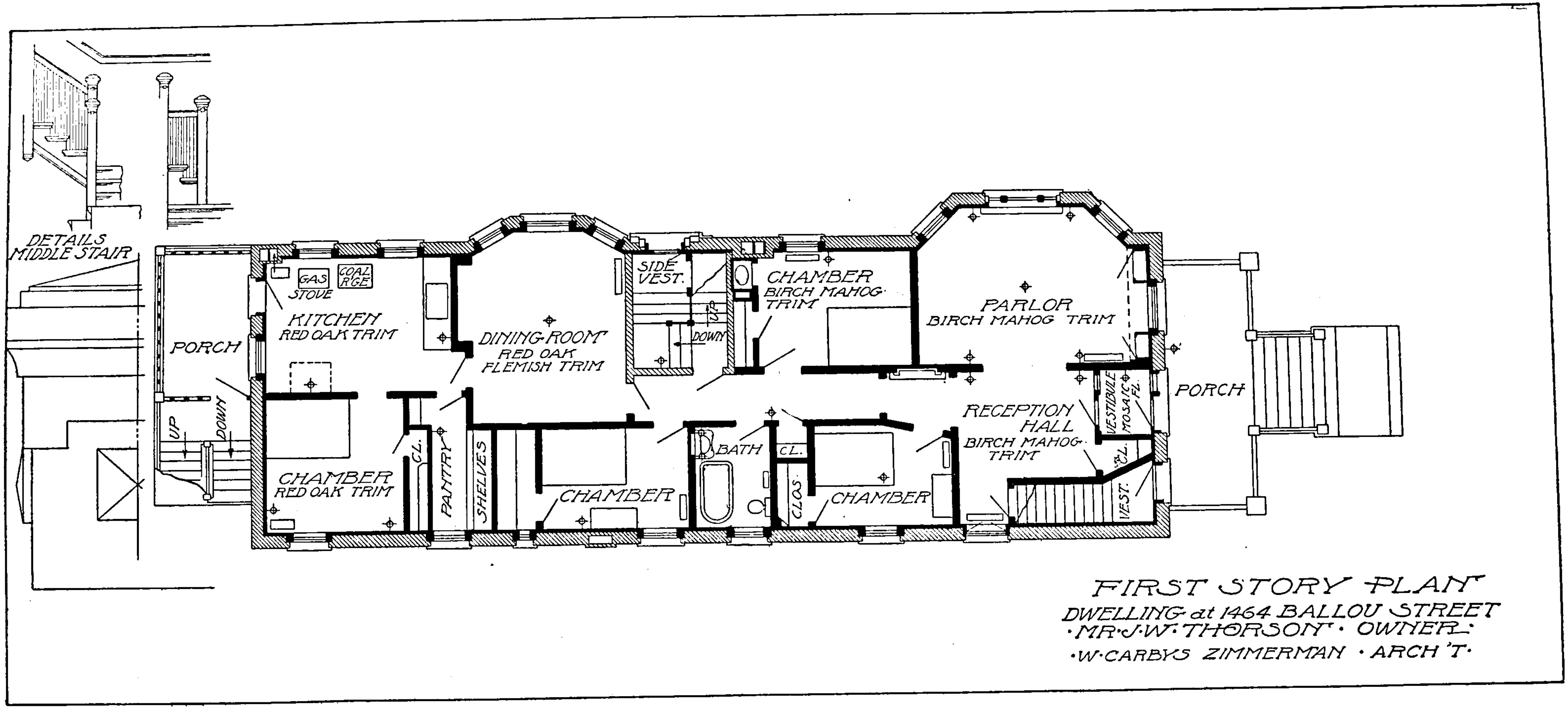
G B, etc., into four equal parts—each $\frac{1}{4}$ inch—and draw light pencil lines with the T-square and triangle as shown.

In Fig. 3, divide *A D* and *A B* into eight equal parts, and through the points *O*, *P*, *Q*, *H*, *I*, *J*, etc., draw horizontal and vertical lines. Now draw lines connecting *O* and *H*, *P* and *I*, *Q* and *J*, etc. As these lines form an angle of 45 degrees with the horizontal, a 45-degree triangle may be used. Similarly from each one of the given points on *A B* and *A D*, draw lines at an angle of 45 degrees to *B C* and *D C* respectively.

Fig. 4 is drawn with the compasses. Draw the diagonals *A C* and *D B*, and with the T-square draw the line *E H*. Now mark off on *E H* distances of $\frac{1}{4}$ inch, and with *H* as a center describe, by means of the compasses, circles having radii respectively 2 inches, $1\frac{1}{2}$ inches, 1 inch, $\frac{3}{4}$ inch, $\frac{1}{2}$ inch, and $\frac{1}{4}$ inch. Similarly with *H* as a center and a radius of $1\frac{3}{4}$ inches and $1\frac{1}{4}$ inches respectively draw the arcs *F G* and *I J* and *K L* and *M N*, being careful to end the arcs in the diagonals.

Fig. 5 is an exercise with the line pen and compasses. Draw the diagonals *A C* and *D B*, the horizontal line *L M* and the vertical line *E F* passing through the center *Q*. Mark off distances of $\frac{1}{2}$ inch on *L M* and *E F* and complete the squares *N R R′ N′*, etc. With the bow pencil adjusted so that the distance between the pencil point and the needle point is $\frac{1}{2}$ inch, draw arcs having centers at the corners of the inner squares. The arc whose center is *N* will be tangent to the lines *A L* and *A E* and the arc whose center is *O* will be tangent to *N N′* and *N R*. Since the smallest square has 1 inch sides, the $\frac{1}{2}$-inch arcs drawn with *Q* as a center will form a circle.

In Fig. 6, draw the center lines *E F* and *L M*, and find the centers of the four squares thus formed. Through the center *I* draw the construction lines *H I T* and *R I P* forming angles of 30 degrees with *EF*. Now adjust the compasses to draw circles having a radius of one inch, and with *I* as a center, draw the circle *H P T R*. With the same radius draw the arcs with centers at *A*, *B*, *C*, and *D*, and also draw the semicircles with centers at *L*, *F*, *M*, and *E*. Now draw the arcs as shown having centers at the centers of the four squares. To locate the centers of the six small circles within the circle *H P T R*, draw a circle with a radius of $\frac{11}{16}$ inch and having the center in *I*. The small circles each have a radius of $\frac{5}{16}$ inch.



FIRST-STORY PLAN OF TWO-STORY FLAT BUILDING FOR MR. J. WM. THORSON, CHICAGO, ILL.

W. Carbys Zimmerman, Architect, Chicago, Ill.

Second-Story Plan Shown on Opposite Page. For Basement Plan, See Page 26; for Elevations, See Page 58.

SECOND-STORY PLAN OF TWO-STORY FLAT BUILDING FOR MR. J. WM. THORSON, CHICAGO, ILL.

W. Carbys Zimmerman, Architect, Chicago, Ill.

First-Story Plan Shown on Opposite Page. For Basement Plan, See Page 26; for Elevations, See Page 58.

Inking. In *Plate II* ink in only the lines shown *full* in the specimen plate. First ink the star and then the square and diamonds. As this is an exercise for practice, the cross-hatching should be done *without* measuring the distance between the lines and without the aid of any cross-hatching device. The lines should be about $\frac{1}{16}$ inch apart. After inking in the plate all construction lines should be erased.

In inking Fig. 2 first ink the principal horizontal and vertical lines and then very carefully ink in the short lines. Make these lines all of the same width.

Fig. 3 is drawn entirely with the 45-degree triangle. In inking the oblique lines make *P I, R K, T M*, etc., of the usual width, while the alternate lines *O H, Q J, S L*, etc., should be somewhat heavier. All of the lines which slope in the opposite direction are light. Now ink in the border lines and erase all other horizontal and vertical lines.

In inking Fig. 4 use only the compasses, adjusting the legs so that the pen will always be perpendicular to the paper. In inking the arcs, see that the pen stops *exactly* at the diagonals. The inner circle and the next but one should be dotted as shown in the specimen plate. After inking the circles and arcs erase the construction lines that are without the outer circles, leaving in *pencil* the diagonals inside the circles.

In Fig. 5 *draw all arcs first* and then the straight lines meeting these arcs, as it is much easier to make a straight line meet an arc or tangent to it, than the reverse. Leave all construction lines in pencil. This exercise is difficult, and as in all mechanical and machine drawing, arcs and tangents are frequently used, the beginner is advised to draw this exercise several times.

Fig. 6 is an exercise with compasses. If the laying out has been accurately done in pencil, the inked arcs will be tangent to each other and the finished exercise will have a good appearance. If, however, the distances were not accurately measured and the lines carefully drawn, the inked arcs will not be tangent. The arcs whose centers are *L, F, M*, and *E*, and *A, B, C*, and *D* should be heavier than the rest. The small circles may be drawn with the bow pen. After inking the arcs all construction lines should be erased.

Finally ink in the figure numbers, the border lines of the plate, name, address, and plate number as in *Plate I*.

PLATE III

Penciling. *Plate III* should be laid out in the same manner as *Plate II*, that is, for size and border lines. In laying out the nine rectangles, however, the space between the center lines and rectangles must in every case be made ½ inch. Each rectangle is to be filled in with what is called *section lining*, illustrating the material of which the object is composed, and, therefore, differing accordingly. The conventions here shown are not standard, as their use is a matter left largely to the opinion of the draftsman himself. The styles here suggested are to give only an idea of how it may be done.

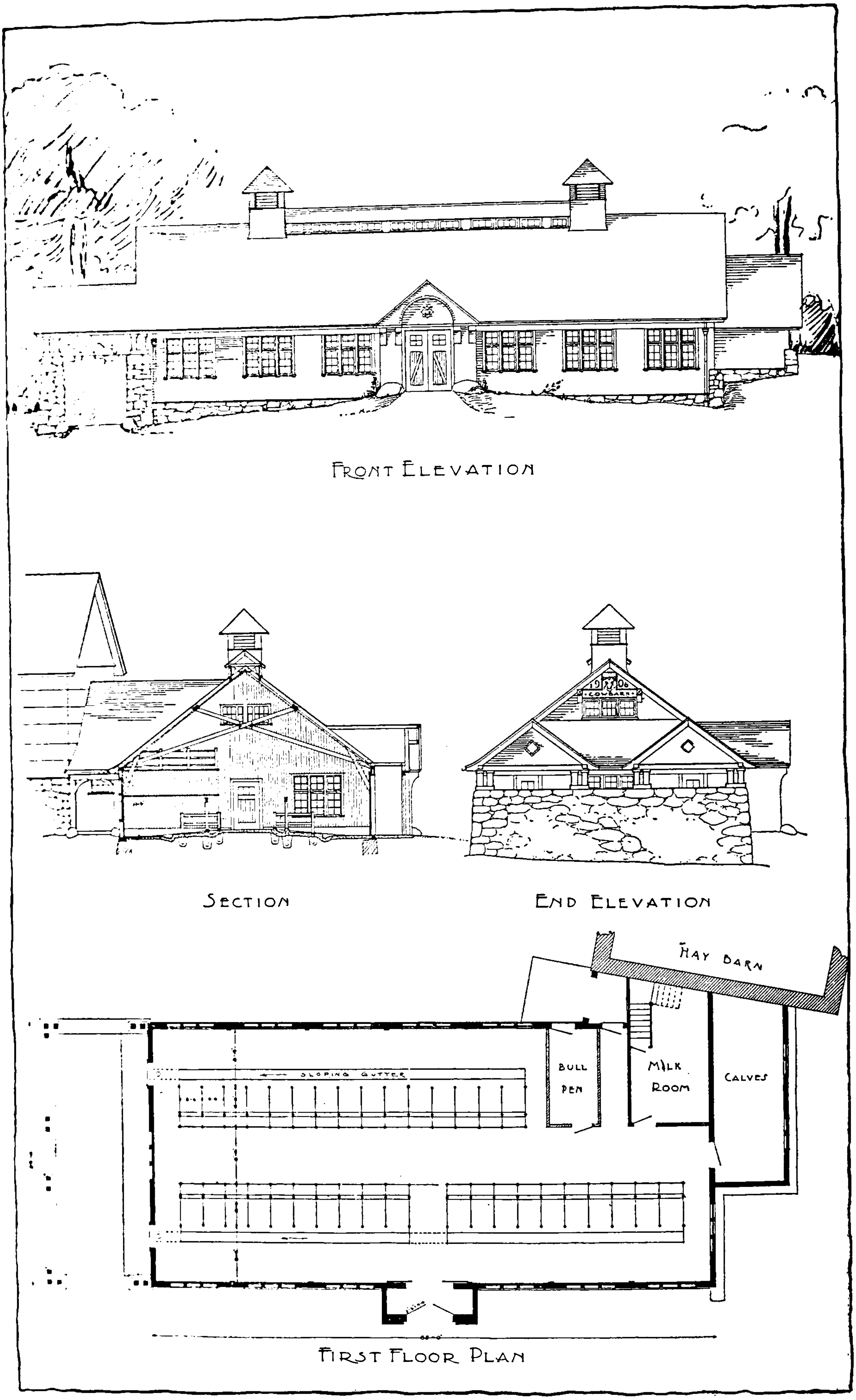
Draw the nine figures in full and then draw the border lines of the plate. Make the lettering conform to that in *Plate I* and *Plate II*.

Inking. After all the penciling of *Plate III* has been completed, the exercises should be inked.

EXAMINATION PLATES

Drawing *Plates I* to *III* inclusive constitute the Examination for this Instruction Paper. The student should draw these Plates in ink and send them to the School for correction and criticism.

The vertical letters are merely **for explanation and should not be placed** upon the plates sent us. **The dot and dash center lines and the** lines **used for** spacing the sheet should **not be inked.** The date, student's name and address, and the plate number should be lettered on each plate in inclined Gothic capitals.



COW-BARN ON ESTATE OF J. J. GLESSNER, ESQ., LITTLETON, N. H.

H V. von Holst, Architect, Chicago, Ill.

Built in 1906-07.

MECHANICAL DRAWING

PART II

GEOMETRICAL DEFINITIONS

A *point* is used for marking position; it has neither length, breadth, nor thickness.

LINES

A *line* has length only; it is produced by the motion of a point.

A *straight line* or *right line* is one that has the same direction throughout. It is the shortest distance between two points.

A *curved line* is one that is constantly changing in direction. It is sometimes called a curve.

A *broken line* is one made up of several straight lines.

Parallel lines are lines which lie in the same plane and are equally distant from each other at all points.

A *horizontal line* is one having the direction of a line drawn upon the surface of water that is at rest. It is a line parallel to the horizon.

A *vertical line* is one that lies in the direction of a thread suspended from its upper end and having a weight at the lower end. It is a line that is perpendicular to a horizontal plane.

An *oblique line* is one that is neither vertical nor horizontal.

In Mechanical Drawing, lines drawn along the edge of the T-square, when the head of the T-square is resting against the left-hand edge of the board, are called *horizontal* lines. Those drawn at right angles or perpendicular to the edge of the T-square are called *vertical* lines.

If two lines cut each other, they are called *intersecting lines*, and the point at which they cross is called the *point of intersection*.

ANGLES

An *angle* is the measure of the difference in direction of two lines. The lines are called *sides,* and the point of meeting, the *vertex.* The size of an angle is independent of the length of the lines.

If one straight line meets another (extended if necessary), Fig. 40, so that the two angles thus formed are equal, the lines are said

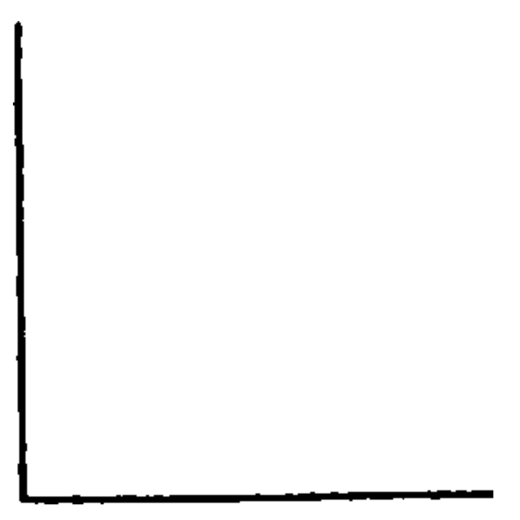


Fig. 40 Right Angle

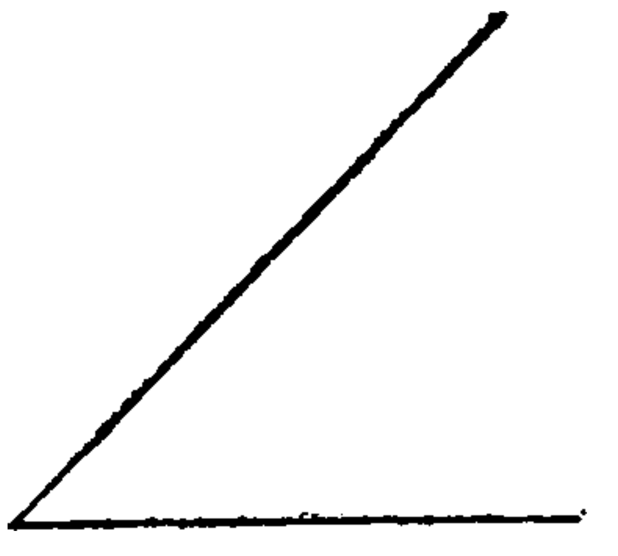


Fig. 41. Acute Angle

Fig. 42. Obtuse Angle

to be *perpendicular* to each other and the angles formed are called *right angles.*

An *acute angle* is less than a right angle, Fig. 41.

An *obtuse angle* is greater than a right angle, Fig. 42.

SURFACES

A *surface* is produced by the motion of a line; it has two dimensions—length and breadth.

A *plane figure* is a plane bounded on all sides by lines; the space included within these lines (if they are straight lines) is called a *polygon* or a *rectilinear figure.*

POLYGONS

A *polygon* is a plane figure bounded by straight lines. The

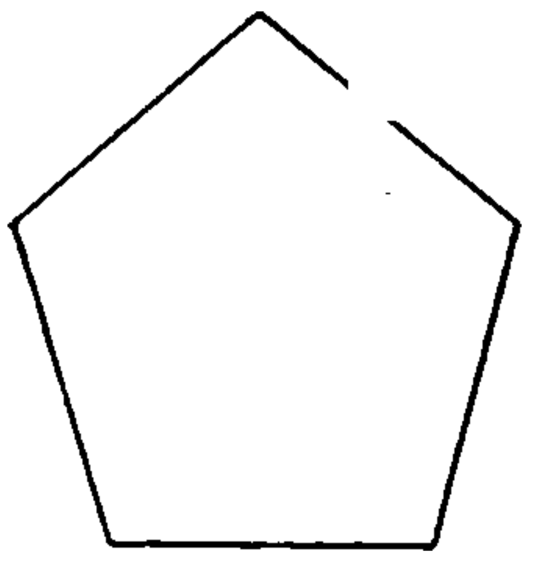


Fig 43 Pentagon

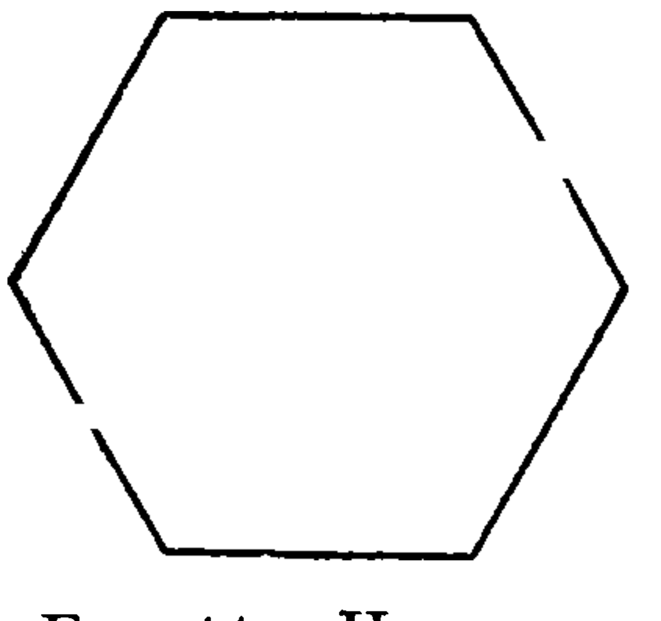


Fig 44 Hexagon

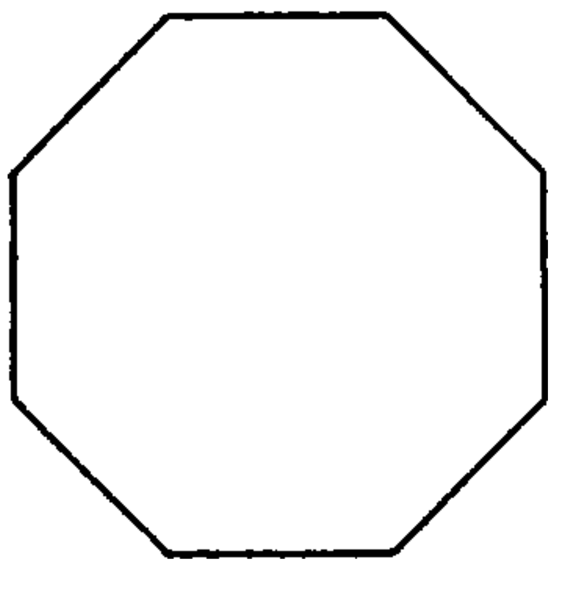


Fig. 45 Octagon

boundary lines are called the *sides* and the sum of the sides is called the *perimeter.*

Polygons are classified according to the number of sides.

A *triangle* is a polygon of *three* sides.

A *quadrilateral* is a polygon of *four* sides.

A *pentagon* is a polygon of *five* sides, Fig. 43.

A *hexagon* is a polygon of *six* sides, Fig. 44

A *heptagon* is a polygon of *seven* sides.

An *octagon* is a polygon of *eight* sides, Fig. 45.

A *decagon* is a polygon of *ten* sides.

A *dodecagon* is a polygon of *twelve* sides.

An *equilateral* polygon is one all of whose sides are equal.

An *equiangular* polygon is one all of whose angles are equal.

A *regular* polygon is one all of whose angles and all of whose sides are equal.

Triangles. A triangle is a polygon enclosed by three straight lines called *sides*. The *angles* of a triangle are the angles formed by the sides.

A *right-angled* triangle, often called a *right* triangle, Fig. 46, is one that has a right angle. The longest side (the one opposite

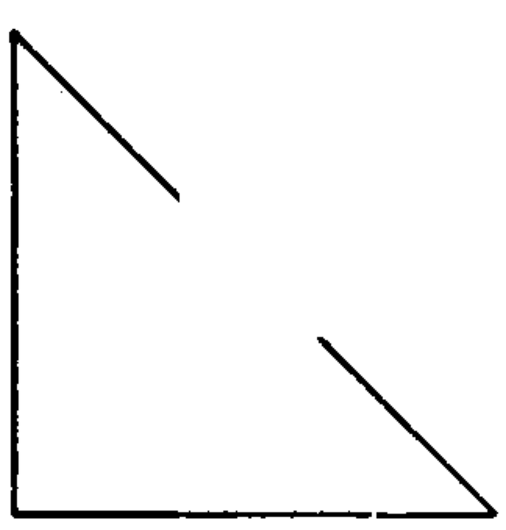


Fig. 46. Right-Angled Triangle

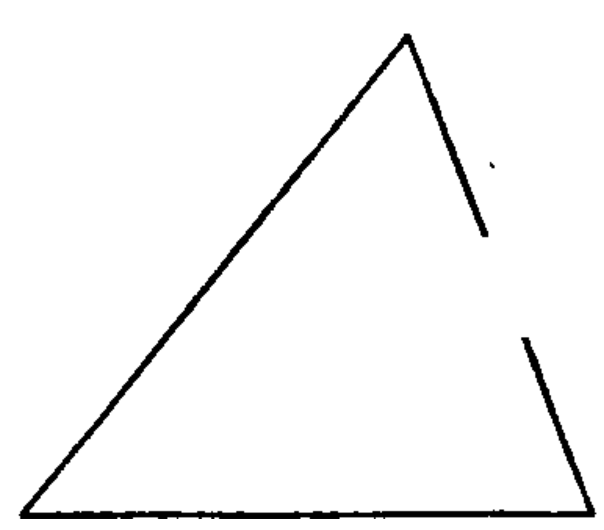


Fig 47 Acute-Angled Triangle

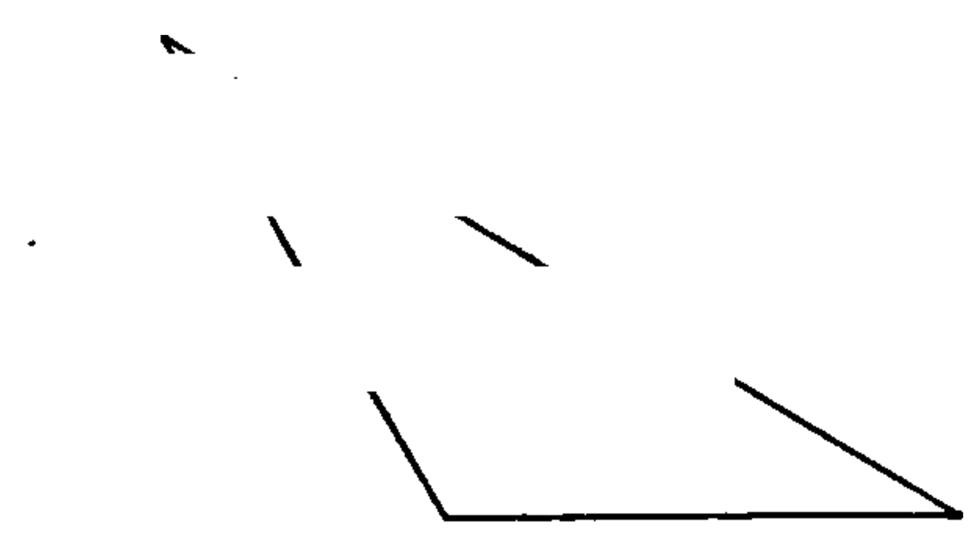


Fig. 48. Obtuse-Angled Triangle

the right angle) is called the *hypotenuse,* and the other sides are sometimes called *legs*.

An *acute-angled* triangle is one that has all of its angles acute, Fig. 47.

An *obtuse-angled* triangle is one that has an obtuse angle, Fig. 48.

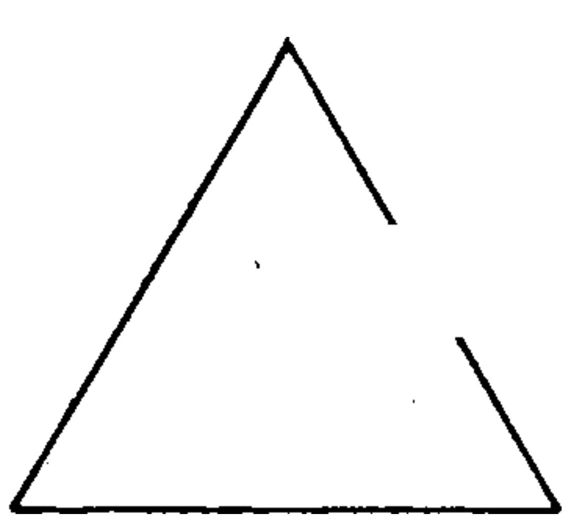


Fig. 49 Equilateral Triangle

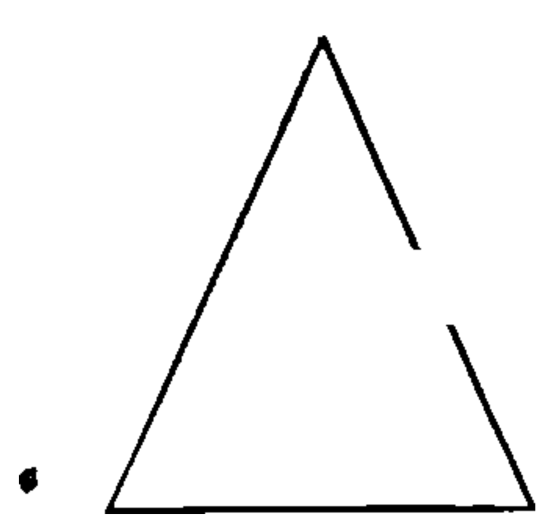


Fig. 50. Isosceles Triangle

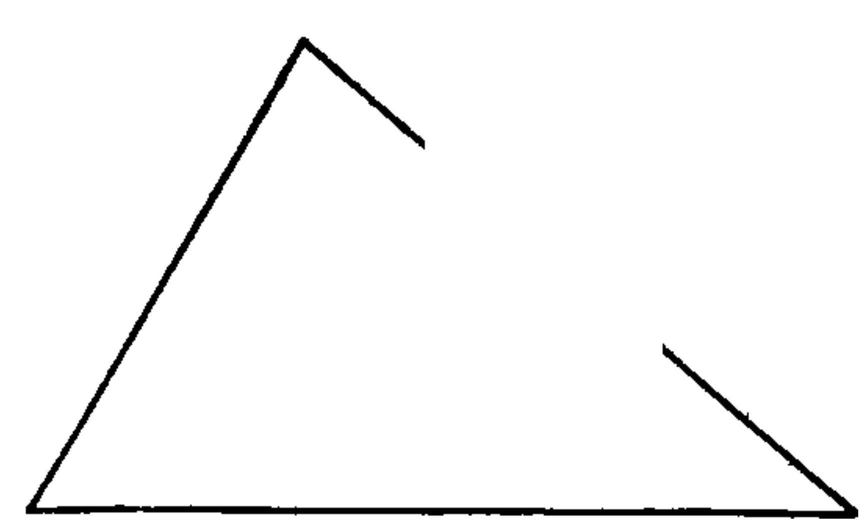


Fig. 51. Scalene Triangle

An *equilateral* triangle is one having all of its sides equal, Fig. 49.

An *equiangular* triangle is one having all of its angles equal.

An *isosceles* triangle, Fig. 50, is one, two of whose sides are equal.

A *scalene* triangle, Fig. 51, is one, no two of whose sides are equal.

The *base* of a triangle is the lowest side; it is the side upon which the triangle is supposed to stand. Any side may, however, be taken as the base. In an isosceles triangle, the side which is not one of the equal sides is usually considered as the base.

The *altitude* of a triangle is the perpendicular drawn from the vertex to the base.

Quadrilaterals. A quadrilateral is a polygon bounded by four straight lines, as Fig. 52.

The *diagonal* of a quadrilateral is a straight line joining two opposite vertices.

Trapezium. A trapezium is a quadrilateral, no two of whose sides are parallel

Trapezoid. A trapezoid is a quadrilateral having two sides

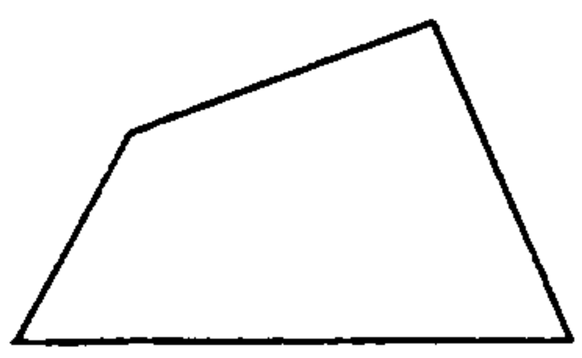


Fig 52 Quadrilateral

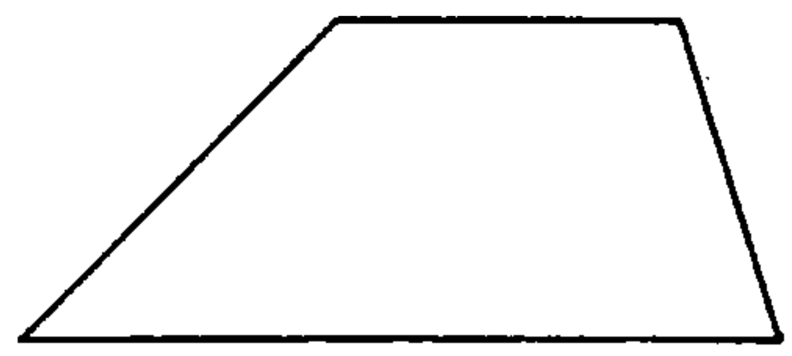


Fig. 53 Trapezoid

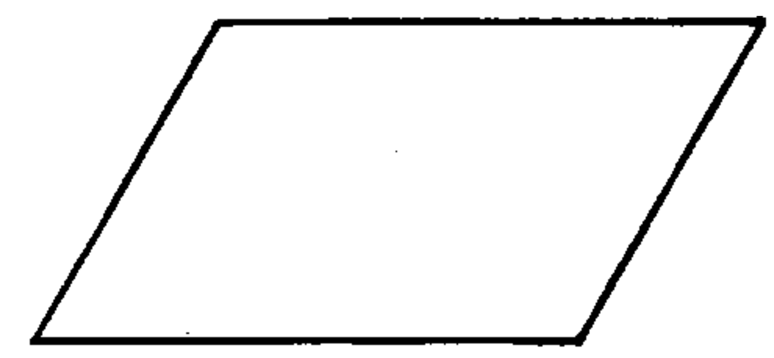


Fig 54 Parallelogram

parallel, Fig. 53. The parallel sides are called the *bases* and the perpendicular distance between the bases is called the *altitude.*

Parallelogram. A parallelogram is a quadrilateral whose opposite sides are parallel, Fig. 54.

There are four kinds of parallelograms: rectangle, square, rhombus, and rhomboid.

The *rectangle,* Fig. 55, is a parallelogram whose angles are right angles.

Fig 55 Rectangle

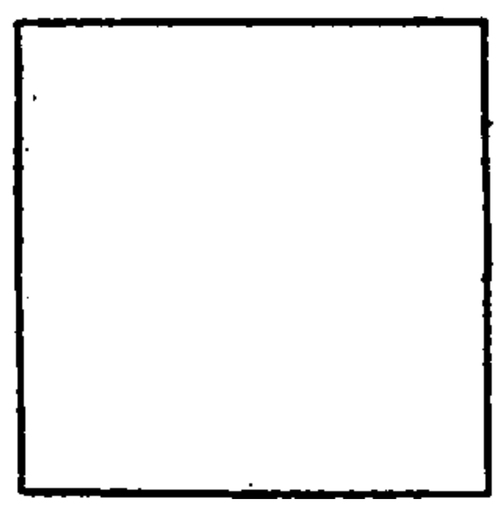


Fig. 56 Square

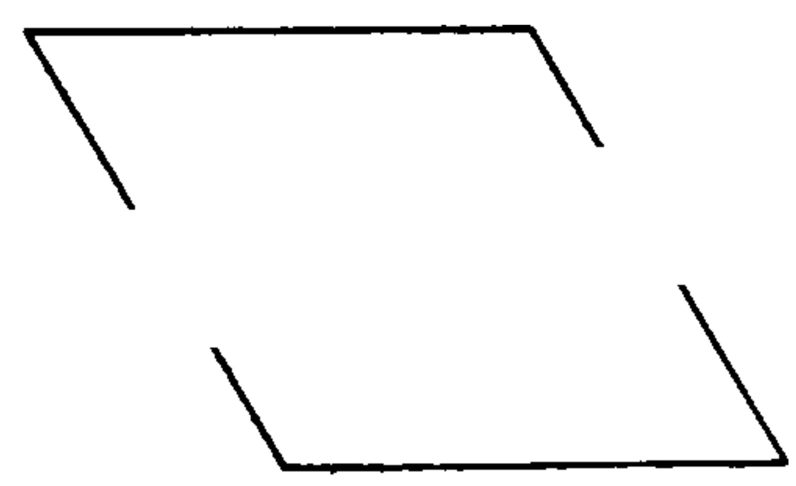


Fig. 57 Rhombus

The *square,* Fig. 56, is a parallelogram all of whose sides are equal and whose angles are right angles.

The *rhombus,* Fig. 57, is a parallelogram whose sides are equal but whose angles are not right angles.

The *rhomboid* is a parallelogram whose adjacent sides are unequal, and whose angles are not right angles.

CIRCLES

A *circle* is a plane figure bounded by a curved line called the *circumference,* every point of which is equally distant from a point within called the *center,* Fig. 58.

A *diameter* of a circle is a straight line drawn through the center, terminating at both ends in the circumference, Fig. 59.

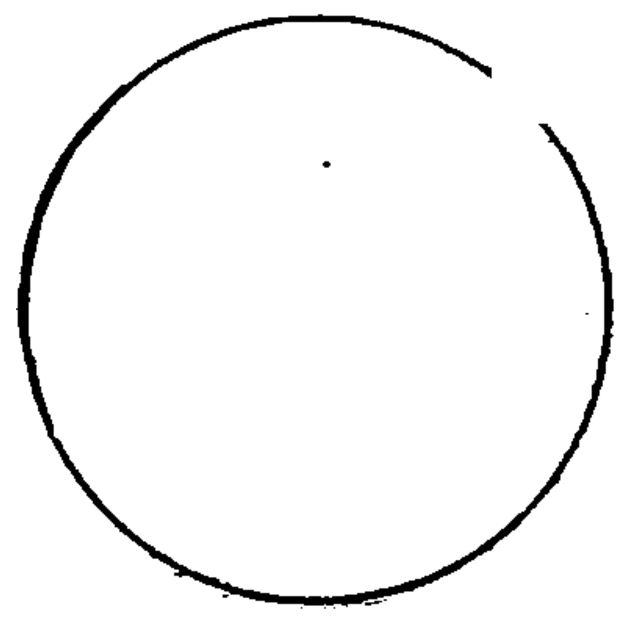


Fig 58. Circle

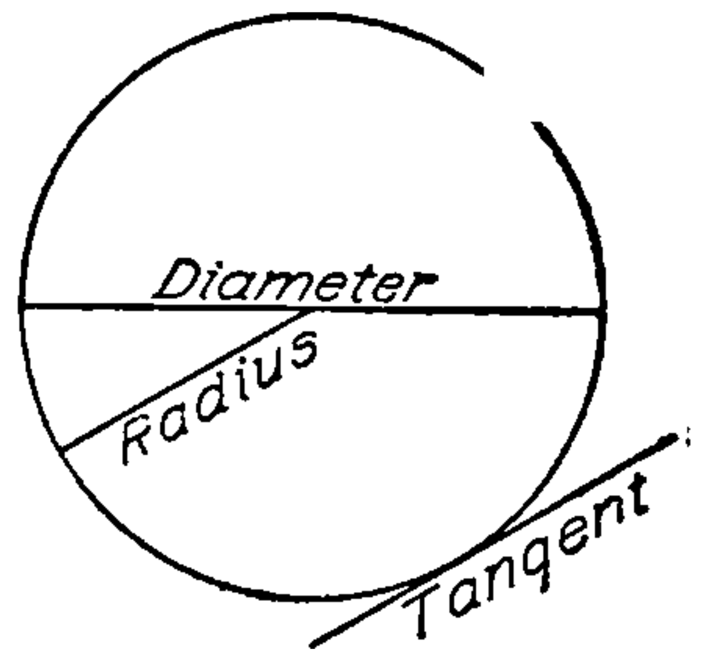


Fig. 59. Diameter and Tangent

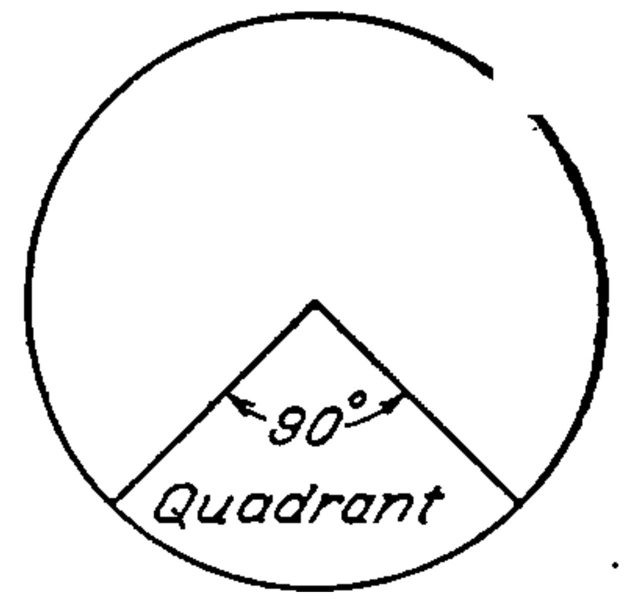


Fig. 60. Quadrant

A *radius* of a circle is a straight line joining the center with the circumference. All radii of the same circle are equal and their length is always one-half that of the diameter.

An *arc* is any part of the circumference of a circle. An arc equal to one-half the circumference is called a *semi-circumference,* and an arc equal to one-quarter of the circumference is called a *quadrant,* Fig. 60. A quadrant may mean the arc or angle.

A *chord,* Fig. 61, is a straight line which joins the extremities of an arc but does not pass through the center of the circle.

A *secant* is a straight line which intersects the circumference in two points, Fig. 61.

A *segment* of a circle, Fig. 62, is the area included between an arc and a chord.

A *sector* is the area included between an arc and two radii drawn

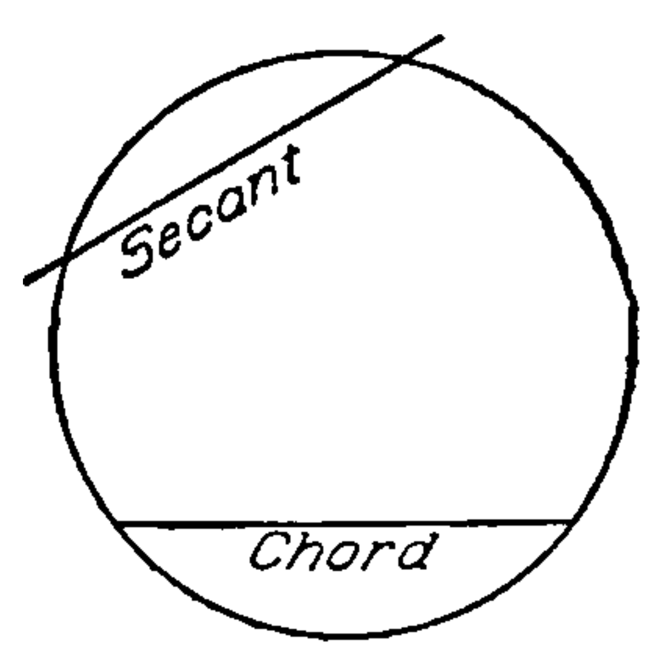


Fig 61. Chord and Secant

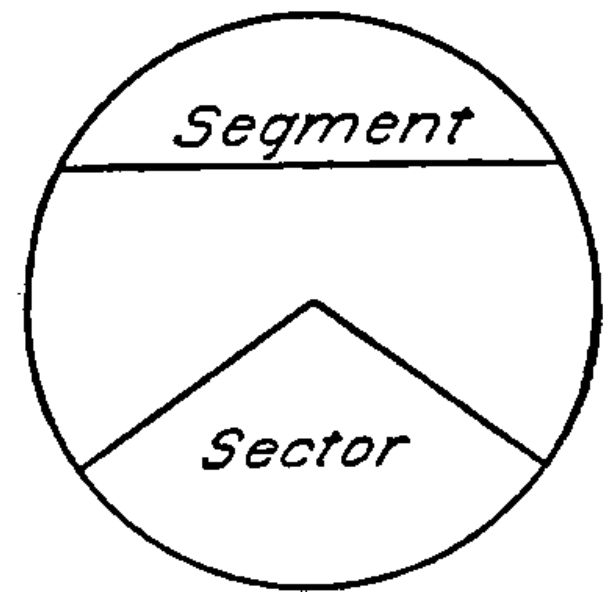


Fig. 62 Segment and Sector

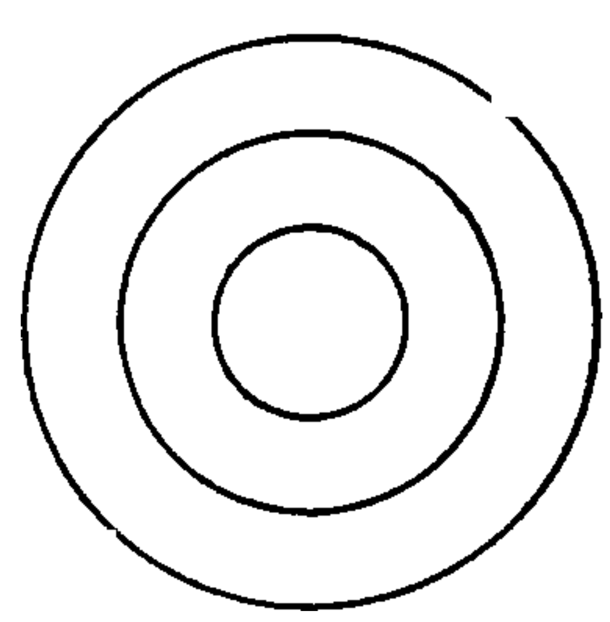


Fig 63 Concentric Circles

to the extremities of the arc, Fig. 62.

A *tangent* is a straight line which touches the circumference at only one point, called the *point of tangency or contact,* Fig. 59.

Concentric circles are circles having the same center, Fig. 63.

An *inscribed angle* is an angle whose vertex lies in the circumference and whose sides are chords. It is measured by one-half the intercepted arc, Fig. 64.

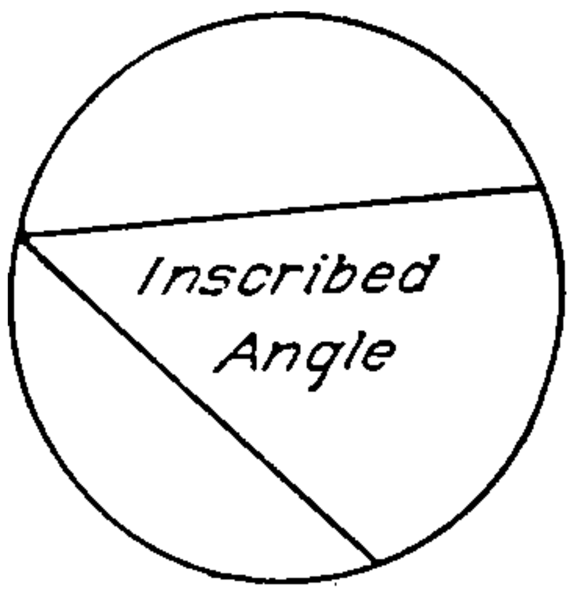


Fig 64 Inscribed Angle

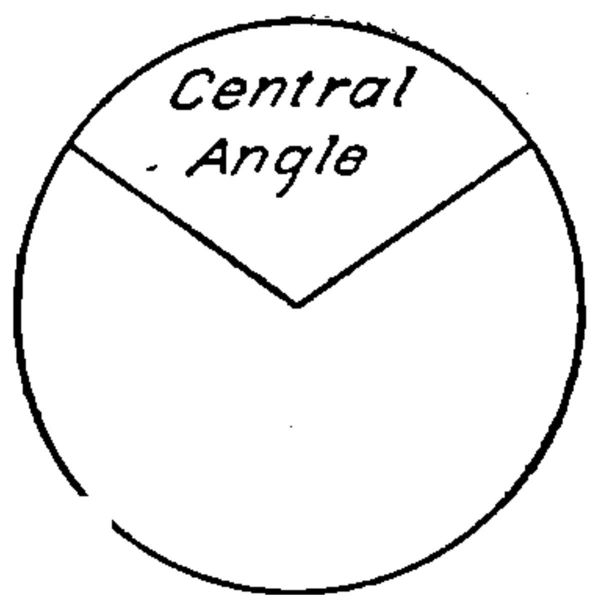


Fig 65. Central Angle

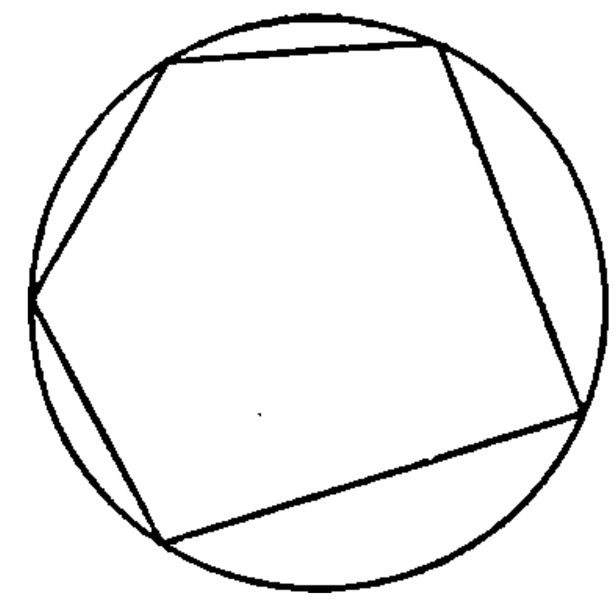


Fig 66. Inscribed Polygon

A *central angle* is an angle whose vertex is at the center of the circle and whose sides are radii, Fig. 65.

An *inscribed polygon* is one whose vertices lie in the circumference and whose sides are chords, Fig. 66.

MEASUREMENT OF ANGLES

To measure an angle, take any convenient radius and describe an arc with the center at the vertex of the angle. The portion of the arc included between the sides of the angle is the *measure of the angle.* If the arc has a constant radius, the greater the divergence of the sides, the longer will be the arc. If there are several arcs drawn with the same center, the intercepted arcs will have different lengths but they will all be the *same fraction* of the entire circumference.

In order that the size of an angle or arc may be stated without saying that it is a certain fraction of a circumference, the circumference is divided into 360 equal parts called *degrees,* Fig. 67. Thus, it may be said that a certain angle contains 45 degrees, *i. e.*, it is $\frac{45}{360} = \frac{1}{8}$ of a circumference. In order to obtain accurate measurements each degree is divided into 60 equal parts called *minutes* and each minute into 60 equal parts called *seconds.*

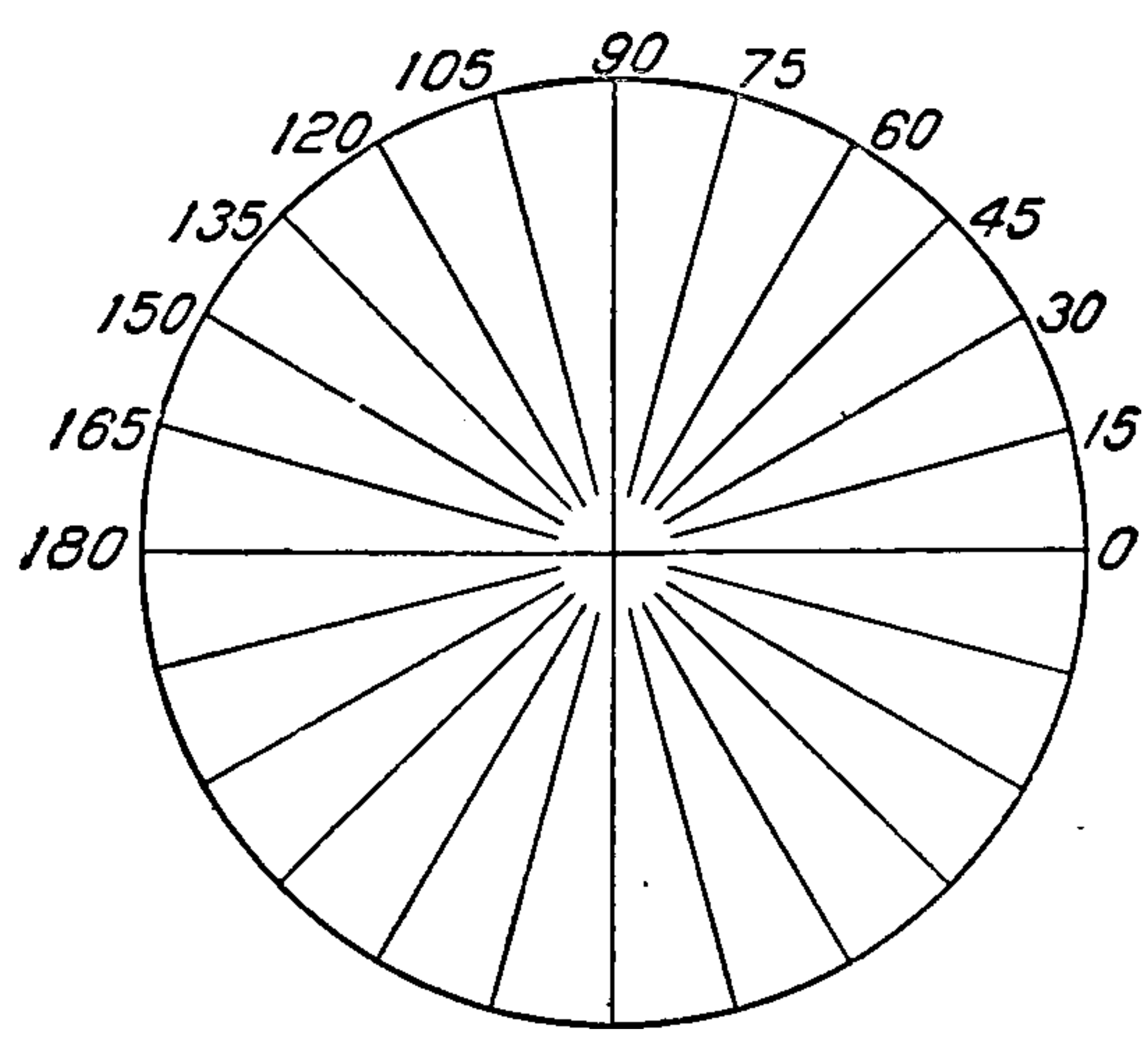


Fig. 67. Angular Measurement

parallelograms. Fig. 71 If all the edges are perpendicular to the bases, it is called a *right parallelopiped.*

A *rectangular parallelopiped* is a right parallelopiped whose bases and lateral faces are rectangles, Fig. 72.

A *cube* is a rectangular parallelopiped all of whose faces are squares

A *truncated prism* is the portion of a prism included between the base and a plane not parallel to the base, Fig. 73.

Pyramids. A pyramid is a polyedron whose base is a polygon and whose lateral faces are triangles having a common vertex called the *vertex* of the pyramid.

The *altitude* of the pyramid is the perpendicular distance from the vertex to the base.

Pyramids are named according to the kind of polygon forming the base, viz, *triangular, quadrangular,* Fig. 74, *pentagonal,* Fig. 75, *hexagonal.*

A *regular pyramid* is one whose base is a regular polygon and

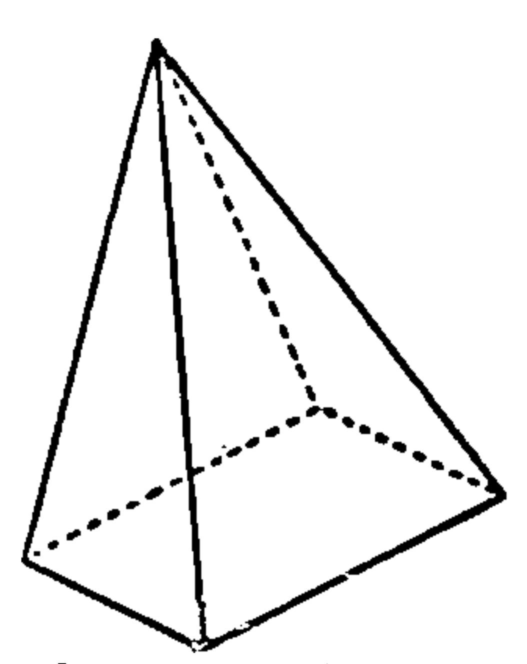


Fig 74 Pyramid

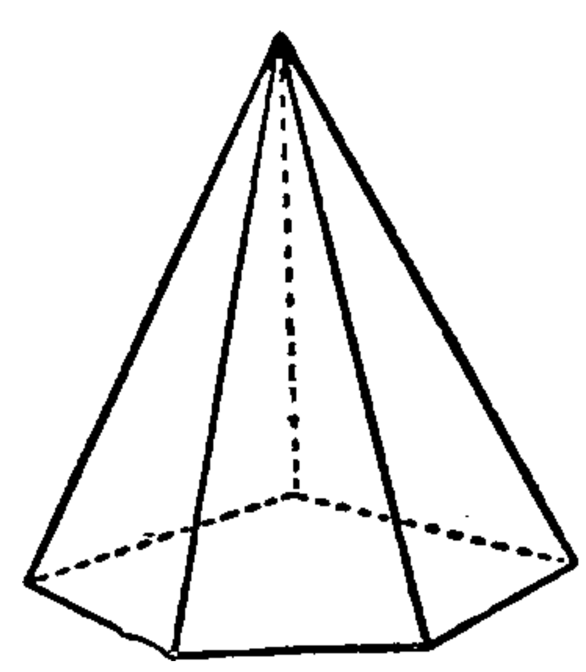


Fig 75 Regular Pyramid

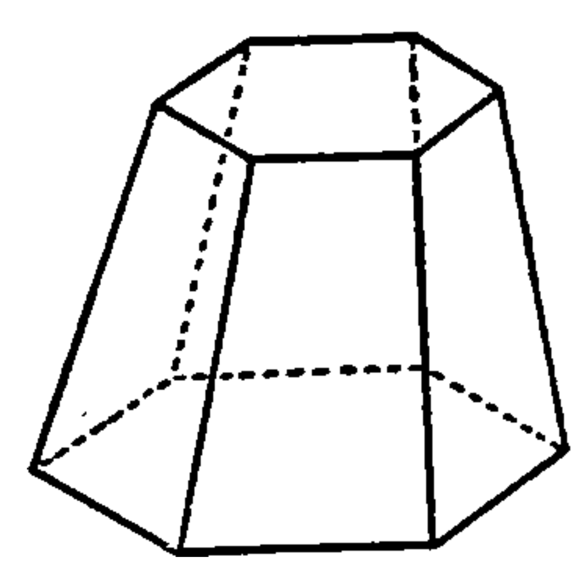


Fig 76 Frustum of Pyramid

whose vertex lies in a perpendicular erected at the center of the base, Fig. 75

A *truncated* pyramid is the portion of a pyramid included between the base and a plane not parallel to the base.

A *frustum* of a pyramid is the solid included between the base and a plane parallel to the base, Fig 76; its *altitude* is the perpendicular distance between the bases.

CYLINDERS

A *cylinder* is a solid having as bases two equal parallel curved surfaces and as its lateral face the continuous surface generated by a straight line connecting the bases and moving along their circumferences The bases are usually circles and such a cylinder is called a *circular cylinder,* Fig 77

A *right cylinder,* Fig. 78, is one whose side is perpendicular to the bases.

The *altitude* of a cylinder is the perpendicular distance between the bases.

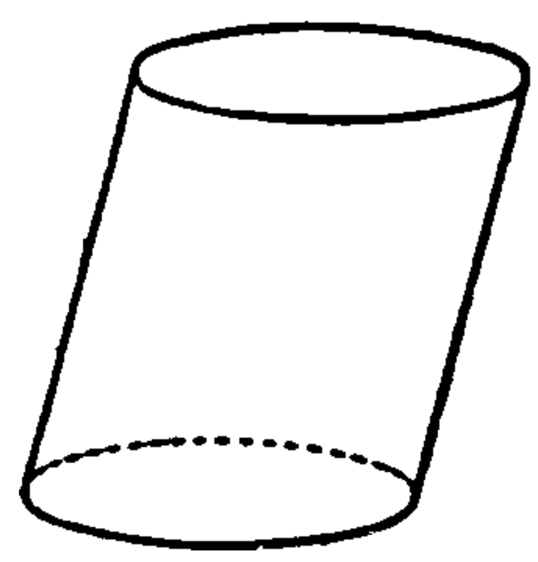


Fig 77. Cylinder

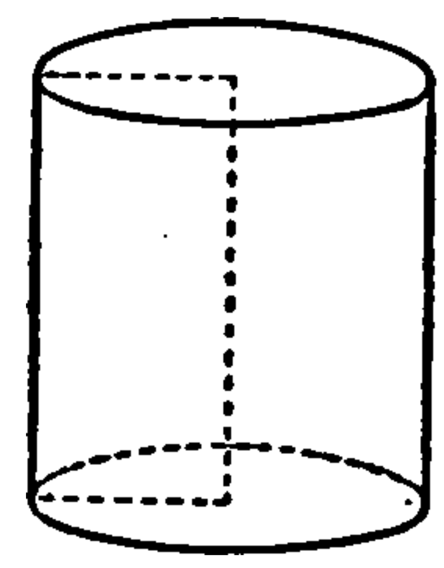


Fig 78. Right Cylinder

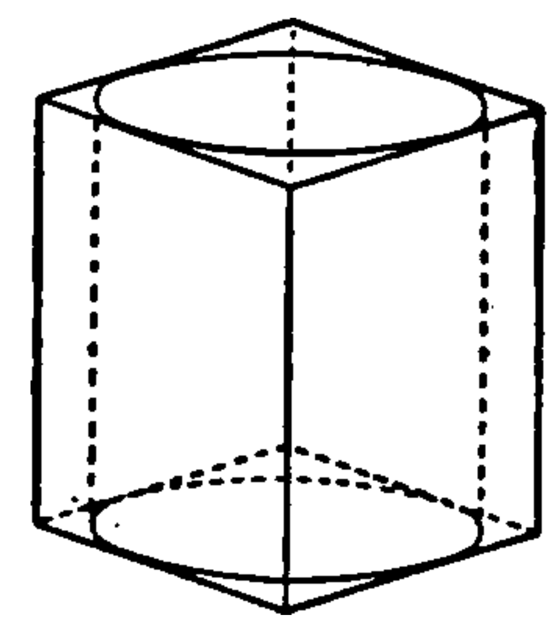


Fig. 79 Inscribed Cylinder

A prism whose base is a regular polygon may be inscribed in or circumscribed about a circular cylinder, Fig. 79.

CONES

A *cone* is a solid bounded by a conical surface and a plane which cuts the conical surface. It may be considered as a pyramid with an infinite number of sides, Fig. 80.

The conical surface is called the *lateral area* and it tapers to a point called the *vertex;* the plane is called the *base.*

The *altitude* of a cone is the perpendicular distance from the vertex to the base.

An *element of the cone* is any straight line from the vertex to the circumference of the base.

A *circular cone* is a cone whose base is a circle

A *right circular cone,* or *cone of revolution,* Fig. 81, is a cone

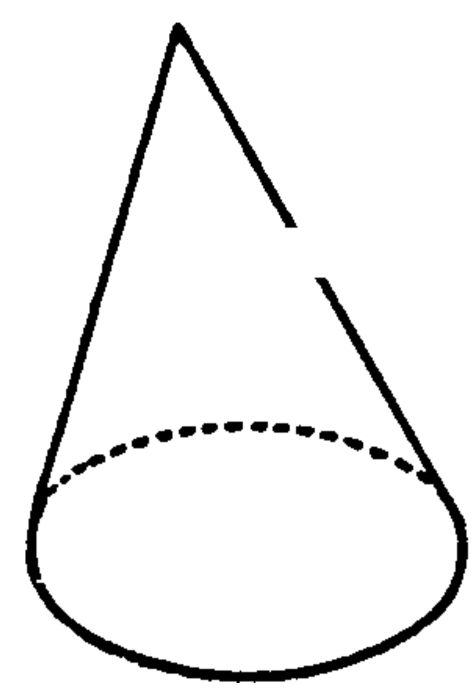


Fig 80 Cone

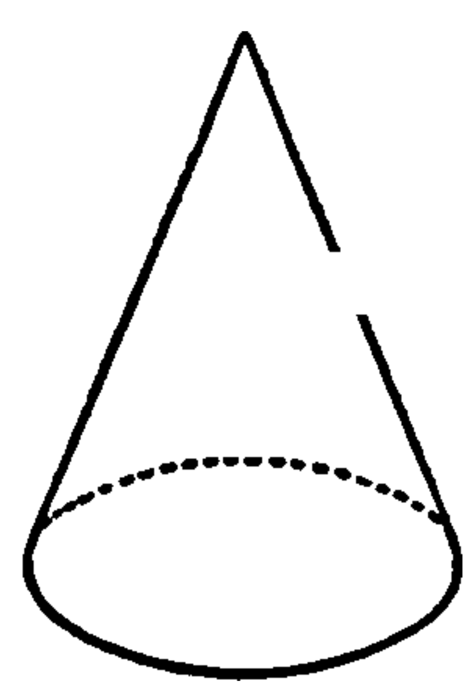


Fig. 81. Right Circular Cone

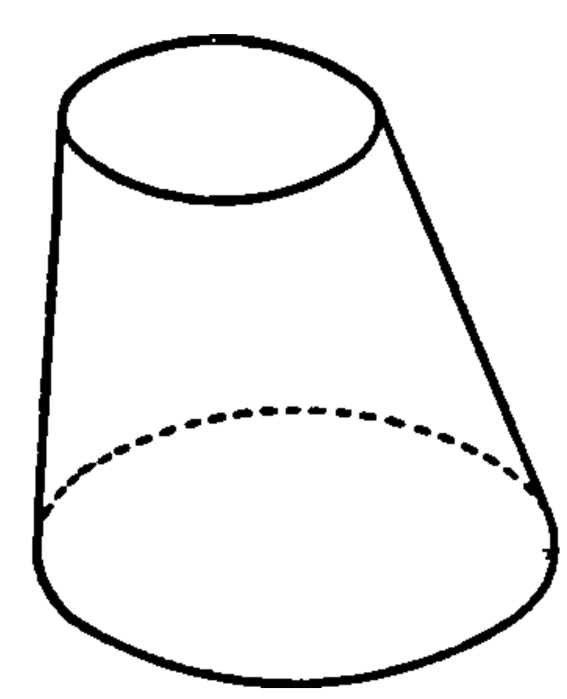


Fig. 82 Frustum of Cone

whose axis is perpendicular to the base. It may be generated by the revolution of a right triangle about one of the legs as an axis.

A *frustum* of a cone, Fig. 82, is the portion of the cone included between the base and a plane parallel to the base; its *altitude* is the perpendicular distance between the bases.

SPHERES

A *sphere* is a solid bounded by a curved surface, every point of which is equally distant from a point within called the *center*.

The *diameter* is a straight line drawn through the center and having its extremities in the curved surface. The *radius* — $\frac{1}{2}$ diameter —is the straight line from the center to a point on the surface.

A *plane is tangent to a sphere* when it touches the sphere in only

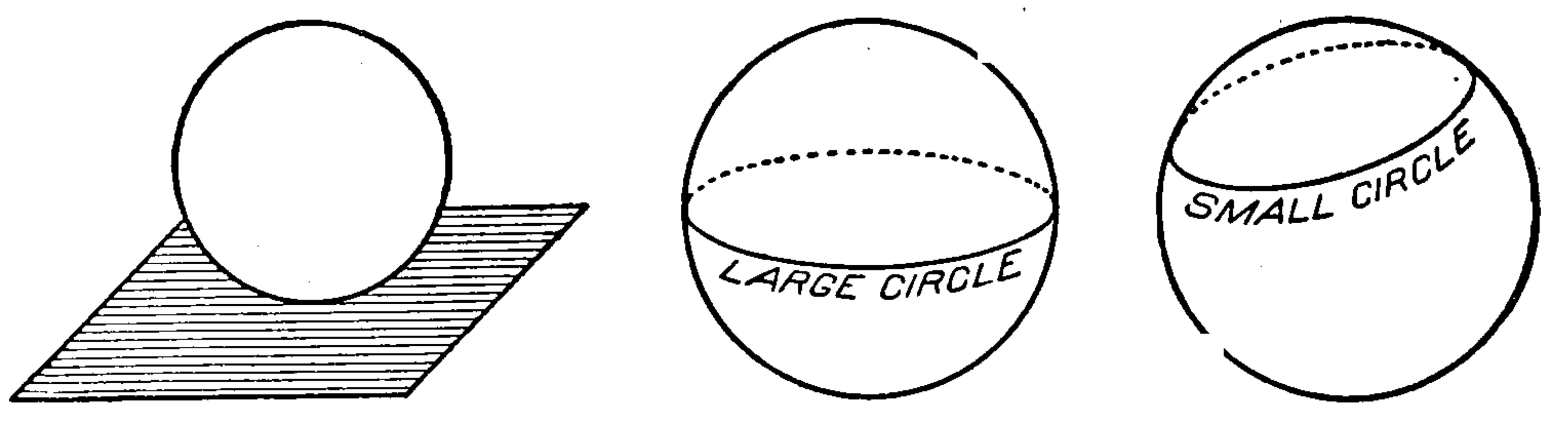


Fig 83. Plane Tangent to Sphere   Fig. 84 Large Circle   Fig 85 Small Circle

one point. A plane perpendicular to a radius at its outer extremity is tangent to the sphere, Fig. 83.

An *inscribed polyedron* is a polyedron whose vertices lie in the surface of the sphere.

A *circumscribed polyedron* is a polyedron whose faces are tangent to a sphere.

A *great circle* is the intersection of the spherical surface and a plane passing through the center of a sphere, Fig. 84.

A *small circle* is the intersection of the spherical surface and a plane which does not pass through the center, Fig. 85.

CONIC SECTIONS

If a plane intersects a cone the geometrical figures thus formed are called *conic sections*. A plane perpendicular to the base and

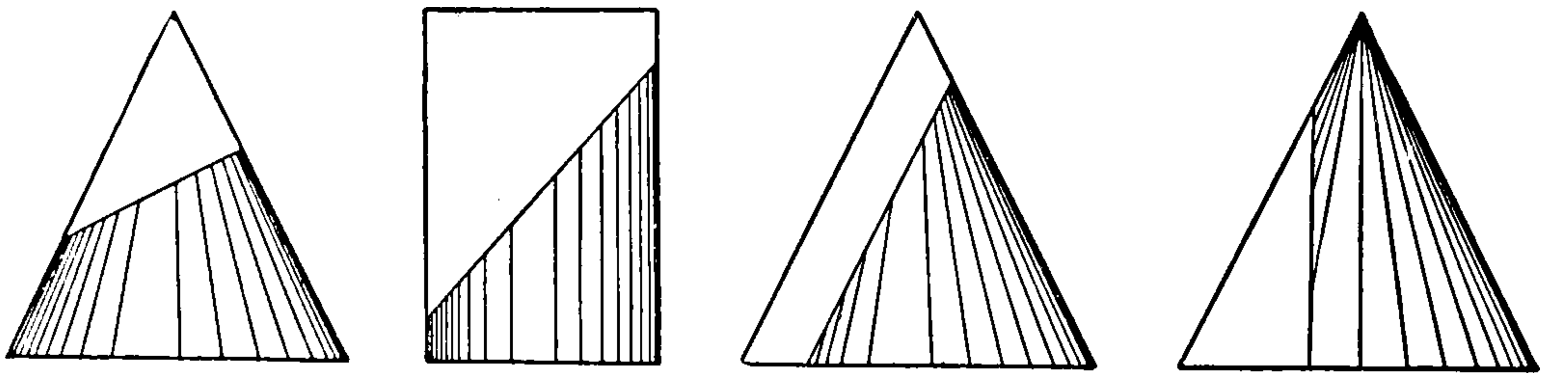


Fig 86*a*   Fig 86*b*   Fig 86*c*   Fig 86*d*

Illustrations of Method of Forming Conic Sections

passing through the vertex of a right circular cone forms an isosceles triangle. If the plane is parallel to the base the intersection of the plane and conical surfaces will be the circumference of a circle.

Ellipse. An ellipse is a curve formed by the intersection of a plane and a cone, Fig. 86*a*, or cylinder, Fig. 86*b*, the plane being oblique to the axis but not cutting the base. An ellipse may be defined as *a curve generated by a point moving in a plane in such a manner that the sum of the distances from the point to two fixed points shall always be constant.*

The two fixed points are called *foci*, Fig. 87, and shall lie on the longest line that can be drawn in the ellipse which is called the

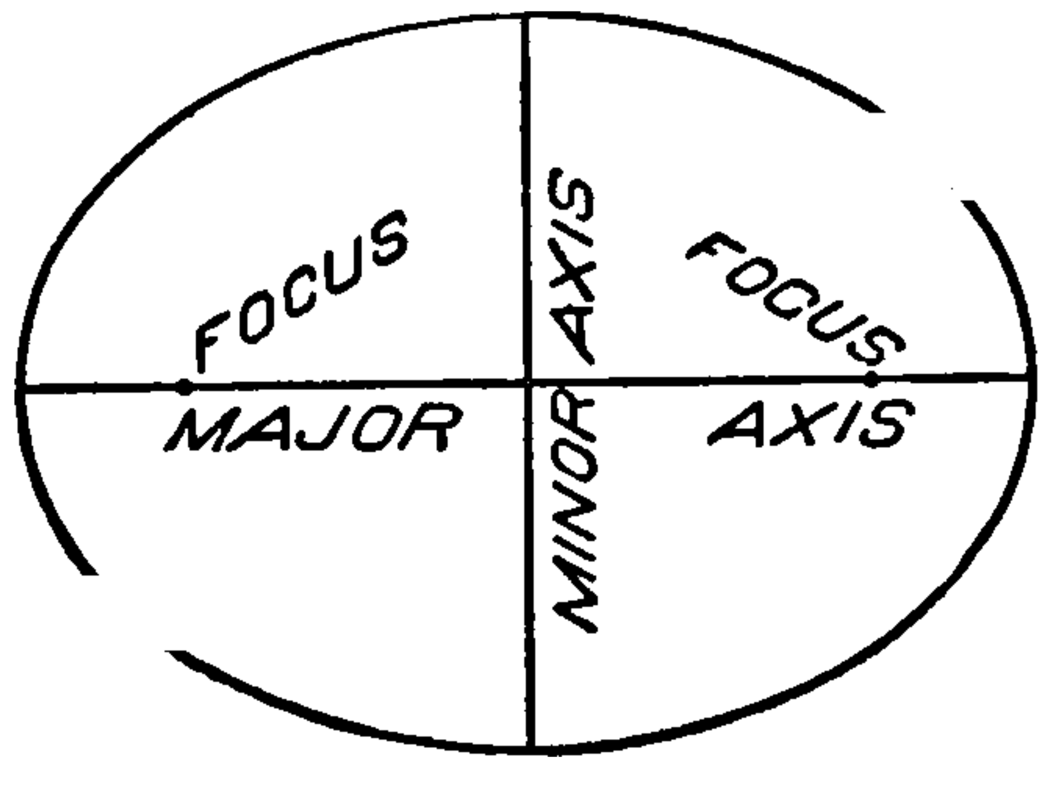


Fig. 87. Ellipse

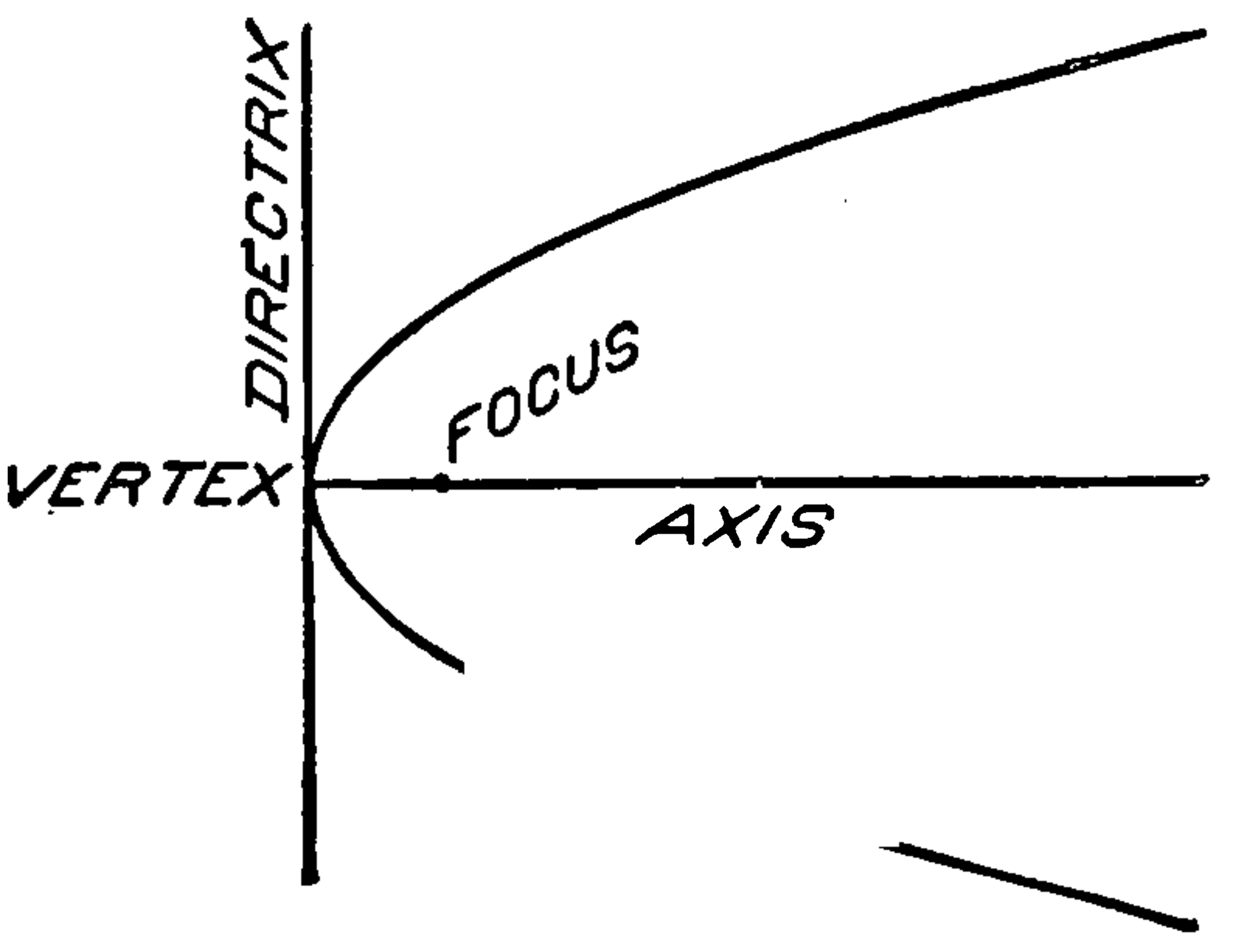


Fig. 88. Parabola

major axis; the shortest line is called the *minor axis*, and is perpendicular to the major axis at its middle point, called the *center.*

An ellipse may be constructed if the major and minor axes are given or if the foci and one axis are known.

Parabola. The parabola is a curve formed by the intersection of a cone and a plane parallel to an element of the cone, Fig. 86*c*. This curve is not a closed curve for the branches approach parallelism.

A parabola may be defined as *a curve every point of which is equally distant from a line and a point.*

The point is called the *focus*, Fig. 88, and the given line, the *directrix*. The line perpendicular to the directrix and passing through the focus is the *axis*. The intersection of the axis and the curve is the *vertex*.

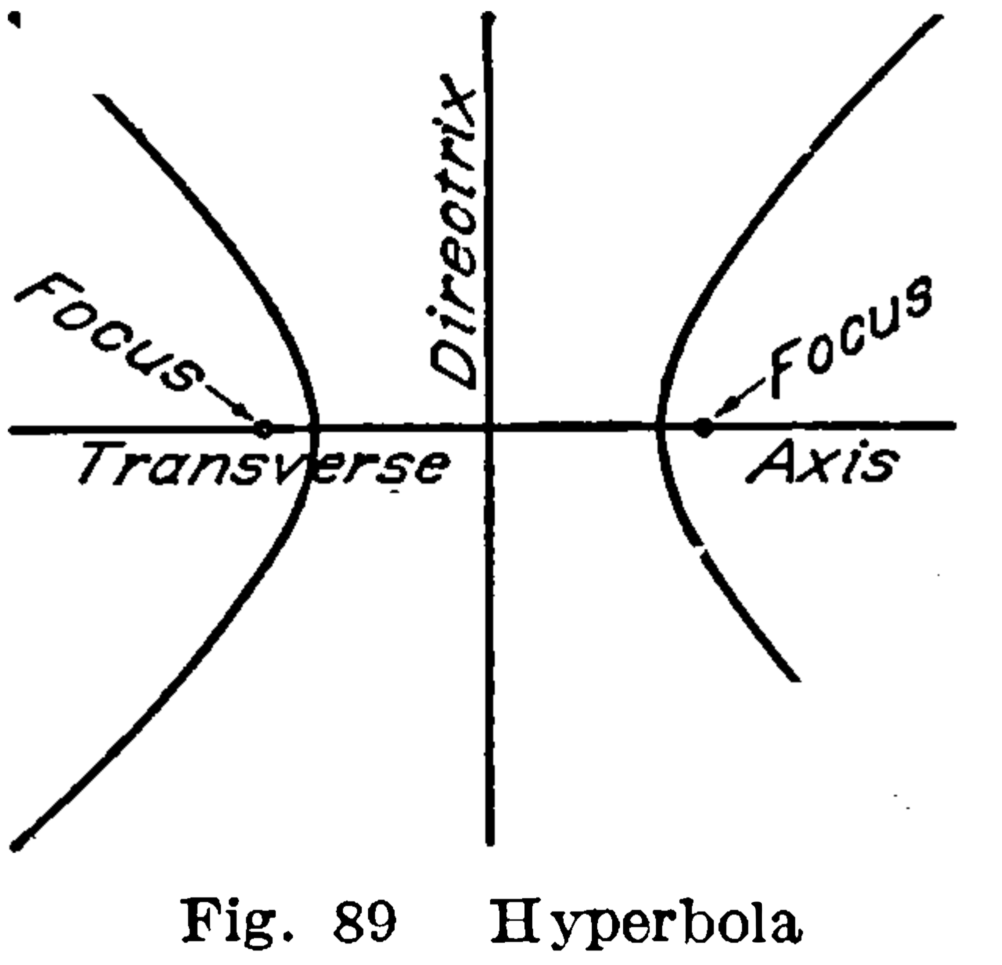


Fig. 89 Hyperbola

Hyperbola. This curve is formed by the intersection of a plane and a cone, the plane being parallel to the axis of the cone, Fig. 86*d*.

Like the parabola, the curve is not closed, the branches constantly diverging.

An hyperbola is defined as *a plane curve such that the difference between the distances from any point in the curve to two fixed points is equal to a given distance.*

The two fixed points are the *foci* and the line passing through them is the *transverse axis,* Fig. 89.

Rectangular Hyperbola. The form of hyperbola most used in Mechanical Engineering is called the rectangular hyperbola because it is drawn with reference to rectangular coördinates. This curve is constructed as follows: In Fig. 90, OX and OY are the two coördinate axes drawn at right angles to each other. These lines are also called *asymptotes.* Assume A to be a known point on the curve. Draw AC parallel to OX and AD perpendicular to OX. Mark off any convenient points on AC such as E, F, G, and H, and through these points draw EE', FF', GG', and HH', perpendicular to OX. Connect E, F, G, H, and C with O. Through the points of intersection of the oblique lines and the vertical line AD draw the horizontal lines LL', MM', NN', PP', and QQ'. The first point on the curve is the assumed point A, the second point is R, the intersection of LL' and EE'. The third is the intersection S of MM' and FF'. The other points are found in the same way.

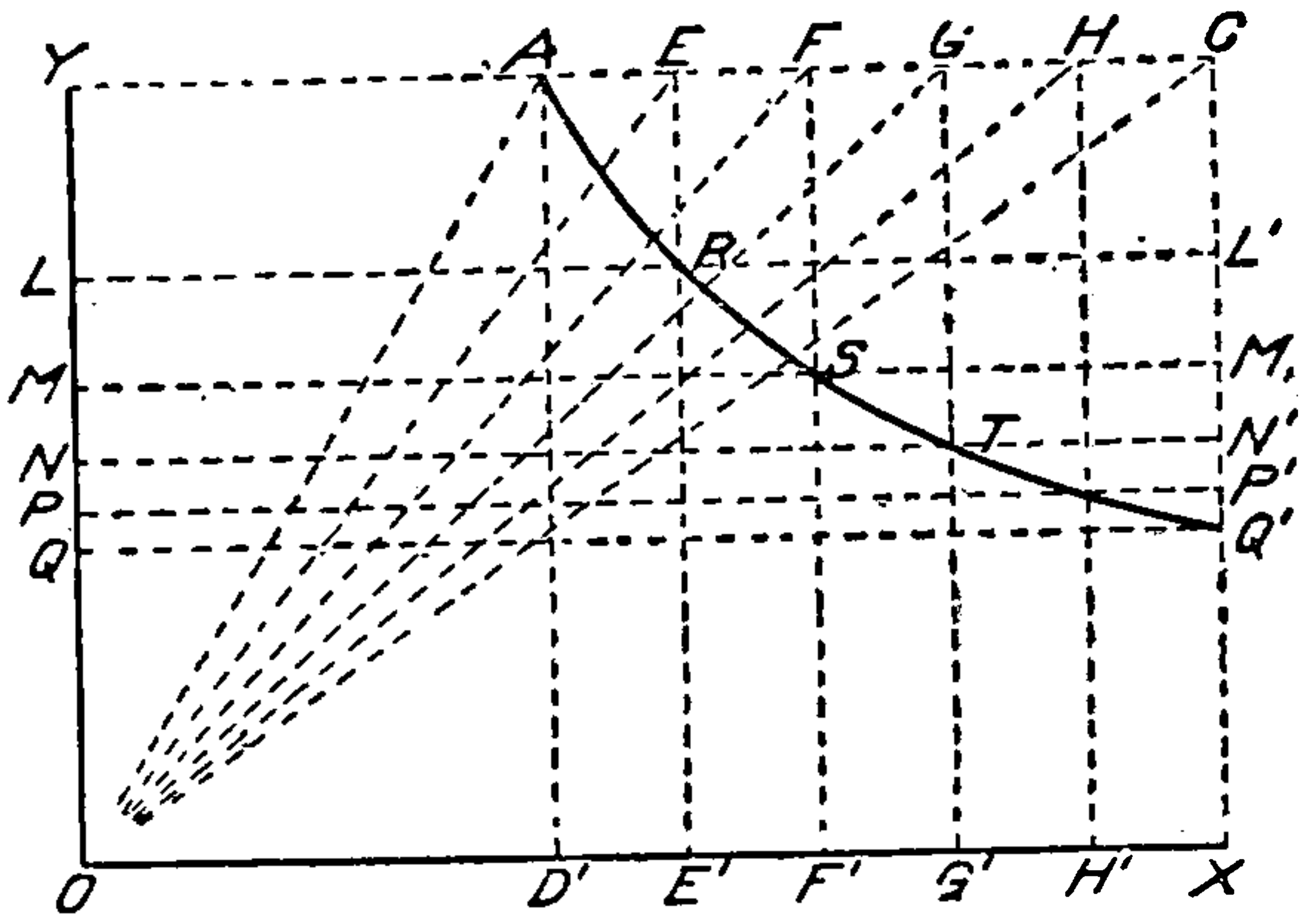


Fig 90 Construction of Rectangular Hyperbola

In this curve the products of the coördinates of all points are equal. Thus $LR \times RE' = MS \times SF' = NT \times TG'$.

ODONTOIDAL CURVES

Gears have their teeth cut by a machine so as to conform to certain shapes which will bring about smoothness of running when the gears are in mesh. The curves generally employed in shaping the gear teeth are the cycloidal and the involute.

Cycloidal Curves. *Cycloid.* The cycloid is a curve generated

Like the parabola, the curve is not closed, the branches constantly diverging.

An hyperbola is defined as *a plane curve such that the difference between the distances from any point in the curve to two fixed points is equal to a given distance.*

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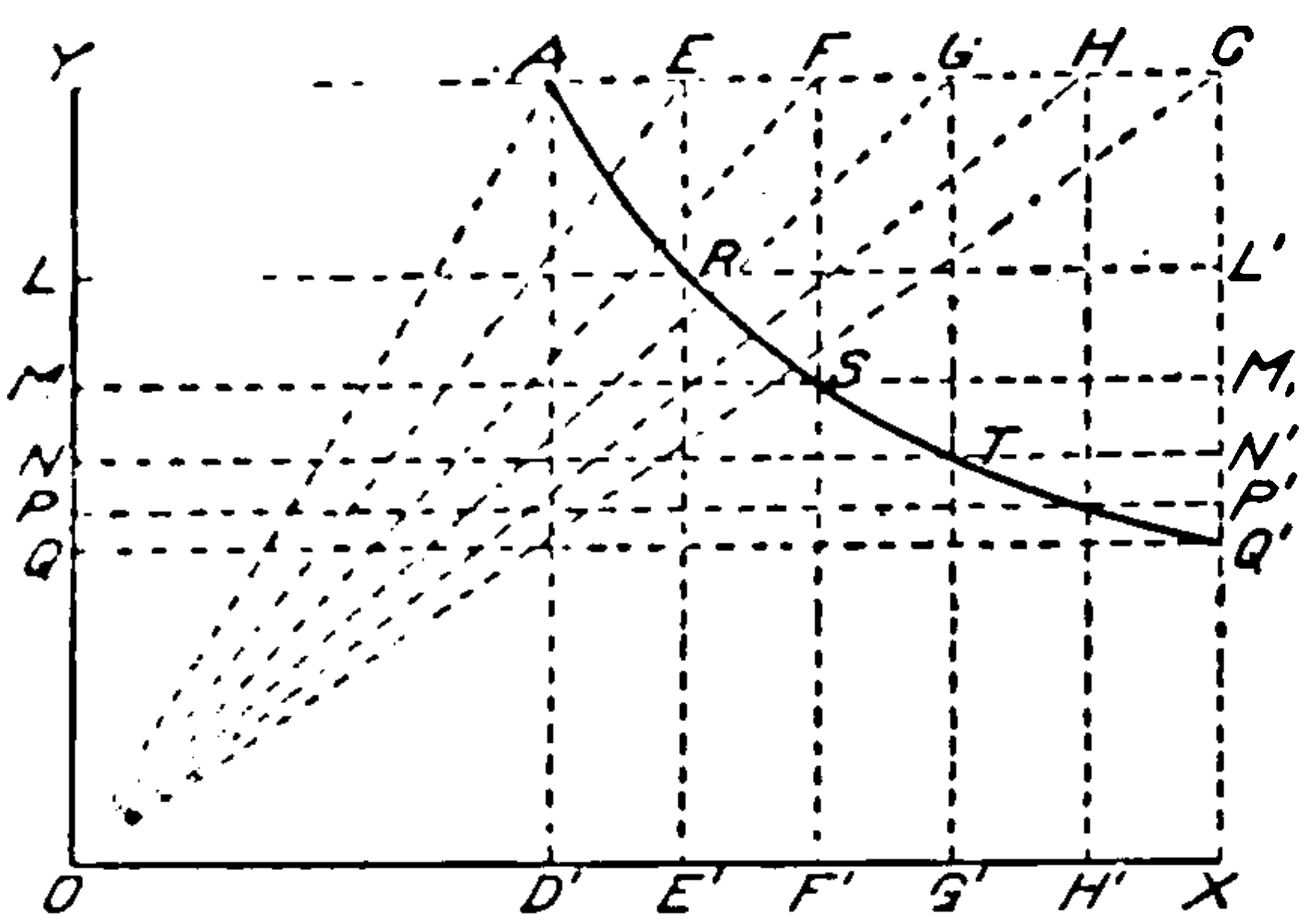

Fig. 90 Construction of Rectangular Hyperbola

In this curve the products of the coördinates of all points are equal. Thus $LR \times RE' = MS \times SF' = NT \times TG'$.

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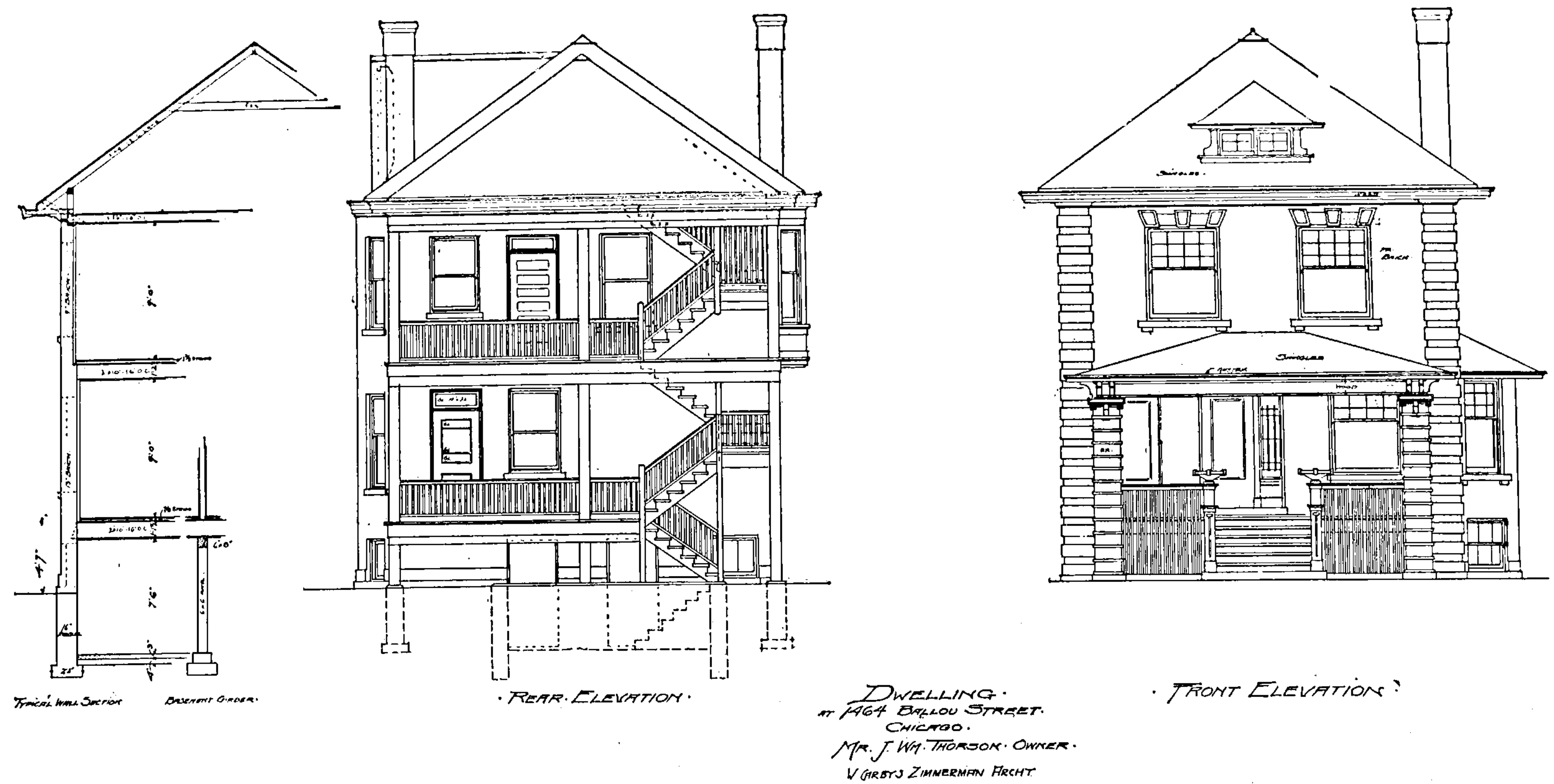
Cycloidal Curves. *Cycloid.* The cycloid is a curve generated



SECTION, AND REAR AND FRONT ELEVATIONS, OF TWO-STORY FLAT BUILDING FOR MR. J. WM. THORSON, CHICAGO, ILL.

W. Carbys Zimmerman, Architect, Chicago, Ill.

Built on a 40-foot Lot. Building Faced with Red Paving Brick on All Four Sides. Roofs of Shingles. Inside Trim of Red Oak and Birch. Dining Rooms Have Beam Ceilings. Tile in Bathrooms. Cost of Building Complete, $9,000. Side Elevation Shown on Opposite Page. For Plans, See Pages 26 and 42.

SIDE ELEVATION OF TWO-STORY FLAT BUILDING FOR MR. J. WM. THORSON, CHICAGO, ILL.

W. Carbys Zimmerman, Architect, Chicago, Ill.

Front and Rear Elevations Shown on Opposite Page. For Plans, See Pages 26 and 42.

by a point on the circumference of a circle which rolls on a straight line tangent to the circle, Fig. 91.

The rolling circle is called the *describing* or *generating circle,* the point on the circle, the *describing* or *generating point,* and the

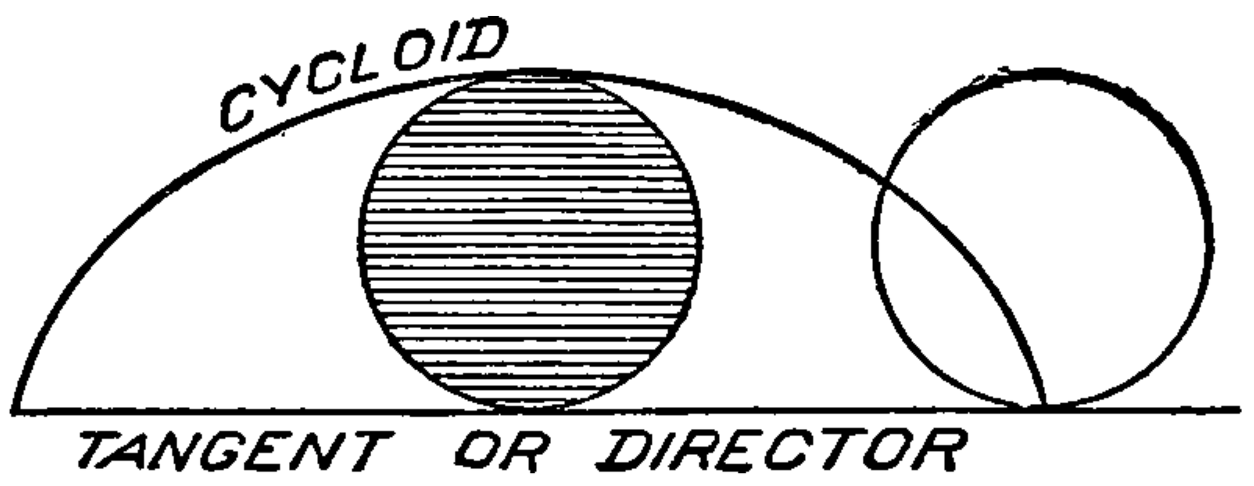


Fig. 91. Geometrical Construction for a Cycloid

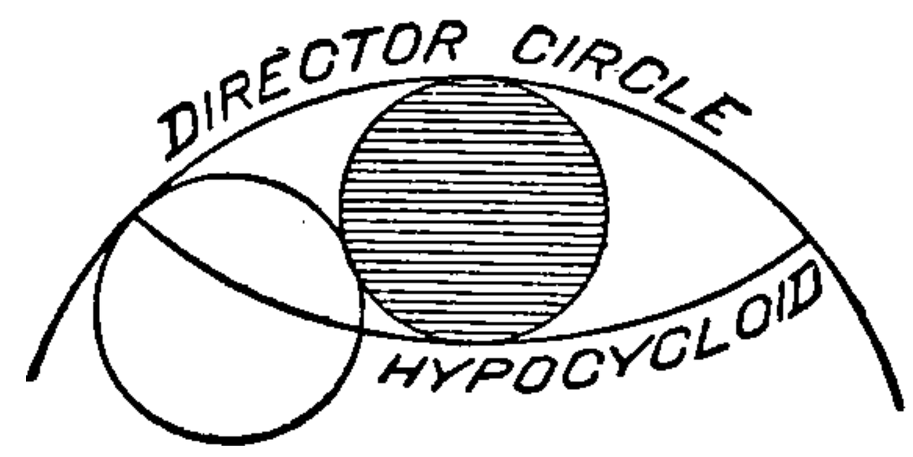


Fig. 92 Geometrical Construction for a Hypocycloid

tangent along which the circle rolls, the *director.* In order that the curve described by the point may be a true cycloid the circle must roll without any slipping.

Hypocycloid. In case the generating circle rolls upon the inside of an arc or circle, the curve thus generated is a hypocycloid, Fig. 92 If the generating circle has a diameter equal to the radius of the director circle the hypocycloid becomes a straight line.

Epicycloid. If the generating circle rolls upon the *outside* of an arc or circle, called the *director circle,* the curve thus generated is an epicycloid, Fig. 93.

Involute Curves If a thread or fine wire is wound around a cylinder or circle and then unwound, the end will describe an involute

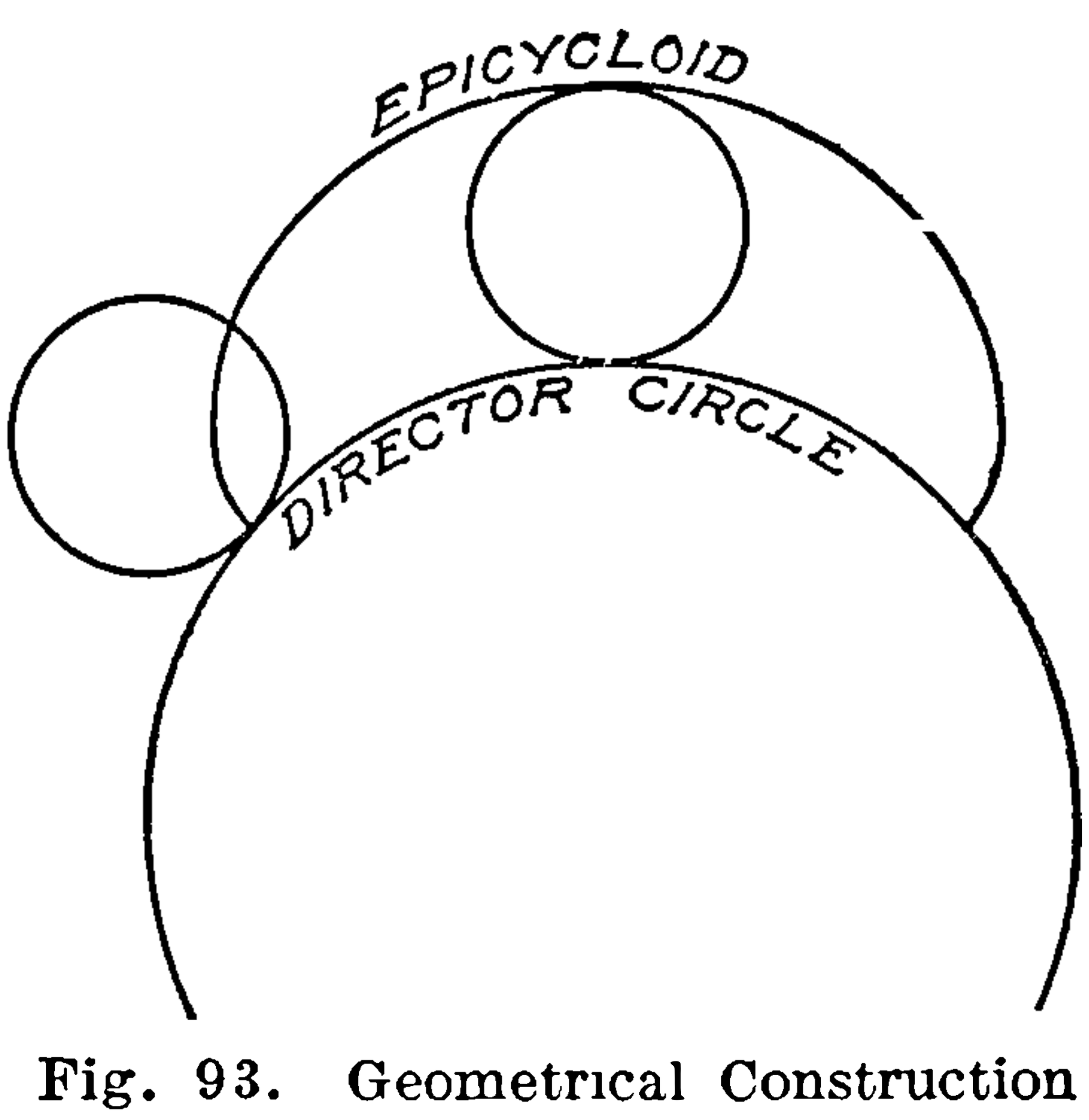


Fig. 93. Geometrical Construction for an Epicycloid

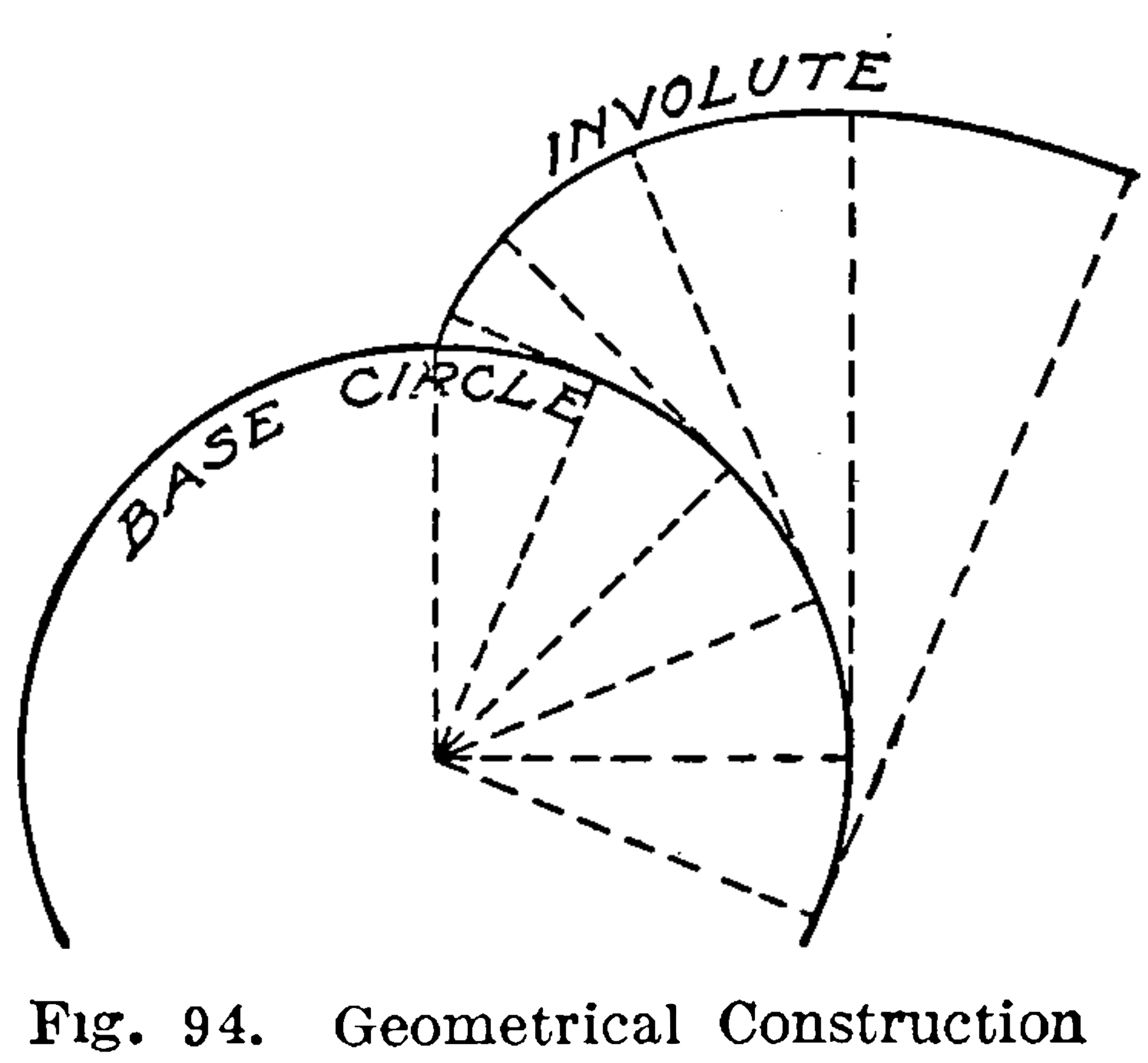


Fig. 94. Geometrical Construction for an Involute

curve. The involute may be defined as *a curve generated by a point in a tangent rolling on a circle, known as the base circle,* Fig. 94.

The details of the construction of the ellipse, parabola, hyperbola, cycloid, and involute will be taken up in connection with the plates.

GEOMETRICAL PROBLEMS

The problems given in Plates IV to VIII inclusive have been chosen because of their particular bearing on the work of the mechanical draftsman. They should be solved with great care, as the principles involved will be used in later work.

PLATE IV

Penciling. The horizontal and vertical center lines and the border lines should be laid out in the same manner as in *Plate I.* Now measure off $2\frac{1}{4}$ inches on both sides of the vertical center line and through these points draw vertical lines as shown by the dot and dash lines, *Plate IV.* In locating the figures, place them a little above the center so that there will be room for the number of the problem.

Draw in lightly the lines of each figure with pencil and after the entire plate is completed, ink them. In penciling, all intersections must be formed with great care as the accuracy of the results depends upon it. Keep the pencil points in good order at all times and draw lines *exactly* through intersections.

Problem 1. *To bisect a given straight line.*

Draw the horizontal straight line $A\,C$ about 3 inches long. With the extremity A as a center and any convenient radius—about 2 inches—describe arcs above and below the line $A\,C$. With the other extremity C as a center and with the same radius draw similar arcs intersecting the first arcs at D and E. The radius of these arcs must be greater than one-half the length of the line in order that they may intersect. Now draw the straight line $D\,E$ passing through the intersections D and E. This line will cut $A\,C$ at its middle point F.
Therefore

$$A\,F = F\,C$$

Proof. Since the points D and E are equally distant from A and C a straight line drawn through them is perpendicular to $A\,C$ at its middle point F.

Problem 2. *To construct an angle equal to a given angle.*

Draw the line $O\,C$ about 2 inches long and the line $O\,A$ of about the same length. The angle formed by these lines may be any convenient size—about 45 degrees is suitable. This angle *A O C* is the given angle.

Now draw *F G,* a horizontal line about $2\frac{1}{4}$ inches long, and let *F,* the left-hand extremity, be the vertex of the angle to be constructed

With *O* as a center and any convenient radius—about $1\frac{1}{2}$ inches —describe the arc *L M* cutting both *O A* and *O C.* With *F* as a center and the same radius draw the indefinite arc *O Q.* Now set the compass so that the distance between the pencil and the needle point is equal to the chord *L M.* With *Q* as a center and a radius equal to *L M* draw an arc cutting the arc *O Q* at *P.* Through *F* and *P* draw the straight line *F E.* The angle *E F G* is the required angle since it is equal to *A O C.*

Proof. Since the chords of the arcs *L M* and *P Q* are equal, the arcs are equal. The angles are equal because with equal radii equal arcs are intercepted by equal angles.

Problems 3 and 4. *To draw through a given point a line parallel to a given line.*

First Method. Draw the straight line *A C* about $3\frac{1}{2}$ inches long and assume the point *P* about $1\frac{1}{2}$ inches above *A C.* Through the point *P* draw an oblique line *F E* forming any convenient angle —about 60 degrees—with *A C.* Now construct an angle equal to *P F C* having its vertex at *P* and the line *E P* as one side. (See Problem 2.) The straight line *P O* forming the other side of the angle *E P O* will be parallel to *A C.*

Proof. If two straight lines are cut by a third making the corresponding angles equal, the lines are parallel.

Second Method. Draw the straight line *A C* about $3\frac{1}{4}$ inches long and assume the point *P* about $1\frac{1}{2}$ inches above *A C.* With *P* as a center and any convenient radius—about $2\frac{1}{2}$ inches—draw the indefinite arc *E D* cutting the line *A C.* Now with the same radius and with *D* as a center, draw an arc *P Q.* Set the compass so that the distance between the needle point and the pencil is equal to the chord *P Q.* With *D* as a center and a radius equal to *P Q,* describe an arc cutting the arc *E D* at *H.* A line drawn through *P* and *H* will be parallel to *A C.*

Proof. Draw the line *Q H.* Since the arcs *P Q* and *H D* are equal and have the same radii, the angles *P H Q* and *H Q D* are equal. Two lines are parallel if the alternate interior angles are equal.

Problems 5 and 6. *To draw a perpendicular to a line from a point in the line.*

First Method. WHEN THE POINT IS NEAR THE MIDDLE OF THE LINE

Draw the line *A C* about $3\frac{1}{2}$ inches long and assume the point *P* near the middle of the line. With *P* as a center and any convenient radius—about $1\frac{1}{4}$ inches—draw two arcs cutting the line *A C* at *E* and *F*. Now with *E* and *F* as centers and any convenient radius —about $2\frac{1}{2}$ inches—describe arcs intersecting at *O*. The line *O P* will be perpendicular to *A C* at *P*.

Proof. The points *P* and *O* are both equally distant from *E* and *F*. Hence a line drawn through them is perpendicular to *E F* at *P*.

Second Method. WHEN THE POINT IS NEAR THE END OF THE LINE.

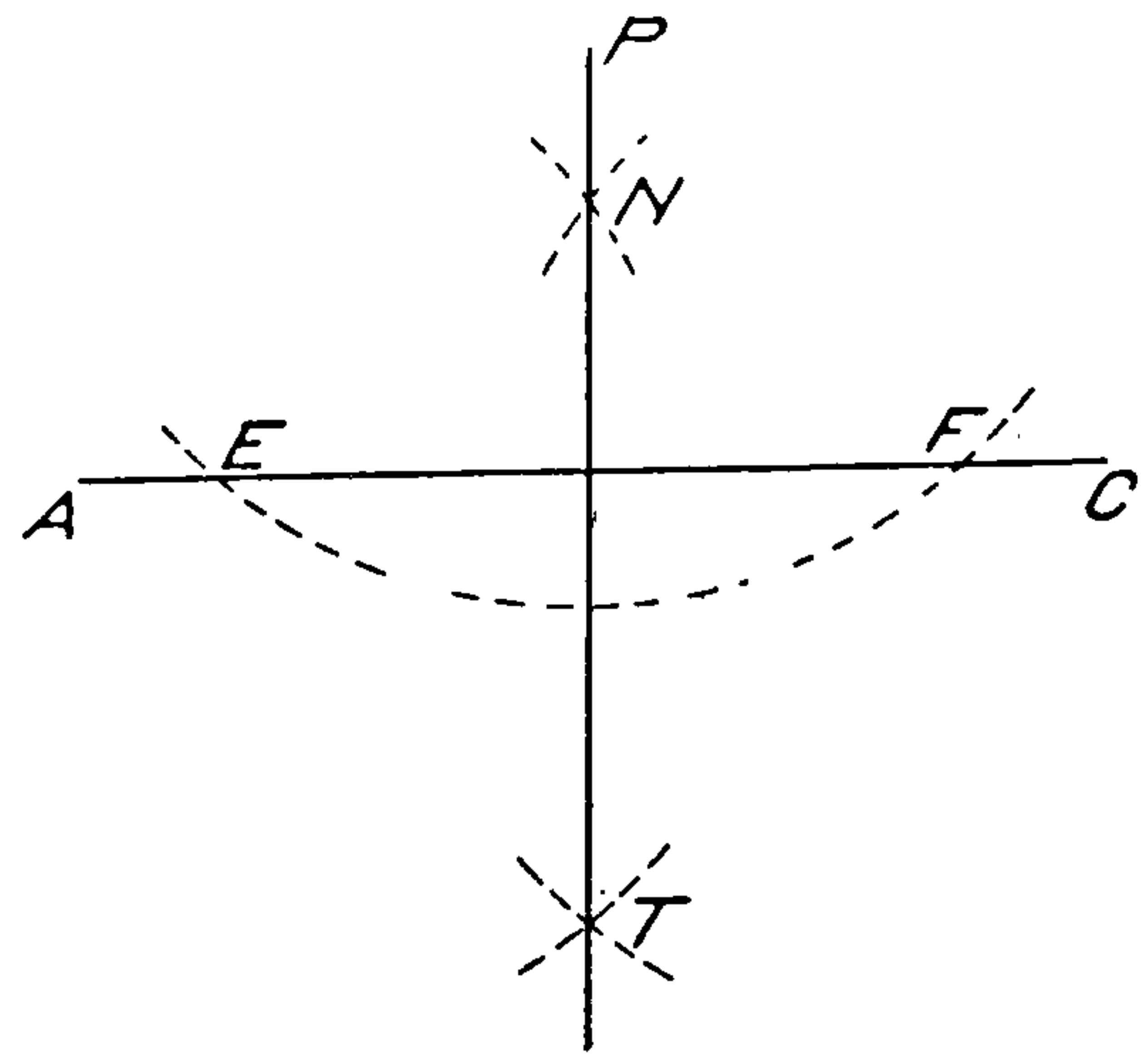
Draw the line *A C* about $3\frac{1}{2}$ inches long. Assume the given point *P* to be about $\frac{3}{4}$ inch from the end *A*. With any point *D* as a center and a radius equal to *D P*, describe an arc cutting *A C* at *E*. Through *E* and *D* draw the diameter *E O*. A line from *O* to *P* is perpendicular to *A C* at *P*.

Proof. The angle *O P E* is inscribed in a semicircle; hence it is a right angle, and the sides *O P* and *P E* are perpendicular to each other.

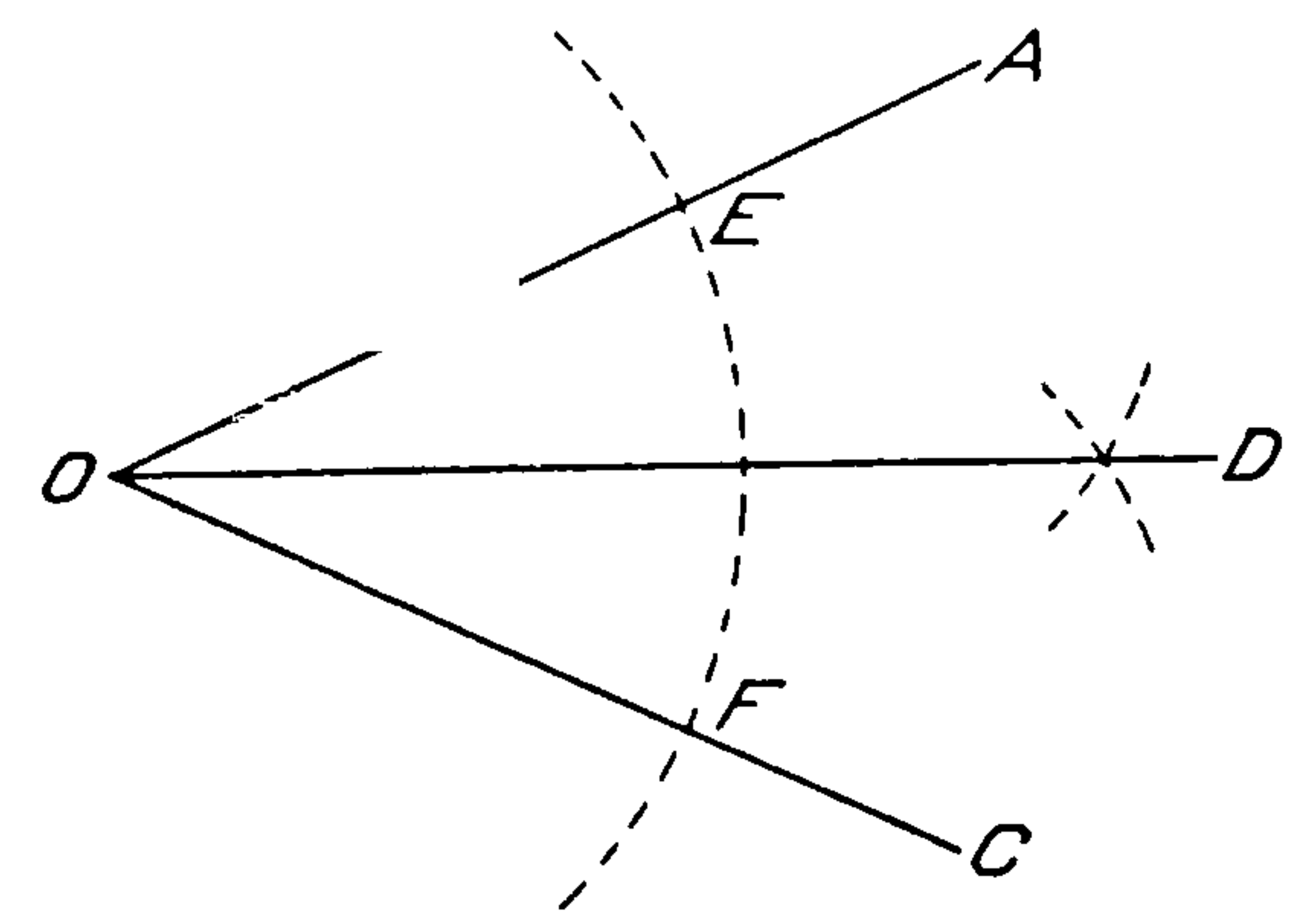
Lettering. After completing these figures draw pencil lines for the lettering. Place the words "*Plate IV*" and the date and the name in the border, as in preceding plates. To letter the words "Problem 1," "Problem 2," etc., draw three horizontal lines $\frac{1}{4}$ inch, $\frac{3}{8}$ inch, and $\frac{7}{16}$ inch respectively, above the horizontal center line and the lower border line to serve as a guide for the size of the letters.

Inking. In inking *Plate IV*, ink in the figures first. Make the line *A C*, Problem 1, a full line as it is the given line; make the arcs and the line *D E* dotted as they are construction lines. Similarly in Problem 2, make the sides of the angles full lines and the chord *L M* and the arcs dotted. Follow the same plan in inking the lines of Problems 3, 4, 5, and 6. In Problem 6, ink in only that part of the circumference which passes through the points *O*, *P*, and *E*.

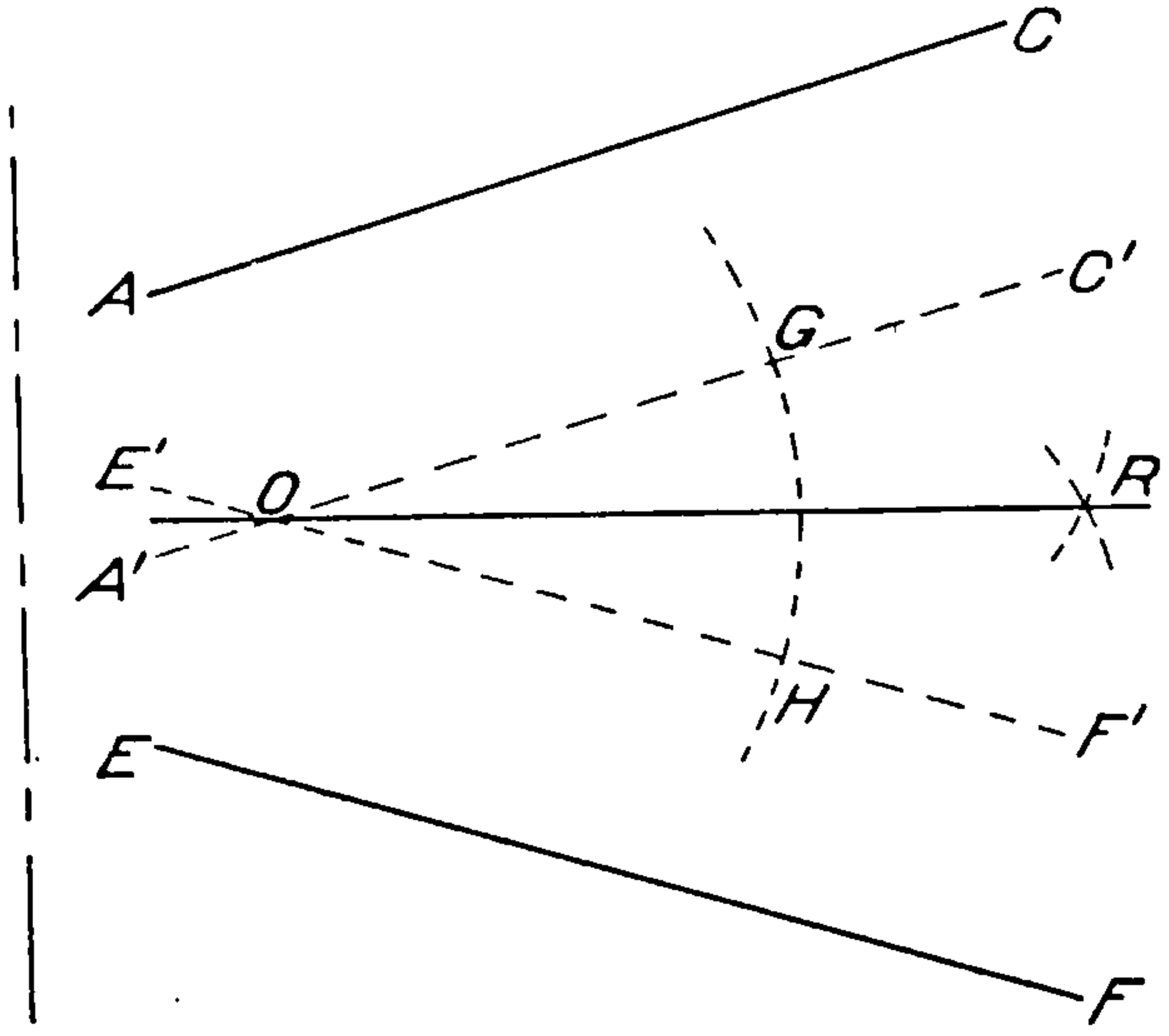
PLATE V



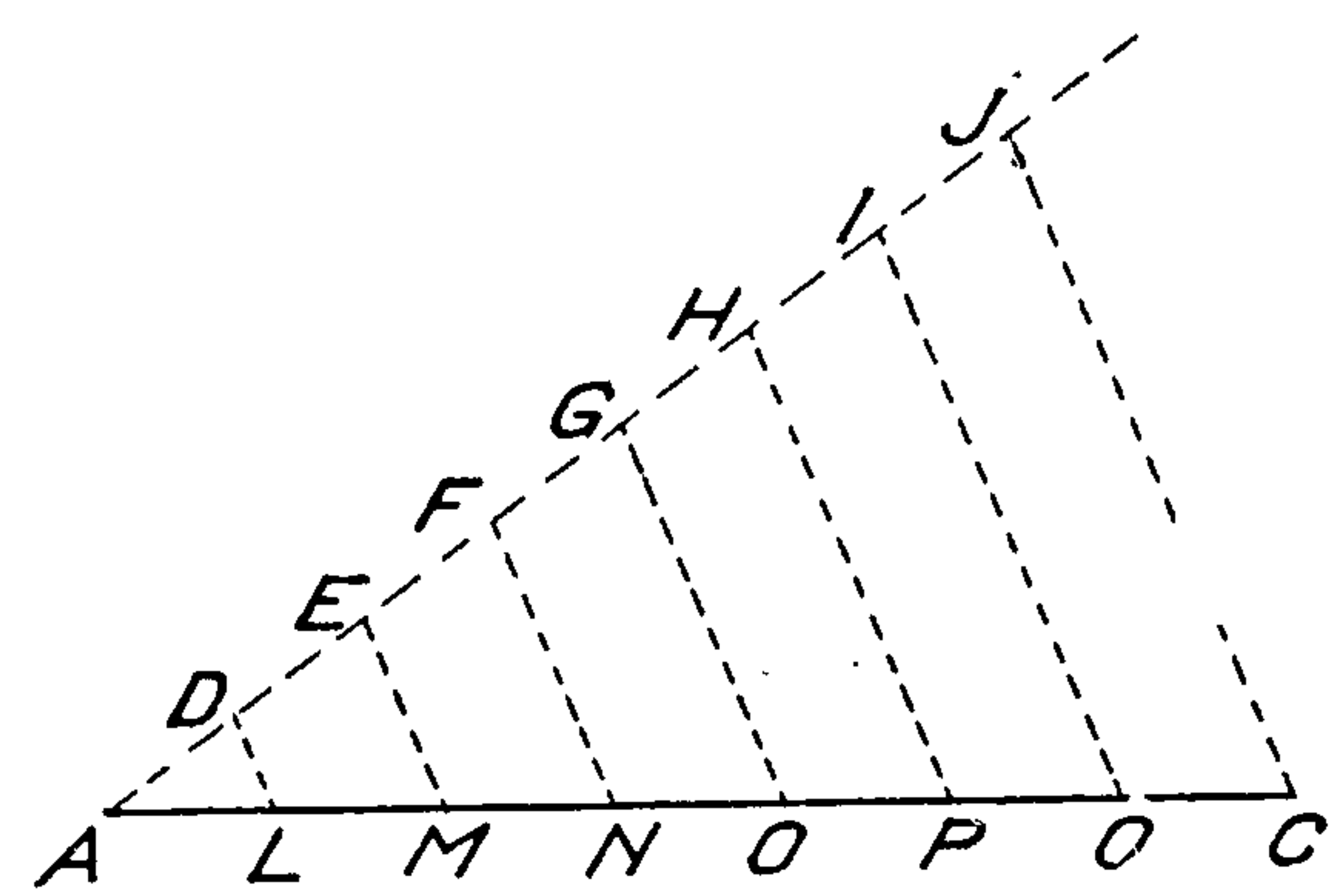
Problem 7



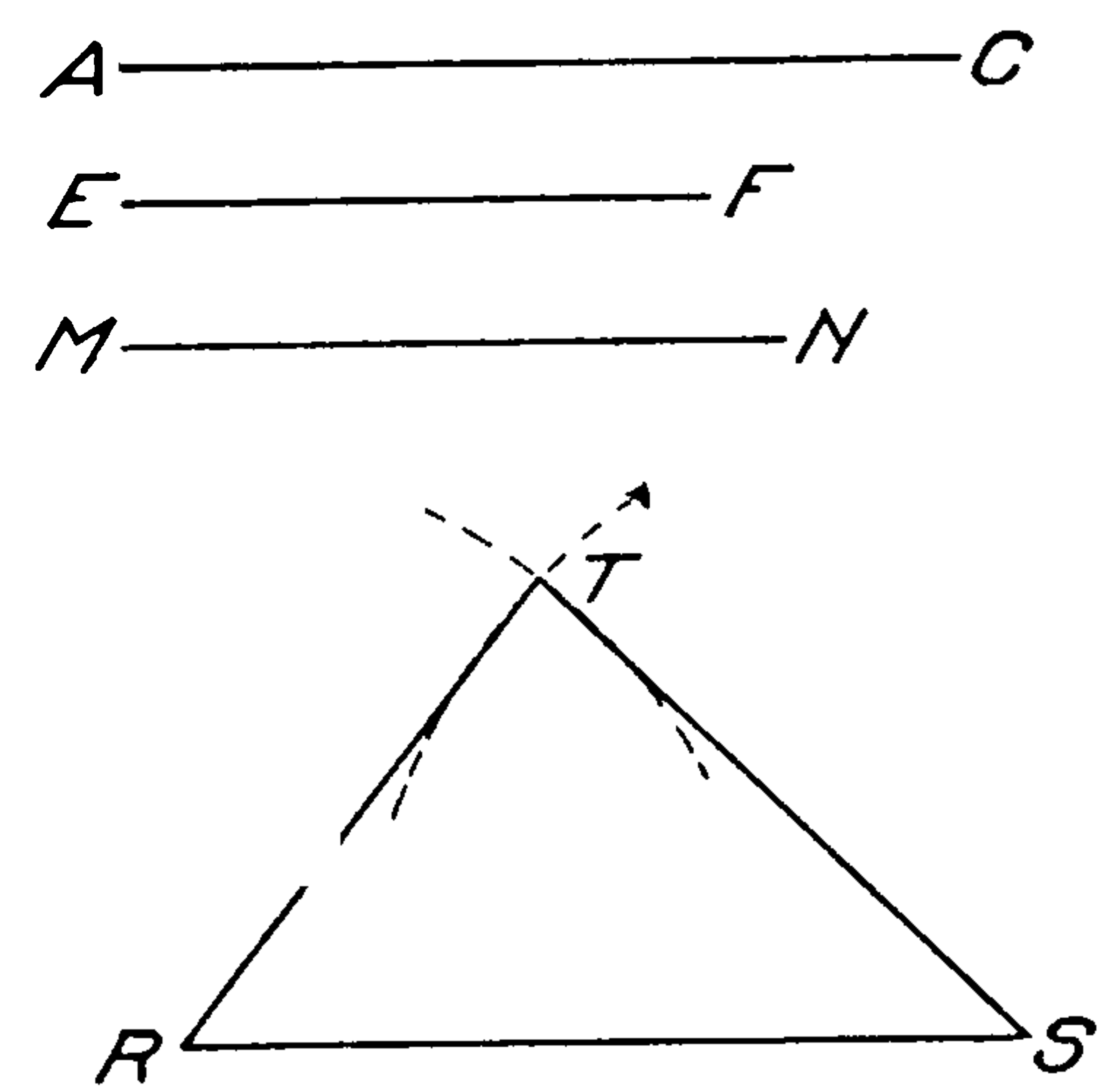
Problem 8



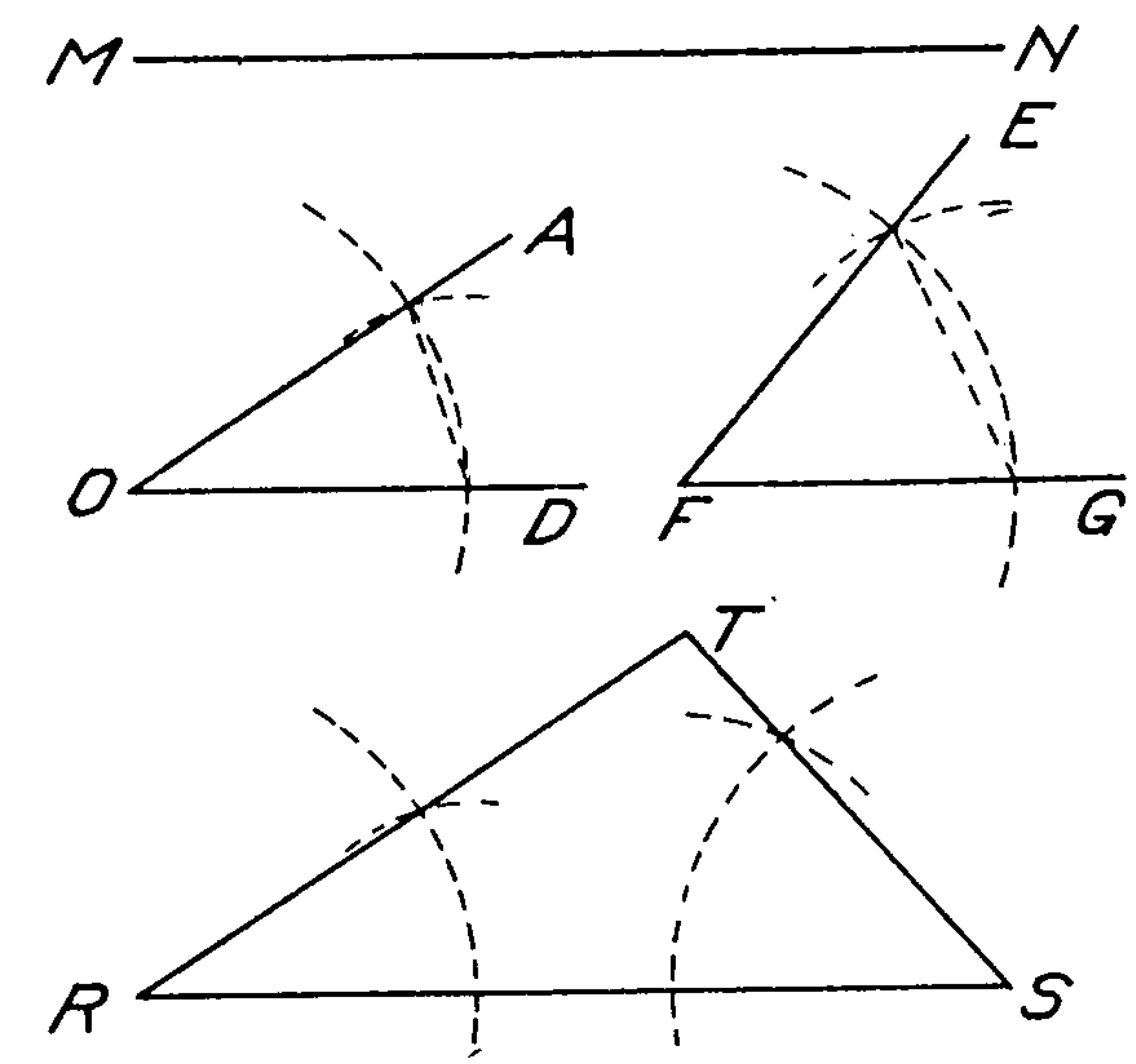
Problem 9



Problem 10



Problem 1



Problem 12

After inking the figures, ink in the heavy border line, and the lettering.

PLATE V

Penciling. In laying out the border lines and center lines follow the directions given for *Plate IV*. Draw the dot and dash lines in the same manner, as there are to be six problems on this plate.

Problem 7. *To draw a perpendicular to a line from a point without the line.*

Draw the straight line *A C* about $3\frac{1}{4}$ inches long, and assume the point *P* about $1\frac{1}{2}$ inches above the line. With *P* as a center and any convenient radius—about 2 inches—describe an arc cutting *A C* at *E* and *F*. The radius of this arc must always be such that it will cut *A C* in two points; the nearer the points *E* and *F* are to *A* and *C*, the greater will be the accuracy of the work.

Now with *E* and *F* as centers and any convenient radius—about $2\frac{1}{4}$ inches—draw the arcs intersecting below *A C* at *T*. A line through the points *P* and *T* will be perpendicular to *A C*. In case there is not room below *A C* to draw the arcs, they may be drawn intersecting above the line as shown at *N*. Whenever convenient draw the arcs below *A C* for greater accuracy.

Proof. Since *P* and *T* are both equally distant from *E* and *F*, the line *P T* is perpendicular to *A C*.

Problems 8 and 9. *To bisect a given angle.*

First Method. WHEN THE SIDES INTERSECT.

Draw the lines *O C* and *O A*—about 3 inches long—forming any angle of 45 to 60 degrees. With *O* as a center and any convenient radius—about 2 inches—draw an arc intersecting the sides of the angle at *E* and *F*. With *E* and *F* as centers and a radius of $1\frac{1}{2}$ or $1\frac{3}{4}$ inches, describe short arcs intersecting at *I*. A line *O D*, drawn through the points *O* and *I*, bisects the angle.

In solving this problem the arc *E F* should not be too near the vertex if accuracy is desired.

Proof. The central angles *A O D* and *D O C* are equal because the arc *E F* is bisected by the line *O D*. The point *I* is equally distant from *E* and *F*.

Second Method. WHEN THE LINES DO NOT INTERSECT.

Draw the lines *A C* and *E F* about 4 inches long making an angle approximately as shown. Draw $A' C'$ and $E' F'$ parallel to $A C$ and $E F$ and at such equal distances from them that they will intersect at O. Now bisect the angle $C' O F'$ by the method given in Problem 8. The line $O R$ bisects the given angle.

Proof. Since $A' C'$ is parallel to $A C$ and $E' F'$ is parallel to $E F$, the angle $C' O F'$ is equal to the angle formed by the lines $A C$ and $E F$. Hence as $O R$ bisects angle $C' O F'$ it also bisects the angle formed by the lines $A C$ and $E F$.

Problem 10. *To divide a line into any number of equal parts.*

Let $A C$—about $3\frac{3}{4}$ inches long—be a given line. Suppose it is desired to divide it into 7 equal parts. First draw the line $A J$ at least 4 inches long, forming any convenient angle with $A C$. On $A J$ lay off, by means of the dividers or scale, points D, E, F, G, etc., each $\frac{1}{2}$ inch apart. (If dividers are used, the spaces need not be exactly $\frac{1}{2}$ inch.) Draw the line $J C$ and through the points D, E, F, G, etc., draw lines parallel to $J C$. These parallels will divide the line $A C$ into 7 equal parts.

Proof. If a series of parallel lines, cutting two straight lines, intercept equal distances on one of these lines, they also intercept equal distances on the other.

Problem 11. *To construct a triangle having given the three sides.*

Draw the three sides, $A C$, $2\frac{3}{4}$ inches long; $E F$, $1\frac{15}{16}$ inches long; and $M N$, $2\frac{3}{16}$ inches long.

Draw $R S$ equal in length to $A C$. With R as a center and a radius equal to $E F$ describe an arc. With S as a center and a radius equal to $M N$ draw an arc cutting the arc previously drawn, at T. Connect T with R and S to form the triangle.

Problem 12. *To construct a triangle having given one side and the two adjacent angles.*

Draw the line $M N$ $3\frac{1}{4}$ inches long and draw two angles $A O D$ and $E F G$ about 30 degrees and 60 degrees respectively.

Draw $R S$ equal in length to $M N$ and with R as a vertex and $R S$ as one side construct an angle equal to $A O D$. In a similar manner construct at S an angle equal to $E F G$. Draw lines from R and S through the two established points until they meet at T. The triangle $R T S$ will be the required triangle.

Lettering. Draw the pencil lines and put in the lettering as in plates already drawn.

Inking. In inking *Plate V,* follow the principles previously used and do not make certain lines dotted until sure that they should be dotted.

After inking the figures, ink in the border lines and the lettering as already explained.

PLATE VI

Penciling. Lay out this plate in the same manner as the preceding plates.

Problem 13. *To describe an arc or circumference through three given points not in the same straight line.*

Locate the three points *A, B,* and *C* with a distance between *A* and *B* of about 2 inches and a distance between *A* and *C* of about $2\frac{1}{4}$ inches. Connect *A* and *B* and *A* and *C.* Erect perpendiculars to the middle points of *A B* and *A C* as explained in Problem 1. Now draw light pencil lines connecting the intersections *I* and *J* and *E* and *F.* These lines will intersect at *O.*

With *O* as a center and a radius equal to the distance *O A,* describe the circumference passing through *A, B,* and *C.*

Proof. The point *O* is equally distant from *A, B,* and *C,* since it lies in the perpendiculars to the middle points of *A B* and *A C.* Hence the circumference will pass through *A, B,* and *C.*

Problem 14. *To inscribe a circle in a given triangle.*

Draw the triangle *L M N* of any convenient size. *M N* may be made $3\frac{1}{4}$ inches, *L M,* $2\frac{3}{4}$ inches, and *L N,* $3\frac{1}{2}$ inches. Bisect the angles *M L N* and *L M N* by the method used in Problem 8. The bisectors *M I* and *L J* intersect at *O,* which is the center of the inscribed circle. The radius of the circle is equal to the perpendicular distance from *O* to one of the sides.

Proof. The point of intersection of the bisectors of the angles of a triangle is equally distant from the sides.

Problem 15. *To inscribe a regular pentagon in a given circle.*

With *O* as a center and a radius of about $1\frac{1}{2}$ inches, describe the given circle. With the T-square and triangles draw the center lines *A C* and *E F* perpendicular to each other and passing through *O.* Bisect one of the *radii, O C,* at *H* and with this point as a center and a radius *H E,* describe the arc *E P.* This arc cuts the diameter *A C* at *P.* With *E* as a center and a radius *E P,* draw arcs cutting the circumference at *L* and *Q*. With the same radius and centers at *L* and *Q*, draw the arcs cutting the circumference at *M* and *N*.

The pentagon is completed by drawing the chords *E L*, *L M*, *M N*, *N Q*, and *Q E*.

Problem 16. *To inscribe a regular hexagon in a given circle.*

With *O* as a center and a radius of $1\frac{3}{8}$ inches draw the given circle. With the T-square draw the diameter *A D*. With *D* as a center, and a radius equal to *O D*, describe arcs cutting the circumference at *C* and *E*. Now with *C* and *E* as centers and the same radius, draw the arcs, cutting the circumference at *B* and *F*. Draw the hexagon by joining the points thus formed.

Therefore, in order to inscribe a regular hexagon in a circle, mark off chords equal in length to the radius.

To inscribe an equilateral triangle in a circle the same method may be used, the triangle being formed by joining the opposite vertices of the hexagon.

Proof. Since the triangle *O C D* is an equilateral triangle by construction, the angle *C O D* is one-third of two right angles and one-sixth of four right angles. Hence arc *C D* is one-sixth of the circumference and the chord is a side of a regular hexagon.

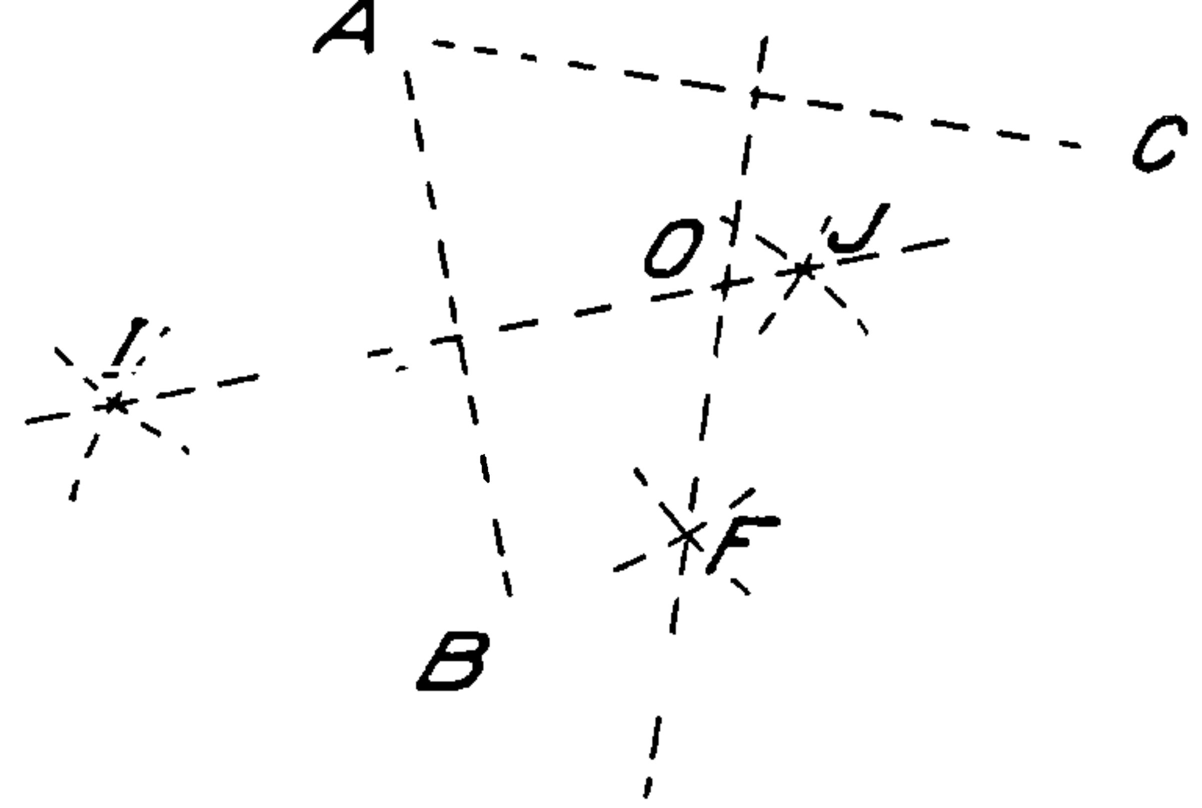
Problem 17. *To draw a line tangent to a circle at a given point on the circumference.*

With *O* as a center and a radius of about $1\frac{1}{4}$ inches draw the given circle. Assume some point *P* on the circumference and join the point *P* with the center *O*. By the method given in Problem 6, *Plate IV*, construct a perpendicular to *P O*, which perpendicular will be the desired tangent to the circle at the point *P*.

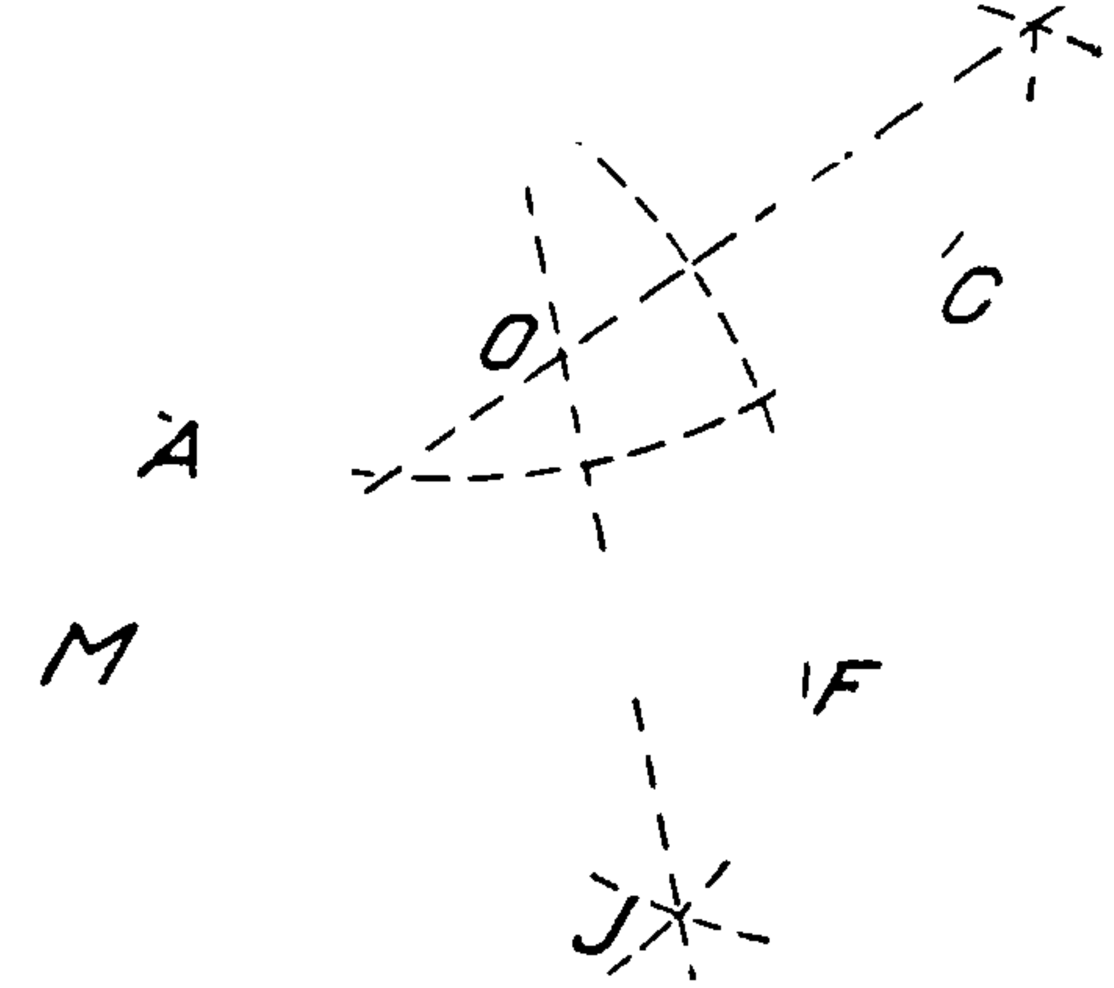
Proof. A line perpendicular to a radius at its extremity is tangent to the circle.

Problem 18. *To draw a line tangent to a circle from a point outside the circle.*

With *O* as a center and a radius of about 1 inch draw the given circle. Assume *P* some point outside of the circle about $2\frac{1}{2}$ inches from the center. Draw a straight line passing through *P* and *O*. Bisect *P O* and with the middle point *F* as a center describe the circle passing through *P* and *O*. Draw a line from *P* through the intersection of the two circumferences *C*. The line *P C* is tangent to the given circle. Similarly *P E* is tangent to the circle.



Problem 13



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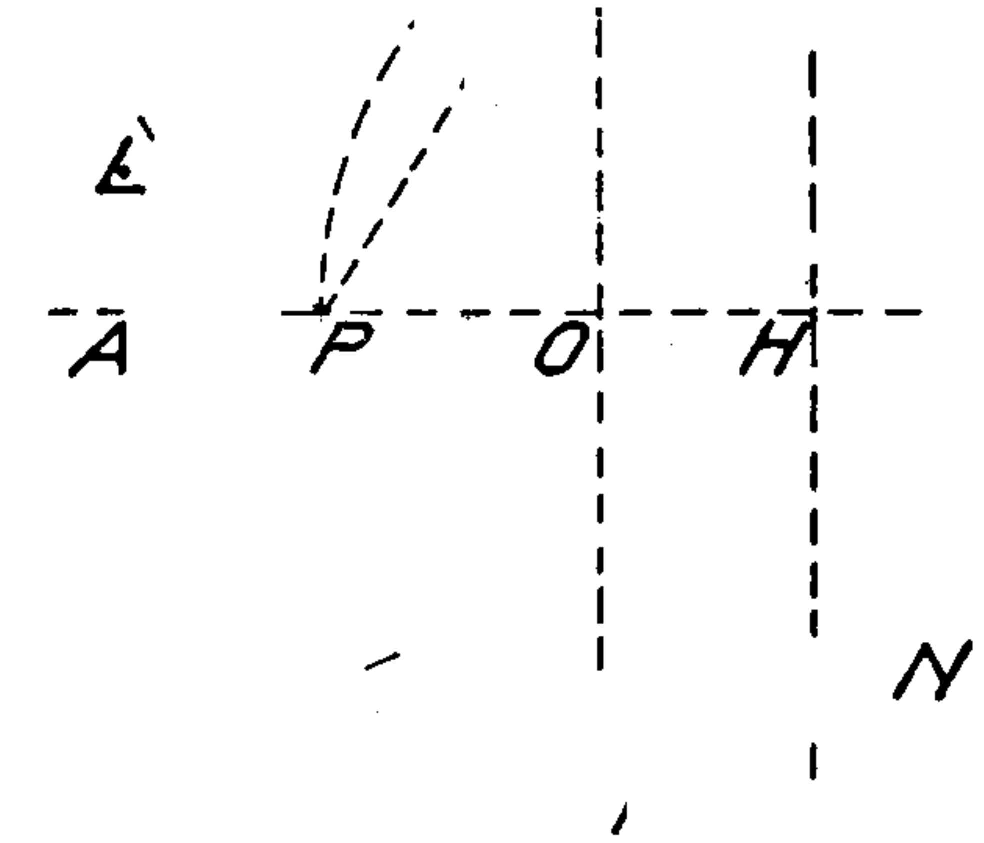
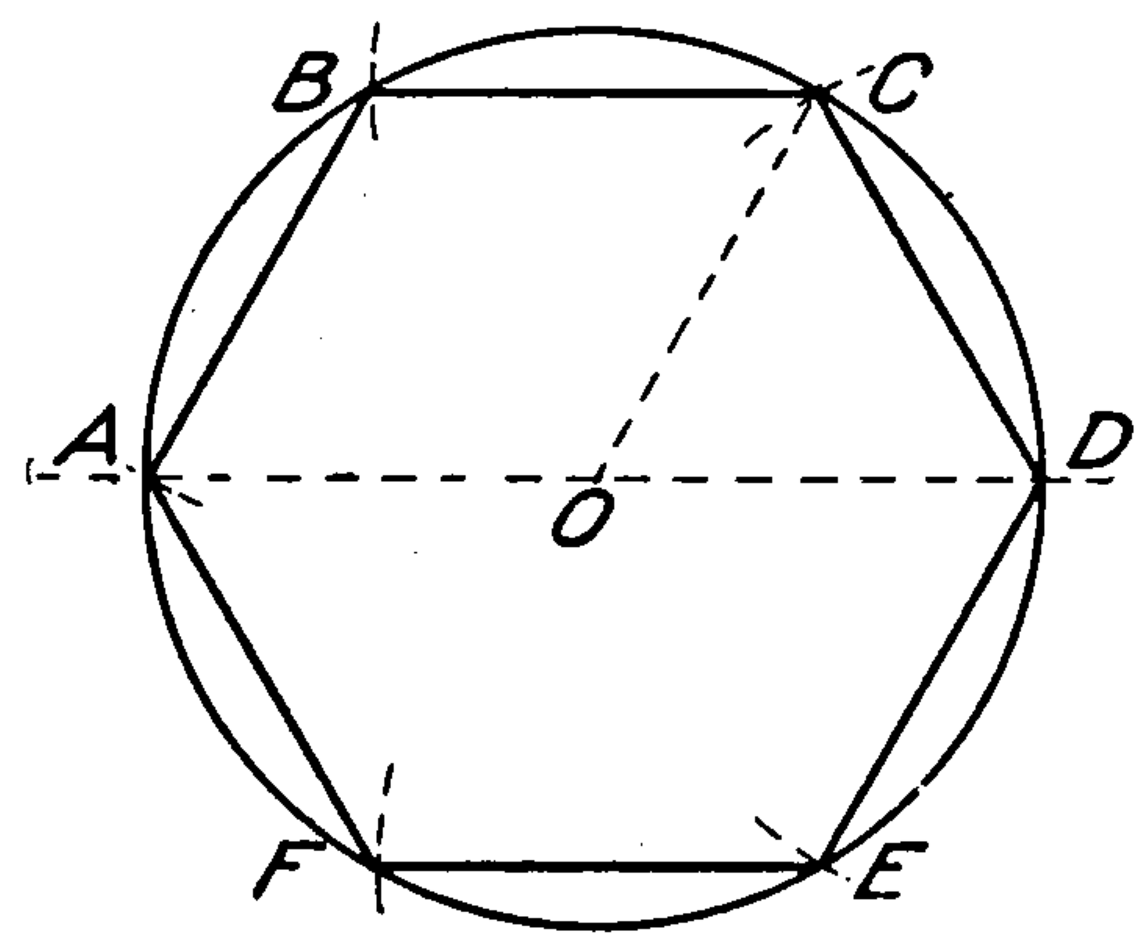
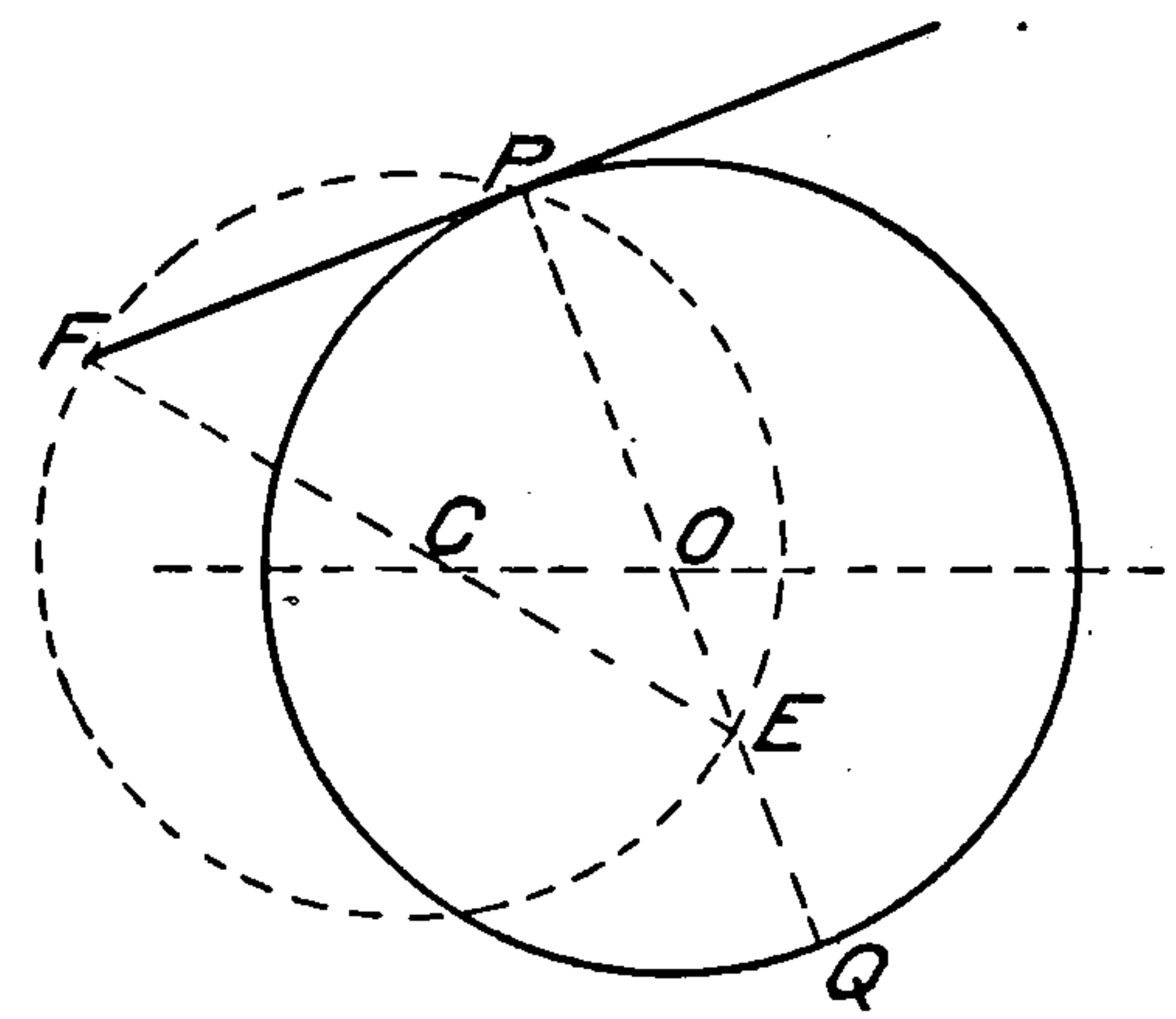


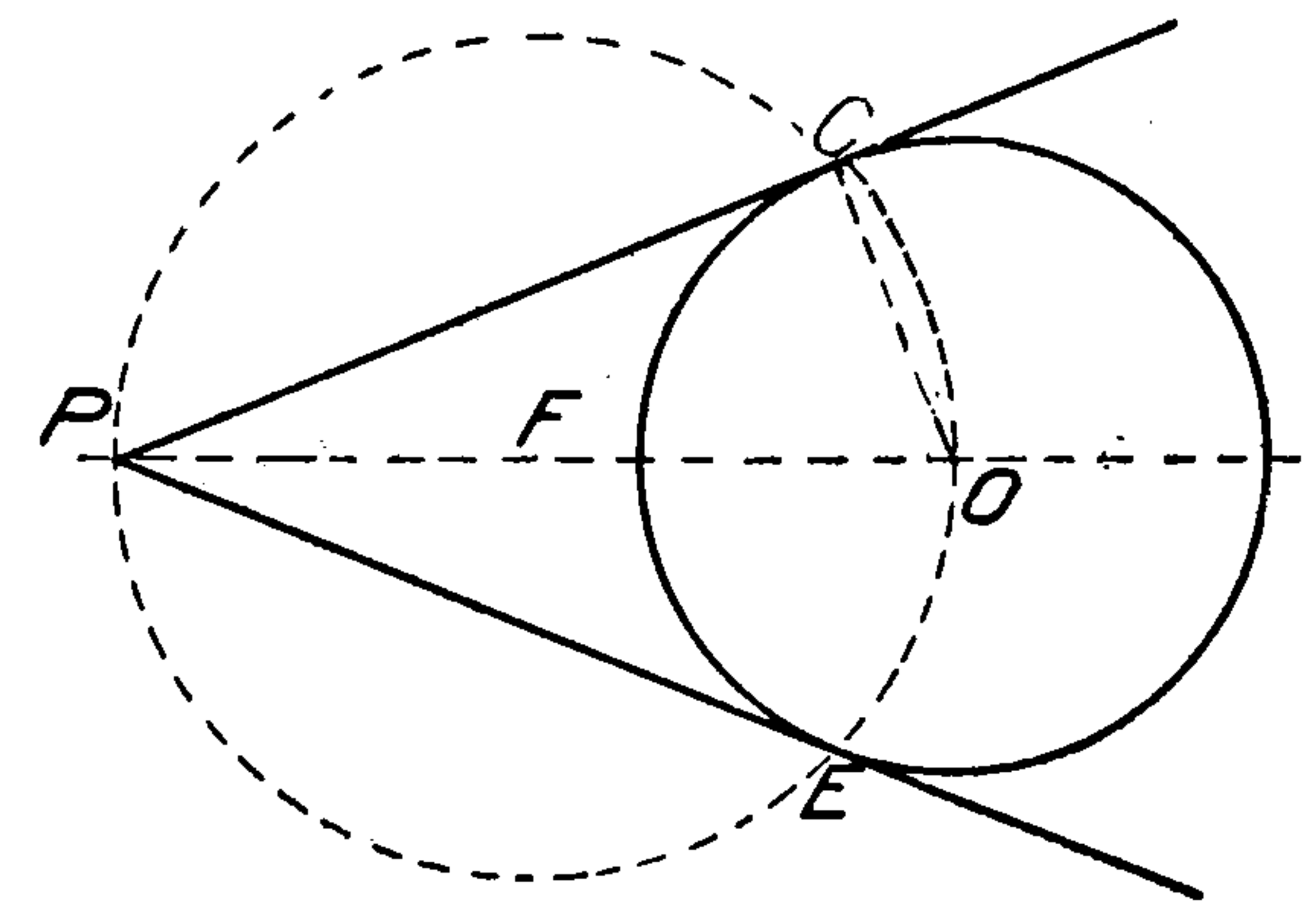
Problem 15



Problem 16



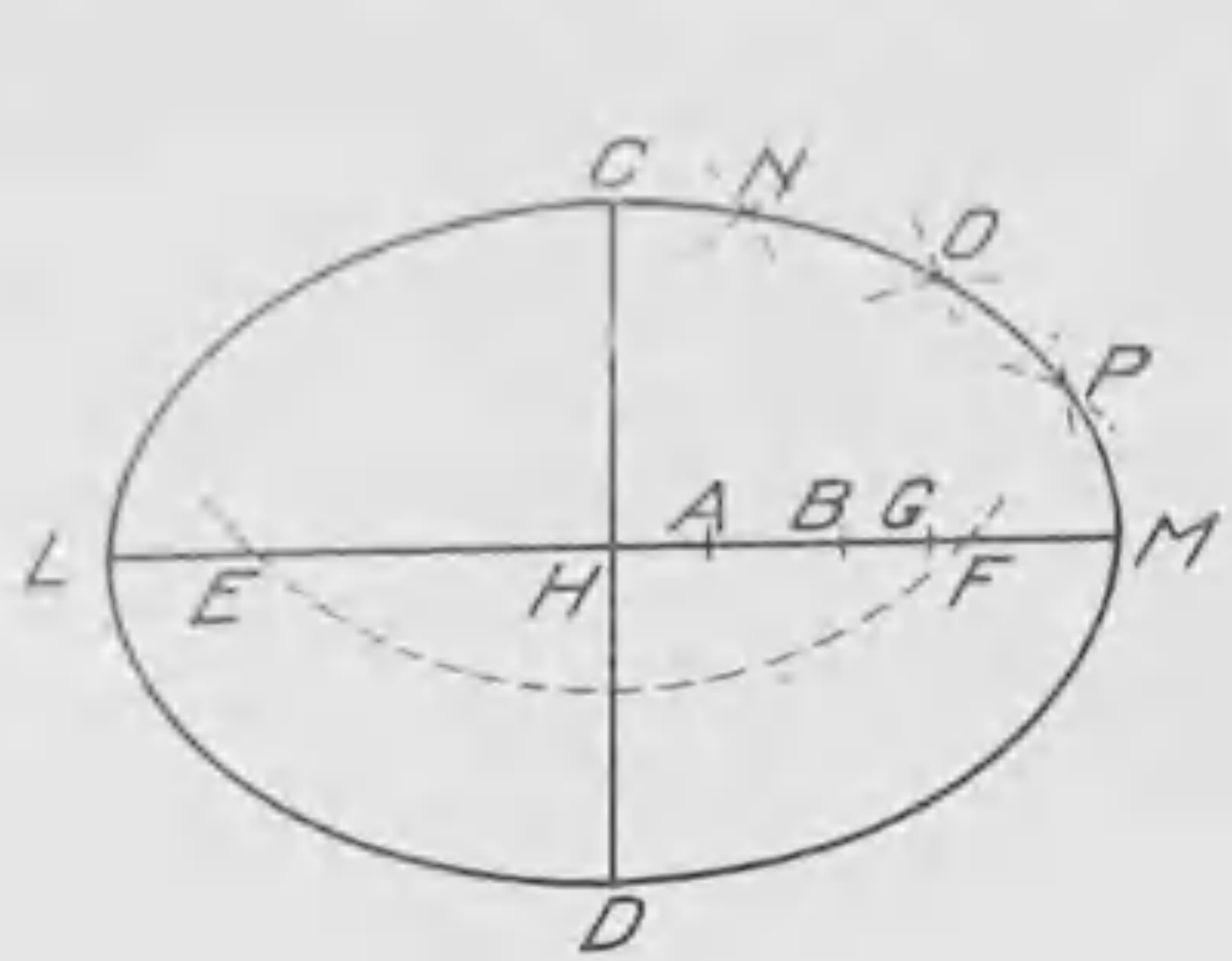
Problem 17



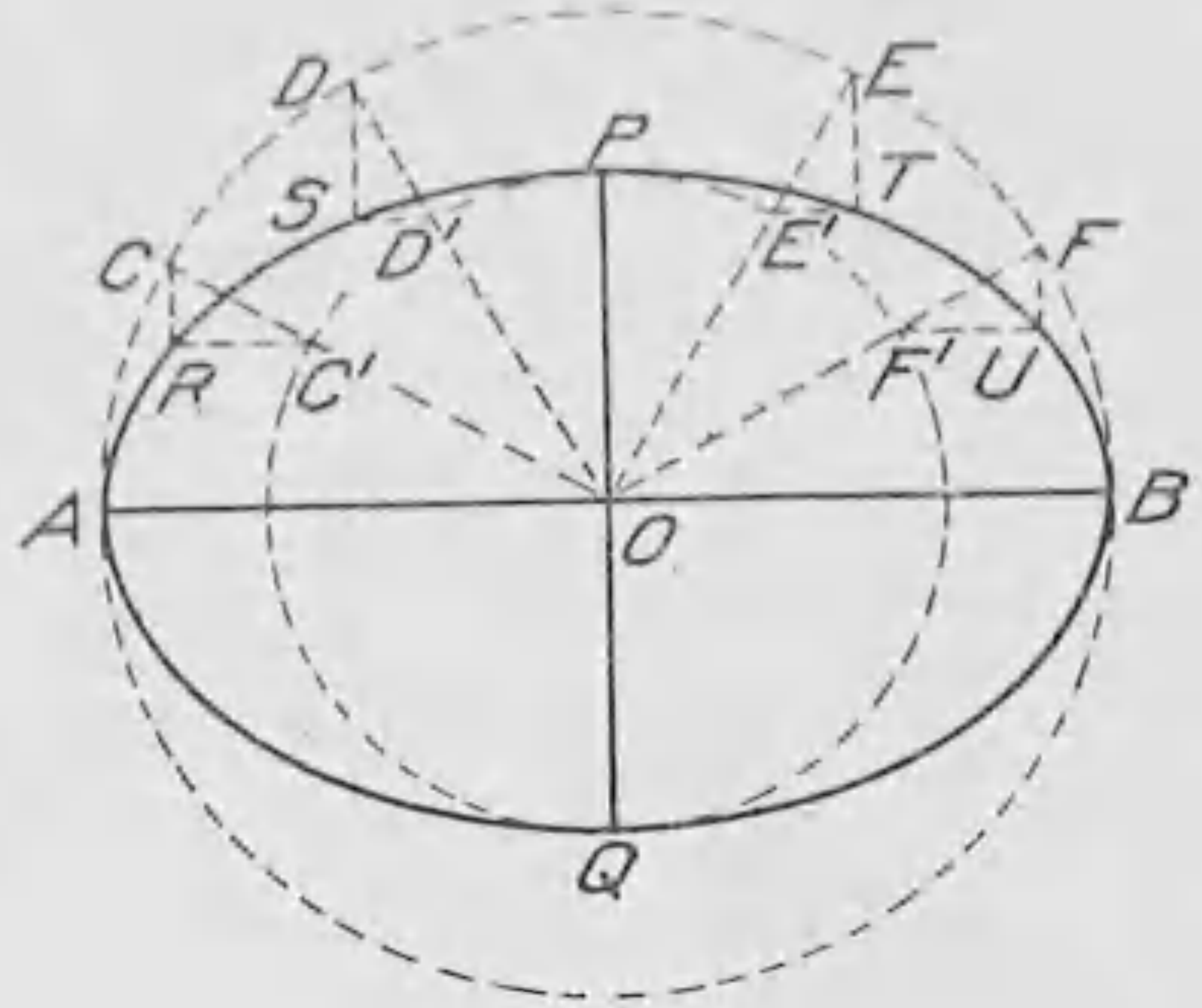
Problem 18

JANUARY 29, 1910. HERBERT CHANDLER, CHICAGO, ILL.

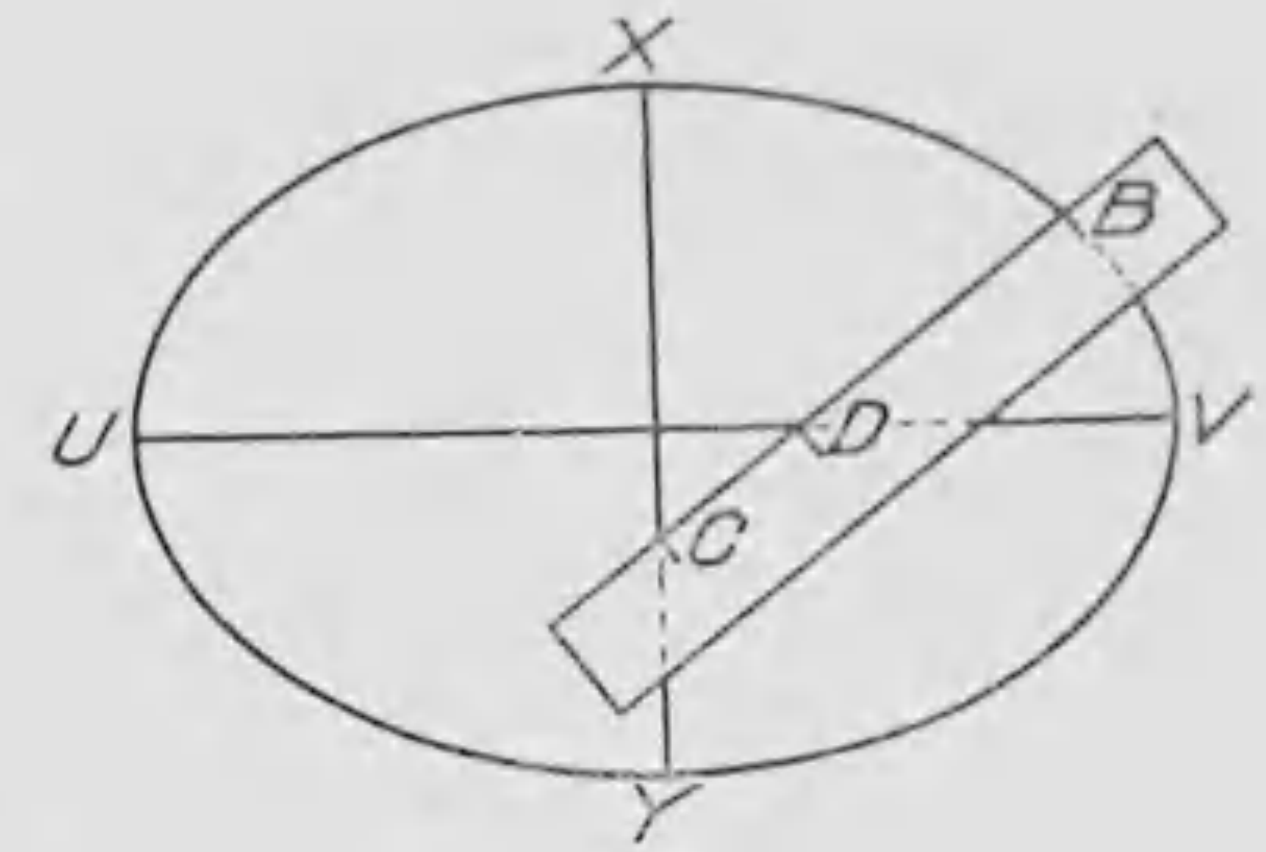
PLATE VII



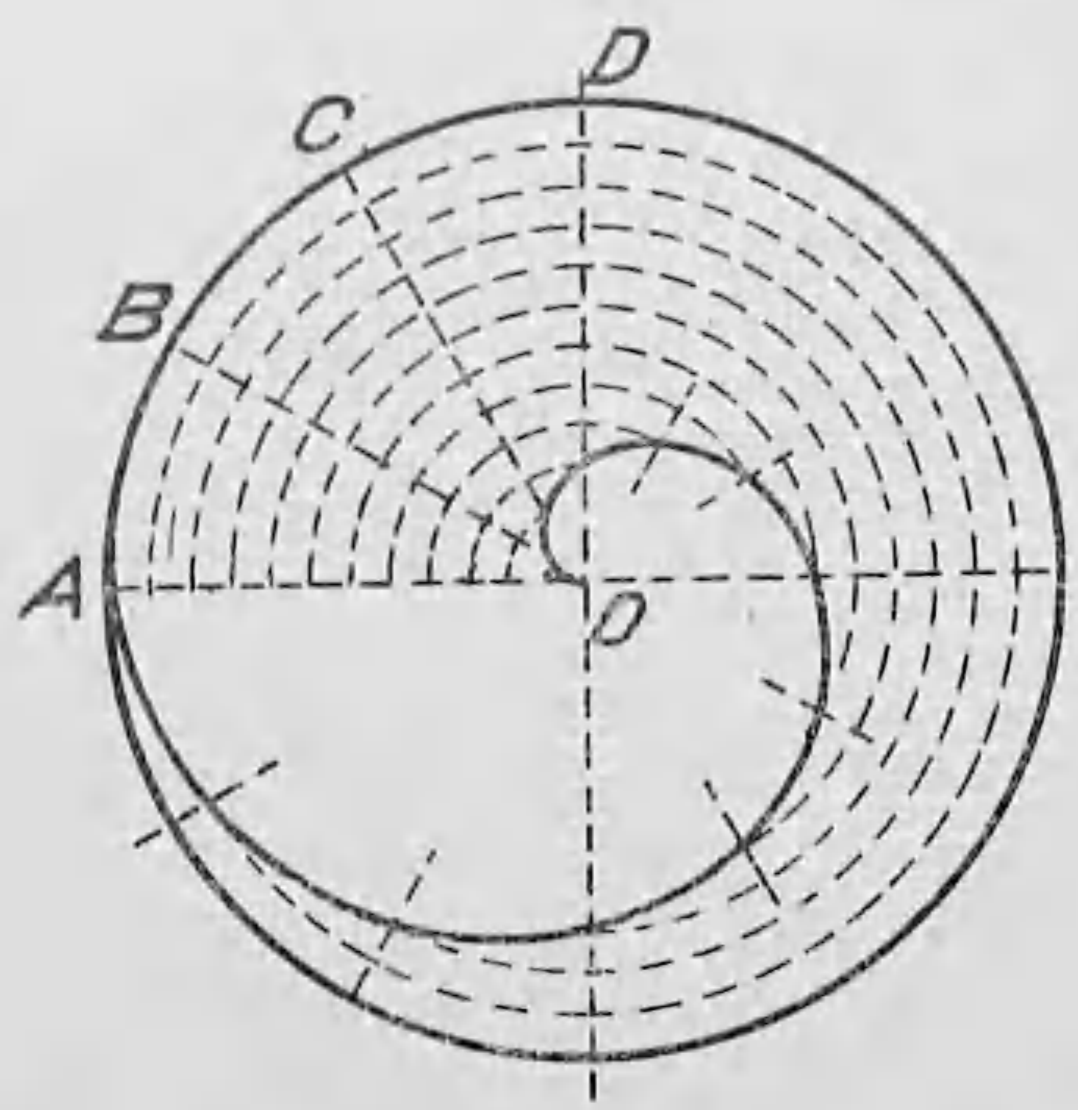
Problem 19



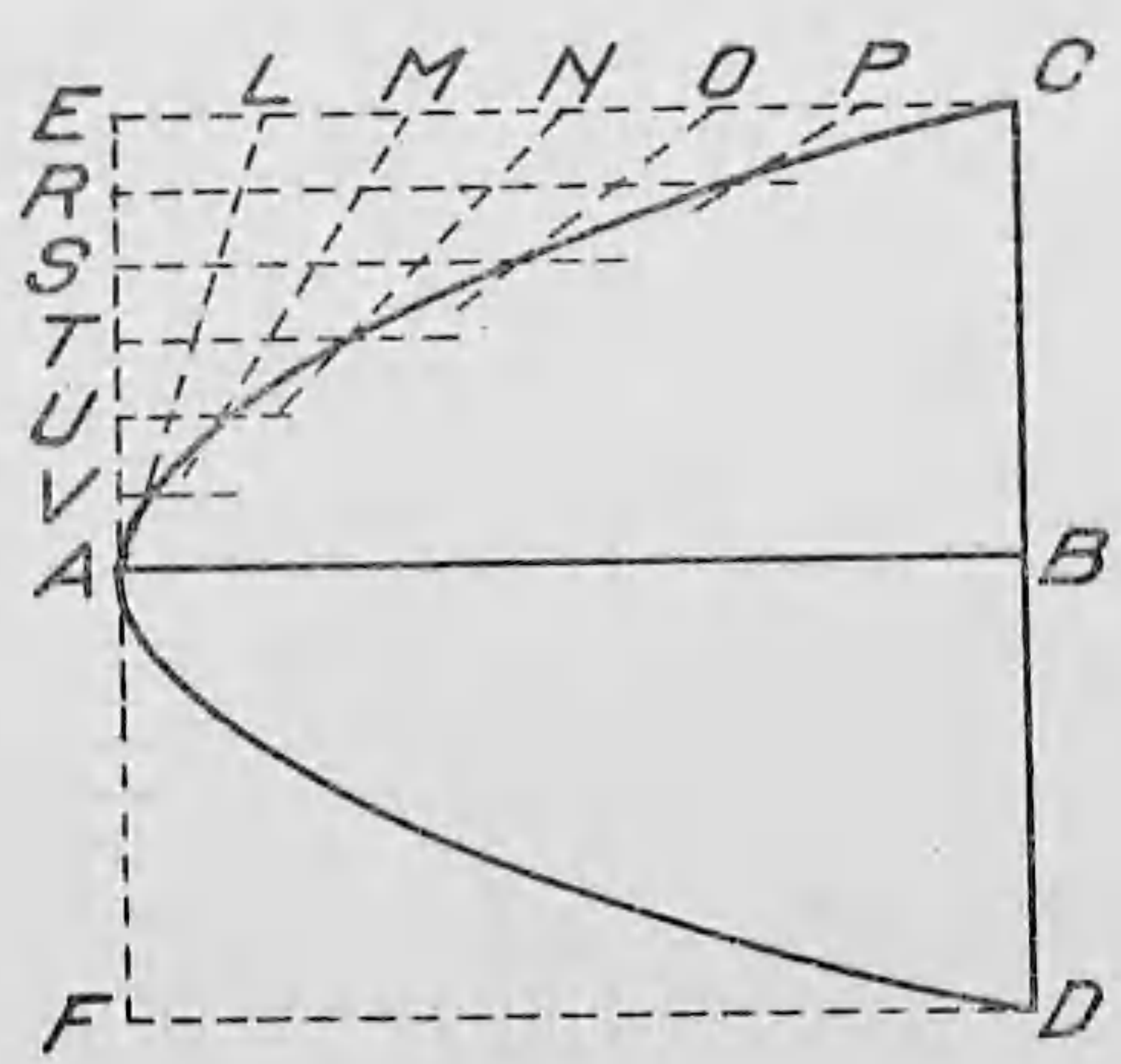
Problem 20



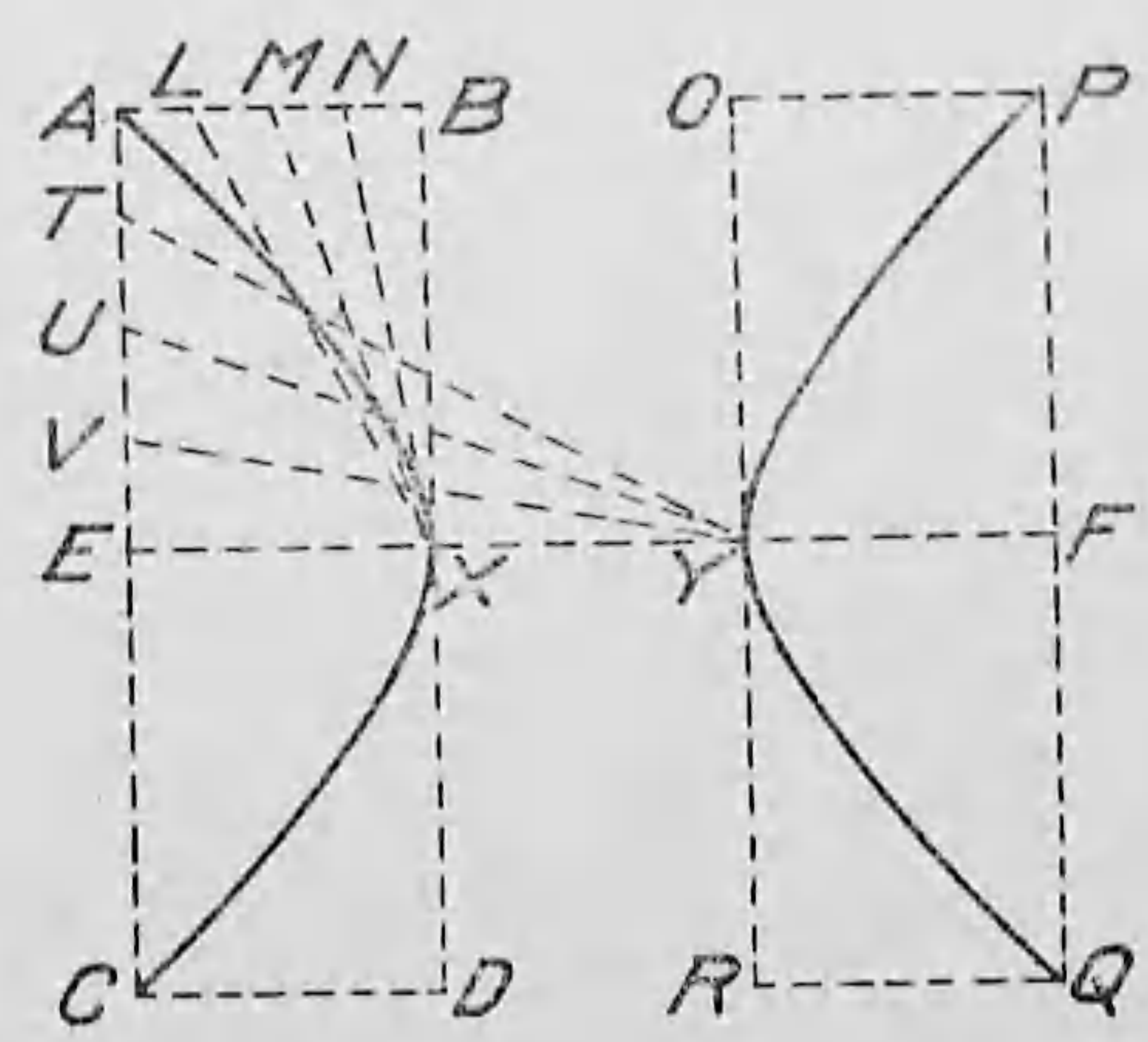
Problem 21



Problem 22



Problem 23



Problem 24

the small circle, draw *horizontal* lines The intersections of these lines are points on the ellipse.

Draw a free-hand curve passing through these points; about five points in each quadrant will be sufficient.

Problem **21.** *To draw an ellipse by means of a trammel.*

As in Problems 19 and 20, draw the major and minor axes, *U V* and *X Y*. Take a slip of paper having a straight edge and mark off *C B* equal to one-half the major axis, and *D B* equal to one-half the minor axis. Place the slip of paper in various positions keeping the point *D* on the major axis and the point *C* on the minor axis. If this is done, the point *B* will mark various points on the curve. Find as many points as necessary and sketch the ellipse.

Problem **22.** *To draw a spiral of one turn in a circle.*

Draw a circle with the center at *O* and a radius of $1\frac{1}{2}$ inches. Locate twelve points, $\frac{1}{8}$ inch apart on the radius *O A* and draw circles through these points. Now, by means of the 30-degree triangle, draw radii *O B, O C, O D,* etc., 30 degrees apart, thus dividing the circle into 12 equal parts.

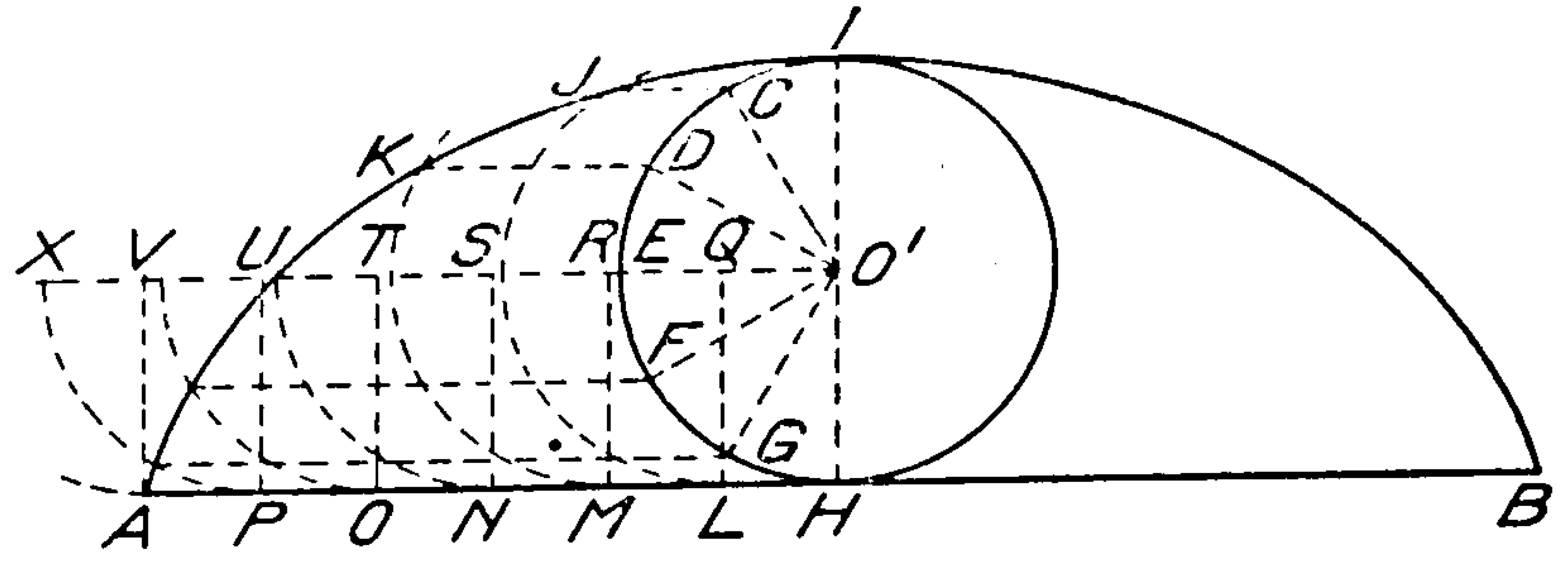
The points on the spiral are now located; the first is at the center *O;* the next is at the intersection of the line *O B* and the first circle; the third is at the intersection of *O C* and the second circle; the other points are located in the same way. Sketch in pencil a smooth curve passing through these points.

Problem **23.** *To draw a parabola when the abscissa and ordinate are given.*

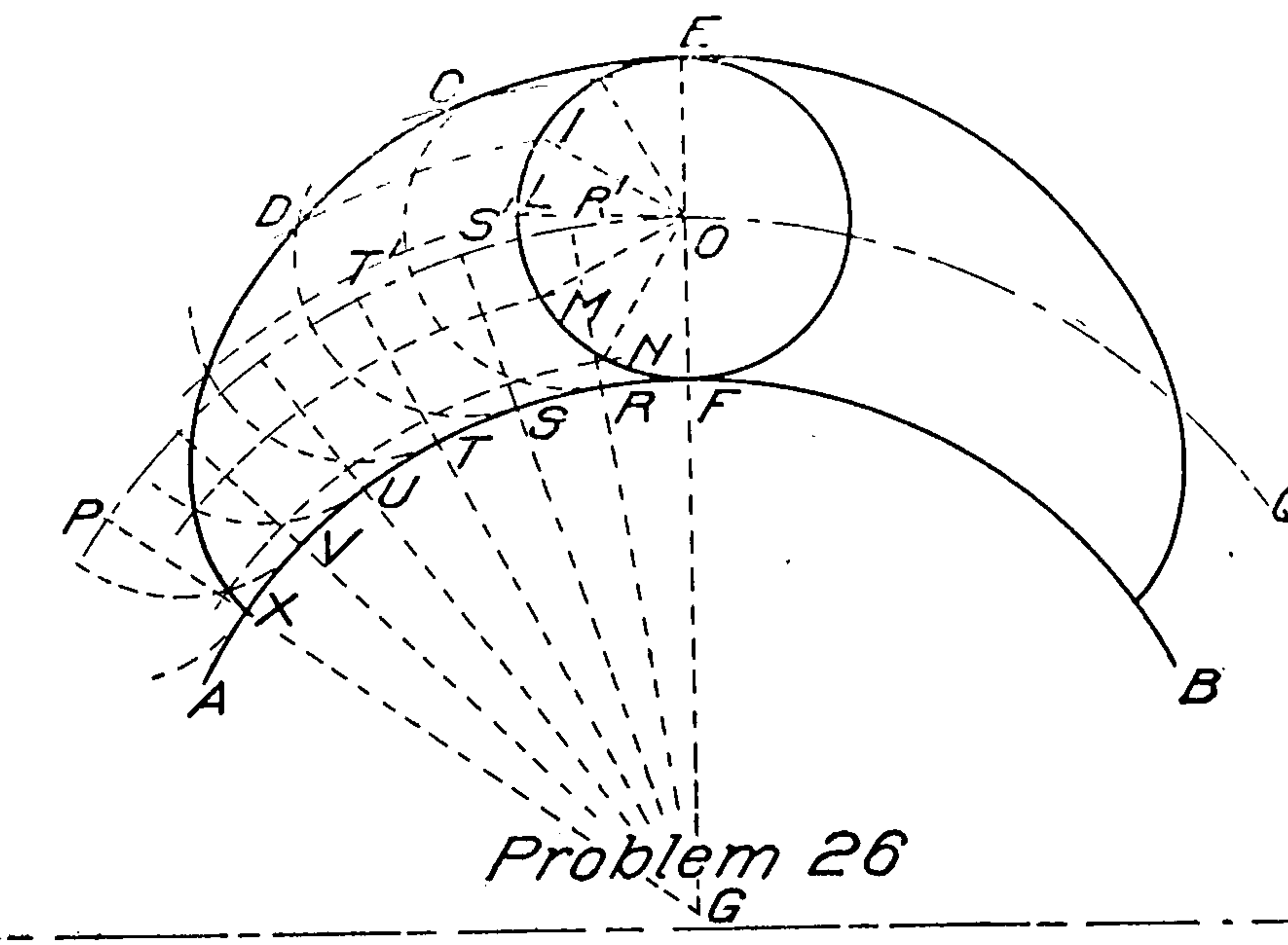
Draw the straight line *A B*—about three inches long—as the axis, or *abscissa* of the parabola. At *A* and *B* draw the lines *C D* and *E F* perpendicular to *A B,* and with the T-square draw *E C* and *F D,* $1\frac{1}{2}$ inches above and below *A B,* respectively. Let *A* be the vertex of the parabola. Divide *A E* and *E C* into the same number of equal parts. Through *R, S, T, U,* and *V,* draw horizontal lines and connect *L, M, N, O,* and *P,* with *A.* The intersections of the horizontal lines with the oblique lines are points on the curve. For instance, the intersection of *A L* and the line *V* is one point and the intersection of *A M* and the line *U* is another.

The lower part of the curve *A D* is drawn in a similar manner.

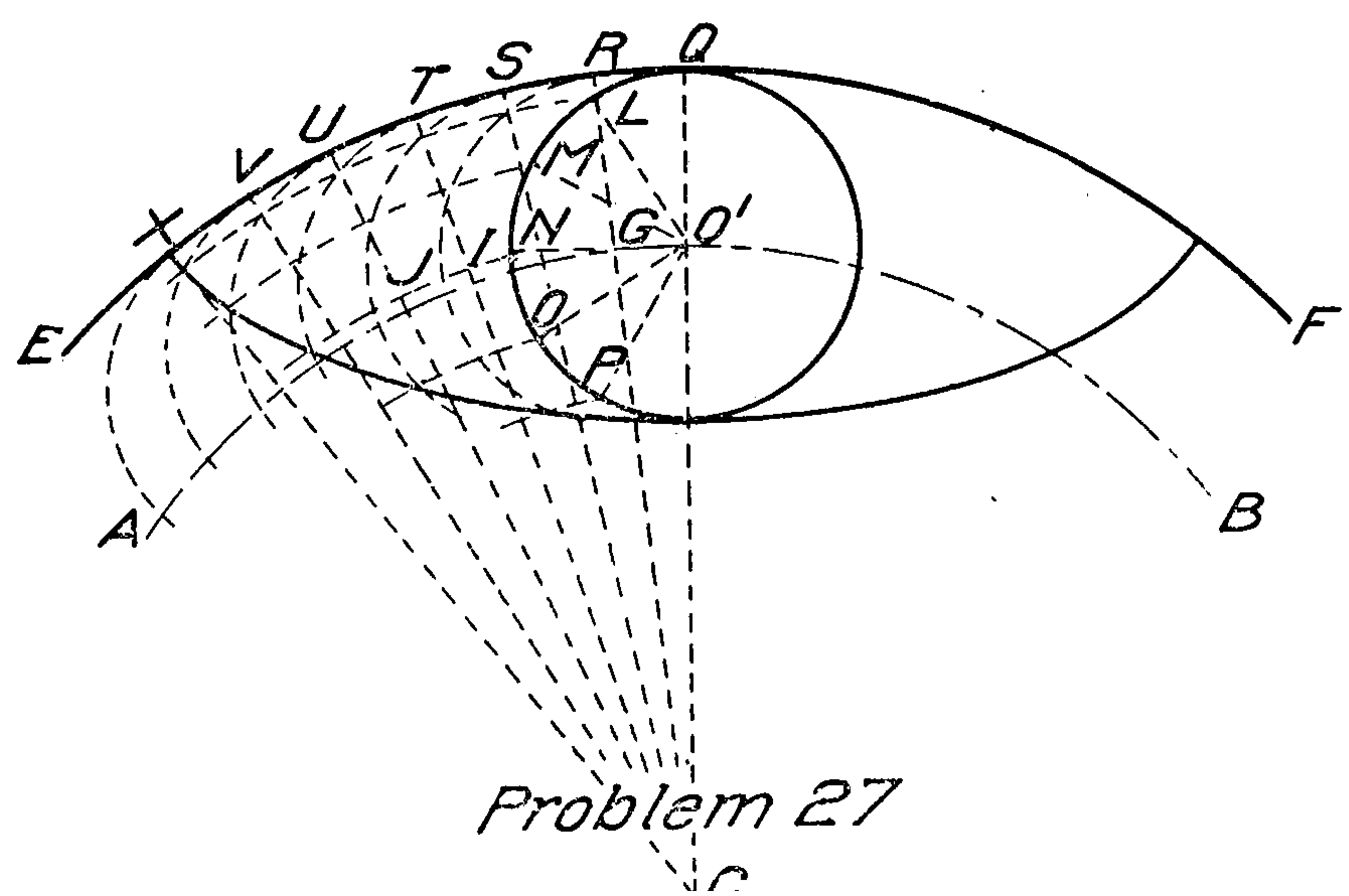
Problem **24.** *To draw a hyperbola when the abscissa E X, the ordinate A E, and the diameter X Y are given.*



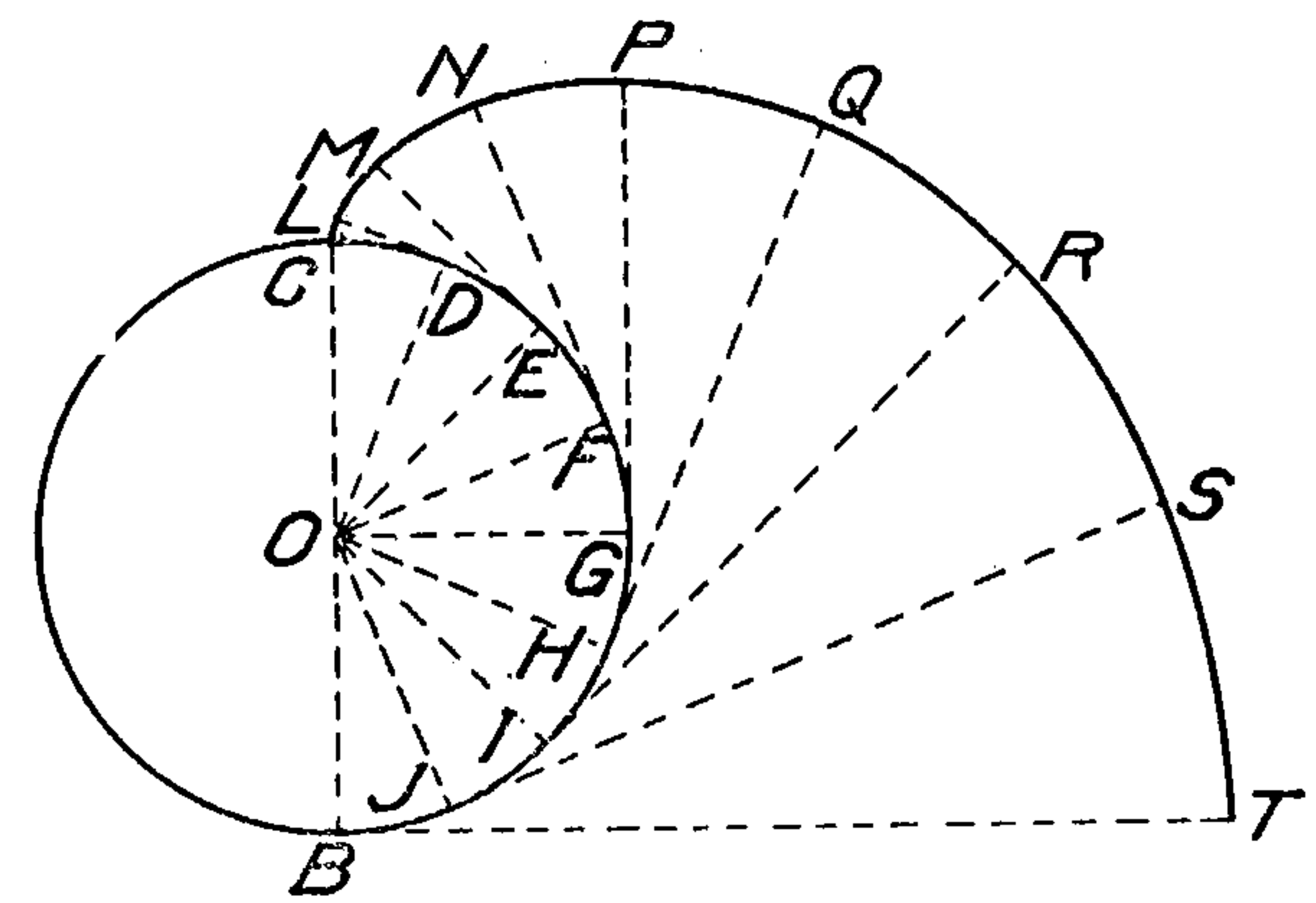
Problem 25



Problem 26



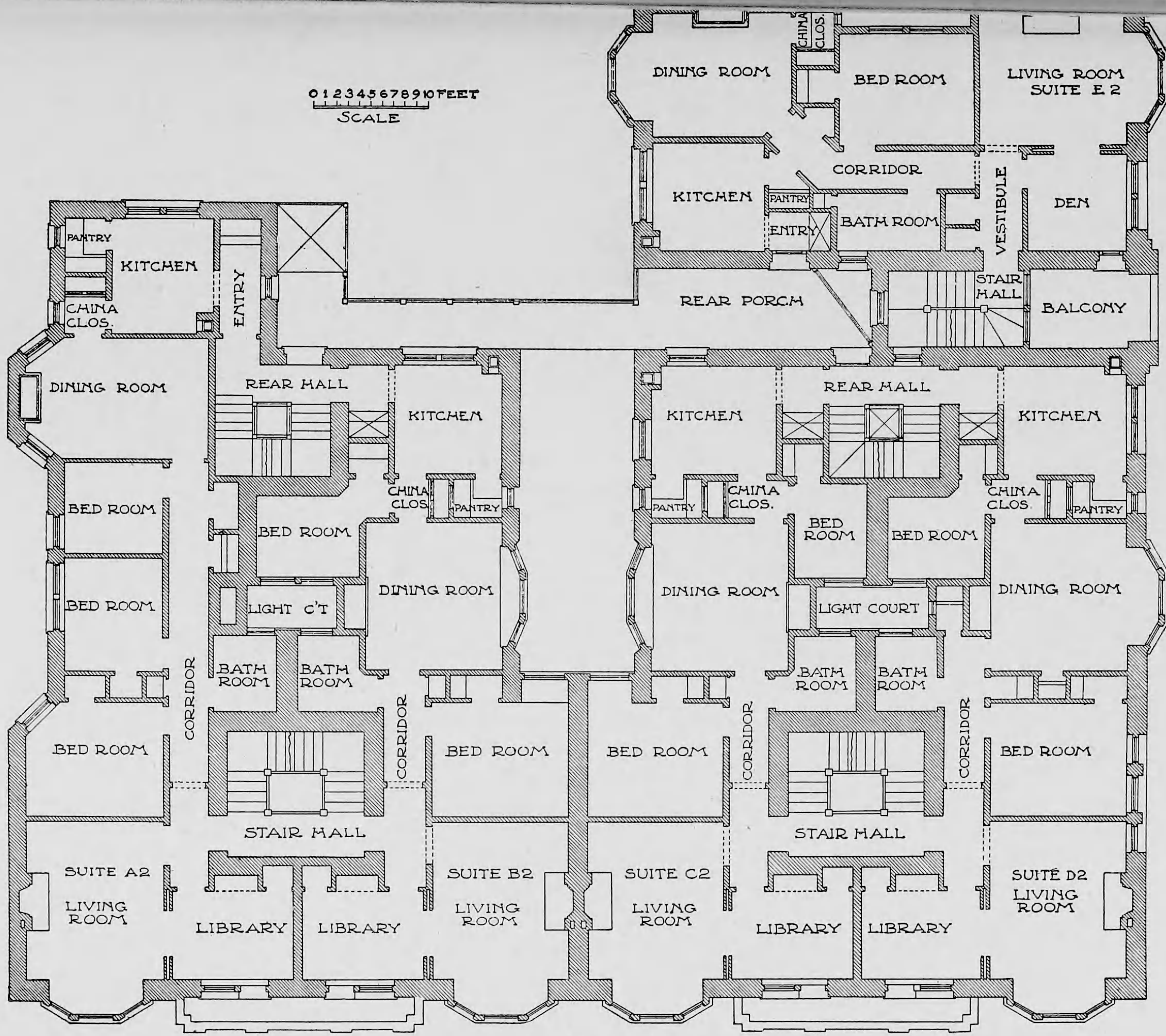
Problem 27



Problem 28

MARLBORO FLAT BUILDING, MILWAUKEE, WIS.

MARLBORO FLAT BUILDING, MILWAUKEE, WIS.
Fernekes & Cramer, Architects, Milwaukee, Wis.
Walls of Continental Paving Brick; Entrances and all Stonework of Bedford Stone; Cornice of Galvanized Iron; Balconies of Wrought
Composition Roof. All Public Halls and All Living Rooms...



SECOND-STORY PLAN OF MARLBORO FLAT BUILDING, MILWAUKEE, WIS.
Fernekes & Cramer, Architects, Milwaukee, Wis.
Exterior View Shown on Opposite Page.

these arcs and the horizontal lines drawn through the points *C, D, E, F,* etc. Thus the intersection of the arc whose center is *Q* and the horizontal line through *C* is a point *I* on the curve. Similarly, the intersection of the arc whose center is *R* and the horizontal line through *D* is the point *J* on the curve. The remaining points on the left, as well as those on the right, are found in the same manner. To obtain great accuracy in this curve, the circle should be divided into a large number of equal parts, because the greater the number of divisions the less the error due to the difference in length between a chord and its arc.

Problem 26. *To construct an epicycloid when the diameter of the generating circle and the diameter of the director circle are given.*

The epicycloid and the hypocycloid may be drawn in the same manner as the cycloid if arcs of circles are used in place of the horizontal lines. With *O* as a center and a radius of $\frac{3}{4}$ inch describe a circle. Draw the diameter *E F* of this circle and produce *E F* to *G* such that the line *F G* is $2\frac{1}{4}$ inches long. With *G* as a center and a radius *F G*, describe the arc *A B* of the director circle. With the same center *G*, draw the arc *P Q* which will be the path of the center of the generating circle as it rolls along the arc *A B*. Now divide the generating circle into any number of equal parts—twelve for instance—and through the points of division *H, I, L, M,* and *N,* draw arcs having *G* as a center. With the dividers set so that the distance between the points is equal to the chord *H I*, mark off distances on the director circle *A F B*. Through these points of division *R, S, T, U,* etc., draw radii intersecting the arc *P Q* in the points *R′, S′, T′*, etc., and with these points as centers describe arcs of circles as in Problem 25. The intersections of these arcs with the arcs already drawn through the points *H, I, L, M,* etc., are points on the epicycloid. Thus the intersection of the circle whose center is *R′* with the arc drawn through the point *H* is a point upon the curve. Also the arc whose center is *S′* with the arc drawn through the point *I* is another point on the curve. The remaining points are found by repeating this process.

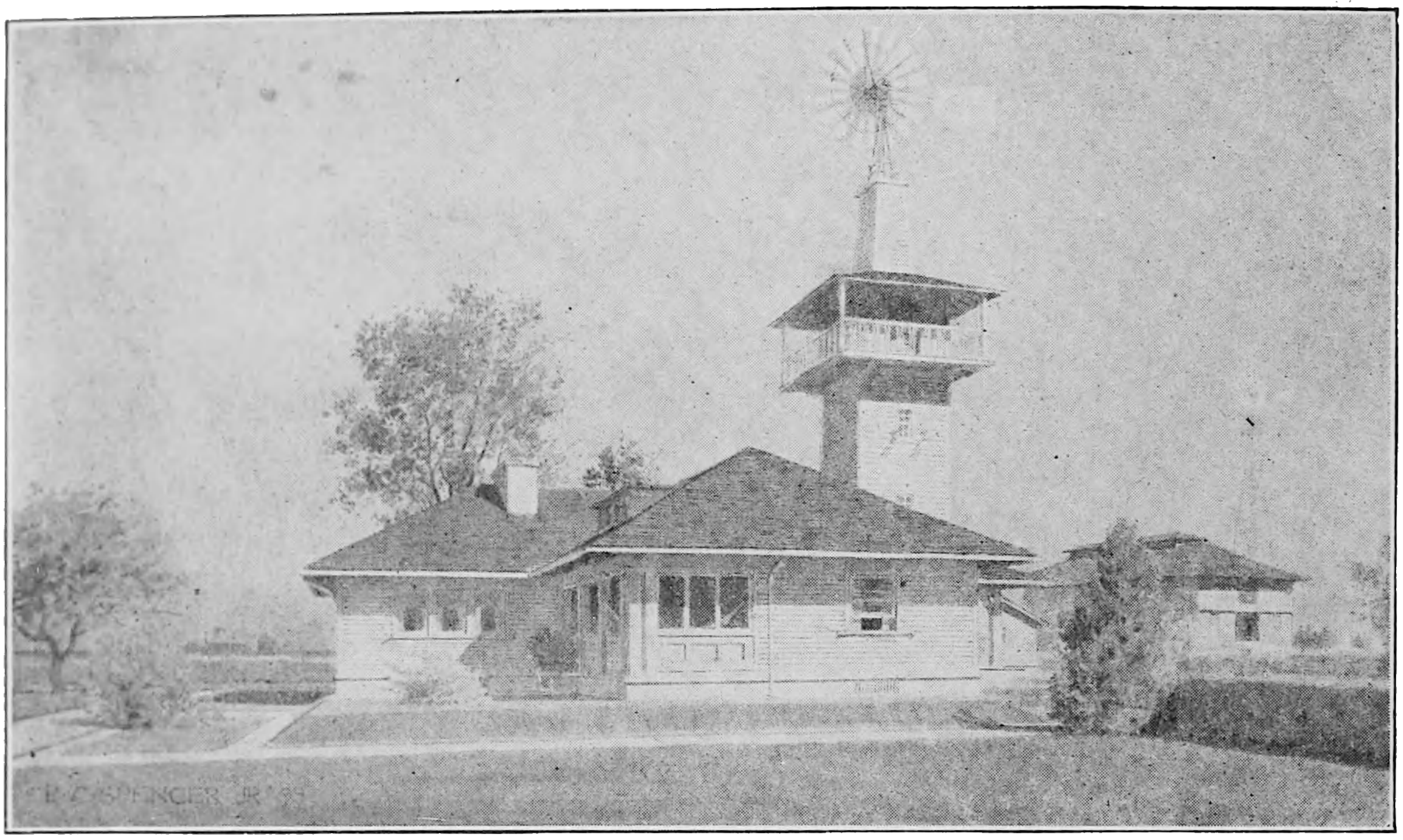
Problem 27. *To draw an hypocycloid when the diameter of the generating circle and the radius of the director circle are given.*

With *O* as a center and a radius of 4 inches describe the arc *E F*, which is the arc of the director circle. Now with the same center and a radius of $3\frac{1}{4}$ inches, describe the arc *A B*, which is the line of centers of the generating circle as it rolls on the director circle. With *O′* as a center and a radius of $\frac{3}{4}$ inch describe the generating circle. As before, divide the generating circle into any number of equal parts—12, for instance—and with these points of division *L, M, N, O*, etc., draw arcs having *C* as a center. Upon the arc *E F*, lay off distances *Q R, R S, S T*, etc., equal to the chord *Q L*. Draw radii from the points *R, S, T*, etc., to the center of the director circle *O* and describe arcs of circles having a radius equal to the radius of the generating circle, using the points *G, I, J*, etc., as centers. As in Problem 26, the intersections of the arcs are the points on the hypocycloid. By repeating this process, the right-hand portion of the curve may be drawn.

Problem 28. *To draw the involute of a circle when the diameter of the base circle is known.*

With the point *O* as a center and a radius of 1 inch, describe the base circle. Divide the circle into any number of equal parts—16, for instance—and draw radii to the points of division. At the point *D*, draw a light pencil line perpendicular to *O D*. This line will be tangent to the circle. Similarly at the points *E, F, G, H*, etc., draw tangents to the circle. Set the dividers so that the distance between the points will be equal to the chord of the arc *C D*, and measure this distance from *D* along the tangent. From the point *E*, measure on the tangent a distance equal to two of these chords; from the point *F*, three divisions; and from the point *G*, four divisions. Similarly, measure distances on the remaining tangents, each time adding the length of the chord. This will give the points *L, M, N, P*, etc., to *T*. The curve drawn through these points will be the involute of the circle.

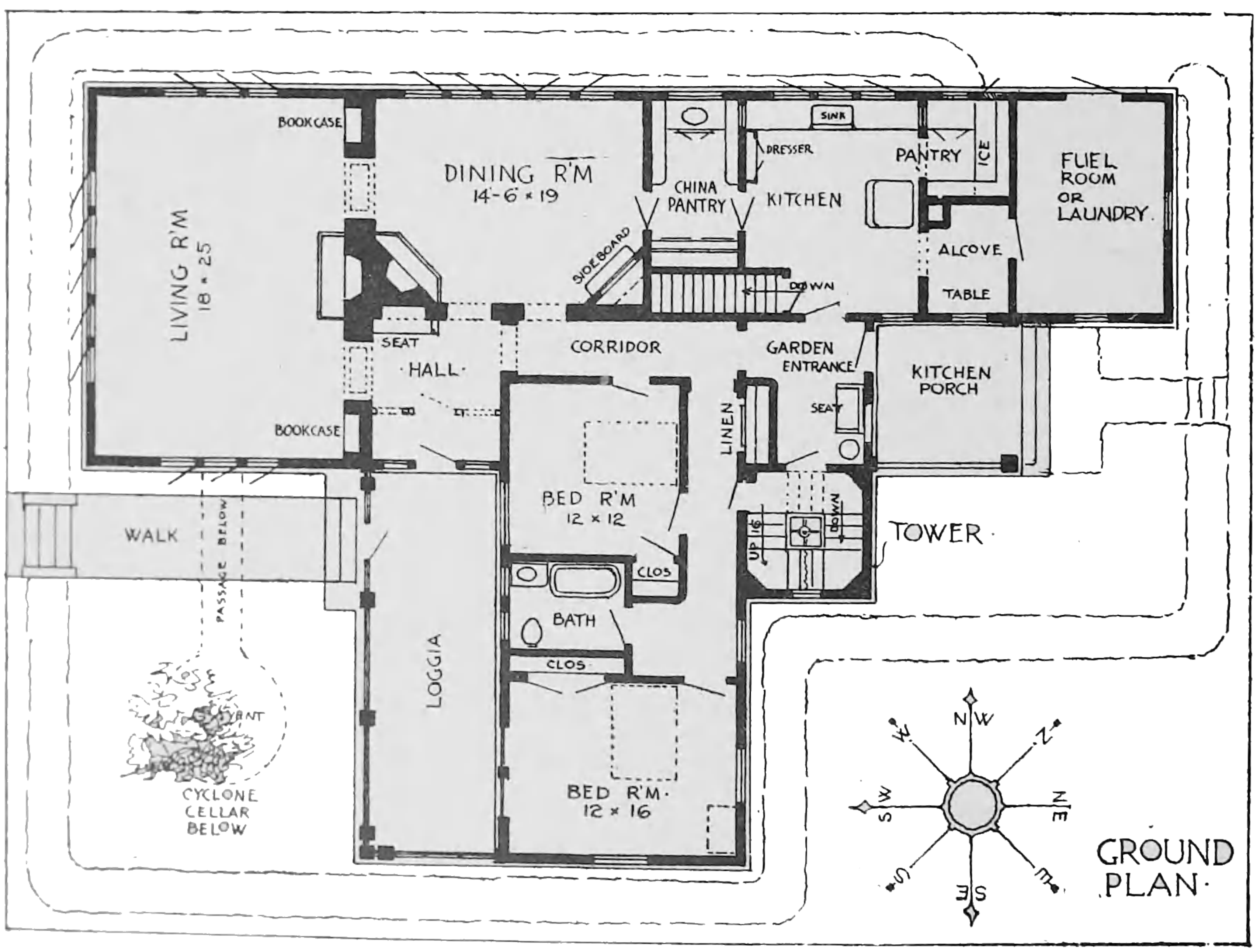
Inking. Observe the same rules in inking *Plate VIII* as were given for *Plate VII*. In Problems 25 and 26 the arcs and lines used in locating the points of the other half of the curve may be left in pencil. In Problem 28, all construction lines should be inked. After completing the problems the same lettering should be done on this plate as on previous plates.



PRAIRIE FARM BUNGALOW IN A WESTERN STATE

R. C. Spencer, Jr., Architect, Chicago, Ill.

The Windmill Tower Contains the Staircase Leading to Attic and Cellar



PLAN OF PRAIRIE FARM BUNGALOW

R C. Spencer, Jr , Architect, Chicago, Ill

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If the sun is in a position such that its rays are perpendicular to the V plane a similar square 3-4-5-6, Fig. 95, will be projected on this plane as the elevation. In order that the projected views, or projections, Fig. 96, as they are better known, may be shown on one plane or on a sheet of drawing paper, the plane H with the projection upon it is revolved about GL as an axis until it lies in the same plane as V.

Fig. 95 represents the picture and is for the purpose of showing the student how the object is projected to the horizontal and vertical

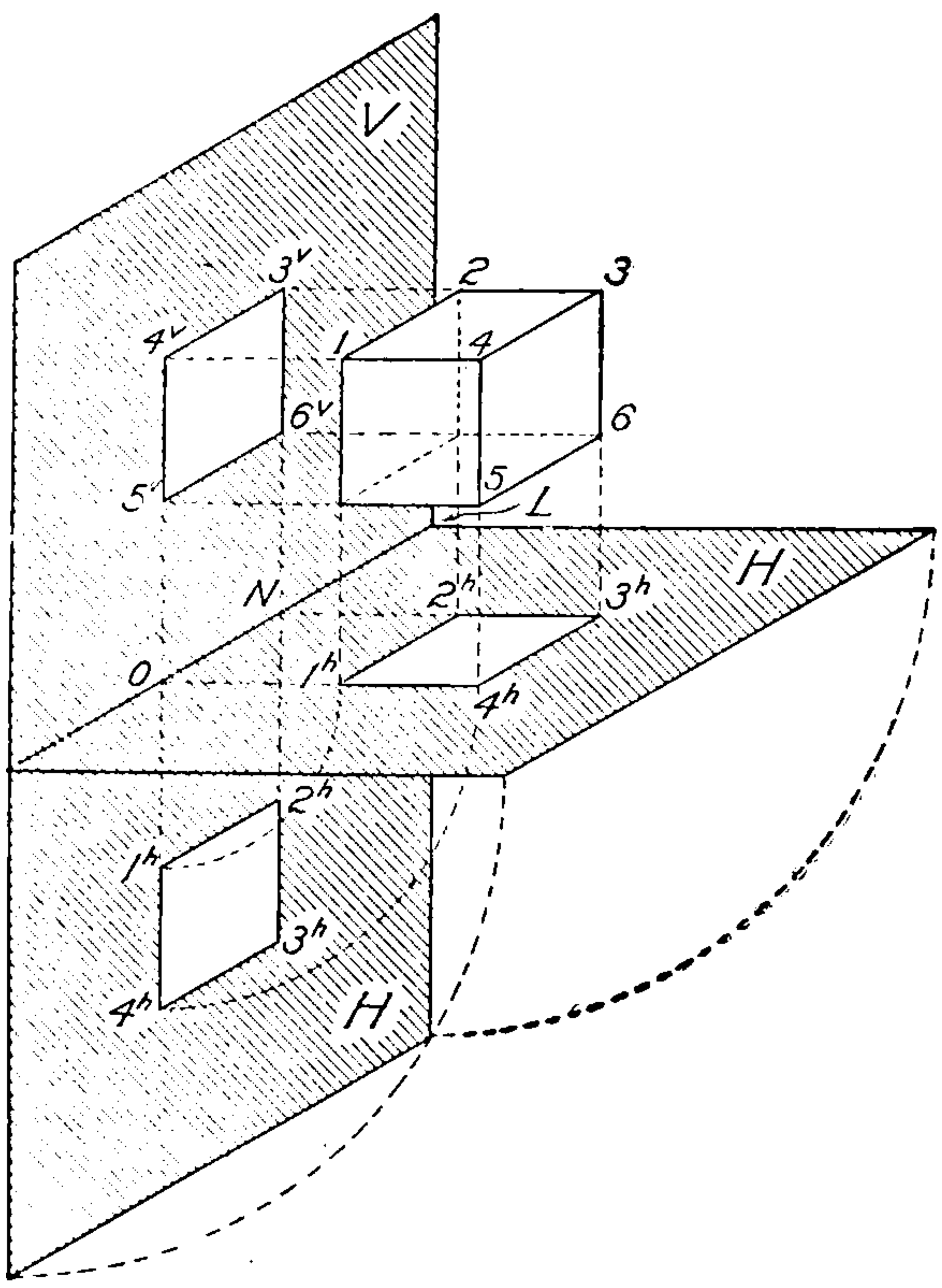


Fig 95 Object and Its Projections

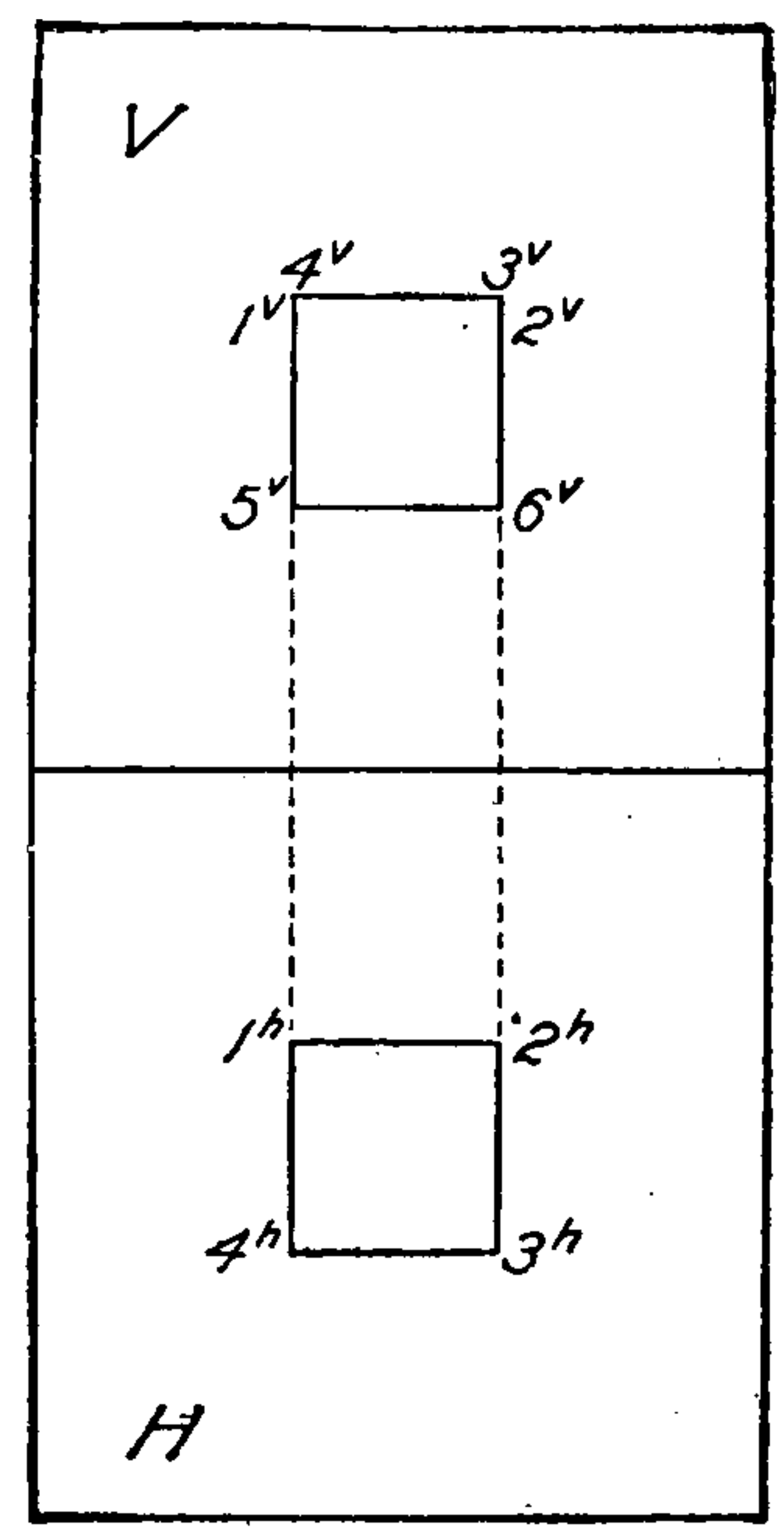


Fig. 96. Vertical and Horizontal Projections

planes Fig. 96 represents the actual projections, plan and elevation, as the problem would be drawn. The projections of a point a and line B drawn according to the first method are shown in Fig. 97.

It may be seen from the above explanation that the projected view of a point of an object on a plane is in a perpendicular drawn to the plane through the point of the object.

In Fig 95, the lines 1^h O and 2^h N, being perpendicular to GL, are in the same straight lines as 5^v O and 6^v N, which also are perpendicular to GL. That is—*two views of a point are always in a line* *perpendicular to GL.* From this it is evident that the plan must be vertically below the elevation, point for point. Now looking directly at the two planes in the revolved position, a true orthographic projection of the cube is obtained, as shown in Fig. 96.

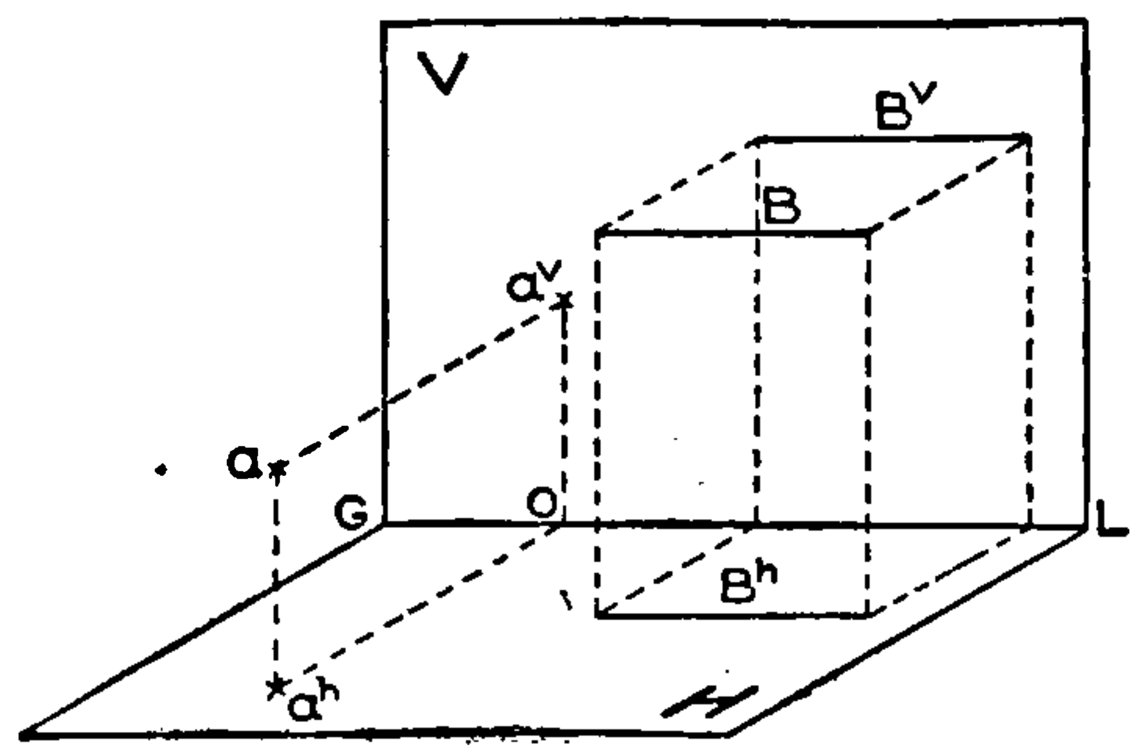


Fig. 97. Projections of a Point and a Line

All points on an object at the same height must appear in elevation at the same distance above the ground line. If numbers 1, 2, 3, and 4 on the plan, Fig. 96, indicate the top corners of the cube, then these four points, being at the same height, must be shown in elevation at the same height and at the top, $\frac{4^v}{1^v}$ and $\frac{3^v}{2^v}$. From the same figure it is seen that the top of the cube, 1-2-3-4, is shown in elevation as the straight line $\frac{4^v}{1^v}$ $\frac{3^v}{2^v}$. This illustrates the fact that *if a surface is perpendicular to either plane of projection, its projection on that plane is simply a line—a straight line if the surface is plane, a curved line if the surface is curved.* From Fig. 96 it is seen that the top edge of the cube, 1-4, has for its projection on the vertical plane the point $\frac{4^v}{1^v}$, the principle of which is stated in this way: *If a straight line is per-*

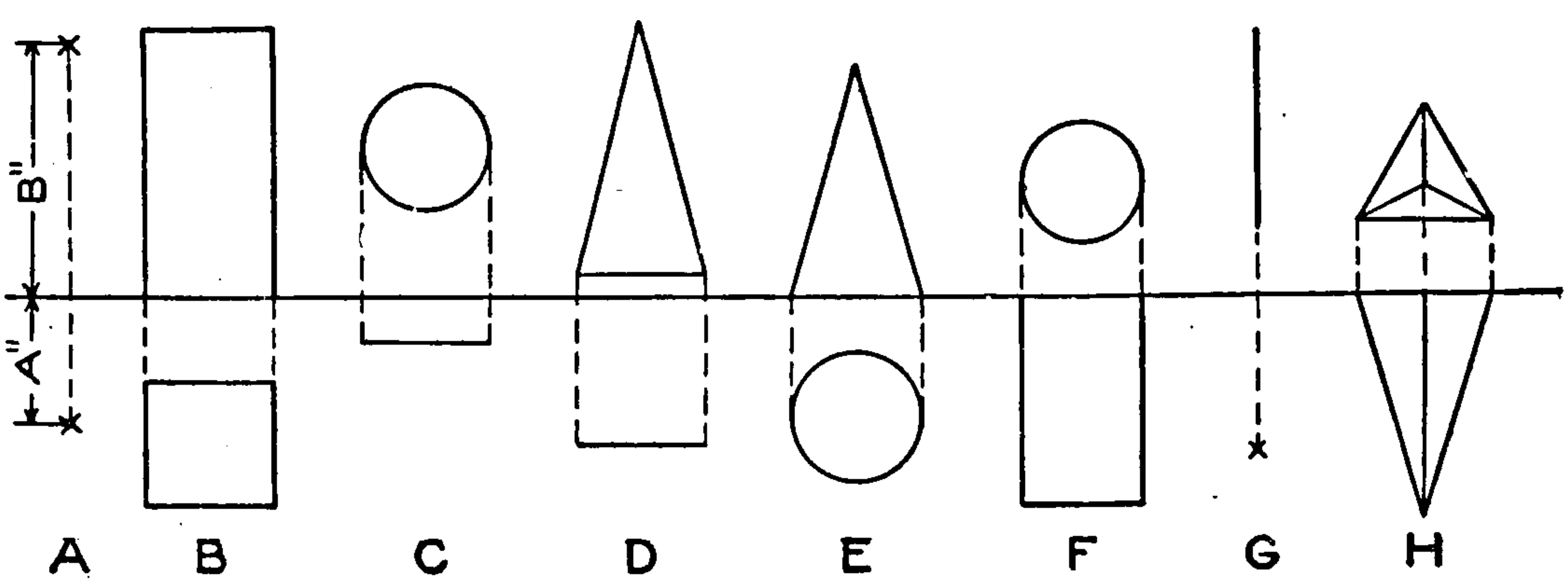


Fig. 98. Typical Projections

pendicular to either V or H, its projection on that plane is a point, and on the other plane is a line equal in length to the line itself, and perpendicular to the ground line.

Typical Examples. Fig. 98 is given as an exercise to show clearly the idea of plan and elevation.

A = a point B'' above H, and A'' in front of V
B = square prism resting on H, two of its faces parallel to V
C = circular disk in space parallel to V
D = triangular card in space parallel to V
E = cone resting on its base on H
F = cylinder perpendicular to V, and with one end resting against V
G = line perpendicular to H
H = triangular pyramid above H, with its base resting against V

Suppose in Fig. 99, that it is desired to construct the projections of a prism $1\frac{1}{2}$ in. square, and 2 in. long, standing on one end on the horizontal plane, two of its faces being parallel to the vertical plane. In the first place, as the top end of the prism is a square, the top view or plan will be a square of the same size, that is, $1\frac{1}{2}$ in. Then, since the prism is placed parallel to and in front of the vertical plane, the plan, $1\frac{1}{2}$ in. square, will have two edges parallel to the ground line. As the front face of the prism is parallel to the vertical plane its projection on V will be a rectangle, equal in length and width to the length and width respectively of the prism, and as the prism stands with its base on H, the elevation, showing height above H, must have its base on the ground line. Observe carefully that points in elevation are vertically over corresponding points in plan.

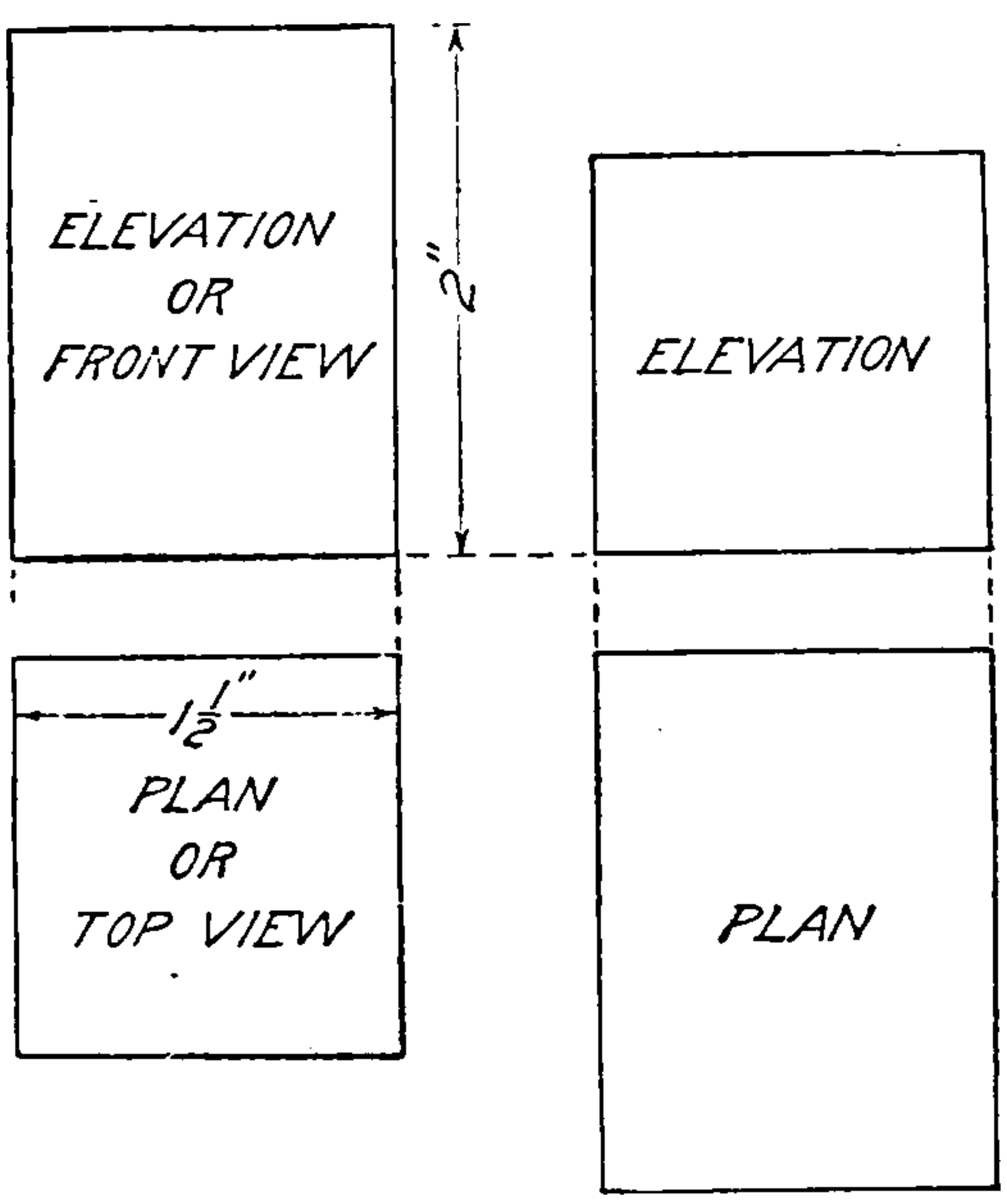


Fig. 99. Projections of a Square Prism

The second drawing in Fig. 99 represents a prism of the same size as the first but lying on one side on the horizontal plane, and with the ends parallel to V.

Summary. The principles which have been used thus far may be stated as follows:

1. If a line or point is on either plane, its other projection must be in the ground line.

2. Height above H is shown in elevation as height above the ground

center of the base. What this length is, however, does not appear in either projection, as these edges are not parallel to either V or H.

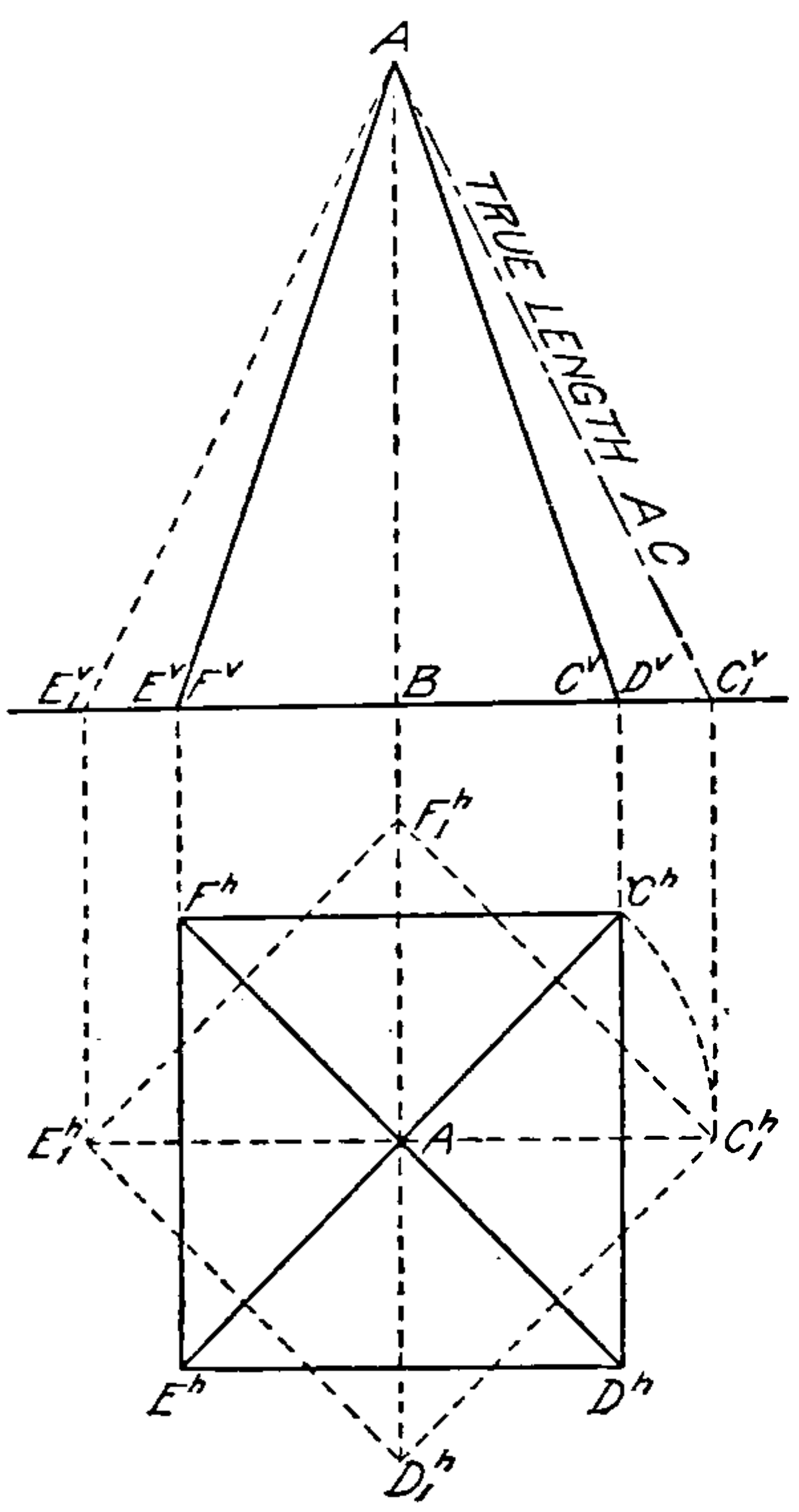


Fig 102 Projections of Square Pyramid

Suppose the pyramid be turned around into the dotted position C_1^h D_1^h E_1^h F_1^h where the horizontal projections of two of the slanting edges, AC_1^h and AE_1^h, are parallel to the ground line. These two edges, having their horizontal projections parallel to the ground line, are now parallel to V, and therefore their new vertical projections will show their true lengths. The base of the pyramid is still on H, and therefore is projected on V in the ground line. The apex is in the same place as before, hence the vertical projection of the pyramid in its new position is shown by the dotted lines. The vertical projection $A\ C_1^v$ is the true length of edge AC^h. Now if it is desired to find simply the true length of $A\ C^h$, it is unnecessary to turn the whole pyramid around, as the one line $A\ C^h$ will be sufficient.

The true length of lines may therefore be found in any case by

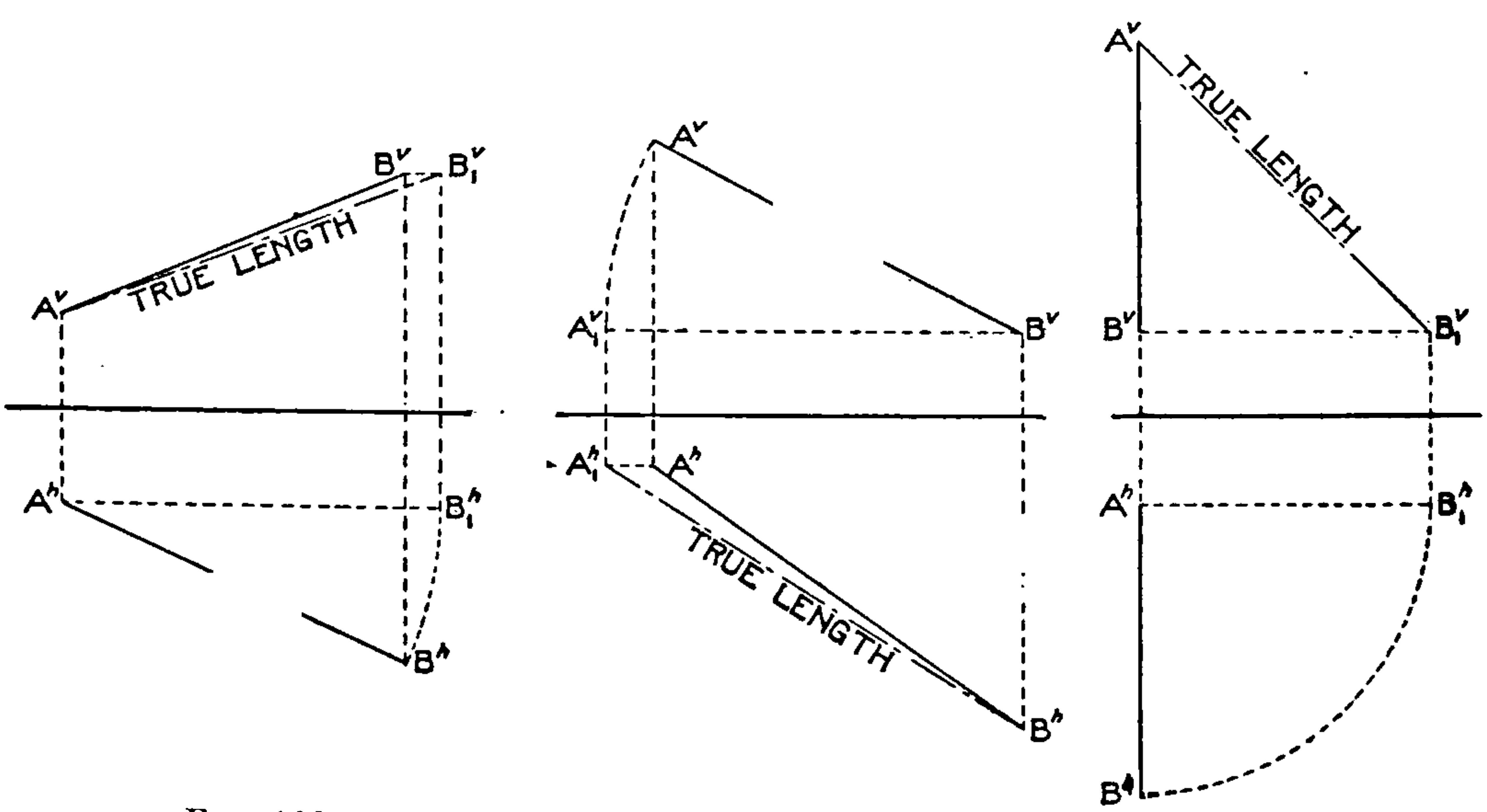


Fig 103 Fig 104 Fig 105

True Length of a Line by Rotating its Projection

applying the following principle. *Swing one projection of the line parallel to the ground line, using one end as center. On the other projection* *the moving end remains at the same distance from the ground line and of course vertically above or below the same end in its parallel position. This new projection of the line shows its true length,* Fig. 103, Fig. 104, and Fig. 105.

PROFILE PLANE

A third plane perpendicular to both coordinate planes, and hence to the ground line, is called a *profile plane.* This plane is vertical in position, and may be used as a plane of projection. A projection on the profile plane is called a profile view, or *end view,* or sometimes edge view, and is often required in machine or other drawing when the plan and elevation do not sufficiently give the shape and dimensions.

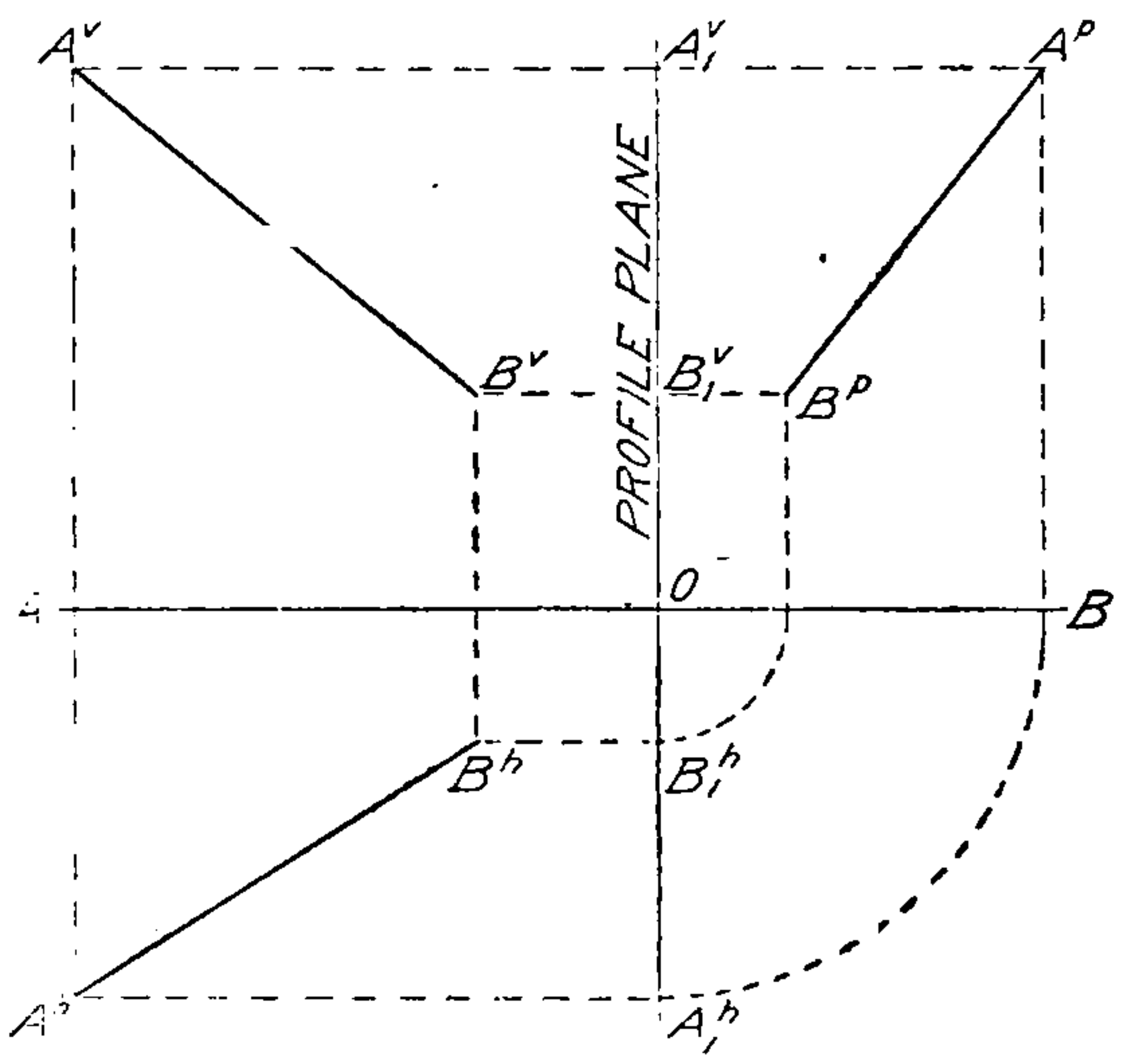


Fig 106 Projections of a Line on Horizontal, Vertical, and Profile Planes

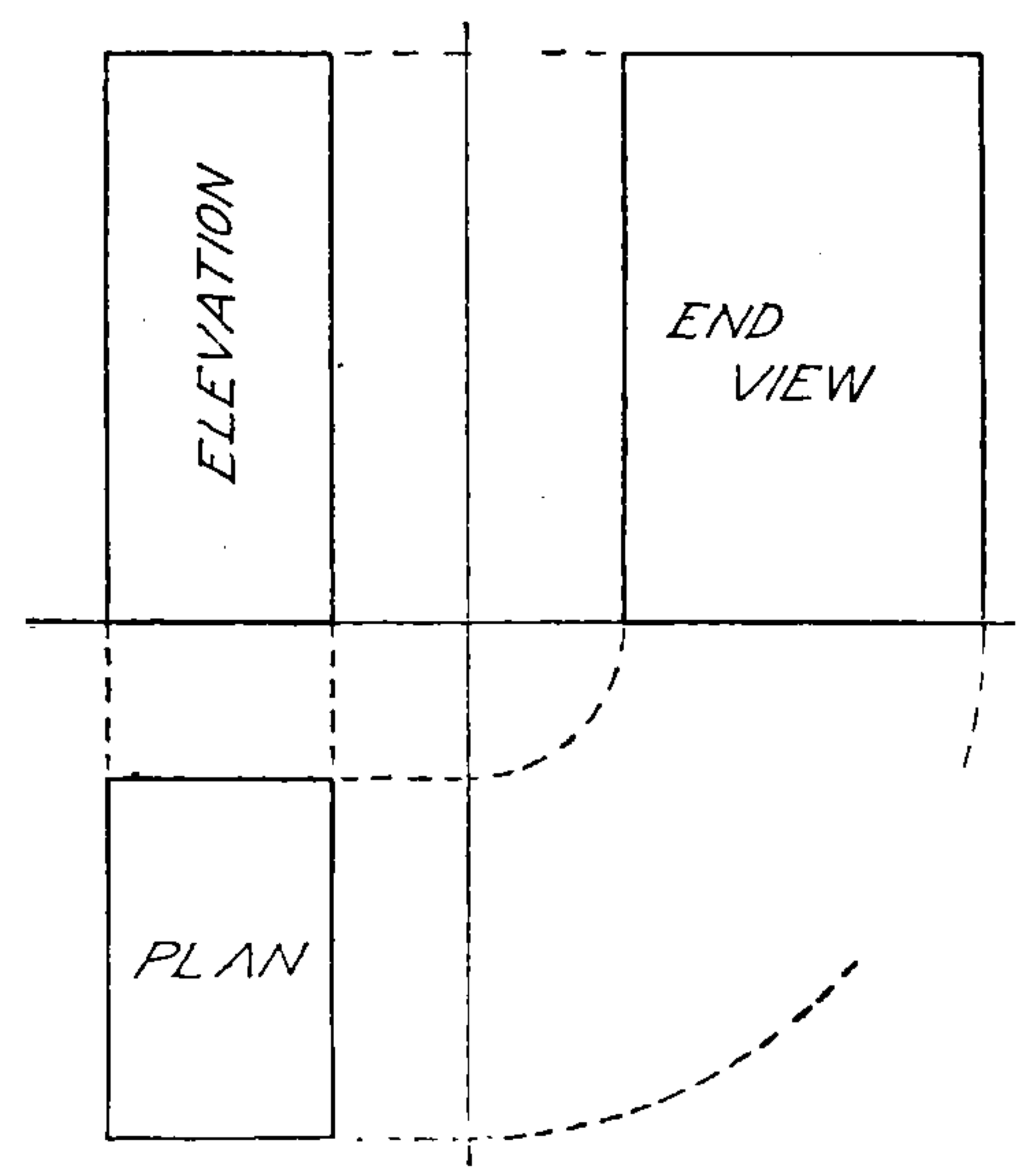


Fig 107 Three Projections of a Rectangular Prism

A projection on this plane is found in the same way as on the *V* plane, *i. e.,* by perpendiculars drawn from points on the object.

Since, however, the profile plane is perpendicular to the ground line, it will be seen from the front and top simply as a straight line; in order that the size and shape of the profile view may be shown, the profile plane is revolved into *V* using its intersection with the vertical plane as the axis.

Given the line *A B,* Fig. 106, by its two projections A^v B^v and A^h B^h, and given also the profile plane. Now by projecting the line on the profile by perpendiculars, the points A_1^v B_1^v and $B_1^h A_1^h$ are found. Revolving the profile plane like a door on its hinges, all points in the plane will move in horizontal circles, so the horizontal projections A_1^h and B_1^h will move in arcs of circles with *O* as center to the ground line, and the vertical projections $B_1{}^v$ and $A_1{}^v$ will move in lines parallel to the ground line to positions directly above the revolved points in the ground line, giving the profile view of the line A^p B^p. Heights, it will be seen, are the same in profile view as in elevation. By referring to the rectangular prism, Fig. 107, it is seen that the elevation gives vertical dimensions and those parallel to V, while the end view shows vertical dimensions and those perpendicular to V. The profile view of any object may be found as shown for the line *A B*, Fig. 106, by taking one point at a time.

REPRESENTATION OF OBJECTS

In Fig. 108 there is represented a rectangular prism or block, whose length is twice the width. The elevation shows its height. As the prism is placed at an angle, three of the vertical edges will be visible, and the fourth, invisible.

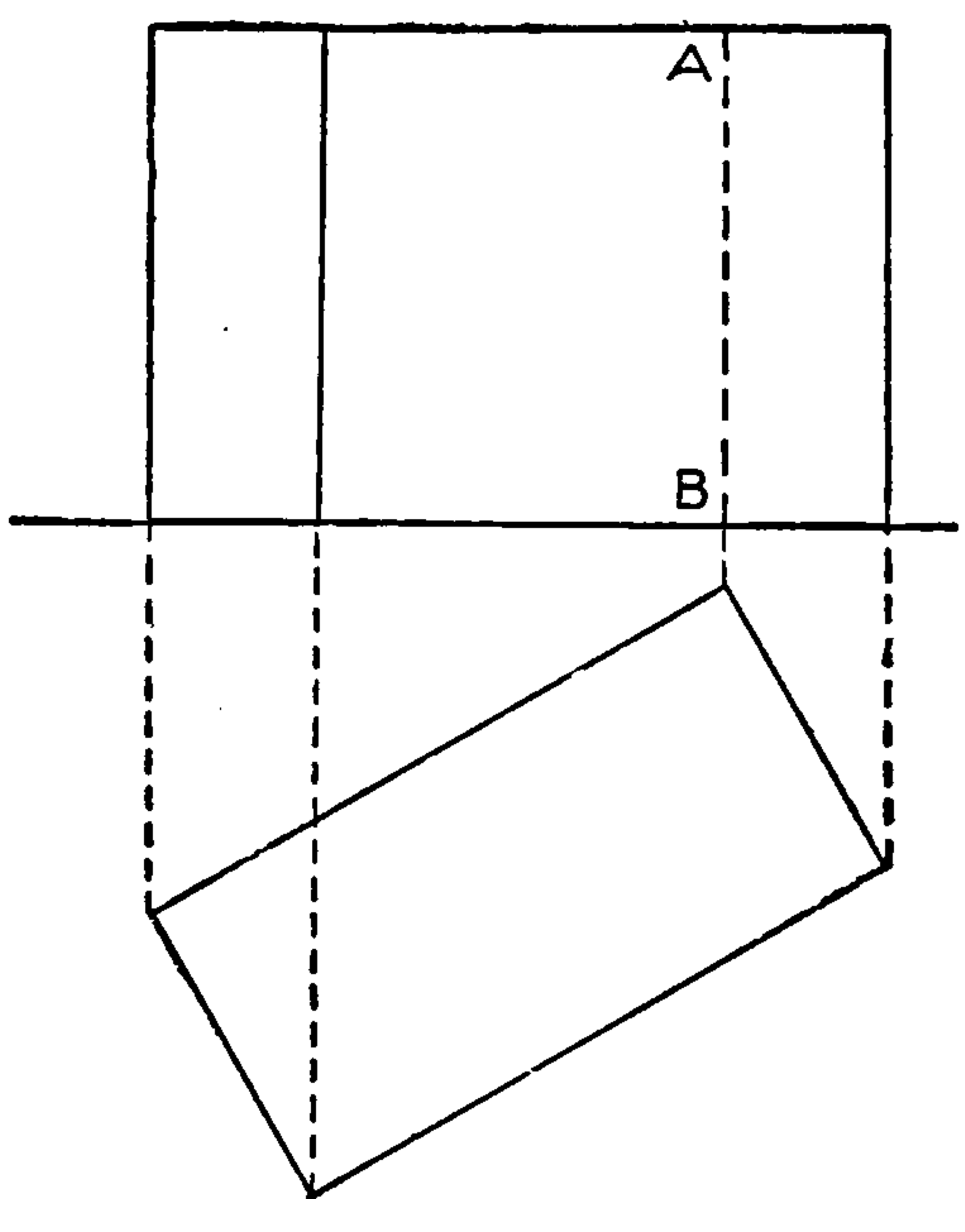


Fig 108 Proper Representation of Rectangular Prism

In mechanical drawing the edges which in projection form a part of the outline or contour of the figure must always be visible, hence are always drawn as *full lines*, while the lines or edges which are invisible are drawn *dotted*. The plan shows what lines are visible in elevation, and the elevation determines what are visible in plan. In Fig 108, the plan shows that the dotted edge *A B* is the back edge, and in Fig 109, the elevation shows that the dotted edge *C D* is the lower edge of the triangular prism. In general, if in elevation an edge

ROTATION OF OBJECTS

Frustum of a Square Pyramid. In Fig. 112 is shown the plan and elevation of the frustum of a square pyramid, placed with its base on the horizontal plane. If the frustum is turned through 30°, as shown in the plan of Fig. 113, the top view or plan must still be the same shape and size, and as the frustum has not been raised or lowered, the heights of all points must appear the same in eleva-

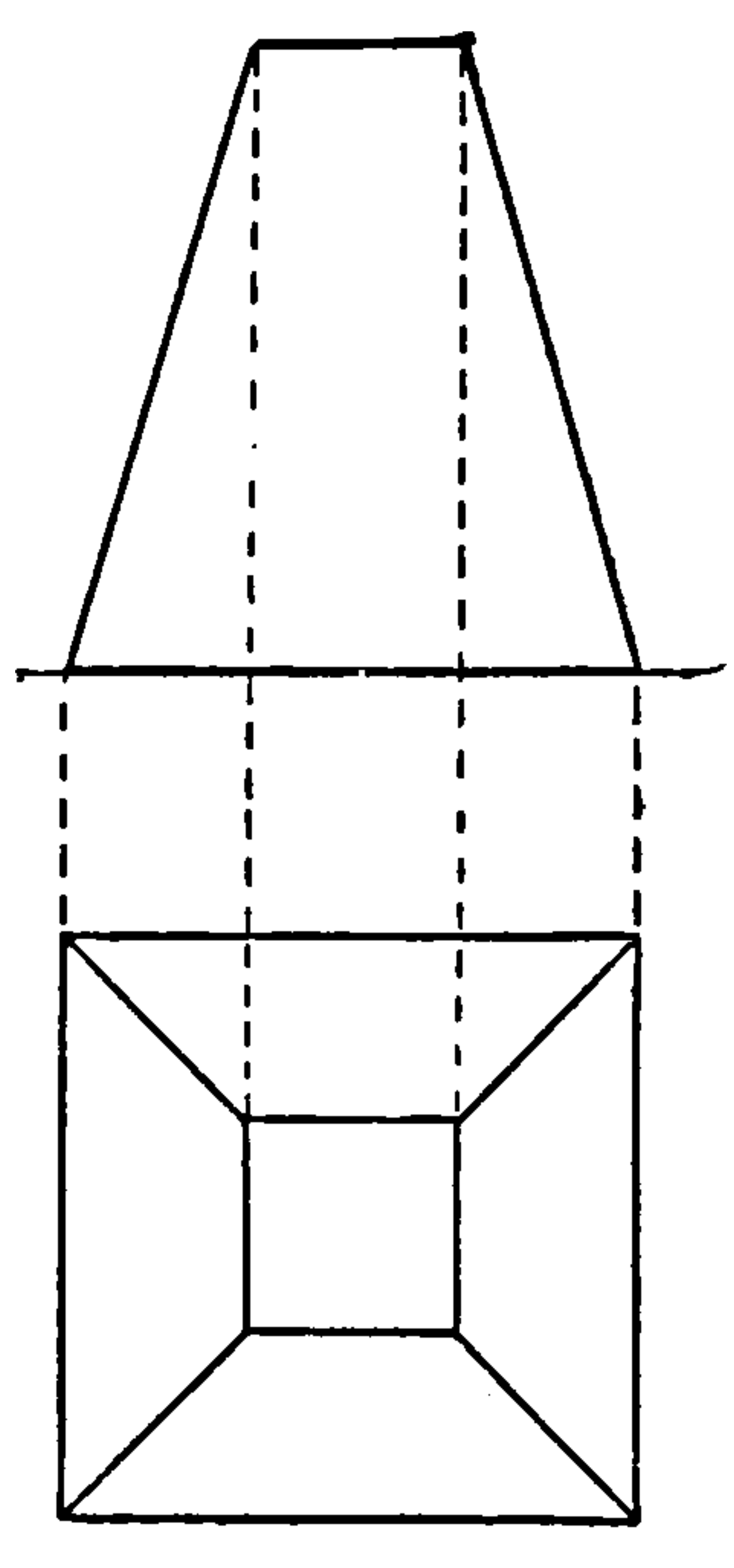


Fig. 112 Frustum of Square Pyramid

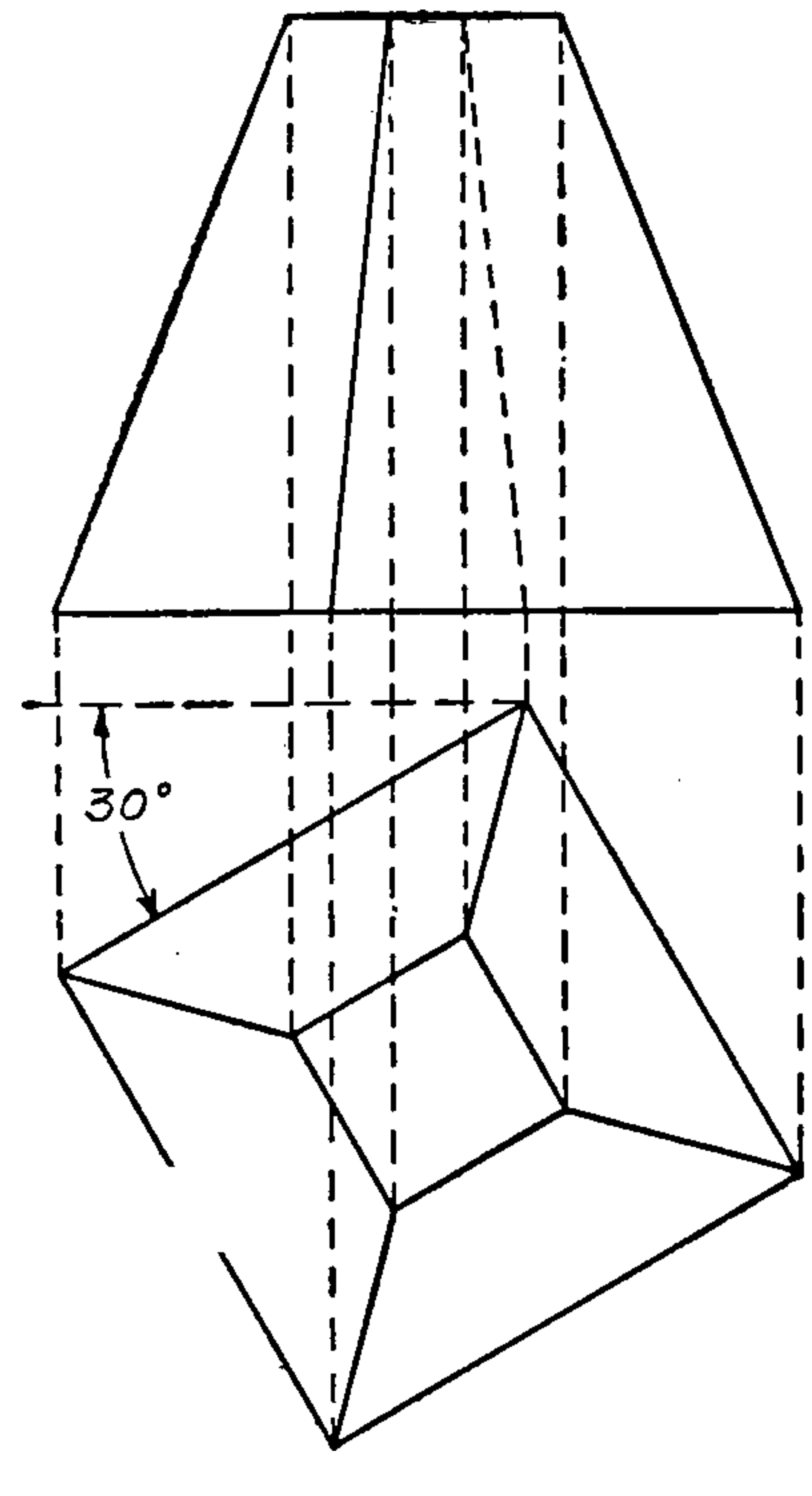


Fig. 113 Frustum of Square Pyramid Rotated Through 30°

tion as in Fig. 112. The elevation is easily found by projecting points up from the plan, and projecting the height of the top horizontally across from the first elevation.

Square Prism. The same principle is further illustrated in Figs. 114 and 115. The elevation of Fig. 114 shows a square prism resting on one edge, the lower side making an angle of 30° with the horizontal. The plan gives the true width or thickness, $\frac{5}{8}$ in., but the true length of the side, 2 in., must be obtained from the elevation, for the length of the plan is greater than 2 in. and will vary with the angle at which the prism is slanted. Now if the prism be turned around through an angle of 45° with the vertical plane, the lower edge still being on H, and the inclination of 30° with H remaining the same, the plan must remain the same size and shape, as shown in the right-hand view of Fig. 114. The elevation is found by projecting the corners of the prism vertically to the heights of the same points in the first elevation.

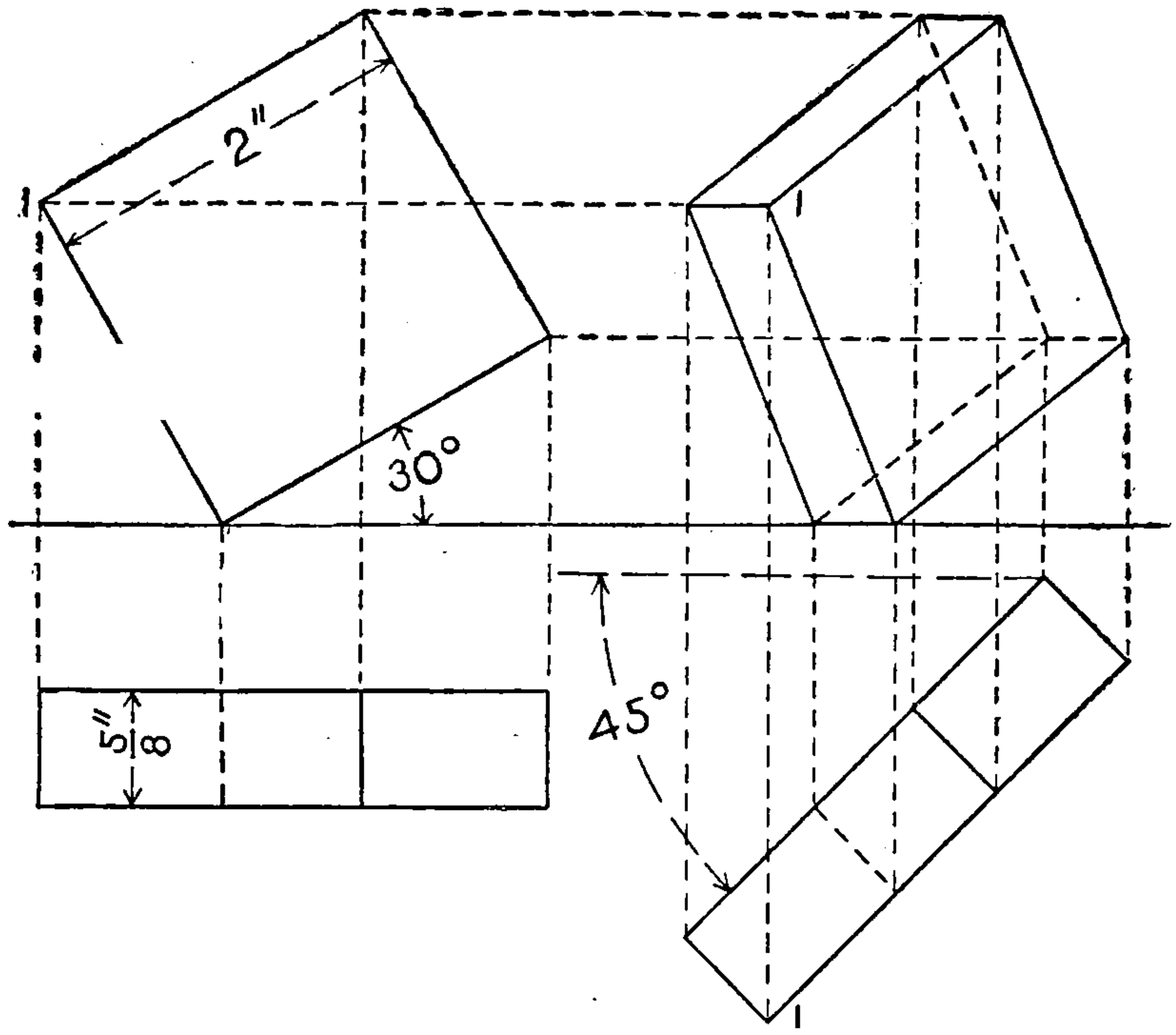


Fig 114 Views of a Square Prism Showing Effect of Rotating Axis of Prism

Rectangular Prism. Three positions of a rectangular prism are shown in Fig. 115. In the first view, the prism stands on its

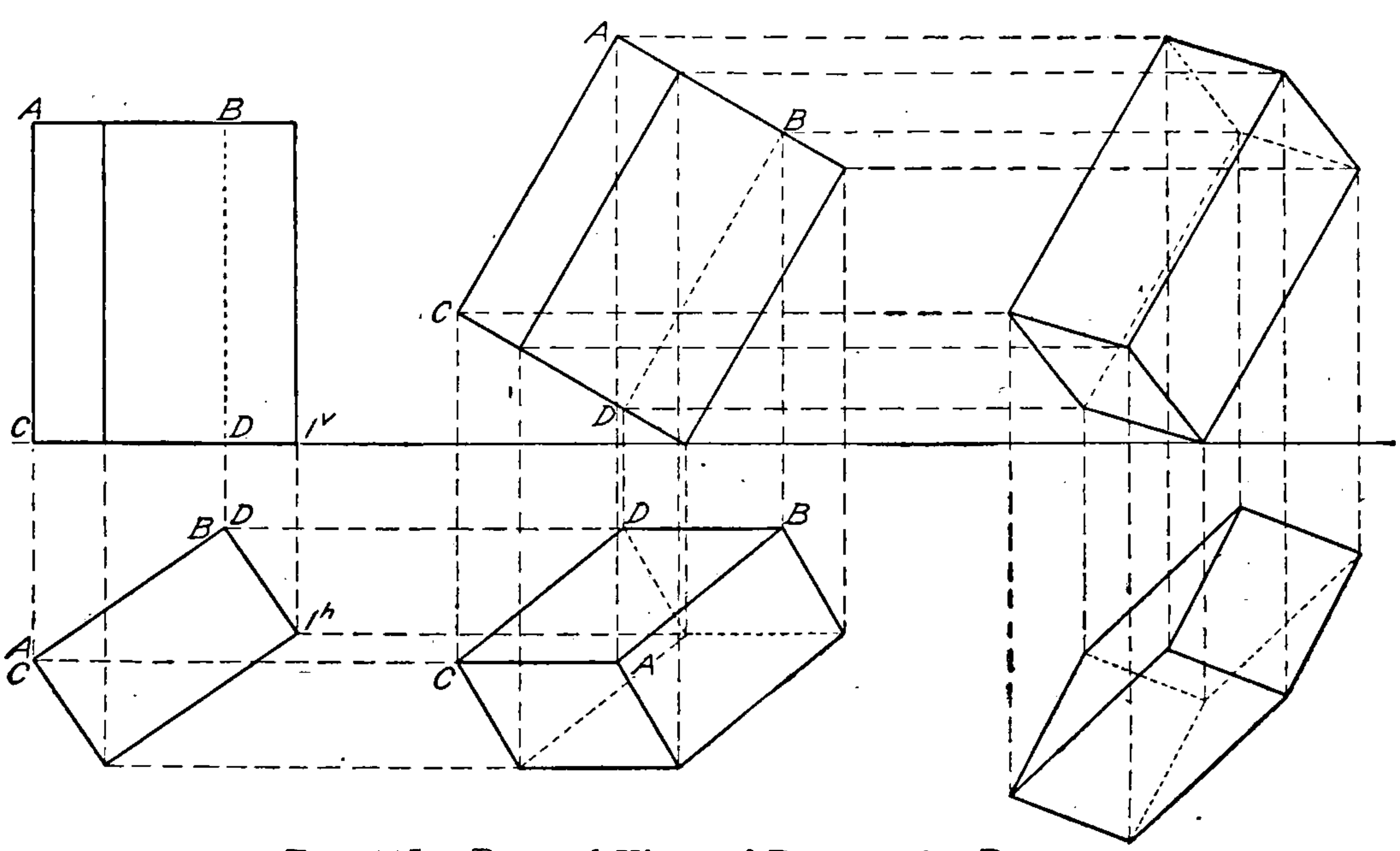


Fig 115 Rotated Views of Rectangular Prism

base, and its axis, therefore, is parallel to the vertical plane. In the second position, the axis is still parallel to *V* and one corner of the base is on the horizontal plane, but the prism has been turned on the line 1^h 1^v as an axis, so that the inclination of all the faces of the prism to the vertical plane remains the same as before. That is, if in the first figure the side *A B D C* makes an angle of 30° with the vertical, the same side in the second position still makes 30° with the vertical plane. Hence the elevation of No. 2 is the same shape and size as in the first case. The plan is found by projecting the corners down from the elevation to meet horizontal lines projected across from the corresponding points in the first plan. The third position shows the prism with all its faces and edges making the same angles with the horizontal as in the second position, but with the plan at a different angle with the ground line. The plan then is the same shape and size as in No 2, and the elevation is found by projecting up to the same heights as shown in the preceding elevation. This principle may be applied to any solid, whether bounded by plane surfaces or curved; as far as it relates to heights, it is the same that was used for profile views.

End View a Means of Obtaining True Height. An end view is sometimes necessary before the plan or elevation of an object can be drawn. Suppose that in Fig. 116 it is desired to draw the plan and elevation of a triangular prism 3 inches long, the end of which is an equilateral triangle $1\frac{1}{2}$ inches on each side. The prism is lying on one of its three faces on *H*, and inclined toward the vertical plane at an angle of 30°. The plan may be drawn at once, because the width will be $1\frac{1}{2}$ inches, and the top edge will be projected half way between the other two. The length of the prism will also be shown. Before the elevation can be drawn the height of the top edge must be found by obtaining the altitude of the triangle forming the end of the prism. All tha is necessary, then, is to construct

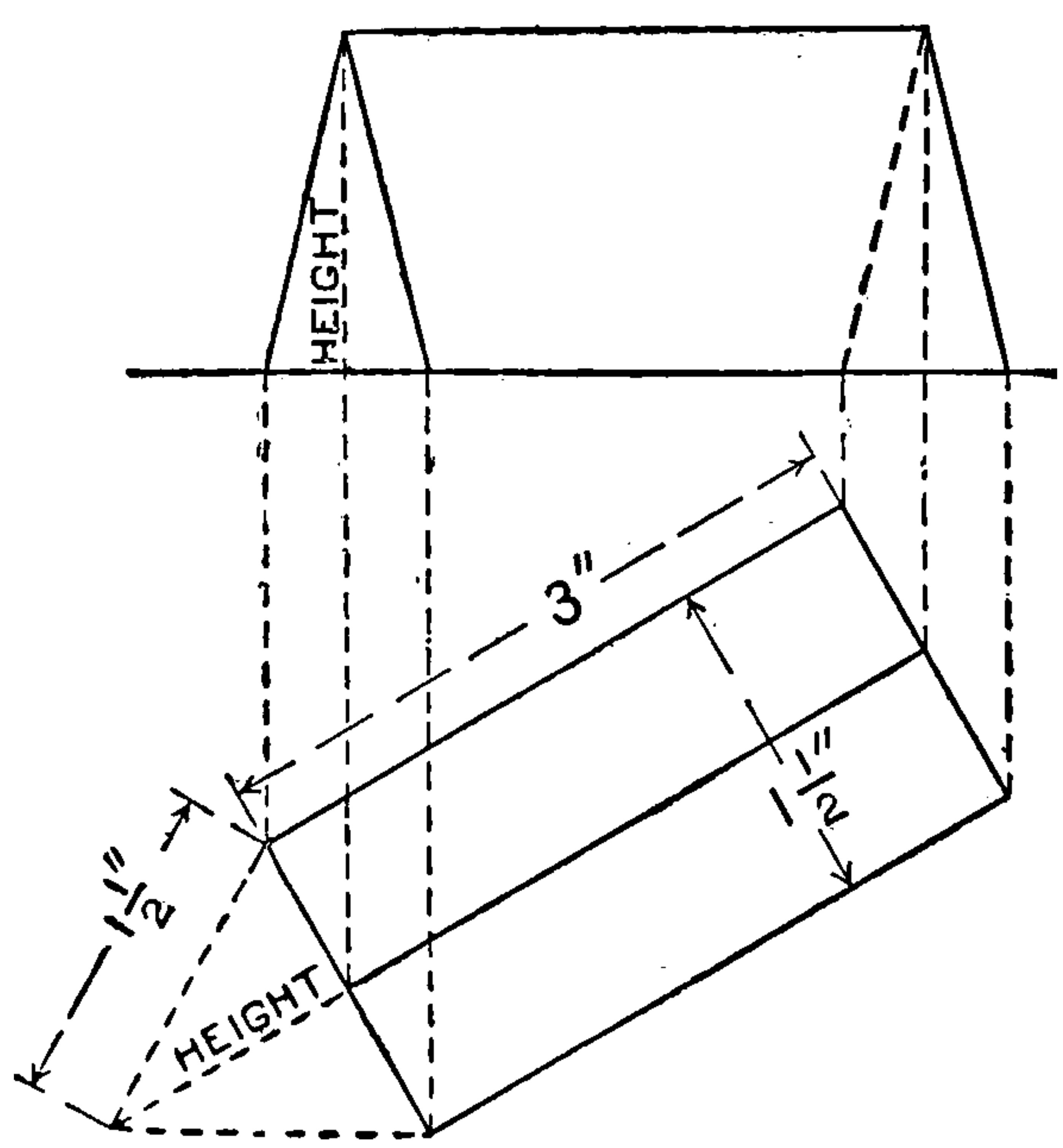
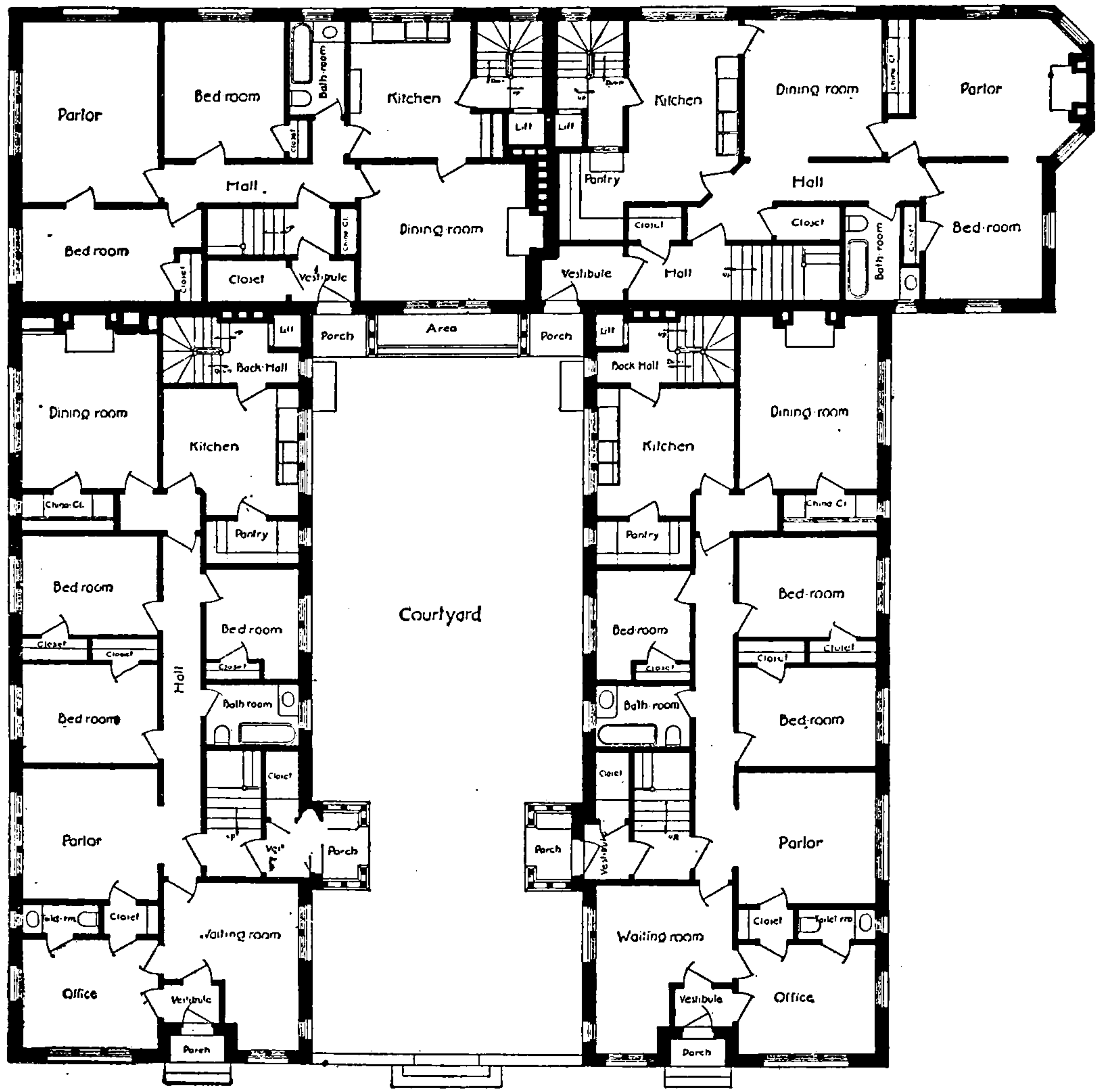


Fig 116 True Height on Horizontal Plane

APARTMENT HOUSE IN ASHMONT, MASS.
Edwin J. Lewis, Architect, Boston, Mass.
For Plans, See Opposite Page.



FIRST FLOOR PLAN.

SECOND FLO

FIRST AND SECOND FLOOR PLANS OF APARTMENT HOUSE IN ASHMONT, MASS.

Edwin J. Lewis, Architect, Boston, Mass.

For Exterior, See Opposite Page.

(Reproduced by Courtesy of "The Brickbuilder.")

joined by straight lines, will form the figure *A′ B′ C′ D′ E′ F′*, which is the base of the pyramid; and the lines *A′ D′*, *B′ E′*, and *C′ F′*, will represent the projections of its edges foreshortened as they would appear in the plan. If this operation has been correctly performed, the opposite sides of the hexagon should be parallel to each other and to one of the diagonals; this should be tested by the application of the square or other instrument proper for the purpose.

By the help of the plan obtained as above described, the vertical projection of the pyramid may be easily constructed. Since its base rests upon the horizontal plane, it must be projected vertically upon

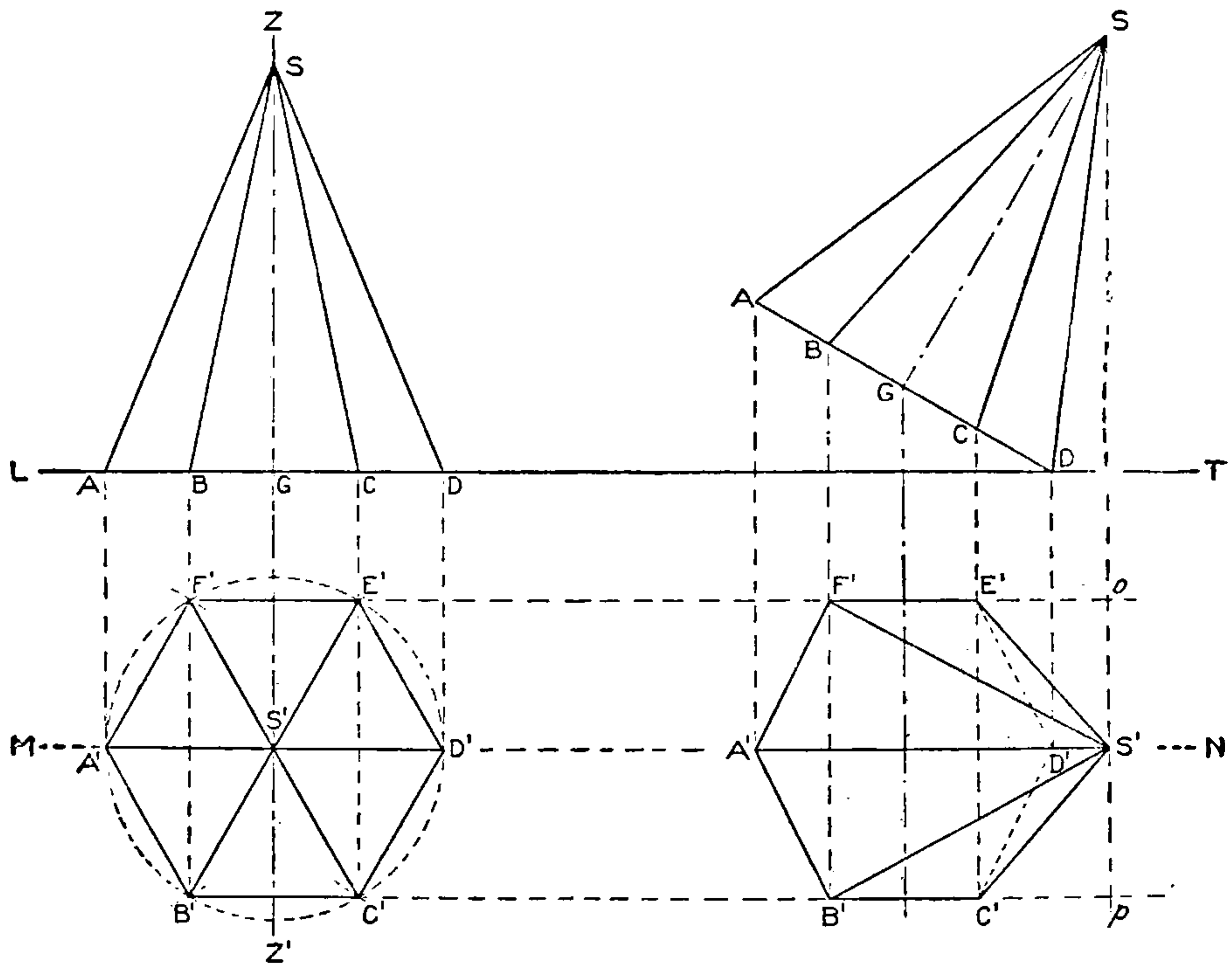


Fig. 118 Construction of Regular Hexagonal Pyramid

the ground line; therefore, from each of the points *A′*, *B′*, *C′*, and *D′*, raise perpendiculars to that line. The points of intersection, *A*, *B*, *C*, and *D*, are the true positions of all the angles of the base; and it only remains to determine the height of the pyramid, which is to be set off from the point *G* to *S*, and to draw *S A*, *S B*, *S C*, and *S D*, which are the only edges of the pyramid visible in the elevation. Of these it is to be remarked that *S A* and *S D* alone, being parallel to the vertical plane, are seen in their true length; and moreover, that from the assumed position of the solid under examination, the points *F′* and *E′* being situated in the lines *B B′* and *C C′*, the lines *S B* and *S C* are each the projections of two edges of the pyramid.

2. *Construct the projections of the pyramid, Example 1, having its base set in an inclined position, but with its edges S A* and *S D still parallel to the vertical plane,* Fig. 118.

It is evident, that with the exception of the inclination, the vertical projection of this solid is precisely the same as in the preceding example, and it is only necessary to show the same view of the prism in its new position. For this purpose, after having fixed the position of the point *D* upon the ground line, draw through this point a straight line *D A*, making with *L T* an angle equal to the desired inclination of the base of the pyramid. Then set off the distance *D A*, equal to that used in Example 1; erect a perpendicular on the center, and set off *G S* equal to the height of the pyramid. Transfer also from the first example the distance *B G* and *C G* to the corresponding points, and complete the figure by drawing the straight lines *A S*, *B S*, *C S*, and *D S*.

In constructing the plan of the pyramid in this position, it is to be remarked, that since the edges *S A* and *S D* are still parallel to the vertical plane, and the point *D* remains unaltered, the projection of the points *A*, *D*, and *S*, will still be in the line *M N*. The position of *A′* is determined by the intersection of the perpendicular *A A′* with *M N*. The remaining points, *B′*, *C′*, etc., in the projection of the base, are found in a similar manner, by the intersections let fall from the corresponding points in the elevation, with lines drawn parallel to *M N*, at a distance (set off at *o*, *p*,) equal to the width of the base. By joining all the contiguous points, the figure *A′ B′ C′ D′ E′ F′* is obtained representing the horizontal projection of the base, two of its sides, however, being dotted, as they must be supposed to be concealed by the body of the pyramid. The vertex *S* having been similarly projected to *S′*, and joined by straight lines to the several angles of the base, the projection of the solid is completed.

INTERSECTIONS

If one surface meets another at some angle, an intersection is produced. Either surface may be plane, or curved. If both are plane, the intersection is a straight line; if one is curved, the intersection is a curve, except in a few special cases; and if both are curved, the intersection is usually curved. In the latter case, the entire curve does not always lie in the same planes. If all points of any curve lie in the same plane, it is called a *plane curve*. A plane intersecting a curved surface must always give either a plane curve or a straight line.

Planes with Planes. In Fig. 119 a square pyramid is cut by a plane *A* parallel to the horizontal. This plane cuts from the pyramid a four-sided figure, the four corners of which will be the points where *A* cuts the four slanting edges of the solid. The plane intersects edge *o b* at point 4^v in elevation. This point must be found in plan vertically below on the horizontal projection of line *o b*, that is, at point 4^h. Edge *o e* is directly in front of *o b*, so is shown in elevation as the same line, and plane *A* intersects *o e* at point 1^v in elevation, found in plan at 1^h. Points 3 and 2 are obtained in the same way. The intersection is shown in plan as the square 1-2-3-4, which is also its true size as it is parallel to the horizontal plane. In a similar way the intersections are found in Figs. 120 and 121. It will be seen that in these three cases where the planes are parallel to the bases, the sections are of the same shape as the bases, and have their sides parallel to the edges of the bases.

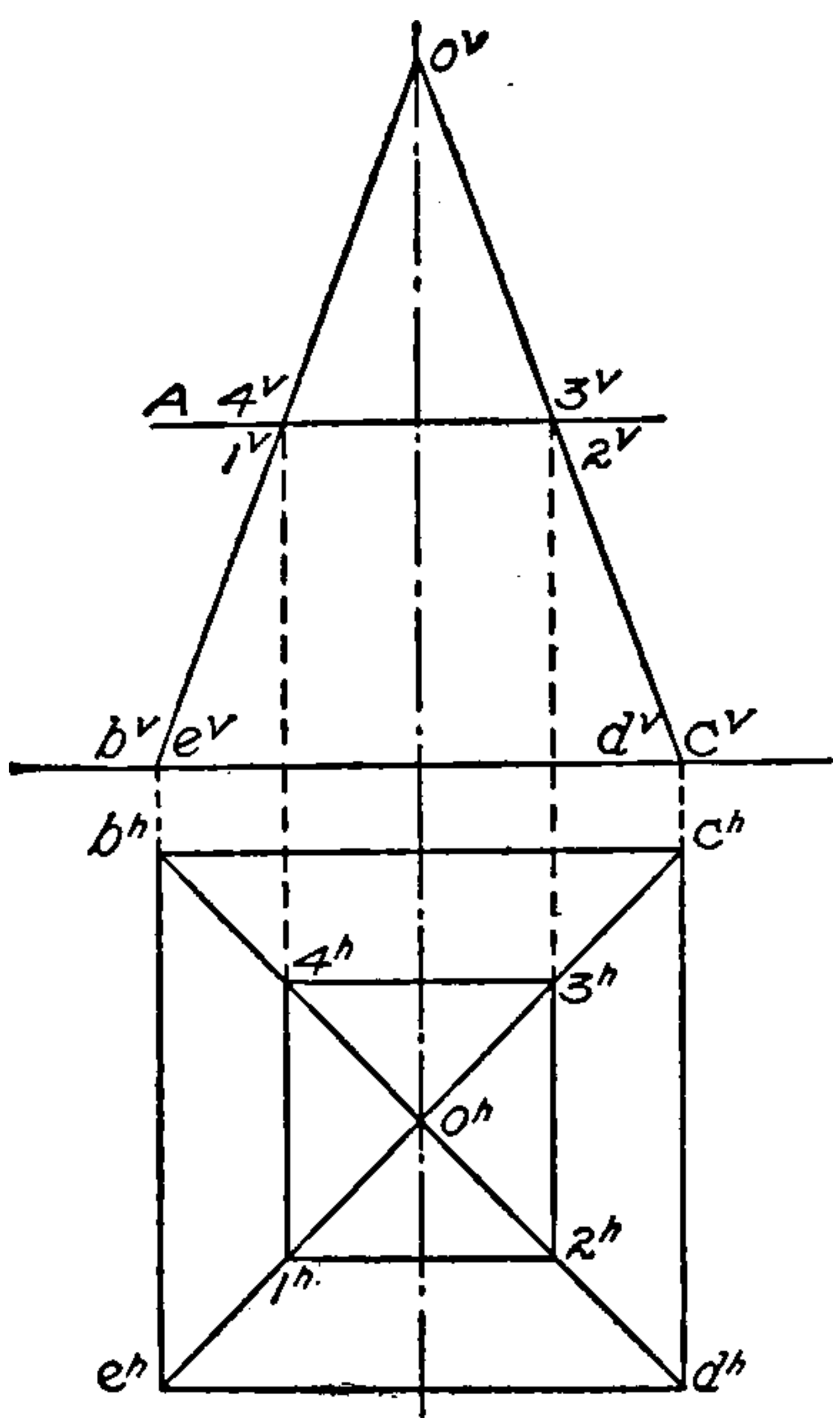


Fig 119 Intersection of Plane and Pyramid

It is an invariable rule that when such a solid is cut by a plane parallel to its base, the section is a figure of the same shape as the base. If then in Fig. 122 a right cone is intersected by a plane parallel to the base the section must be a circle, the center of which in plan coincides with the apex. The radius must equal *o d.*

In Fig. 123 and Fig. 124 the cutting plane is not parallel to the base, hence the section will not be of the same shape as the base. The intersections are found, however, in exactly the same manner as in the previous figures, by projecting the points where the plane intersects the edges in elevation, on to the other view of the same line.

ILLUSTRATIVE EXAMPLES

1. Find the horizontal projection of a transverse section of the pyramid of Fig. 118, made by a plane perpendicular to the vertical,

but inclined at an angle to the horizontal plane of projection; and let all the sides of the base be at an angle with the ground line, Fig. 125.

Having drawn the vertical $S\ S'$, the center line of the figures, its point of intersection with the line $M\ N$ is the center of the plan. Since none of the sides of the base are to be parallel with the ground line, draw a diameter $A'\ D'$ making the required angle with $M\ N$, and from the points A' and D' proceed to set out the angular points of the hexagon, as in Fig. 118. Then join the angular points which are diametrically opposite and project the figure thus obtained upon the vertical plane, as shown.

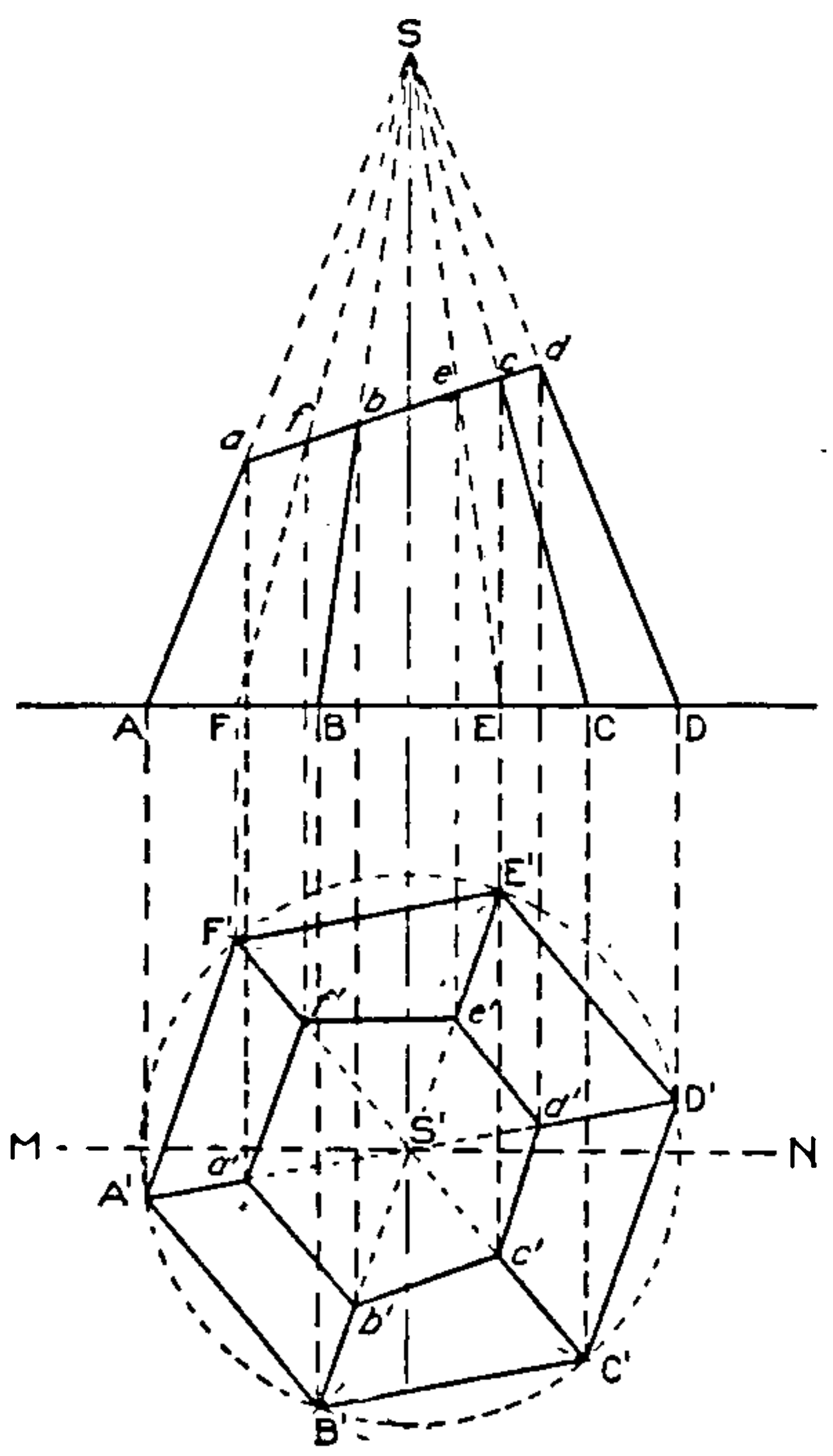


Fig 125 Frustum of Hexagonal Pyramid

Now, if the cutting plane be represented by the line $a\ d$ in the elevation, it is obvious that it will expose, as the section of the pyramid, a polygon whose angular points being the intersections of the various edges with the cutting plane, will be projected in perpendiculars drawn from the points where it meets these edges respectively. From the points a, f, b, etc., let fall the perpendiculars aa', ff', bb', etc., to meet the lines $A'\ D'$, $F'\ C'$, $B'\ E'$, etc. When the contiguous points of intersection of these lines are joined, a six-sided figure will be formed which will represent the section required. The edges $F\ S$ and $E\ S$ being concealed in the elevation, but necessary for the construction of the plan, have been expressed in dotted lines, as is also the portion of the pyramid situated above the cutting plane which, though supposed to be removed, is necessary in order to draw the lines representing the edges.

2. Find the horizontal projection of the transverse section of a regular five-sided pyramid, cut by a plane perpendicular to the vertical, but inclined at an angle to the horizontal plane of projection; and let one edge of the pyramid be in a plane perpendicular to both the horizontal and the vertical planes of projection, as shown in Fig 126.

The plan of the pyramid is constructed by describing from the center S', a circle circumscribing the base, and from B' dividing the circumference into five equal parts, and joining the contiguous points of division by straight lines. These form the polygon A' B' C' D' E', whose angles, when joined to the center S', show the projections of the edges of the pyramid. Then, following the method above explained, the elevation and the horizontal projection of the section made by the plane $a\ c$ are obtained. But that method will not suffice for the determination of the point b', because the perpendicular let fall from the corresponding point b, in the elevation, coincides with the projection of the edge $B\ S$. Let the pyramid supposedly be turned a quarter of a revolution round its axis; the line B' S' will then have assumed the position S' b^2. Project the point b^2 to b^3, and join Sb^3. Then, since the required point must also be conceived to have described a quarter of a circle in a plane parallel to the horizontal plane, and that its new position must be in the line Sb^3, it is obvious that its vertical projection is the point b^4, the intersection of a horizontal line drawn through b with the line Sb^3. The distance $b\ b^4$ may then be used to determine the distance from S' to b', and determines the position of the latter point in the plan; or, following a more methodical process, by projecting the point b^4 to b^5, and describing a circle from the center S' passing through b^5, its intersection with B' S' is the point sought.

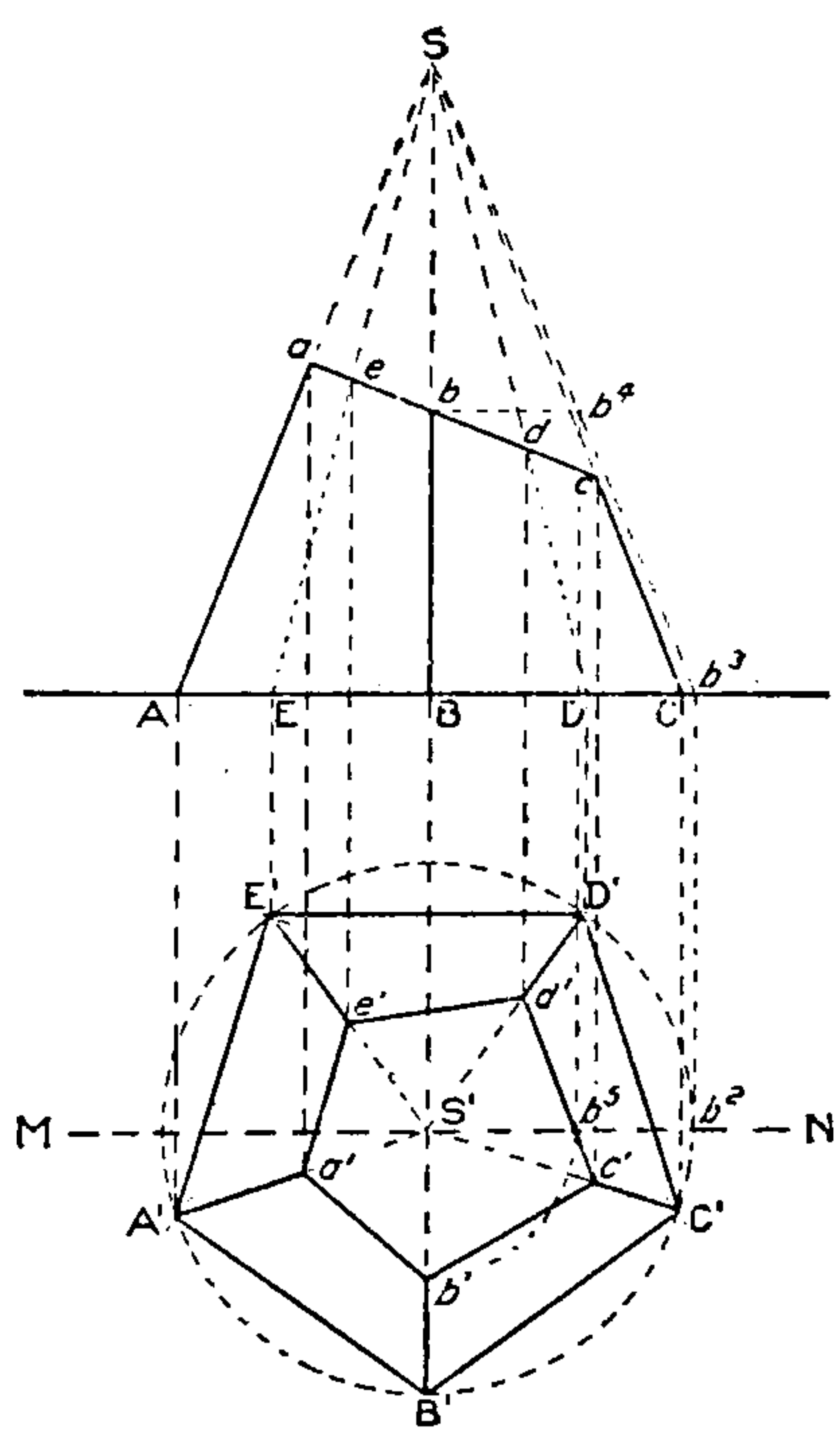


Fig 126 Frustum of Pentagonal Pyramid

Planes with Cones or Cylinders. Sections cut by a plane from a cone have already been defined as *conic sections.* These sections may be any of the following: two straight lines, circle, ellipse, parabola, hyperbola. All except the parabola and hyperbola may also be cut from a cylinder.

Methods have previously been given for constructing the ellipse, parabola, and hyperbola, without projections; it will now be shown that they may be obtained as actual intersections.

Ellipse. In Fig. 127 the plane cuts the cone obliquely. To find points on the curve in plan take a series of horizontal planes x y z, etc., between points c^v and d^v. One of these planes, as w, should be taken through the center of c d. The points c and d must be points on the curve, since the plane cuts the two contour elements at these points. Contour elements are those forming the outline. The horizontal projections of the contour elements will be found

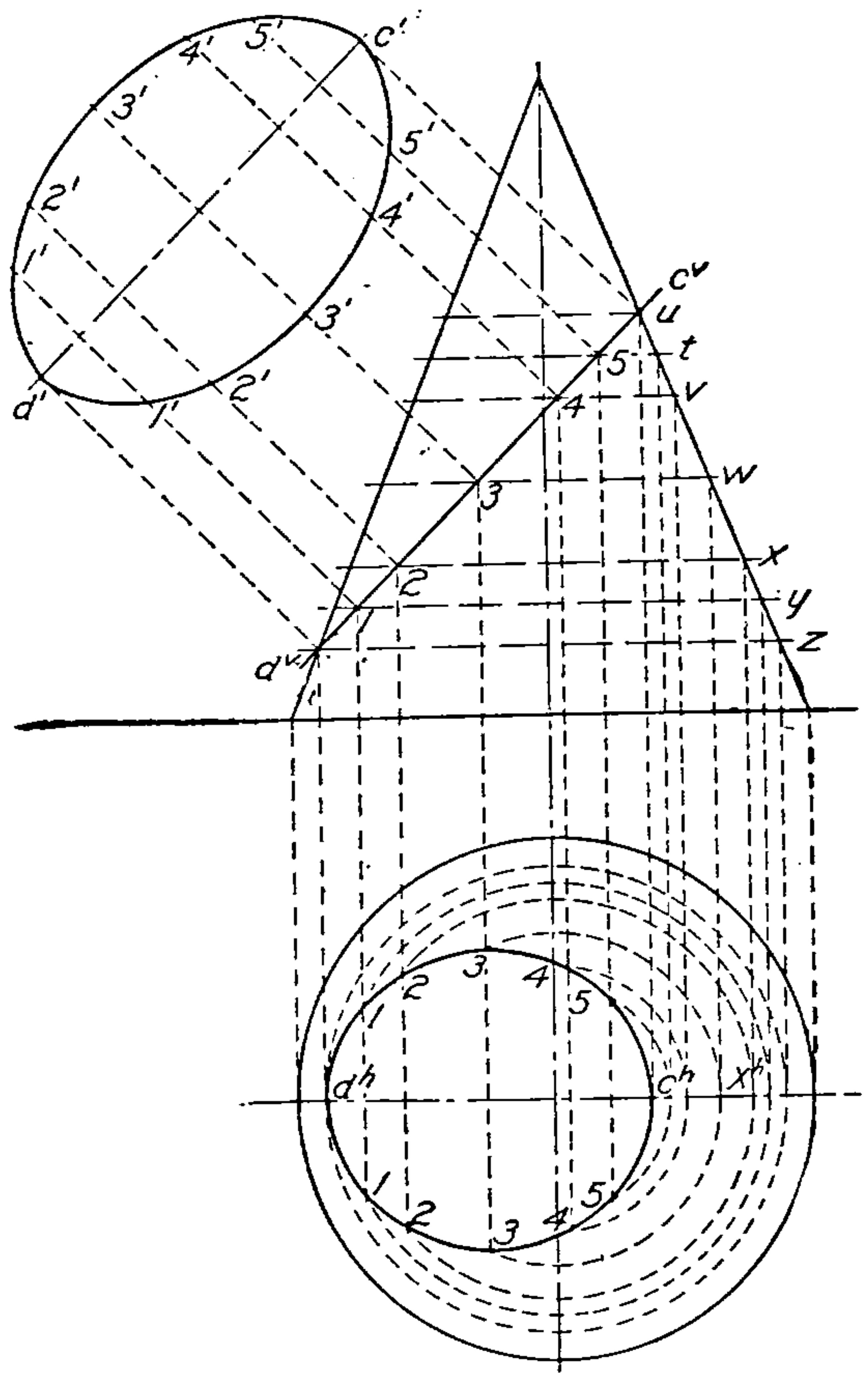


Fig 127 Ellipse—Section from a Cone

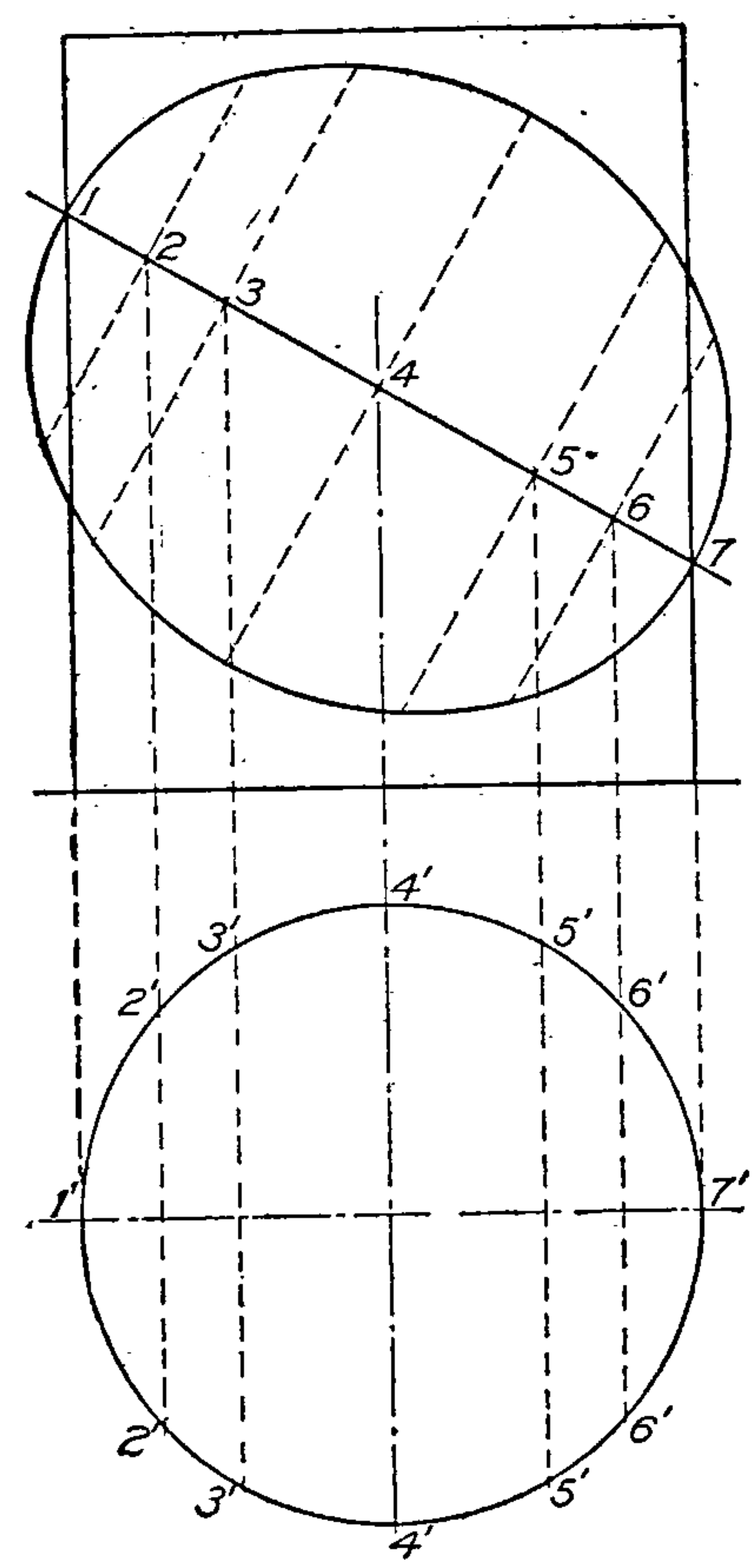


Fig 128 Ellipse—Section from a Cylinder

in a horizontal line passing through the center of the base; hence the horizontal projection of c and d will be found on this center line, and will be the extreme ends of the curve.

The plane x cuts the surface of the cone in a circle, as it is parallel to the base, and the diameter of the circle is the distance between the points where x crosses the two contour elements. This circle, lettered x on the plan, has its center at the horizontal projection of the apex. The circle x and the curve cut by the plane are both on the surface of the cone, and their vertical projections intersect at the points 2-2. Point 2 on the elevation then represents two points

3-3 on the plan show the true width of the ellipse, as these lines are parallel to H, but are projected closer together than their actual distances. In elevation these lines are shown as the points 1, 2, 3, at their true distance apart. Hence if the ellipse is revolved around its axis c^v d^v, the distances 1-1; 2-2; 3-3 may be laid off on lines perpendicular to c^v d^v, and the true size of the figure be shown.

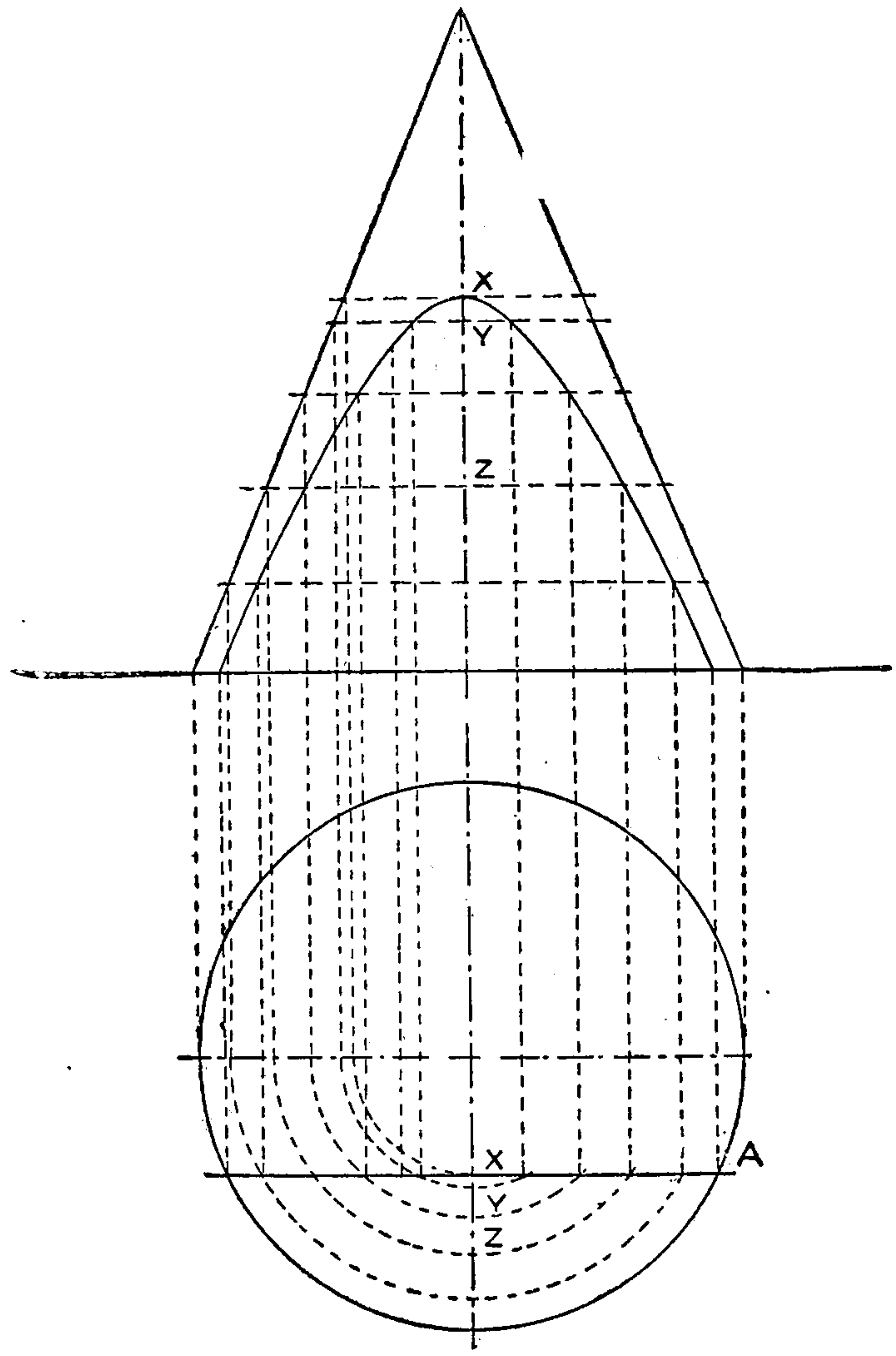


Fig 130 Hyperbola—Section from a Cone

In Fig. 128 a plane cuts a cylinder obliquely. This is a simpler case, as the horizontal projection of the curve coincides with the base of the cylinder. To obtain the true size of the section, which is an ellipse, any number of points are assumed on the plan and projected up on the cutting plane, at 1, 2, 3, etc. The lines drawn through these points perpendicular to 1′-7′ are made equal in length to the corresponding distances 2′-2′; 3′-3′; etc., on the plan, because 2′-2′ is the true width of curve at 2.

Parabola. If a cone is intersected by a plane which is parallel to only one of the elements, as in Fig. 129, the resulting curve is the *parabola,* the construction of which is exactly similar to that for the ellipse as given in Fig. 127. If the intersecting plane is parallel to more than one element, or is parallel to the axis of the cone, a hyperbola is produced.

In Fig. 130, the vertical plane A is parallel to the axis of the cone. In this instance the curve when found will appear in its true size, as plane A is parallel to the vertical. Observe that the highest point of the curve is found by drawing the circle X on the plan tangent to the given plane. One of the points where this circle crosses the diameter is projected up to the contour element of the cone, and the horizontal plane X drawn. Intermediate planes Y, Z, etc., are chosen, and corresponding circles drawn in plan. The points where these circles are crossed by the plane A are points on the curve, and these points are projected up to the elevation on the planes Y, Z, etc.

DEVELOPMENT OF SURFACES

The development of a surface is the true size and shape of the surface extended or spread out on a plane. If the surface to be developed is of such a character that it may be flattened out without tearing or folding, an exact development is obtained, as in case of a cone or cylinder, prism or pyramid. If this cannot be done, as with the sphere, the development is only approximate.

Rectangular Prism. In order to find the development of the rectangular prism in Fig. 131, the back face, 1-2-7-6, is supposed to be placed in contact with some plane, then the prism turned on the edge 2-7 until the side 2-3-8-7 is in contact with the same plane, and this process continued until all four faces have been placed on the same plane. The rectangles 1-2-3-4 and 6-7-8-5 are for the top and bottom respectively. The development then is the exact size and shape of a covering for the prism. If a rectangular hole is cut through the prism, the openings in the front and back faces will be shown in the development in the centers of the two broad faces.

The development of a right prism, then, consists of as many rectangles joined together as the prism has sides, these rectangles being the exact size of the faces of the prism, and in addition two polygons the exact size of the bases. It will be found helpful in developing a solid to number or letter all of the corners on the projections, then designate each face when developed in the same way as in the figure.

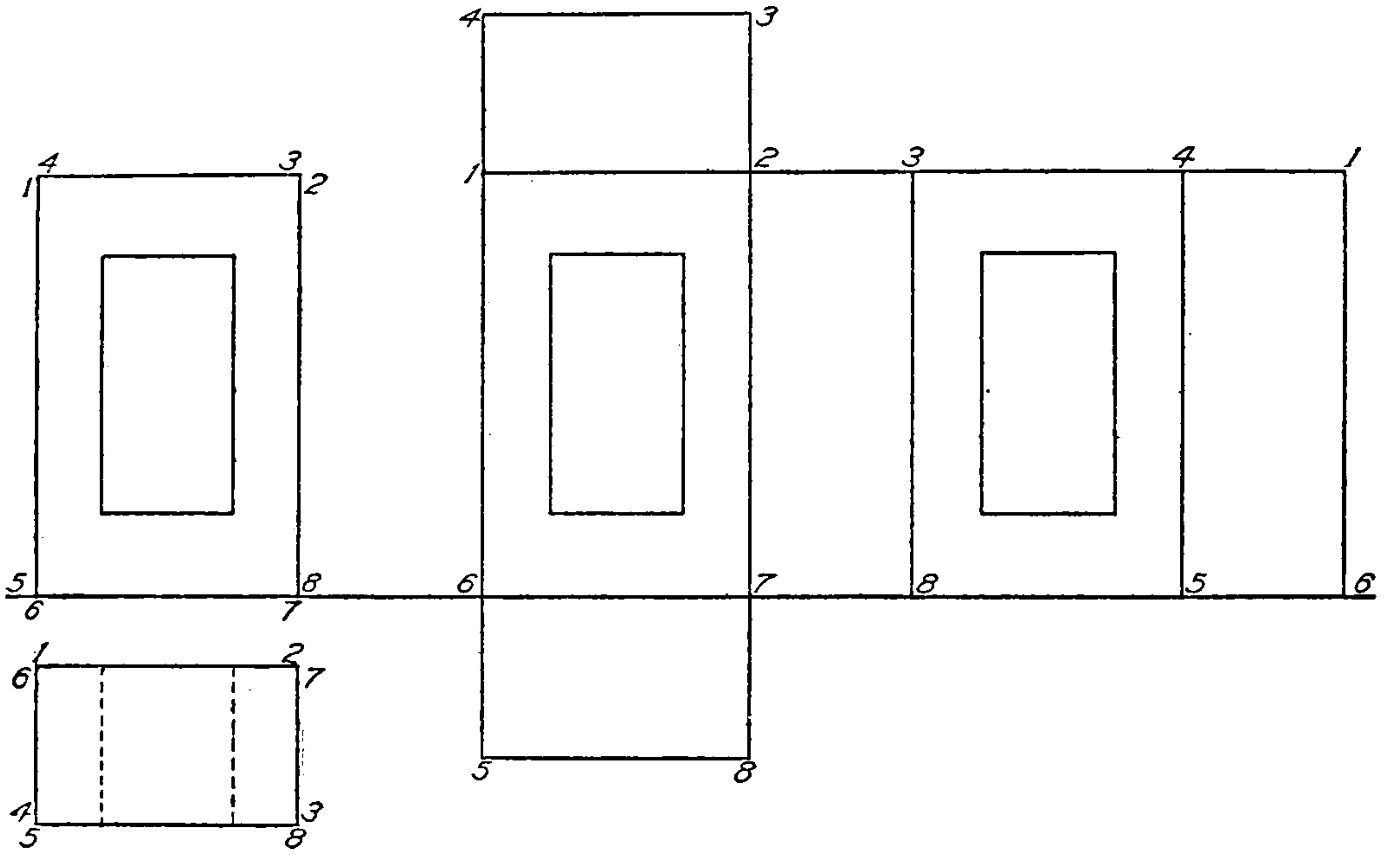


Fig 131 Development of Hollow Rectangular Prism

Cone. If a cone be placed on its side on a plane surface, one element will rest on the surface. If now the cone be rolled on the plane, the vertex remaining stationary until the same element is in

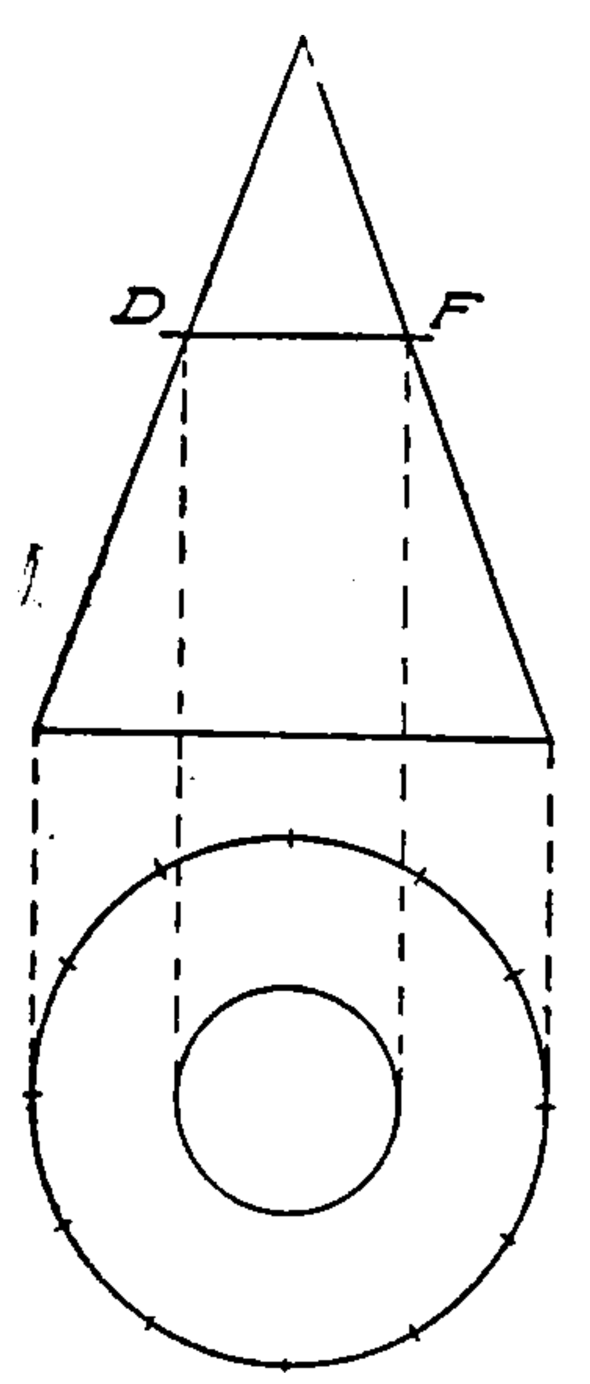


Fig 132 Plan and Elevation of Cone

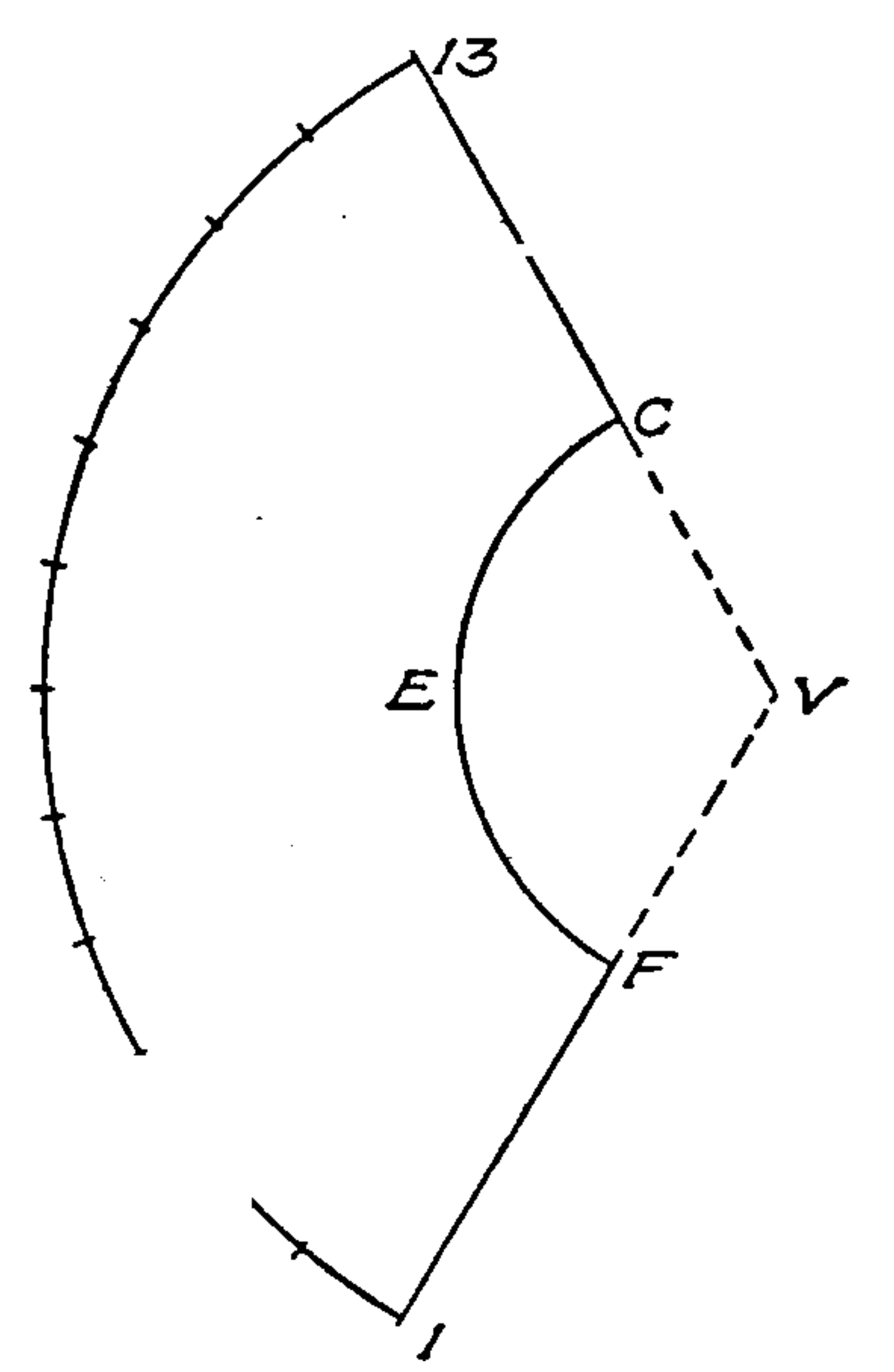


Fig 133 Development of Cone

contact again, the space rolled over will represent the development of the convex surface of the cone. Fig. 132 is a cone cut by a plane parallel to the base. In Fig. 133, let the vertex of the cone be placed

be obtained by the method given on Page 64, as indicated in Fig. 134. The triangle may now be drawn in its full size at *C* in the development, and as the pyramid is regular, two other equal triangles, *D* and *E*, may be drawn to represent the other sides. These, together with the base *F*, constitute the complete development.

Truncated Circular Cylinder. If a truncated circular cylinder is to be developed, or rolled upon a plane, the elements, being parallel, will appear as parallel lines, and the base line being perpendicular to the elements, will appear as a straight line of length equal to the circumference of the base. The base of the cylinder in Fig. 136 is

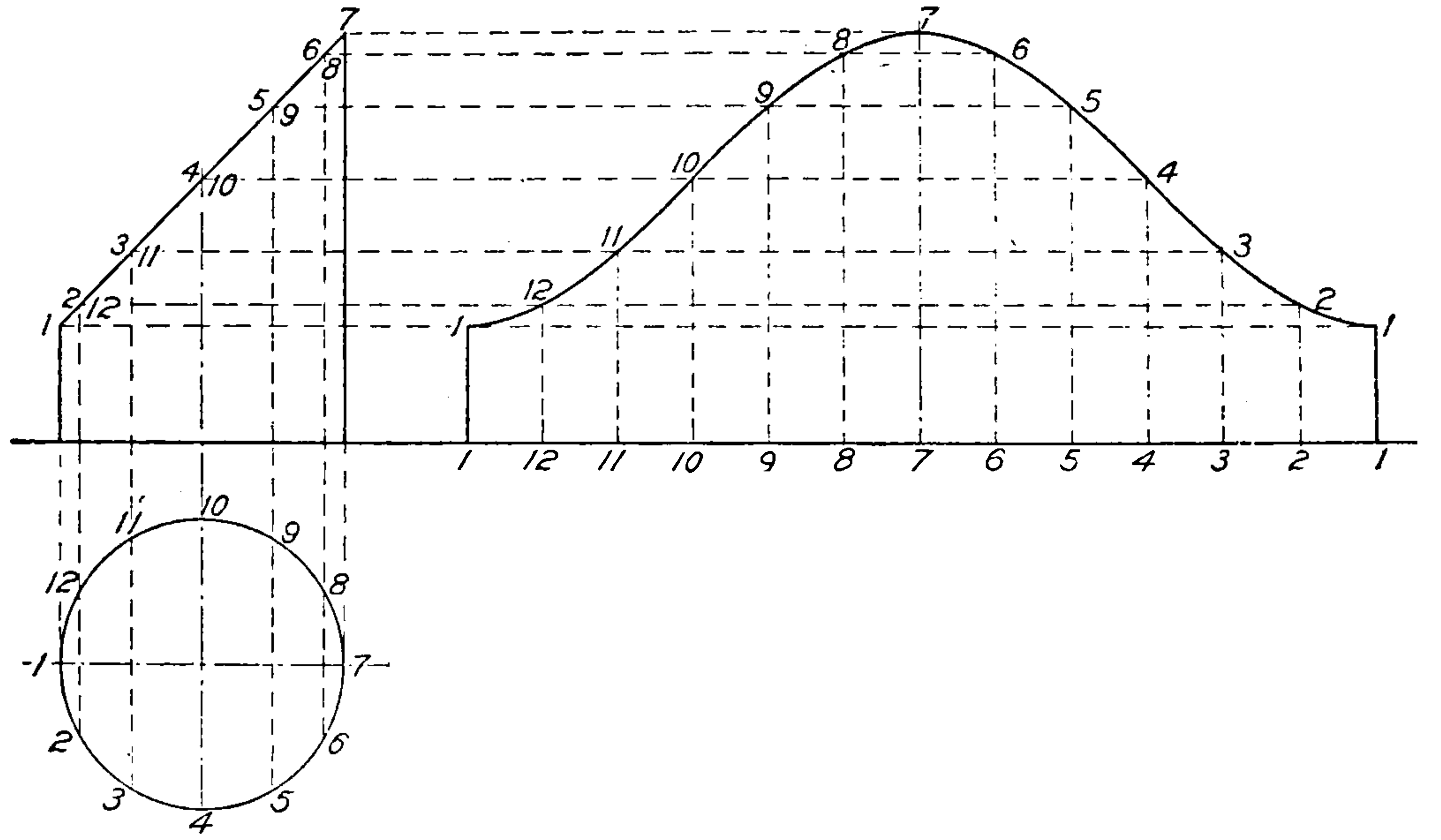


Fig 136. Projections and Development of Truncated Cylinder

divided into twelve equal parts, 1, 2, 3, etc., and commencing at point 1 on the development, these twelve equal spaces are laid off along the straight line, giving the total width.

Draw in elevation the elements corresponding to the various divisions of the base, and note the points where they intersect the oblique plane. As the cylinder is rolled beginning at point 1, the successive elements, 1, 12, 11, etc., will appear at equal distances apart, and equal in length to the lengths of the same elements in elevation. Thus point number 10 on the development is found by projecting horizontally across from 10 in elevation. It will be seen that the curve formed is symmetrical, the half on the left of 7 being similar to that on the right. The development of any similar surface may be found in the same manner.

The principle of cylinder development is used in laying out elbow joints, pipe ends cut off obliquely, etc. In Fig. 137 is shown plan and elevation of a three-piece elbow and collar, and developments of the four pieces. In order to construct the various parts making up the joint, it is necessary to know what shape and size must be marked out on the flat sheet metal so that when cut out and rolled up the three pieces will form cylinders with the ends

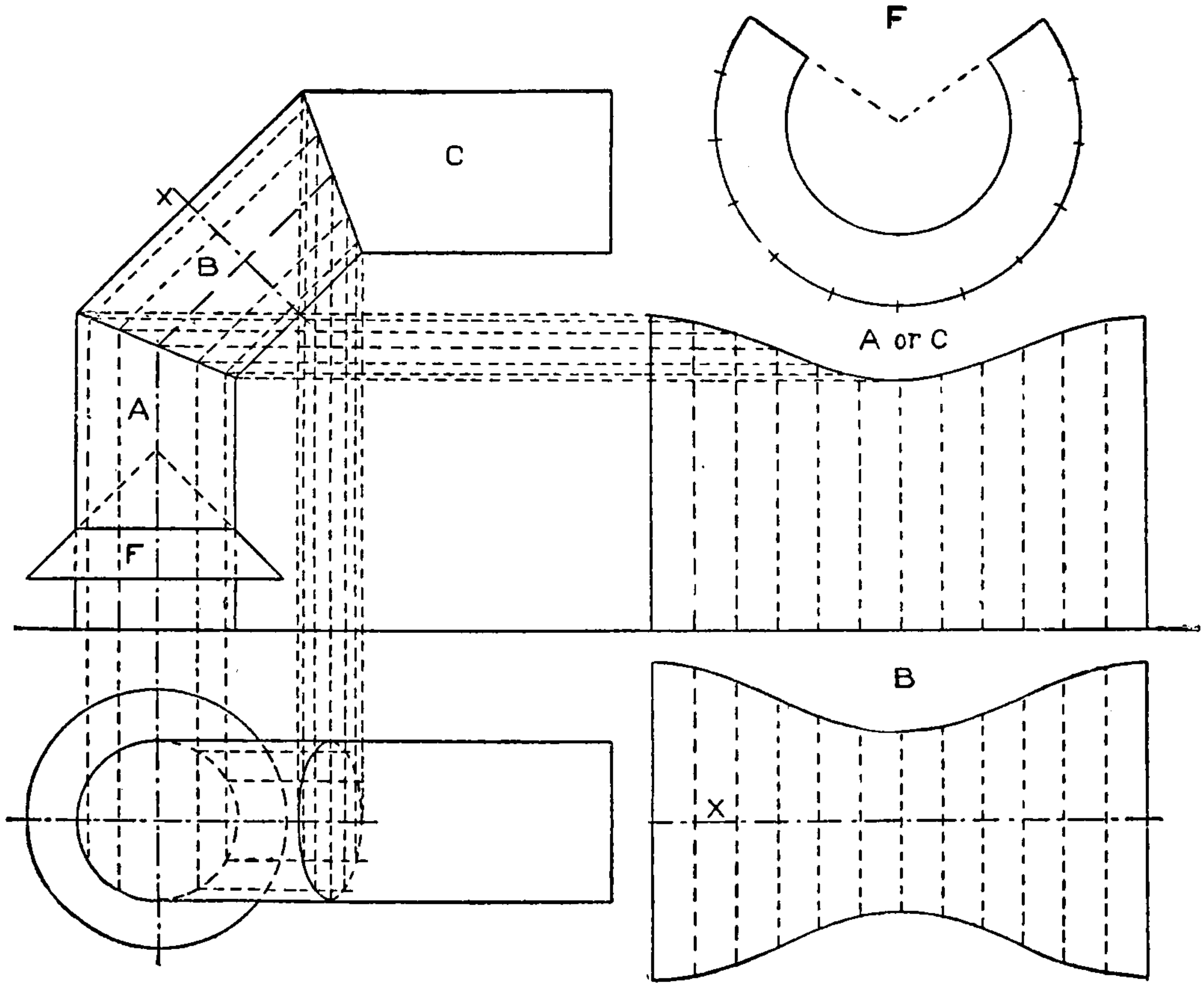


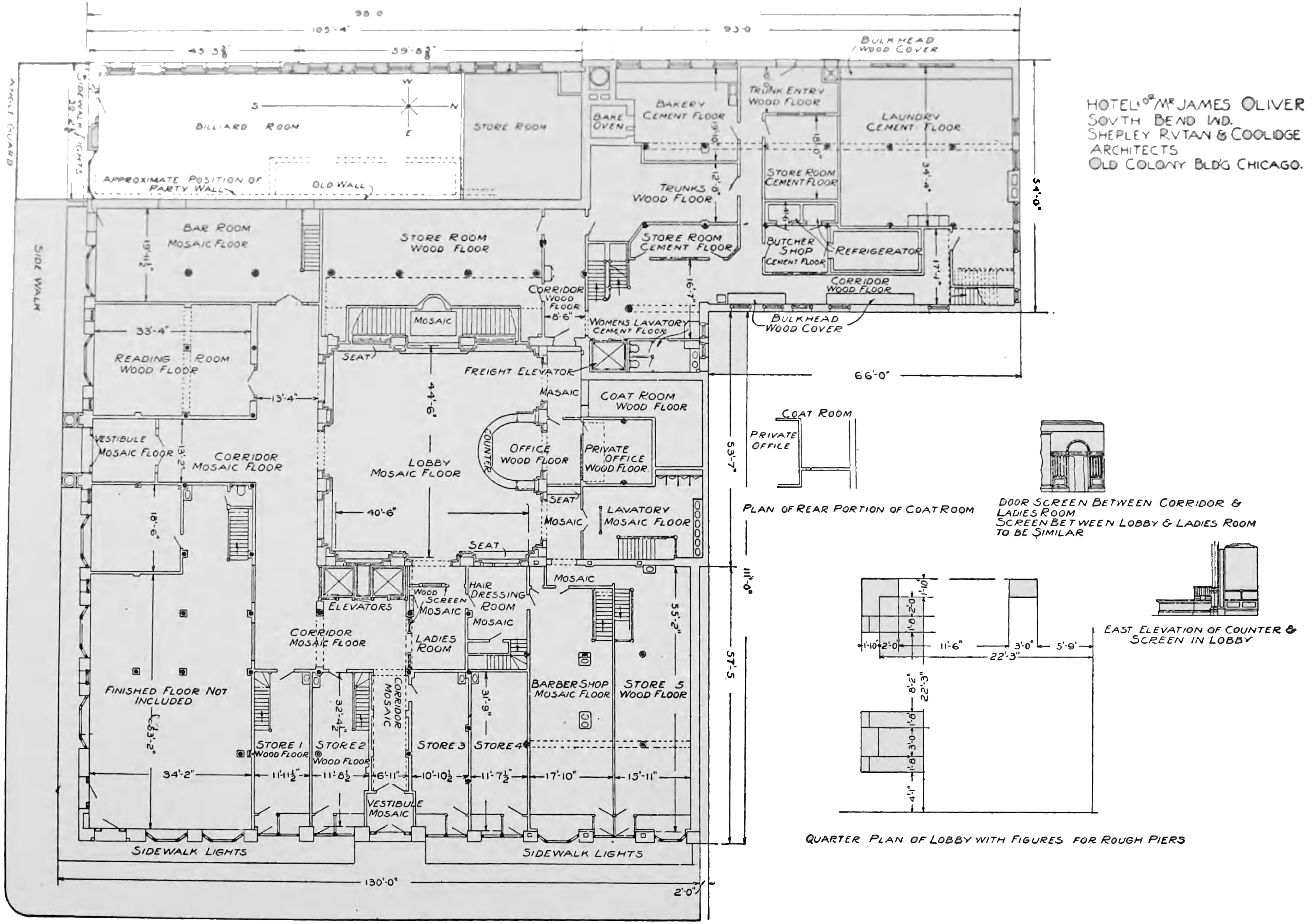
Fig. 137. Plan, Elevation, and Development of Three-Piece Elbow and Collar

fitting together as required. Knowing the kind of elbow desired, first draw the plan and elevation, and from these make the developments. Let the lengths of the three pieces A, B, and C be the same on the upper outside contour of the elbow, the piece B at an angle of 45°; the joint between A and B bisects the angle between the two lengths, and in the same way the joint between B and C. The lengths A and C will then be the same, and one pattern will answer for both. The development of A is made exactly as just explained for Fig. 136, and this is also the development of C.

It should be borne in mind that in developing a cylinder the base must always be at right angles to the elements, and if the cylinder as given does not have such a base, it becomes necessary to cut the cylinder by a plane perpendicular to the elements, and use the intersection as a base. This point must be clearly understood in order to proceed intelligently. A section at right angles to the elements is the only section which will unroll in a straight line, and is, therefore, the section from which the other sections must be developed. As *B*, Fig. 137, has neither end at right angles to its length, the plane *X* is drawn at the middle and perpendicular to the length. *B* has the same diameter as *C* and *A*, so the section cut by *X* will be a circle of the same diameter as the base of *A*, and is shown in the development at *X*.

The elements on *B* are drawn from the points where the elements on the elevation of *A* meet the joint between *A* and *B*, and are equally spaced as shown on the plan of *A*. Commencing with the left-hand element in *B*, the length of the upper element between *X* and the top corner of the elbow is laid off above *X*, giving the first point in the development of the end of *B* fitting with *C*. The lengths of the other elements in the elevation of *B* are measured in the same way and laid off from *X*. The development of the other end of the piece *B* is laid off below *X*, using the same distances, since *X* is half way between the ends. The development of the collar is simply the development of the frustum of a cone, which has already been explained, Fig. 133. The joint between *B* and *C* is shown in plan as an ellipse, the construction of which the student should be able to understand from a study of the figure.

Intersection of Rectangular Prism and Pyramid. The intersection of a rectangular prism and a pyramid is shown in Fig. 138. The base *b c d e* of the pyramid is shown dotted in plan, as it is hidden by the prism. All four edges of the pyramid pass through the top of the prism 1-2-3-4. As the top of the prism is a horizontal plane, the edges of the pyramid are shown passing through the top in elevation at x^v g^v i^v k^v. These four points might be projected to the plan on the four edges of the pyramid; but it is unnecessary to project more than one, since the general principle applies here that if a cone, pyramid, prism or cylinder be cut by a plane parallel to the base, the section is a figure parallel and similar to the base. The one point x^v is therefore projected down to *a b* in plan, giving

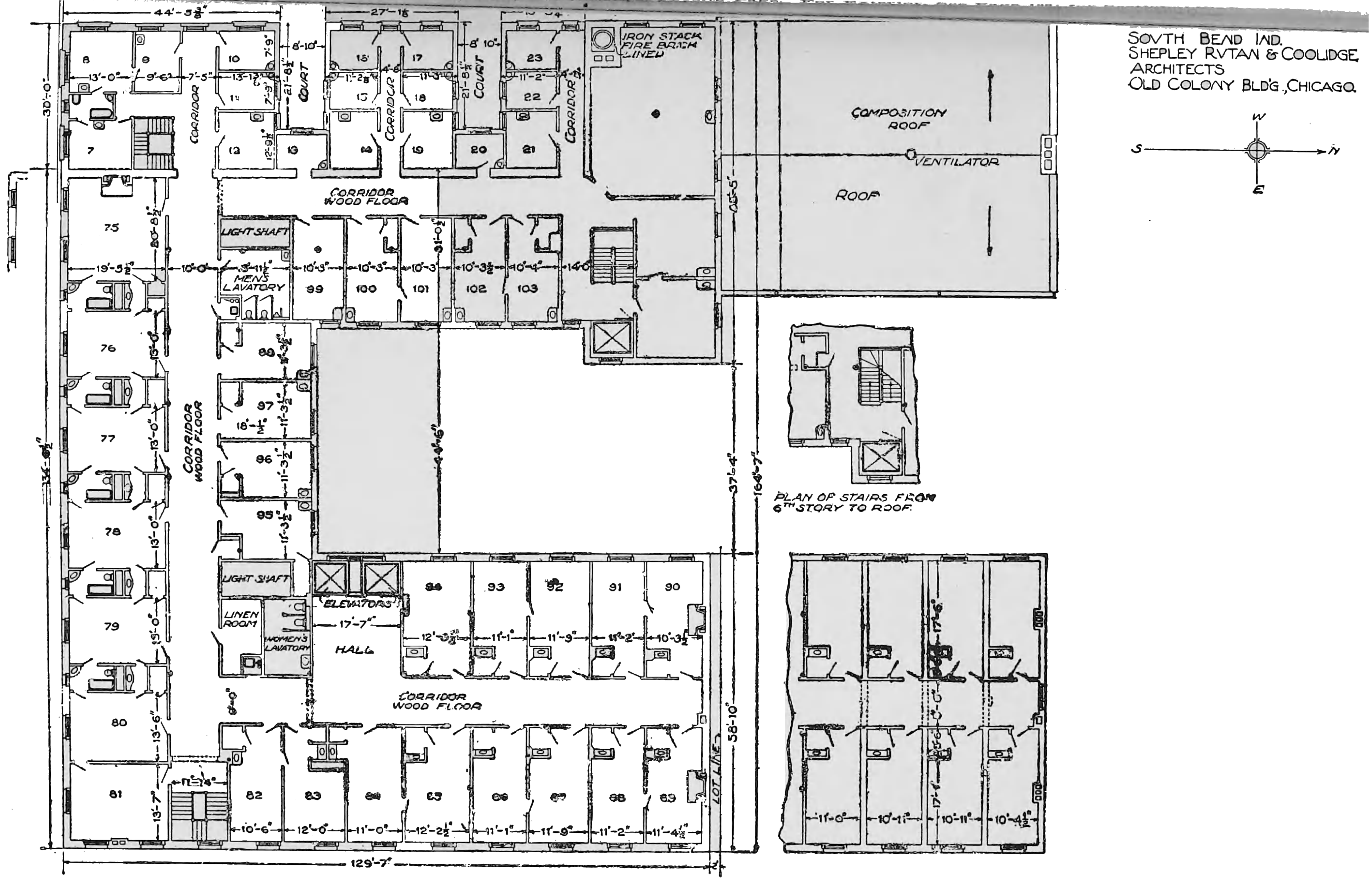


FIRST-STORY PLAN OF HOTEL, "THE OLIVER," SOUTH BEND, IND.

Shepley, Rutan & Coolidge, Architects, Chicago, Ill.

Typical Bedroom Floor Plan Shown on Opposite Page. For Exterior, See Page 138; for Sectional View

FIRST-STORY PLAN OF HOTEL, "THE OLIVER," SOUTH BEND, IND.
Shepley, Rutan & Coolidge, Architects, Chicago, Ill.



PLAN of FIFTH STORY
6TH STORY TO BE SIMILAR EXCEPT WHERE OTHERWISE SHOWN.

PLAN of N.E. PORTION of 6TH STORY
ROOMS NUMBERED FROM 106 TO 141 INCLUSIVE IN ORDER SIMILAR TO 5TH STORY
LIGHT OUTLETS THE SAME AS 5TH STORY

TYPICAL BEDROOM FLOOR PLAN OF "THE OLIVER," SOUTH BEND, IND.

Shepley, Rutan & Coolidge, Architects, Chicago, Ill.

First-Floor Plan Shown on Opposite Page. For Exterior and Main Cornice Details, See Page 138; for Sectional View and Elevation, See Page 122.

Fig. 139 is the development of the rectangular prism, showing the openings in the top and bottom surfaces through which the pyramid passed. The development of the top and the bottom, the back and the front faces will be four rectangles joined together, the same sizes as the respective faces. Commencing with the bottom face 5-6-7-8, next would come the back face 6-1-2-7, then the top, etc. The rectangles at the ends of the top face 1-2-3-4 are the ends of the prism. These might have been joined on any other face as well. Now find the development of the square in the bottom 5-6-7-8. As the size will be the same as in projection, it only remains

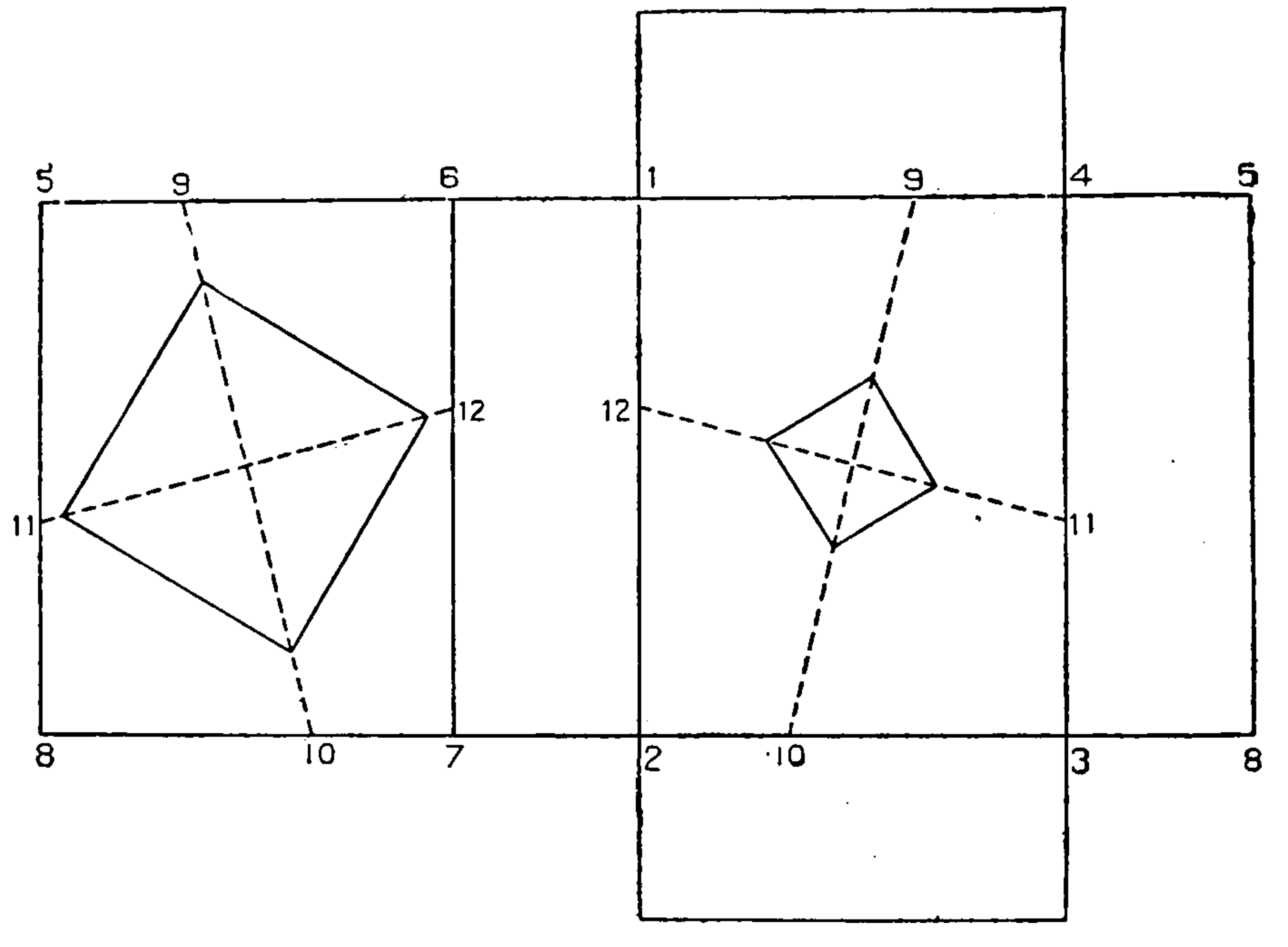


Fig 139 Development of Objects Shown in Fig 138

to determine its position. This position, however, will have the same relation to the sides of the rectangle as in the plan. The center of the square in this case is in the center of the face. To transfer the diagonals of the square to the development, extend them in plan, Fig. 138, to intersect the edges of the prism in points 9, 10, 11, and 12. Take the distance from 5 to 9 along the edge 5-6, and lay it on the development, Fig. 139, from 5 along 5-6, giving point 9. Point 10, located in the same way and connected with 9, gives the position of one diagonal. The other diagonal is obtained in a similar way, and the square is constructed on these diagonals. The same method is used for locating the small square on the top face.

Intersection of Triangular Prism and Cylinder. The intersection of a cylinder and prism is found by obtaining the points where elements of the cylinder pierce the prism, or where edges and lines parallel to edges on the surface of the prism cut the cylinder.

A series of parallel planes may also be taken cutting curves from the cylinder and straight lines from the prism; the intersections give points on the intersection of the two solids.

Fig. 140 represents a triangular prism intersecting a cylinder. The axis of the prism is parallel to V and inclined to H. Starting

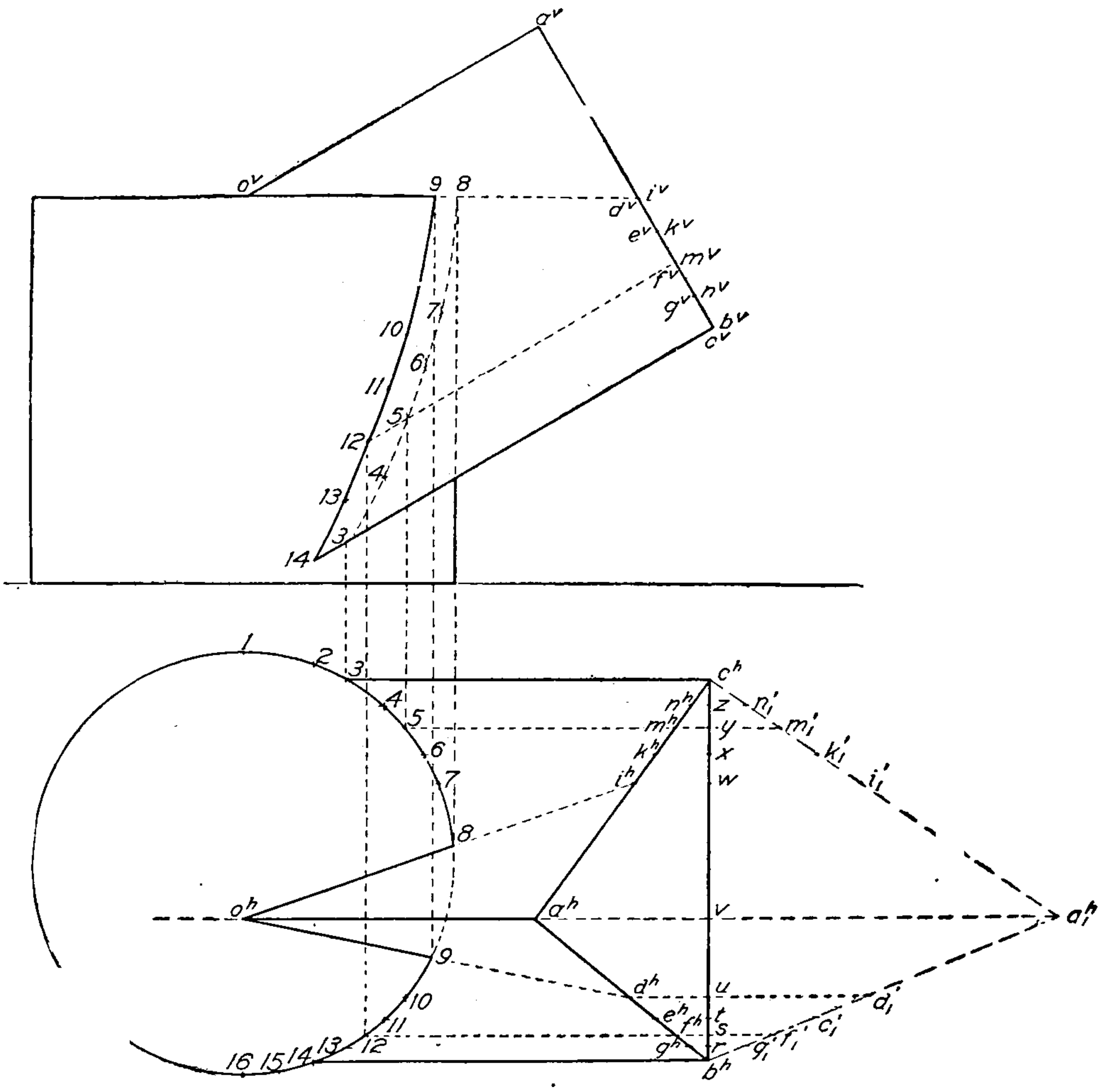


Fig 140 Plan and Elevation of Intersection of Cylinder and Triangular Prism

with the size and shape of the base, this is laid off at a_1^h b^h c^h, and the altitude of the triangle is taken and laid off at a^v c^v in elevation, making right angles with the inclination of the axis to H. The plan of the prism is then constructed. To find the intersection of the two solids, lines are drawn on the surface of the prism parallel to the length and the points where these lines and the edges pierce the cylinder are obtained and joined, giving the curve.

The top edge of the prism goes into the top of the cylinder. This point will be shown in elevation, since the top of the cylinder is a plane parallel to H and perpendicular to V, and therefore projected on V as a straight line. The upper edge, then, is found to pass into the top of the cylinder at point o^v and o^h. The intersection of the two upper faces of the prism with the top of the cylinder will be straight lines drawn from point o and will be shown in plan. If a point can be found where another line of the surface $o\ a\ b$ 14 pierces the upper base of the cylinder, this point joined with o will determine the intersection of this face with the top of the cylinder. A surface may always be produced, if necessary, to find an intersection.

Edge $a\ b$ pierces the plane of the top of the cylinder at point d, shown in the elevation; therefore the line joining this point with o is the intersection of one upper face of the prism with the upper base of the cylinder. The only part of this line needed, of course, is within the actual limits of the base, that is, o 9. The intersection o 8 of the other top face is found by the same method. On the convex surface of the cylinder there will be three curves, one for each face of the prism. Points 8 and 9 on the upper base of the cylinder, will be where the curves for the two upper faces will begin. The point d is found on the revolved position of the base at d_1, and $d_1\ b$ is divided into the equal parts $d_1 - e_1$, $e_1 - f_1$, etc., which revolve back to d^h, e^h, f^h, and g^h. The divisions are made equal merely for convenience in developing. The vertical projections of d, e, etc , are found on the vertical projection of $a\ b$, directly above d^h, e^h, etc., or may be found by taking from the revolved position of the base, the perpendiculars from $d_1\ e_1$, etc., to $c^h\ b^h$ and laying them off in elevation from b^v along $b^v\ a^v$. Lines such as f 12, m 5, etc., parallel to $a\ o$ are drawn in plan and elevation. Points i^h, k^h, m^h, n^h are taken directly behind d^h, e^h, f^h, g^h, hence their vertical projections coincide. Points n_1, m_1, k_1, and i_1 are formed by projecting across from n^h, m^h, k^h, and i^h.

The convex surface of the cylinder is perpendicular to H, so the points where the lines on the prism pierce it will be projected on plan as the points where these lines cross the circle, 14, 13, 12,

hand end to its intersection with the cylinder, beginning at the left with the top edge *a o*, the straight line *a b c a* being the base in the development. As this must be the actual distance around the base, the length is taken from the true size of the base $a_1^h\ b^h\ c^h$, in Fig. 140.

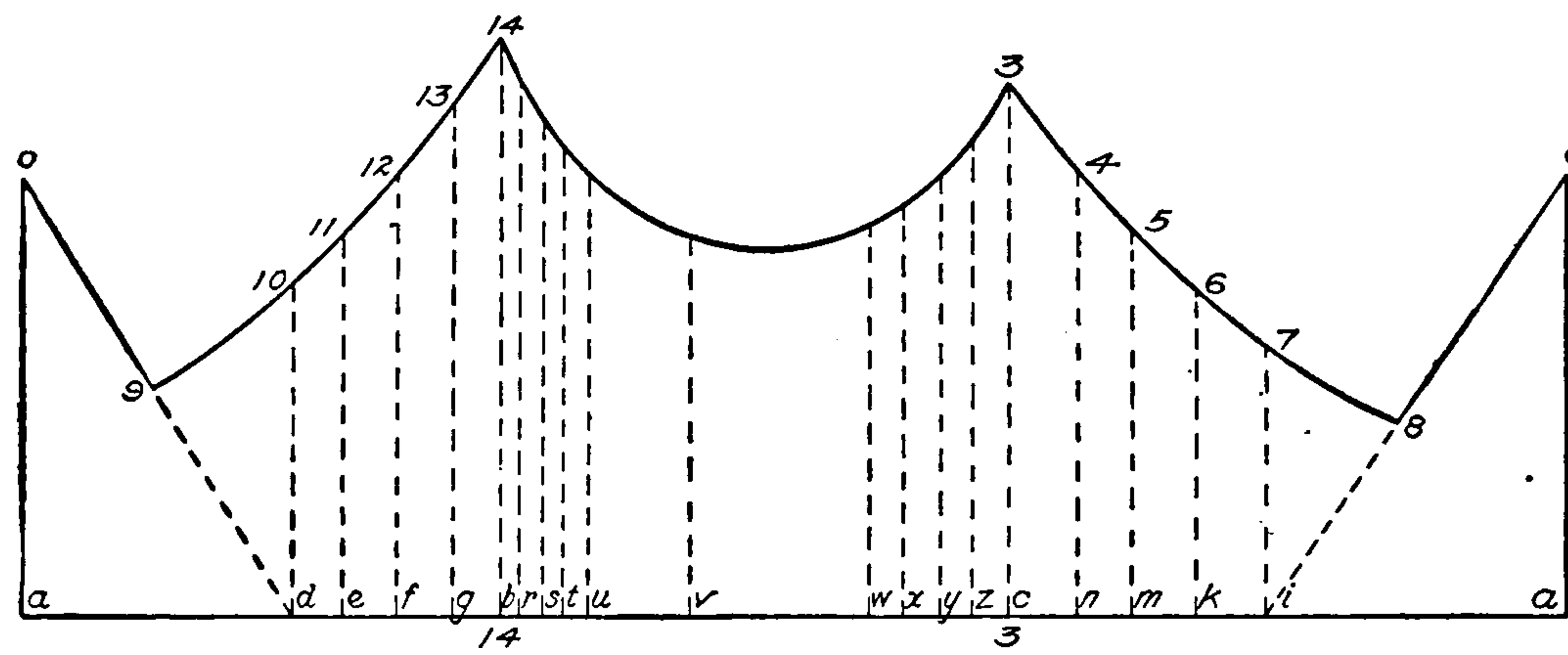


Fig 142. Development of Prism Shown in Fig 140

The parallel lines drawn on the surfaces of the prism must appear on the development their true distances apart, hence the distances $a_1^h\ d_1'$, $d_1'\ e_1'$, etc., are made equal to *a d*, *d e*, etc., on the development. The actual distances between the parallel lines on the bottom face of the prism are shown along the edge of the base $b^h\ c^h$ in Fig. 140. Perpendicular lines are drawn from the points of division on the development.

The position of the curve is found by laying off the true lengths on the perpendiculars. These true lengths (of the parallel lines) are not shown in plan, as the lines are not parallel to the horizontal plane, but are found in elevation. The length *o a* on the development is equal to $a^v\ o^v$, the length *d* 10 is equal to d^v 10, and so on for all the rest. Point 9 is found as follows: on the projections, the straight line from *o* to *d* passes through point 9, and the true distance from *o* to 9 is shown in plan. All that is necessary, then, is to connect *o* and *d* on the development, and lay off from *o* the distance $c^h 9$ Point 8 is found in the same way.

ISOMETRIC PROJECTION

In orthographic projection an object has been represented by two or more projections; another system, called *isometrical drawing*, is often used to show in one view the three dimensions of an object, length (or height), breadth, and thickness. An isometrical drawing of an object, as a cube, is called for brevity the *isometric* of the cube.

To obtain a view which shows the three dimensions in such a way that measurements may be taken from them, draw the cube in the simple position shown at the left, Fig. 143, in which it rests on *H* with two faces parallel to *V;* the diagonal from the front upper right-hand corner to the back lower left-hand corner is indicated by the dotted line. Swing the cube around until the diagonal is parallel with *V* as shown in the second position. Here the front face is at the right. In the third position the lower end of the diagonal has been raised so that it is parallel to *H*, becoming thus parallel to both planes. The plan is found by the principles of projection, from the elevation and the preceding plan. The front face is now the lower of the two faces shown in the elevation. From this position the cube is swung around, using the corner resting on *H* as a pivot, until the diagonal is perpendicular to *V* but still parallel to *H*. The plan remains the same, except as regards position; while the elevation, obtained by projecting across from the previous elevation, gives the isometrical projection of the cube. The front face is now at the left.

In the last position, as one diagonal is perpendicular to *V*, it follows that all the faces of the cube make equal angles with *V*, hence

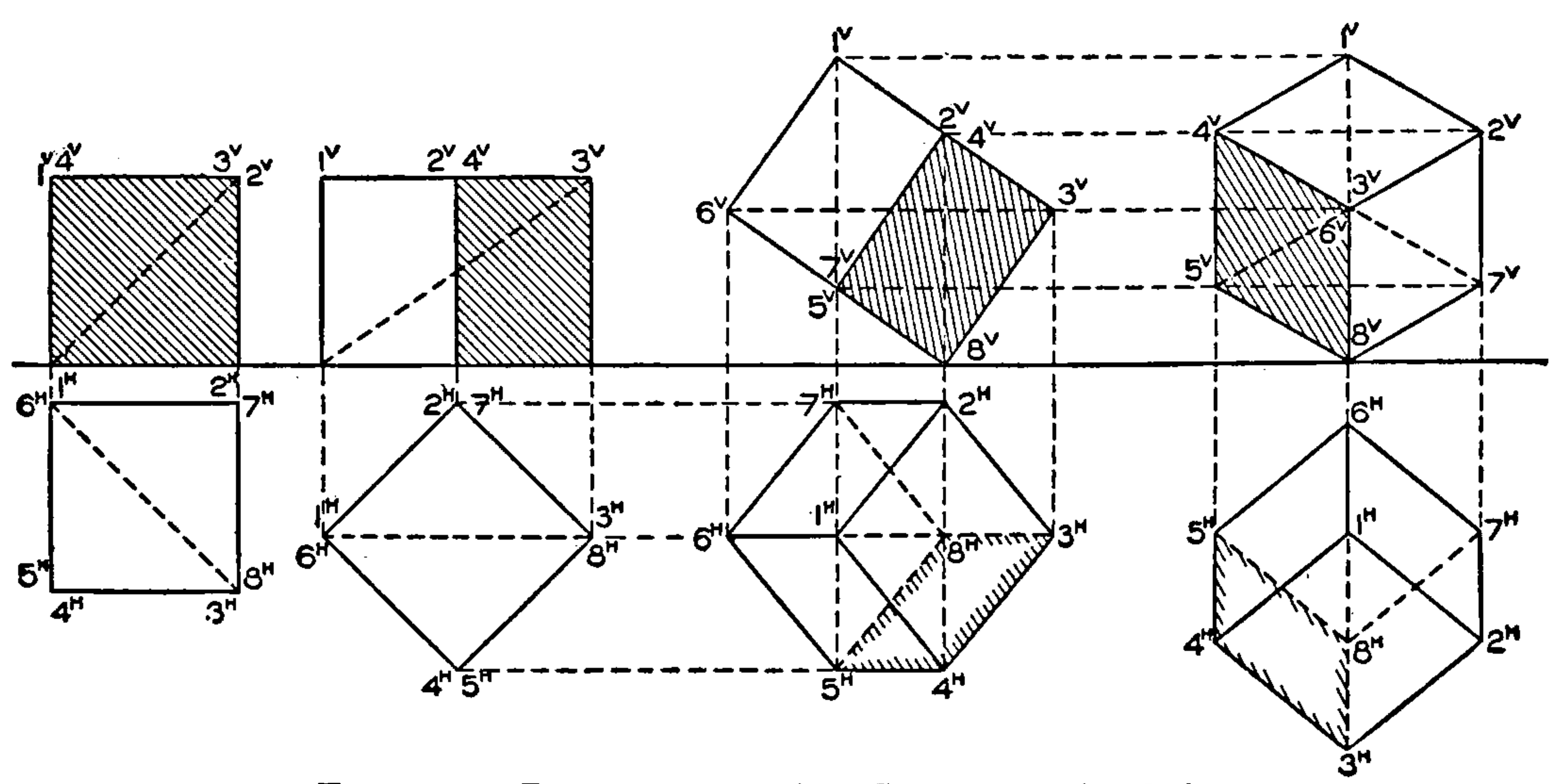


Fig 143 Development of an Isometric of a Cube

are projected on that plane as equal parallelograms. For the same reason all the edges of the cube are projected in elevation in equal lengths, but, being inclined to *V*, appear shorter than they actually are on the object. Since they are all equally foreshortened and since a drawing may be made at any scale, it is customary to make all the isometrical lines of a drawing full length. This will give the same proportions, and is much the simpler method. Herein lies the distinction between an isometric projection and an isometric drawing.

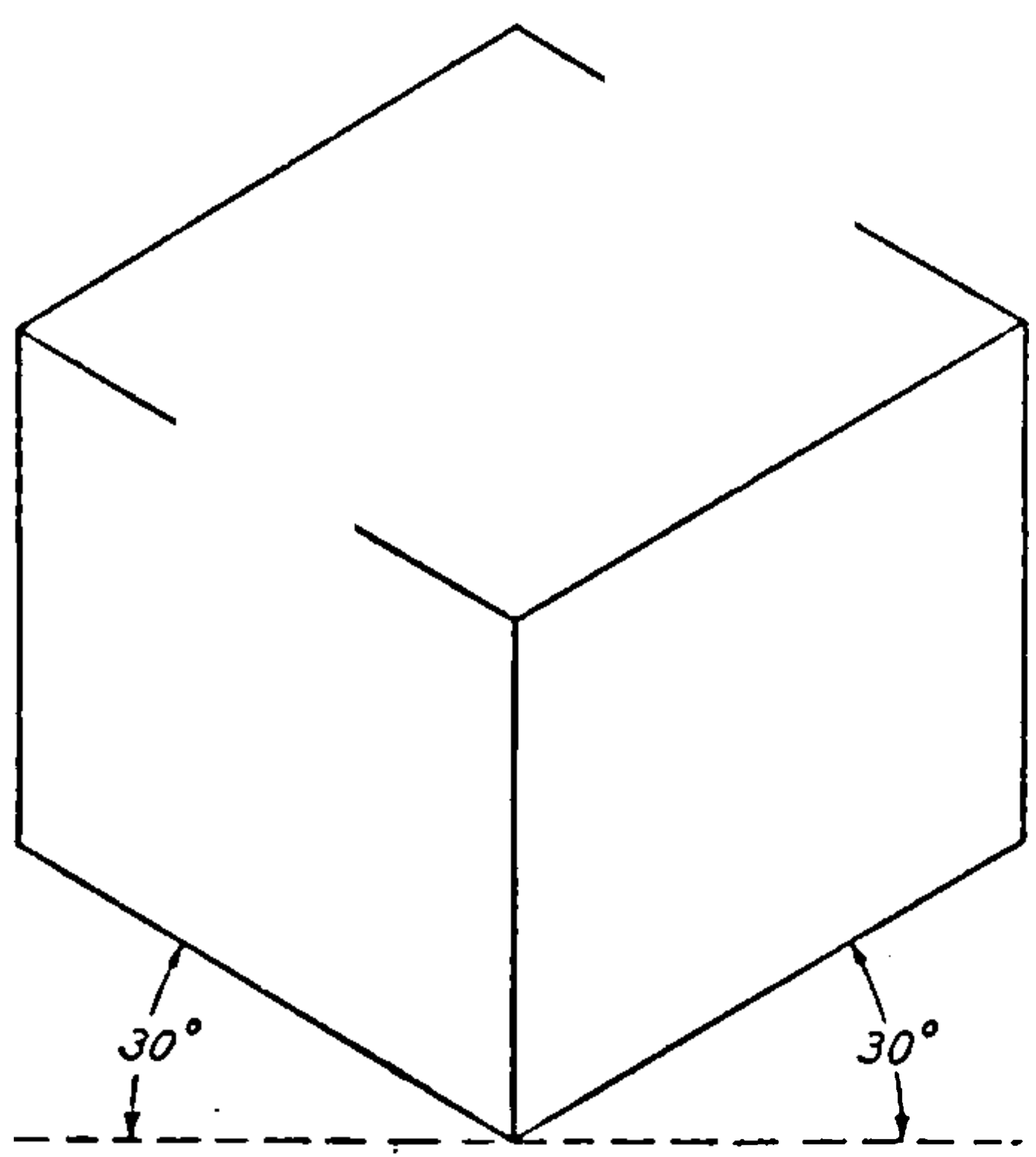


Fig 144 Isometric of a Cube

It will be noticed that the figure may be inscribed in a circle, and that the outline is a perfect hexagon. Hence the lines showing breadth and length are 30° lines, while those showing height are vertical.

Fig. 144 shows the isometric of a cube 1 inch square. All of the edges are shown in their true length, hence all the surfaces appear of the same size. In the figure the edges of the base are inclined at 30° with a T-square line, but this is not always the case For rectangular objects, such as prisms,

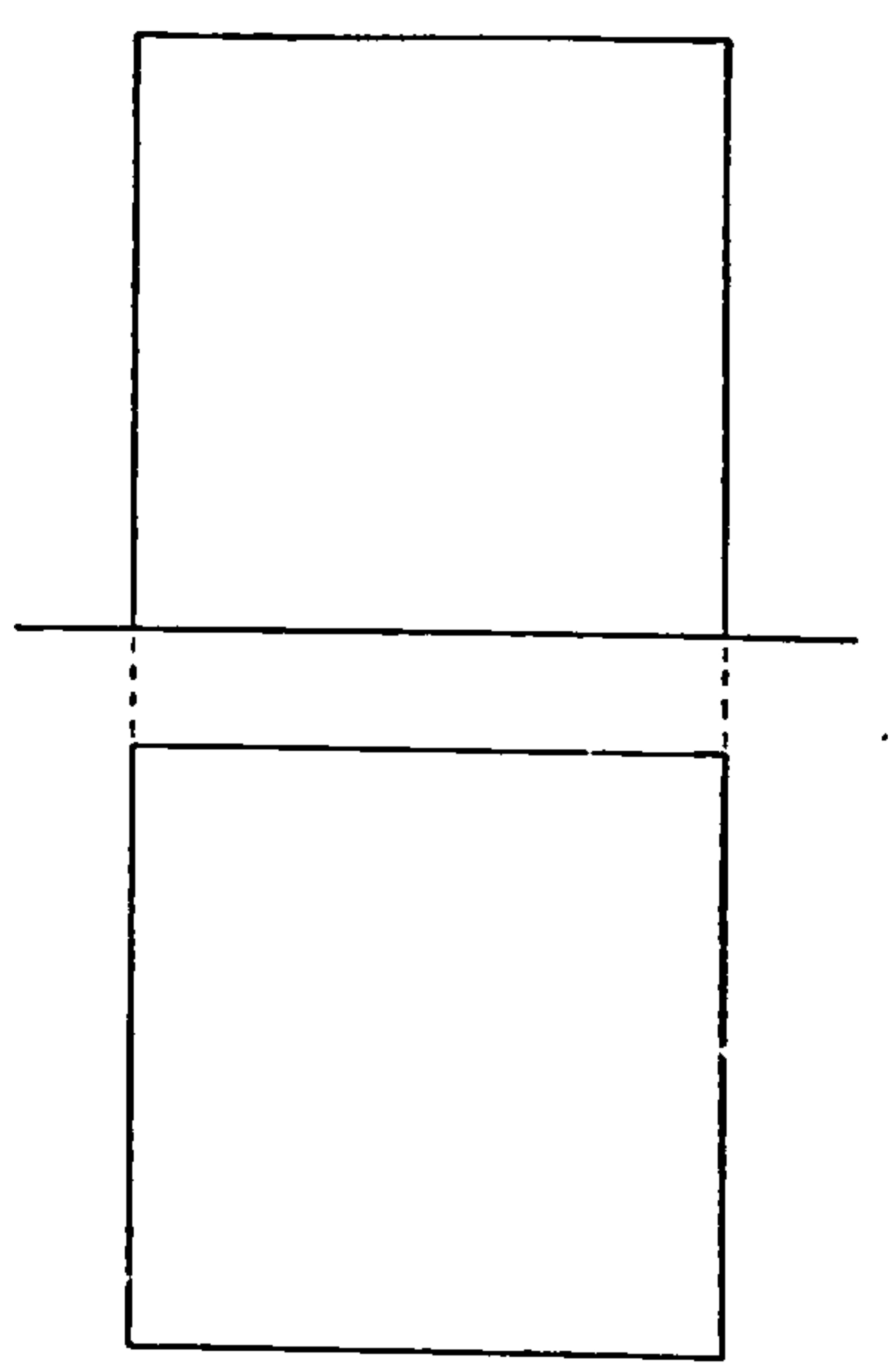


Fig 145 Plan and Elevation of a Cube

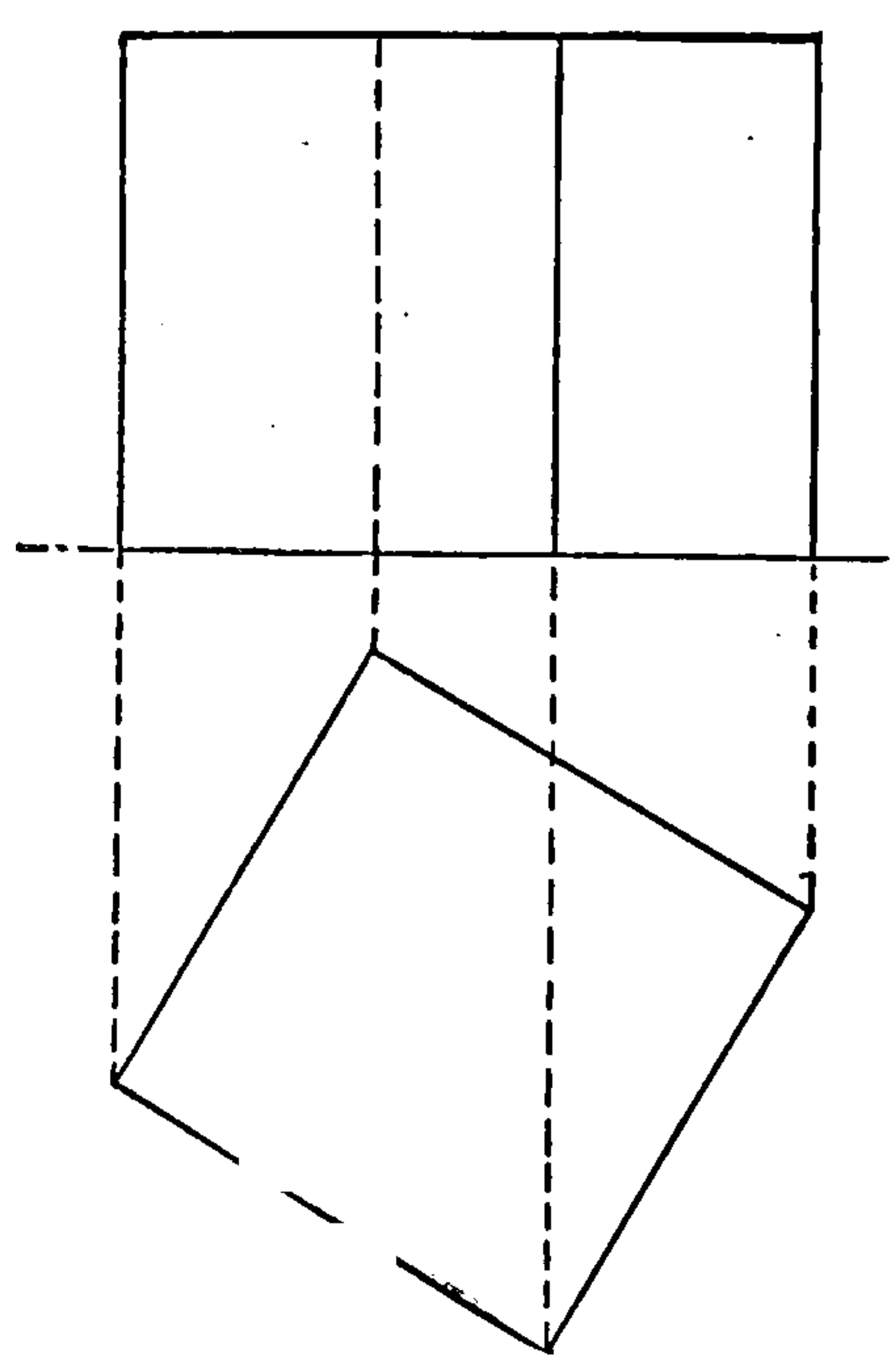


Fig 146 Cube of Fig 145 Rotated 30° with Vertical Plane

cubes, etc , the base edges are at 30° only when the prism or cube is supposed to be in the simplest possible position. The cube in Fig 144 is supposed to be in the position indicated by plan and

a d is drawn, and with *f* as center and radius *f d*, the arc *d c* is drawn; the ellipse is finished by using centers *h* and *e*. This construction is applied to all three faces.

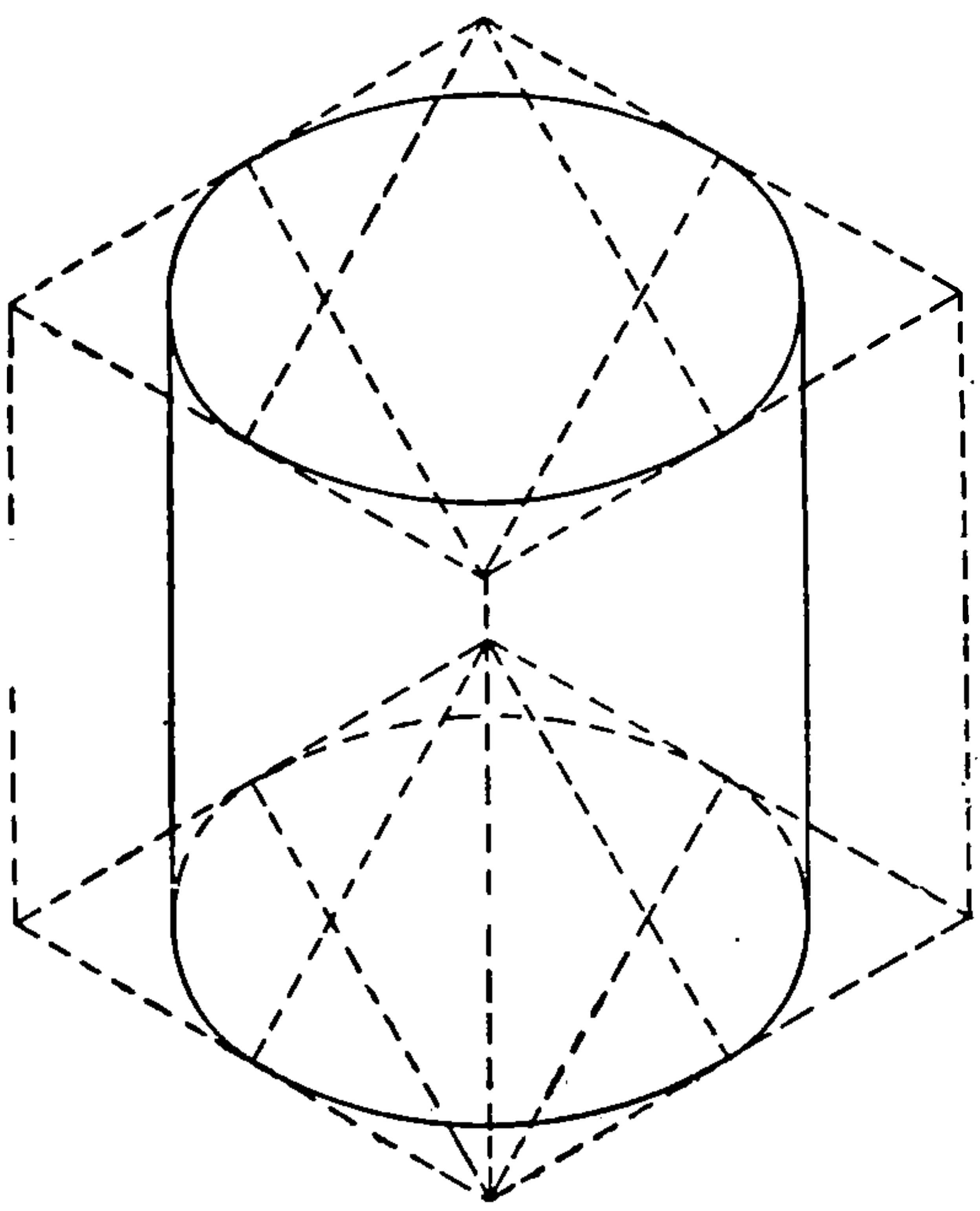


Fig 148 Isometric of a Cylinder

Fig. 148 is the isometric of a cylinder standing on its base.

Fig. 149 represents a block with smaller blocks projecting from three faces.

Fig. 150 shows a framework of three pieces, two at right angles and a slanting brace. The horizontal piece is mortised into the upright, as indicated by the dotted lines.

In Fig. 151 the isometric outline of a house is represented, showing a dormer window and a partial hip roof; *a b* is a hip rafter, *c d* a valley. Let the pitch of the main roof be shown at *B*, and let *m* be the middle point of the top of the end wall of the house. Then, by measuring vertically up a distance *m l* equal to the vertical height

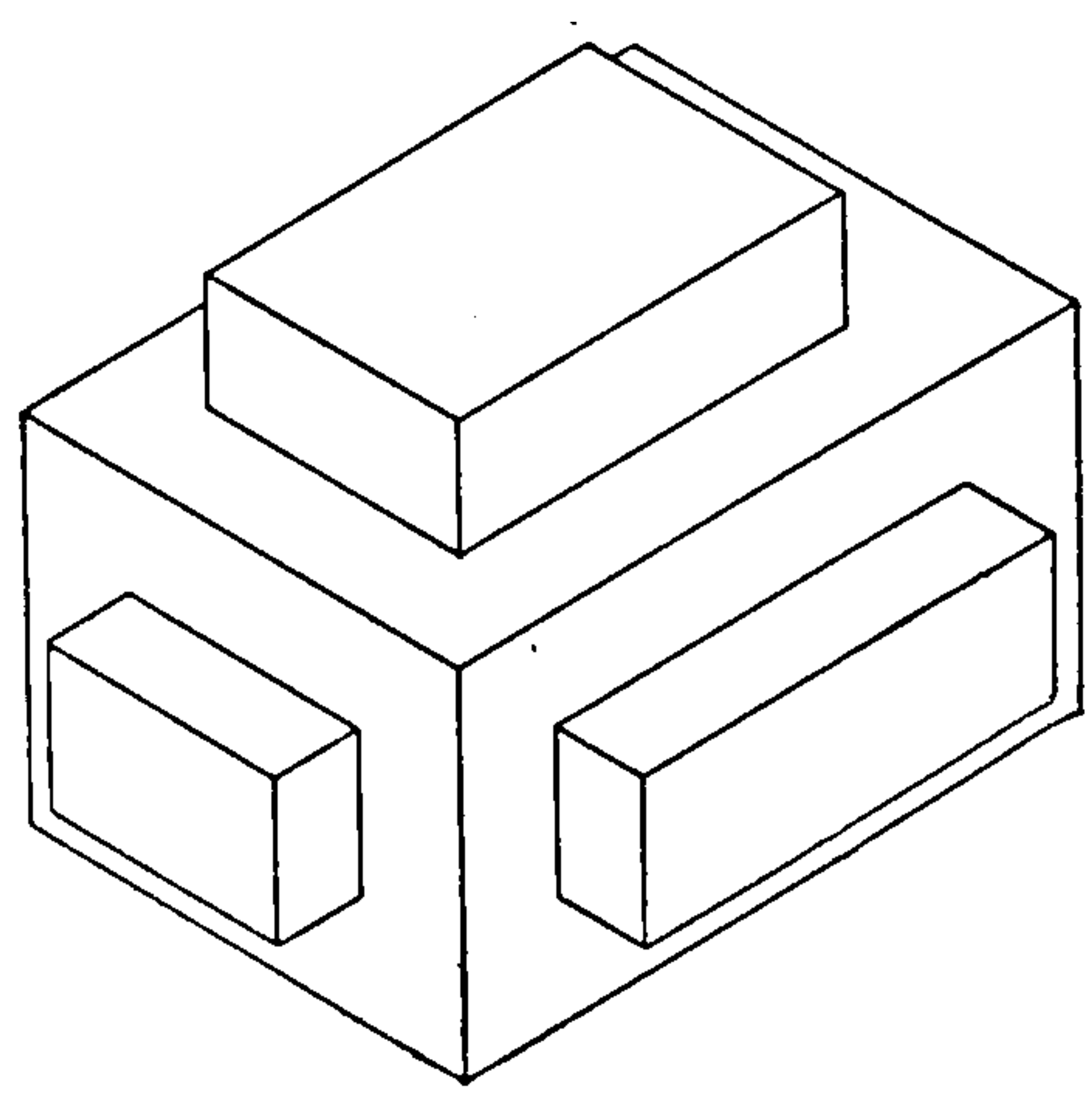


Fig. 149 Isometric of a Wooden Block

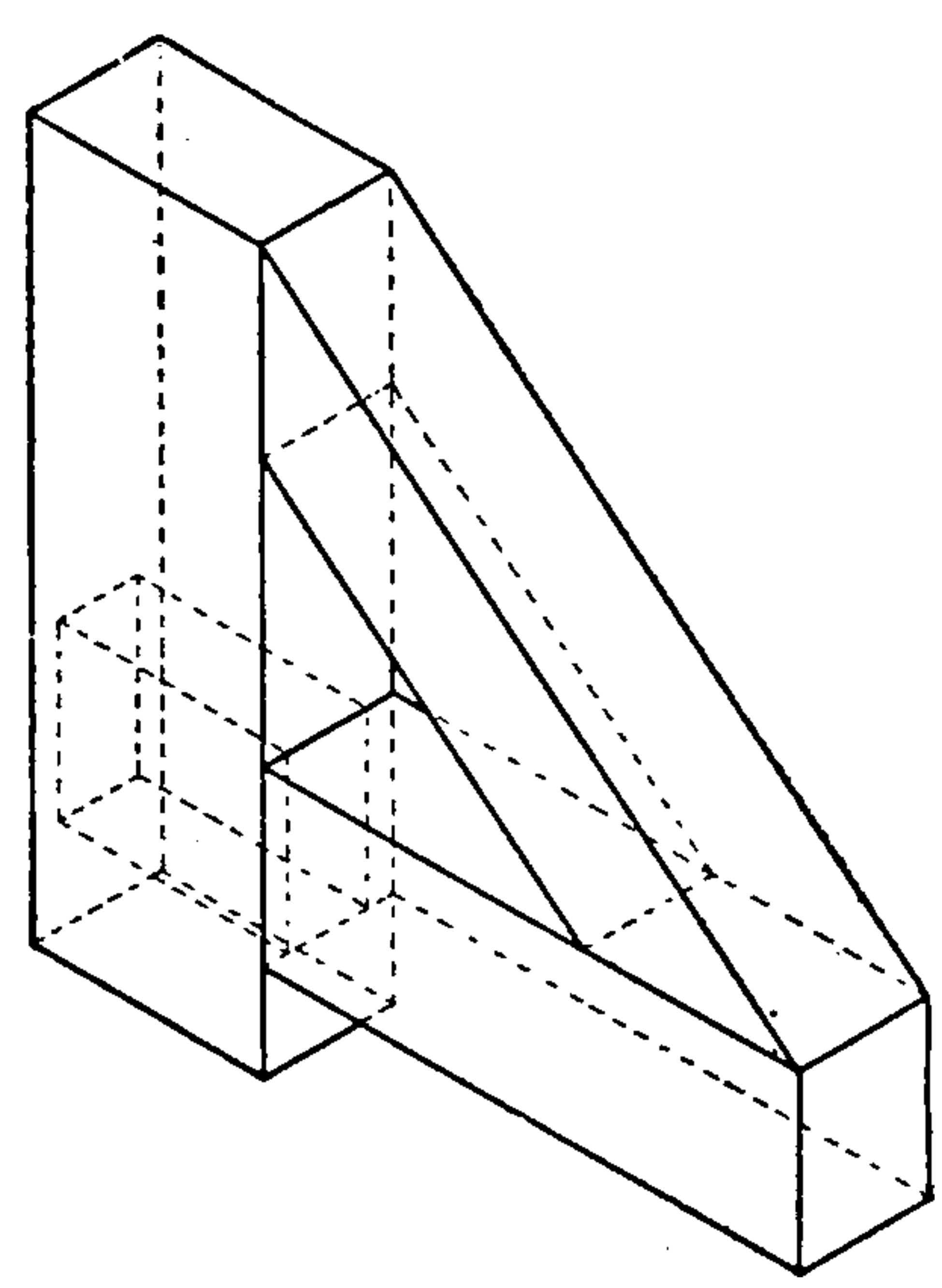


Fig 150 Isometric of a Wooden Brace

a n shown at *B*, a point on the line of the ridge will be found at *l*. Line *l i* is equal to *b h*, and *i h* is then drawn. Let the pitch of the end roof be given at *A*. This shows that the peak of the roof,

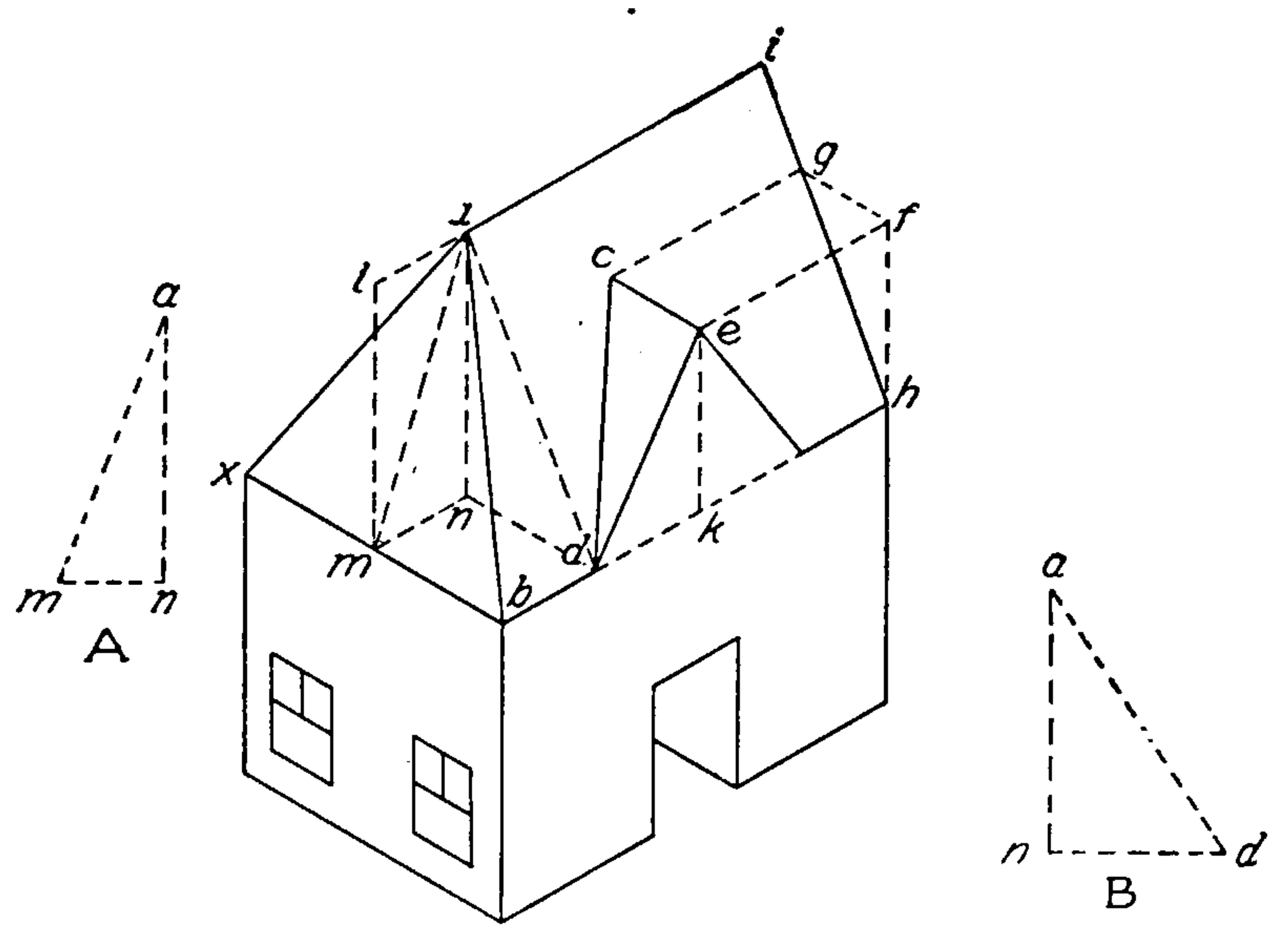


Fig. 151. Isometric Outline of a House

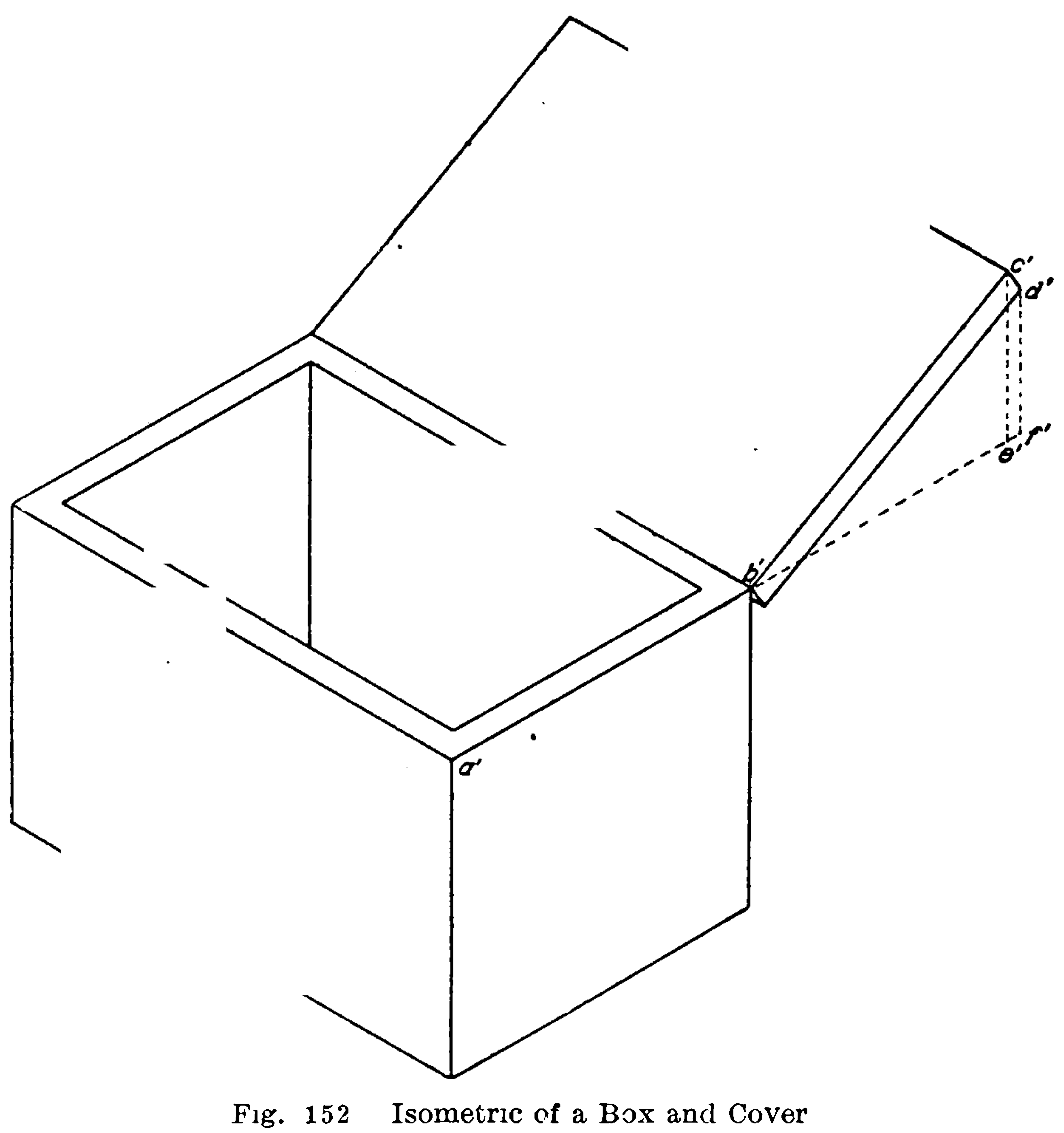


Fig. 152 Isometric of a Box and Cover

or the end *a* of the ridge, will be back from the end wall a distance equal to the base of the triangle at *A*. Hence, lay off from *l* this distance, giving point *a*, and join *a* with *b* and *x*.

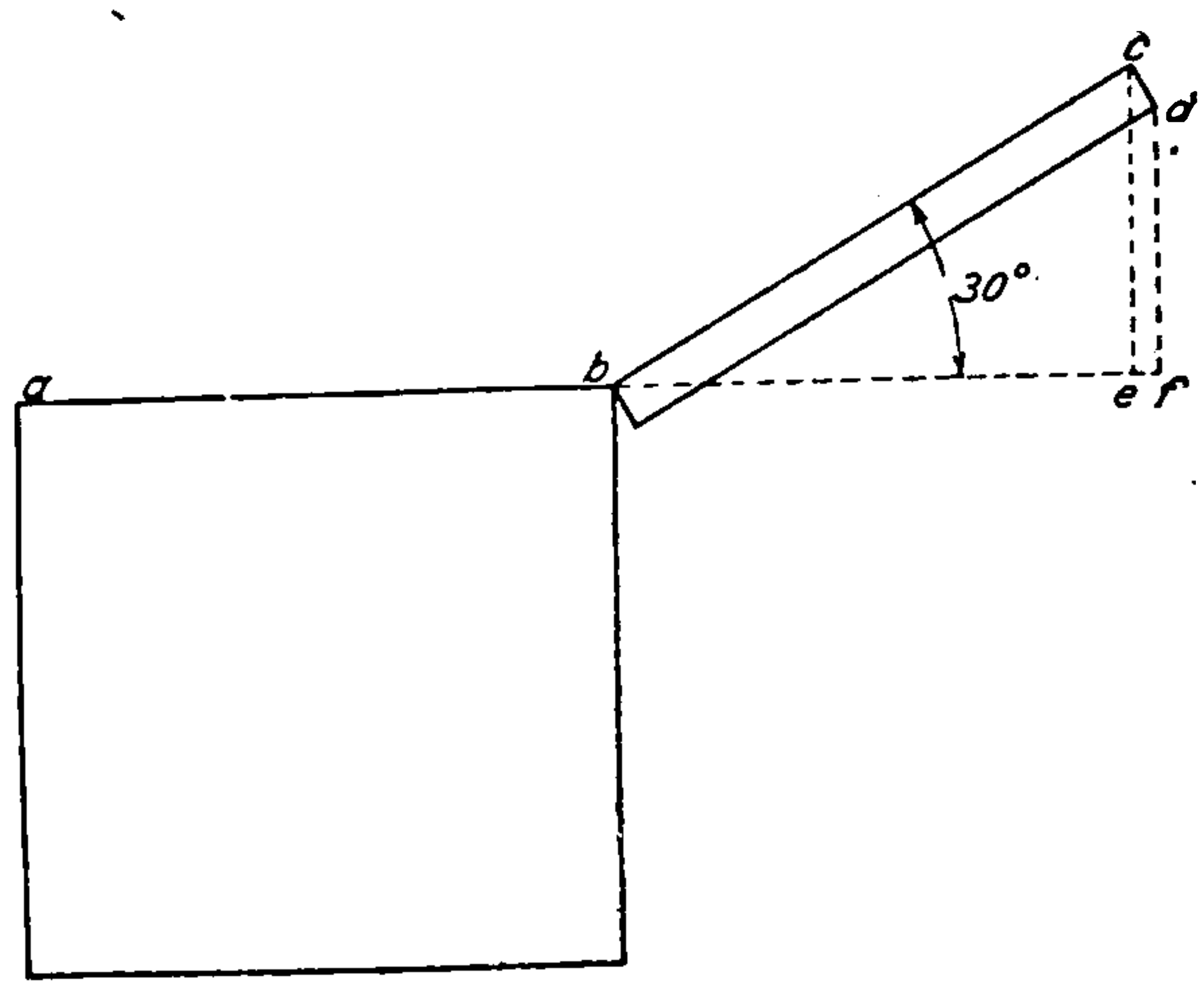


Fig 153 End View of Box Shown in Fig. 152

The height *k e* of the ridge of the dormer roof is known, and it must be found where this ridge will meet the main roof. The ridge must be a 30° line as it runs parallel to the end wall of the house and to the ground. Draw from *e* a line parallel to *b h* to meet a vertical through *h* and *f*. This point is in the vertical plane of the end wall of the house, hence in the plane of *i h*. If now a 30° line be drawn from *f* parallel to *x b*, it will meet the roof of the house at *g*. The dormer ridge and *f g* are in the same horizontal plane, hence will meet the roof at the same distance below the ridge *a i*. Therefore draw the 30° line *g c*, and connect *c* with *d*.

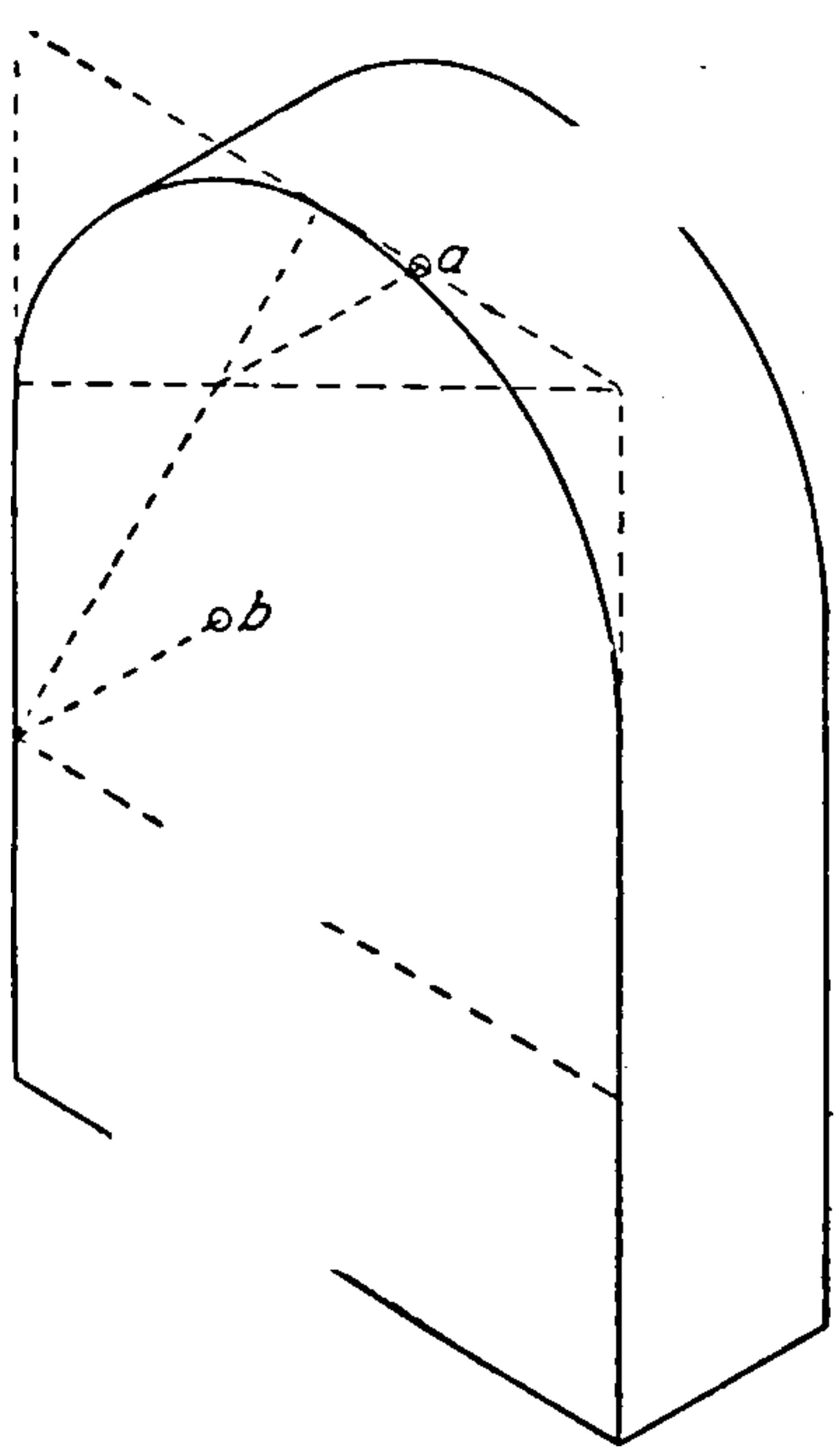


Fig 154 Isometric of a Prism with Semicircular Top

In Fig. 152 a box is shown with the cover opened through 150°. The right-hand edge of the bottom shows the width, the left-hand edge shows the length and the vertical edge shows the height. The short edges of the cover are not isometric lines, hence are not shown in their true lengths; neither is the angle through which the cover is opened represented in its actual size.

The corners of the cover must then be determined by co-ordinates from an end view of the box and cover. As the end of the cover is in the same plane as the end of the box, the simple end view as shown in Fig 153 will be sufficient. Extend the top of the box to the right, and from *c* and *d* let fall perpendiculars on *a b* produced, giving the points *e* and *f*. The point *c* may be located by means

mate method. The centers for the back face are found by projecting the front centers back 30° equal to the thickness of the

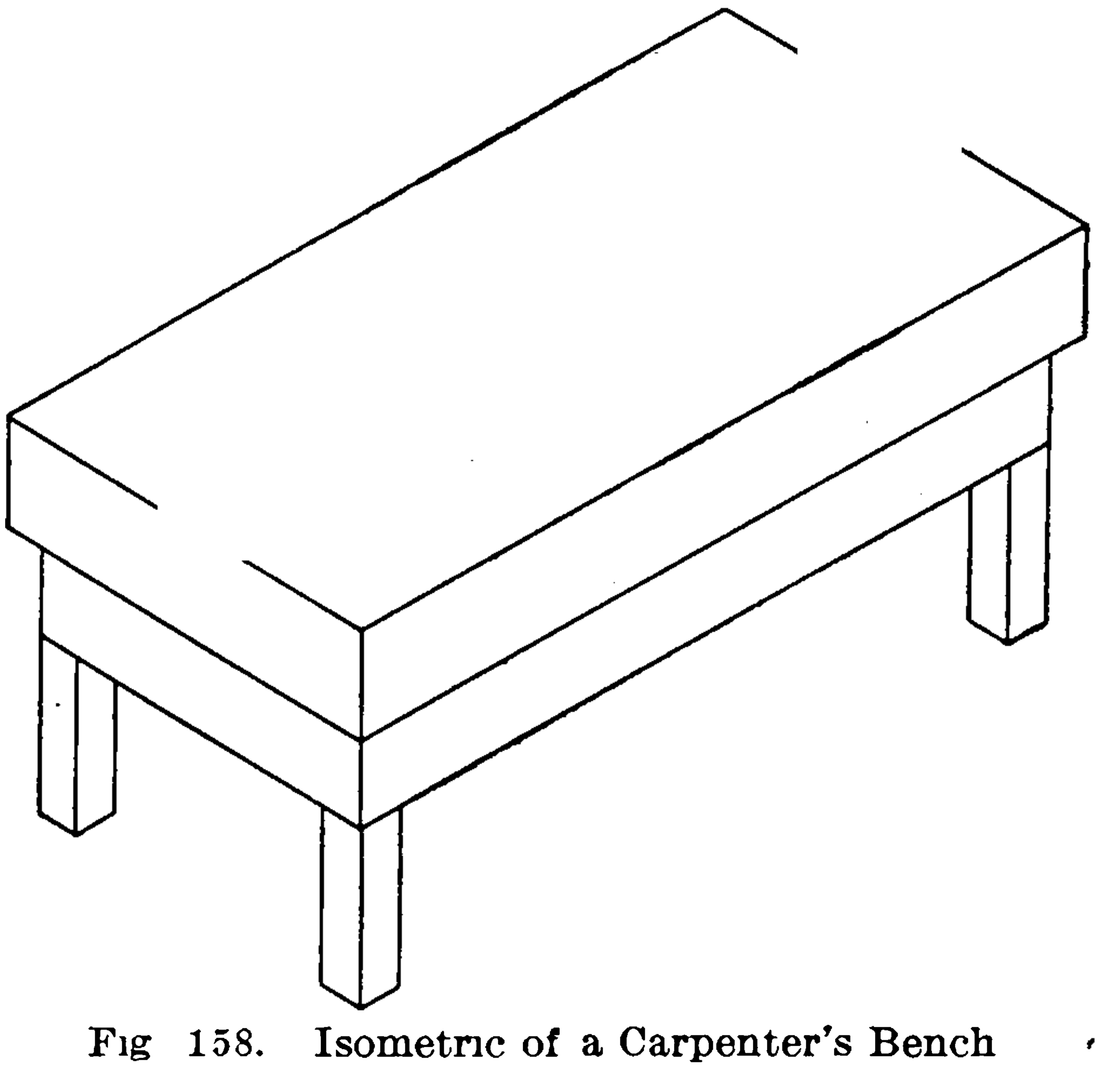


Fig 158. Isometric of a Carpenter's Bench

prism, as shown at *a* and *b*. The plan and elevation of an oblique pentagonal pyramid are shown in Fig. 155. It is evident that none of the edges of the pyramid can be drawn in isometric

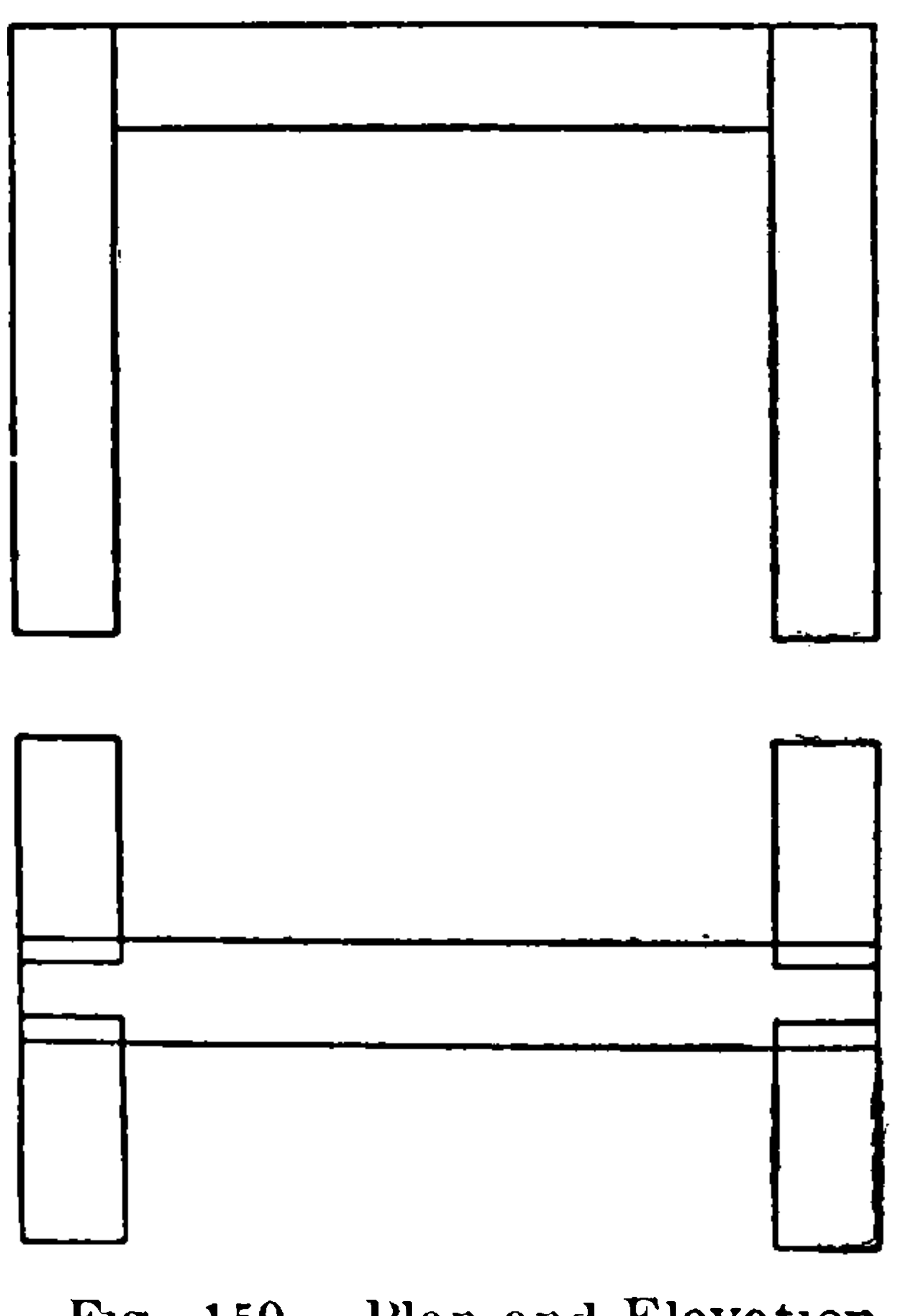


Fig 159 Plan and Elevation of Sawhorse

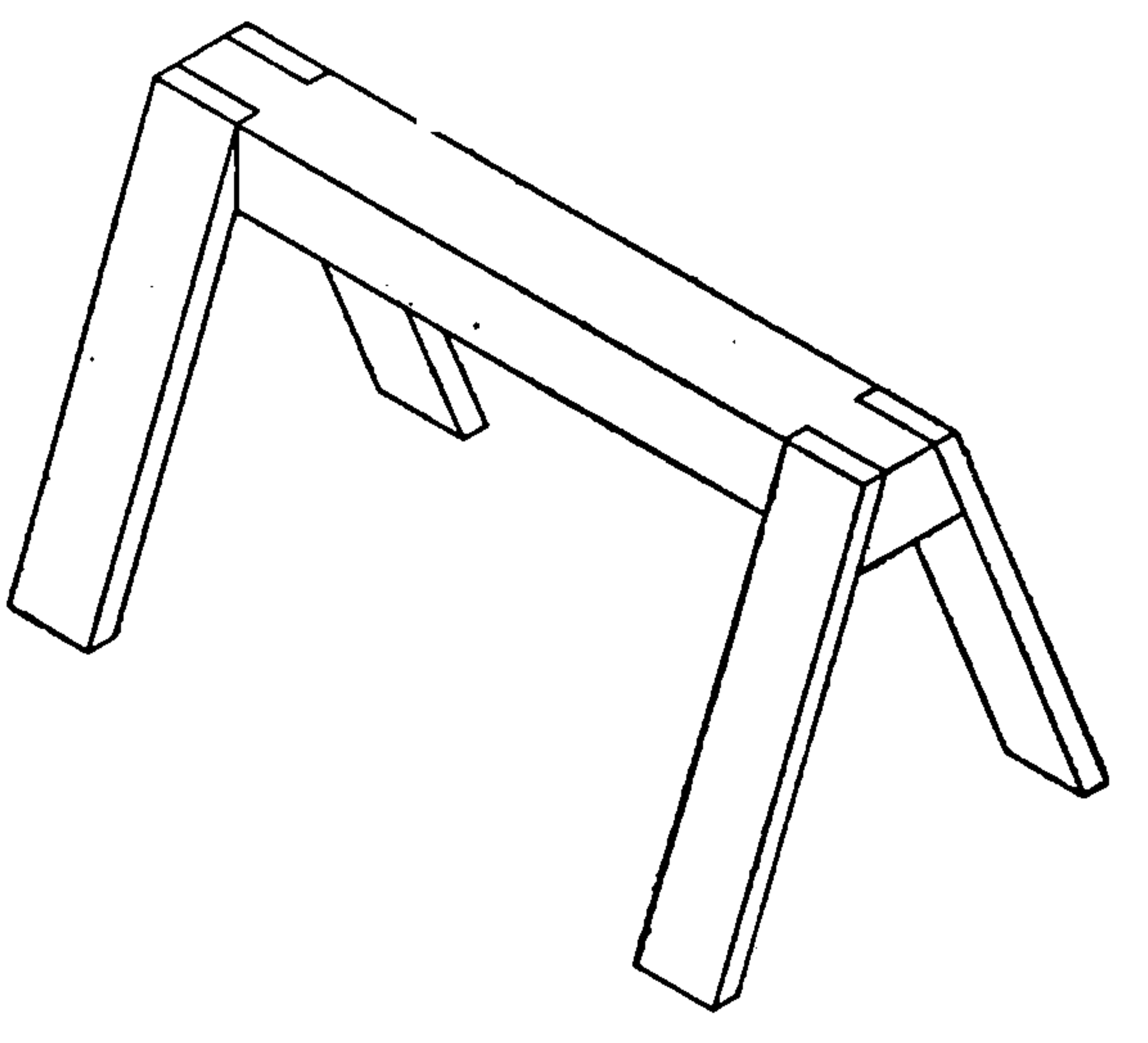


Fig. 160. Isometric of Fig 159

as either vertical or 30° lines; hence, a system of co-ordinates must be used as shown in Fig. 156 This problem illustrates the most general case, and to locate some of the points three co-ordinates must be used, two at 30° and one vertical.

Circumscribe, about the plan of the pyramid, a rectangle which shall have its sides respectively parallel and perpendicular to the

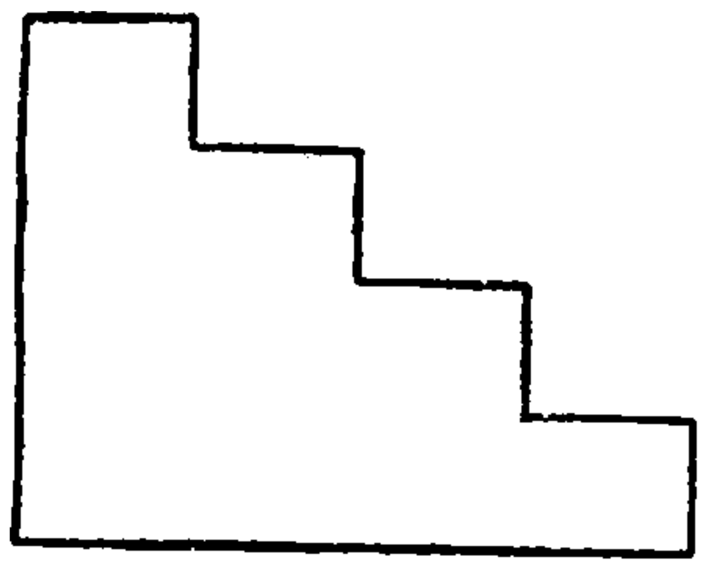


Fig 161. End Elevation of Stairs

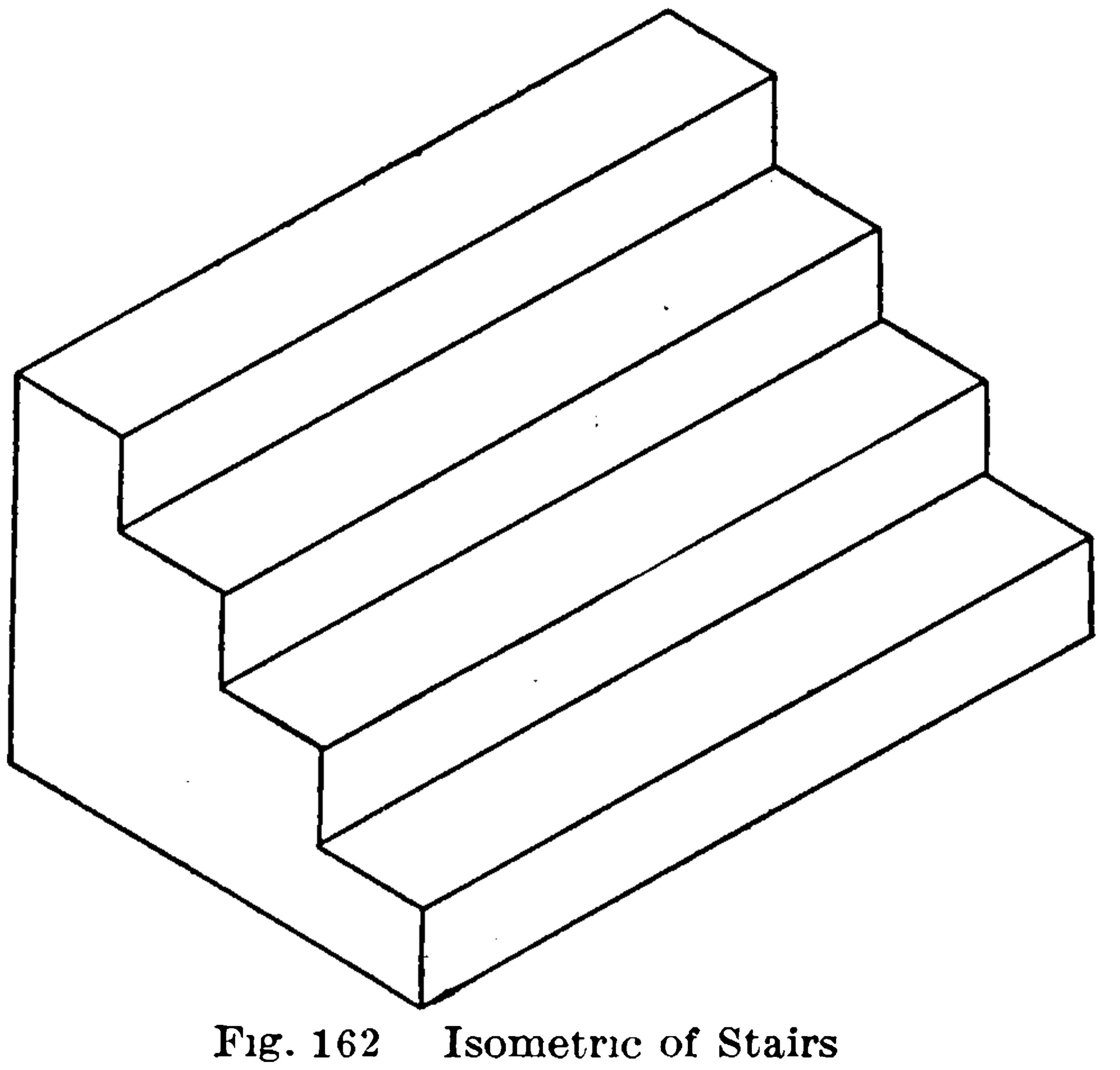


Fig. 162 Isometric of Stairs

ground line. This rectangle is on H, and its vertical projection is in the ground line.

The isometric of this rectangle can be drawn at once with 30° lines, as shown in Fig. 156, o being the same point in both figures. The horizontal projection of point 3 is found in isometric at 3^h, at the same distance from o as in the plan. That is,

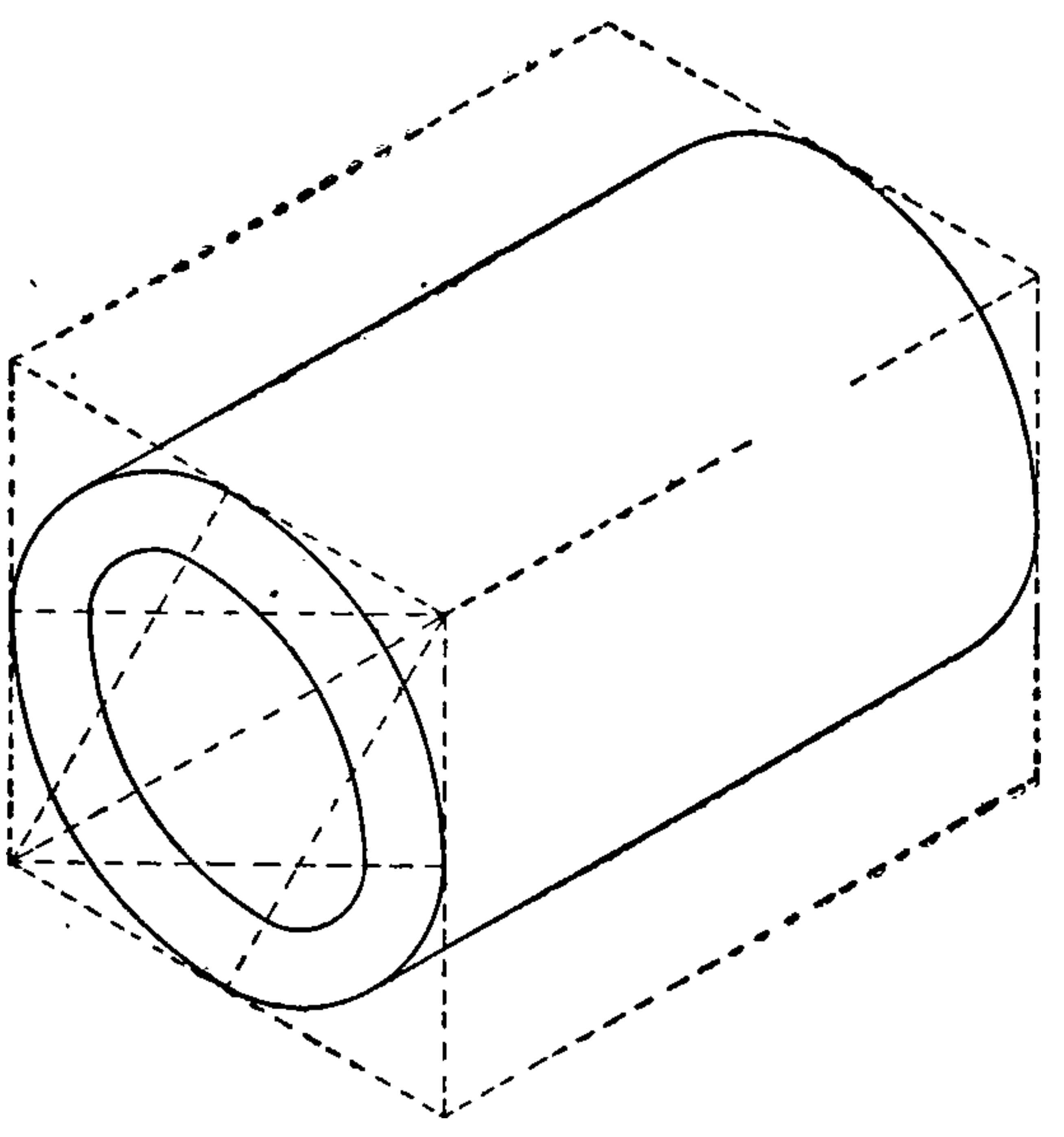


Fig 163 Isometric of a Hollow Cylinder

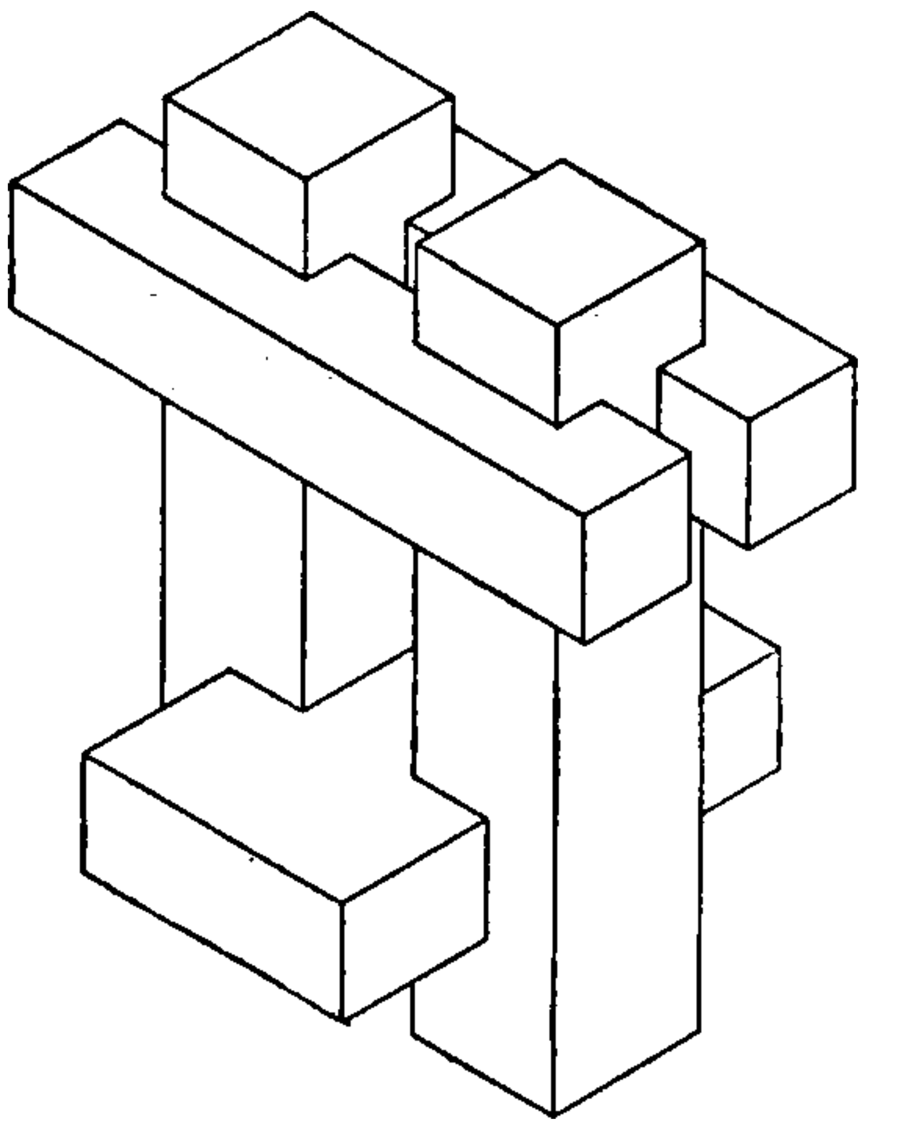


Fig 164 Isometric of a Wooden Model

any distance which in plan is parallel to a side of the circumscribing rectangle, is shown in isometric in its true length and parallel to the corresponding side of the isometric rectangle. If point 3 were on the horizontal plane its isometric would be 3^h, but the point is at the vertical height above H given in the elevation; hence, lay off above

3^h this vertical height, obtaining the actual isometric of the point. To locate point 4, draw 4 *a* parallel to the side of the rectangle; then lay off *o a* and *a* 4^h, giving what may be called the isometric plan of 4. The vertical height taken from the elevation locates the isometric of the point.

In like manner all the corners of the pyramid, including the apex, are located The rule is, *locate first in isometric the horizontal*

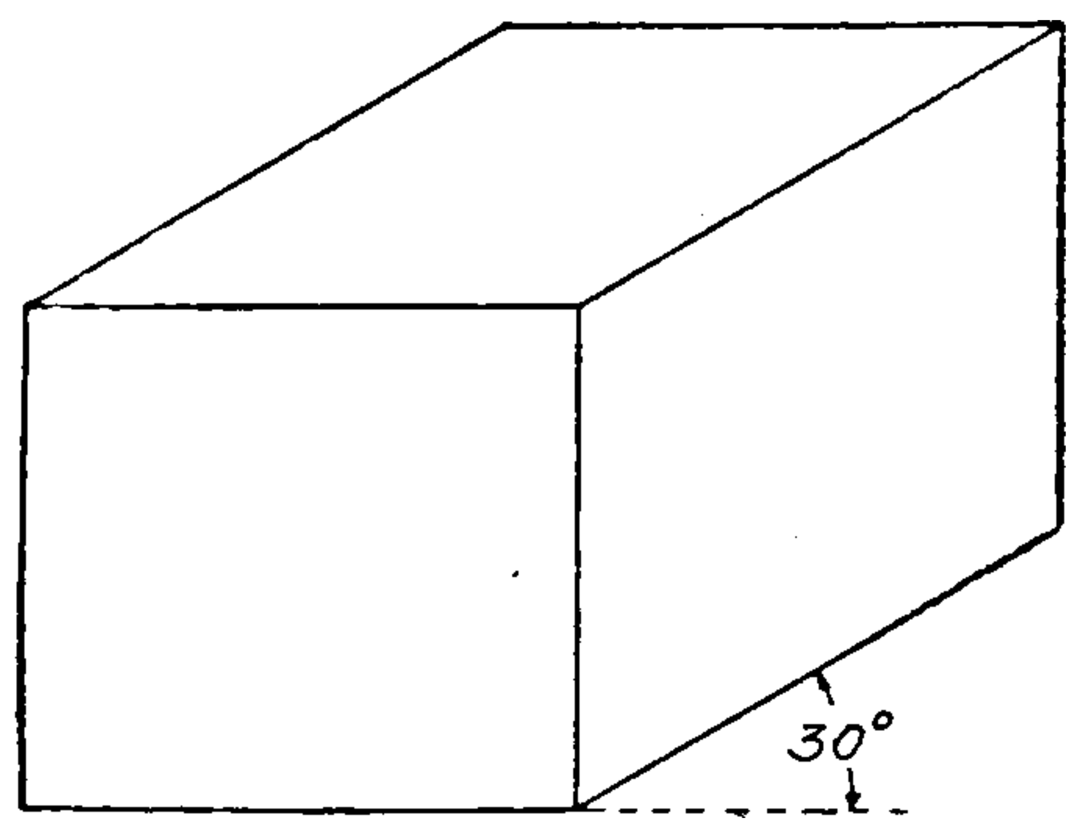


Fig 165 Oblique View of Cube at 30°

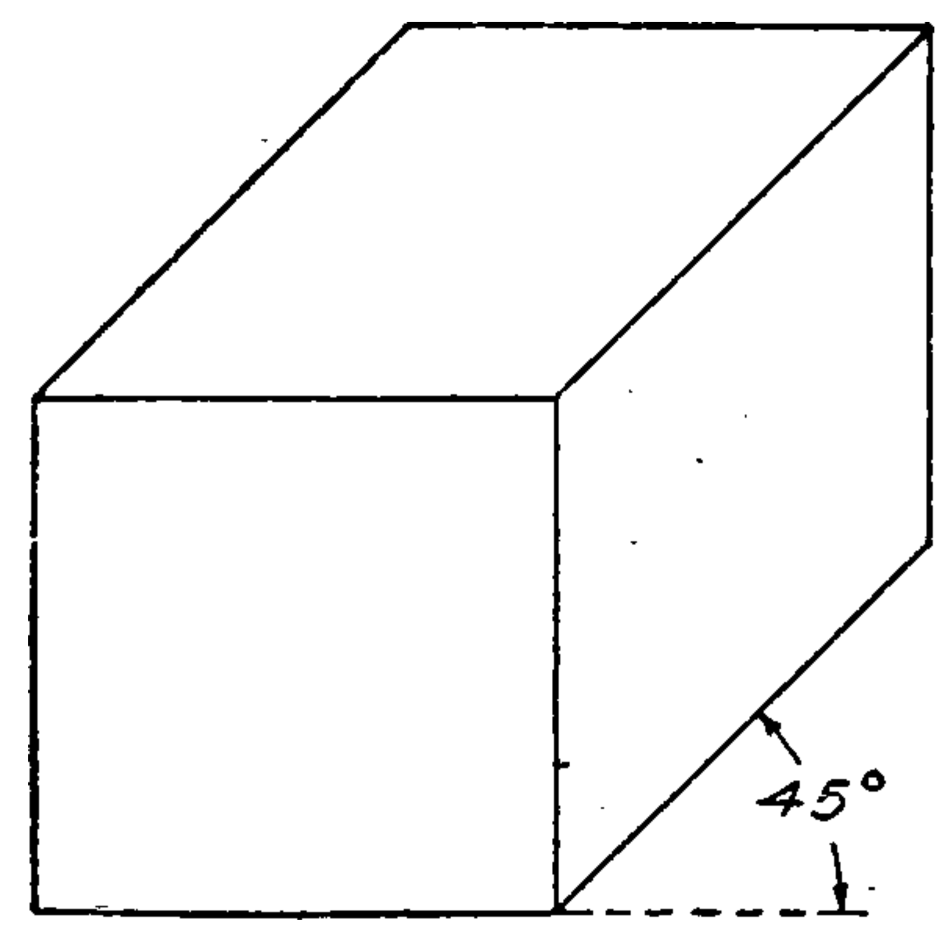


Fig 166 Oblique View of Cube at 45°

projection of a point by one or two 30° co-ordinates; then vertically above this point, locate its height as taken from the elevation.

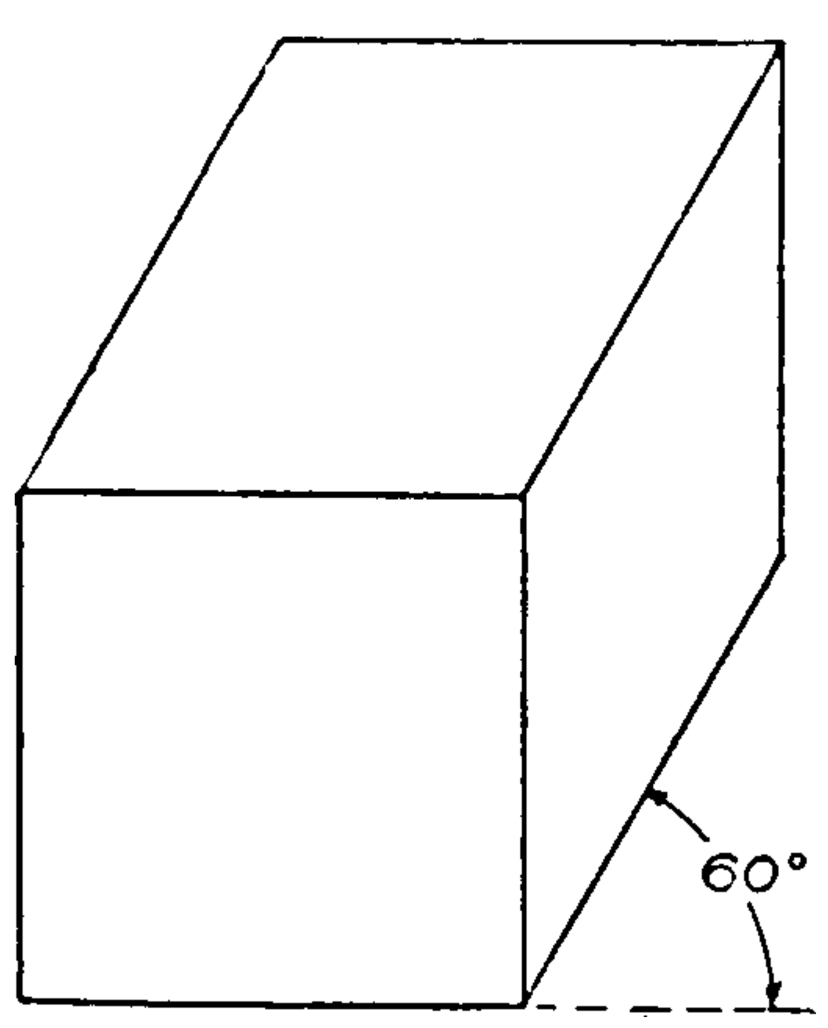


Fig 167 Oblique View of Cube at 60°

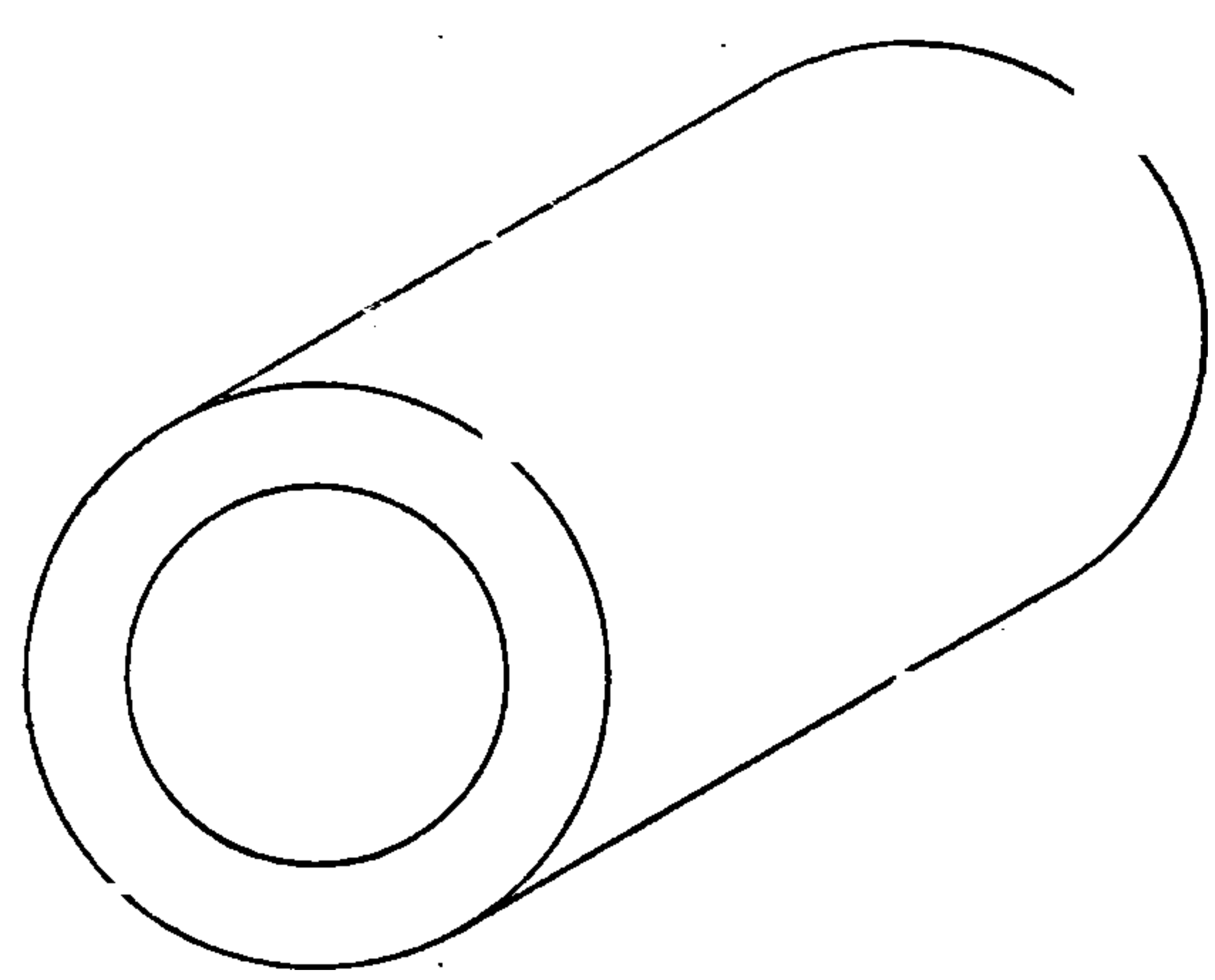


Fig 168 Oblique View of Hollow Cylinder

Figs. 157 to 164 give examples of the isometric of various objects. Fig. 159 is the plan and elevation, and Fig. 160 the isometric, of a carpenter's sawhorse.

OBLIQUE PROJECTIONS

In oblique projection, as in isometric, the end sought for is the same—a more or less complete representation, in one view, of

WASHINGTON STREET ELEVATION OF "THE OLIVER," SOUTH BEND, IND.

SECTION THROUGH MAIN VESTIBULE AND HALF OF LOBBY OF "THE OLIVER," SOUTH BEND, IND.

Shepley, Rutan & Coolidge, Architects, Chicago, Ill.

Elevation Shown on Opposite Page. For Plans, See Page 106; for Exterior and Details of Main Cornice, See Page 138.

and elevation in Fig. 172. The dotted lines in the elevation, Fig. 172, show the heights of the corners above the horizontal stick. The feet of these perpendiculars give the horizontal distances of the top corners from the end of the horizontal piece.

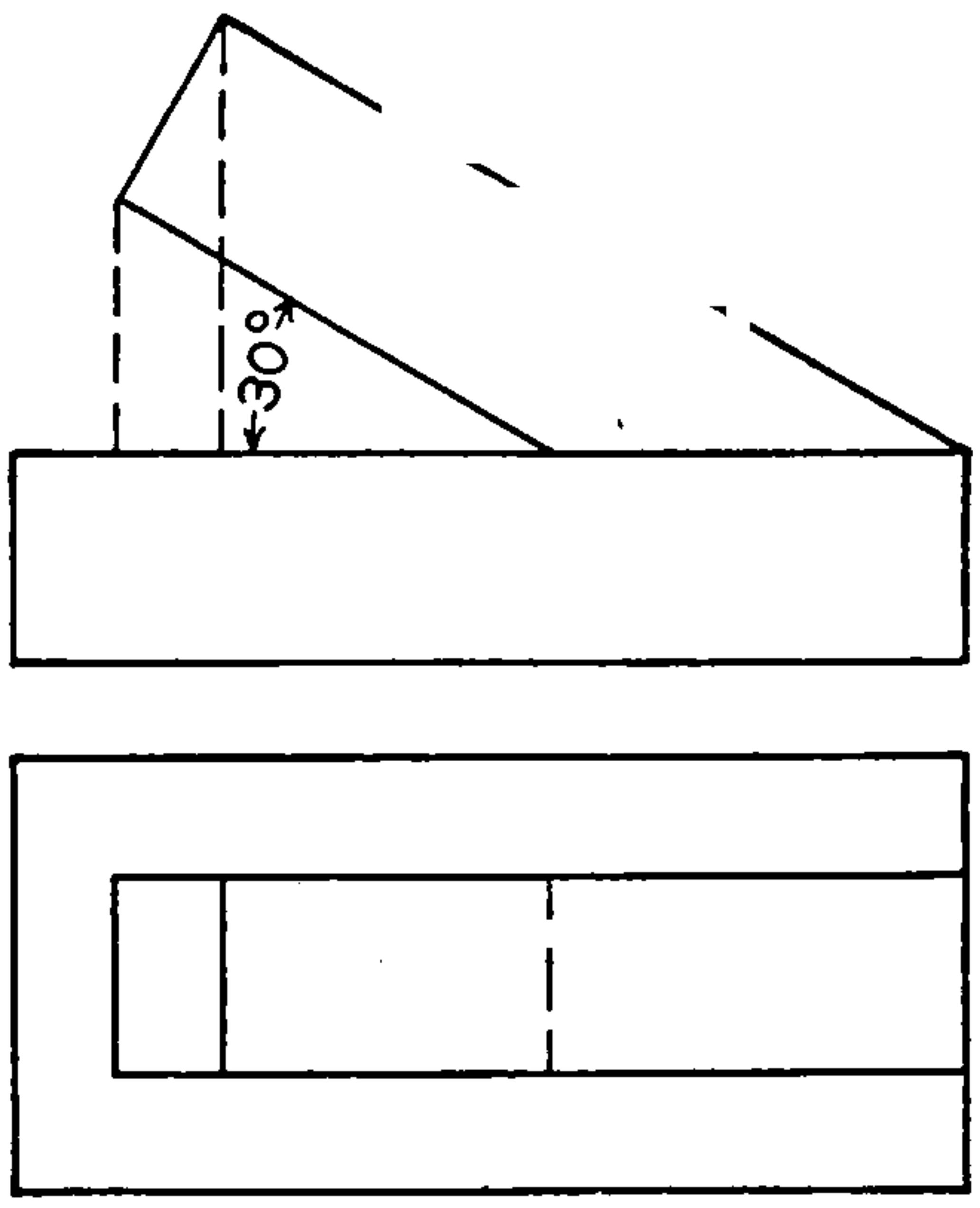


Fig 172 Plan and Elevation of Wooden Brace

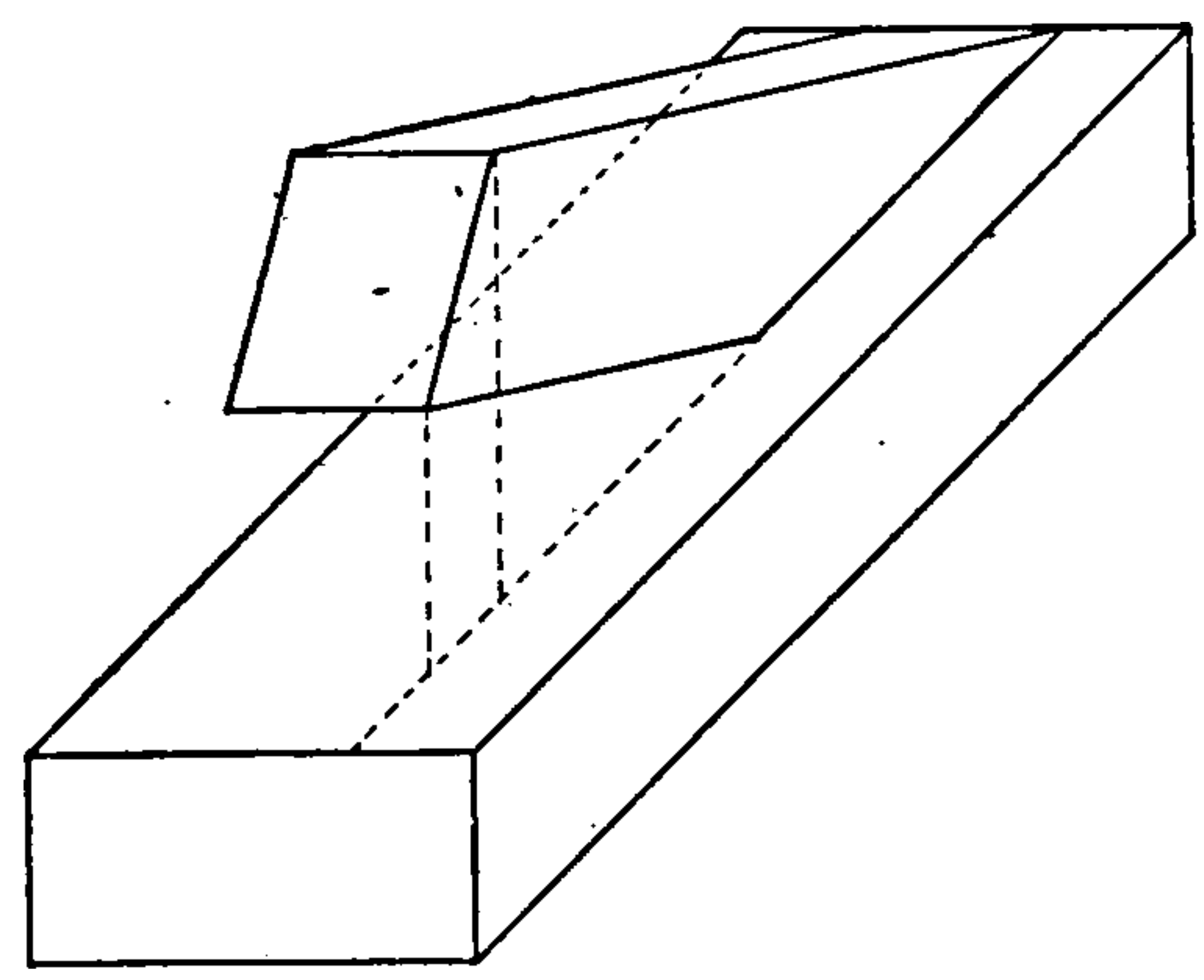


Fig 173 Oblique View of Wooden Brace

In Fig. 173 lay off from the upper right-hand corner of the front end a distance equal to the distance between the front edge of the inclined piece and the front edge of the bottom piece, Fig. 172. From this point draw a dotted line parallel to the length. The horizontal distances from the upper left corner to the dotted perpendicular are then marked off on this line. From these points verticals are drawn, and made equal in length to the dotted perpendiculars of Fig 172, thus locating two corners of the end.

LINE SHADING

In finely finished drawings it is frequently desirable to make the various parts more readily seen by showing the graduations of light and shade on the curved surfaces. This is especially true of such surfaces as cylinders, cones, and spheres. The effect is obtained by drawing a series of parallel or converging lines on the surface at varying distances from one another. Sometimes draftsmen vary the width of the lines, themselves. These lines are farther apart on the lighter portion of the surface, and closer together and heavier on the darker part.

Fig. 174 shows a cylinder with elements drawn on the surface equally spaced, as on the plan. On account of the curvature of the surface the elements are not equally spaced on the elevation,

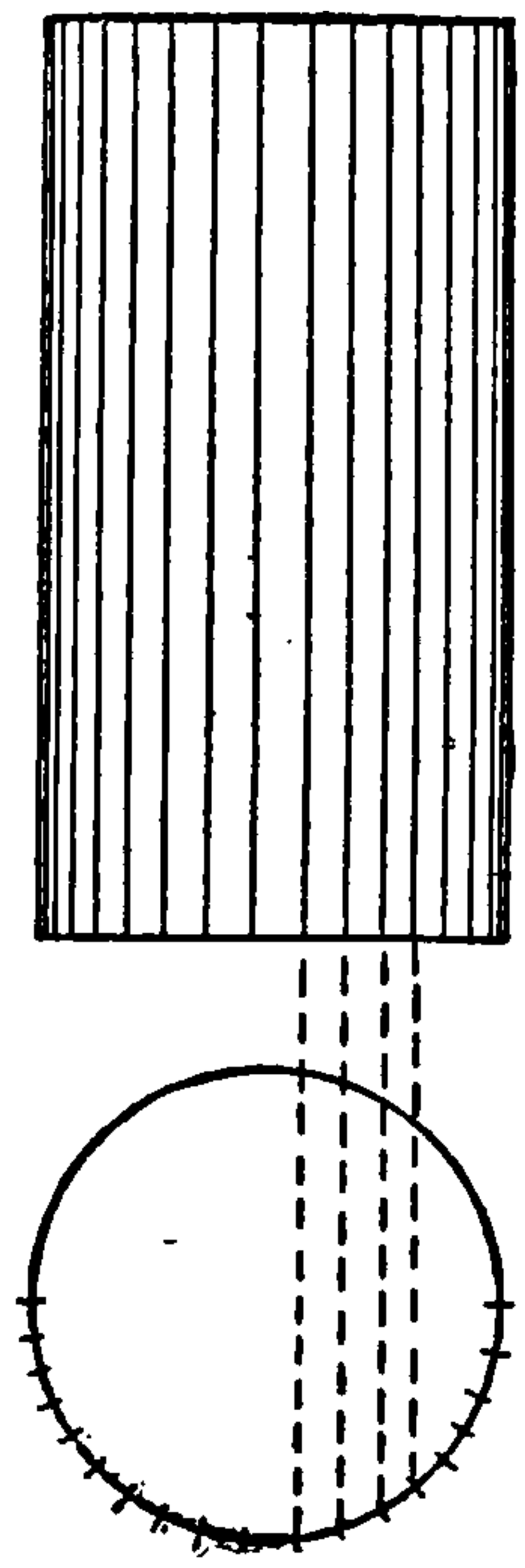


Fig 174 Plan and Shaded Elevation of Cylinder

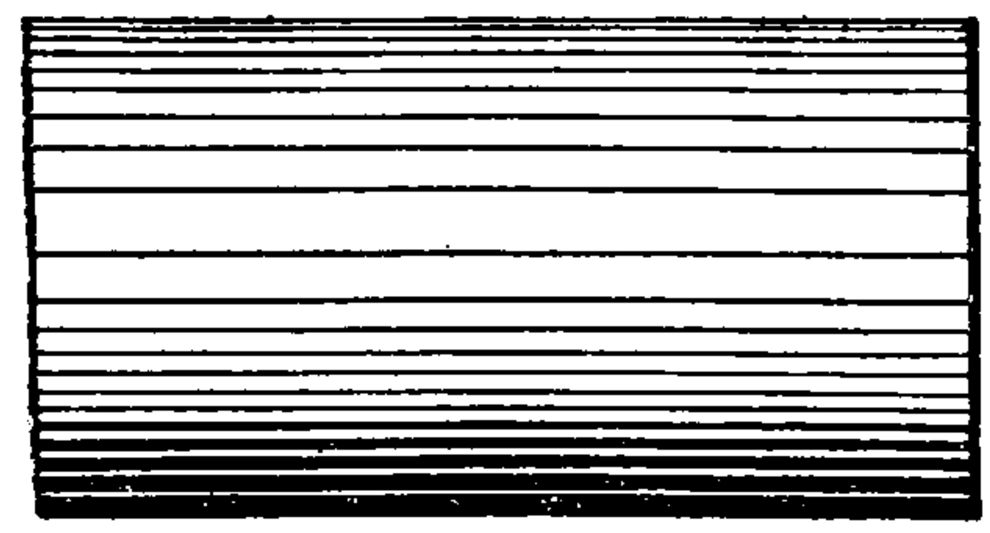


Fig 176 Shaded Horizontal Cylinder

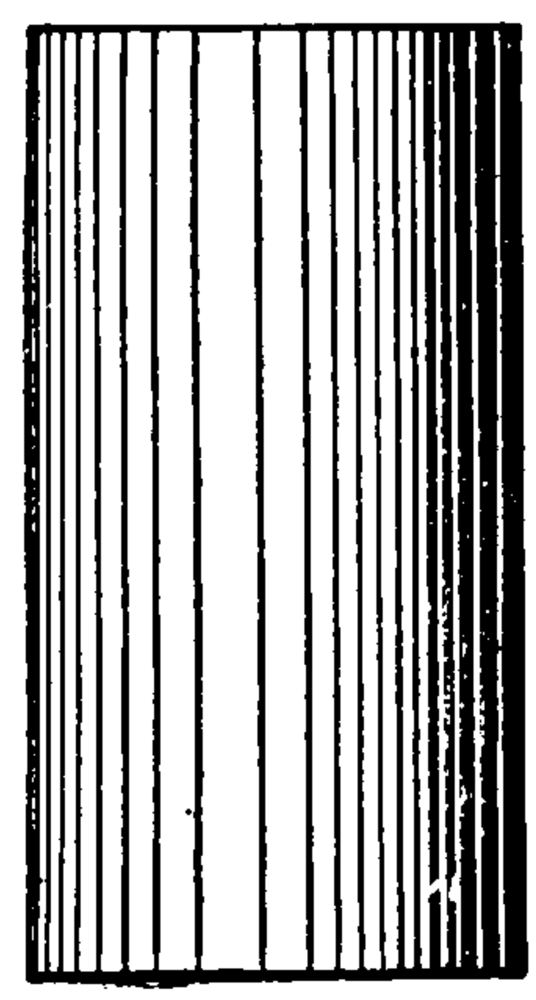


Fig 175 Shaded Vertical Cylinder

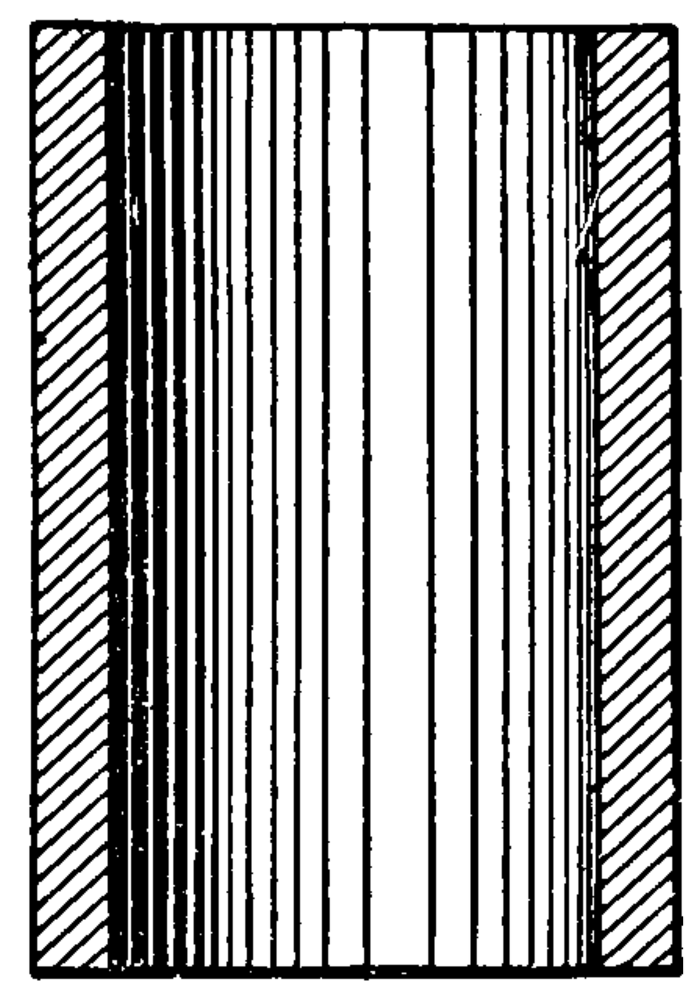


Fig 177 Shaded Section of Hollow Cylinder

but give the effect of graduation of light. The result is that in elevation the distances between the elements gradually lessen from the

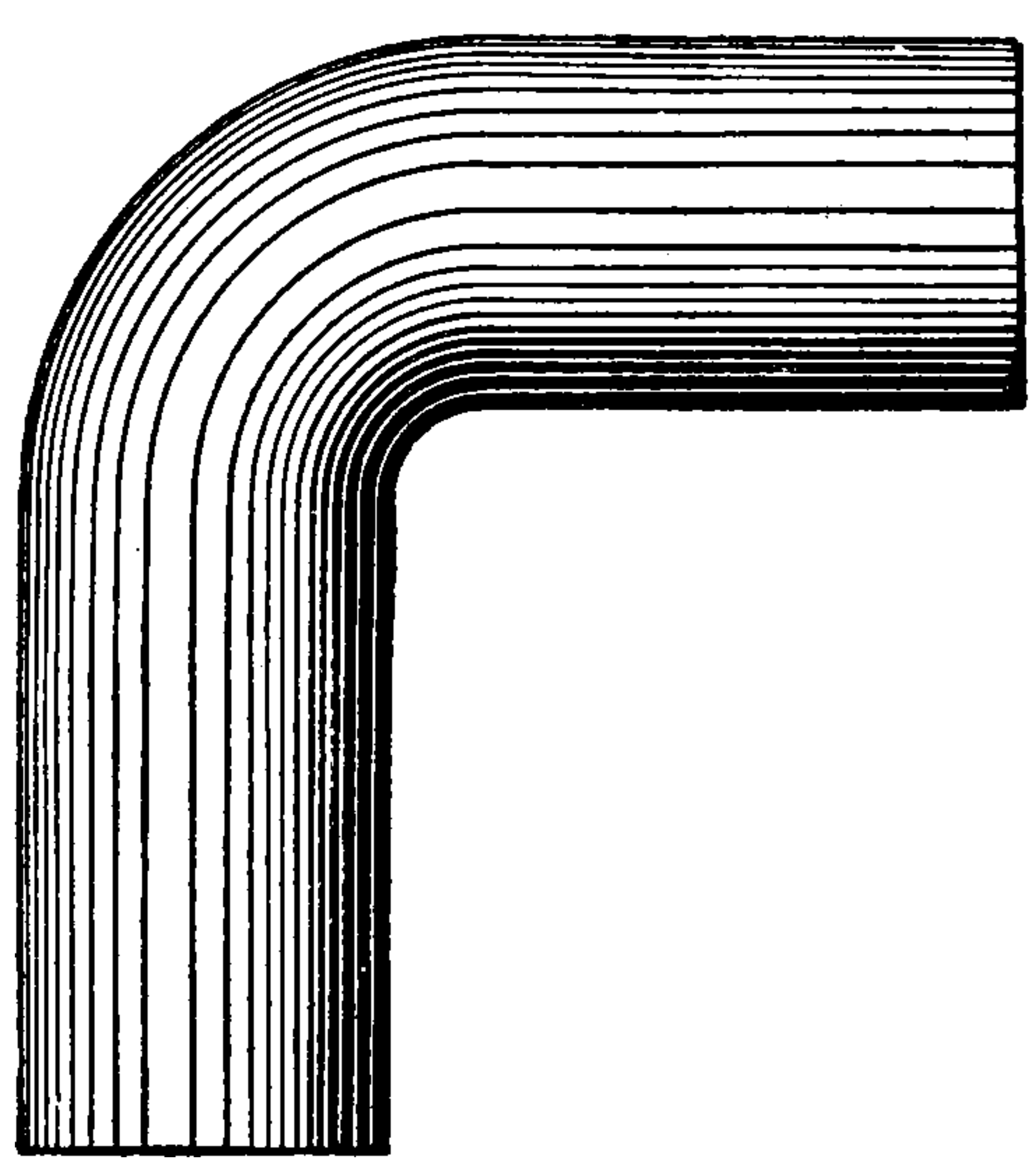


Fig. 178 Shaded Elbow Joint

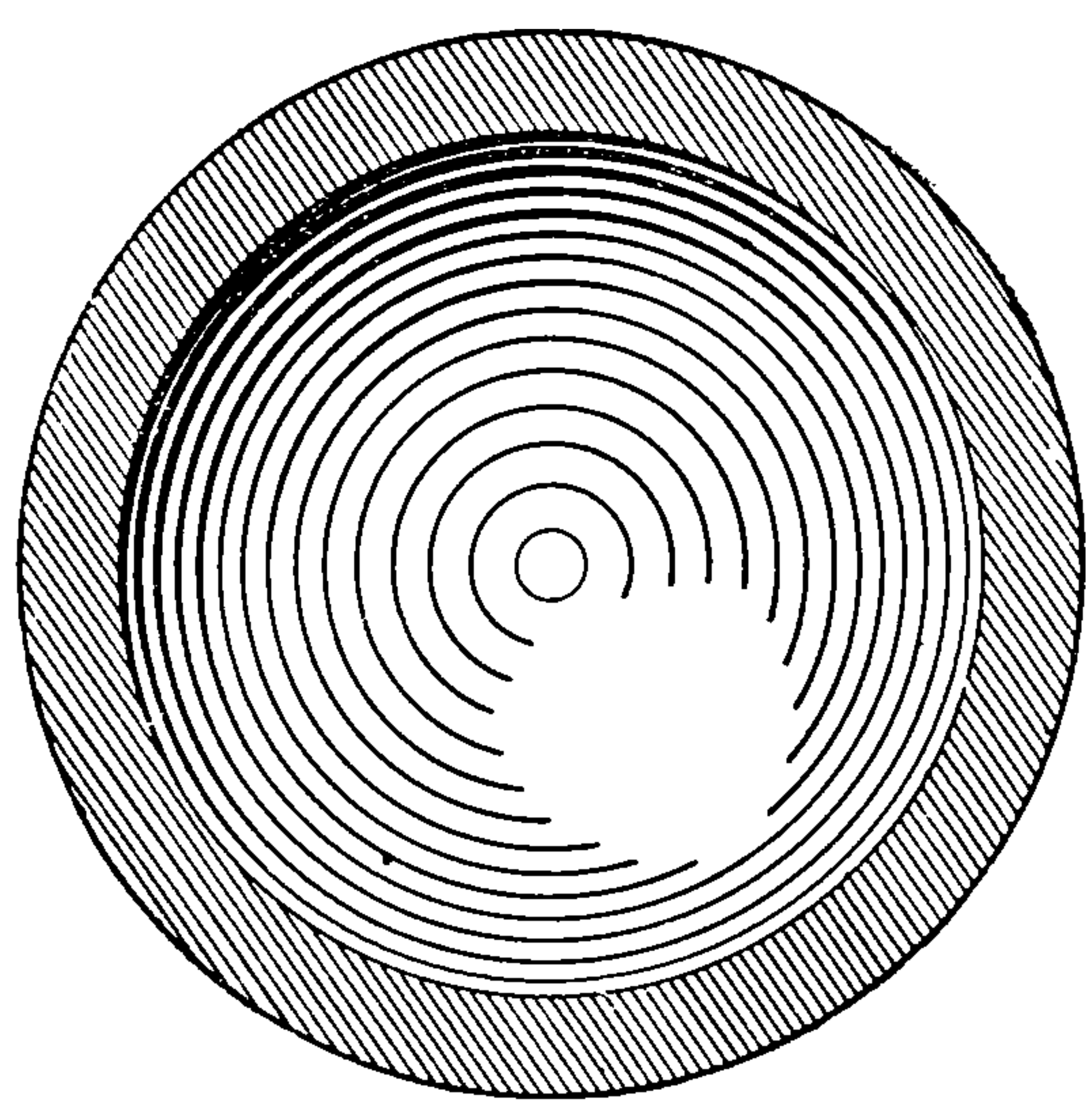


Fig. 179 Shaded Section of Hollow Sphere

center toward each side, thus showing that the cylinder is convex. The effect is intensified, however, if the elements are made heavier, as well as closer together, as shown in Figs. 175 to 181.

Fig. 175 is a cylinder showing the heaviest shade at the right, a method often used. Considerable practice is necessary to obtain good results; but in this, as in other portions of mechanical drawing,

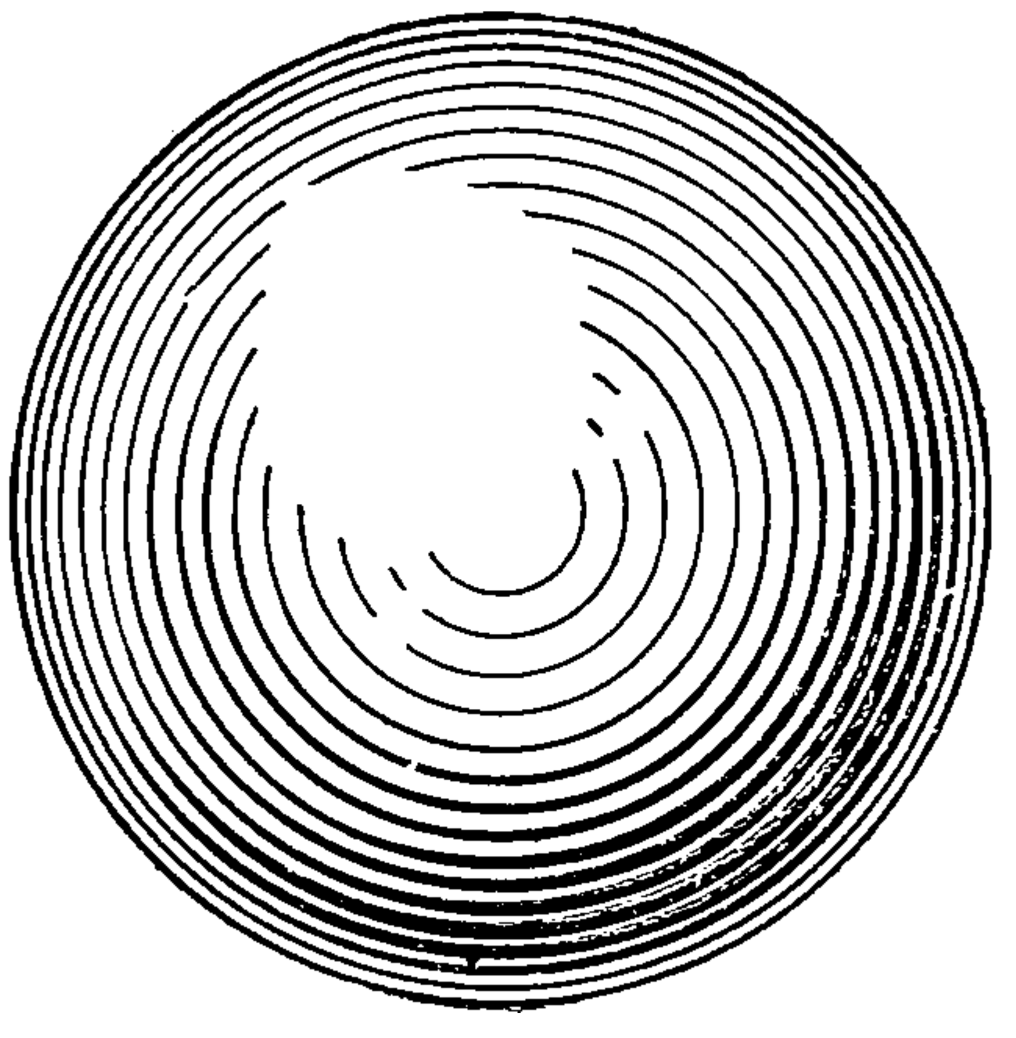


Fig. 180 Shaded Sphere

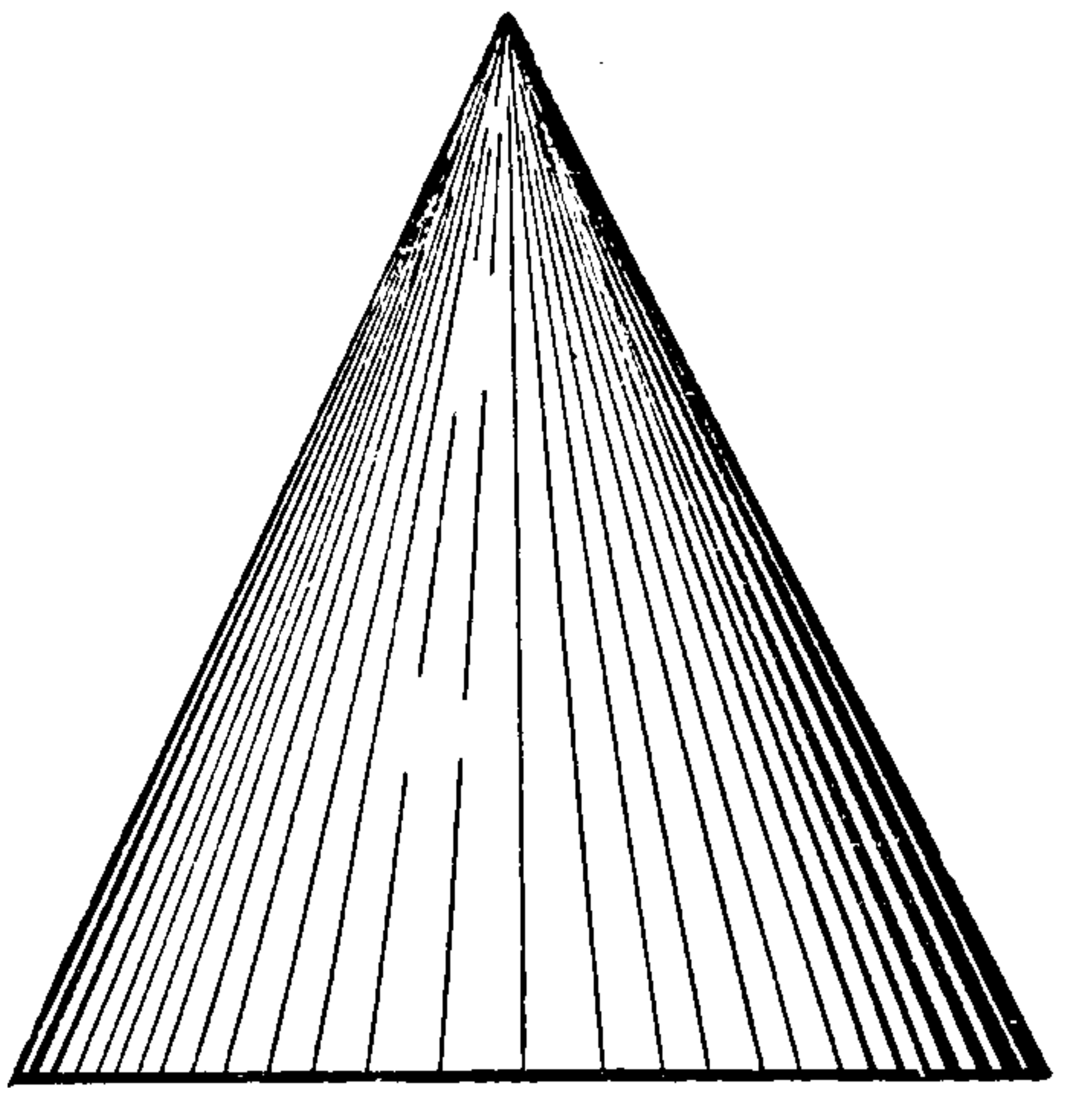


Fig. 181 Shaded Cone

repetition is unavoidable. Fig. 176 represents a cylinder in a horizontal position, and Fig. 177 represents a section of a hollow vertical cylinder. Figs. 178 to 181 give other examples of familiar objects.

In the elevation of the cone shown in Fig. 181 the shade lines should diminish in weight as they approach the apex. Unless this is done it will be difficult to avoid the formation of a blot at that point.

LETTERING

In the early part of this course, the inclined Gothic letter was described, and the alphabet given. The Roman, Gothic, and block letters are perhaps the most used for titles. These letters, being of comparatively large size, are generally made mechanically; that is, drawing instruments are used in their construction. In order that the letters may appear of the same height, some of them, owing to their shape, must be made a little higher than the others. This is the case with the letters curved at the top and bottom, such as C, O, S, etc., as shown somewhat exaggerated in Fig. 182. Also, the letter A should extend a little above, and V a little below, the guide lines, because if made of the same height as the others they will appear shorter. This is true of all capitals, whether of Roman, Gothic, or other alphabets. In the block letter, however, they are frequently all of the same size.

Fig. 184. Vertical Roman Letters and Figures

Fig. 185. Inclined Roman Letters and Figures

There is no absolute size or proportion of letters, as the dimensions are regulated by the amount of space in which the letters are to be placed, the size of the drawing, the effect desired, etc. In some cases letters are made so that the height is greater than the width, and sometimes the reverse; sometimes the height and width are the same. This last proportion is the most common. Certain relations of width, however, should be observed. Thus, in whatever style of alphabet used, the W should be the widest letter; J the narrowest, M and T the next widest to W, then A and B. The other letters are of about the same width.

In the vertical Gothic alphabet, the average height is that of B, D, E, F, etc., and the additional height of the curved letters

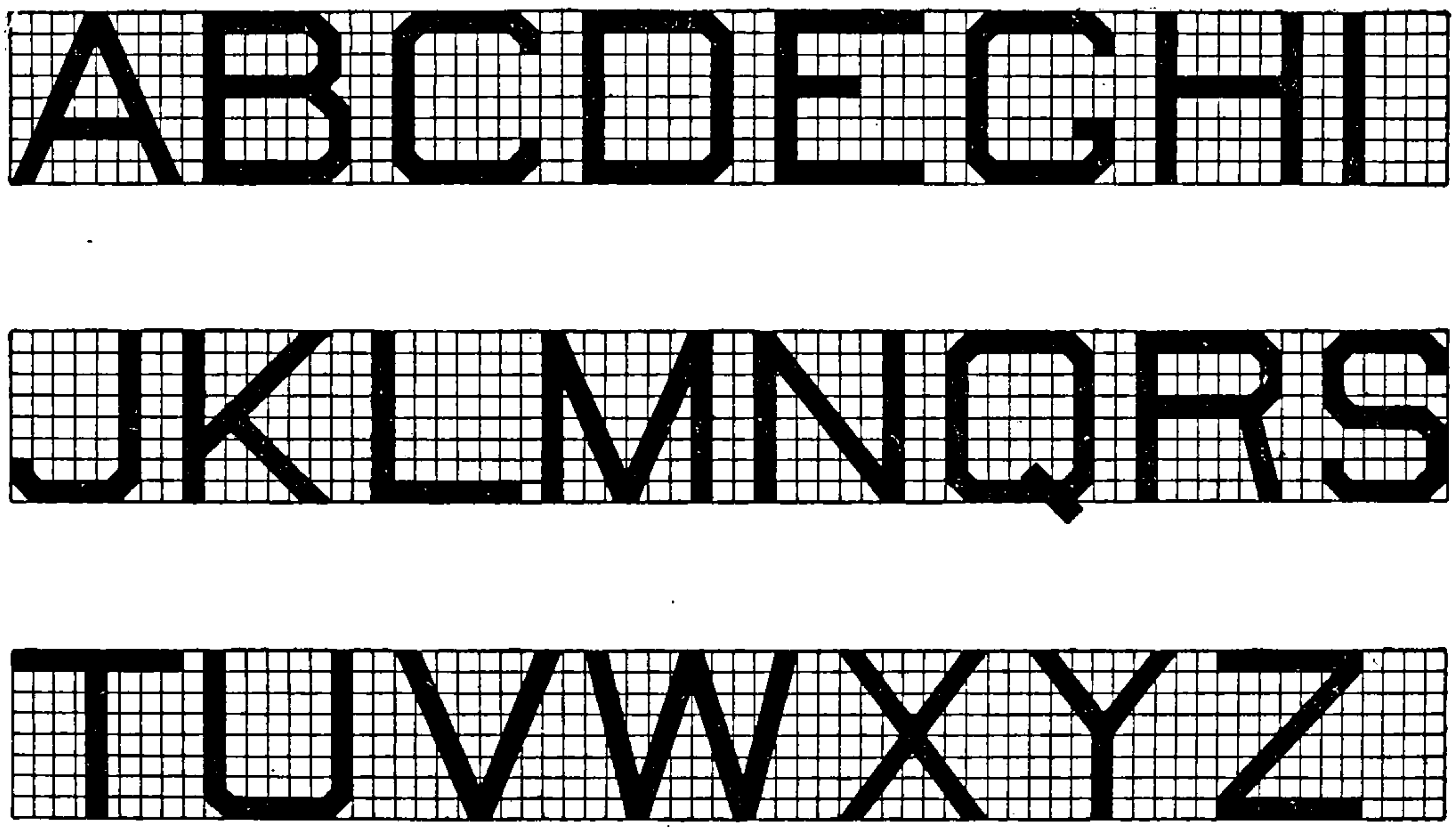


Fig 186 Block Letters

and of the A and V is very slight. The horizontal cross lines of such letters as E, F, H, etc., are slightly above the center; those of A, G, and P slightly below.

For the inclined letters, Fig. 183, 60° is a convenient angle, although they may be at any other angle suited to the convenience or fancy of the draftsman. Many draftsmen use an angle of about 70°.

The letters of the Roman alphabet, whether vertical, Fig. 184, or inclined, Fig. 185, are quite ornamental in effect if well made, the inclined Roman being a particularly attractive letter, although rather difficult to make. The block letter, Fig. 186, is made on the same general plan as the Gothic, but much heavier. Small squares are taken as the unit of measurement, as shown. The use of this letter is not advocated for general work, although if made merely in outline the effect is pleasing. The styles of numbers correspond-

Fig 187 Vertical Gothic Lower-Case Letters

ing with the alphabets of capitals given here, are also inserted. When a fraction, such as $2\frac{5}{8}$ is to be made, the proportion should be about as shown. For small letters, usually called *lower-case* letters, the

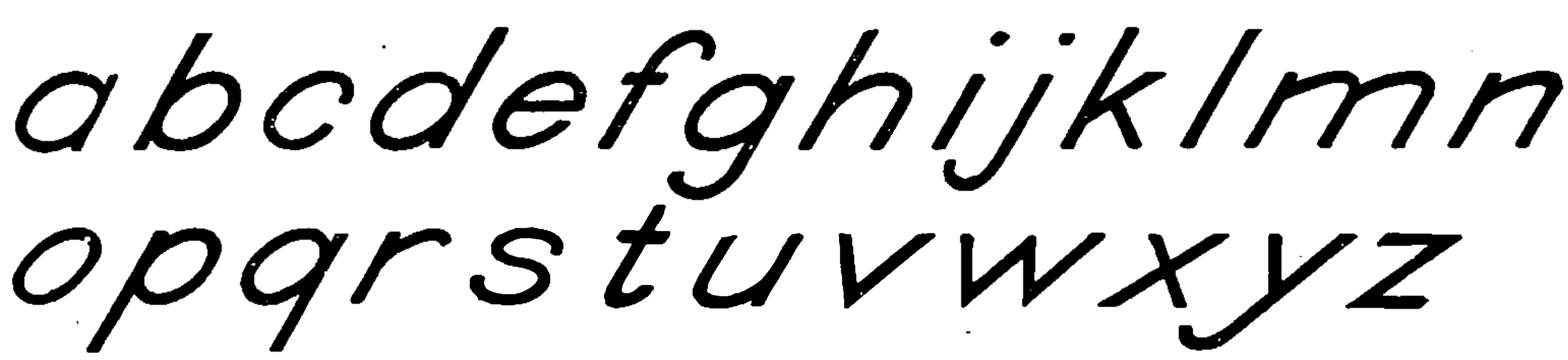


Fig. 188. Inclined Gothic Lower-case Letters

height may be made about two-thirds that of the capitals. This proportion, however, varies in special cases.

The principal lower-case letters in general use among draftsmen are shown in Figs. 187, 188, 189, and 190. The Gothic letters

Fig 189 Vertical Roman Lower-Case Letters

shown in Figs. 187 and 188 are much easier to make than the Roman letters in Figs. 189 and 190. These letters, however, do not give as finished an appearance as the Roman. As has already been stated in Mechanical Drawing, Part I, the inclined letter is easier to make because slight errors are not so apparent.

the outlines may be drawn with the ruling pen or compasses, and the spaces between filled in with a fine brush.

The titles for working drawings are generally placed in the lower right-hand corner. Usually a draftsman has his choice of letters, mainly because after he has become used to making one style he can do it rapidly and accurately. However, in some drafting rooms the head draftsman decides what lettering should be used.

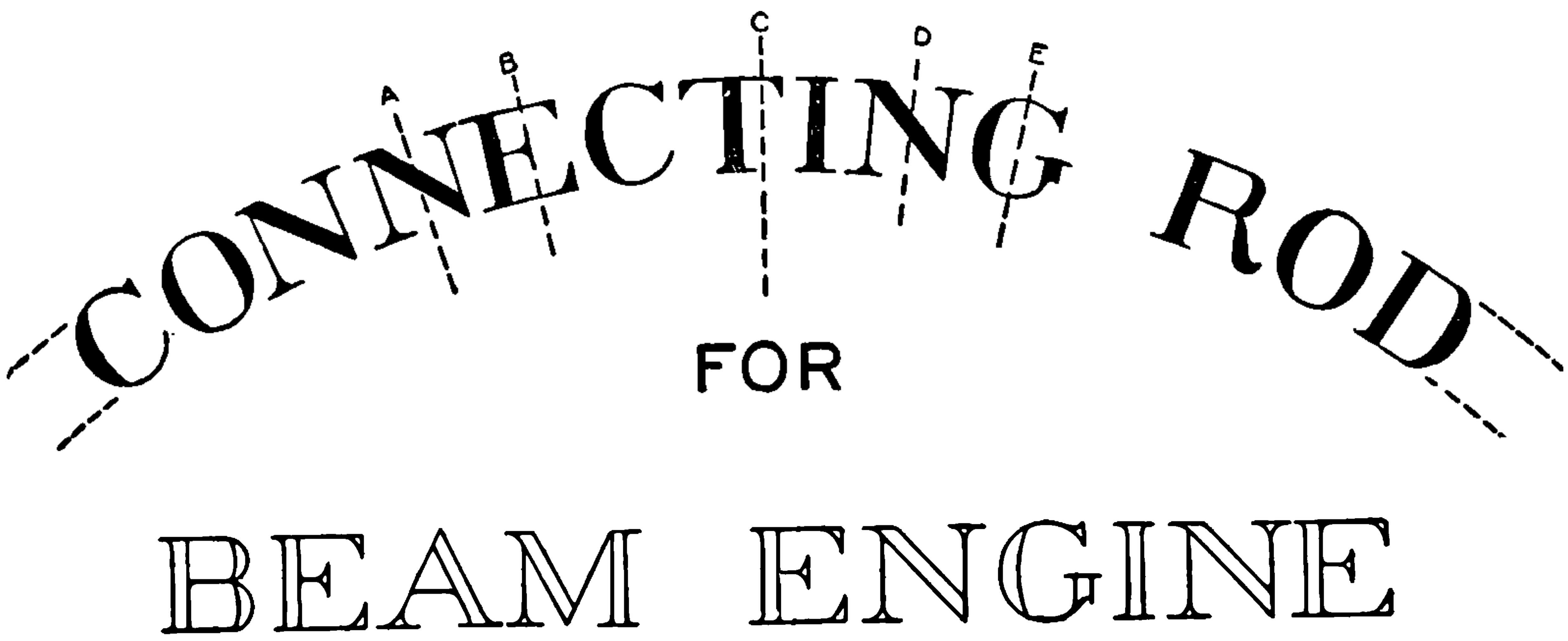


Fig 192. Sample Title

In making these titles, the different alphabets are selected to give the best results without spending too much time. In most work the letters are made in straight lines, although frequently a portion of the title is found lettered on an arc of a circle.

In Fig. 192 is shown a title having the words CONNECTING ROD lettered on an arc of a circle. To do this work requires considerable patience and practice. First, draw the vertical center line as shown at *C* in Fig. 192; then, draw horizontal lines for the

SAFETY STOP VALVE

Fig 193 Sample Title

horizontal letters. The radii of the arcs depend upon the general arrangement of the entire title, and this is a matter of taste. The difference between the arcs should equal the height of the letters. After the arc is drawn, the letters should be sketched in pencil to find their approximate positions. After this is done, draw radial lines from the center of the letters to the center of the arcs. These lines will be the centers of the letters, as shown at *A*, *B*, *D*, and *E*.

The vertical lines of the letters should not radiáte from the center of the arc, but should be parallel to the center lines already drawn; otherwise the letters will appear distorted. Thus, in the letter *N* the two verticals are parallel to the line *A*. The same applies to the other letters in the alphabet. In making the curved letters such as O and C, the centers of the arcs will fall upon these center lines; and if the compasses are used, the lettering is a comparatively simple matter. In Fig. 193 is shown another title in which all the letters are in horizontal lines.

PROBLEMS IN PROJECTION

PLATE IX

The plates of this Instruction Paper should be laid out the same size as the plates in Parts I and II. The center lines and border lines should also be drawn as described.

Draw two ground lines across the sheet, one 3 inches below the upper border line and the other 3 inches above the lower border line. The first problem on each ground line is to be placed 1 inch from the left border line; and spaces of about 1 inch should be left between the figures.

Isolated points are indicated by a small cross, x, and projections of lines are to be drawn full unless invisible. All construction lines should be fine dotted lines. Given and required lines should be drawn full

Problems on Upper Ground Line:

1. Locate both projections of a point on the horizontal plane 1 inch from the vertical plane.

2. Draw the projections of a line 2 inches long which is parallel to the vertical plane and which makes an angle of 45 degrees with the horizontal plane and slants upward to the right.

Note The line should be 1 inch from the vertical plane and the lower end ½ inch above the horizontal.

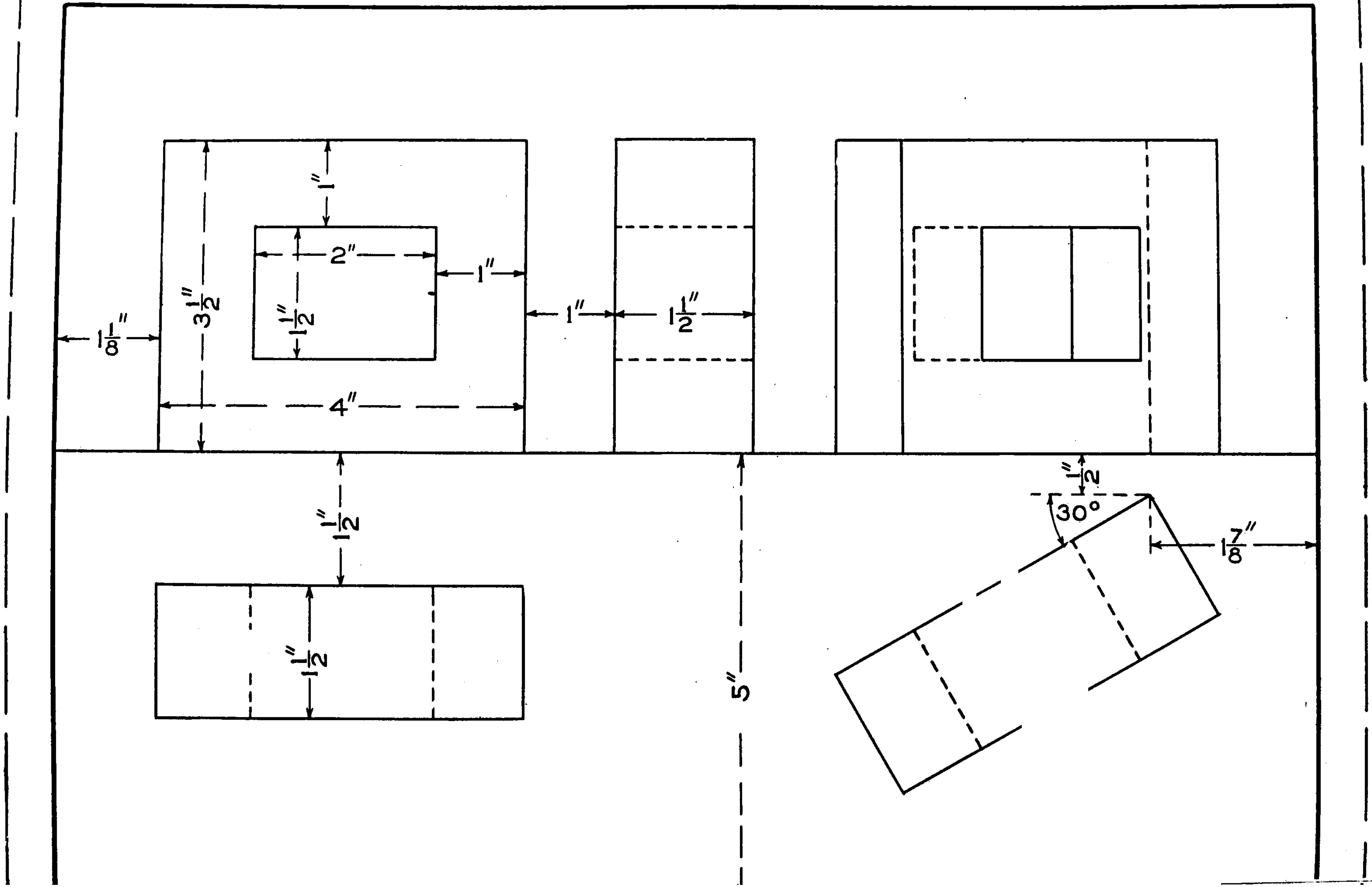
3. Draw the projections of a line 1½ inches long which is parallel to both planes, 1 inch above the horizontal, and ¾ inch from the vertical.

4 Draw the plan and elevation of a line 2 inches long which is parallel to *H* and makes an angle of 30 degrees with *V*. Let the right-hand end of the line be the end nearer *V*, ½ inch from *V*. The line to be 1 inch above *H*.

5 Draw the plan and elevation of a line 1½ inches long which is perpendicular to the horizontal plane and 1 inch from the vertical. Lower end of line is ½ inch above *H*.

6 Draw the projections of a line 1 inch long which is perpendicular to the vertical plane and 1½ inches above the hori-

PLATE X



1"
2"
1"
$3\frac{1}{2}$"
$1\frac{1}{2}$"
$1\frac{1}{8}$"
1"
$1\frac{1}{2}$"
4"
$\frac{1}{2}$"
30°
$1\frac{1}{2}$"
$1\frac{7}{8}$"
$1\frac{1}{2}$"
5"

zontal. The end of the line nearer V, or the back end, is $\frac{1}{2}$ inch from V.

7. Draw two projections which shall represent a line oblique to both planes.

NOTE. Leave 1 inch between this figure and the right-hand border line.

Problems on Lower Ground Lines:

8. Draw the projections of two parallel lines each $1\frac{1}{2}$ inches long. The lines are to be parallel to the vertical plane and to make angles of 60 degrees with the horizontal. The lower end of each line is $\frac{1}{4}$ inch above H. The right-hand end of the right-hand line is to be $2\frac{3}{4}$ inches from the left-hand margin.

9. Draw the projections of two parallel lines each 2 inches long. Both lines to be parallel to the horizontal and to make an angle of 30 degrees with the vertical. The lower line to be $\frac{3}{4}$ inch above H, and one end of one line to be against V.

10. Draw the projections of two intersecting lines. One 2 inches long to be parallel to both planes, 1 inch above H, and $\frac{3}{4}$ inch from the vertical; and the other to be oblique to both planes and of any desired length.

11. Draw plan and elevation of a prism 1 inch square and $1\frac{1}{2}$ inches long. The prism to have one side on the horizontal plane, and its long edges to be perpendicular to V. The back end of the prism is $\frac{1}{4}$ inch from the vertical plane.

12. Draw plan and elevation of a prism the same size as given above, but with the long edges parallel to both planes, the lower face of the prism to be parallel to H and $\frac{1}{4}$ inch above it. The back face to be $\frac{1}{2}$ inch from V.

PLATE X

The ground line is to be in the middle of the sheet, and the location and dimensions of the figures are to be as given. The first figure shows a rectangular block with a rectangular hole cut through from front to back. The other two figures represent the same block in different positions. The second figure is the end or profile projection of the block. The same face is on H in all three positions. The figures given on the plate for dimensions, etc., are to be used but not repeated on the plate by the student.

PLATE XI

Three ground lines are to be used on this plate, two at the left $4\frac{1}{2}$ inches long and 3 inches from top and bottom margin lines; and one at the right, half way between the top and bottom margins, $9\frac{1}{2}$ inches long.

The figures 1, 2, 3, and 4 are examples for finding the true lengths of the lines. Begin No. 1 at $\frac{3}{4}$ inch from the border, the vertical projection $1\frac{3}{4}$ inches long, one end on the ground line and inclined at 30°. The horizontal projection has one end $\frac{1}{2}$ inch from *V*, and the other $1\frac{1}{2}$ inches from *V*. Find the true length of the line by completing the construction commenced by swinging the arc, as shown in the figure.

Locate the left-hand end of No. 2 at 3 inches from the border, 1 inch above *H*, and $\frac{5}{8}$ inch from *V*. Extend the vertical projection to the ground line at an angle of 45°, and make the horizontal projection at 30°. Complete the construction for true length as commenced in the figure

In Figs. 3 and 4, the true lengths are to be found by completing the revolutions indicated. The left-hand end of Fig. 3 is $\frac{3}{4}$ inch from the margin, $1\frac{1}{2}$ inches from *V*, and $1\frac{3}{8}$ inches above *H*. The horizontal projection makes an angle of 60° and extends to the ground line, and the vertical projection is inclined at 45°.

The fourth figure is 3 inches from the border, and represents a line in a profile plane connecting points *a* and *b*. *a* is $1\frac{1}{4}$ inches above *H* and $\frac{3}{4}$ inch from *V;* and *b* is $\frac{1}{4}$ inch above *H* and $1\frac{1}{2}$ inches from *V*.

The figures for the middle ground line represent a pentagonal pyramid in three positions. The first position is the pyramid with the axis vertical, and the base $\frac{5}{8}$ inch above the horizontal. The height of the pyramid is $2\frac{1}{2}$ inches, and the diameter of the circle circumscribed about the base is $2\frac{1}{2}$ inches. The center of the circle is 6 inches from the left margin and $1\frac{3}{4}$ inches from *V*. Spaces between figures to be $\frac{3}{4}$ inch.

In the second figure the pyramid has been revolved about the right-hand corner of the base as an axis, through an angle of 15°. The axis of the pyramid, shown dotted, is therefore at 75°. The method of obtaining 75° and 15° with the triangles was shown in

"THE OLIVER" (HOTEL), SOUTH BEND, IND.
Shepley, Rutan & Coolidge, Architects, Chicago, Ill.

DETAILS OF MAIN CORNICE OF HOTEL "THE OLIVER," SOUTH BEND, IND.

Shepley, Rutan & Coolidge, Architects, Chicago, Ill.

For Exterior, See Opposite Page; for Plans, See Page 106, for Section and Elevation, See Page 122.

prism is 3 inches high, and the base is inscribed in a circle $2\frac{1}{8}$ inches in diameter. The plane forming the truncated prism is passed as indicated, the distance *A B* being 1 inch. Ink a sufficient number

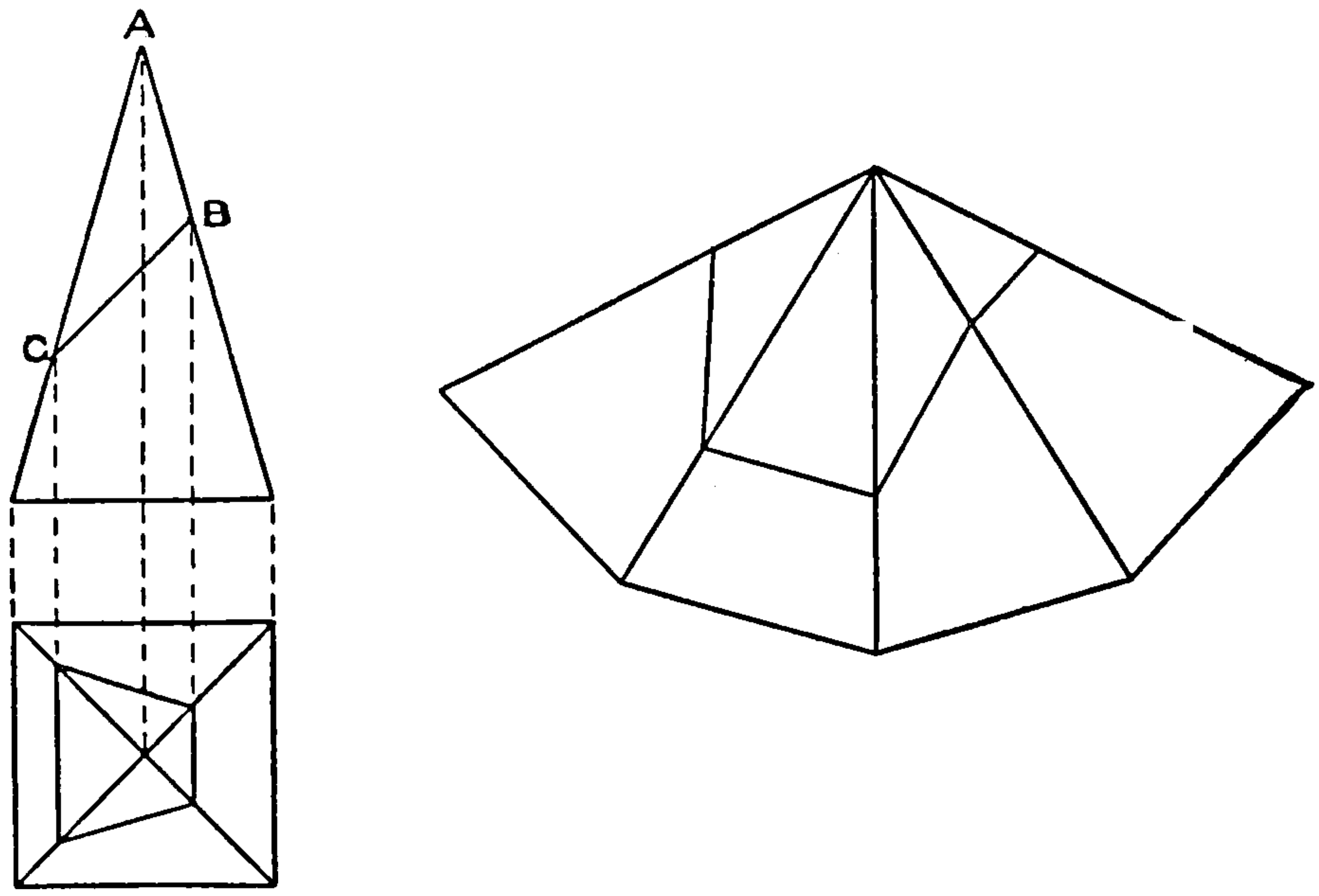


Fig. 195 Plan, Elevation, and Development of a Square Pyramid and Cutting Plane

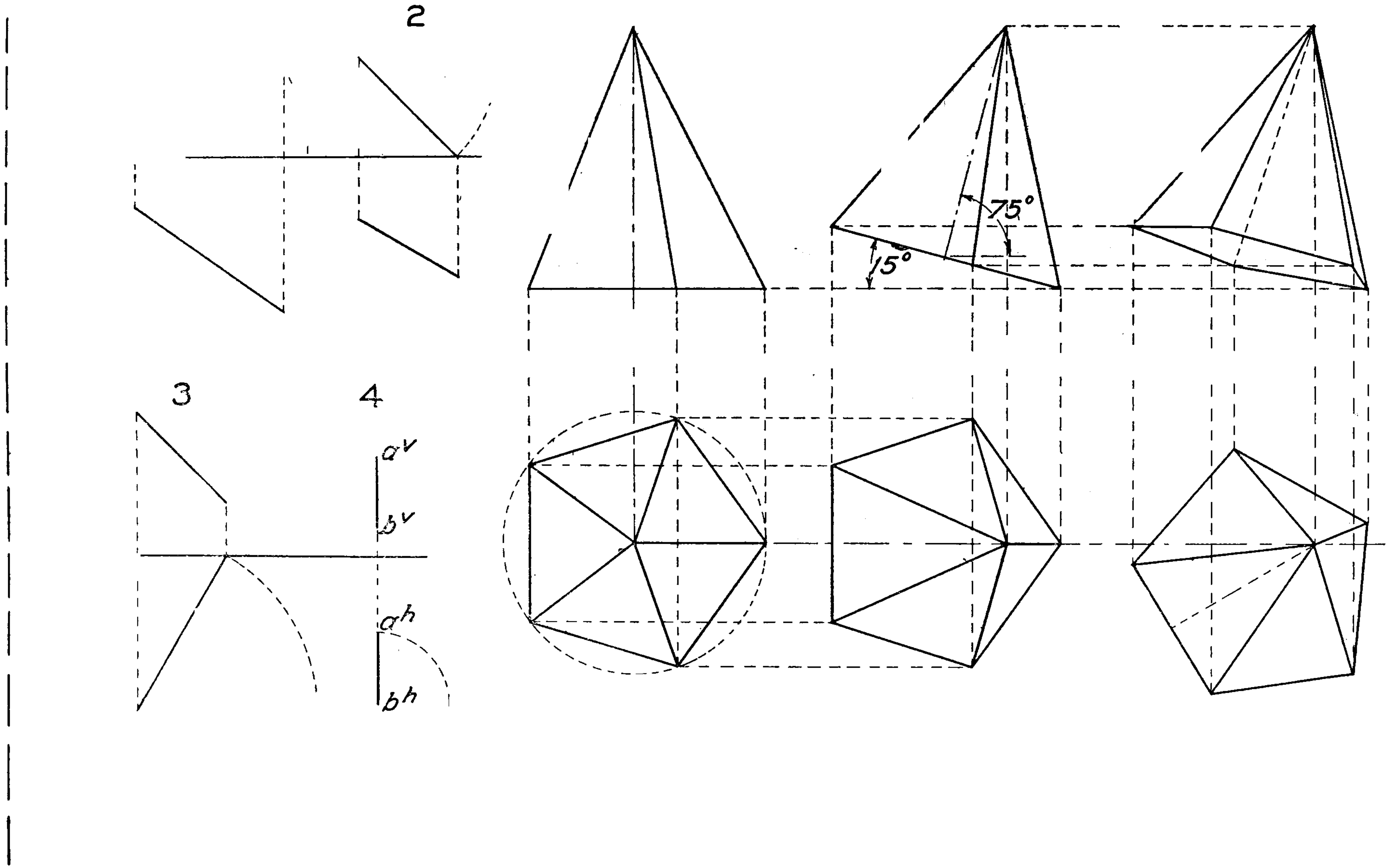
of construction lines to show clearly the method of finding the development.

The pyramid and its development are shown in Fig. 195. Each side of the square base is 2 inches, and the altitude is $3\frac{1}{2}$ inches. The plane forming the truncated pyramid is passed in such a position that *A B* equals $1\frac{3}{8}$ inches, and *A C* equals $2\frac{1}{2}$ inches. In this figure the development may be drawn in any convenient position, but in the case of the prism it is better to draw the development as shown. Indicate clearly the construction by inking the construction lines.

PLATE XIII

Isometric and Oblique Projection

Draw the oblique projection of a portable closet. The angle to be used is 45°. Make the height $3\frac{1}{2}$ inches, the depth $1\frac{1}{2}$ inches, and the width 3 inches. See Fig. 196. The width of the closet is to be shown as the right-hand face. The front left-hand lower corner is to be 1 inch from the left-hand border line and 2 inches from the lower border line. The door to be placed in the closet should be $1\frac{5}{8}$ inches wide and $2\frac{3}{4}$ inches high. Place the door centrally in the front of the closet, the bottom edge at the height of



FEBRUARY 27, 1910. HERBERT CHANDLER, CHICAGO, ILL.

PLATE XV

COURSE

IN

MECHANICAL DRAWING

AMERICAN SCHOOL

OF

CORRESPONDENCE

CHICAGO, ILL., U.S.A.

1" — $\frac{1}{2}$" — $\frac{3}{8}$" — $\frac{1}{2}$" — $\frac{3}{4}$" — $\frac{3}{8}$" — $\frac{3}{4}$" — $\frac{1}{2}$" — $\frac{1}{2}$" — $1\frac{1}{4}$"

should be constructed on a separate sheet of paper, from the dimensions given, the points on the curve being located by horizontal co-ordinates from the vertical edge of the wall, and then these co-ordinates transferred to the isometric drawing. After the isometric of one curved edge has been made, the others can be readily found from this. The width of the steps inside the walls is 3 inches.

PLATE XIV

Free-hand Lettering

On account of the importance of free-hand lettering, the student should practice it at every opportunity. For additional practice, and to show the improvement made since completing Part I, lay out Plate XIV in the same manner as Plate I, and letter all four rectangles. Use the same letters and words as in the lower right-hand rectangle of Plate I.

PLATE XV

Lettering

First lay out Plate XV in the same manner as previous plates. After drawing the vertical center line, draw light pencil lines as guide lines for the letters. The height of each line of letters is shown on the reproduced plate. The distance between the letters should be $\frac{1}{2}$ inch in every case. The spacing of the letters is left to the student. He may facilitate his work by lettering the words on a separate piece of paper, and finding the center by measurement or by doubling the paper into two equal parts. The styles of letters shown on the reproduced plate should be used.

ACKNOWLEDGMENT SHOULD BE MADE TO THE SEVERAL ARCHITECTS, DESIGNERS AND PUBLISHERS WHO HAVE ALLOWED THEIR DRAWINGS TO BE REPRODUCED IN THE SECTION ON ARCHITECTURAL LETTERING, AND TO THE BATES & GUILD CO., OF BOSTON, FOR PERMISSION TO INCLUDE THE VARIOUS PLATES FROM "LETTERS AND LETTERING," A LARGER TREATISE BY FRANK CHOUTEAU BROWN.

RUBBING OF INCISED SLATE LETTERING FROM HEAD STONE IN KING'S CHAPEL BURYING GROUND, BOSTON, 1773.

height must be exactly determined by the size, shape and weight of the plan or elevation itself, as well as its location upon and relation to the paper on which it is drawn, in order to give a pleasing effect and to best finish or set off the drawing itself. The style of letter used may be suggested, or even demanded, by the design of the building represented. Thus Gothic lettering might be appropriate on a drawing of a Gothic church, just as Italian Renaissance lettering would be for a building of that style, or as Classic lettering would seem most suitable on the drawings for a purely Classic design; while each letter or legend would look equally out of place on any one of the other drawings.

LETTER FORMS.

It may be said that practically all the lettering now used in architectural offices in this country is derived, however remotely it may seem in some cases, from the old Roman capitals as developed and defined during the period of the Italian Renaissance. These Renaissance forms may be best studied first at a large size in order to appreciate properly the beauty and the subtlety of their individual proportions. For this purpose it is well to draw out at rather a large scale, about four or four and one-half inches in height, a set of these letters of some recognized standard form, and in order to insure an approximately correct result some such method of construction as that shown in Figs. 1 and 2 should be followed. This alphabet, a product of the Renaissance, though of German origin, is one adapted from the well-known letters devised by Albrecht Dürer about 1525, and is here merely redrawn to a simpler constructive method and arranged in a more condensed fashion. This may be accepted as a good general form of Roman capital letter in outline, although it lacks a little of the Italian delicacy of feeling and thus betrays its German origin.

The letter is here shown in a complete alphabet, including those letters usually omitted from the Classic or Italian inscriptions: the J, U (the V in its modern form) and two alternative W's, which are separately drawn out in Fig. 1.

These three do not properly form part of the Classic alphabet and have come into use only within comparatively modern times. For this reason in any strictly Classic inscription the letter I should be used in place of the J, and the V in place of the U. It is sometimes necessary to use the W in our modern spelling, when the one composed of the double V should always be employed.

The system of construction shown in this alphabet is not exactly the one that Dürer himself devised. The main forms of the letters as well as their proportions are very closely copied from the original alphabet, but the construction has been somewhat simplified and some few minor changes made in the letters themselves, tending more towards a modern and more uniform character. The two W's, one showing the construction with the use of the two overlapping letter V's, and one showing the W incorporated upon the same square unit which carries the other

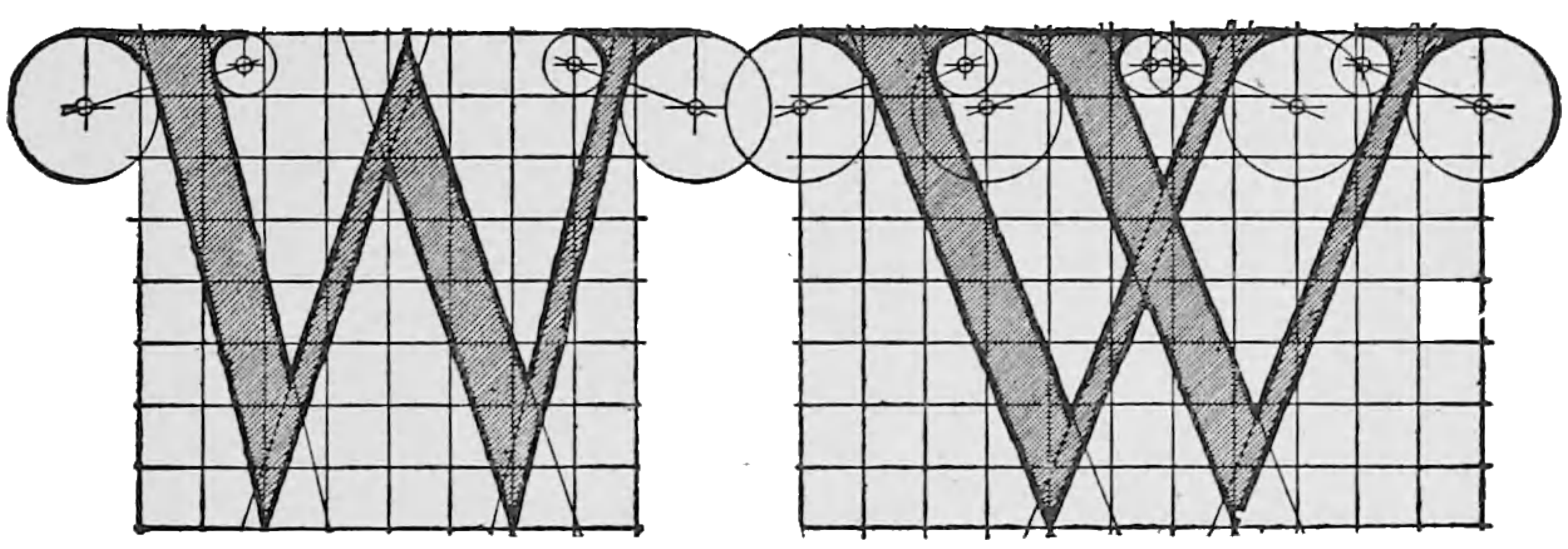


Fig. 1. Two Alternative Forms of the Letter W, to accompany the Alphabet shown in Fig. 2.

letters (the latter form being the one used by Dürer himself), are shown separately in Fig. 1. It should be noticed that every letter in the **alphabet,** except one or two that of necessity lack the requisite width—such as the I and J—is based upon and fills up the outline of a square, or in the case of the round letters, a circle which is itself contained within the square. This alphabet should be compared with the alphabet in Fig. 4, attributed to Sebastian Serlio, an Italian architect of the sixteenth century. By means of this comparison a very good idea may be obtained of the differences and characteristics which distinguish the Italian and German traits in practically contemporaneous lettering.

After once drawing out these letters at a large size, the beginner may find that he has unconsciously acquired a better constructive feeling for the general proportions of the *individual* letters and should thereafter form the letters free-hand without the aid of any such scheme of construction, merely referring occasionally to the large chart as a sort of guide or check upon the

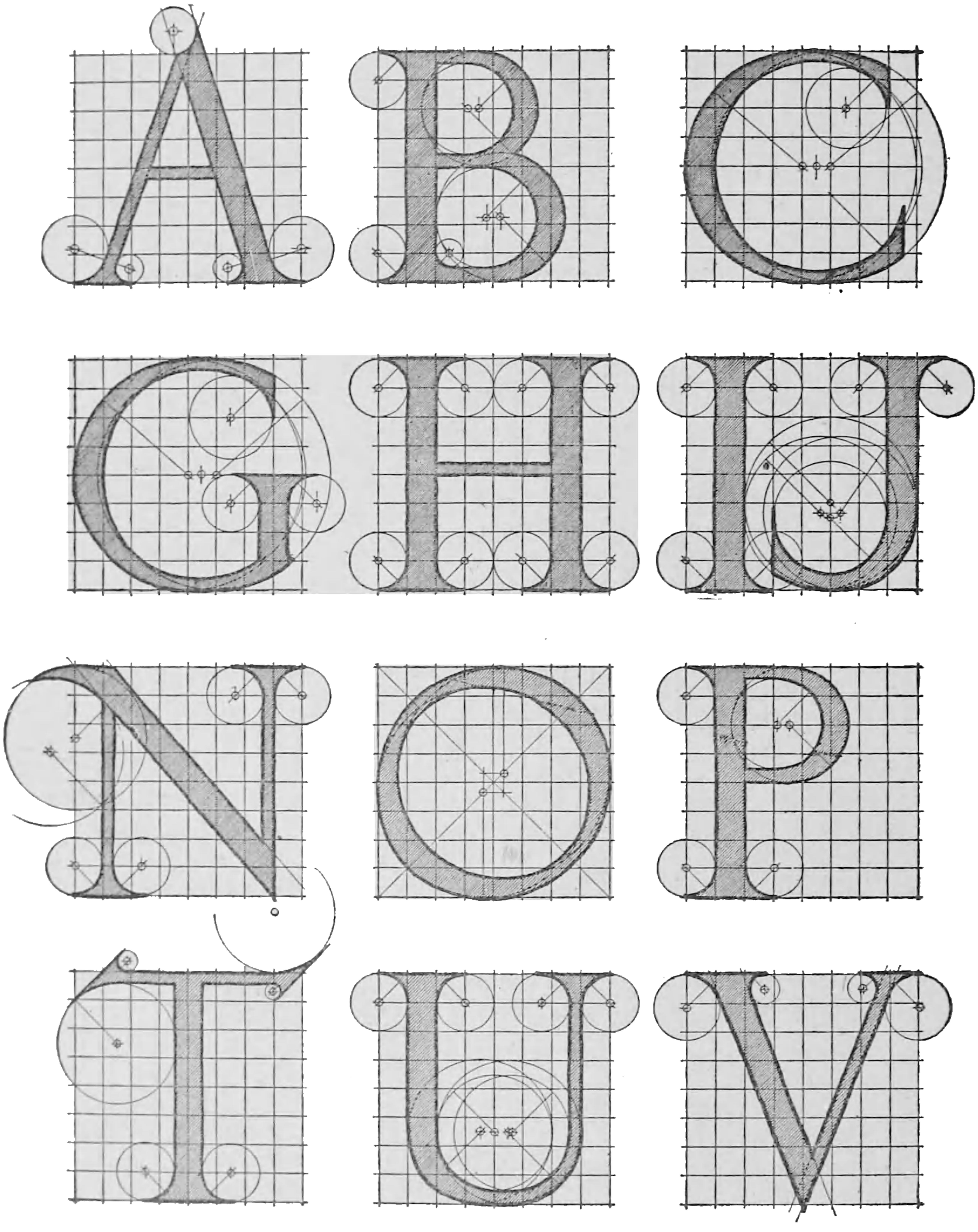


Fig. 2 Alphabet of Classic Renaissance Letters according to Albrecht Durer, adapted and reconstructed by F C Brown (See Fig. 1)

eye For this purpose it should be placed conveniently, so that it may be referred to when in doubt as to the outline of any individual letter. By following this course and practicing thor-

its edges; and that as the eye follows more the inner side of this line than it does the outer, both in drawing and afterwards in recognizing the letter form, the inaccuracies of the outer side of the line are likely to show up against the neighboring letters, and produce an irregularity of effect that it is difficult to overcome, especially for the beginner; while in a solidly blacked-in letter, it is the outline and proportions alone with which the draftsman must concern himself. Therefore, a letter in the same style is more easily and rapidly drawn when solidly blacked-in than as an "open" or outline letter. In many cases where it is desired to give a more or less formal and still sketchy effect, a letter of the same construction but with certain differences in its characteristics may be used. It should not be so difficult to draw, and much of the same character may still be retained in a form that

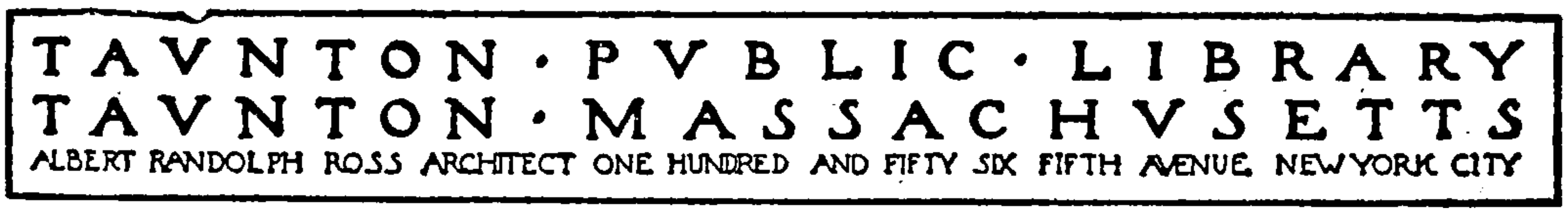


Fig. 3. Title from Competitive Drawings for the Taunton Public Library, Albert Randolph Ross, Architect.

is much easier to execute. Some such letter as is shown at the top of Fig. 10, or any other personal variation of a similar form such as may be better adapted to the pen of the individual draftsman would answer this purpose. The titles shown in Figs. 3 and 5 include letters of this same general type, but of essentially different character.

In drawing a letter that is to be incised in stone it is customary to show in addition to the outline, a third line about in the center of the space between the outside lines. This additional line represents the internal angle that occurs at the meeting of the two sloping faces used to define the letter. An example is shown in Figs. 24 and 25, while in Fig. 7, taken from drawings for a building by McKim, Mead & White, the same convention is frankly employed to emphasize the principal lettering of a pen-drawn title.

Fig. 4. Italian Renaissance Alphabet, according to Sebastian Serlio.

For the purpose of devising a letter that may be drawn with one stroke of the pen and at the same time retain the general character of the larger, more Classic alphabet, in order that it may be consistently used for less important lettering on the same drawing, it is interesting to try the experiment of making a skeleton of the letters in Figs. 1 and 2. This consists in running a single heavy line around in the middle of the strokes that form

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·SCALE · ONE · INCH · EQVALS · FOVR · FEET ·
BRITE · AND · BACON · ARCHITECTS · III · FIFTH · AVENVE · NEW · YORK · CITY ·

Fig. 5. Title from Drawings for the Jersey City Public Library, Brite & Bacon, Architects.

the outline of these letters. This "skeleton" letter, with a few modifications, will be found to make the best possible capital letter for rapid use on working drawings, etc., and in a larger size it may be used to advantage for titling details (Fig. 9). It will also prove to be singularly effective for principal lettering

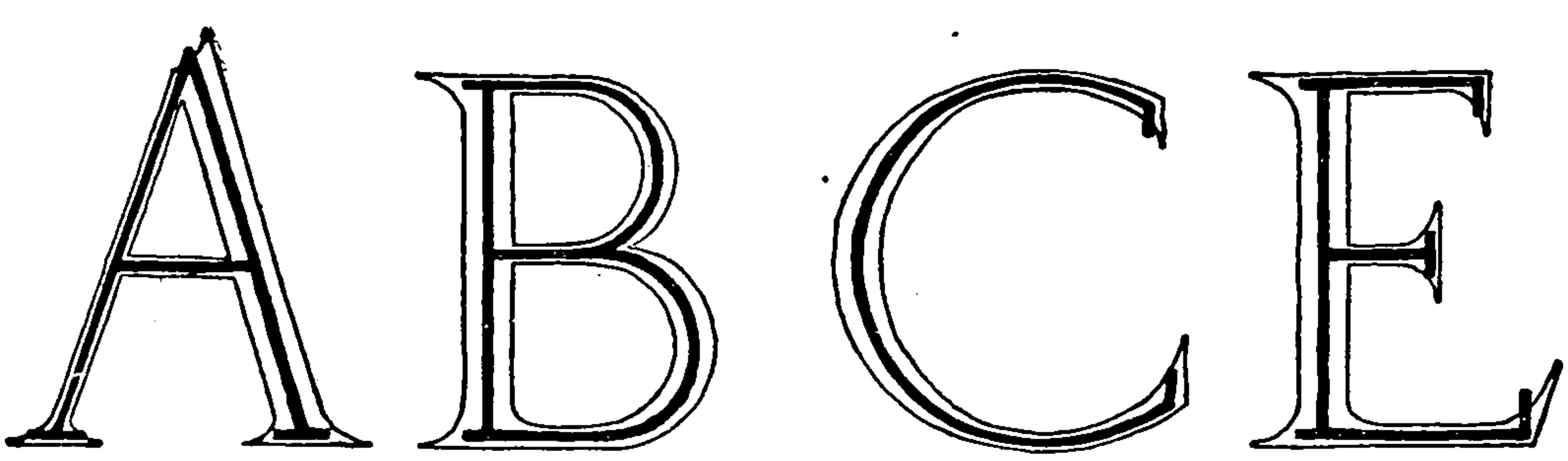
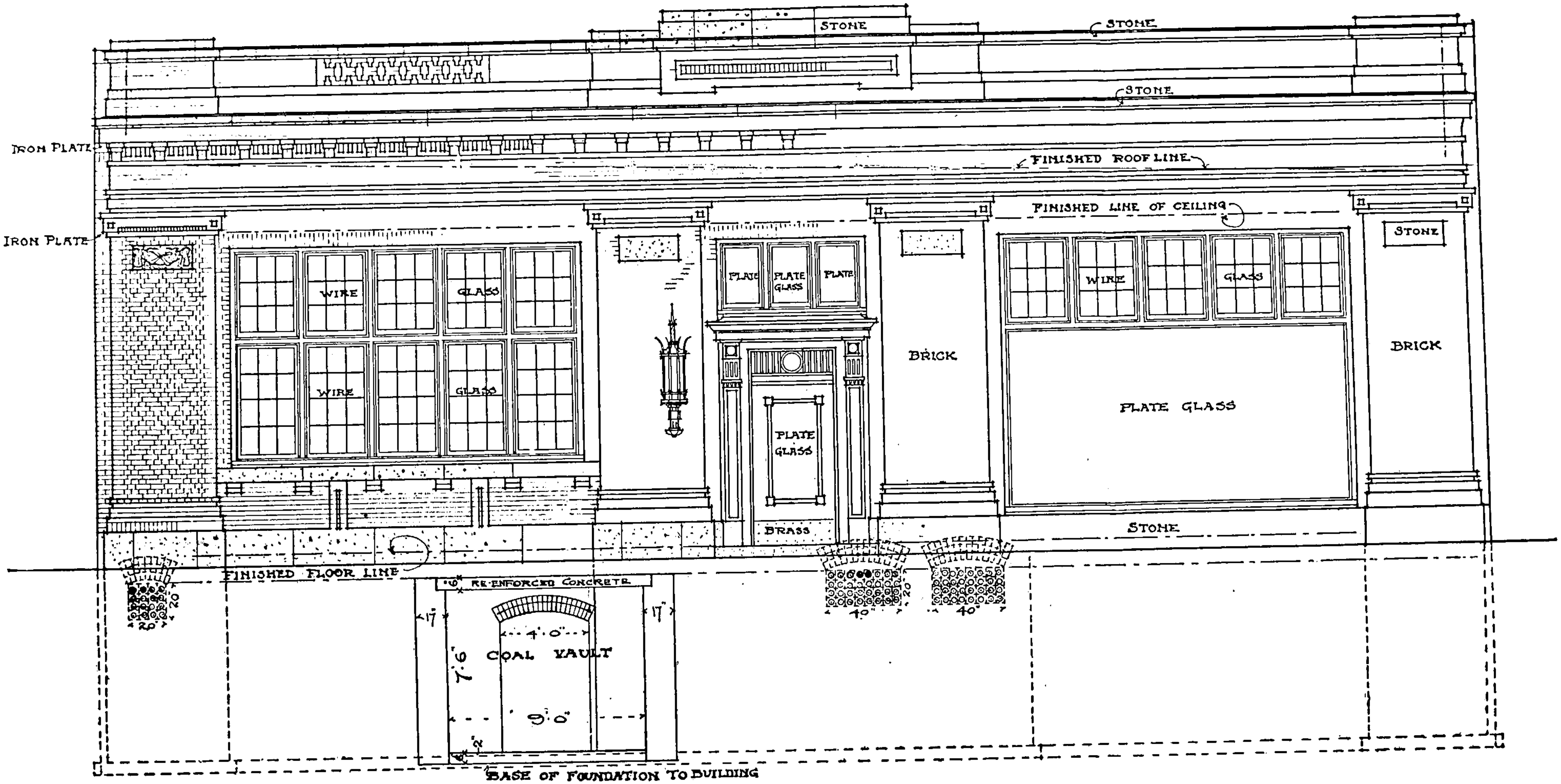


Fig 6 "Skeleton" Construction of Letters shown in Fig. 2.

on plans, to give names of rooms, etc. (Fig. 13), while in a still smaller size it may sometimes be used for notes, although a minuscule or lower case letter will be found more generally useful for this purpose.

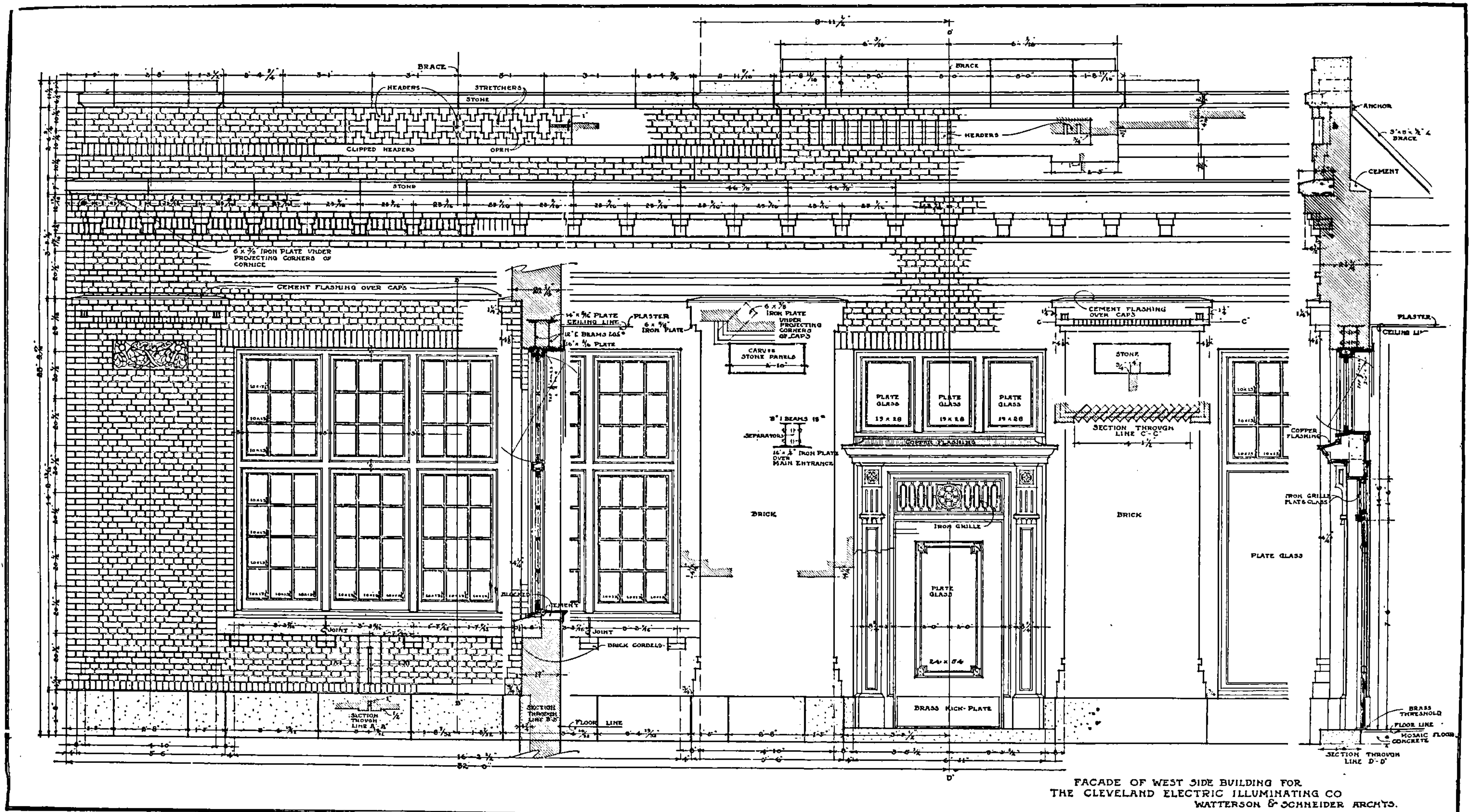
In Fig. 6 are shown four letters where the skeleton has been drawn within the outline of the more Classic form. It is un-



WEST SIDE BUILDING FOR THE CLEVELAND ELECTRIC ILLUMINATING COMPANY, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

For Detail, See Opposite Page, for Exterior, See Page 170.



DETAIL OF WEST SIDE BUILDING FOR THE CLEVELAND ELECTRIC ILLUMINATING COMPANY, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.

For Exterior View, See Page 170. Front Elevation and Basement Section Shown on Opposite Page.

used with classic outline or blacked-in capitals on drawings, Figs. 3, 5 and 7.

In Figs. 8, 9 and 13 these one-line letters are used for principal titles as well, and with good effect.

In Fig. 10 is shown a complete alphabet of this single-line

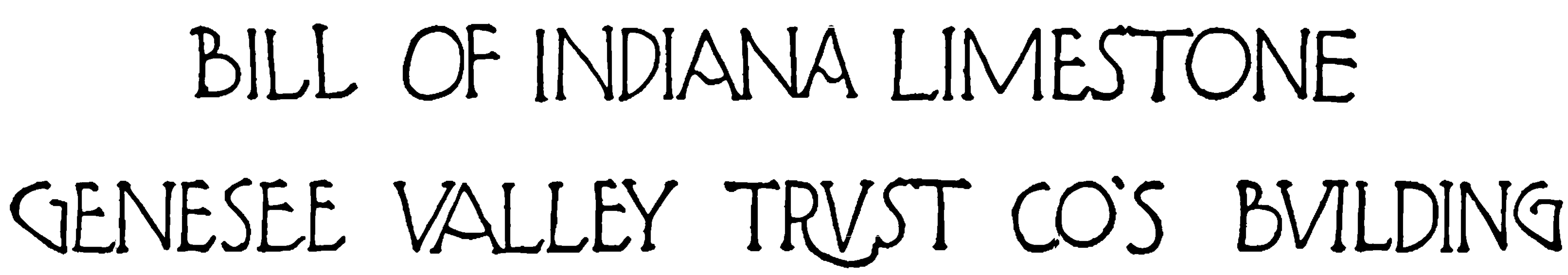


Fig. 8 Title from Architectural Drawing, Claude Fayette Bragdon, Architect.

letter, and the adaptability of this character for use on details is indicated by the title taken from one and reproduced in Fig. 9. In the same plate, Fig. 10, is also shown an excellent form of small letter that may be used with any of these capitals. It is

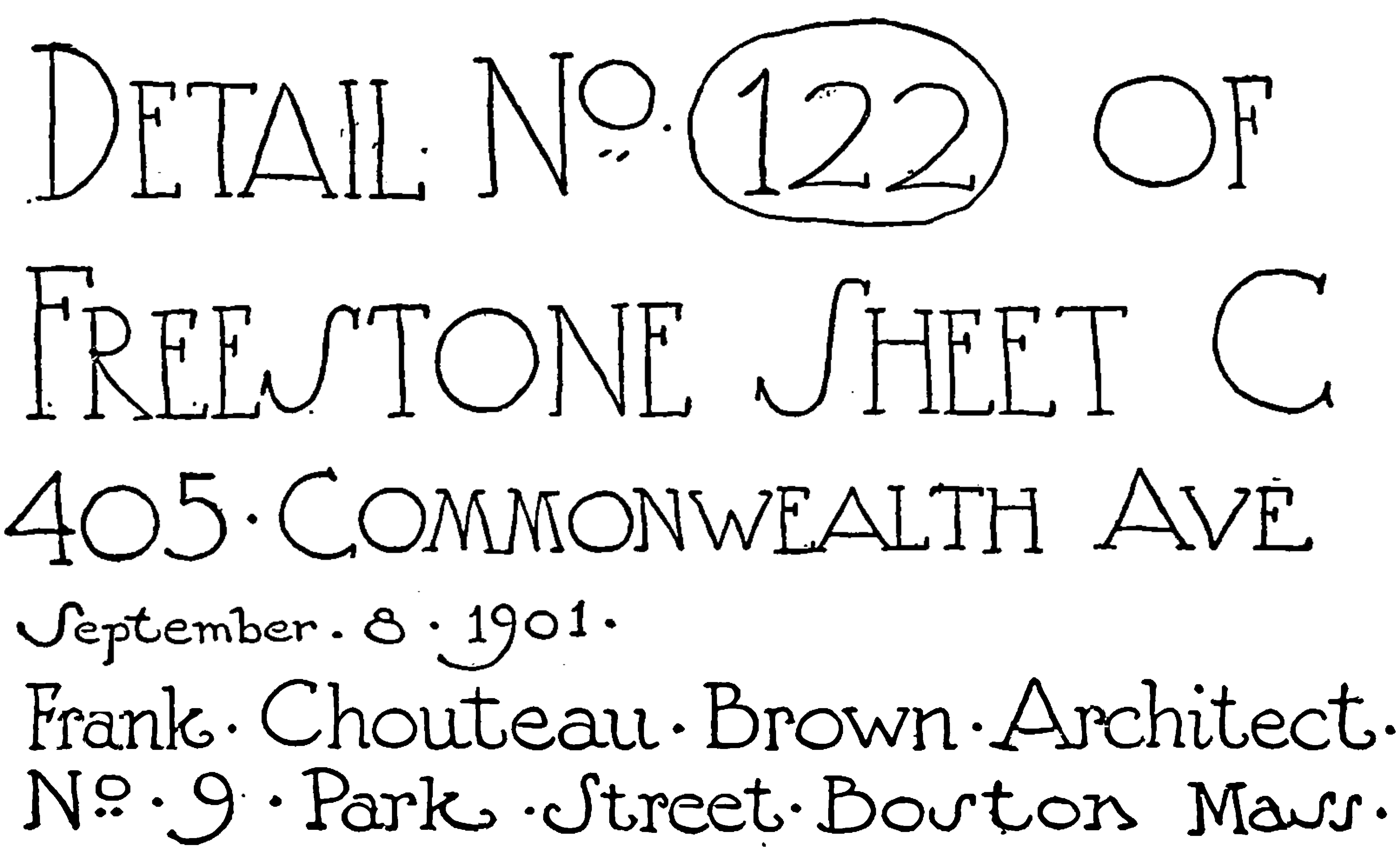


Fig. 9. Title from Detail

quite as plain as any Engineer's letter, and is easier to make, and at the same time when correctly placed upon the drawing it is much more decorative. This entire plate is reproduced at a slight reduction from the size at which it was drawn, so that it may be studied and followed closely.

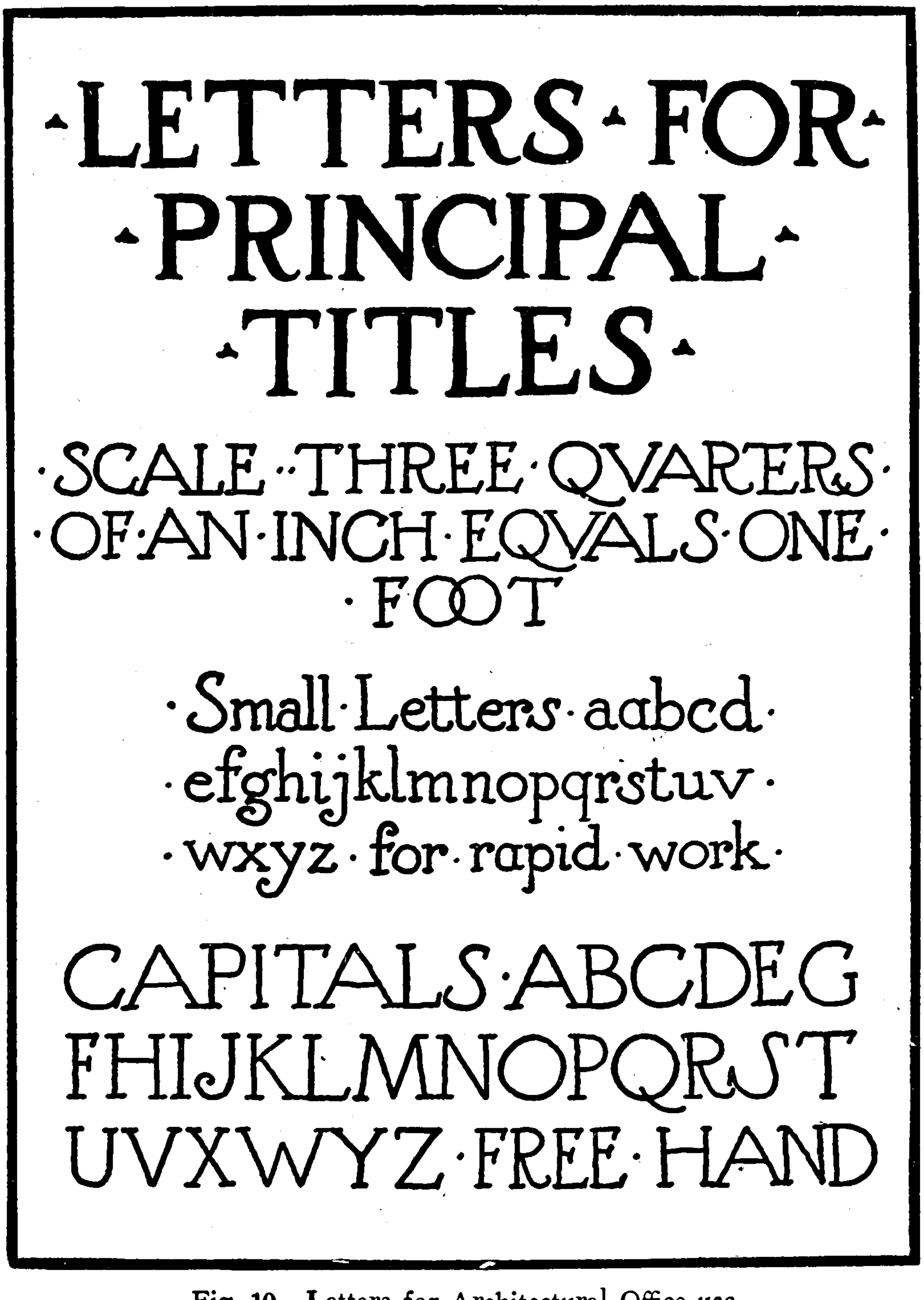


Fig. 10. Letters for Architectural Office use.

Fig. 10 should be most carefully studied and copied, as it represents such actual letter shapes as are used continually on

Fig. 11. Single-line Italic Letters, by Claude Fayette Bragdon.

architectural drawings, and such as would, therefore, be of the most use to the draftsman. He should so perfect himself in these alphabets that he will have them always at hand for instant use.

cially to show this point, but was selected from among several as best illustrating the use of the letter forms themselves, as well as good placing and composition of the titles, both in regard to the general outline of the plan and their spacing and location in the various rooms. It is apparent that it is not exactly accurate in the centering in one or two places. For instance, in the general title, the two lower lines are run too far to the right of the center line, and this should be corrected in any practice work where these principles will be utilized. It may be well to say that the actual length of this plan in the original drawing was thirteen inches, and the rest of it large in proportion. The student should not attempt to redraw any such example as this at the size of the illustration. He must always allow for the reduction from the original drawing, and endeavor to reconstruct the example at the original size, so that it would have the same effect when reduced as the model that he follows.

The letters for notes and more detailed information should be much simpler and smaller than and yet may be made to accord with the larger characters. Such a rapid letter as that shown in Fig. 10, for instance, may be used effectively with a severely classical title. Of course, no one with a due regard for propriety or for economy of time would think of using the Gothic small letter for this purpose.

The portion of a drawing shown in Fig. 14 illustrates another instance of the use of lettering on an architectural working drawing. The lettering defined by double lines is in this case a portion of the architectural design, the two letters on the pendant banners being sewn on to the cloth while those on the lower portion of the drawing are square-raised from the background and gilded. Single-line capitals are used in this example for the notes and information necessary to understand the meaning of the drawing.

A drawing of distinction should have a principal title of equal beauty, such as that shown in Fig. 5 or Fig. 7. The excellent lettering reproduced in Fig. 12, from a drawing by Mr. Claude Fayette Bragdon, is a strongly characteristic and individual form, although based on the same "skeleton" idea as the other types of single-line lettering already referred to.

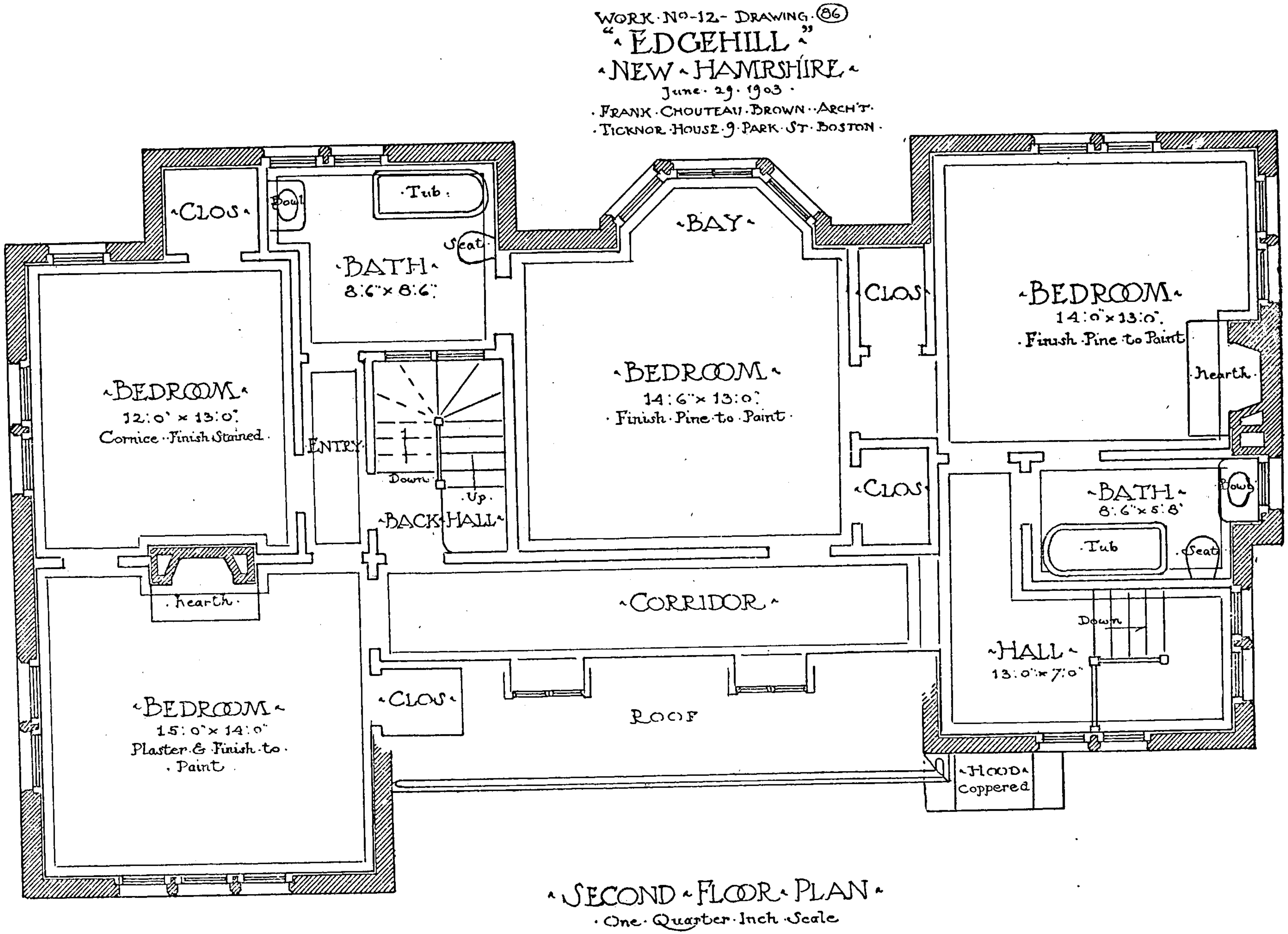

WORK · No-12 - DRAWING · 86
"EDGEHILL"
NEW · HAMPSHIRE
June · 29 · 1903 ·
· FRANK · CHOUTEAU · BROWN · · ARCH'T ·
· TICKNOR · HOUSE · 9 · PARK · ST · BOSTON ·
CLOS
Bowl
Tub
Seat
BATH
8' 6" x 8' 6"
BAY
CLOS
BEDROOM
14' 0" x 13' 0"
Finish Pine to Paint
Hearth
BEDROOM
12' 0" x 13' 0"
Cornice · Finish Stained ·
ENTRY
Down
Up
BACK HALL
BEDROOM
14' 6" x 13' 0"
· Finish · Pine · to · Paint ·
CLOS
BATH
8' 6" x 5' 8"
Bowl
Tub
Seat
Hearth
CORRIDOR
Down
HALL
13' 0" x 7' 0"
CLOS
ROOF
BEDROOM
15' 0" x 14' 0"
Plaster & Finish to
Paint
HOOD
Coppered
SECOND FLOOR PLAN
· One · Quarter · Inch · Scale

Fig. 13.

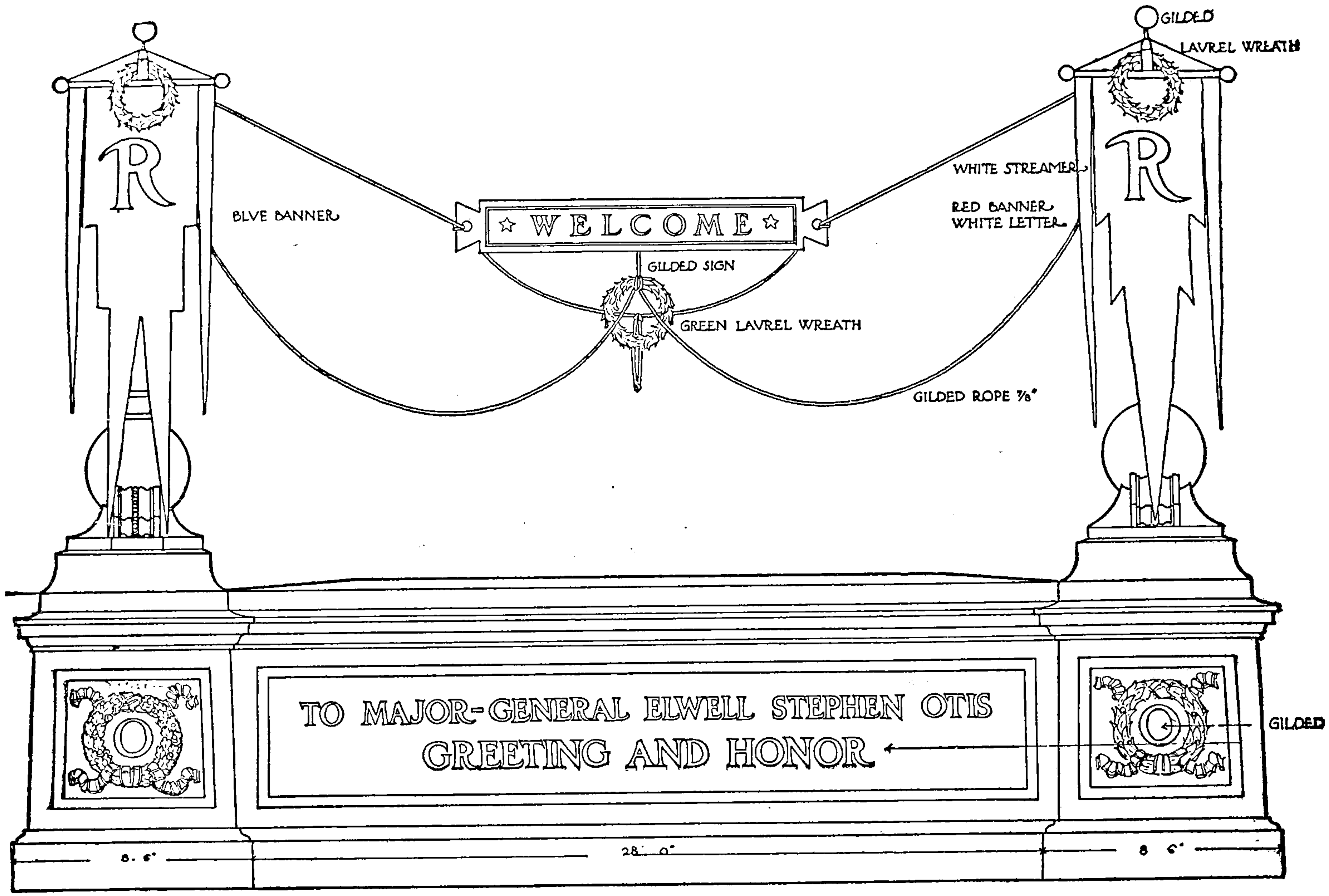
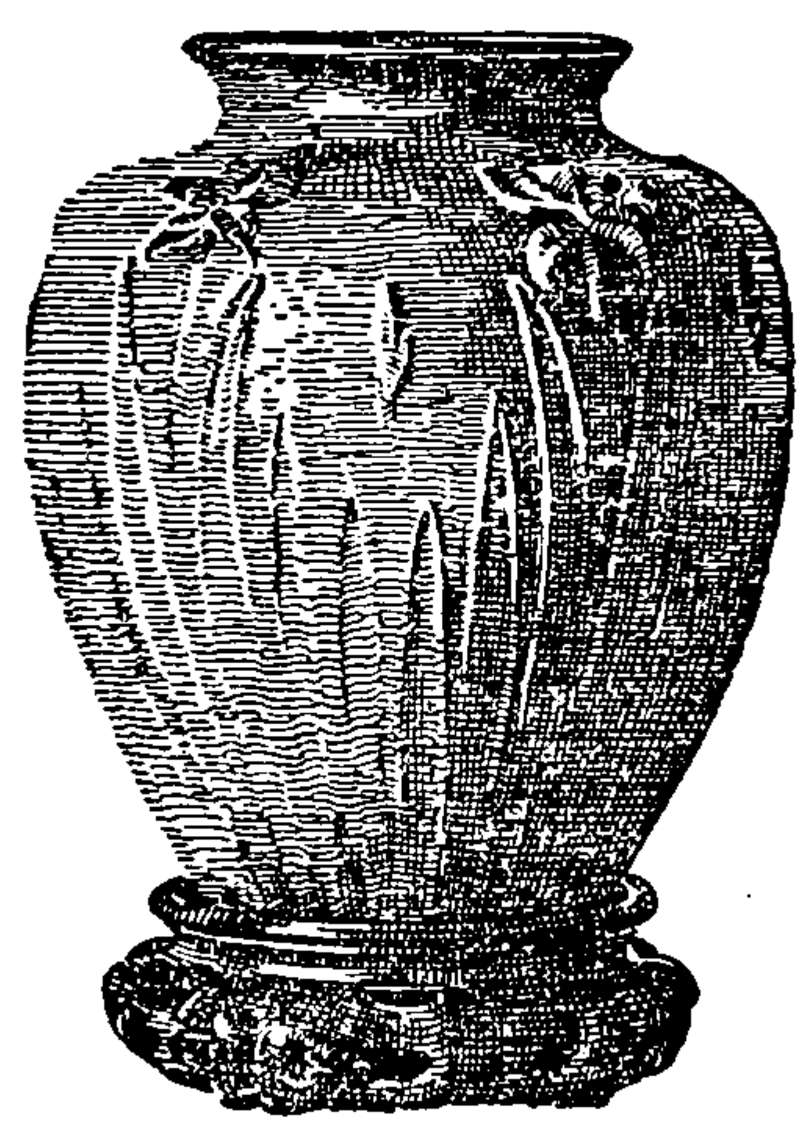


Fig. 14. Upper Portion of Drawing for Otis Memorial Arch, Claude Fayette Bragdon, Architect.

BIGELOW, KENNARD AND CO.
WILL HOLD, IN THEIR ART
ROOMS, MARCH 25 TO APRIL 6
INCLUSIVE, A SPECIAL EXHIBI-
TION AND SALE OF GRUEBY
POTTERY INCLUDING THE
COLLECTION SELECTED FOR
THE BUFFALO EXPOSITION
MDCCCCI



WASHINGTON STREET, COR-
NER OF WEST STREET, BOSTON

Fig 16 Cover Announcement, by Addison B. Le Boutillier.

is not the vital part in lettering, for the *composition* of these separate characters is by far the most important part of the problem.

Composition in lettering is almost too intangible to define by any rule. All the suggestions that may be given are of necessity laid out on merely mathematical formulæ, and as such are incapable of equaling the result that may be obtained by spacing and producing the effect solely from artistic experience and intuition. The final result should always be judged by its effect upon the eye, which must be trained until it is susceptible to the slightest deviation from the perfect whole. It is more difficult to define what good composition is in lettering than in painting or any other of the more generally accepted arts, and it resolves itself back to the same problem. The eye must be trained by constant study of good and pleasing forms and proportions, until it appreciates instinctively almost intangible mistakes in spacing and arrangement.

This point of "composition" is so important that a legend of most beautiful individual letter forms, badly placed, will not produce as pleasing an effect as an arrangement of more awkward letters when their composition is good. This quality has been so much disregarded in the consideration of lettering, that it is important the student's attention should be directed to it with additional force, in order that he may begin with the right feeling for his work.

An excellent example of composition and spacing is shown in Fig. 16, from a drawing by Mr. Addison B. Le Boutillier. The relation between the two panels of lettering and the vase form, and the placing of the whole on the paper with regard to its margins, etc., are exceptionally good, and the rendered shape of the vase is just the proper weight and color in reference to the weight and color of the lettered panels.

In this reproduction the border line represents the edge of the paper upon which the design itself was printed, and not a border line enclosing the panel. The real effect of the original composition can be obtained only by eliminating the paper outside of this margin and by studying the placing and mass of the design in relation to the remaining "spot" and proportions of the paper. Perhaps the simplest and most certain way to realize the effect of the original is to cut out a rectangle the size of this panel from a differently colored piece of paper, and place it over the page as a "mask," so that only the outline of the original design will show through.

The other example by the same designer, shown in Fig. 15, is equally good. The use of the letter with the architectural ornament, and the form, proportion, spacing and composition of the lettering are all admirable.

The title page, by Mr. Claude Fayette Bragdon, shown in Fig. 17, is a composition including the use of many different types of letters; yet all belong to the same period and style, so that an effect of simplicity is still retained. In composition, this page is not unlike its possible composition in type, but in that case no such variety of form for the letters would be feasible, while the entire design has an effect of coherence and fusion which the use of a pen letter alone makes possible, and which could not be obtained at all in typographical examples. The treatment of the ornament incorporated in this design should be noticed for its weight and rendering, which bear an exact relation to the "color" of the letter employed.

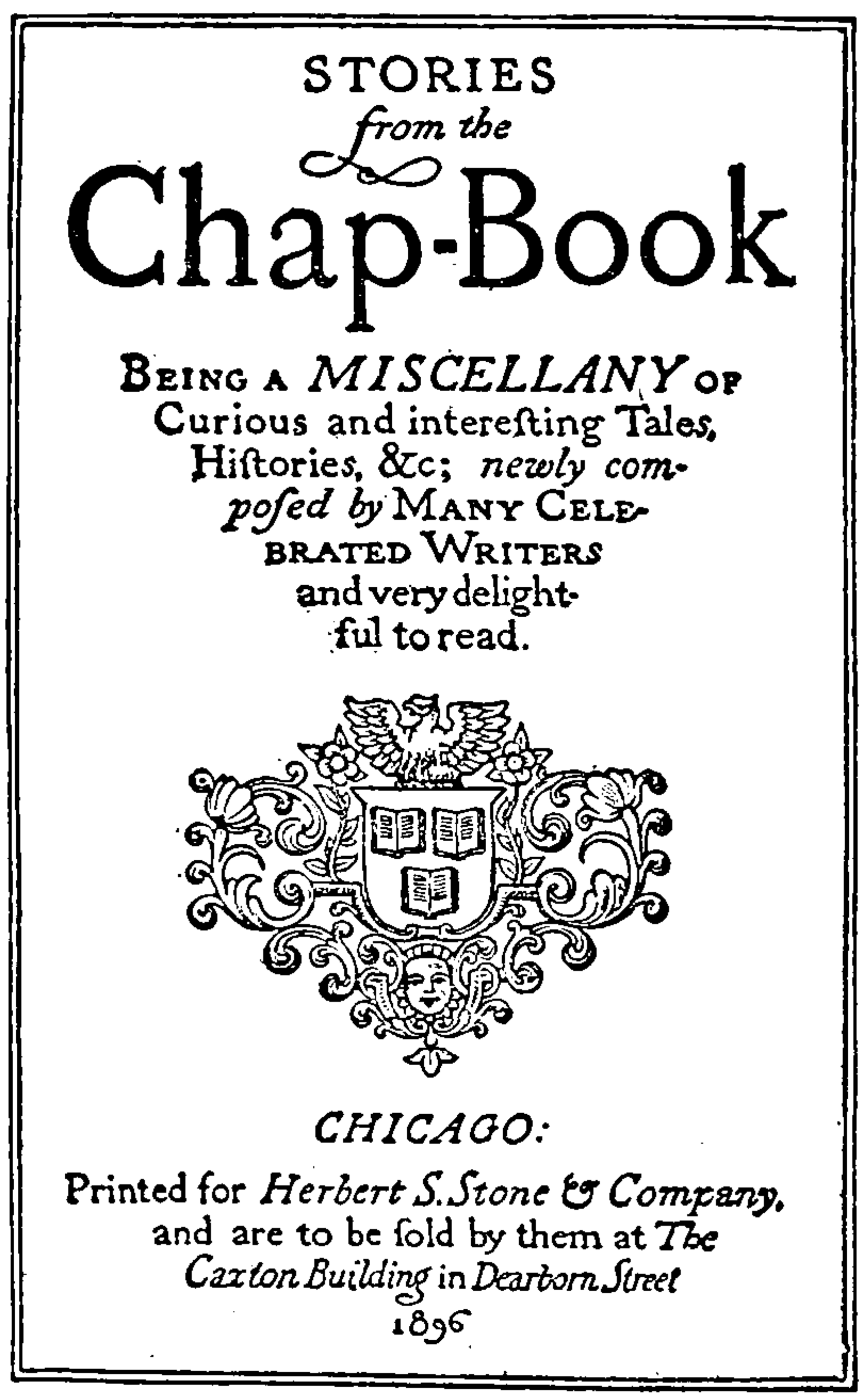


Fig 17. Title Page, by Claude Fayette Bragdon

In Fig. 18 is a lettered panel that will well repay careful study. The composition is admirable, the letter forms of great distinction—especially the small letters—and yet this example has not the innate refinement of the others. The decorative panel at the top is too heavy, and the ornament employed has no special beauty of form, fitness, or charm of rendering (compare Figs. 15 and 16), while the weight of the panel requires

composition, in connection with a bolder design, in this case for a book cover, by Mr. H. Van Buren Magonigle. Note the nice sense of relation between the style of lettering employed and the design itself, as well as the subject of the work. The letter form is a most excellent modernization of the classic Roman letter shape (compare Figs. 22 and 23).

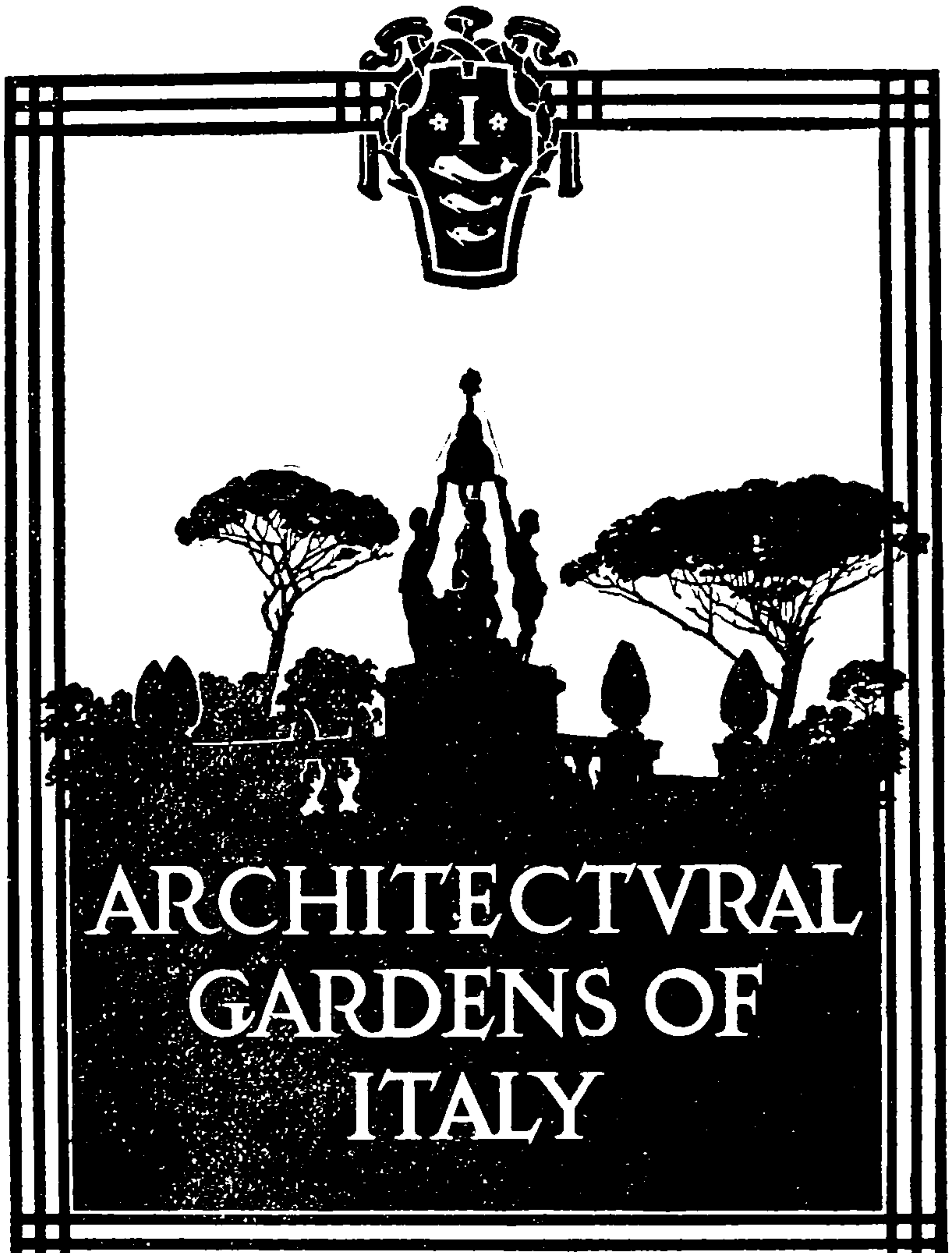


Fig. 19 Book Cover, by H. Van Buren Magonigle.

The student must be ever appreciative of all examples of the good and bad uses of lettering that he sees, until he can distinguish the niceties of their composition and appreciate to the utmost such examples as the first of these here shown. It is only by constant analysis of varied examples that he can be able to distinguish the points that make for good or bad lettering.

SPACING.

There is a workable general rule that may be given for obtaining an *even* color over a panel of black lettering; that is, if the individual letters are so spaced as to have an equal area of white between them this *evenness* of effect may be attained. But when put to its use, even this rule will be found to be surrounded by pitfalls for the unwary. This rule for spacing must not be understood to mean that it applies as well to *composition.* It does not: it is, at the best, but a makeshift to prevent one from going far wrong in the general tone of a panel of lettering, and must therefore fully apply only to a legend employing one single type of letter form.

One with sufficient authority and experience to give up dependence upon merely arbitrary rules, and to rely upon his own judgment and taste may, by varying sizes and styles of letters, length of word lines, etc., obtain a finer and much more subtle effect.

To acquire this authority in modern lettering it is necessary to observe and study the work turned out today by the best designers and draftsmen, such as the drawings of Edward Penfield, Maxfield Parrish, A. B. Le Boutillier and several others. The architectural journals, also, publish from month to month beautifully composed and lettered scale drawings by such draftsmen as Albert R. Ross, H. Van Buren Magonigle, Claude Fayette Bragdon, Will S. Aldrich and others, who have had precisely the same problem to solve as is presented to the draftsman in every new office drawing that he begins.

Of course, the freer and the further removed from a purely Classic capital form is the letter shape employed by the draftsman, the less obliged is he to follow Classic precedent; but at the same time he will find that his drawing at once tends more toward the bizarre and eccentric, and the chances are that it will lose in effectiveness, quietness, legibility and strength.

The student will soon find that he unconsciously varies and individualizes the letters that he constantly employs, until they become most natural and easy for him to form. This insures his developing a characteristic letter of his own, even when at the start he bases it upon the same models as have been used by many other draftsmen.

MINUSCULE OR SMALL LETTERS.

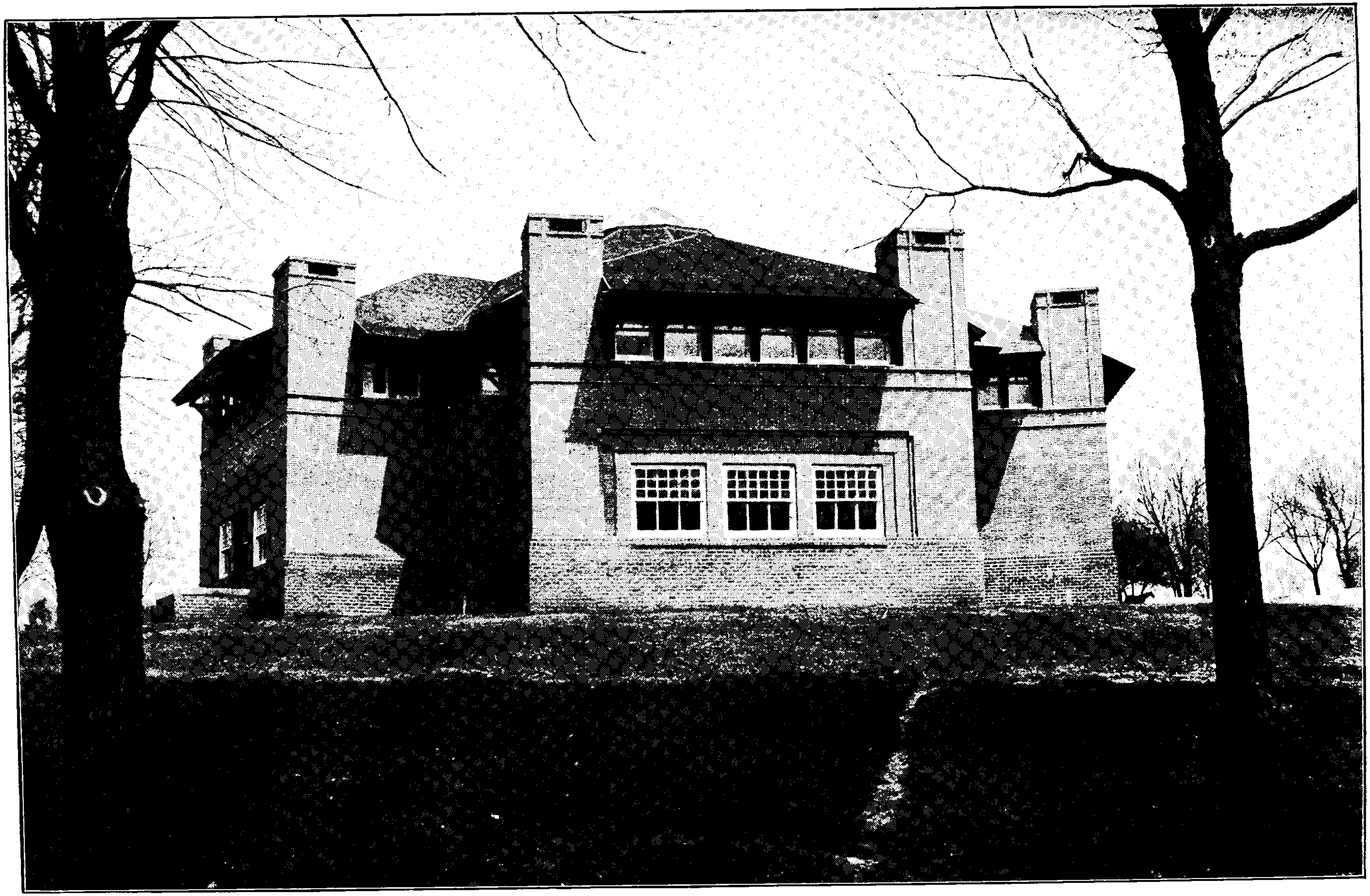
In taking up the use of the small or minuscule letter, a word of warning may be required. While typographical work may furnish very valuable models for composition and for the individual shapes of minuscule letters, they should never be studied for the *spacing* of letters, as such spacing in type is necessarily arbitrary, restricted and often unfortunate. Among the lower case types will be found our best models of individual minuscule letter forms, and the Caslon old style is especially to be commended in this respect; but in following these models the aim must be to get at and express the essential characteristics of each letter form, to reduce it to a "skeleton" after much the same fashion as has already been done with the capital letter, rather than to strive to copy the inherent faults and characteristics of a type-minuscule letter. The letter must become a "pen form" before it will be appropriate or logical for pen use; in other words, the necessary limitations of the instrument and material must be yielded to before the letter will be amenable to use for lettering architectural drawings.

The small letters shown in Figs. 17, 18 and 20 are all adapted from the Caslon or some similar type form, and all exhibit their superiority of spacing over the possible use of any type letter. Fig. 20 is a particularly free and beautiful example indicating the latent possibilities of the minuscule form that are as yet almost universally disregarded. An instance of the use of the small letter shown in a complete alphabet in Fig. 10, may be seen in Figs. 9 and 13.

In lettering plans for working drawings, the small letter is used a great deal. All the minor notes, instructions for the builders or contractors, and memoranda of a generally unimportant character, are inscribed upon the drawing in these letters. Referring again to Fig. 10, the letters at the top of the page would be those used for the principal title, the name of the drawing, the name of the building or its owner, while the outline capitals would be used in the small size beneath the general title, to indicate the scale and the architect, together with his address. In a small building, or one for domestic use, these same letters would be employed in naming the various rooms, etc., although in an

WEST SIDE BUILDING FOR THE CLEVELAND ELECTRIC ILLUMINATING COMPANY, CLEVELAND, OHIO

Watterson & Schneider, Architects, Cleveland, Ohio.



MUSIC BUILDING FOR DOANE COLLEGE, CRETE, NEB.

Dean & Dean, Architects, Chicago, Ill.

For Plans and Section, See Page 186.

elaborate ornamental or public building, letters similar to those in the principal title might be better used, while the minuscule letter would be utilized for all minor notes, memoranda, directions, etc. By referring to Figs. 3, 5, 7, 8, 9, 13 and 14, examples from actual working drawings and plans are shown, which should sufficiently indicate the application of this principle.

It must again be emphasized that practice in the use of these forms combined together in words, as well as in more difficultly composed titles and inscriptions where various sizes and kinds of letters are employed, is the only method by which the draftsman can become proficient in the art of lettering; and even then he must intelligently study and criticise their effect

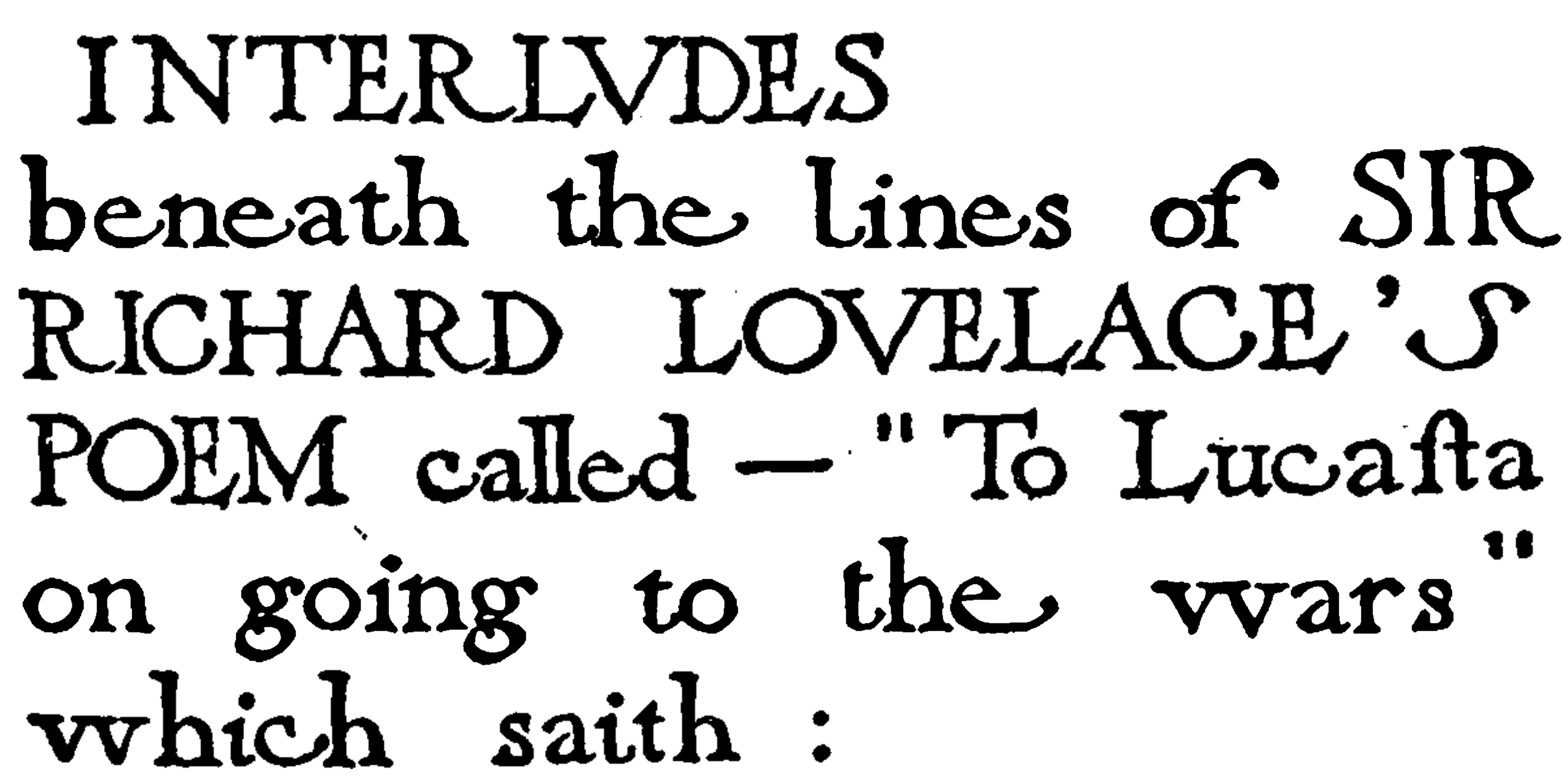


Fig. 20. Pen-drawn Heading, by Harry Everett Townsend.

after they are finished, as well as study continually the many good drawings carrying lettering reproduced in the architectural journals. For this purpose, in order to keep abreast of the modern advance in this requirement, he must early learn to distinguish between the instances of good and bad composition and lettering.

ARCHITECTURAL INSCRIPTION LETTERING.

The use of a regular Classic letter for any purpose necessitates the reversion to and the study of actual Classic examples for spacing and composition. In using this letter in a pen-drawn design, certain changes must be made in adapting it from the incised stone-cut form—which variations are, of course, practically the reverse of those required in first adapting the letter for use in stone. The same letter for stone incision requires, in addition, a careful consideration of the nature of the material, and the spacing and letter section that it allows. Also the effect

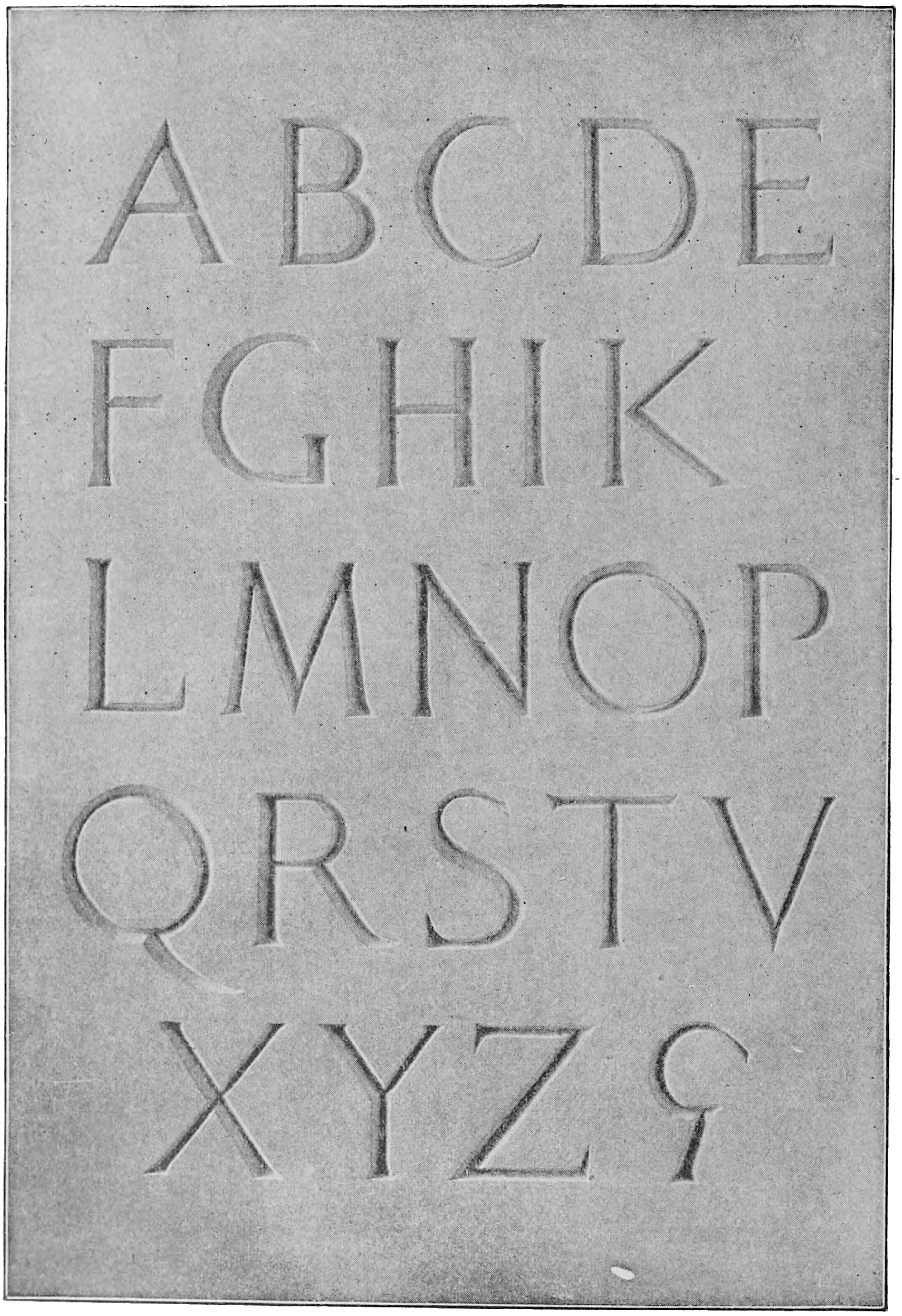


Fig. 21. Study for Lettering on Granite Frieze of Boston Public Library, McKim, Mead & White, Architects.

Such pleasant grading of shadows as may be attained by the other method is then impossible, and there are no subtle cross

Fig 22. Classic Roman Alphabet.
From Marble Inscriptions in the Roman Forum.

lights on the rounding letters to add interest and variety, but the letter certainly carries farther and has more strength.

In Fig. 21 is shown a photograph from a model of the incised V-sunk letters cut in granite on the frieze of the Boston

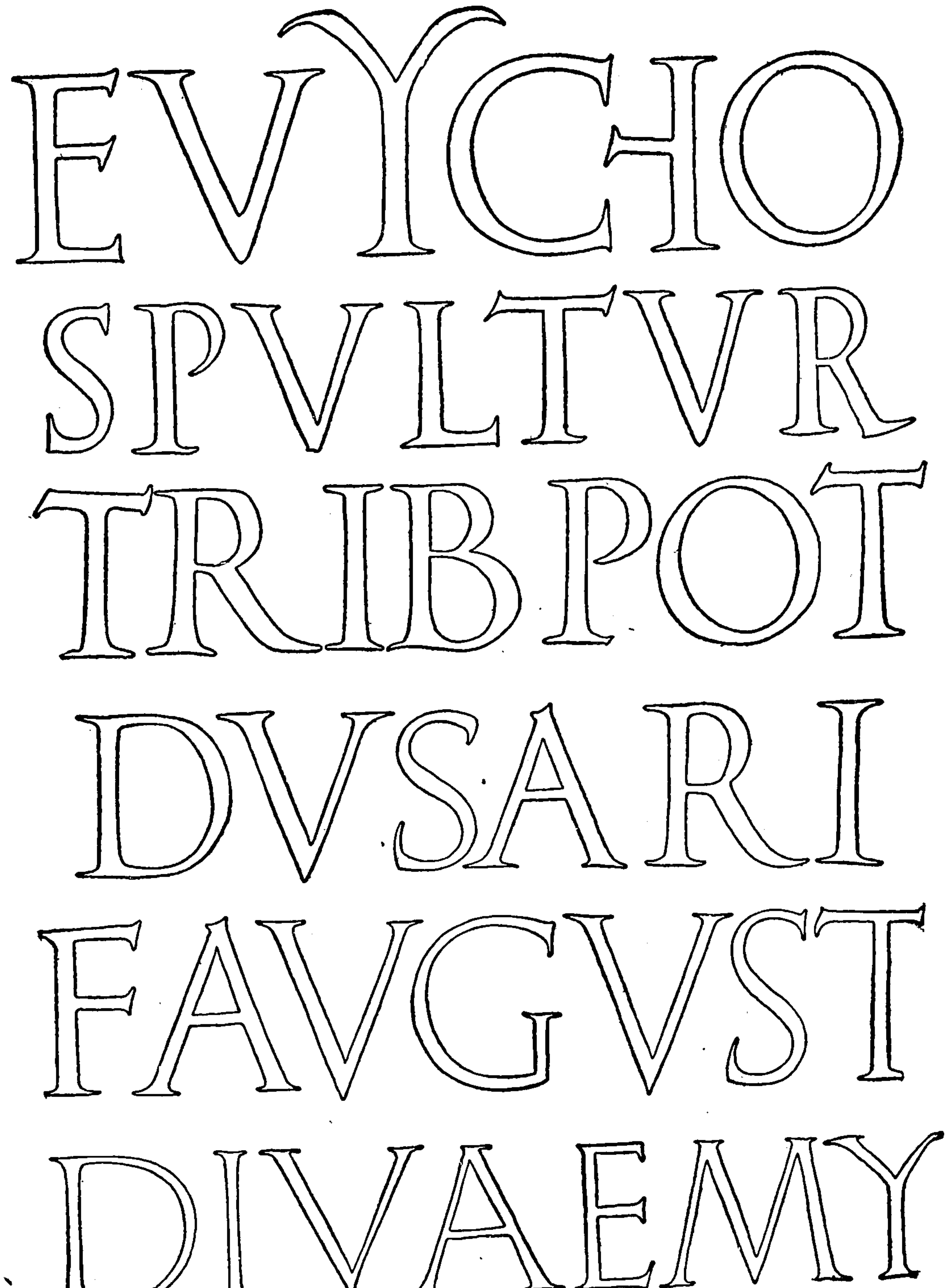


Fig. 23. Fragments of Classic Roman Inscriptions.

Public Library. This photograph indicates the shadow effect that defines the incised form of the letter, and will assist the student somewhat in determining the section required for the best effect. It will be observed that this letter is different in character from the one used by the same architects in a different material, sandstone, shown in Fig. 24.

In Fig. 22 is shown an alphabet redrawn from a rubbing of Roman lettering, and in Fig. 23 are shown portions of Classic inscriptions where letters of various characters are indicated. These letters were very sharply incised with a V-sunk section in marble, and were possibly cut by Greek workmen in Rome. It is on some such alphabet as this that we must form any modern letter to be used in a Classic inscription or upon a Classic building. These forms should be compared with the letters shown in Fig. 24, on the Architectural Building at Harvard, by McKim, Mead & White, architects, where they were employed with a full understanding of the differences in use and material. The Roman letter was cut in marble; the modern letter in sandstone. Both were incised in the V-sunk section, but the differences in material will at once indicate that the modern letter could not have been cut as clearly nor as deeply as the old one. The modern letter was done a little more than twice the original size of the old one, which explains certain subtleties in its outline as here drawn. The sandstone being a darker material than the marble, the letter should of necessity be heavier and larger in the same location, in order to "carry" or be distinguishable at the same distance; while the Classic example, being sharply and deeply cut in a beautiful white material which even when wet retains much of its purity of color, would be defined by a sharper and blacker outline, and therefore be more easily legible, other conditions being the same, even for a longer distance. In both these figures, the composition of the letters may be seen to advantage, as in even the Classic example, where they are alphabetically arranged, they are placed in the same relation to each other as they held in the original inscription. A complete alphabet of the letter shown in word use in Fig. 24, is shown at larger size in Fig. 25.

Although the lettering of the Italian Renaissance period was modeled closely after the Classic Roman form, it was influenced by many different considerations, styles and peoples.

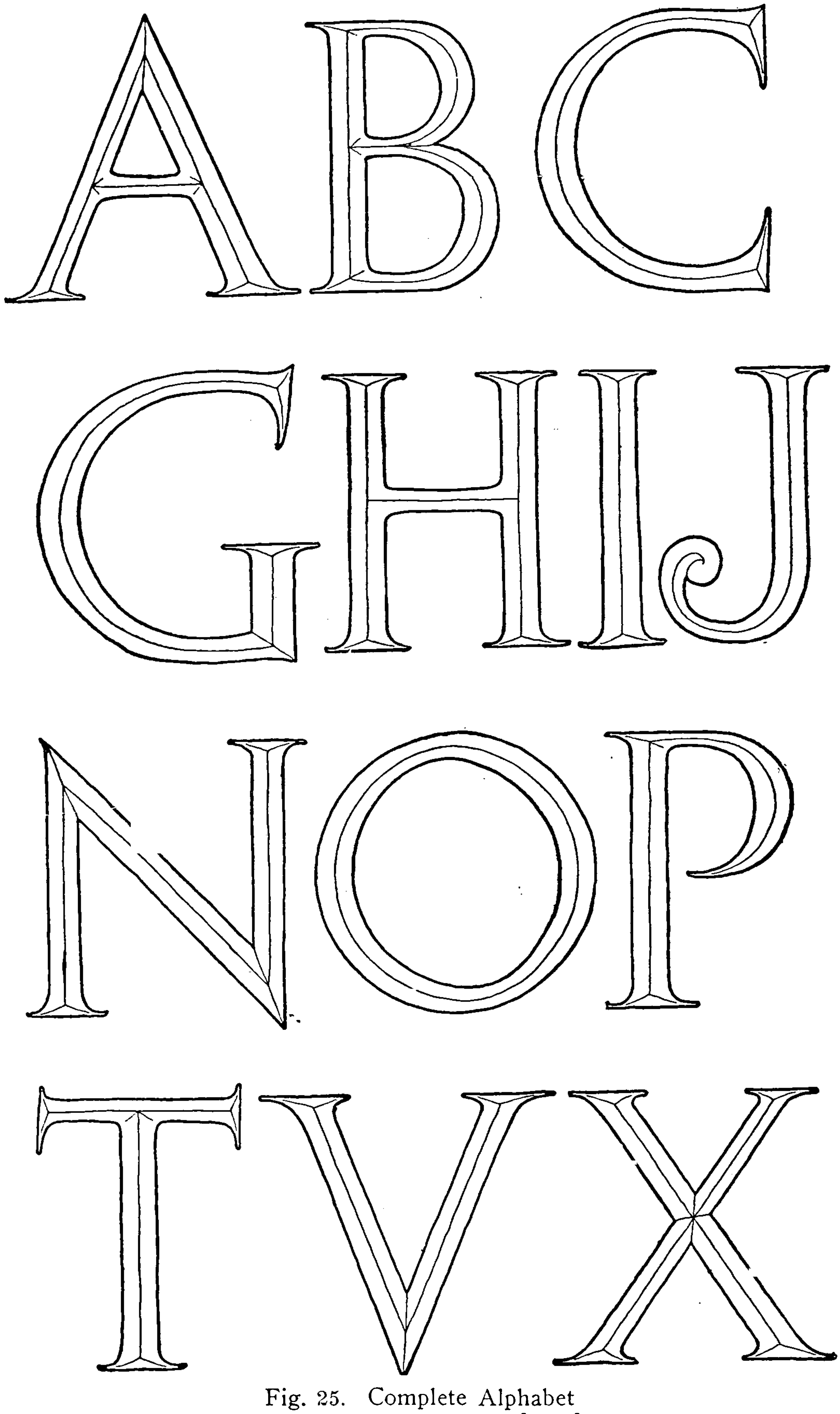


Fig. 25. Complete Alphabet
Redrawn from Inscription on Architectural Building (See Fig 24)

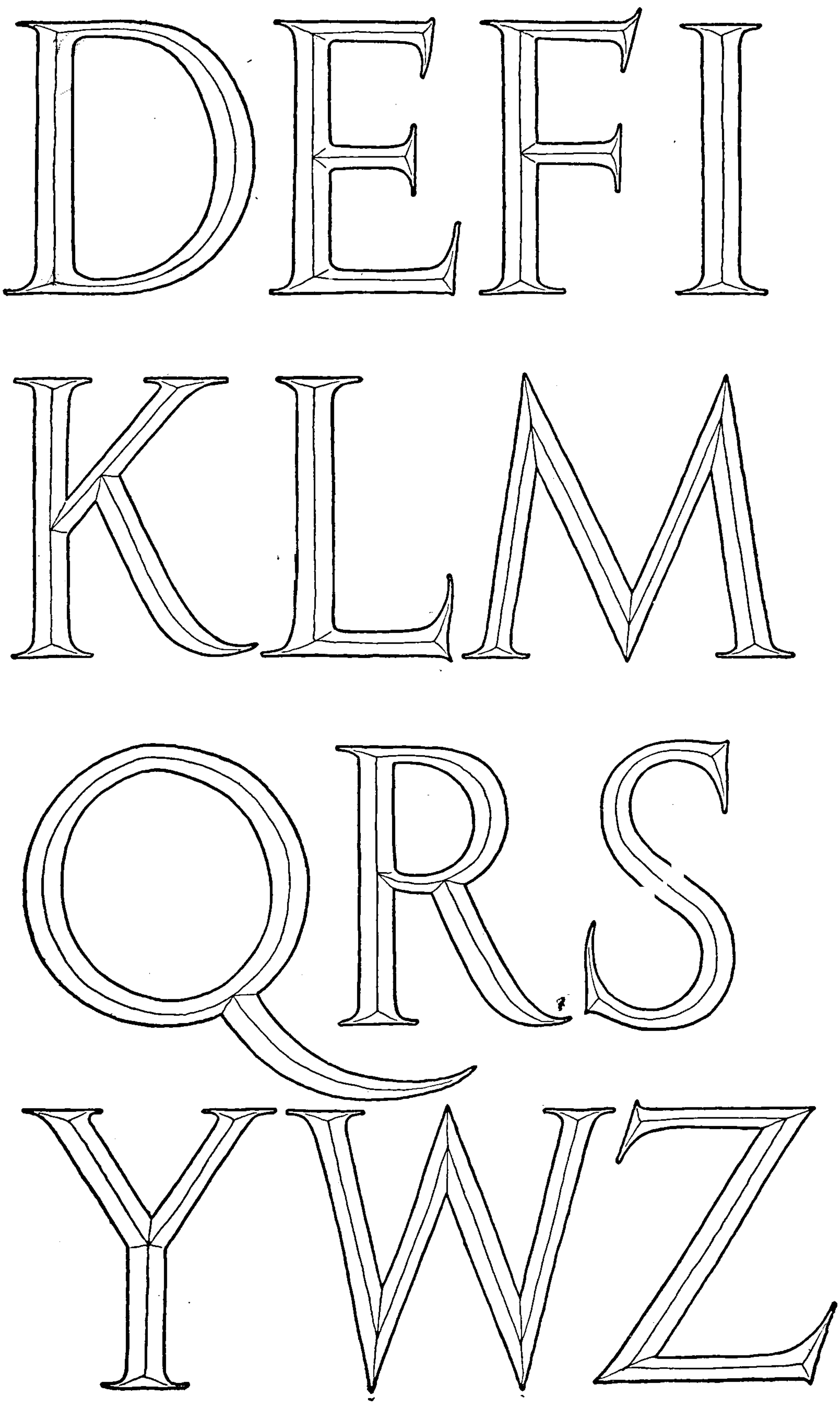


Fig. 25. (Continued)

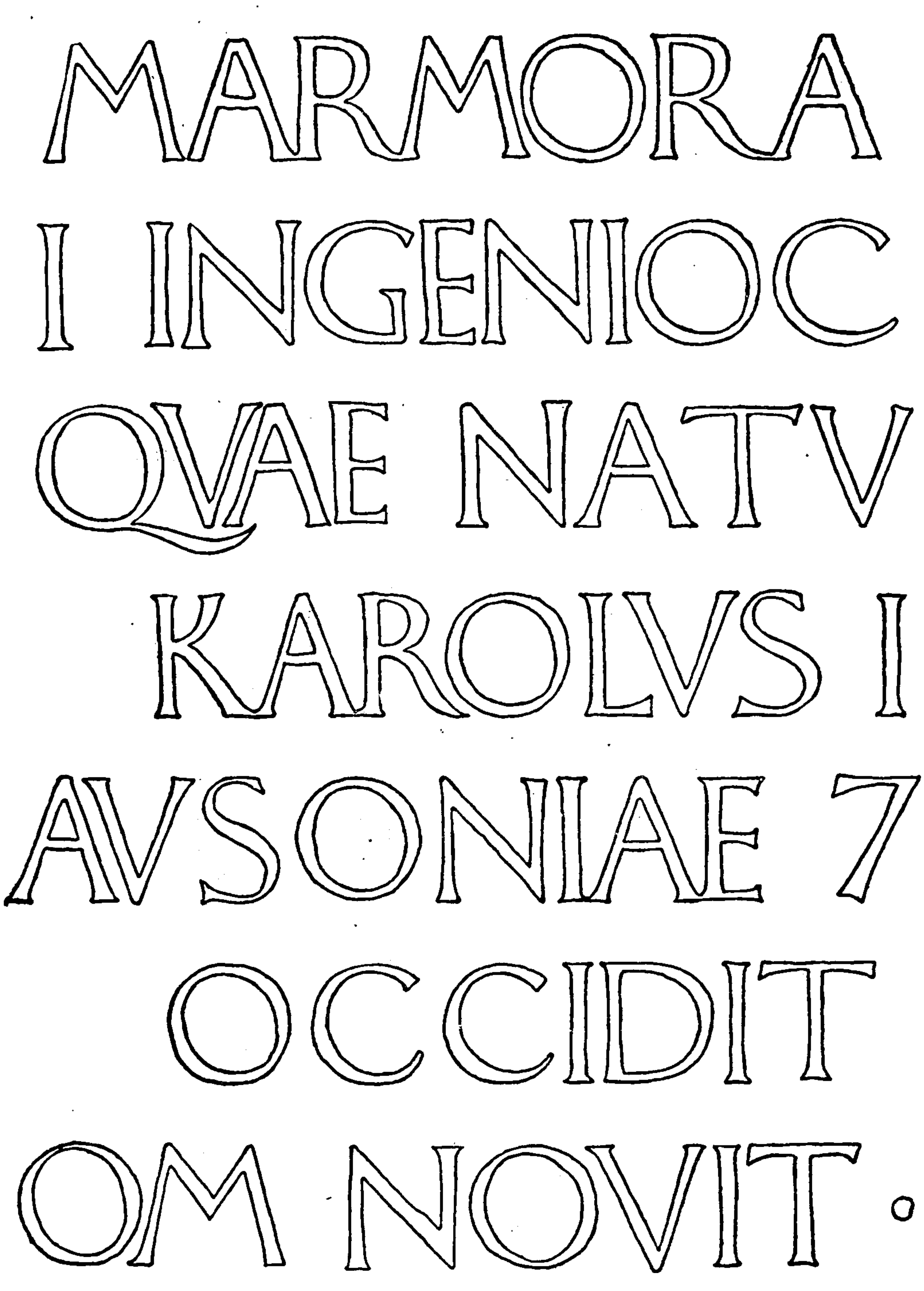
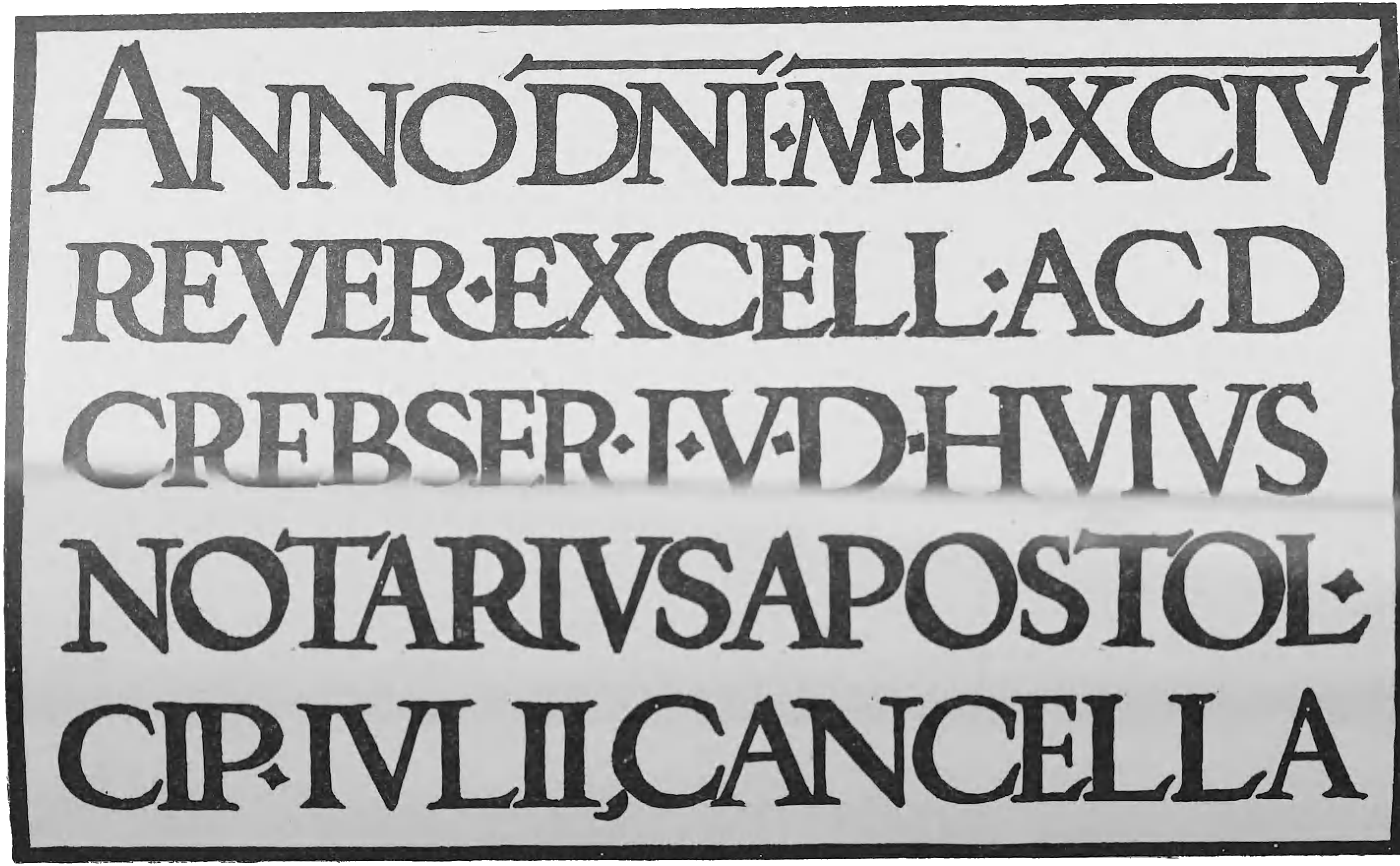


Fig. 26. Fragment of Italian Renaissance Inscription.
From the Marsuppini Tomb in Florence.



LETTERING FROM BRONZE PLATE IN CATHEDRAL CHURCH AT WURZBURG. 1594.

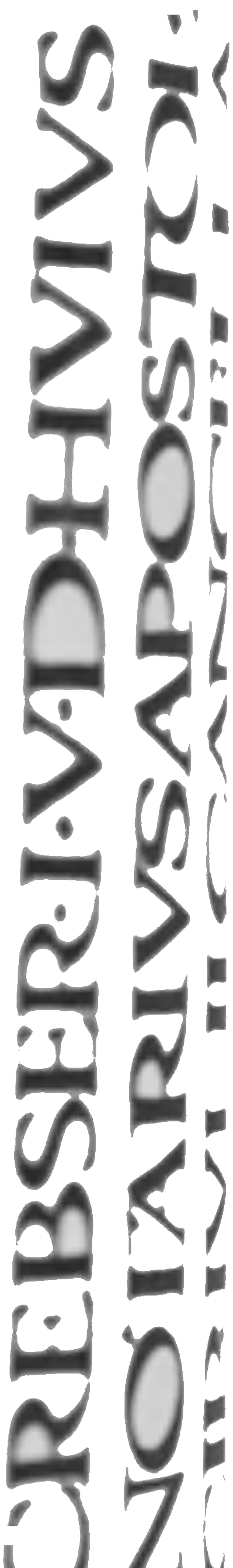
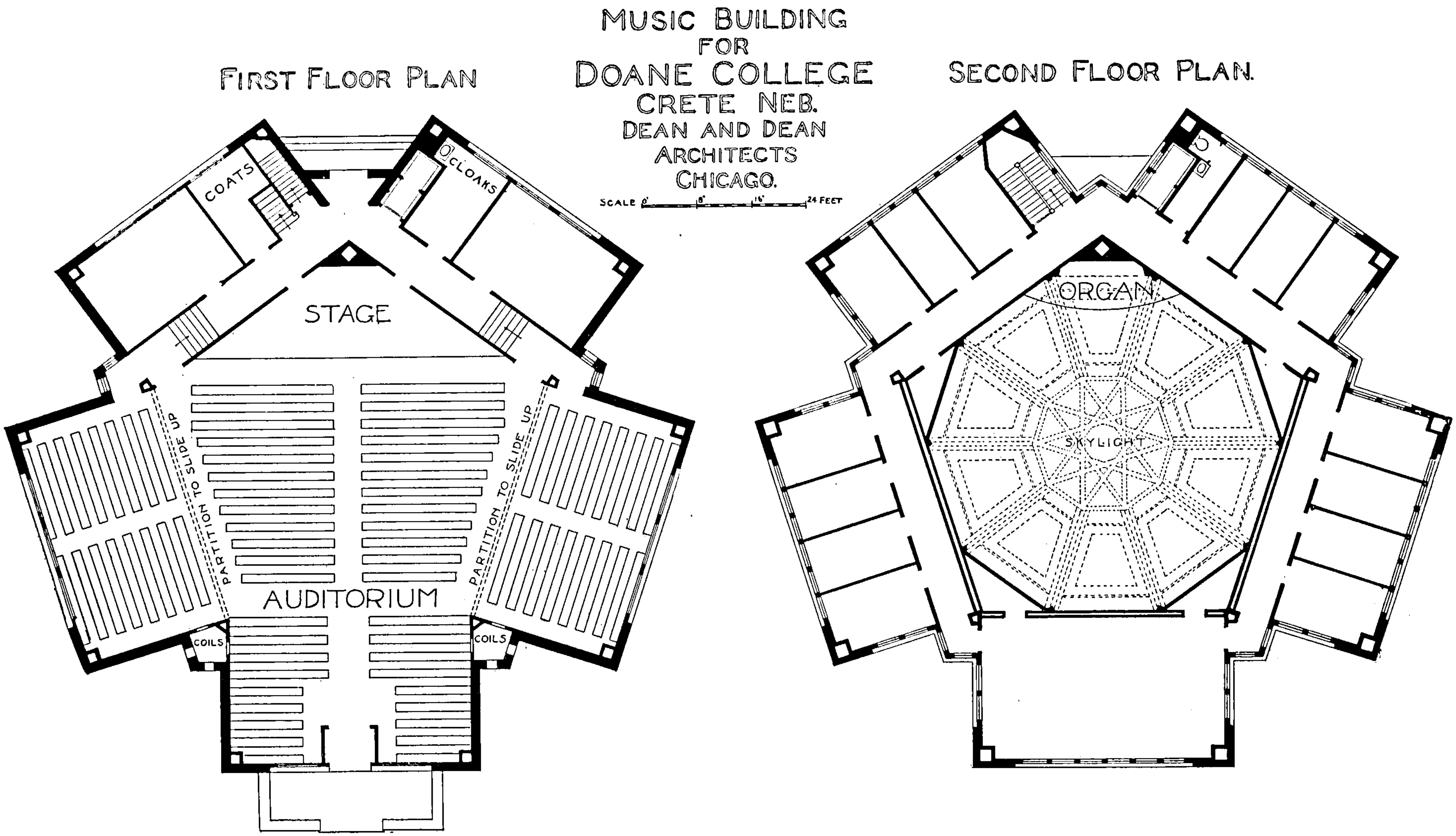


Fig. 27. Italian Raissance Lettering.
Adapted from Inscrition shown in Fig. 26.

LETTERING FROM BRONZE PLATE IN CATHEDRAL CHURCH AT WURZBURG. 1594.



FIRST AND SECOND FLOOR PLANS OF MUSIC BUILDING FOR DOANE COLLEGE, CRETE, NEB.

Dean & Dean, Architects, Chicago, Ill.

For Exterior View, See Page 170. Longitudinal Section Shown on Opposite Page.

LONGITUDINAL SECTION THROUGH MUSIC BUILDING FOR DOANE COLLEGE, CRETE, NEB.

Dean & Dean, Architects, Chicago, Ill.

For Exterior, See Page 170. Plans Shown on Opposite Page.

been to narrow up the thin lines in relation to the thick lines to the proportions that they should have in a solidly black and inked-in letter form.

The two small panels, one from a monument in Bologna, and one from the Chiaravelle Abbey in Milan, Figs. 28 and 29, show a letter which was incised in stone and follows the so-called uncial or round form, with characteristics showing the probable influence of the Byzantine art and period. These two inscriptions may be compared with another alphabet showing the uncial character when used in black against a white page, as in Fig. 30. This same style of letter was often used in metal, and may be seen in many of the mortuary slabs of this and succeeding periods.

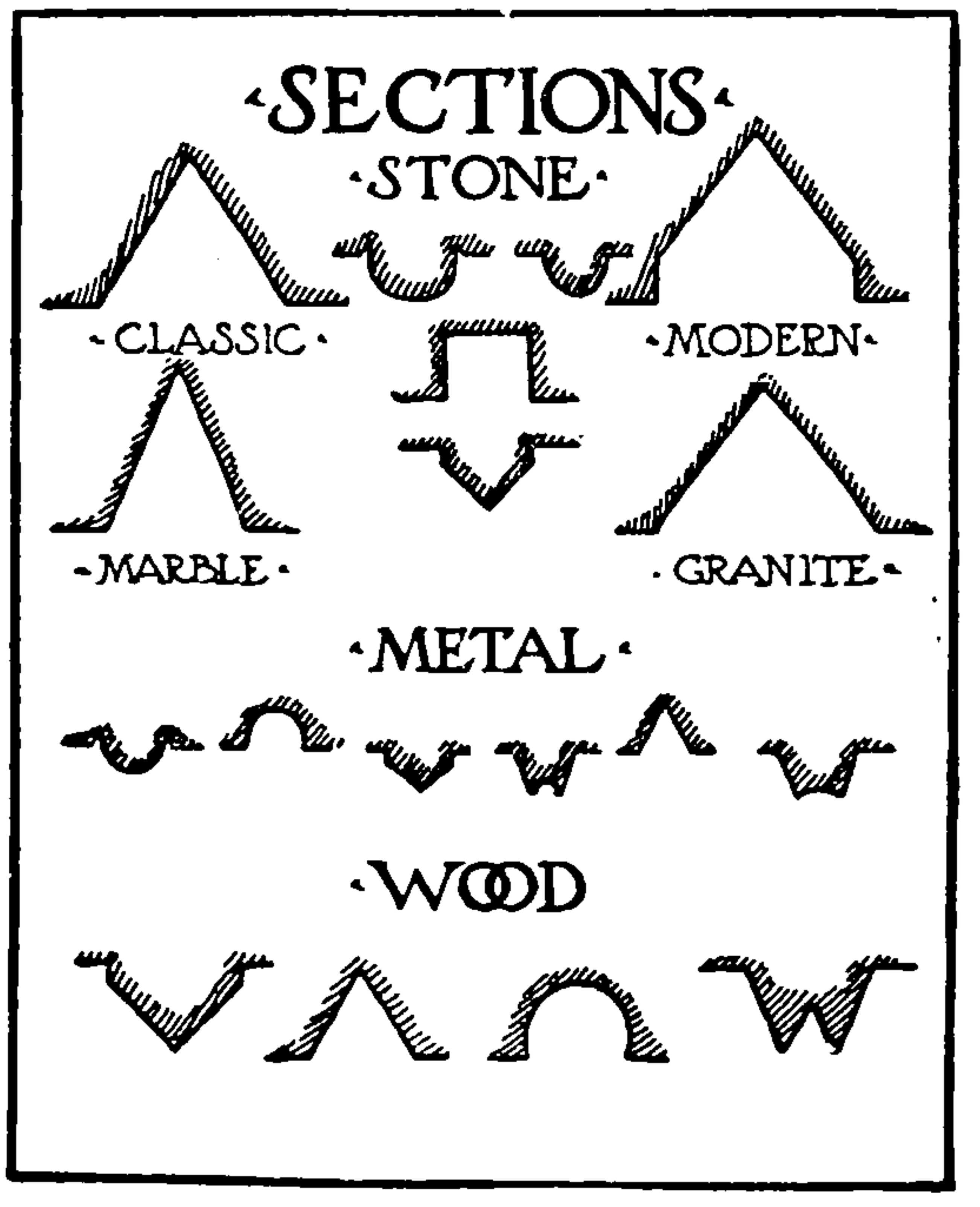


Fig. 31. Inscription Letter Sections.

In many of the Renaissance wall monuments the V-sunk letter sections have been filled with a black putty to make the letter very clear, and when this falls out, as it often does, the V-cut section may still be seen behind it. Also in many Italian floor slabs the letters are either V-sunk or shallow, square sinkages filled with mastic, or sometimes they are of inlaid marble of a color different from the ground. Again a V-sunk letter section sometimes carries an additional effect because it is smoothly cut

Fig. 32. English 17th Century Letters, from Tombstones.

and finished and the surface of the stone is left rough, thus obtaining a different texture and color effect; or, though more rarely, the opposite treatment may be used. Then, again, the sides of the letter sinkage may be painted or gilded. Often even the shadow is painted into the section, but this is generally done on interior cutting where there is no direct light from the sun, because if direct sunlight does fall upon a letter so treated, a very amusing effect occurs when the shadow is in any other position than that occupied by the painted representation.

For still further effects, *raised lettering* may be cut on stone surfaces. This is more expensive, as it necessitates the more labor in cutting back the entire ground of the panel, but for certain purposes it is very appropriate.

In such a letter the section may be a raised V-shape, or it may be rounded over to make a half circle in section, as drawn in Fig. 31. This latter form is especially effective in marble, but it is, of course, very delicate and does not carry to any great distance. Its use should be restricted to small monumental headstones or to lettering to be read close to, and below the level of, the eye.

A raised letter is more generally appropriate for cast copper and bronze tablets, when its section may be a half round, a raised V-form, or square-raised with sharp corners; or, better still, a combination of square and V-raised with a hollow face. See Fig. 31. Experience has proved that this last-named section produces the most telling letter for an ordinary cast-metal panel.

Fig. 32 shows an alphabet of a letter derived from English tombstones. This letter was cut in slate or an equally friable material, and was comparatively shallow. A certain tendency toward easing the acute angles may be observed in this alphabet, evidently on account of the nature of the material in which it was carved rendering it easily chipped or broken.

In wood carving, a letter exactly reversing the V-sunk section with direct sinkage, gives the best effect for a raised letter.

Every material, from its nature and limitations, requires special consideration. A letter with many angles is not adapted to slate, as that material is liable to chip and sliver; hence an

uncial form with rounded angles suggests itself (as in Fig. 29), and is, indeed, frequently used.

It would be quite impossible to take up in detail the entire list of available materials and consider their limitations at length, as the task would be endless. For the same reason, it is not possible to take up each letter style and consider its use in stone and other materials. Of course, a Roman letter or any other similar form when drawn for stone-incised use must have its narrow lines at least twice as wide as when drawn in ink, black against a white background. (Compare Figs. 26 and 27.)

Experience and intuition combined with common sense will go farther than all the theory in the world to teach the limitations

Fig. 34. Black-Letter Alphabet.

required by letter form and material. The student, however, should bear in mind that it is not necessary that he himself should make a number of mistakes in order to learn what *not* to do. He may get just as valuable information at a less cost by observing the mistakes and successes of others in actually executed work, and avail himself of their experience by applying it with intelligence to his own problems and requirements.

GOTHIC LETTERING.

Gothic lettering is extremely difficult, and has little practical use for the architectural designer or draftsman. It is often appropriate, but it is quite possible to get along without employing this form at all. However, in case he should require a letter of this style, it would be better to refer him to some book where he may study its characteristics more particularly, remembering it is just as important he should know something of the history, uses and materials from which this letter has been taken, as in any instance of the use of the Roman form. Indeed, it might be

Fig. 35. Italian Black Letters, after Bergomensis.

said, it is even more important, as the Gothic letter is more universally misunderstood and misapplied than the simpler Roman letter.

Fig. 36. English Gothic Text.

PLATE IV.

Make a careful reproduction of Fig. 10 on the left-hand side of the plate. The letters should be of the same size as in Fig. 10. On the right-hand side of the plate use the letter forms shown in Fig. 10 and of the same size, and letter the following title, arranging the legend to look well on the plate: Front Elevation, Country House at Glen Ridge, New Jersey, Aug. 24, 1903. David Carlson Mead, Architect, No. 5925 State St., Chicago, Ill.

PLATE V.

Reproduce on this plate Figs. 27 and 32 of the Instruction Paper, using letters of the same size.

PLATE VI.

On the left-hand side of this plate, copy the lettering shown in Fig. 9, making the letters at least as large as those in the illustration. On the right-hand side, following the same style and size, letter the following title: Detail of Entrance Porch, Country House at Glen Ridge, New Jersey, Sept. 10, 1903. David Carlson Mead, Architect, No. 5925 State St., Chicago, Ill.

This plate to be done in pencil only.

PLATE VII.

Using individual letter forms like those shown in Figs. 24 and 25, letter the following title: Museum of Architecture, Erected in Memory of John Howard Shepard, First President Technology, Bangor, Maine.

The letters should be of a size suited to the title; the title should occupy five lines.

All plates except Plate VI should be inked in The student should first lay out his lettering in pencil in order to obtain the proper spacing of the center line on his page or panel He should also place guide lines in pencil at the top and bottom of his lettering for both capitals and small letters

The plates should be drawn on a smooth drawing paper 11 inches by 15 inches in size The panel inside the border lines should be 10 inches by 14 inches For best work Strathmore (smooth finish) or Whatman's hot-pressed drawing paper is recommended

The date, the student's name and address, and the plate number should be lettered on each plate in one-line letters such as are shown in Fig 10.

THE STUDY OF ARCHITECTURAL DRAWING INCLUDES PREPARATORY WORK IN USE OF INSTRUMENTS, MECHANICAL DRAWING, THE WORKING OUT OF PROBLEMS IN DESCRIPTIVE GEOMETRY, CASTING SHADOWS, AND PERSPECTIVE, FREEHAND DRAWING, LETTERING AND RENDERING IN PEN AND INK, WASH AND COLOR, THE STUDY OF THE ORDERS AND THEIR USE IN DESIGN, AND THE CARRYING OUT OF THESE DESIGNS IN WORKING DRAWINGS. ALL THESE MUST BE CAREFULLY STUDIED IN DETAIL. IN THIS BOOK WE CONSIDER SOME OF THE GENERAL PRINCIPLES OF ARCHITECTURAL DRAWING, INCLUDING RENDERING IN WASH AND COLOR.

FRAGMENTS FROM ROMAN TEMPLE AT CORI, ITALY.

One of the most interesting examples of architectural rendering in existence.

Original drawing by Emanuel Brune.

Reproduced by permission of Massachusetts Institute of Technology.

of openings, corresponding to the erasures to be made, called in draftsman's parlance, the "office goat," is useful. Holes can be cut in cardboard or detail paper for this purpose.

Set of Instruments. Good instruments are advisable, as it is hard enough to make good drawings, even with the best. Compasses with pencil and pen points and extension legs; large and small dividers, bow-pen and bow-pencil, and two ruling pens, form the usual equipment of the architectural draftsman's instrument case. Besides these a simple form of proportional dividers will be found very useful, especially in changing drawings from one scale to another, and also when it is desired to translate a rough sketch into a definite scale, preserving the proportions of the sketch. A small protractor will be sufficient for the rare occasions when an architect lays off angles to a given number of degrees.

Beam compasses are useful, though many offices have only long straight edges and carpenters' clamps for this purpose. Sometimes a taut string will serve the purpose where perfect accuracy is not required, or two points on a straight edge may be taken, one point being held with one hand, while a curve is struck from another point by a pencil held in the other hand.

Drawing Boards. It is necessary to have two drawing boards, one a "Double Elephant" size, 28 × 42 inches, to accommodate paper of a size called "Double Elephant," which is 27 × 40 inches, thus allowing ½ inch at the sides and an inch at the ends; the other board 23 × 32 inches, to accommodate the size of paper called "Imperial," which is 22 × 30 inches. It will be found convenient also to have a small "Half Imperial" board 23 × 16 inches in size. These boards should have a straight grained cleat at each end, or should be entirely surrounded with a framework of hard wood, having soft wood in the center. Cherry makes a good hard wood for the frames or ends, and pine or white wood for center. In many offices the boards are made entirely of pine or white wood, but it will be found preferable to have better made boards, and to take good care of them, keeping them square. If adjacent sides of the board make a true right-angle, the T-square can be used on these two sides, which is an advantage in drawing long lines. When the boards have cleats at the ends only, however, it is always necessary to use the T-square from the left-hand end only.

Triangles and T-Squares. There are T-squares to correspond to the size of the boards. They are usually made of straight, fine grained hard wood. The simplest form of fixed T-square will be found the most satisfactory for general office use. As even the best are apt to vary, it is a good idea to number every T-square in the office and note the number on commencing a drawing. If, however, the T-square is changed, and the new square does not line up with the old work, a thumb tack in the edge of the head next the drawing board may be used to bring the blade into line, as shown in Fig. 1. The drawing edge (upper edge) of a T-square should never be used as a straight edge for paper cutting.

Two triangles are required, one 30 degrees to 60 degrees, and one of 45 degrees. Triangles are made of wood, hard rubber or celluloid.

Materials for Wash-Drawings. For tinting, a nest of tinting saucers, brushes, a soft sponge, large blotters, a stick of India ink, a slate slab for grinding it, a half cake of carmine and a half tube of Prussian blue will make a good beginning.

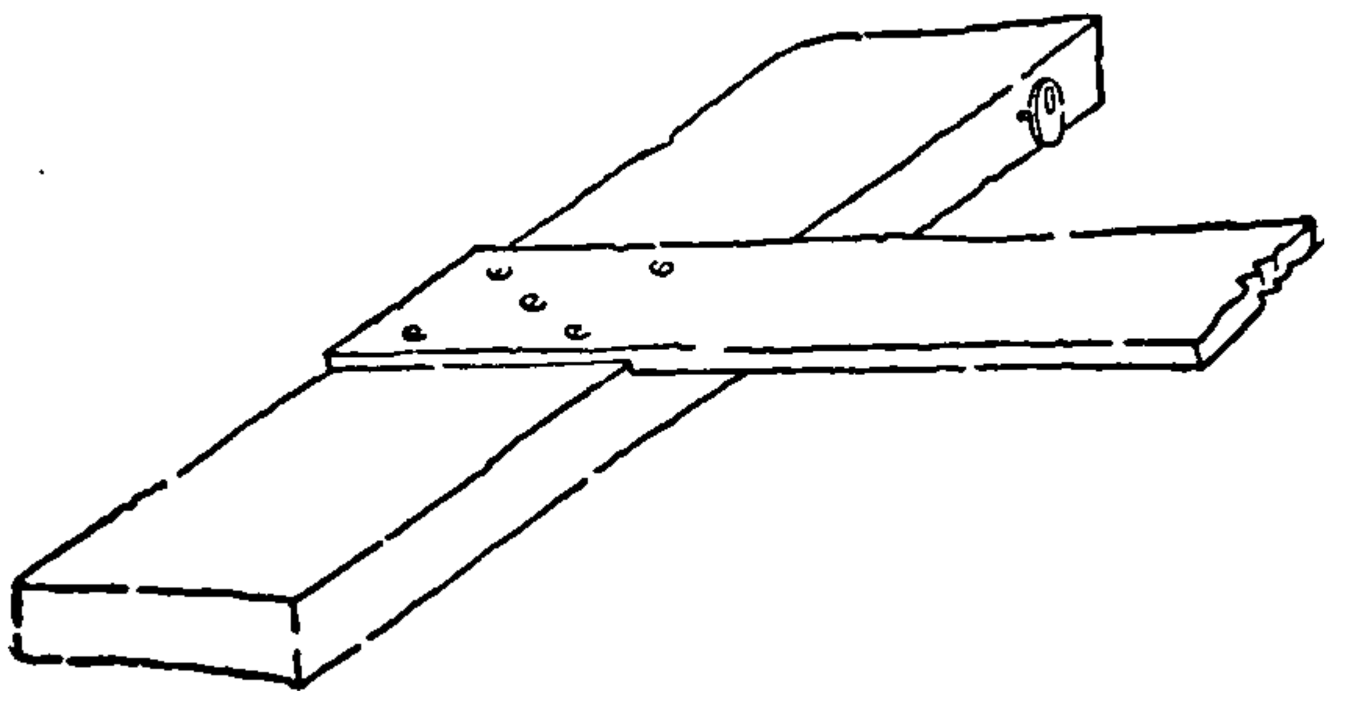


Fig. 1. T-Square with Thumb Tack.

Paper. Paper comes in certain conventional sizes. "Whatman's paper" is most easily obtained in two sizes, the "Imperial," 22 × 30 inches, and "Double Elephant," 27 × 40 inches, and is a useful paper for all-around architectural work, being good for pencilling, inking in, and wash drawings; colors can be laid on it even after erasures have been made. The Whatman "hot-pressed" paper has a smooth surface and is generally used for fine pencil or ink drawings. The Whatman "cold-pressed" paper has a rough surface and good texture, and is useful for all-around work.

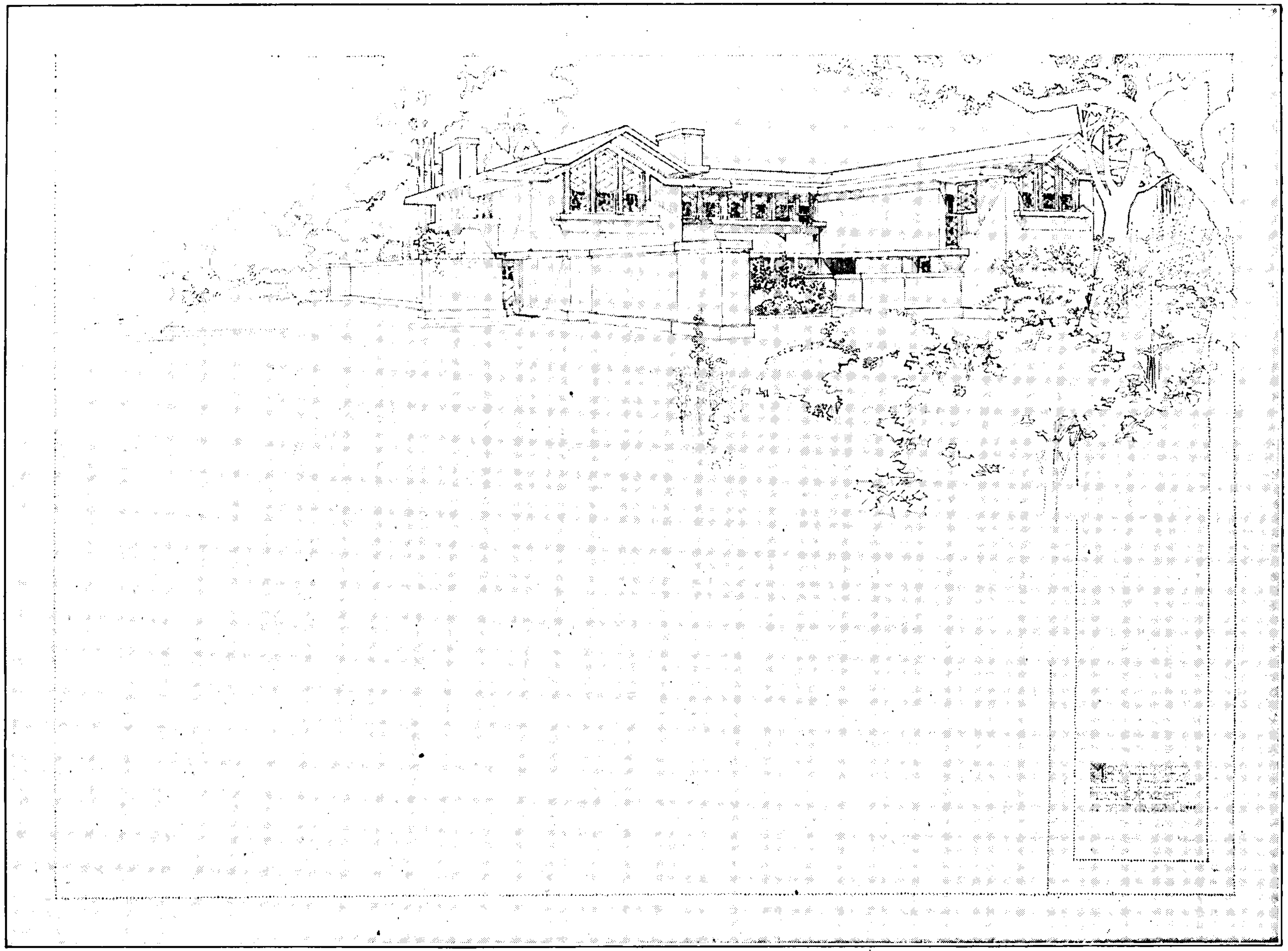
Tinted Papers. Gray or other colored papers are frequently employed, pencil or pen and ink being used for the lines and shadows, and chalk or Chinese white for the high lights. Pastels and water colors are used on special colored papers; "scratch papers" are those on which white is obtained by scratching through the colored surface of the paper. Some of these papers, including buff or manila detail paper, have already been fully described under the subject of mechanical drawing. The process of stretching paper is also there described.

Tracing Paper. In architectural work a great deal of tracing paper is used. A cheap manila tracing paper is convenient for rough preliminary studies not intended to be preserved. "Alba," a white tough tracing paper, and "Economy," a cheaper form, are very good for pencil sketching and also for careful pencil drawings. Rowney's English tracing paper is very transparent, is good for accurate pencilling, and takes color, but becomes brittle with age; it is, however, the best paper for careful studies of architectural work. Bond paper which comes in sheets 20 × 28 inches, is very useful for working drawings of small frame houses, as the drawing can be inked-in and blue prints taken directly from this paper without the necessity of tracing.

Some offices make many of their details in black pencil on this paper and where work on different houses is similar, let blue prints of these details serve for each new building.

Tracing Cloth. Tracing cloth is used for important work where the tracing will be roughly used or where changes are likely to be made in the drawing. In drawing on tracing cloth, there are three ways of making the ink flow well: (1) The most common is to rub powdered chalk over the surface, dusting off the superfluous chalk; (2) Benzine applied with a towel will clean the cloth; (3) Oxgall, a preparation obtainable at any artists' materials store, may be mixed with the ink. Sometimes pencil drawings are made directly on the cloth, and after inking-in benzine is used to remove all pencil marks. As a rule, the rough side of the tracing cloth is used, but some draftsmen prefer to ink-in on the smooth side, thinking they can make a cleaner line, and then turn the cloth over to color the drawing on the rough side with water colors or crayons.

Scales. Scales for architectural work are like those used for mechanical drawing, one-quarter inch to the foot for working drawings, and three-quarter inch to the foot for details, being the customary scales used in American offices, though some offices use one-eighth inch to the foot, with one-half inch to the foot for details—the custom usually followed in England. It is customary to make full-size details of mouldings and of special constructive parts. Three-sixteenths inch to the foot is sometimes useful as a scale drawing, or

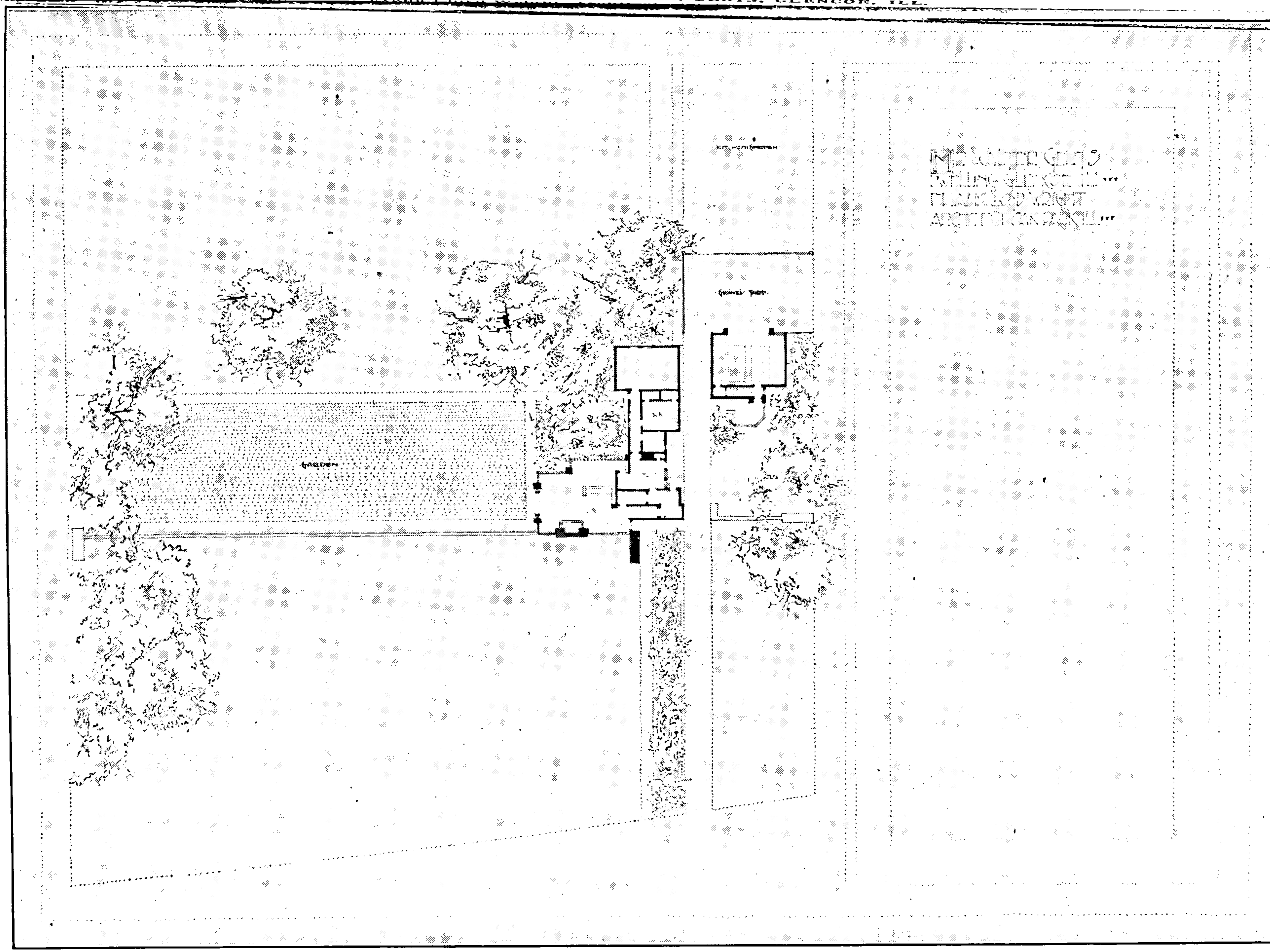


SKETCH FOR RESIDENCE OF MR. WALTER GERTS, GLENCOE, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill.

For Plan, See Opposite Page.

SKETCH FOR RESIDENCE OF MR. WALTER GERTS, GLENCOE, ILL.



PLAN OF RESIDENCE FOR MR. WALTER GERTS, GLENCOE, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill.

For Sketch of Exterior, See Opposite Page. Built in 1906.

in laying out stairs in section, as will be described later. This scale is also frequently used for exhibition drawings. One and one-half inch to the foot, one inch to the foot, and three inches to the foot, are also used. For the scale of three inches to the foot, the ordinary quarter-inch scale may be read as inches instead of feet, as one-quarter inch is one-twelfth of three inches. The three-quarter inch scale is the favorite among carpenters for the reason that the ordinary two-foot rule can be used on the drawings; as there are twelve-sixteenths of an inch in every three-quarters of an inch, each sixteenth of an inch on the rule represents one inch actual measurement. The inch scale is very popular for drawing mantels, interior finish, etc., where the total dimensions can be read directly from the two-foot rule, each inch being equal to the foot full size.

The accompanying illustration of an architect's scale, Fig. 2, shows the usual divisions on a scale for ordinary architectural work.

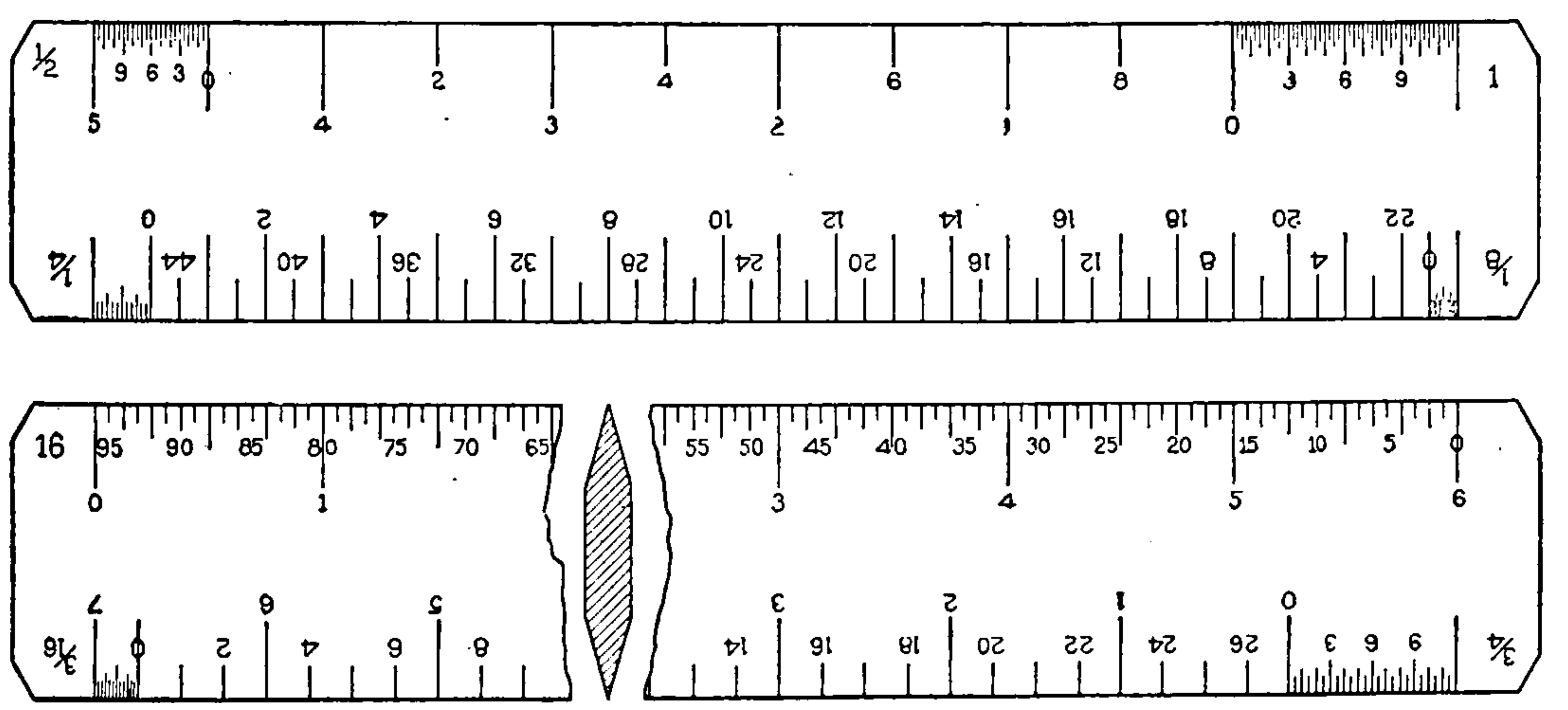


Fig 2 Architects' Scale.

A six-inch scale of this size is very convenient for ordinary measurements and a similar one eighteen inches or two feet long is useful for laying out larger work. This scale gives the full-size measurements in inches divided into sixteenths with the scales of sixteenths reading in the reverse order from zero up, so that the number can be read directly from a sixteenth scale or doubled for a thirty-second inch scale. The common quarter-inch and eighth-inch scales are given, as well as the half-inch and one-inch scales. The useful three-quarter inch scale is given with the three-sixteenths scale in reverse order.

The accompanying sketch, Fig. 3, shows how a scale may be used in laying out staircases in plan and section much more rapidly than is usual in architects' offices. The sketch shows the plan and section of a staircase at a scale of one-quarter of an inch to the foot, the staircase to be three feet six inches wide. The section shows that the floors are nine feet six inches between finished surfaces. As it is desirable to economize space, the stairs are to be laid out with about seven and one-half inches rise and eleven inches tread. Dividing nine feet six inches by seven and one-half, we find that fifteen

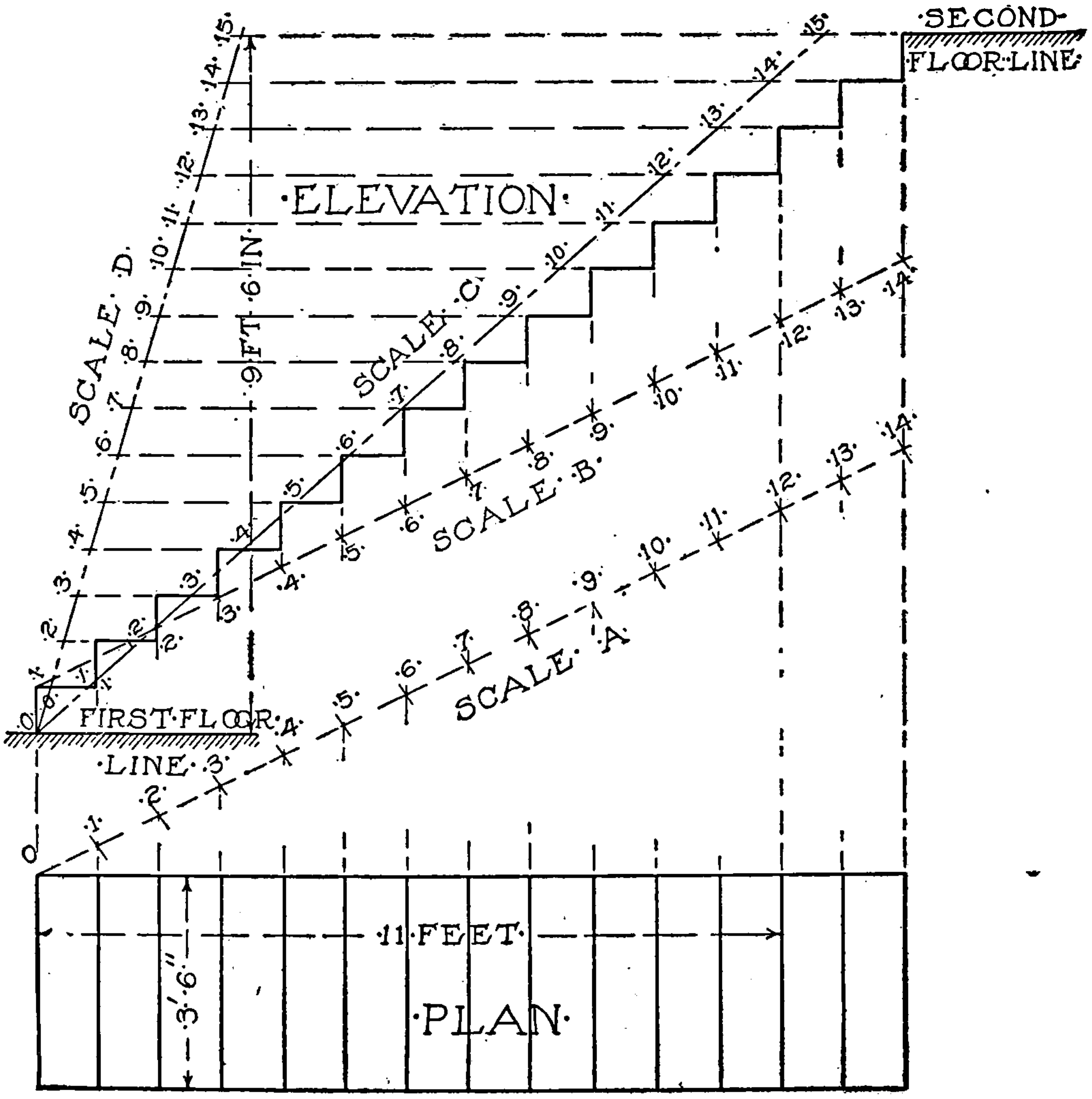


Fig 3 Use of Scales in Laying-out Stairs

risers will give us slightly over seven and one-half inches. To lay out fourteen treads—which locate the fifteen risers including the first and last—instead of spacing over fourteen treads, start from the first riser, lay off parallel to run of stairs in plan eleven feet on the quarter-inch scale; then draw a line perpendicular to the run of the stairs. Tip the scale until the zero coincides with the first tread and twelve

immediately in ink, between limiting lines in pencil. But the draftsman should be very sure of himself and his drawing before using this method.

Shade lining, or indicating shadows by making the lower and right-hand edges of projecting planes in elevation heavier, see Fig. 4, is used in architectural drawing, especially in illustrations for publication. In office work, when it is desired to show the shadows, the latter are generally laid in washes. The brilliancy of the architectural drawing shown in many recent examples, especially from New York offices, is much increased by strengthening the outline of projecting members and ornamental parts, by accenting certain points, and by carrying through only certain important lines of mouldings, and drawing other lines only a short distance. Finished lines coming down on to projecting surfaces may be stopped short just before reaching the surface, giving effect of high light on those surfaces, as shown in Fig. 4; and lines at outer angles may be carried slightly across each other, giving a firm intersection, instead of stopping just at the junction. For plans the same holds good, as is shown in Fig. 5.

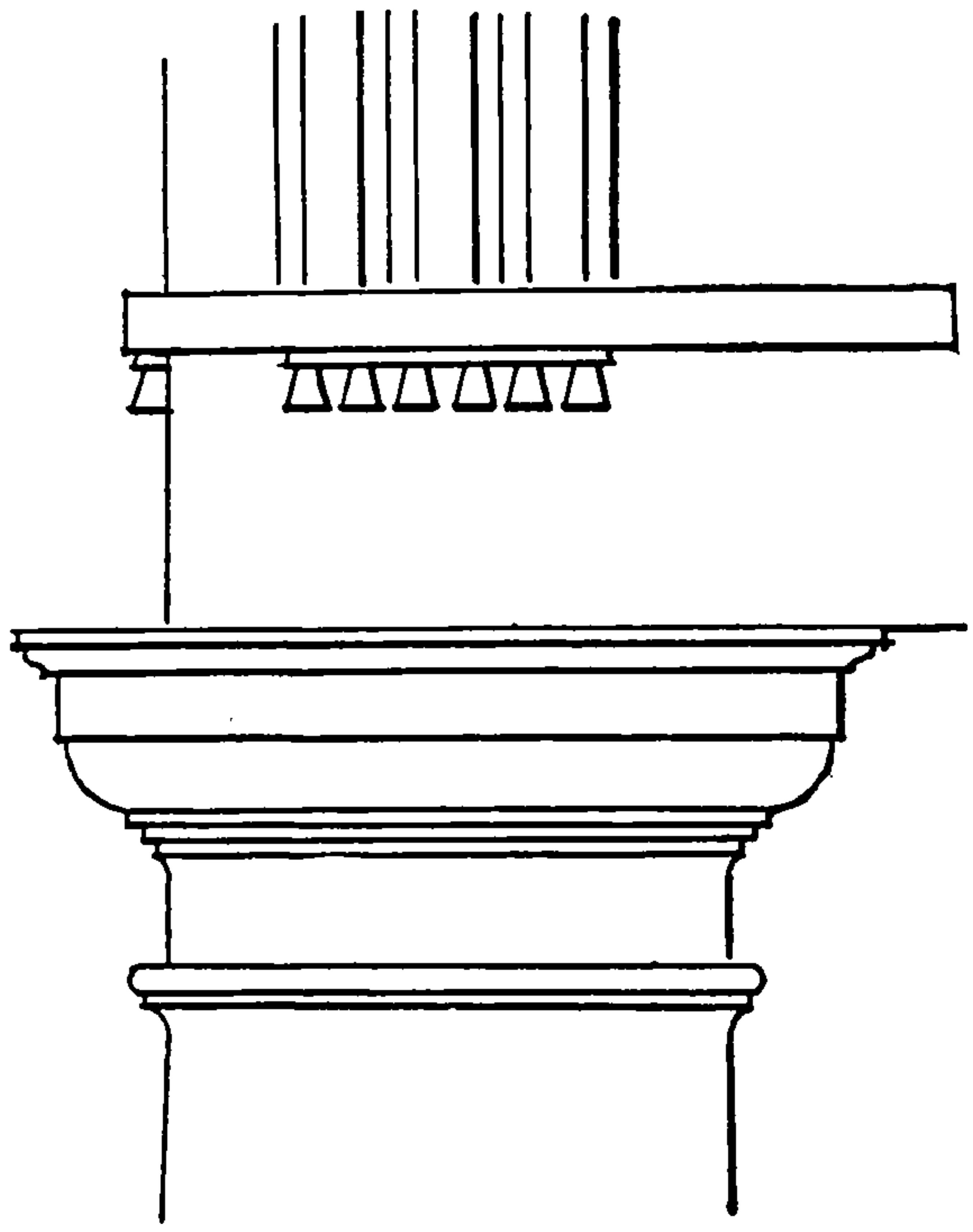


Fig 4. Shade Lines

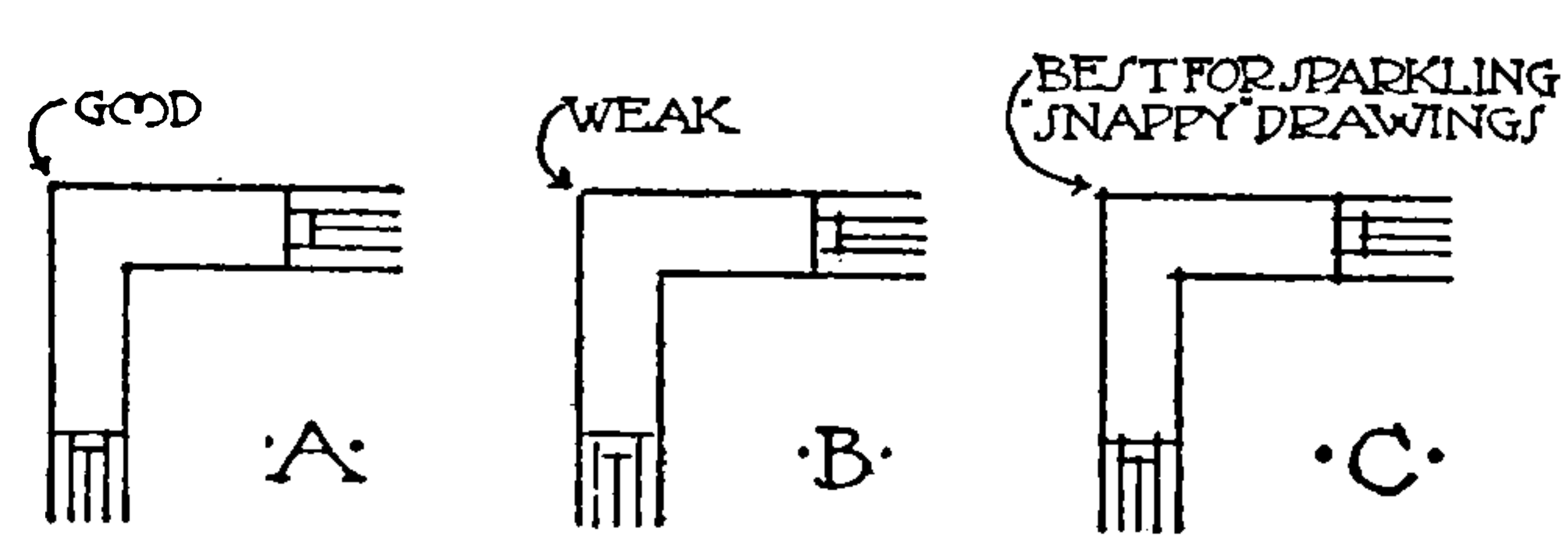
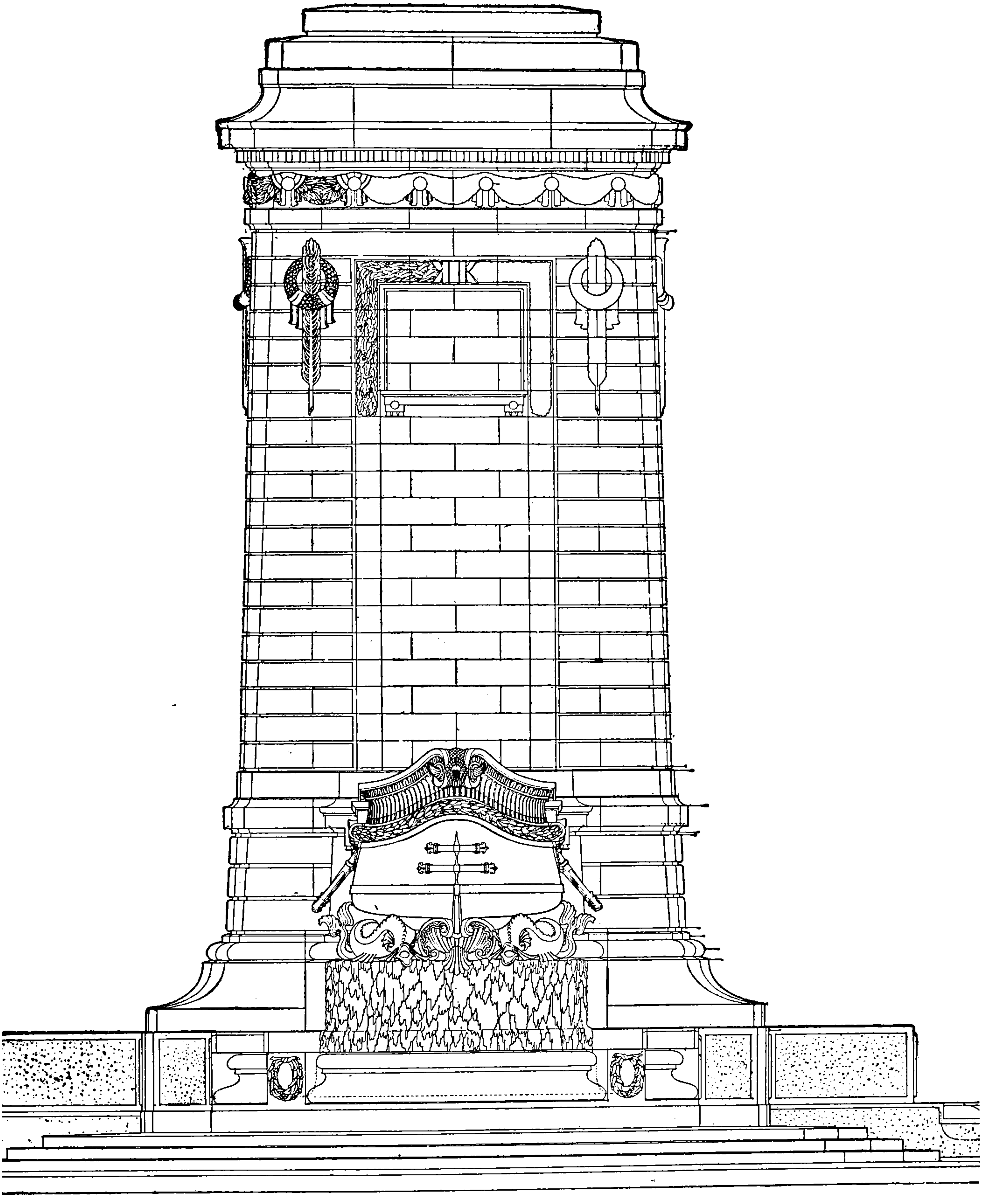


Fig 5. Junctions of Lines

In an elevation, the planes toward the front may be drawn with dark lines and those farther back with lighter lines. Joint lines in masonry and the lighter lines of carving should be drawn in ink which has been diluted with water. The design for the National Maine Monument, page 9, shows a good method of lining an architectural drawing.



First Prize Design. National Maine Monument

H Van Buren Magonigle, Architect

Sometimes lines of different colors, as red to indicate brick, blue for stone, yellow for wood, etc., are used on working drawings to take the place of tinting.

DEFINITIONS.

Architectural drawing is geometric. If the student is making the drawing of a model, he should try to think how the author of the model laid it out, and how he, the student, would proceed if he had the opportunity to lay it out. He will find that the model is represented on paper by the different projections such as the plans, sections and elevations. These are laid out to a certain scale; that is to say, one-fourth inch to the foot, which means that one-fourth inch in the drawing represents one foot in the model; or one-eighth inch to the foot, etc.

Definition of Plan. A plan of a building is a section cut by a horizontal plane through the walls, supports, etc., at such a height so as to show the greatest number of peculiarities in construction, walls, doors, windows, supports, columns and pilasters, fireplaces, etc. It is possible to consider a plan as a horizontal impression that could be taken of the building in course of construction when it had arrived at a certain level in the height of a story. On the plan the construction is shown invariably by horizontal sections, but it is possible to project up all that is below and also to show what is above. In the first case the plan will show the architectural portions which project beyond the base of the walls or supports such as the base, steps, approaches, etc. In the other case it will show vaultings, ceilings, entablatures, cornices, etc. Sometimes it is desirable to show both—half of each—provided the parts shown are sufficiently interesting or necessary for explaining the entire scheme.

Definition of Section. The section is a plane cut through a building vertically, that is to say, it is the same thing perpendicularly that the plan is horizontally. This plane should be taken along the line of some main axis.

A single section rarely is sufficient to give all the interior of the building. It is necessary to have, as a rule, at least two, one a longitudinal section, perpendicular as a rule to the facade, and the other a transverse section, usually parallel to the facade. Very often a

be best explained by examples. Let us commence by the study of a plan, that of a vestibule, in a public building; *e.g.*, the Hotel des Monnaies at Paris, Fig. 6.

After having drawn the axis 1, which is the principal axis of the building, it will be noticed that there are five bays of the central pavilion which are spaced equally. Of these draw first the extreme axes, 2 2; by dividing the space between axes 1 and 2 into equal parts, the intermediate axes 3 3, will be found. In this way the chances of error would be decreased, for if the axes were placed in the order 1, 3, 2, the possible error would be doubled. Now taking the portion to the right, draw first the extreme axis 4, then 5, and divide the space 4 5 into equal parts, which will give the axis 6.

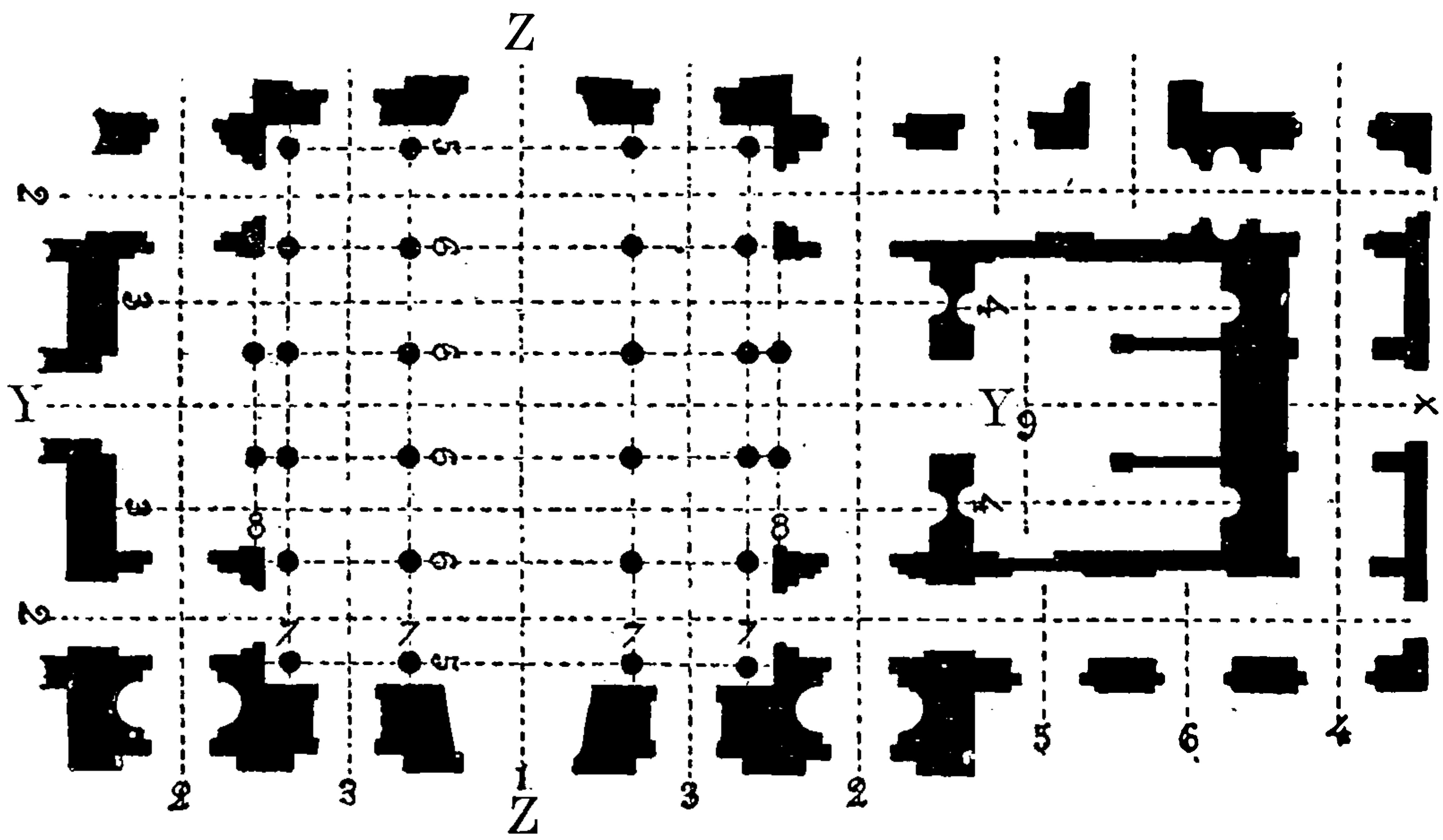


Fig. 6. Plan of Vestibule of Hotel des Monnaies.

Now consider the axes of the rows of columns 7 7. These are to be arranged in relation to the axes 3 3; finally the axes 8 8 are located in relation to the extreme axes 7 7, being checked in relation to the axes 2 2.

In the longitudinal direction the same process will be gone through, placing the first axis 1, then the extremes 2 2; by division 3 3 will be obtained, and dividing the spaces between the axes 1, 2, and 3, into half, the axes 5 and 6 of the columns are obtained. The secondary axes will be placed in the same way. Finally it will be found advisable to check up the different steps by verifying the distances of the secondary symmetrical axes from the central main axis.

In carefully studying the plan, and the different methods of drawing it, the student will become convinced that the methods of spacing the axes are of great importance, and that in this way he will arrive at exactness and will avoid many mistakes.

The student must understand that it is much more difficult to draw a good plan than is popularly supposed; more difficult, perhaps, than anything else, from the mere fact that everything builds up from the plan. In the plan especially, extreme exactness is necessary

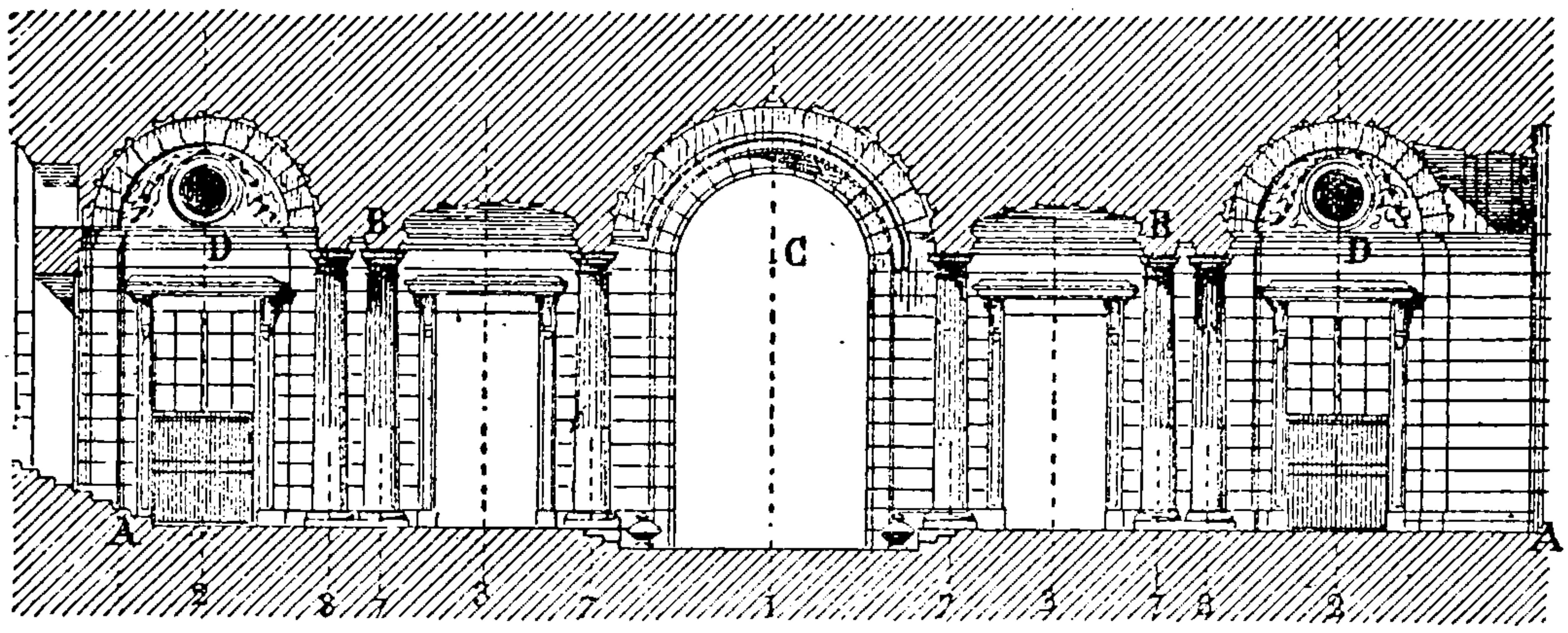


Fig 7 Hotel des Monnaies, Transverse Section of Vestibule.
Section on YY

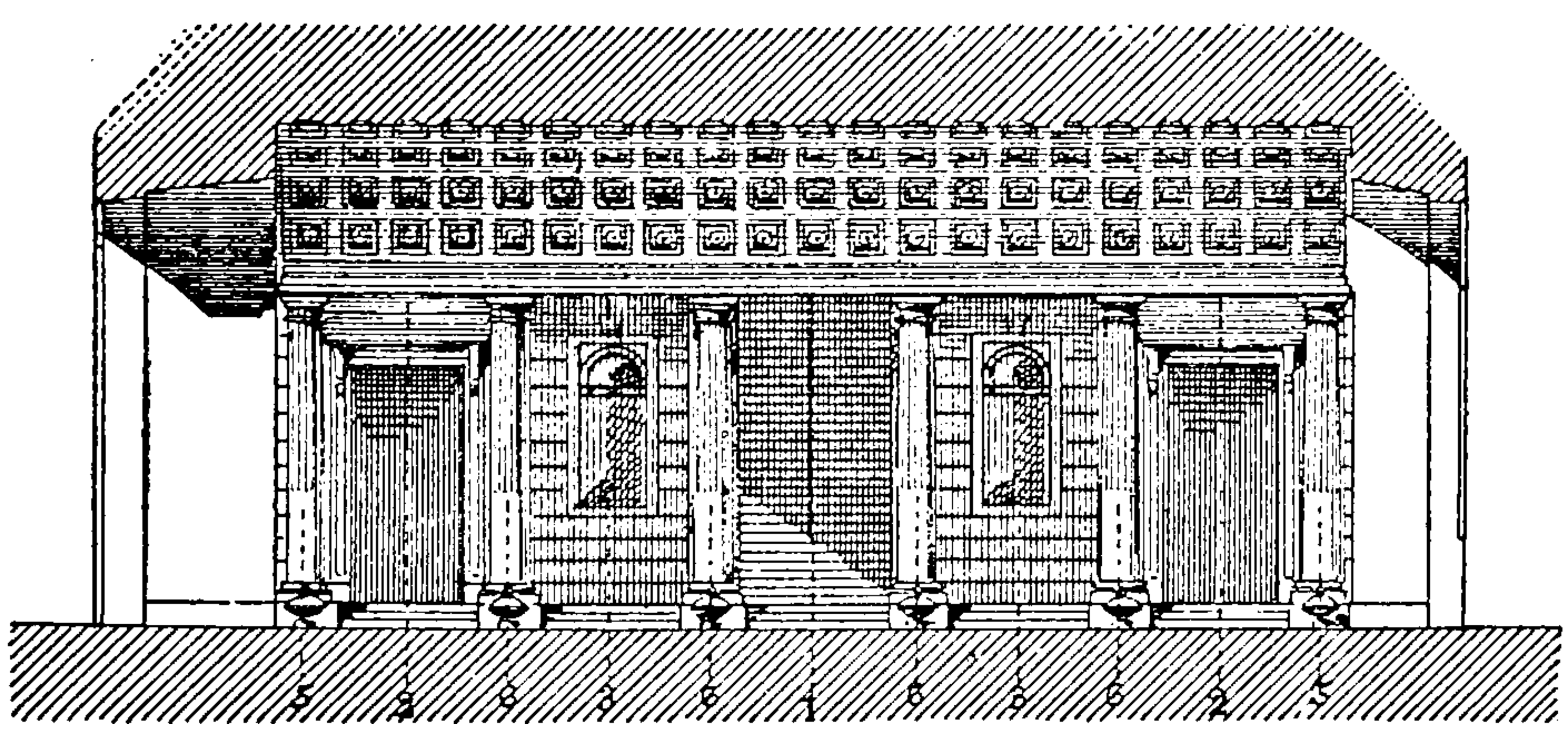


Fig 8 Hotel des Monnaies, Longitudinal Section of Vestibule
Section on ZZ

and the student will do well, in order to become familiar with architectural drawing, to practice the drawing of plans constantly.

Now let us consider the sections, taking the same example that we have just considered. The student will easily see that the architect cannot study his composition thoroughly without the aid of numerous sections. Two sections, however, are especially necessary, those following the principal transverse and longitudinal axes of symmetry. If the student wishes to draw both of them, he should decide first which one of the two controls the other. See Figs. 7 and 8. He will see that in this case it is the transverse section, parallel to the front elevation. The other, the longitudinal section, is chiefly the projection of elements of the other section. Therefore, in this case the drawing should be commenced by laying out the transverse section.

First, place the axes just as has been done in the plan, 1, 2 2, 3 3, 7 7, 8 8. In regard to the profiles or the parts in section, the first thing necessary is to locate the heights of the essential parts, taking for the first level the main floor A A, next drawing the upper line of the capitals of the columns B B, then the centers of the vaults C D.

Starting with these principal lines, draw in the details, as for example, the heights of the bases in relation to the floor A A. The capitals and heights of the architraves will be located in relation to the line B B. It is evident that if all the measurements were taken from the level of the main floor A A, the least inexactness would affect the capitals, while if the total height of the column A B is once determined, no mistake can be made in the height of the base and that of the capital, and even admitting a slight inexactness, it will be inappreciable on the total height of the shaft of the column.

In all which has preceded, the drawing has been laid out along the lines of the axes. But besides these are some conventional methods by which the drawing of profiles in section or in elevation can be facilitated. Let us take for example a fragment of the Doric order—one from the Parthenon, Fig. 9. To reproduce this drawing one should measure the different projections by referring them to one single vertical line. In this case the axis of the column would not furnish a convenient axis for measurement, as with exception of the column, it determines nothing. It is best to proceed just as in measuring an existing order, that is, by dropping a plumb line from the overhanging cornice and measuring the distance from that plumb line to the various members. But this vertical line from the outer member of the cornice will be only useful for laying out the profile and in locating the axis of the column; axes should be drawn in every other possible case. For instance, place the column on the axis A; the triglyphs, on B; the metopes, on C; the head of the lion, on D, etc. To obtain the heights draw the principal divisions in first; the total height of

of the mouldings should be drawn in. Between C and D, however, the profile of the shaft may vary very much and the student will not be able to copy it except by laying off horizontal divisions. For that purpose, draw the limiting lines of its greatest width *m m*, mark its point of application M, and repeat this operation on the drawing. In the same manner lay off the line *n n*, and the point N, which gives the smallest diameter of the shaft, and do not mark these points by a single point with the pencil, but be careful to draw the limiting (in this case vertical) lines at every point, and do not erase them until after you have inked in the drawing. These lines will be a safe guide and will enable one to make an exact and clean drawing.

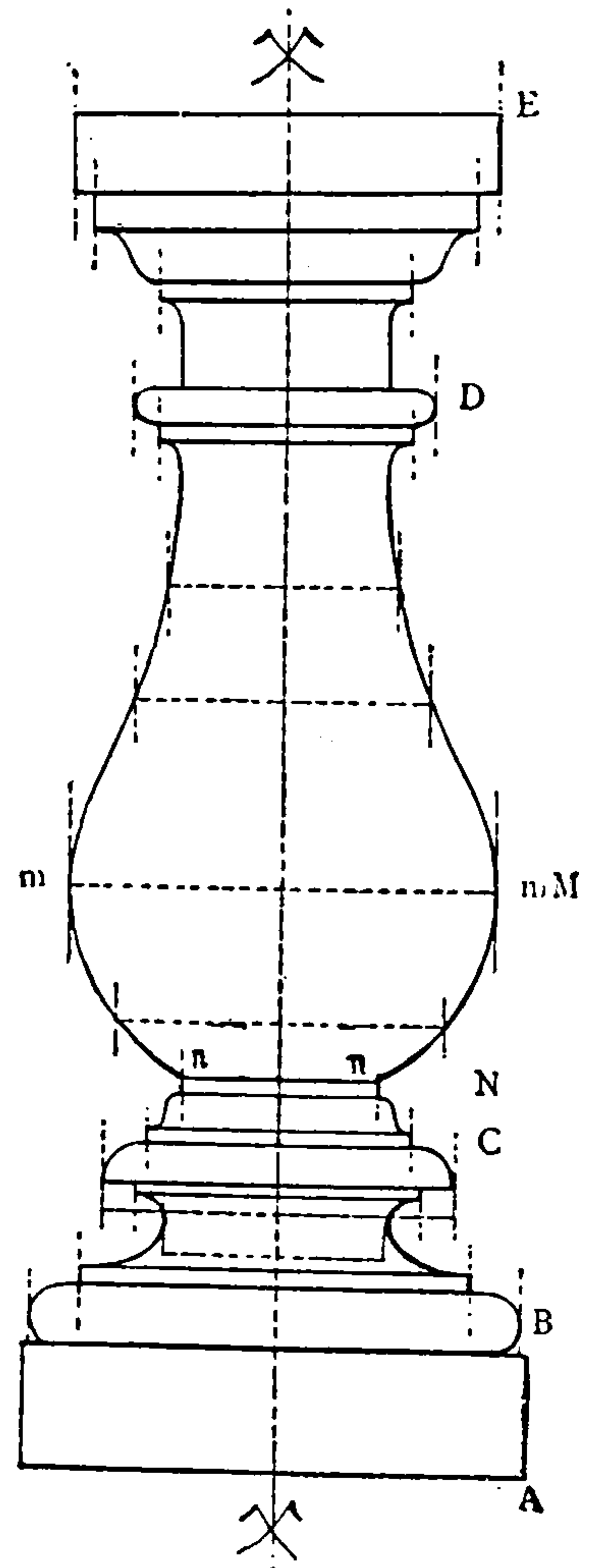


Fig 10 Baluster

As another example take the fragment of the cornice with different ornaments, taken from the Temple of Concord, at Rome, Fig. 11. The construction lines marked on the drawing, and which should be kept in pencil until the drawing is completed, show especially well the method previously explained.

Finally, to produce an architectural drawing with precision demands primarily a rational method and methodical habits. The design gains by its facility, but the method can only be a general one In its application, an intelligent draftsman will recognize each time what should be the logical sequence in carrying out the drawing. And still, all of this will be only the mechanism of the design; it is necessary to put into it taste and sentiment. For all of this there is only one precept—it is by practice that one becomes a good workman.

Oblique Projections. It happens often that in an elevation or section architectural motives are represented obliquely in relation to the principal plane of projection. Thus in a circular building a series of similar windows are in elevation at different angles, consequently the widths differ, but the heights do not.

It is necessary to become familiar with these conditions of drawing which occur frequently. It is here above all that geometry will be very useful, for that study includes the planes of projection and planes of development.

While there is some little difficulty, there is also much profit to be gained in projecting an architectural motive at an angle. In order to project a motive at an angle correctly, one must understand the motive thoroughly. An architectural arrangement drawn out in direct elevation only, will not tell the whole story, but if drawn in oblique projection a thorough understanding of the arrangement is gained.

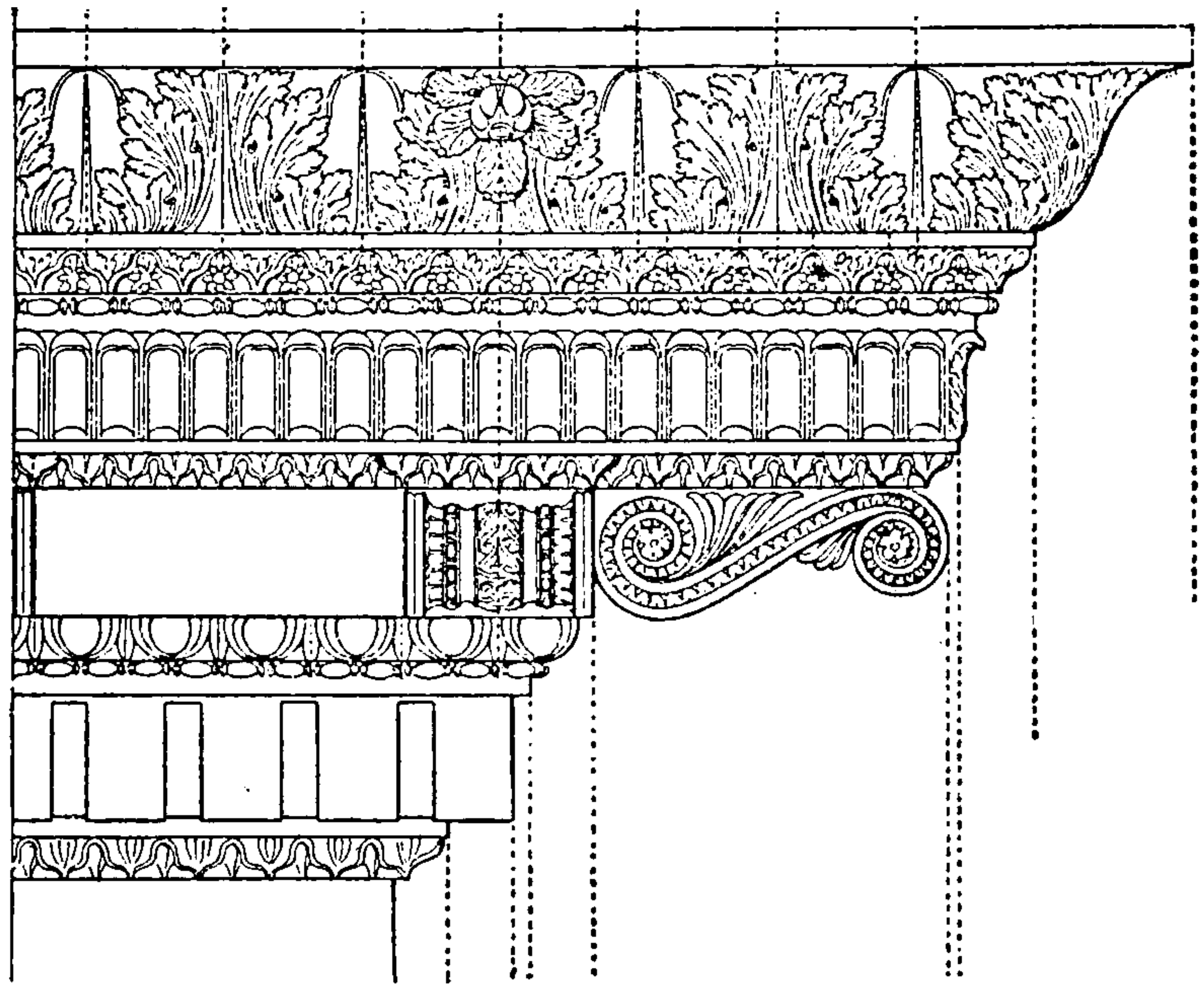


Fig. 11. Entablature from the Temple of Concord, Rome

It is recommended, therefore, as a very useful exercise to draw out in oblique projections, designs that are made in direct elevation; it is a good exercise in design, but above all it is an excellent preparation for architecture, compelling the designer to analyze his model and to see it *as a whole;* to understand its projections and to comprehend the position of the different details. The designer realizes that he is working on the real building rather than in simple imagination, and so will soon see of how much advantage these exercises will be to him.

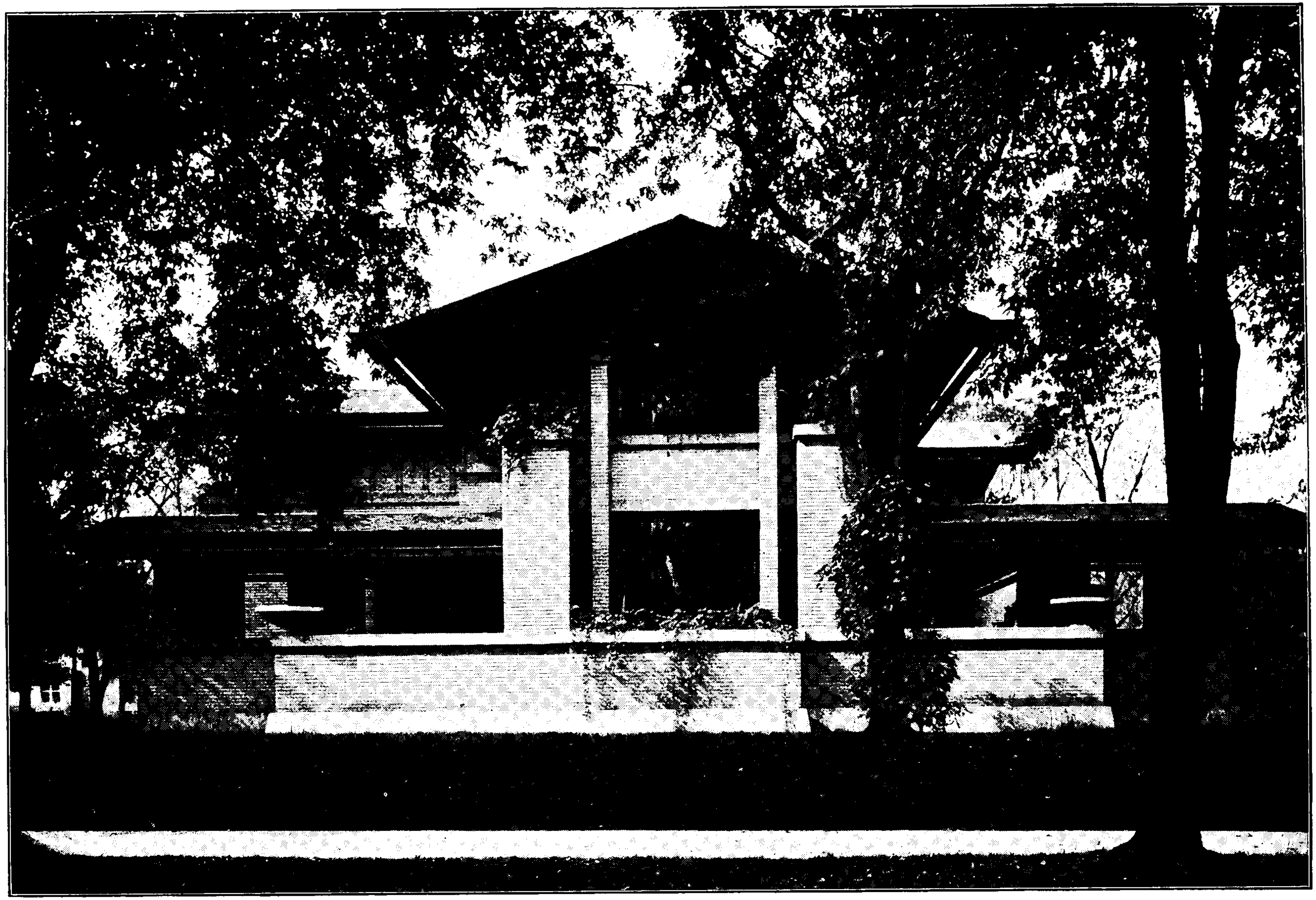
Consider, for example, two windows, one in direct elevation and the other projected at an angle. It is evident that the direct elevation permits the study of proportions and it is evident also that the oblique projection shows more than the direct elevation of the different parts of the window. In the same manner draw out the development of such parts of buildings as vaultings, circular walls, etc.

All this can be summed up thus: Study architectural drawing as an architect. Become accustomed to see in the drawing the object represented. It is very necessary that the drawing should be nothing more for the designer than a sort of language, and that he should see in reality the thing itself, just as a composer of music, as he puts down on paper the notes of his score, can hear them as though they were being played; just as everyone in reading a book of printed characters never notices the printed letters but feels the emotions that are meant to be conveyed as though the words were spoken.

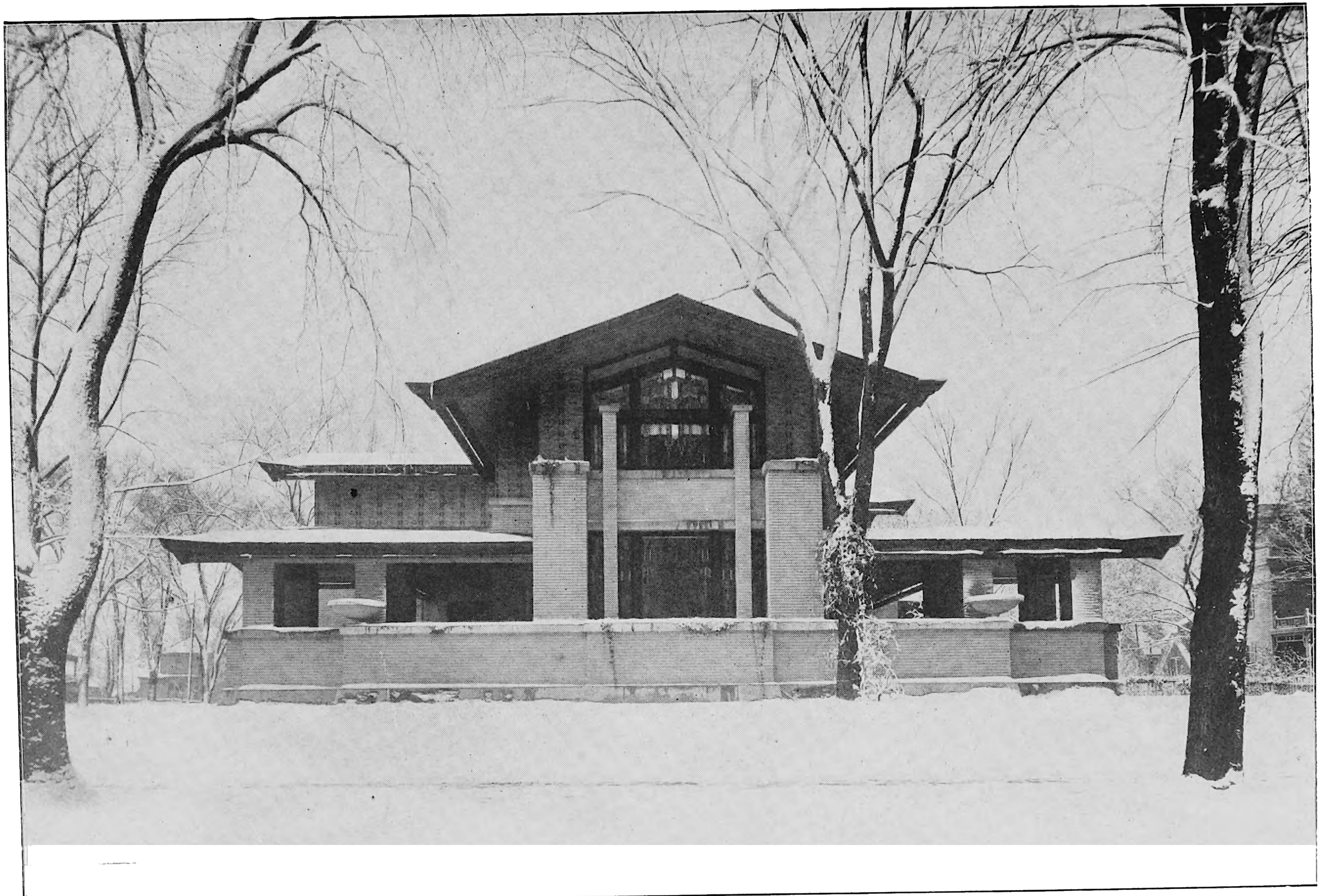
Modeling an Architectural Drawing. A design is only complete when in addition to the outlines, it is modeled, that is to say when the form is expressed. The most common process for modeling an architectural design is by wash drawing, but the methods of modeling are the same whether done by wash drawing or by rendering with the pen, the pencil, or other processes. It is not possible to say that modeling has absolute rules, or that all methods are good even if the desired effect is obtained; *i.e.*, if the reliefs and the forms are represented in their true relations to one another. There are, however, certain general principles that can be used as a guide in modeling a drawing.

Shadows at 45 Degrees. It is the custom to assume that the light rays fall in a direction, the horizontal and vertical projections of which make an angle of 45 degrees with the line of the ground. The luminous ray itself does not make, in reality, an angle of 45 degrees with the planes of projection. Its direction is that of the diagonal of a cube whose faces are respectively parallel and perpendicular to the planes of projection.

This method has two advantages; the laying out is easier, which it is well to consider, for the drawing of shadows is often a long and complicated process, and in this case the depth of the shadows is equal to the projections. Consequently, the size of the shadows permits anyone to understand, without further drawings, the projection of one architectural body in relation to another, and the relative positions in space of the different surfaces in one body.



RESIDENCE OF MRS. R. D. LAWRENCE, SPRINGFIELD, ILL.
Frank Lloyd Wright, Architect, Oak Park, Ill.



WINTER VIEW OF RESIDENCE OF MRS. R. D. LAWRENCE, SPRINGFIELD, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill.

Summer View Shown on Opposite Page. For Entrance and Studio, See Page 234. Building Completed in 1903.

The drawing of shadows is often difficult; it is one of the essential parts of descriptive geometry that will also be found in special treatises. As for indicating shadows which cannot be laid out accurately, such as shadows of decorative parts, it is a matter of judgment to determine the amount of projection—a knowledge gained by experience.

Values. After having drawn the shadows, lay over the shadow part a uniform tint. Now the drawing will be seen to be divided into lights and shadows.

As a first principle, it is necessary always to make a distinction between light and shade; shadows will always be modeled, lights will also always be modeled; but it is necessary to be able to distinguish clearly which is light and which is shade in the same drawing, at least where there are large spaces between different planes. The parts having the darkest tint in the light should remain lighter than the lightest reflected lights of the parts in shadow. Besides this, geometrical design, not being able to make use of the illusions of perspective to show distances and projections, has to make use of expressive modeling, since it is *the values* of the tints alone which will indicate the relative distances and projections.

Therefore, in order to bring forward or to set back one plane with relation to another, the only resource will be to tint them differently. Notice what happens in this respect in nature; for instance, an object placed near the eye is modeled very clearly and one at some distance is modeled much less, and one at a great distance or on the horizon, is only a mass without details. So, the nearer the object is, the more it is modeled and the greater are the differences between the shadows and the lights; on the contrary, the further away it is the more the lights and shadows tend to mingle. In the foreground there will be strong shadows and high lights, in the distance dull shadows and softened lights; between these an intermediate proportion of shadows and lights. Therefore, in facade, the planes farthest away from the eye will have the least modeling, while the nearer the plane is to the eye, the more is the modeling accented.

As stated above, in nature every light and every shade is modeled and graded; the shadows are more noticeably graded than the lights. The reason for this gradation of shadows is the indirect lighting thrown back on the shaded objects by neighboring lighted objects, and this is called reflected light.

Take for example a cylindrical body like the shaft of a column. It is easy to distinguish on this cylinder cast shadows and shades. The cast shadows are those which result from the interception by another solid, of luminous rays which without it would have lighted the cylinder. Shades result from the absence of light on the part of the cylinder which by its position cannot receive light rays. Naturally shadows are less affected by reflected light than shades. The reflection of light or the throwing back of light which creates the reflected light comes from lighted bodies, which in theory may be considered as secondary sources of rays of light of which the resultant will be in the direction opposite to the light. That is, since the lighting is in a direction of 45 degrees from above down, and conventionally from left to right, the direction of the reflected light is in the direction of a diagonal from the lower right front corner to the upper rear left corner.

This conventional theory is to be followed as the rule for modeling. Commence with the lights, or where the gradations are more easily comprehended. Take a solid of white stone, for example, a sphere. It is easy to comprehend that the strongest lighting will be at the point of intersection of the surface of the sphere with the luminous ray which prolonged will pass through the center. Then, around this pole of light, the angle of the luminous ray with the surface will be diminishing constantly following parallel zones, having the luminous point for the pole, until it becomes tangent to the sphere following a great circle whose luminous point is also the pole and which will be the line separating the shade from the light. In other words, the light will diminish from the pole to this equator.

In the shadow it will be just the opposite; the greatest reflection will be at the other extreme of the ray prolonged to pass through the luminous point and the center of the sphere, the shadow will increase in intensity from the pole of reflected light to the separating circle of shade and light.

But if any body casts a shadow on the lighted part of the sphere, its shadow will be much less affected by reflected light and consequently will be more intense than the shade itself.

From this follow two rules for modeling: (1) A shadow cannot

Between these extremes the parts C C will have intermediate values, whether shades themselves or cast shadows. Also, observe that the values of the light at contour C′ are symmetrical with the values of the light of contour C. There will be, therefore, a symmetry of modeling, in relation to an axis of the most intense lighting on the column of the luminous part and of the intensity of the shadows; this axis will be on meridian A. As for the mouldings which are straight in plan like D D, their general value will be analogous to the intermediate value C C.

Passing to the lights, we see that the point most lighted will be the point *a*, and finally the generatrix *a′ a′;* and the light will become more and more gray up to the tangent M M. But along the astragal the light will extend in almost uniform intensity, for it will strike more normally than on the cylinder. As for the straight parts, the abacus, the architrave and fillets, they will receive less light than the cylinder at *a′ a′* and approximately the same as at C C; the sloping part of the abacus will naturally have a more intense light. Otherwise each one of the plain surfaces, in shadow or light, will be graded from the upper part down, because the nearer the surface is to the ground, the more reflected light it receives. For each detail use the same reasoning. Thus, for the cavetto, there is a cast shadow in the lower part, but the portion above the tangent is in shade. The shadow is modelled by continuous grading from darkest at the lower part to the lightest in the upper part; the talon will have cast shadows at O and P, the portions at N being in shade, hence O and P are the darkest parts while N is the lightest.

Another element comes into the modeling; *i.e.*, the openings. An opening is always darker than the simple shadows, for there is almost no reflection that comes in the opening to lighten the shadow. Such are the door and window openings of a facade. The parts in shadow, which are less accessible to the reflections, will be darker than the other parts. For instance, the openings between the dentils, the spaces between the consoles, etc., will be darker than the face of the dentils or consoles and may be as dark as the general shade of the openings. The modeling should be such that the parts which are by themselves in reality, will appear so on the drawing. It is not necessary to exaggerate; the modeling should remain simple.

Lacking good models, it is always easy to get good photographs

CORINTHIAN CAPITAL AND BASE.

Showing conventional shadows and rendering.

Original drawing by Emanuel Brune.

Reproduced by permission of Massachusetts Institute of Technology.

Japanese brushes are used a good deal of late, as they are cheaper than the sable brushes and have some spring to them. A stippling brush is one with a square end, used mostly in china painting. A bristle brush is a stiff brush used in oil painting; on account of its stiffness it is used for taking out hard edges, as described later on. Fig. 16 shows a nest of porcelain cabinet saucers.

Fig 15 Sable Brush

Besides these materials the student should provide himself with a large and a small soft sponge, and large blotters, which will sop up water readily. Whatman's "cold pressed" paper is the best paper to use for rendering in India ink.

METHOD OF PROCEDURE.

Stretching Paper. All drawings on which washes are to be laid should be stretched, as described in the Mechanical Drawing, Part 1.

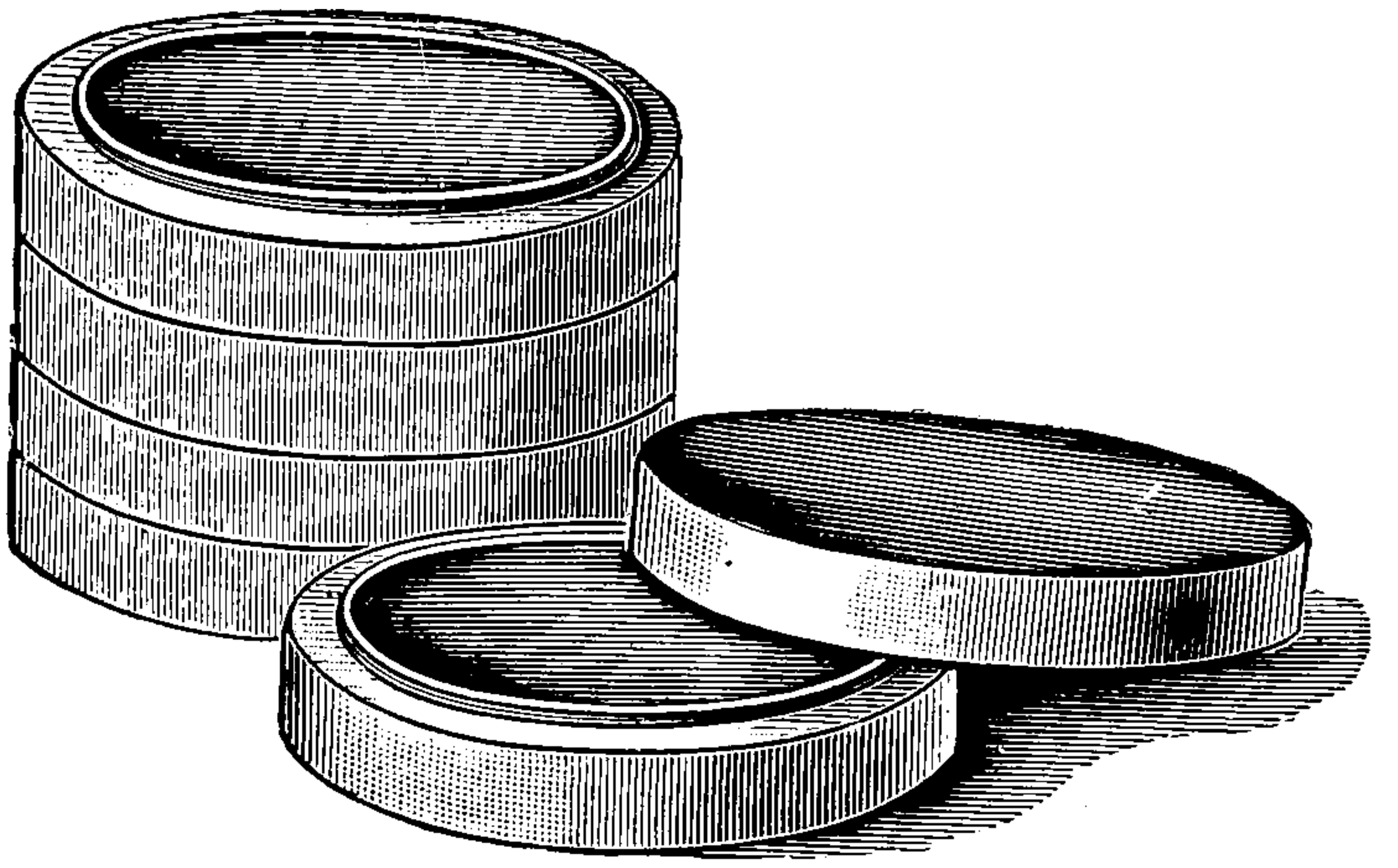
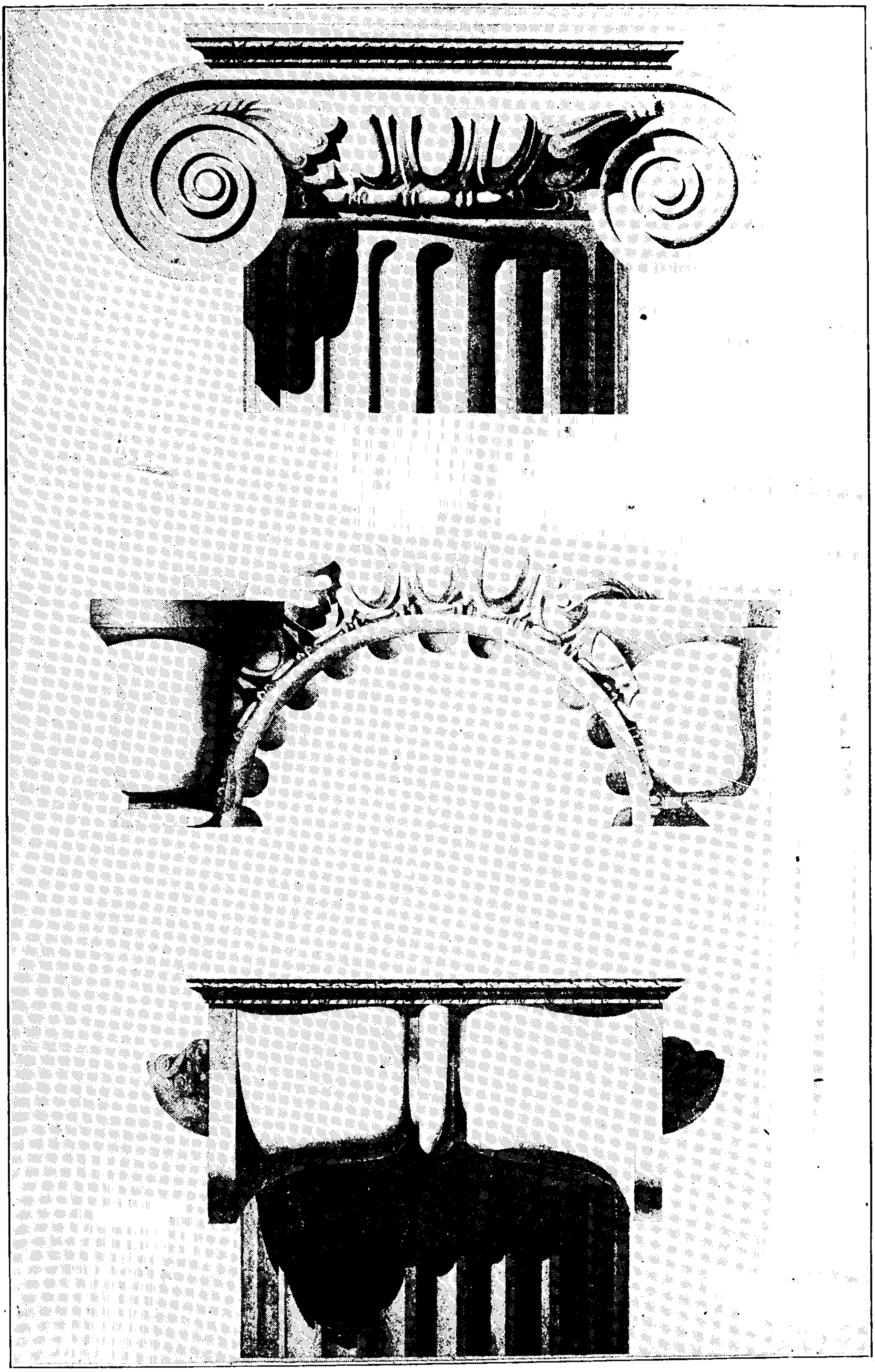


Fig. 16. Nest of Saucers.

Inking the Drawing. The lines should be drawn with ground India ink, the ink being as black as possible without being too thick to flow. Ornament should be inked in with lighter lines than the vertical and horizontal lines. This accents the structural lines. Very often the outline of the ornament is drawn in a heavier line than the remainder. The width of the line



RENDERING OF ROMAN IONIC CAPITAL.

Showing conventional shadows and reflected lights and shadows.

Reproduced by permission of Columbia University.

cleaned by giving it a light sponging with a very soft sponge and perfectly clean water. Touch the surface lightly, sop on the water liberally, and dry it off immediately with a sponge or blotter *without rubbing.* Before washing, the paper should be cleaned by rubbing it *very* lightly with a soft rubber. Especial care must be taken not to injure the surface of the paper by rubbing too hard.

It may seem that all this care is unnecessary, but it is only by observing this extreme care that the skilled draftsman obtains the transparent wash and the beautiful, even, clear tints free from all streaks, which give so much charm to an India ink rendering.

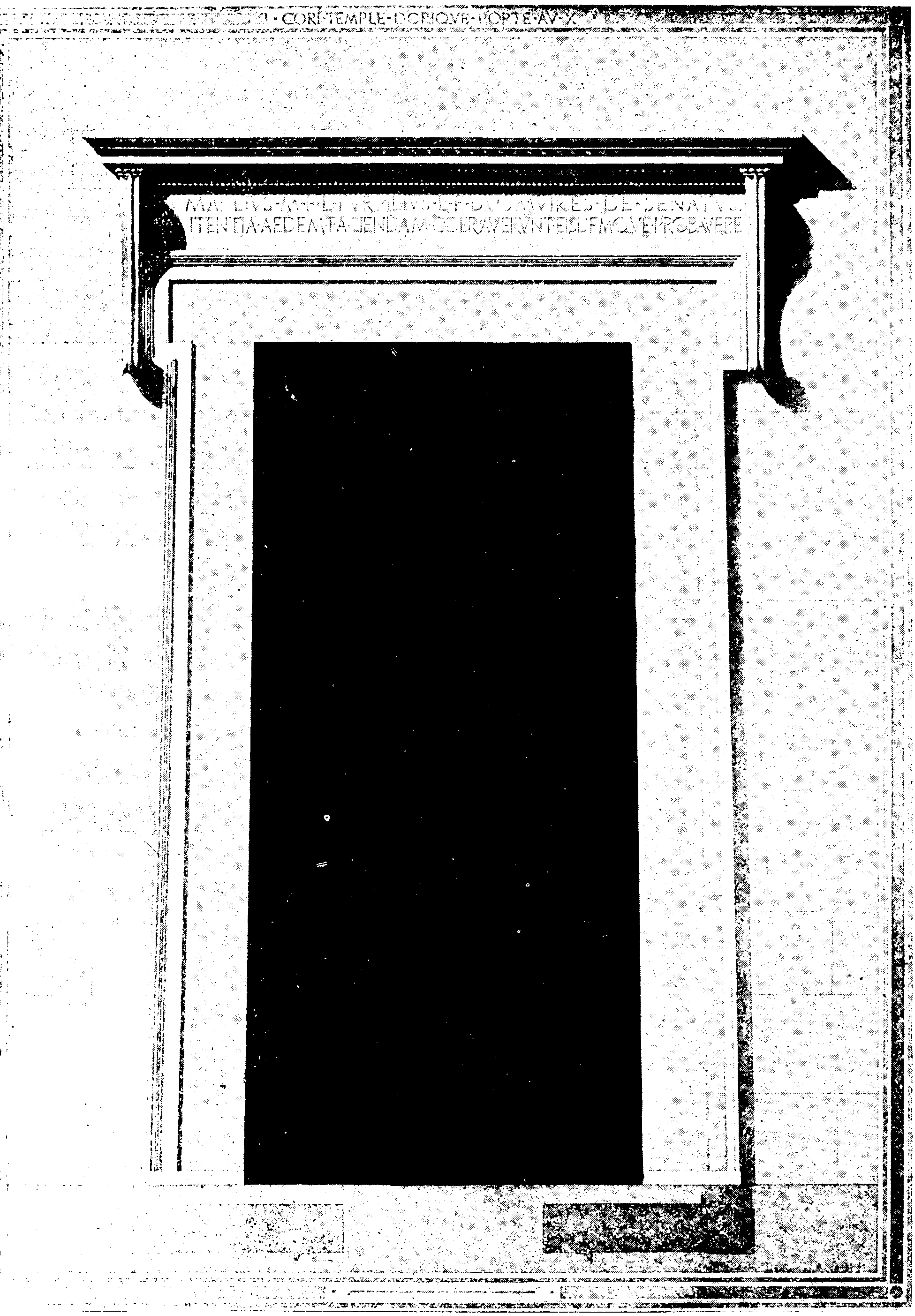
Handling the Brush. Skill in handling the brush is acquired only by constant practice. The brush demands great lightness of hand. The right arm should never support the body. The arm should not rest on the drawing; only the little finger of the right hand should come in contact with the paper. The brush should be held somewhat like a pencil between the thumb and index finger, and the little finger should be very free in its movements. Touch the paper only with the point of the brush.

The brush should be well filled with the tint and care should be taken that there is practically the same amount of tint in the brush at all times. If this is not done, for example, if the brush is allowed to get too dry, one part of the wash will dry faster than the other and streaks will result.

If the brush should be too wet, the surplus moisture can be removed by touching it to blotting paper.

If the paper is too wet the surplus tint can be removed by drying the brush on blotting paper and applying it to the surplus tint which will then be rapidly absorbed by the brush. Great care must be taken not to remove too much of the tint; otherwise it will dry too fast and leave a streak.

Laying Washes. There are two kinds of washes; the clear washes used in rendering shadows, window openings, etc., and the washes in which the color is allowed to settle, the latter being used to render the grounds surrounding a building. When laying clear washes it is better to tip the board slightly so that the washes may flow slowly in the direction in which they are being carried. If the board is placed flat there is danger of the wash running back over the part that is already dry and thus forming a streak.



DORIC DOORWAY FROM ROMAN TEMPLE AT CORI, ITALY.

An example of classic lettering, conventional shadows and rendering.

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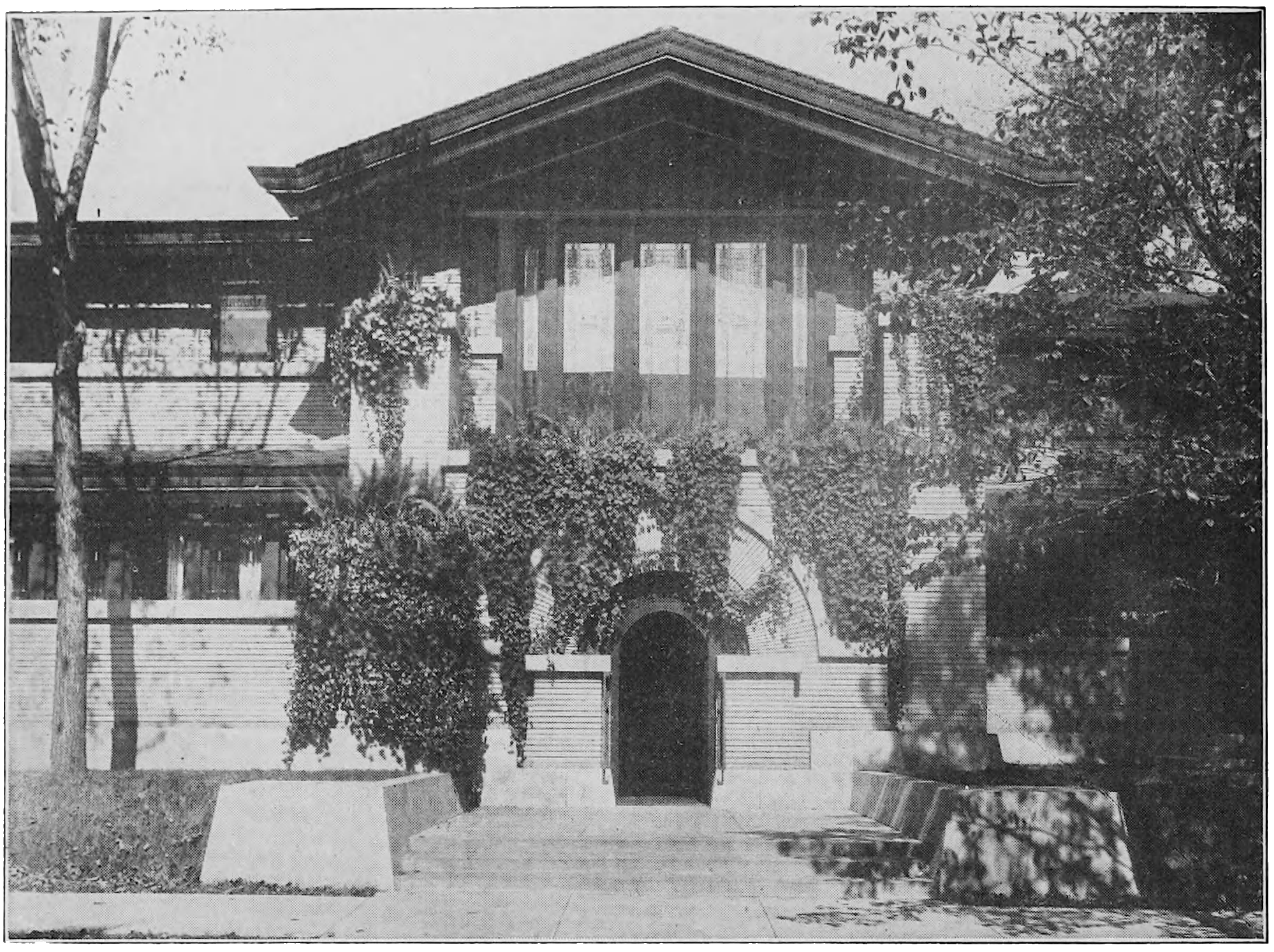
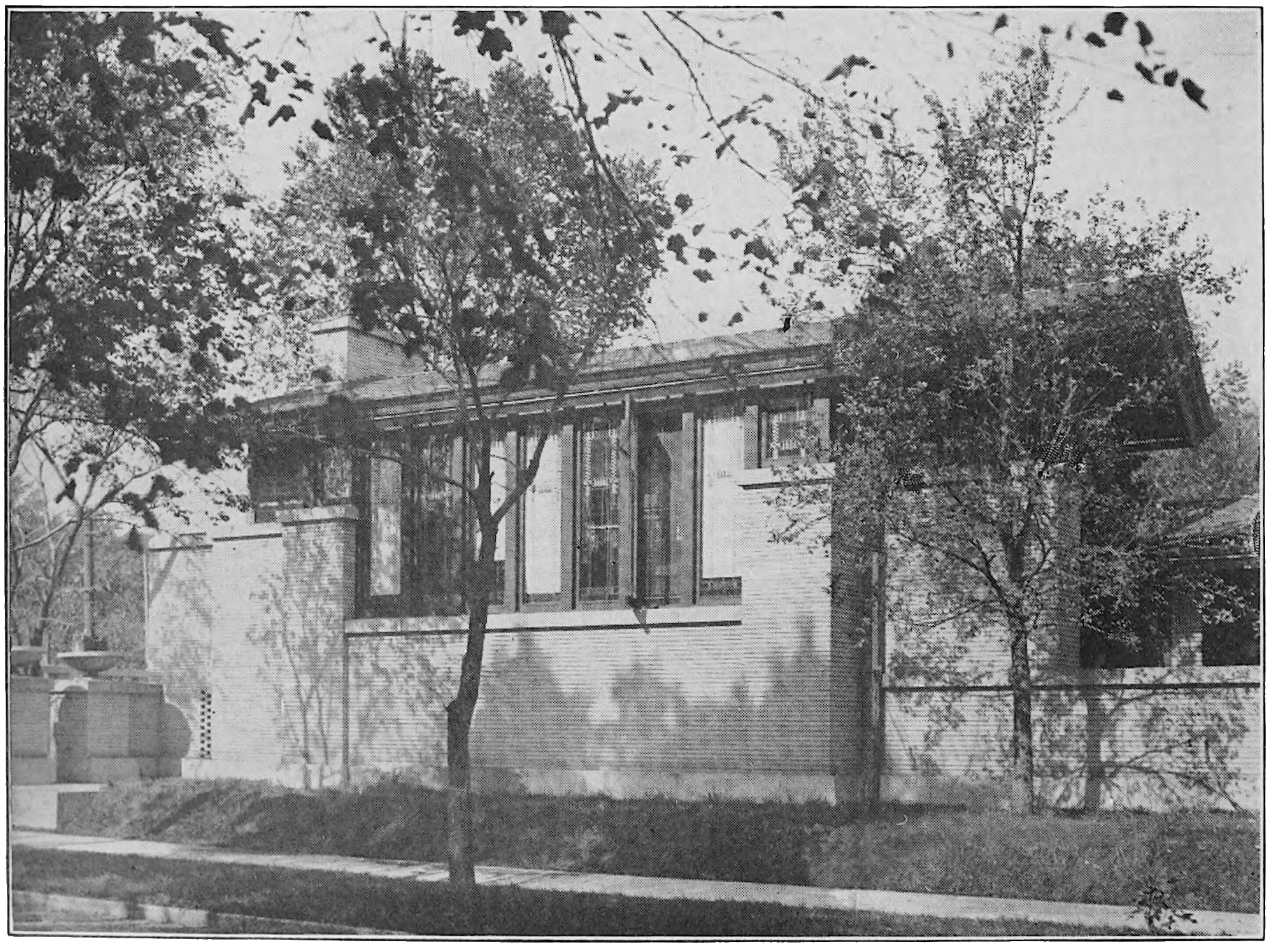


Entrance

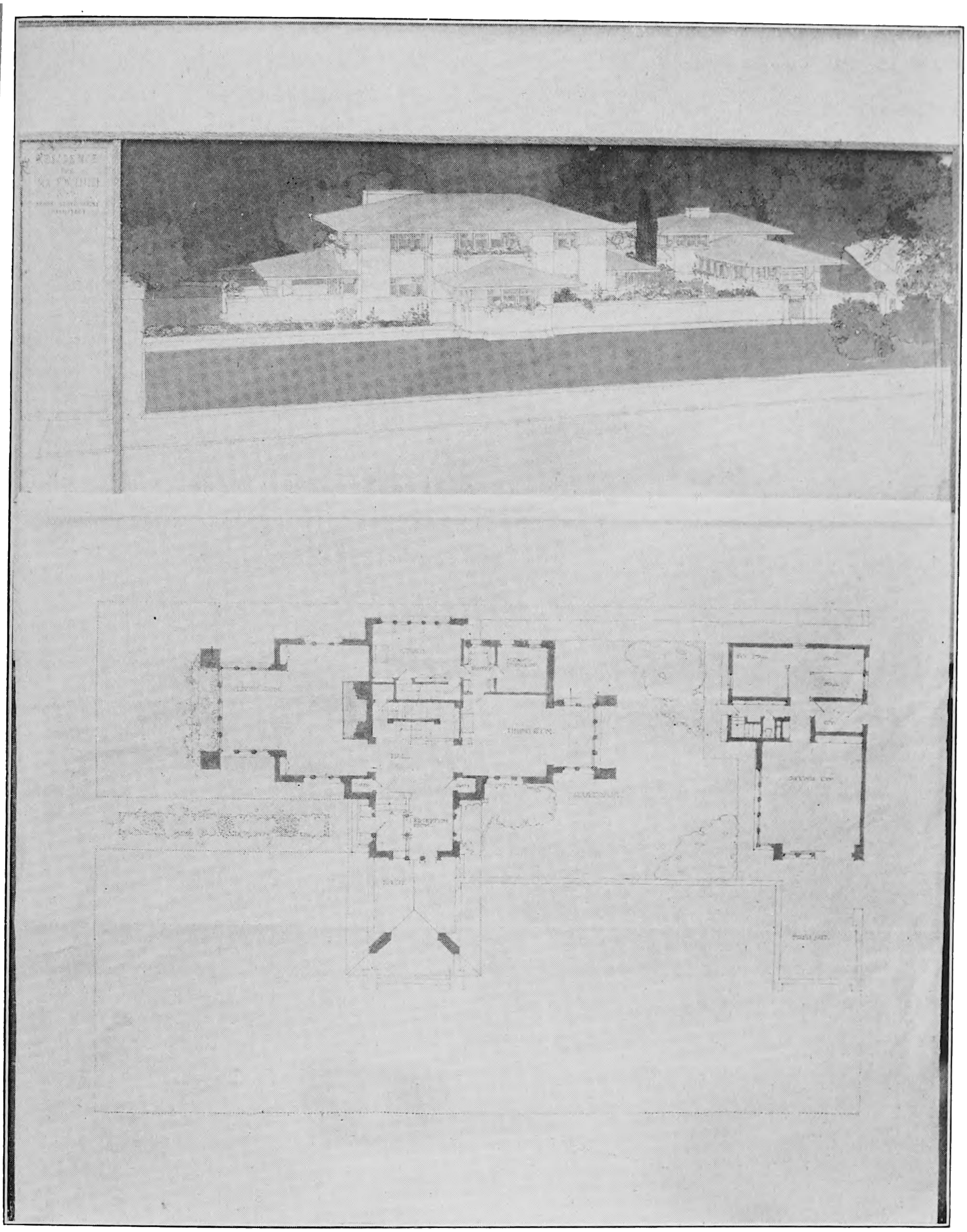


Studio

RESIDENCE OF MRS. R. D. LAWRENCE, SPRINGFIELD, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill

For Other Exterior Views, See Page 218 Building Completed in 1903.



RESIDENCE AND STABLE FOR MR. F. W. LITTLE, PEORIA, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill

Walls of Cream-Colored Vitreous Brick, Roofs Covered with Shingles Completed in 1903 Cost, $18,000

strength and carry each tint for the same distance in each window so that the gradation of color may be the same. In grading in this way it is necessary to carry each new wash well back over the old one so the point where one tint ends and another begins may not show.

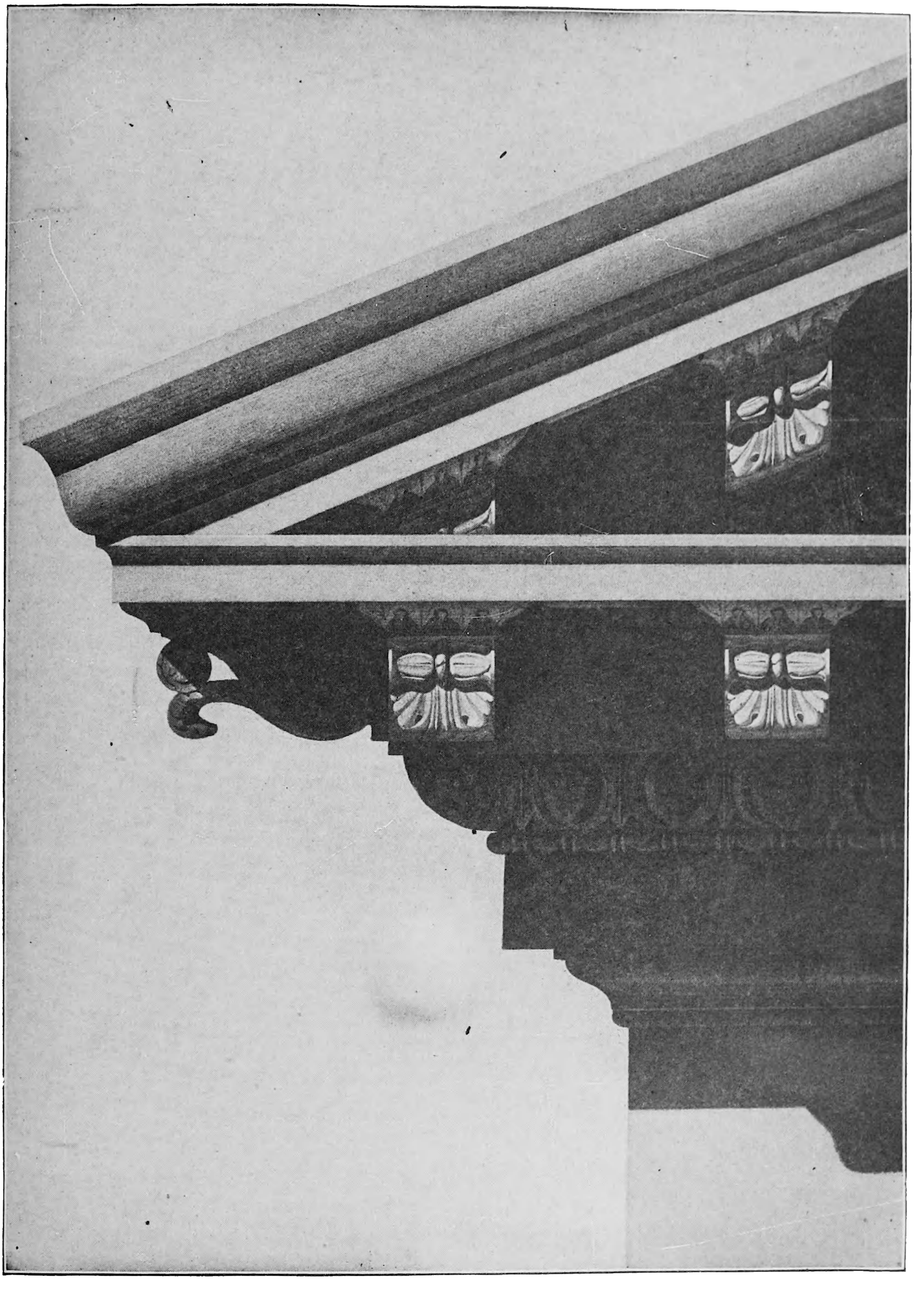
Sometimes gradations are obtained by laying successive flat washes, each wash beginning a little lower than the previous one. In this way the rendered surface will begin with one flat tint and end with a number of tints, one on top of the other. This is called the French method and is done by drawing *very* faint parallel lines at close intervals to mark the limit of each wash. A very light wash is then put over the whole surface, and this is followed with successive washes, each starting from the next lower line. This method is especially good for rendering narrow, long, horizontal graded washes. See rendering of mouldings in classical cornice opposite. Note particularly the application of this method on the crown moulding, and practically all the curved mouldings.

Avoid laying too many washes in the same place, as the continuous wetting and rubbing which the paper gets from the brush is liable to injure the surface.

If the tints are too dark, a soft sponge can be used to lighten them or to take out hard or dark border lines ; but a large brush about two inches wide is still better for this purpose. If it is necessary to use a sponge, use it with a great deal of water, rub *very* lightly and very patiently. The water should be kept *very* clean, and the surrounding parts should be thoroughly wet before wetting the tinted part, otherwise the tint may spread over the other parts of the drawing. After using the sponge, dry the paper carefully with a clean blotter. Another and better way is to place the whole drawing under the faucet, turn on the water and use the sponge or brush, as already described, on the parts to be lightened.

To make light places darker, use the point of a brush, applying the tint in small dots. Be careful not to begin with too dark a tint. This process is called stippling, and it must be done very gradually and very carefully.

Do not forget that the first quality of a wash is crispness. It is necessary to draw with the same precision with a brush as with a pencil. When the drawing is finished it should be allowed to dry thoroughly before it is cut from the drawing board.



Showing Lights and Shadows on Classical Cornice, and French Method of Rendering.

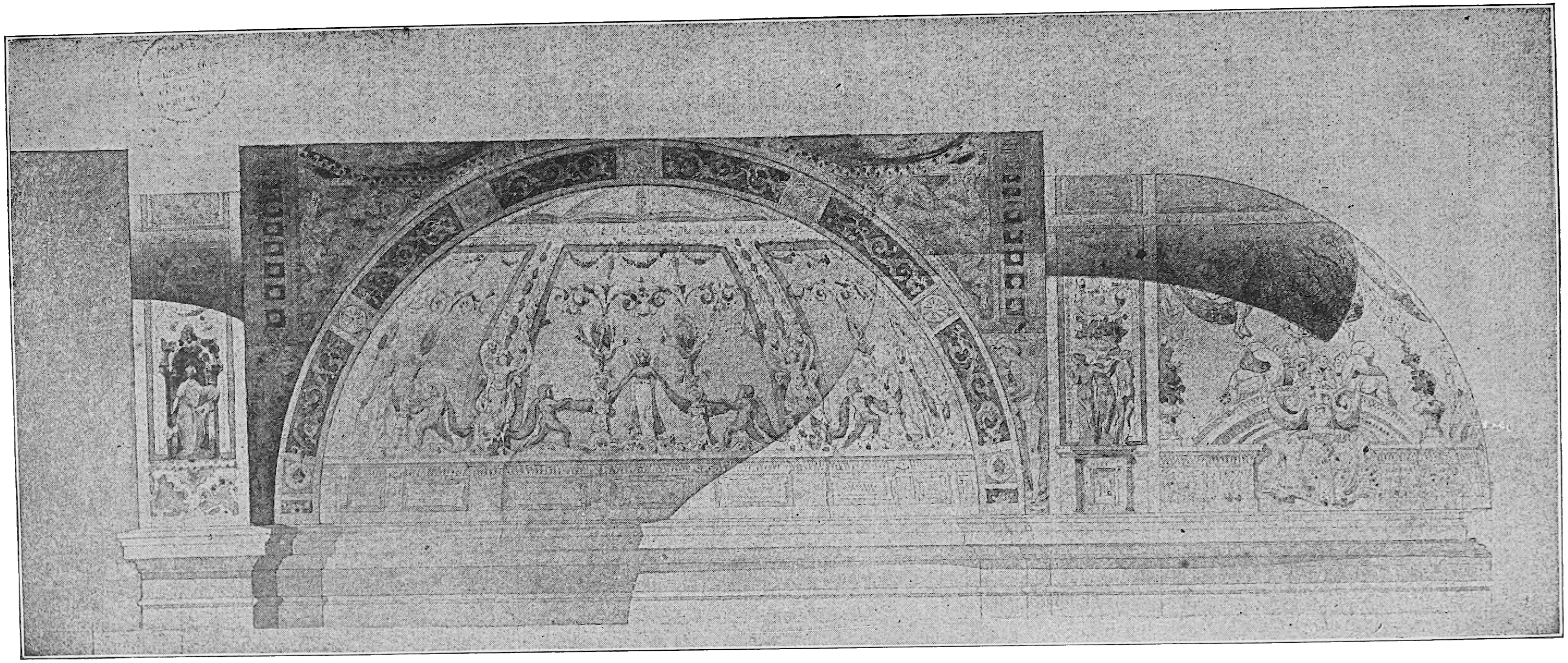
Rendering Sections and Plans. Sections are frequently rendered in the same manner as elevations to show the interior of buildings. The shadows are cast in such a way that they show the dimensions and shapes of the rooms. The parts actually in section are outlined with a somewhat heavier line and tinted with a light tint. The surfaces are modeled just as they are in the elevations. See opposite page.

Plans are rendered to show the character of the different rooms by tinting the mosaic, furniture, surrounding grounds, trees, walks, etc. The shadows of walls, statuary, columns and furniture are often cast, so that the completed rendered plan is an architectural composition which tells more than any other drawing the character of the finished building.

The interior of the building and all covered porticoes are left much lighter than the surrounding grounds because the building is the most important portion of a drawing and should, therefore, receive the first attention of the spectator. The sharp contrast of the black and white of the plan to the surroundings brings about the desired effect. The mosaic, furniture, etc., should be put in in very light tints in order to avoid giving the plan a spotty look. The walls in the plan should be tinted dark or blacked in so that they will stand out clearly. See Fig. 17.

Graded Tints. One rule in laying all tints should be strictly followed: *Grade every wash.* A careful study of the actual shadows on buildings will show that each shadow varies slightly in degree of darkness; that is, shows a gradation. The lower parts of window openings are, as a rule, lighter than the upper parts. Therefore, the washes or tints should grade from dark at the top of the door or window openings to light at the bottom. Furthermore, it will be found that the reflection from the ground lights up shadows cast on the building, so that shadows which are dark at the top become almost as light as the rest of the building at its base.

Windows and doors are voids in the facade of a building, and they have a greater value in the composition of a design than shadows or ornaments in general. This character should be carefully shown in the rendering; and to that end the grading should never show such violent contrasts as to distract the eye from the design as a whole, and thus destroy the unity of the design and



Section Through Vaulted Ceiling, Showing Conventional Shadows and Method of Rendering.

brought out by reflected shadows. These shadows are in a direction opposite to the shadows cast by the sun. If the light is assumed to come in the conventional way, namely at an angle of forty-five degrees from the upper front left corner to the lower back right corner, the reflected light may be assumed to be at an angle of forty-five degrees from the lower right front corner to the upper left rear corner, and the reflected shadows will accordingly be cast in this direction. See detail of Greek Doric Order, page 5.

If these are worked up in their correct relation to one another the character of the details will be well expressed.

Distinction Between Different Planes. The different planes of a building which project one in front of the other are distinguished from each other in the following manner:

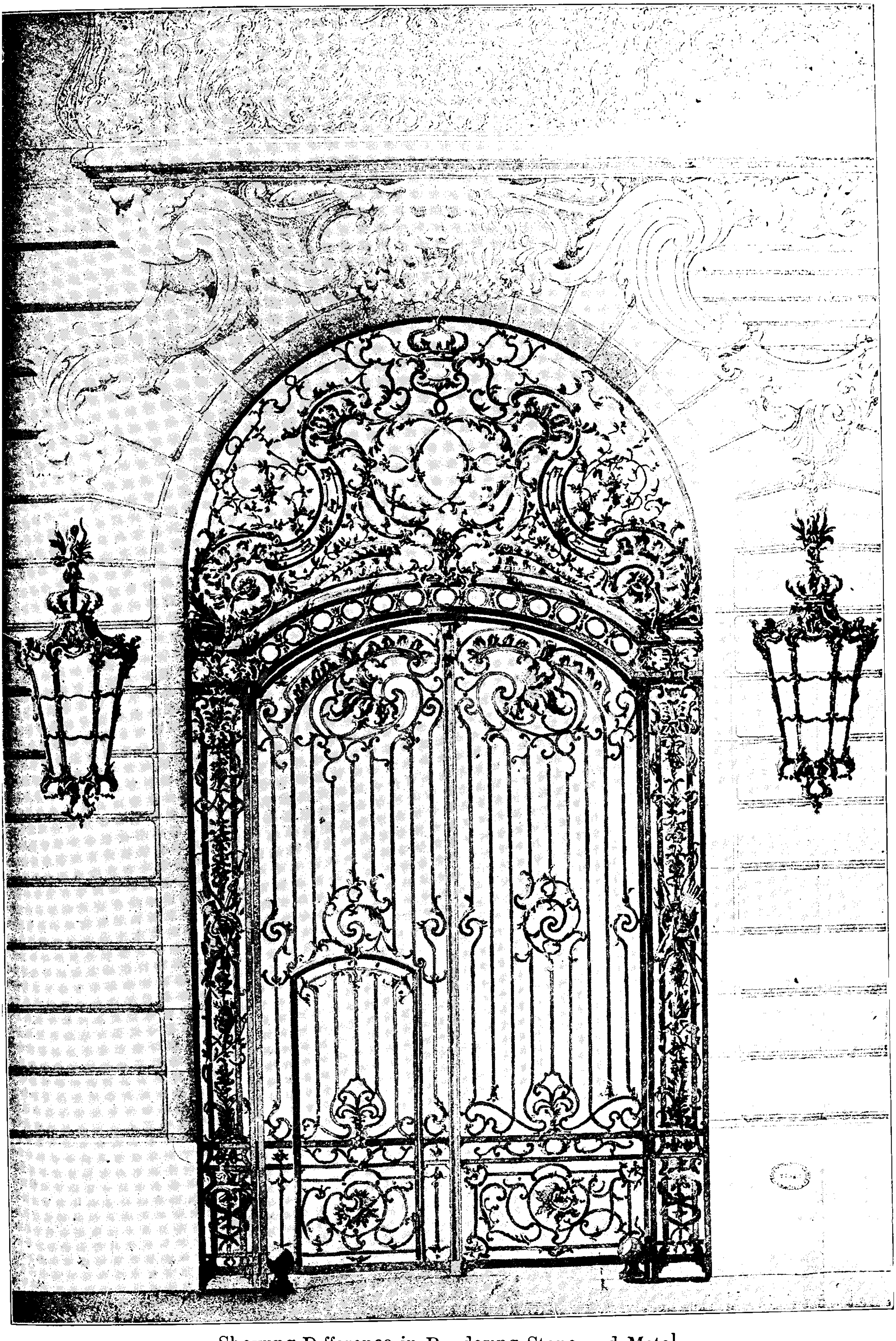
The parts toward the front have a warm color, the portions receiving direct light have a tone over them indicating the material, the shadows are strong and bold, and the reflected shadows are more or less pronounced. The parts toward the rear, on the other hand, have no such strong contrasts of light and dark. The light parts are often left very light and the shadows put in even tones. The further the object is from the spectator the less pronounced will be the reflected lights and shadows. Note the grading on the steps in plate, page 18, and study the frontispiece as an illustration of this point.

In rendering, a difference should be made for different materials. Note the difference between the stone and the metal work on opposite page.

A FEW WATER COLOR HINTS FOR DRAFTSMEN.

Many draftsmen who are strong in drawing, are very weak in color work. The reason for this is, in most cases, that the colors are not fresh, that the brush is too dry, and that the color values are not correct. *Fresh* crisp color is most important. To get this it is necessary to start with a clean color box, clean brushes, and clean paints. The colors should be moist and not dry and hard.

Tube and Pan Colors. After having acquired some facility in the use of colors, tube colors are the best to use, although they are somewhat more wasteful than pan colors. They are less likely to harden and dry up and are not more expensive. The



Showing Difference in Rendering Stone and Metal.

For use in the offices, India ink, Chinese white, gallstone, carmine and indigo will be found very convenient. The latter three are convenient forms of the three primary colors to use with India ink in rendering. Many draftsmen use these alone.

Manipulation. The washed-out look of many of the color sketches seen in architectural exhibitions is very noticeable. The sketches lack strength and crispness.

Color properly applied should be put on boldly in broad simple washes without fear of too much color. Remember that colors when dry are much lighter than when in a moist state. Use plenty of clear water in the brush. Do not go over one wash with another before the first is entirely dry. This is particularly true where a deeper tone is to be put over a lighter one. In broad sky washes where there is a great deal of paper to be covered, dampen the surface well first with a small sponge, then with a large brush and bold yet light quick strokes put in the sky.

Brushes and Paper. A small brush with a good point is necessary for "drawing in" and for detail. A bristle brush is very useful to remove color and to soften hard lines. Chinese brushes are very good, as they hold a great deal of color and at the same time have a good point.

If an edge shows a hard line, this can be softened by dipping the bristle brush into clean water and rubbing the point lightly over the edge that is too hard, sopping up the water at frequent intervals with a clean blotter. It is important that plenty of *clean* water should be used and that the water be taken up with a blotter very often.

When a "high light" is lost, and a bristle brush does not take out enough color, the "high light" may be put in with Chinese white, mixing it with a little of the color of the material.

Look at your subject broadly and do not try to put in too many details. Whatman's hot pressed 70- or 90-lb. paper is good to use. The hot pressed paper, which has a smooth surface, takes the color better than the rough surfaced or cold pressed paper, but the cold pressed has more texture and gives better atmospheric effects.

Combination of Color. For the inexperienced a few hints as to what combinations of color to use may be helpful. It must always be remembered that the colors must be clean to get fresh bright effects.

A simple blue sky: Prussian Blue, Antwerp Blue or Cobalt Blue.

Clouds: Light Red. For the distance use lighter tones with the addition of a little Emerald Green or Carmine.

Dark part of clouds: Light Red and New Blue.

Roads and pathways in sunlight: Yellow Ochre and Light Red with a little New Blue to gray it.

Cast shadows: Cobalt and Light Red or Carmine with a little green added.

Grass in sunlight: Lemon Yellow and Emerald or Hooker's Green; or Indian Yellow and Emerald Green.

Grass in shadow: Prussian Blue and Indian Red; or Prussian Blue and Burnt Sienna. Aurora Yellow and Prussian Blue gives a green color similar to Emerald.

For gray roofs in sunlight: Light Red and New Blue.

Primary, Secondary and Complementary Colors. The combination of colors may be learned by means of the diagram, Fig. 21, which will assist the student greatly in his water color work. The three primary colors are yellow, red and blue. The combination of any two of these will give a secondary color—orange, purple or green. Two colors are called complementary colors if the one is composed of two of the primary colors and the other one is the third primary color. Thus, green, composed of the primary colors blue and yellow, has as complementary color the third primary color; *i.e.*, red. Consulting the diagram it will be found that opposite colors are complementary colors; *i.e.*, blue and orange, red and green, yellow and purple. If two complementary colors are put alongside of one another, each color will look brighter alongside the other than if placed by itself; this is due to the law of contrasts. Thus, the same green if placed alongside red, will look greener than when by itself, and the same holds good for the

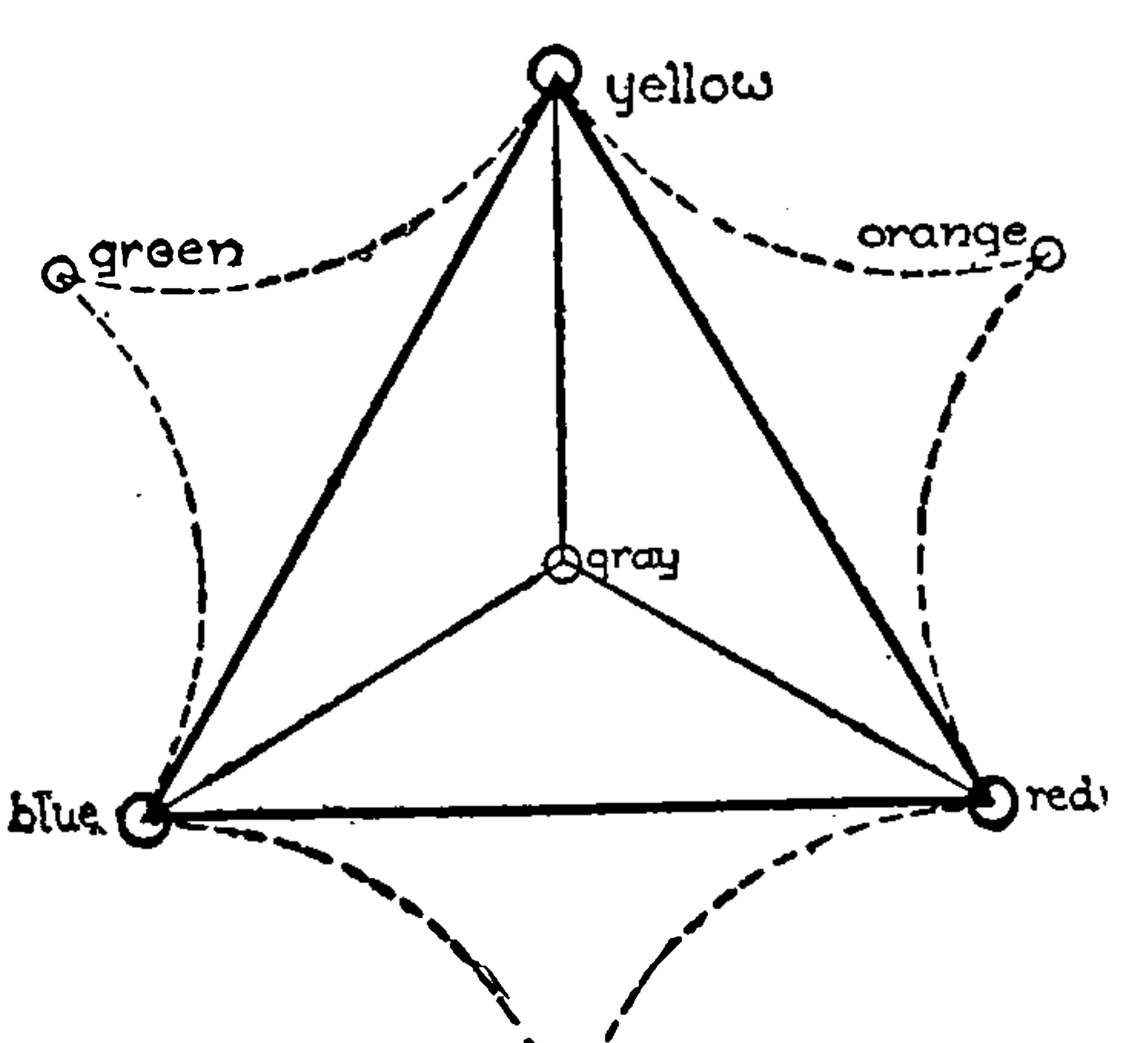


Fig. 21. Diagram of Colors

red. If complementary colors are mixed together you get a softer color, a gray and sometimes muddy effect. If blue, red and yellow are mixed together in the right proportion a soft gray is obtained

Water Color Rendering. Where colors are used for architectural drawings they should be mixed fresh, if clear tints are wanted, but in places where it is desired to have certain effects obtained by allowing color to settle, tints that have stood some time may be used. Especially is this true for plans, where the color is allowed to settle in putting in grass, trees, statues, etc. When it is desired to let the color settle it is better to leave the board flat and carry the color along with the brush, leaving it until it is dry. Some draftsmen keep the board level for all their work.

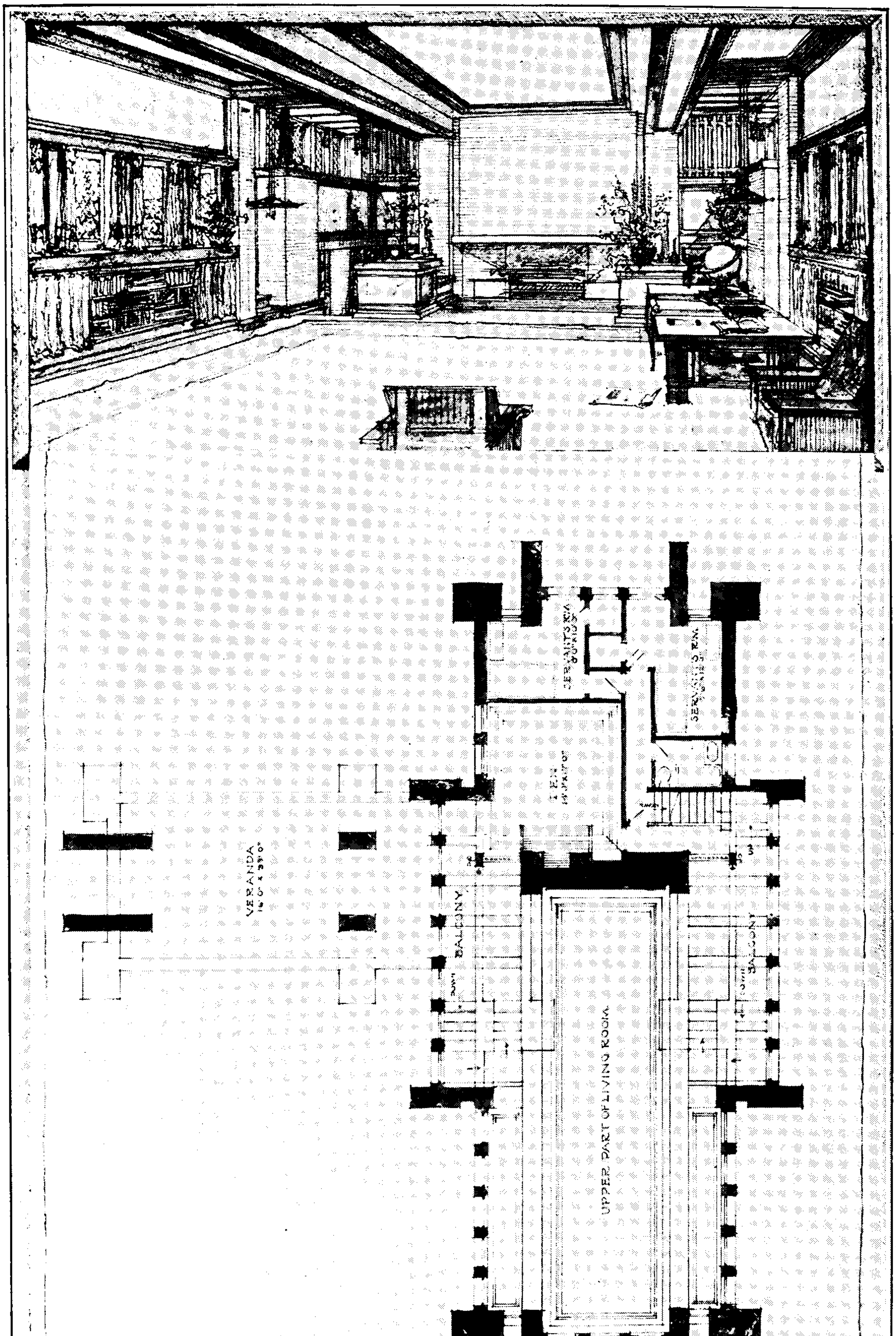
Sketch elevations in pencil may be inked in or may be rendered directly in water color, the shadows being cast and various colored tints laid on to show the different materials, shadows, window openings, etc.

Sketches rendered in sepia only are very effective, putting in the lines with the pen, and rendering with light sepia washes. Elevations are usually most effective when the shadows are put in by washes that grade quickly from dark to light, brilliancy is thus obtained. It is astonishing what effects can be obtained with very faint washes. This applies especially to small scale drawings. The larger the scale of the building or detail, the stronger should be the coloring and values of light and dark.

When sections are colored the parts actually in section are outlined with a strong red line and tinted a very light pink. The colors on the wall are merely suggested.

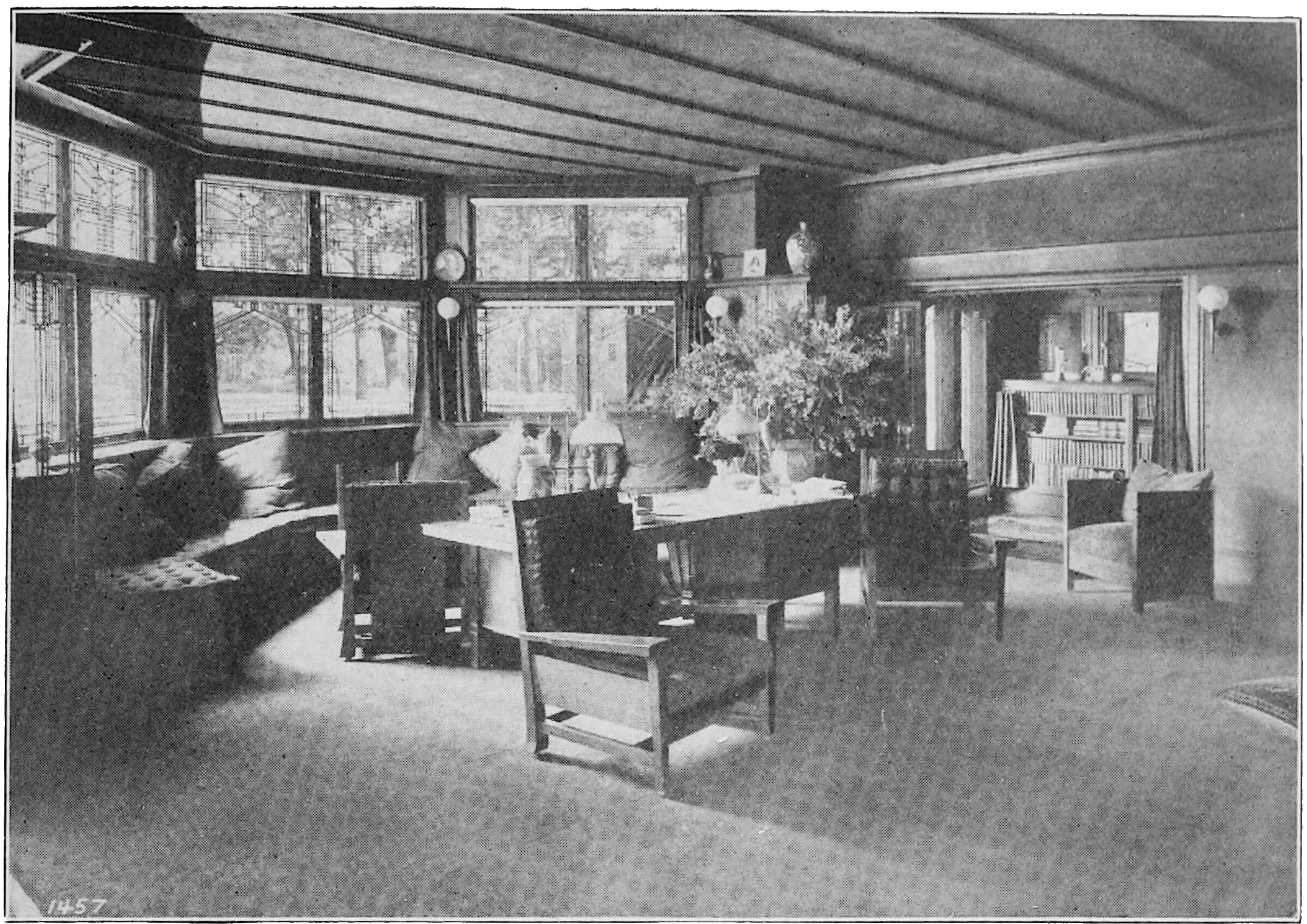
On the plans the mosaic, furniture, etc., is often shown in a light pink. Where a statue has a prominent place it is put in in strong vermilion. Attention is called here to the fact that lettering on a plan counts as mosaic, and should be done in such a way that it will help the effect sought for, a very important point to remember in competition drawings.

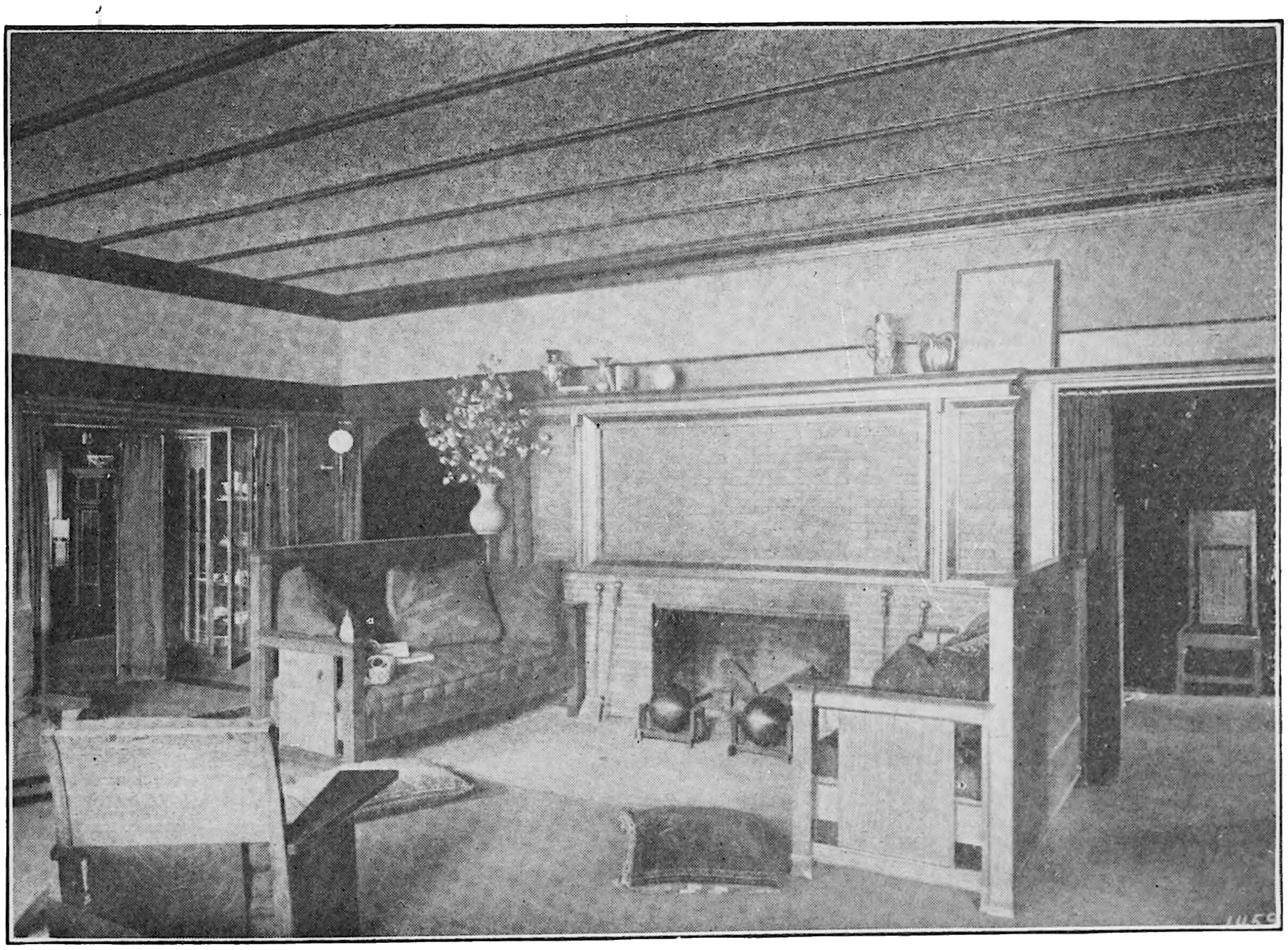
The important thing to remember in rendering is to get the correct relative value of lights and darks. To do this it is necessary to have clearly in mind what the important features to be brought out are and what is the most direct way of accomplishing



DESIGN FOR LIVING ROOM IN RESIDENCE OF MR. H. J. ULLMAN, OAK PARK, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill.





TWO VIEWS OF LIVING ROOM IN RESIDENCE OF MR. B. H. BRADLEY, KANKAKEE, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill

Woodwork of Fumed Oak, Brick, Brown. Built in 1901.

ers will work up their schemes upon the back of an envelope, and these can be brought into scale in the same proportion in which they are sketched out by means of the proportional dividers.

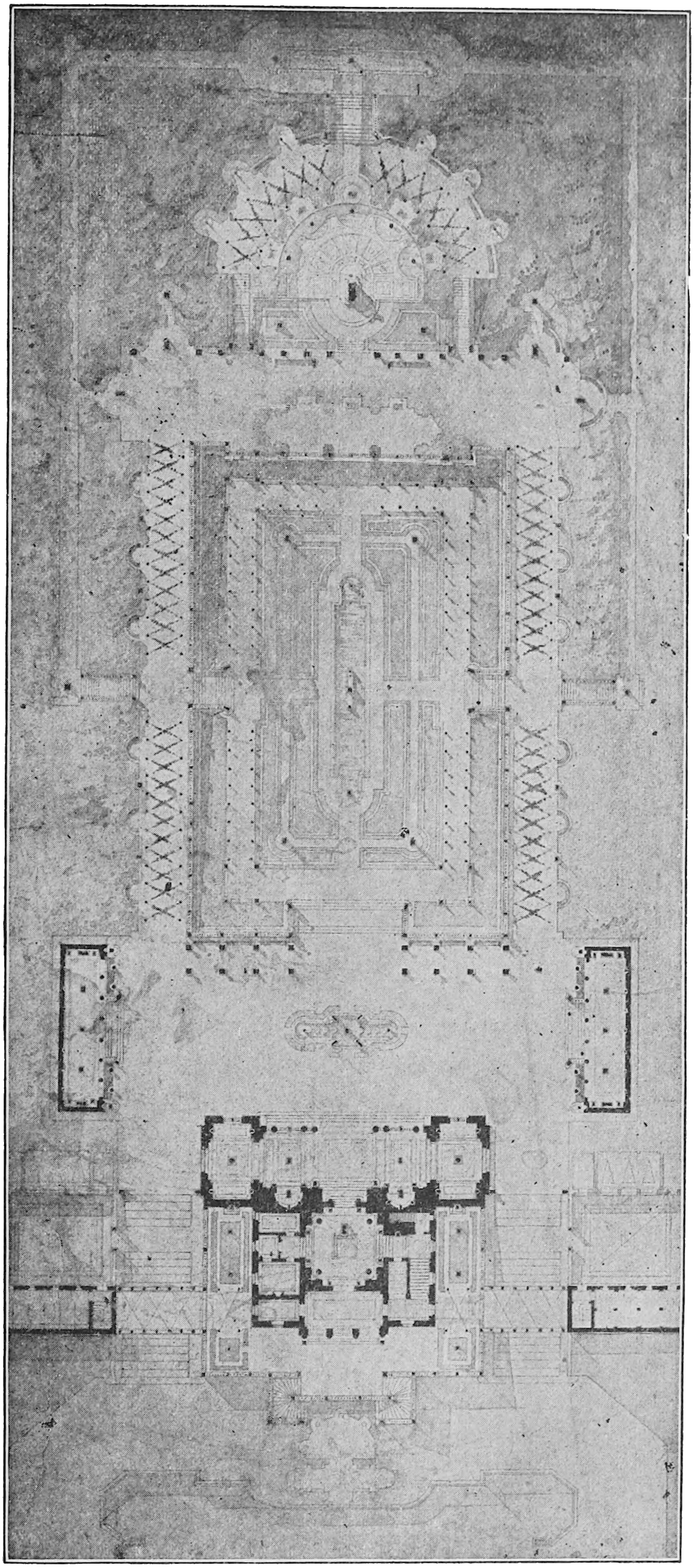
Architectural work is half way between mechanical drawing and so-called freehand drawing, permitting more freehand work than an engineer would consider proper, and demanding more line drawing than an artist would think of employing.

The most successful architectural design generally comes from numerous freehand sketches, as well as accurate studies, frequent erasing and changing on the original drawing, placing studies side by side and comparing them, until a satisfactory solution is found. It is only by continued practice that freedom of expression is obtained, and without this faculty, the best ideas are useless. The well-equipped architect carries a soft pencil, and sketches as rapidly as possible every new impression on paper.

Use of Tracing Paper. When the plan has been well studied, a sketch of the elevation and section should be made as a check on the "scale" of the plan. Tracing paper should be constantly used, both in making rough studies over the drawing and in making accurate line-drawings for comparison of the different schemes. These drawings on tracing paper as studies in proportion, should be as accurate as the finished drawing, though, of course, no care is necessary in giving them a finished appearance, and the straight lines may run across intersections, and erasures and changes may be made freely.

METHOD OF STARTING A PROBLEM AT THE ÉCOLE DES BEAUX ARTS, PARIS.

At the School of Fine Arts, in Paris, when a problem is given to the students, they are obliged to work one day by themselves getting out the scheme of the building. Each student then takes a tracing of his "sketch," leaving the original at the school. In his own "atelier" or drafting room, he works up the "sketch" with the criticism of his own professor and fellow students. At the end of four or six weeks the finished drawings are sent to the school to be exhibited and prizes or mentions awarded by the jury selected by the school. The preliminary work of the "sketch" is very similar to actual practice, because an architect is often obliged, in a very short time, to get out preliminary sketches for a client, and these



A beautiful example of rendering in wash, showing conventional method of representing a plan and surrounding grounds. This is usually done in strong contrasting colors. The black rectangles indicate statuary; the crossed lines arbors. Note how the shadows of the building, terraces, statuary, etc., help to give interest to the drawing.

EXHIBITION DRAWINGS.

Exhibition or show drawings consist of plans, elevations, sections, and perspectives; the drawings are in line, pencil, pen and ink, or color; and all are carefully drawn and mounted, to show the scheme for the proposed building. These may be the preliminary sketches of an architect regularly employed, or they may be competition drawings.

The plan is blacked-in, the furniture delicately tinted, and the surroundings rendered in monotone or color. On the elevations the windows are colored in with graded washes. Every shadow is cast and tinted in; if in color, the different materials are indicated by different colors. In the sections shadows are cast on the section and the color schemes of the various apartments are suggested.

The general idea of the proposed building is best presented to the public by a perspective view, rendered in pencil, pen and ink or color. The perspective is generally laid out in the architect's office and then it is sent to a professional artist for completion.

SKETCHING.

We have considered drawings made on a drawing board with T-square and triangles. There is another way of drawing, that is, by sketching.

The sketch is the most rapid means of progressing in the art of designing. In sketching an object one examines it more closely than one otherwise would. Not only is it necessary to understand a composition, to distinguish its separate parts, but it is necessary to fix the relation of these parts and to study carefully the proportions. The eye alone is the real instrument for measurement and guide for proportion, and the sketch is the means for training the eye. Practice alone will give facility in sketching.

Do not make sketches primarily in order to collect material, but make them in order *to learn how to see.* Sketch books may be kept as souvenirs, but the profit from them will be more in the instruction gained while making the sketch than in the sketches themselves. Through abundant sketching a freedom in the expression of ideas is also gained.

The point to keep in view in sketching is to show the character of the subject attempted. The exact dimensions one can get only with the tape-line, but the most carefully measured drawings often fail to show much character. A photograph is liable to represent a subject other than as the eye and hand see it. But if the effect of the subject, the impression of the beholder, can be reproduced in the sketch,

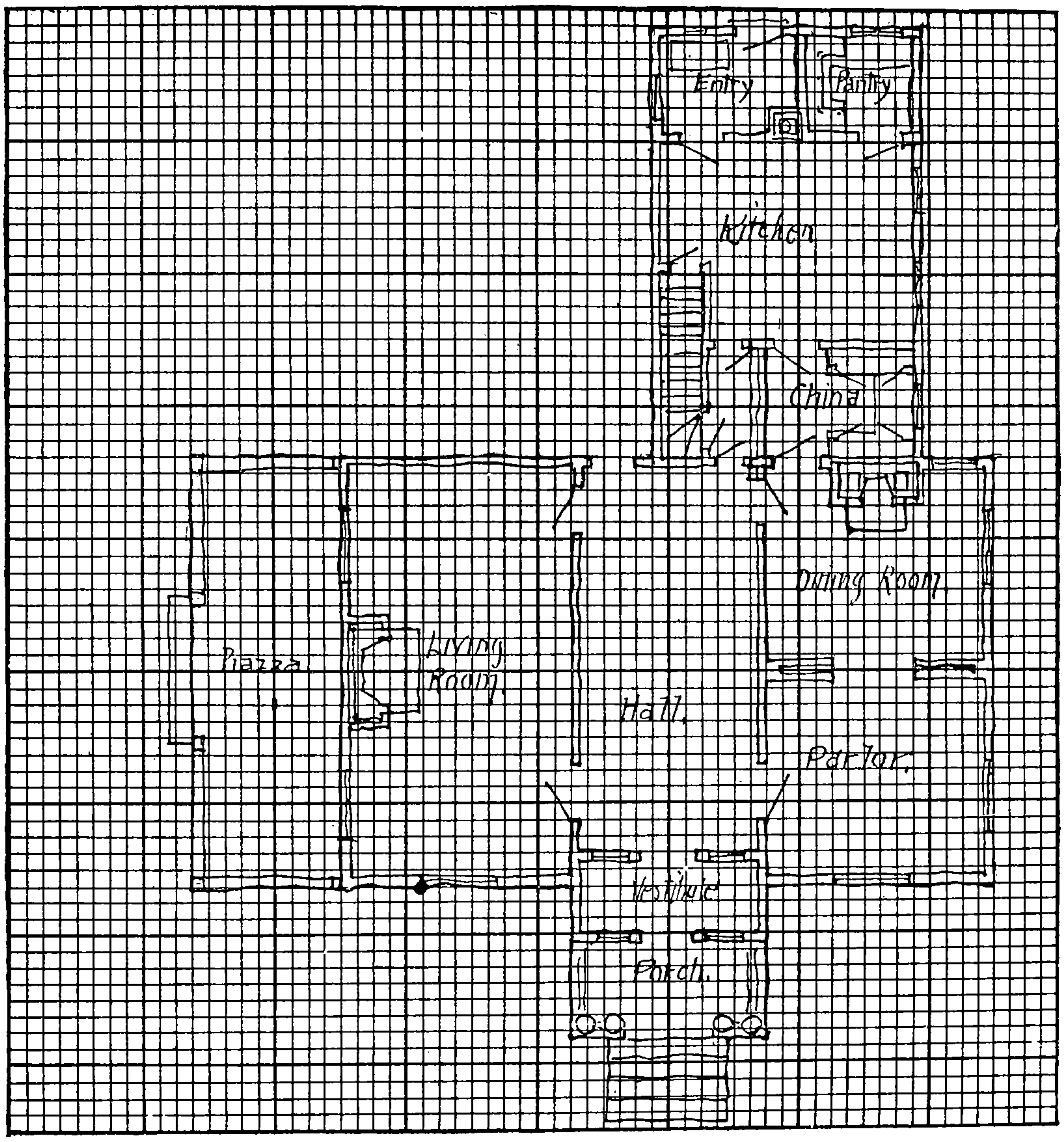


Fig. 22. Cross-Section Paper.

something has been obtained which the tape and the camera cannot hope to accomplish.

Materials for Sketching. At first it is a good idea to use cross-section paper, paper ruled in squares of $\frac{1}{4}$ in. or less, which makes it easier to draw at right angles; but from the moment that the draftsman is able to get along without these lines he should employ only blank paper. A small sketch book should be carried in the pocket. For small pencil sketches a smooth paper (metallic paper) gives crisp effects, but much rubbing cannot be done. A gray paper gives good effects with pencil or color used as a medium, chalk or Chinese white giving the high lights.

The sketches can be made in pencil, charcoal, ink, crayon, or in colors; the medium of expression is of little importance, as, after having learned to see an object rightly, the drawing can be made, as Ruskin says, "with a stick of wood charred at the end." A sketch should be light and clear. Shadows may be cast, but merely to express the projections, and should be only lightly shaded in.

Subjects to Sketch. In almost every city there are small classes in freehand and charcoal drawing which the architectural student should, if possible, attend; and in connection with every art museum there are generally day and evening classes. But great progress may be made by individual work in drawing interesting objects. Do not commence with making a sketch of a whole building. Sketch individual features, like a doorway, some ornament, etc. Sketches of buildings or motives of buildings should be made in direct projection as well as in perspective. The sketches in perspective will help to explain the geometrical sketches and to teach the student to think in three dimensions.

A great deal can be learned by copying photographs of good work, but the greatest benefit is derived by drawing from nature. By the latter the student learns almost unconsciously the laws of perspective, form, and proportion, and above all learns to think "in the solid." It leads to the appreciation of the fact that architectural drawing is the expression of solids, and in order that these solids shall be successfully shown, the one that draws them has to see them in his mind's eye as they actually are going to appear when built.

He should be very careful in the selection of his models to draw from, and choose only such that are beautiful. Too often the student is told to draw no matter what, under the pretext that it is always an exercise. Without doubt it is difficult to draw any model at first exactly, but what does it amount to if he occupies his time with copying those things which do not stimulate and develop his sense of beauty. There is no better practice than to draw a flower, a leaf; and if he has access to museums, etc., he should draw from the antique models, sculpture, and ornamental subjects. By drawing

is a small instrument used by railroad engineers in working out the elevations on each side of the track. The level can be also obtained by looking toward the horizon, pulling down the hat brim until the point coincides with it, turning on the heel carry the horizon level to the direction desired. This will give a point at the level with the eye.

Elevation Measurements. Total distances should be taken, and interior heights from floor to floor (with thickness of floors) should be run from basement floor to top of roof, and if possible a line should be dropped down the outside of the building to check this. It is well to mark size of glass, and give outside dimensions of sashes,

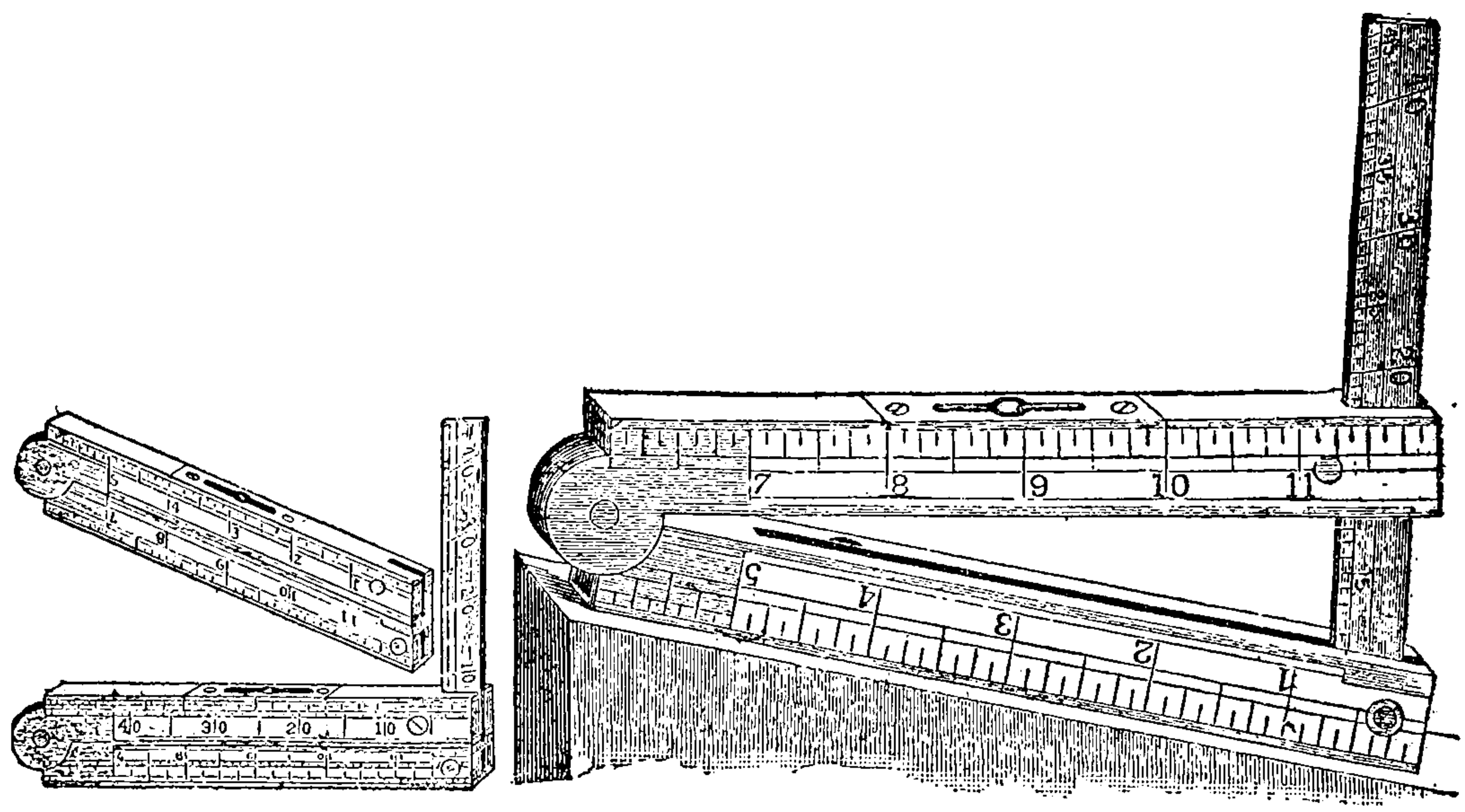


Fig 23. Twelve-inch Single Jointed Rule and Level.

taking dimensions to centers of windows or edges of stone or brick openings. Measurements are given by some architects from frame to glass openings. Sketches or details should be made of typical windows, and variations from the type. Roof pitches may be obtained by a level and measuring the rise per foot, or outside dimensions and total rise may be taken. A convenient instrument for doing this work is a twelve-inch single-jointed rule and level, shown in Fig. 23.

Arches. In measuring arches, the height A, Fig. 24, from the ground to the spring of the arch should be given, the total height B, and the width C. The curve is obtained by giving the length of the radii or by laying a straight edge, D F, against the curve and measuring the distance D E, which will locate one point in the curve. Other points may be taken by offsets from the straight edge.

Projections. Projections are obtained by measuring in from a plumb line. The diameter of columns may be ascertained by means of two parallel straight edges or by dividing the circumference by 3.1416.

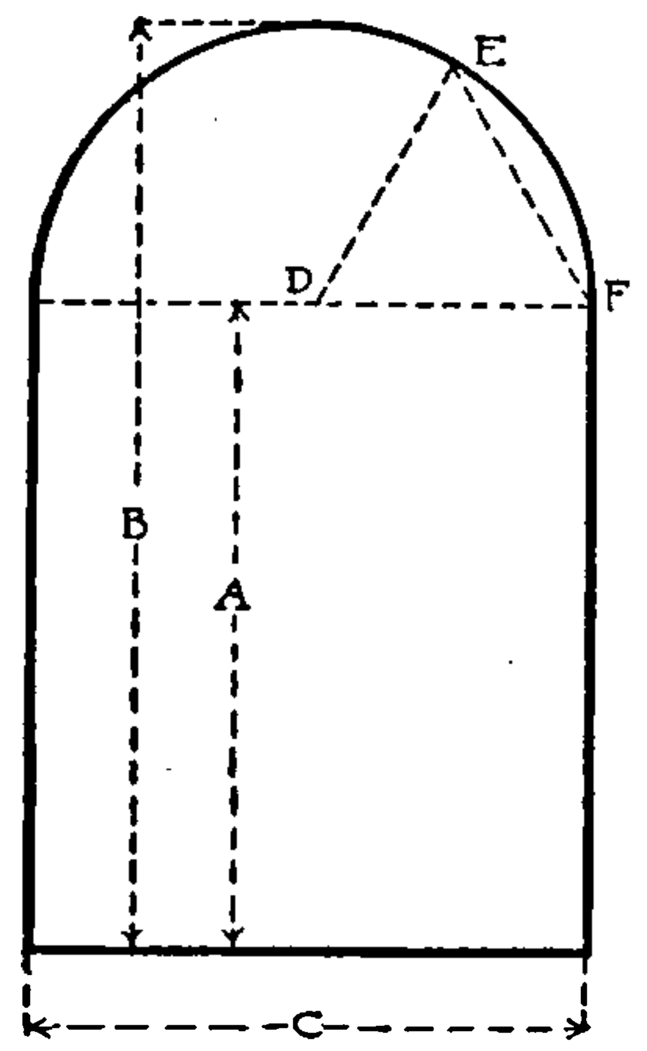


Fig. 24 Measurement of Arches.

Inaccessible Portions. In places where it is impossible to reach the point it is desired to measure there are several ways of obtaining the dimensions with considerable accuracy. A photograph should always be taken of the building measured, and a proportional scale can be made from the known dimensions, which can be used on the photograph for determining unknown dimensions.

Approximations. In brick, stone, clapboarded or shingled buildings the different courses may be counted and the totals figured from those that can be measured. Where rapid memorandum sketches are made distances may be easily obtained by pacing, some men taking nearly a three-foot pace, others walking easily five feet in two steps. In this case every other step is counted as five feet. The total heights may be obtained by measuring up as high as can be reached, then standing at a distance, holding a pencil at this known height, measuring the distance by the eye to the top of the building. Or, a man's height can be taken to gauge the approximate height. The foot rule may be held up at such a distance from the eye that every quarter inch corresponds to a foot on the building, and the dimensions can be read off in this way.

Rubbings. Rubbings may be taken of tablets, lettering and flat ornaments by laying paper on the ornament and rubbing over it with a shoemakers' heel ball. The pattern cut in will be left white and the rest of the surface will be blackened by the heel ball.

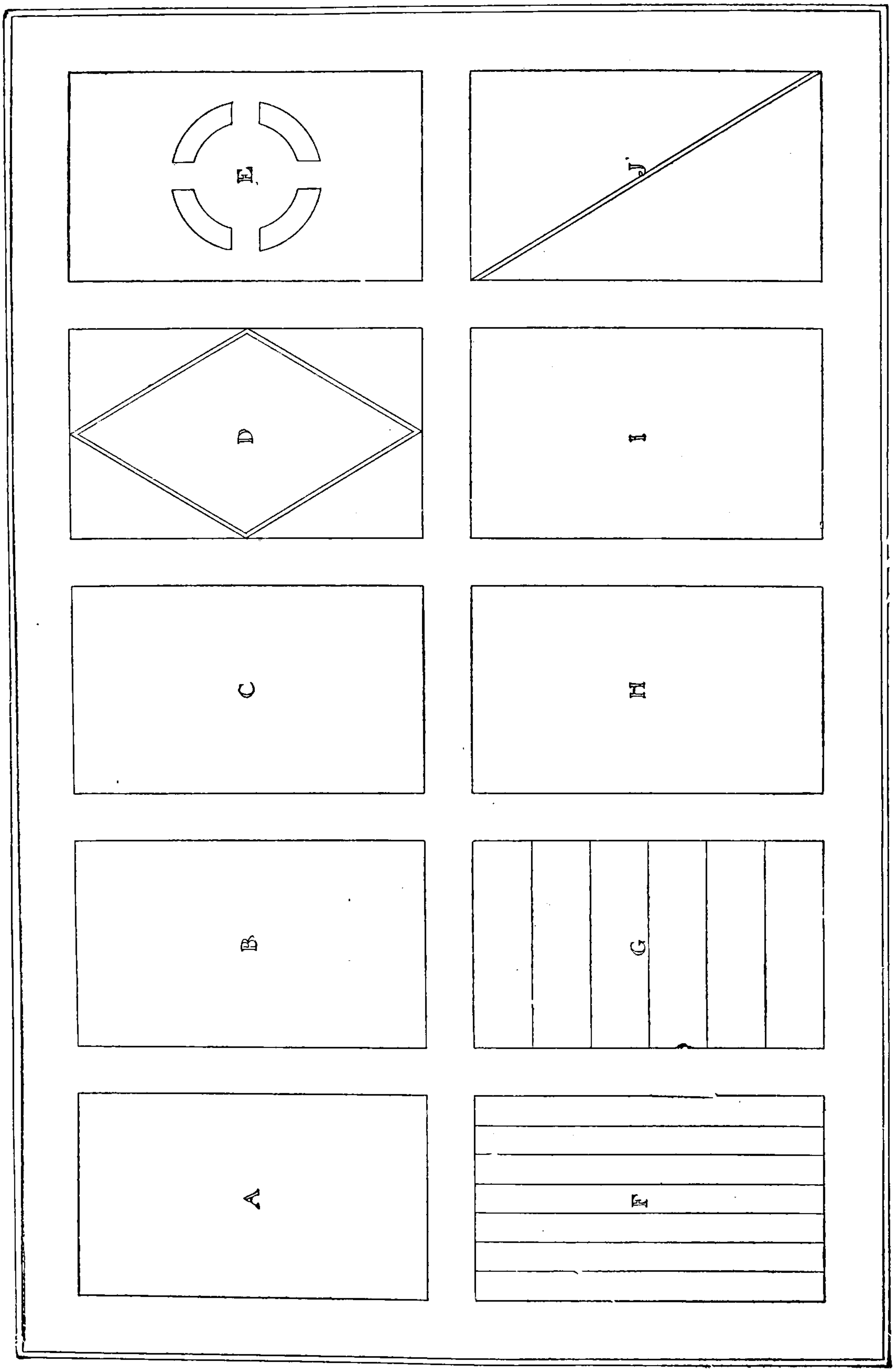


PLATE A

height from finished floor 11 feet 11 inches. Use the short method explained in Fig. 3. (Leave all construction lines.)

12. How is the brilliancy and snap of drawings increased?

13. How are different planes and joint lines indicated in an elevation.

RENDERING IN WASH.

General Remarks. Whatman's cold pressed paper is the best for these examination plates. The Imperial size is 22 in. × 30 in., and one of these sheets will cut into two sheets 15 in. × 22 in., which will be large enough for all of the examination plates. The lines are to be inked with India ink, after which the drawing is to be washed before rendering. The lines must be drawn very neatly and carefully.

Before starting to render, small pencil sketches should be made to study the relations of the lights and shadows and to determine their values. The student will find that with the aid of such pencil sketches, he can render with greater accuracy, and will obtain quicker and better results.

The shadows in plates C to E are indicated by dotted lines. In the finished drawings, these should be shown in *fine light* full pencil lines.

In fastening the paper to the board, care must be taken not to allow the paste to extend more than half an inch back from the edge of the paper.

Be sure to write your name and address legibly on the back of each drawing.

PLATE I.

This plate is to be three times the size of plate A and the different rectangles are to be rendered as follows:

Rectangle A, with a light even wash similar in tone to "High Light" in the value scale:

Rectangle B, with a medium even wash similar to "Middle":

Rectangle C, with a very dark even wash similar in tone to "Dark":

Rectangle D has various compartments which are to be rendered with an even wash having the same tone in each compartment similar to "Low Light":

Rectangle E, with a medium even wash similar to "Middle", leaving the four enclosed spaces "White":

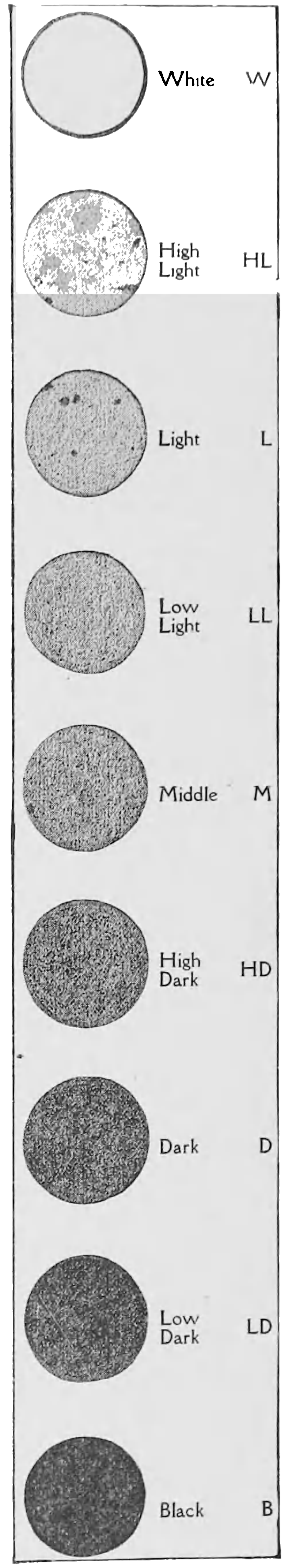
Rectangle F, with alternating dark and medium stripes, the first, third, fifth and seventh stripe to be dark, similar to "High Dark", the others light similar to "Low Light":

Rectangle G has various strips which are to be graded evenly, the top strip being the darkest, the next one a little lighter and so on until the last strip is very light in tone. The successive values of the strips should be "Dark", "High Dark", "Middle", "Low Light", "Light" and "High Light":

Rectangle H, with a graded wash varying from dark at the top to light at the bottom. Care should be taken to have the wash evenly graded. The dark should be similar in value to "High Dark" and the light similar to "Low Light":

Rectangle I, with a graded wash varying from light at the top to dark at the bottom. In rendering this rectangle the board should not be turned around and the wash put on by grading from light to dark, but the board should be left in the same position and the wash graded by the admixture of color instead of water. The light should be similar to "Light" and the dark similar to "Middle":

Rectangle J, with a graded wash varying from dark to light, the spaces between the two halves of the rectangle being left "White". The dark is similar to "Middle" and the light similar to "Light".



VALUE SCALE

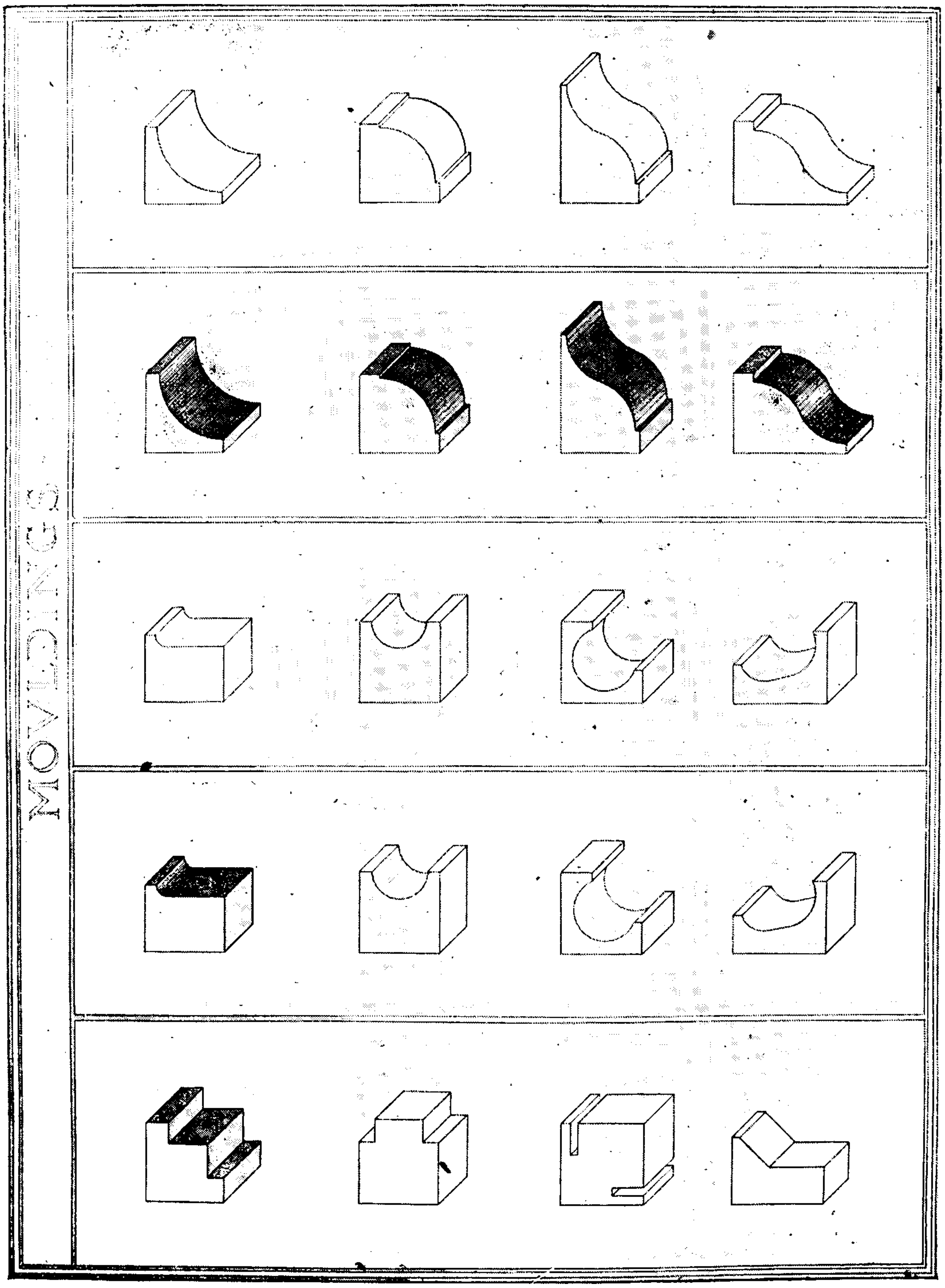
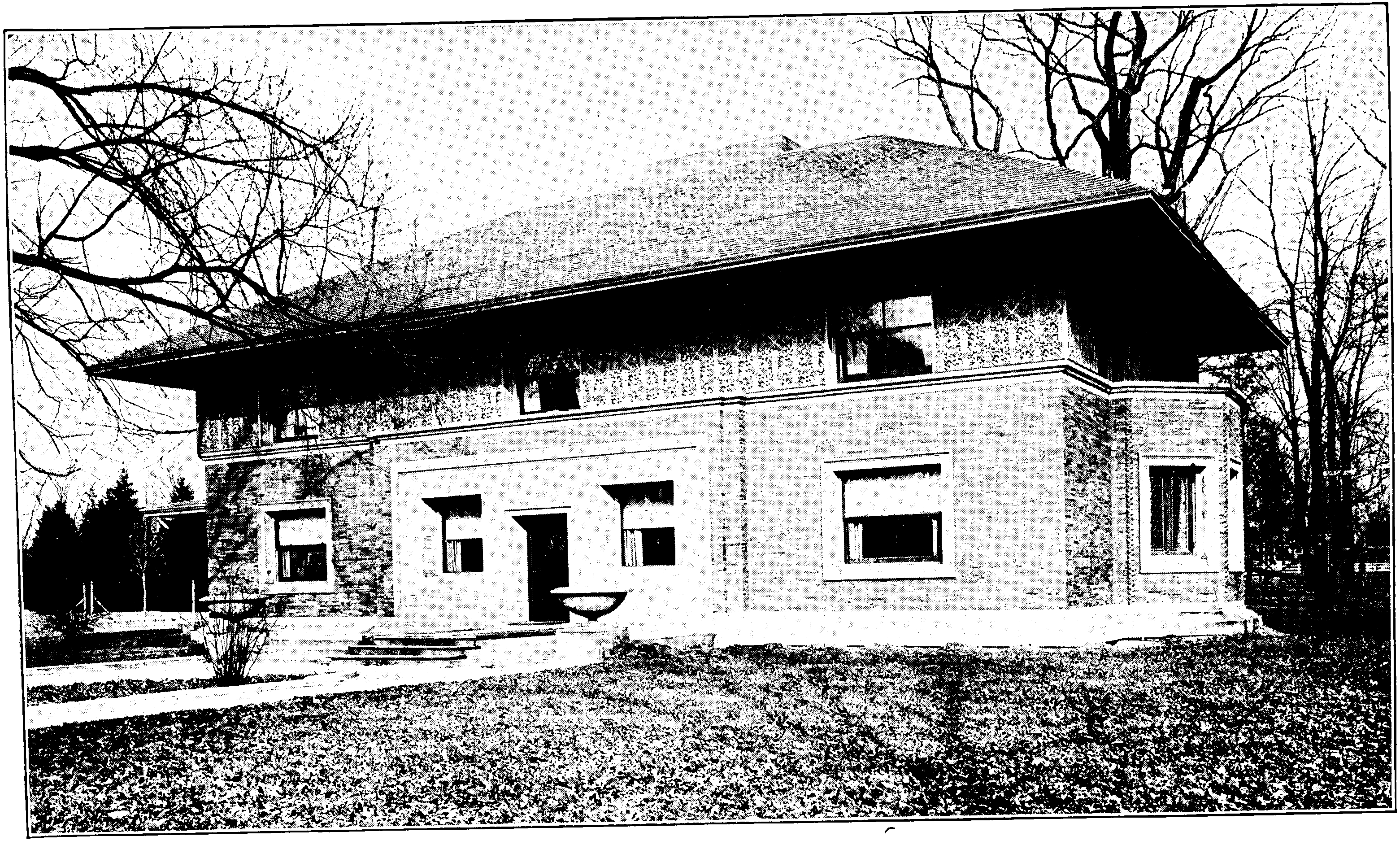


PLATE B

RESIDENCE OF MR. WARREN HICKOX, KANKAKEE, ILL.
Frank Lloyd Wright, Architect, Oak Park, Ill. Built in 1902.



RESIDENCE OF MR. W. H. WINSLOW, RIVER FOREST, ILL.

Frank Lloyd Wright, Architect, Oak Park, Ill.

Lower Story of Orange-Colored Brick, Window and Door Trimmings of Bedford Stone; Upper Story Plaster, with All-Over Decorative Pattern; Roof of Pink Tile. Cost, $25,000. Completed in 1894.

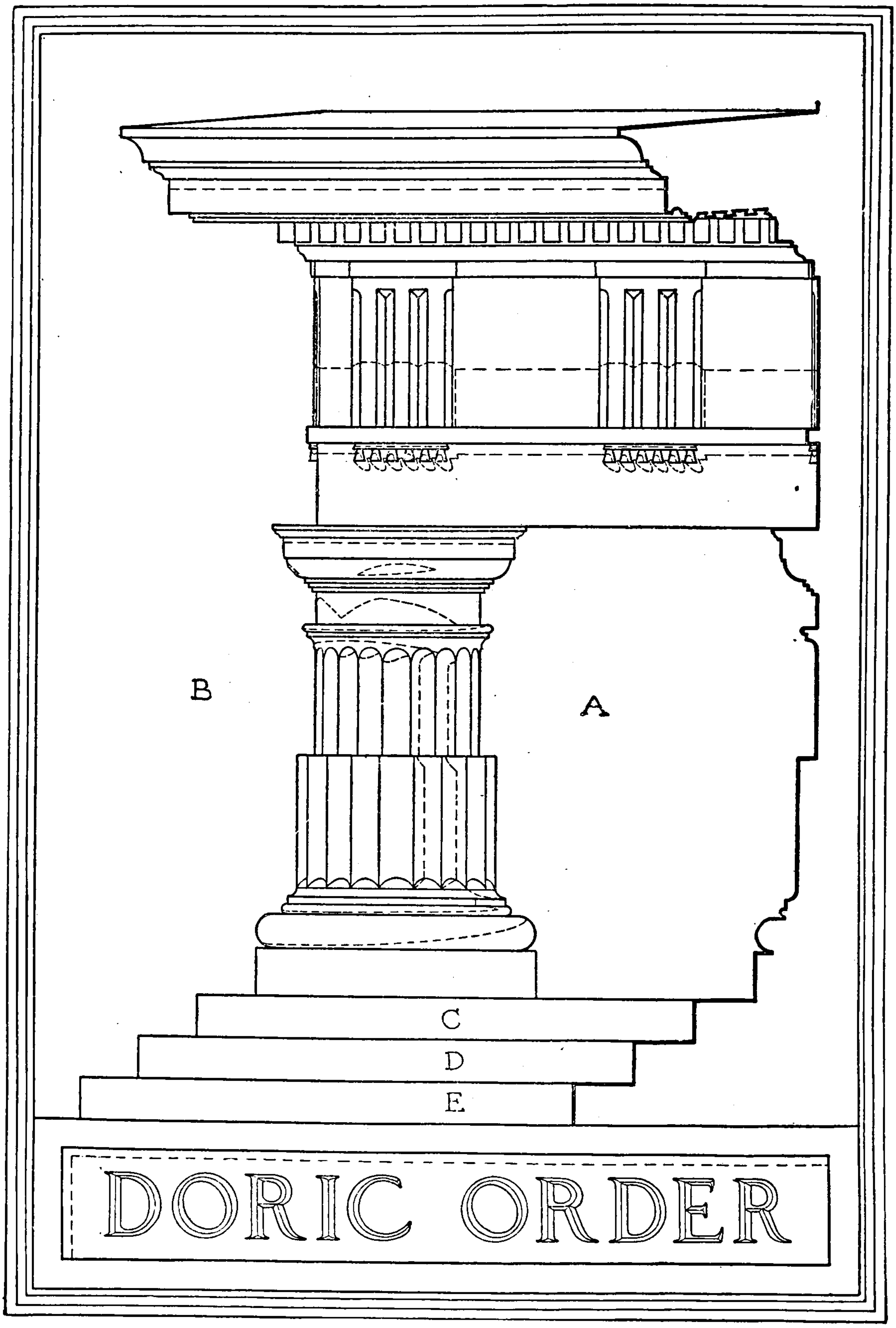


PLATE C

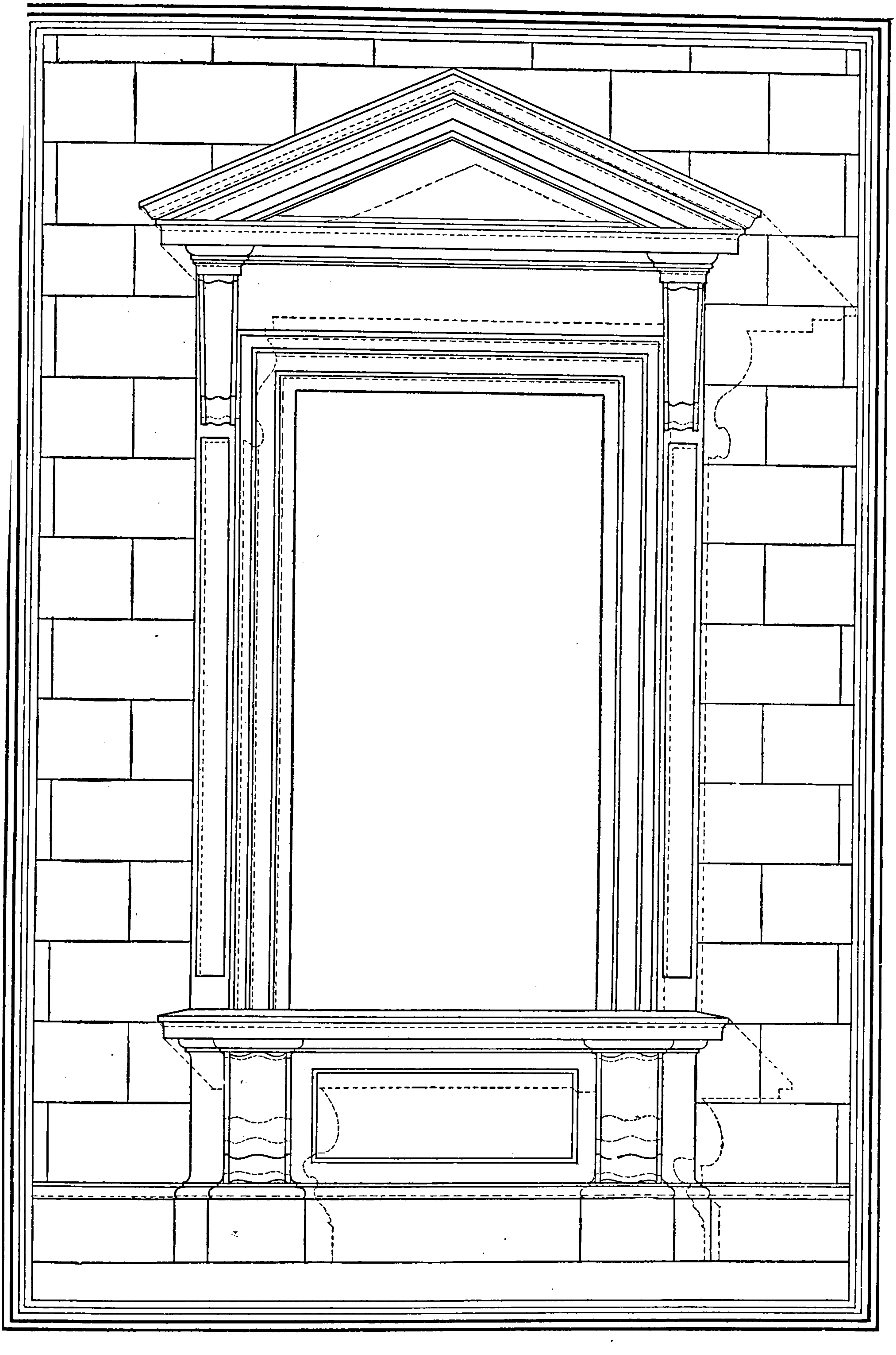


PLATE D

the plate mentioned before. Reflected shadows are to be put in and care should be taken to show the reflected lights in the shade.

PLATE IV.

This plate is to be drawn double the size of plate D. A margin one and one-half inches is to be left as a white border outside the border line. The "Doric Doorway from Roman Temple at Cori", page 27, will serve as a guide for rendering this plate. The window opening is to be rendered with an even dark wash, and the wall surface is to have a light tone. The shadows are indicated by a faint wash and are to be modeled and graded in such a way that they all have proper relative values.

PLATE V.

This plate is to be drawn double the size of plate E, and a margin of an inch and a half of white is to be left outside of the border line. Plate XXXIII, in the Roman Orders, can be used as a guide, the Temple drawn there being of the same size required for this problem. If the flutes on the columns are put in, they should be drawn with watered ink so that they are not too pronounced. The shadows and the parts in shade are shown by a faint flat wash outlined by dotted lines. All the lights and shadows are to be carefully modeled in their proper relations to one another. The wall A_1 and A_2 is on a line with the rear wall of the Temple; hence the portion of the wall, A_2, on the right of the Temple will be in shade, and the portion, A_1, on the left will have a light tone over it to show that it is in the background. For the rendering of the spaces between the columns and the doorway, the plate "Detail from Temple of Mars Vengeur", page 18, will be helpful as well as for the rendering of the steps. The shadows on the steps will be similar in grading to the shadow of the altar on the steps. The bronze candelabra is to be rendered dark, care being taken to leave high lights of "White" on the round surfaces receiving the most direct light. For suggestions for rendering the bronze plate, page 32. In rendering background, the frontispiece, "Fragments from Roman Temple at Cori", will prove helpful.

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14. Draw the plan shown in Fig. 6 at double the present size

Lay it out by axes in the manner described. Study carefully so you may understand *why* axes are used.

15. Draw the capital and entablature shown in Fig. 9 at double size in accordance with the directions.

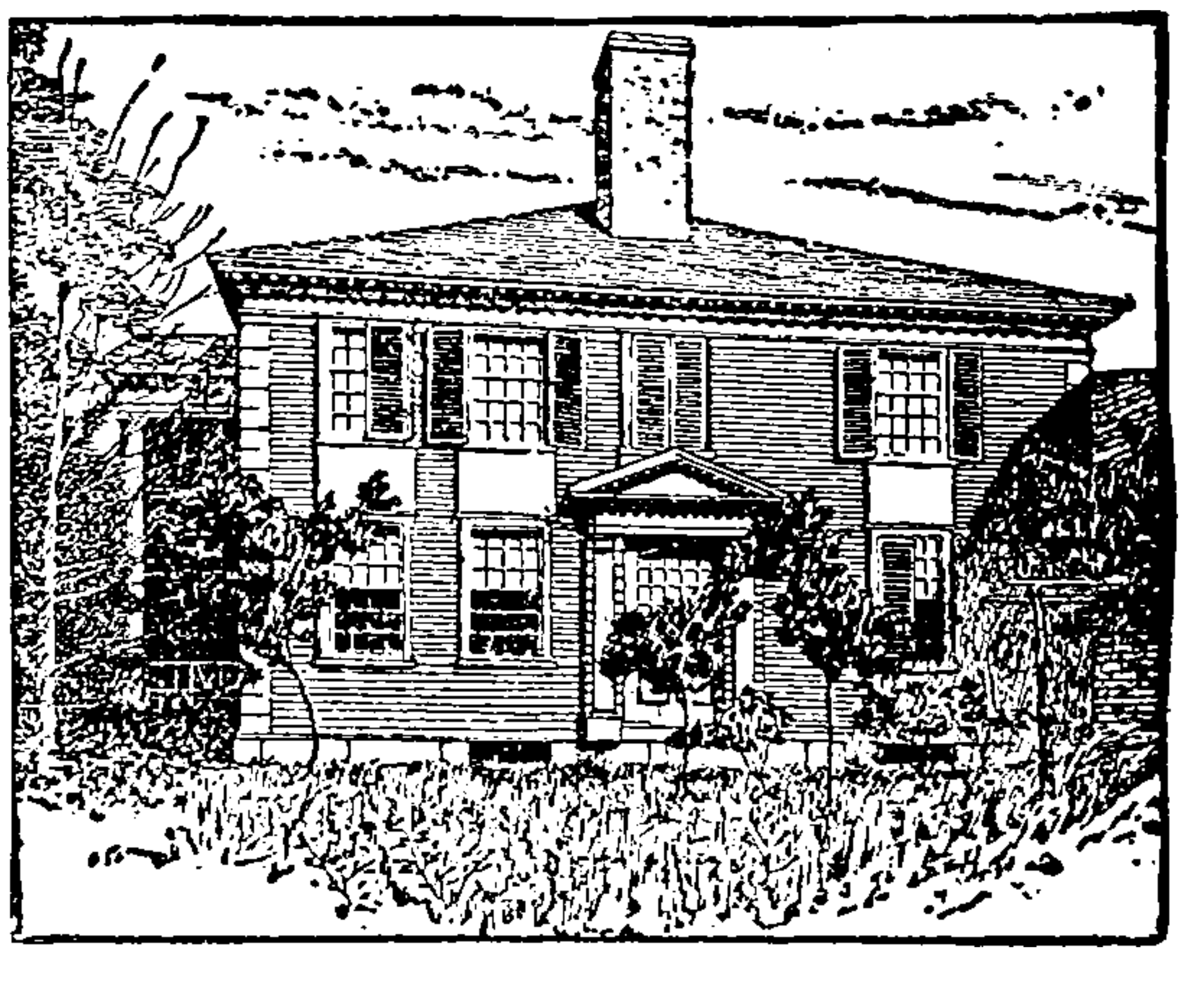
16. Draw the balluster shown in Fig. 10 at double the size by the method of "limiting lines."

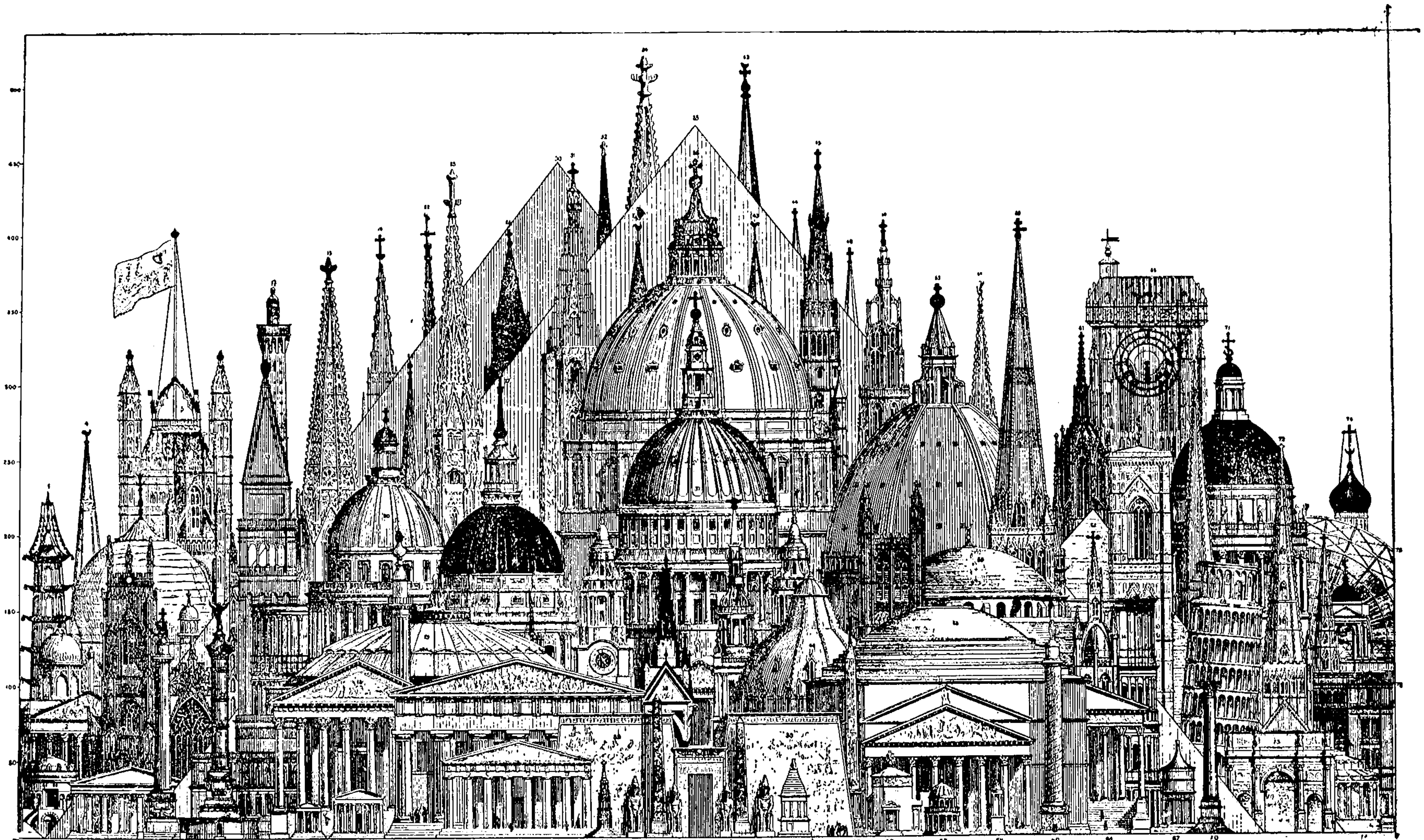
17. What is meant by modelling a drawing; by values?

18. What is the French method of laying washes?

19. What colors will make a good palette? What are the primary colors? What are the secondary colors? What are complementary colors? Show the relations of these colors by a diagram.

20. Draw on cross-section paper in freehand the plan of the first floor of your house as indicated Fig 22, from actual measurements, considering each space equal to 1 foot.





COMPARATIVE HEIGHTS OF SOME OF THE PRINCIPAL BUILDINGS OF THE WORLD

From the Wall Diagram at the South Kensington Museum.

Composition is the art of bringing together various interesting details, so that the whole result will be harmonious and pleasing.

The important features should be on axes, or grouped symmetrically on either side of an imaginary center line. For instance, in a room, if the fire place is to be one of the features, it should be centered on one of the axes of the room. The remaining features should be arranged with relation to the axes or center lines of the room so that as a mass they will balance each other.

In a good composition some single feature should dominate—for example, in a building, the main gable, or a tower, or a long, simple roof line; or in a room, the fireplace or a painting; etc. In decorating a house, the general effect should be pleasing, and should not be too much broken up by spotted details. There must not be too many equally interesting points; otherwise the result is either monotony or competition; one point must dominate. There must not, for example, be other gables competing with the main gable by being too near the size of the main gable. For the same reason it is better to group windows and other features in odd numbers and accent the central one.

It is well to think of the location of the different interesting points. In a cottage—to take an example—the gable that is seen from the best point of view should be near the center of the perspective; or, again, a tower should not be isolated or appear so much at one side from the best point of view that it will look as if disconnected from the house.

The smaller parts of the composition should have a proper relation to the main motive. The dormers, for instance, in a cottage, should be in the same style as the main gable, or in harmony with the style.

Nevertheless, all these different parts must be used so that there will be some contrast, in order to give life and interest to the composition. No detail from a different style, however, should be brought in without the designer being sure that the harmony of the composition is not thereby disturbed. To learn how to compose, it is not sufficient to study books and receive instruction in the school or in the drafting room; the student must supplement this with the study of nature and of objects and buildings themselves.

Scale. The word "scale" has been used to designate a measure of distance—for example, a scale of one-quarter of an inch to a foot.

"Scale" is used also in another sense—that is, to designate the appearance of a building or any artistic composition, which, without considering the actual dimensions, gives us an idea of the size. For example, in the two sketches A and B (Fig. 25) the two vases have the same proportion; but one is a huge decorative vase standing at the side of a fireplace, while the other is a small vase standing on a table.

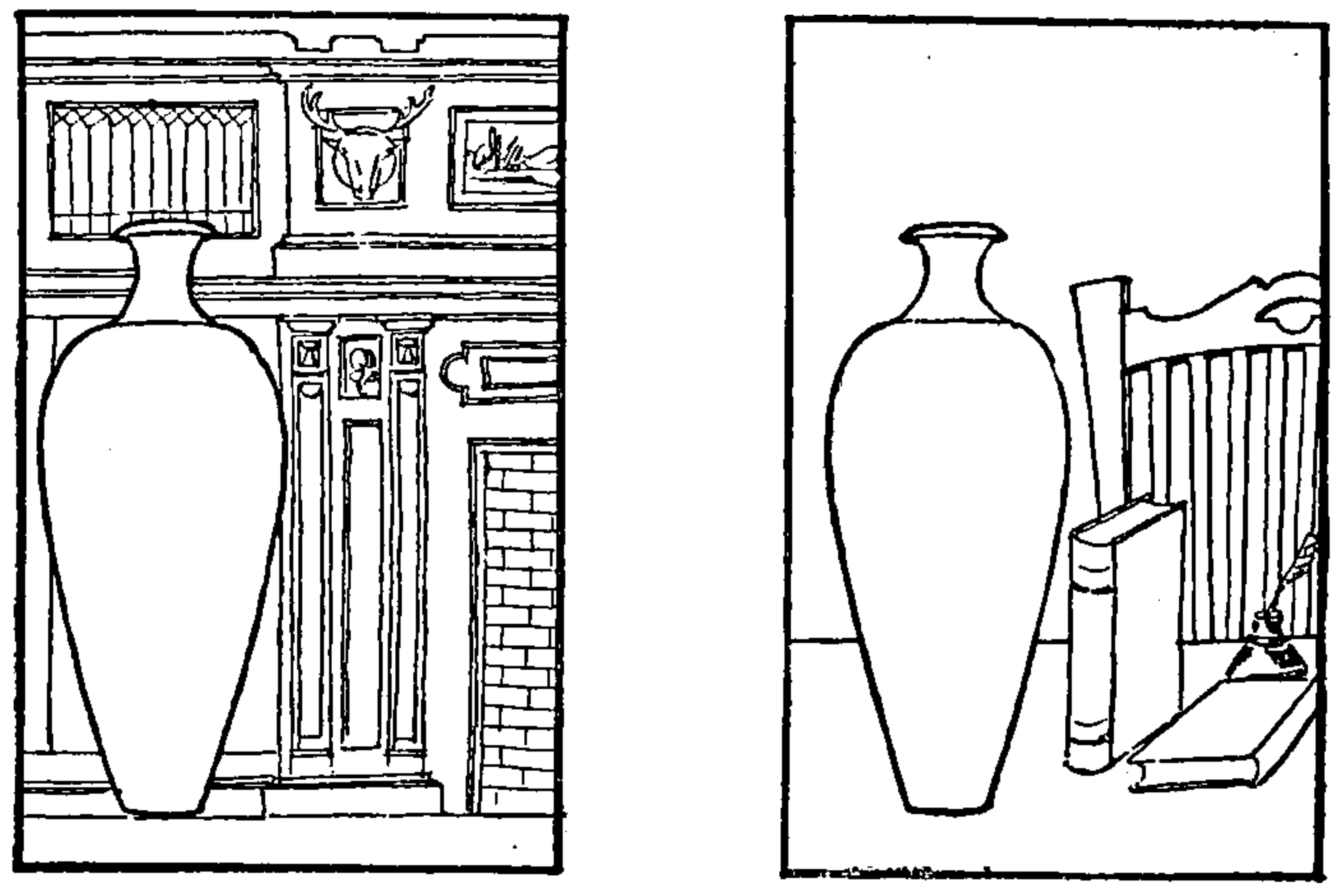


Fig. 25.

It requires the books and other details of well known dimensions to suggest the small scale of the one, and the mantel-piece to suggest the scale of the other. The same principle is seen in doors and windows, in the effect of steps in front of a building, in balustrades, and in all details with which we are familiar in our daily life.

A drawing is "large in scale" when it appears to be drawn at a larger scale than has been really used; for example, a drawing of a building might look as if it were laid out at quarter-inch scale when it was really laid out at one-eighth-inch scale. If such a building were erected, it would be much larger than the drawing would indicate. On the other hand, if it is "small in scale," the details are too small and the building will appear as if it were built for dwarfs.

The materials used in construction affect the scale of a building—such as sizes of brick, stone, clapboards, etc. Arches span larger spaces than lintels; iron construction needs fewer supports than stone construction. The detail should be somewhat larger in scale in the upper part of a building, where it is seen from the ground, from what it is in the lower portion near the observer. Interior detail should be finer and smaller than exterior detail.

Statuary, when called "life-size," is actually made about one-quarter of the height larger than life size. The reason for this is that objects in the open air, or in large spaces, look smaller than they actually are. The size also depends largely on the height from the ground.

If a building does not appear to be in good scale—that is, if the drawing does not suggest the actual size of the building (which may be tested by sketching in a figure of a man, and measuring to see if the house is in scale or not), the detail should be studied to see that it is not too large or too small; other details may be added, such as steps or balustrades; or, if the design is an interior, the walls may be decorated with natural objects in the right scale. Anything that will suggest the height of the human figure may be used, or stone joints and other suggestions of material may be made more evident.

Ornament. Architectural ornament is the decorative treatment of architectural motives on a building. The ornament should be carefully studied on the small-scale designs, and worked up from these to the working drawings.

All ornamentation or decoration should be drawn out on each design, and particularly on the small-scale drawings, even if it is to be carried out by other designers, modelers, or decorators; for it should be remembered that the one man who is to bring together into a single composition all the elements of a design, is the Architect. The decoration, whether sculptured or painted, is executed either from scale details or full-size drawings, by the decorator or sculptor. If any change is made from the main lines of the design, this change should be studied on the small-scale drawings; otherwise it may be found that the detail is entirely out of scale with the general architectural lines.

It should be clearly understood that loading a building, a mantel, a cornice, or any motive with ornament does not make it a work of art. Everything depends on where and how the ornament is applied. Besides, generally, any motive is more artistic if it is perfectly simple.

Criticism. All through the work of design, it is of greatest advantage if criticism can be obtained from other architects and draftsmen; and even the criticism of outsiders, conscientiously made, will frequently suggest valuable improvements in design. Whenever an intelligent criticism is received which suggests a change, it should be a matter of principle with every designer to make a sketch embodying this change, in order to see whether or not the criticism is good.

space, nor arranged in such a way that it will be a draughty part of the house. It should be borne in mind that if open from first floor to roof, the heat will pass up the hallway; for that reason it should be sufficiently closed off from the other rooms. It may be arranged as a comfortable gathering place for the family. Indeed, with the staircase kept properly to one side, and with a large fireplace the hallway may form the central room of the whole house.

Stairways. Some men say that they build a house around a bathroom, because they consider that the most important room in the house. Next in importance is the staircase. The front staircase should be easy and large. A 7 to $7\frac{1}{4}$-inch rise, with 10 to $10\frac{1}{2}$-inch width of tread, is customary, though a $6\frac{1}{2}$-inch rise with an 11-inch tread is easier and looks much better. Staircases, in the better class of house, maybe be as easy as 6-inch rise by 14-inch tread, or even $5\frac{1}{2}$-inch rise with 15-inch tread. In back staircases a 7-inch rise with 9-inch tread is not too steep; and they are frequently found as steep as 8-inch tread. If space allows, the rear staircase should be sufficiently wide to take up trunks and furniture—say $3\frac{1}{2}$ to 4 feet, with wide doors (3 feet 3 inches) opening into it. In this case the stairs should be strongly supported. Staircases may be made fire-resisting by stopping the space between the stringers with brick and by covering the underside or soffit with metal lath.

Proportion of Stair Riser to Tread. A good formula to use in laying out a stairway is as follows: Let R = the rise and T = the tread, then

$$2\,R + T = 25.$$

i. e., twice the height of the riser plus the width of the tread should equal 25 inches.

Living Rooms. The living room, library, parlor, reception room, should all be "livable." The shut-up "best room" is a thing of the past.

Sitting Room. This should have a southerly exposure, so that it will be sunny and cheerful all the time.

The best arrangement for a sitting room is to have the fireplace at one end, the windows at the side, and the entrance at the further corner. The next best arrangement is to have the fireplace on the same side of the room as the entrance, and both on the long side of the room. The most unsatisfactory arrangement is to have the door on the wall opposite the fireplace or close by the fireplace, where there is a constant draft.

The room should express comfort and restfulness. There should be no feeling of over-decoration, and nothing in the room should be so striking as to be the first and only thing to be seen. The great objection to so-called "decoration", is that each decorator or designer thinks only of his own work, consequently making it prominent; and it is extremely difficult to make the decorative elements harmonize.

Dining Room. The dining room should be, as a rule, on the side of the house toward the morning sun. It should be cool in summer and warm in winter, as it is the one room that is necessarily occupied at least three times a day. A westerly outlook is generally disagreeable on account of the low-lying sun for the evening meal.

Butler's Pantry. The butler's pantry should have an outside window, and doors leading into the dining room and kitchen. Sometimes a slide is put in, opening into a small china closet in the dining room. The butler's pantry should be quite large. The story is told, of an architect who dined with his client several times while he was making the sketches; and each time, on his return to his office, he enlarged the butler's pantry, and when the building was erected it was still one of the cramped rooms in the house.

Kitchen. The kitchen should not be placed in too close proximity to the living rooms, and should be on the northwest corner of the house. As a rule, it should be separated from the living parts of the house by at least two doors. This is done, partly on account of the odors from the cooking, and also because of the heat. A basement kitchen is objectionable on this account. The kitchen should be thoroughly ventilated, the windows being set high—as near the ceiling as possible—to let out the hot air, the sill being located above the backs of the tables and sinks. A hood over the range connecting with a ventilating flue, is very useful for ventilating. This ventilating flue will be either a space around the flue from the kitchen range, which will be constantly warm; or it may be a separate, square flue next the smoke flue in the chimney. It is advisable sometimes to put deafening felt over the kitchen, so as to prevent the passage of sound and heat if there are sleeping rooms above.

Refrigerator. The refrigerator should be located so that it will be easily accessible from the outside, for putting in ice; and it should be near the kitchen without being too near the range. The refrigerator drip should never connect directly with the sewer but should have a separate pipe leading to a dry well outside the building. The simplest and cleanest way to trap this is as follows: Build a galvanized-iron pan large enough to rest on the floor under the drip-pipe of the refrigerator; and carry lead pipe from this down into the cellar, ending in an ordinary milk jar which stands in another galvanized-iron drip-pan connecting with the dry well.

Storeroom. The storeroom may be made rat-proof by plastering on metal instead of wooden lath, and by plastering the ceiling underneath with the same lathing, taking the precaution to cover all openings.

Bathroom. The bathroom may have tile floor and walls, or, for ordinary work, a Georgia pine floor, with North Carolina pine sheathing four feet above the floor. A sanitary base—that is, one rounded to avoid a corner between the wall and the floor, such as is used in hospitals and in many schoolhouses, may be used. Waterproof paper should be put in between the upper and the under floor in the bathroom, being connected by lead flashing with the outside of the building. This will prevent damage in the case of an unexpected overflow.

Lavatory. A lavatory on the first floor is very convenient. This may open from the hall or be connected with a coat closet. It should have a window.

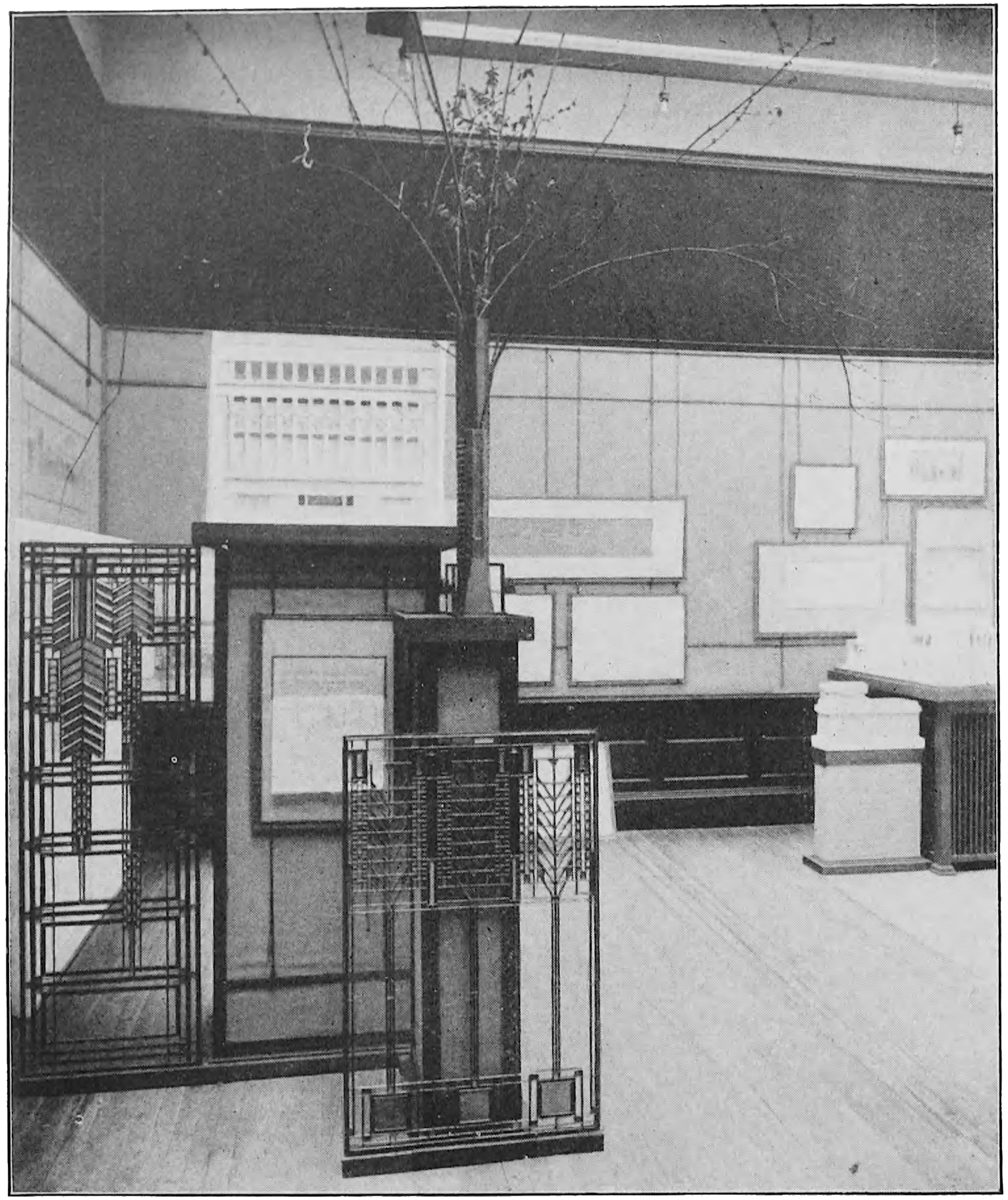
Closets. The closet doors should open in such a way that the light from the window shines into the closet.

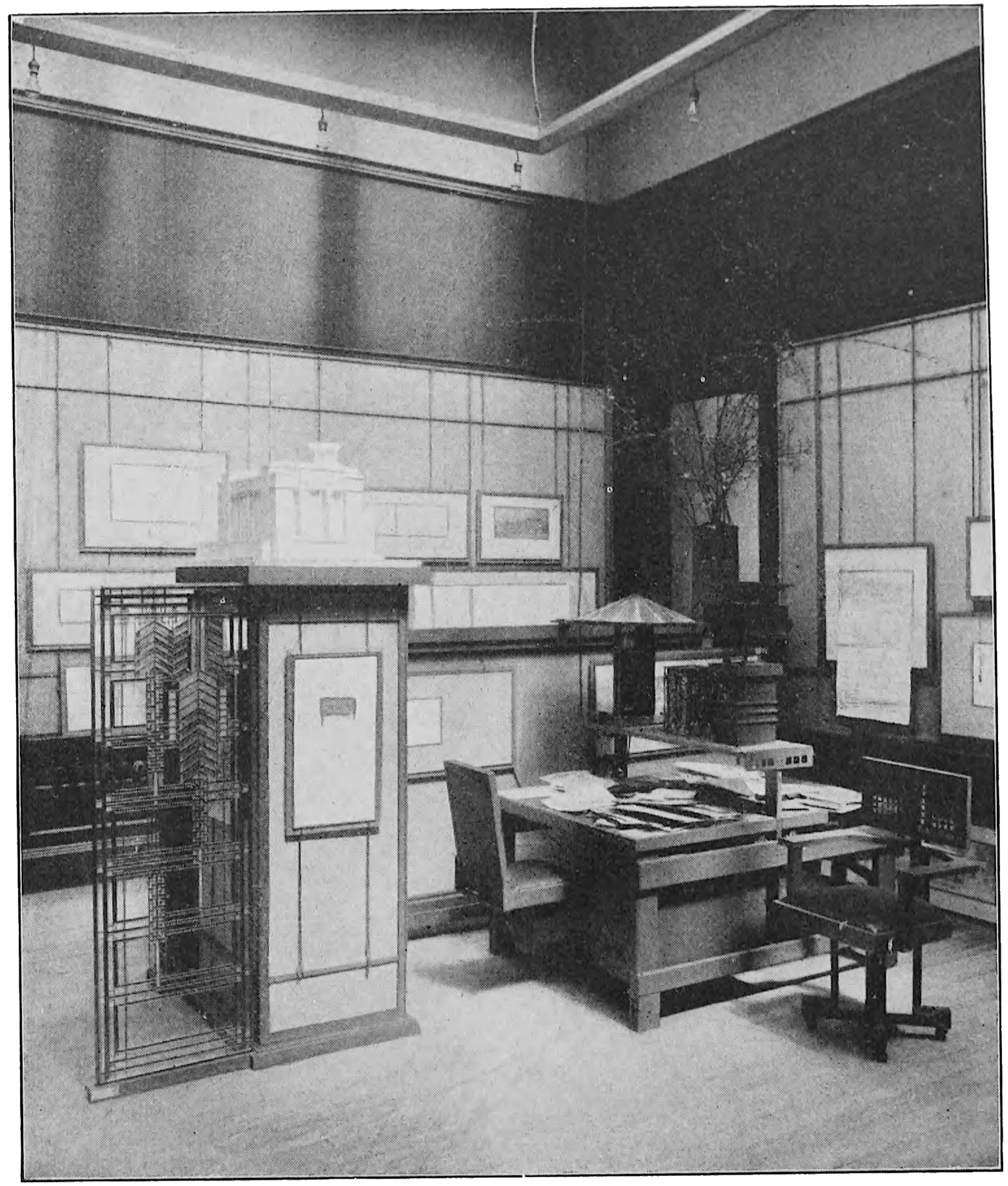
On the sleeping-room floor, a housemaid's closet may be provided—if possible with an outside window. This closet should contain a galvanized -iron or enameled-iron sink, provided with a flushing tank as well as with hot and cold water faucets.

The linen closet should preferably have no drawers, as they furnish hiding places for mice. Shelves will answer every purpose.

Bicycle and dark rooms, play room, sewing room, billiard room, music room, den, conservatory, etc., should also be considered.

Cellar. The cellar should be well drained, if possible, with a drain-pipe separate from the soil-pipe. There should be a blind drain under the wall, and the wall should be damp-proofed in damp locations, by the use of layers of slate stone extending through the wall at the surface of the ground, or layers of well-tarred paper at this point.





CHICAGO ARCHITECTURAL CLUB EXHIBITION, SPRING OF 1907.

Exhibit of Frank Lloyd Wright, Architect, Oak Park, Ill.

Waterproof cellars are made by putting down several layers of tarred paper well mopped with hot tar or asphalt, on which the concrete cellar floor is laid. As a rule, however, it is best to have the cellar connected either with the soil-pipe or with the blind drain, and to have all the concreting put in so that it will slope to one point, where will be placed a trap with grating.

VARIOUS STAGES IN BUILDING A HOUSE

The point where the majority of people, who know nothing about architecture, come in contact with the architect, is when they make up their minds to build houses of their own.

To develop this point more clearly, let us consider the situation that arises when a business man wishes to build.

The problem, as it comes to most men, is a question of number of rooms needed, amount of money available, and proposed location of house.

Let us say that Mr. Smith, after lookng at various lots and making as many inquiries as possible through friends and acquaintances, and having also gone to some real estate agent who deals largely in land in such locations as he considers desirable, has obtained an option on, or possibly has purchased, a lot, the price being, say, $800. He has available $2,000, besides the money he has set aside for furnishing the house and paying the architect's fee. He is willing to give a mortgage on the house for, say, $3,000. Taking $4,600 as the value of his proposed house would leave him a margin of $400. Accordingly, he goes to an architect who, he he thinks, will plan his house satisfactorily, and tells him the circumstances, the requirements, and the amount of money available. A visit is made to the lot, to get the points of view, etc., and preliminary sketches are made.

Sketches. From the architect's point of view, the sketch period is vital in respect to the success or failure of the house. It is at this time that he becomes acquainted with the owner's ideas and does his best to interpret them properly so that there will be no criticism or feeling of disappointment on the part of the owner—in other words, so that the house will harmonize completely with its owner's habits and tastes.

Every man has certain hobbies and independent wishes in regard to his house; these the architect should study and give the proper expression.

In regard to the practical use of the house, every member of the family, should be thought of and consulted. The architect should obtain a careful outline of the requirements from the owner, going over the number of rooms, size of rooms, comparing them with rooms already known to the owner, heights of stories, location and exposure of rooms, for the view, etc.

After sufficient data have been procured to make a complete schedule, several different plans of the proposed house may be sketched out at a small scale. Co-ordinate or section paper is very useful in sketching out different schemes. As a general rule, it is better for the architect to work out with great care some one plan which he considers the most satisfactory. In dealing with some clients, it is sometimes better to show this plan only; in the case of other clients, it is better to show them all the studies and consult with them about details that would be merely wearisome to other men The sketches are generally laid out to the scale of one-eighth inch to the foot, though small "thumb-nail" sketches are frequently made at no scale, or sometimes several different schemes at a scale of one-sixteenth inch to the foot. Memoranda should be kept of all conversations with the client, for use in completing plans and in writing specifications.

Working Drawings. After the sketches are approved, the working drawings can be started. They are sometimes called "contract drawings," meaning the scale drawings accompanying the specifications and contract, though contract drawings really include the details, which are not generally made at the time the contract is signed. The character of these drawings has changed very much, even in the last few years, an astonishing amount of detail being put into the working drawings, while the architectural drawings of the English and Italian Renaissance show that the old masters must have studied much of their detail while the building was being erected. The main purpose of the working drawings is to give complete information of the building to be erected, as far as size and form can be expressed in projection, quality and general description being left to the specification. It is of considerable importance to put on a single drawing as much as

Besides the contract drawings and subsequent detail drawings, other drawings are frequently called for, for which allowances have been made in the contract, as for furniture, special finish, etc.

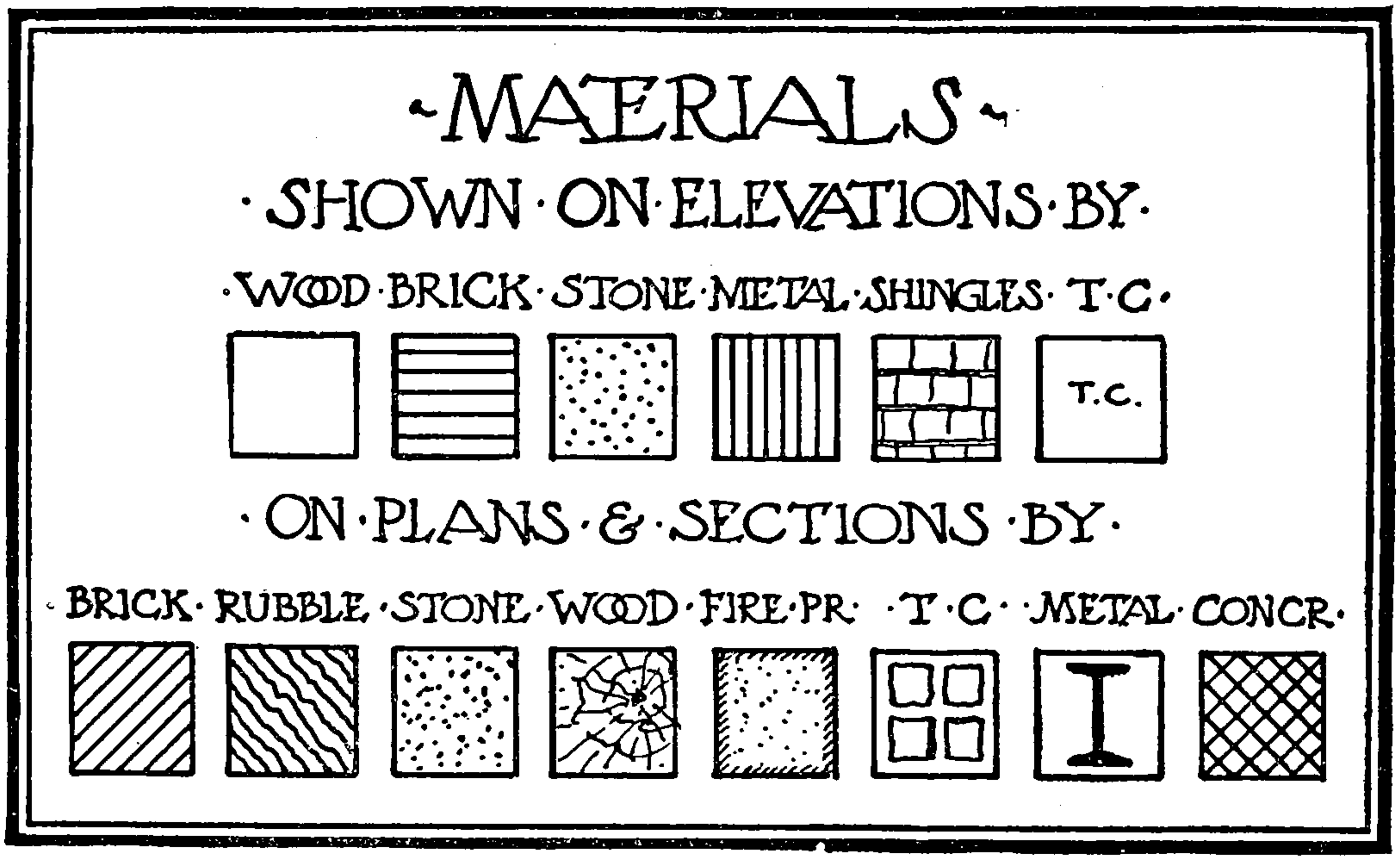


Fig. 26.

Representation of Materials. This may be either by blacking in, hatching, etc., or by use of colors. The former method (Fig. 26) is convenient for tracings to be blue-printed, as it saves coloring the prints.

On elevations, materials are shown as follows:

Wood	white.
Brick	horizontal lines.
Stone	dotted.
Metal	vertical lines.
Shingles	sketched to scale.
Terra-cotta, etc.	abbreviations marked "T.C.", etc.

On plans and sections:

Brick	diagonal hatching, ruled lines.
Rubble	diagonal hatching, wavy lines.
Stone	dotted.
Wood	grain indicated, or black if small-scale.
Fireproofing	hatched margin, dotted surface.
Terra-cotta	divisions to suggest material.
Metal	steel sections suggested.
Concrete	cross-hatched.
Old work	white.

If colors are preferred, the following may be used:

Brass and copper........yellow.
Brick...................light red.
Concrete............... Payne's grey, mottled.
Glass..... ....new blue.
Glass in elevations ... a graded wash of India ink, indigo, new blue with a little carmine.
Old work............. grey or black.
Plaster.................Payne's grey.
Sections......... ......construction not determined, pink with red border line.
Shadow in elevation. ..India ink with indigo or gallstone.
Slate...................indigo.
Steel and iron... ....Prussian blue.
Stone .... raw umber or new blue, or Payne's grey
Terra-cotta .... .burnt umber.
Tiling............ .....light red with yellow.
Wood... ... . yellow ochre.

Coloring may be carried further, following this scheme, always placing guide-squares in one corner of the drawing with the names of the materials represented.

Tracing and Blue-Printing. Drawings of which several copies are needed, may be traced on transparent paper or linen, or laid out directly on these materials. Thin bond paper is often used. Prints may be taken from these, either blue or brown prints, giving white lines on a blue or brown ground, or by first taking negatives, dark lines on a white ground.

Notes should be kept for the specifications while drawings are being made.

Letting the Contract. When the working drawings and specifications are finished, owner and architect decide on three or four builders, any one of whom would be satisfactory, who are asked to submit estimates. The builders are allowed time enough to go over the plans and specifications carefully so that they may know the actual value of the work; and bids are sent in to the architect's office to be opened on a certain day, when the owner meets the successful bidder and a contract is signed for building the house.

In France there is generally a separate contractor for each kind of work; in England a general contractor makes up his bid from quantities given him by a quantity-surveyor; in America usually the subbids are given to a general contractor who takes the responsibility for the whole work.

The work generally starts immediately on the signing of the contract, and is carried on continuously, with visits from the owner and from the architect, payments being made at regular intervals or on completion of certain parts of the work.

During the progress of building, the owner and architect select fixtures, wall papers, etc.

BUILDINGS FOR OFFICES

The plan must be laid out so as to obtain the largest possible amount of space available; it must be made with reference to the constructive requirements.

Arrange the offices so as to take advantage of surroundings and light. A good outlook makes an office more desirable.

Staircases, elevators, piers, etc., should be arranged so that the actual renting space will be an open loft, where offices and windows can be divided up easily to suit different tenants, and can be easily changed.

Make the street entrance and corridors so that the offices can be easily reached and doors and signs easily seen. The corridors should not be less than 3 feet 8 inches wide; as a general rule, they should be 4 feet to 8 feet wide, depending upon the use, the number of offices and the size of the building.

Arrange janitor's and superintendent's offices, telephone, telegraph, news booths, and elevators so that the tenants and public may be quickly accommodated.

As a rule, unless there are two frequently used entrances, the elevators should be placed so that they can all be seen by a person entering the building.

A car 5 feet 3 inches by 6 feet, with a door on the long side and the rest of the side removable, is convenient for handling ordinary office furniture. One elevator in the building should be as large as this. Other elevators may be smaller.

If a building is more than 6 stories high, it is advisable to have one or more elevators express to the 6th story. The doors at the lowest floor, where the largest number of passengers pass in and out, and where there is generally a "starter" to see that the cars are not overcrowded, may be arranged so that the whole side of the car will open, allowing all the passengers in the elevator to pass out at once.

Figs. 28 to 49 show complete working plans of a house fulfilling these conditions—a three-storied frame residence, such as is frequently constructed in our suburban country towns and smaller cities. The drawings include the basement, first floor, second floor, attic, and roof plans, front elevation, and one side elevation, corresponding framing plans, and details of different parts of the house. Details are not always included in the contract drawings, but are made as the work progresses. The rear elevation and one side elevation have been omitted, as they are of the same character as those shown. These plans are usually drawn at the scale of one-quarter inch to the foot; in the illustrations, they are reduced.

Plans. On commencing the quarter-scale, the principal dimensions should be given in feet and inches, not in fractions of an inch, to the outside line of the sill. The main contour lines should be marked first, and then the wall should be shown on the first floor, six inches thick. The sill line is shown on Fig. 29, one inch inside of the outer wall line, and is merely drawn in a little way at the corner of the building. In drawing out the plans in pencil, the lines may be run straight through, taking no notice of openings. The lines that run over can easily be erased later. In commencing to lay out the plan, it is well to draw the center lines or axes first, as all the symmetrical points of the building will be laid out from these axes. Doors and windows either center on an axis, or, as a rule, are equidistant. The bay windows and chimneys are also located if possible on the axis lines. The door and window openings in the exterior walls are not located in plan until the elevations are laid out. When this is done, the sizes of window designed on the elevation can be transferred to the plan. As mentioned previously, in working over the plans, notes should be made for the specifications and marked on the plans; for example—*g. p.* (glass panel); *c. w.* (casement window); *t. l.* (top light or transom light).

Elevations. In laying out the front elevation, the center line should be sketched in sharply, in pencil; and the location of the sill line should be marked at the right and left of this center line. Then the outside finished building line should be drawn one inch outside the sill line, this being the outside of the boarding.

Useful Memoranda. In laying out plans at one-quarter of an inch to the foot, the beginner is often puzzled to know the simplest way

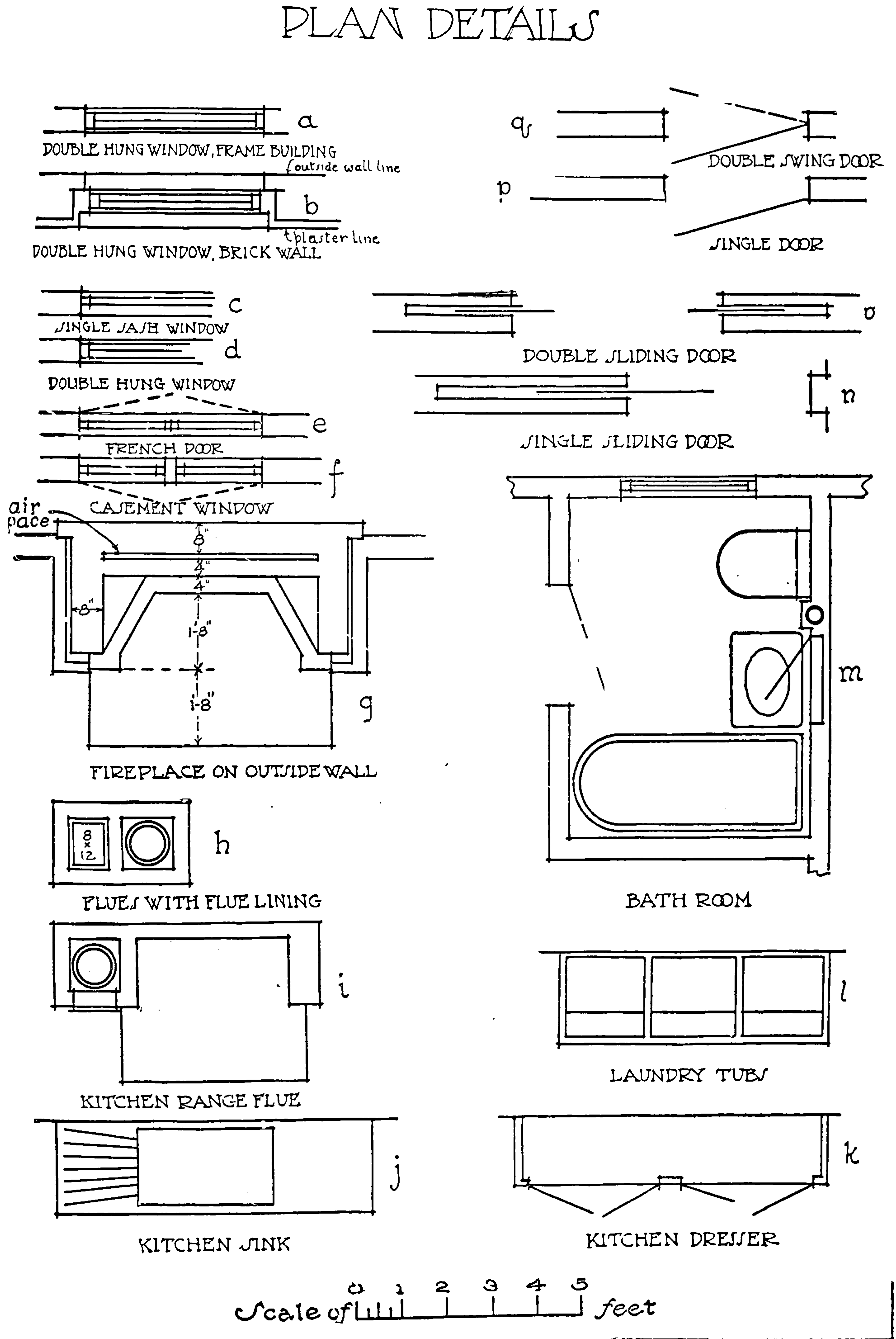

PLAN DETAILS
a
DOUBLE HUNG WINDOW, FRAME BUILDING
outside wall line
b
plaster line
DOUBLE HUNG WINDOW, BRICK WALL
q
p
DOUBLE SWING DOOR
SINGLE DOOR
c
SINGLE SASH WINDOW
d
DOUBLE HUNG WINDOW
e
FRENCH DOOR
f
CASEMENT WINDOW
DOUBLE SLIDING DOOR
o
n
SINGLE SLIDING DOOR
air space
8"
4"
4"
8"
1'-8"
1'-8"
g
FIREPLACE ON OUTSIDE WALL
m
BATH ROOM
8 x 12
h
FLUES WITH FLUE LINING
i
KITCHEN RANGE FLUE
l
LAUNDRY TUBS
j
KITCHEN SINK
k
KITCHEN DRESSER
Scale of 0 1 2 3 4 5 feet

Fig. 27.

to show ordinary constructive forms; and in tracing plans, which a beginner is likely to be called upon to do, if the original is not very distinct, he will find it useful to have some guide for convenient reference—as, for example, that shown in Fig. 27. The lines in the drawing (*a*) of double-hung windows can all be laid to scale, though very simply expressed. The sill is shown, both outside and inside; and also the sash opening and glass opening. In a brick building, the brickwork and wood furring are shown (*b*). The distinction between single-sash (*c*) and double-hung windows (*d*) will be found convenient. The distinction between a casement window (*f*) and a French window (*e*) is not shown in plan, as the difference lies principally in the fact that the French window is carried to the floor. The casement window, on the other hand, is, in general, slightly different in having a mullion in the center for each sash to strike on. The French window is shown opening out, and the casement window opening in; but these could be made to open either way, and the casement window could be built singly, or in pairs, or in series.

In placing a fireplace (*g*) on the outside wall, an air space should always be left to prevent unnecessary cooling of the fines. The finished brick fireplace should be distinguished from the rough chimney; and, where necessary, flue linings should be shown. A space should be shown separating the furring from the brickwork at least one inch, as prescribed in all good building laws. This applies also to fireplaces on inside walls. The hearth is shown, either the width of the finished fireplace, or sometimes the width of the chimney-breast, and projecting 16, 18, 20 inches, or more into the room.

If the kitchen range is to be brick-set, a similar hearth and chimney-breast must be built (*i*); and in all cases it is advisable to have the kitchen duct circular (*h*), set in a rectangular flue which it keeps warm and which is available for ventilating the kitchen through a register set near the kitchen ceiling. The kitchen sink (*j*) should always be shown with drip-board. A kitchen or pantry dresser (*k*) should be shown with doors opening out—not sliding, unless the space is very limited. Laundry tubs (*l*) should be shown as indicated in the drawing. A bath-tub is indicated as shown (*m*), and other toilet fixtures are indicated similarly. Single (*n*) and double (*o*) sliding doors (inside), single doors (*p*) and double swing doors (*q*) are indicated as shown.

Basement Plan. Fig. 28 shows the basement plan of the residence. Dimensions are all given to the outside of the underpinning rubble wall, which in this case is 2 inches outside the sill line, as shown in the half-inch scale section. The footings of piazza piers at the front of the house are shown dotted. On the left side of the piazza is lattice-work covering the opening into the cold-air box for the furnace. The underpinning is of stone 20 inches thick; and the piazza piers are 12 inches square, built of bricks. The posts holding the girders are usually made of iron, three-quarter-inch metal, three and one-half inches in diameter. Sometimes these posts are made of iron about one-quarter inch thick, filled with concrete, the cost being about the same as that of brick piers, with the advantage of taking up less space than the latter in the cellar. The footings of the chimneys are not shown; the ash-pit under the chimney has an iron door for cleaning; and the coal-bins are made with slides, and located conveniently near the furnace and not too far from the kitchen stairs, with the partition so placed that coal can be thrown from the window into either bin. A storeroom is built with shelves, convenient to the cellar stairs. A laundry, with set tubs, is placed in the best lighted part of the cellar. A very desirable item frequently overlooked in planning, is to allow a space at the right-hand end of the laundry tubs for the clothes-basket. The laundry should also have a chimney near the laundry stove. There are also a basement toilet-room and an outside hatchway or rollway. The windows, as a rule, should be located under the windows in the upper story; and as the basement plan is frequently used on the work separately from the other plans, all dimensions should be given, so that no reference to the other plans will be necessary. The window openings may be figured to centers, but they are sometimes figured to the brick or stone opening. The heater, or hot-air furnace, is placed near the center of the cellar. The cold-air box should be arranged so as to take air from the side least affected by the changing winds (south or east). In the case here illustrated, it has been located under the front porch.

First-Floor Plan. This, the most important of all the working drawings (Fig. 29), shows at a glance the main proportions and dimensions of the whole building, besides being the plan of what, in our American manner of living, is the principal story of the house.

This house would be located to the best advantage on a lot facing

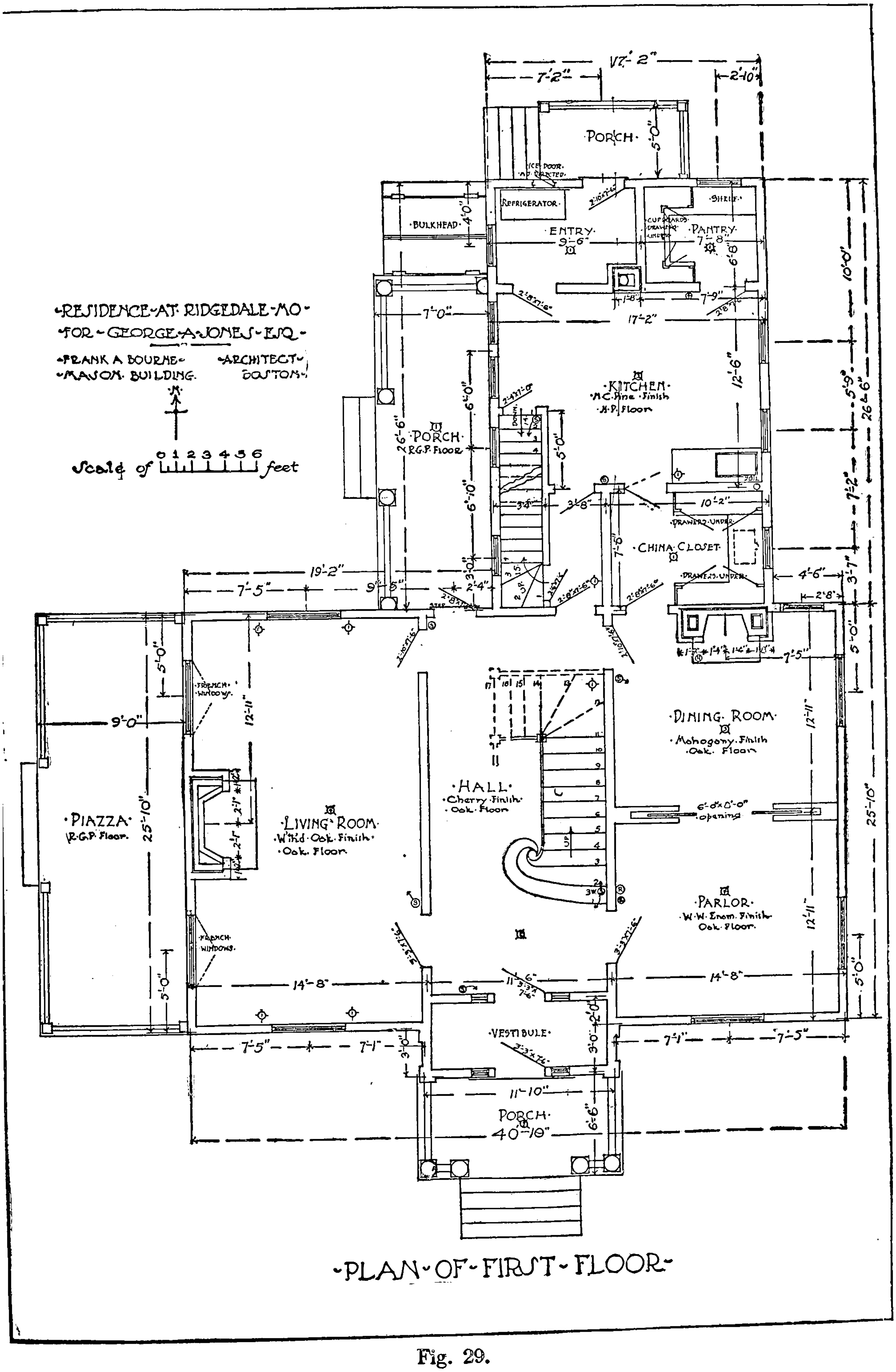

RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A BOURNE ARCHITECT
MASON BUILDING BOSTON
Scale of 0 1 2 3 4 5 6 feet
PORCH
REFRIGERATOR
ENTRY
PANTRY
SHELF
BULKHEAD
KITCHEN
N.C. Pine Finish
H.P. Floor
PORCH
R.G.P. FLOOR
CHINA CLOSET
DRAWERS UNDER
PIAZZA
R.G.P. Floor
FRENCH WINDOWS
LIVING ROOM
W'th'd Oak Finish
Oak Floor
HALL
Cherry Finish
Oak Floor
DINING ROOM
Mahogany Finish
Oak Floor
6'-0"x8'-0" opening
PARLOR
W.W. Enam. Finish
Oak Floor
VESTIBULE
PORCH
40'-10"
PLAN OF FIRST FLOOR

Fig. 29.

the south or southeast. This would put the kitchen on the north, the dining room on the east (which would give it the desirable mornng sun), and the parlor on the south and west.

The front porch sheltering the front doorway, and the vestibule and second door, form a protection necessary in cold northern climates. The hall and staircase in the center of the house open into the principal rooms. The living room on the left, 14 by 25 feet, opens by French windows on the piazza. The parlor to the right connects by sliding doors with the dining room. The living room and dining room both have open fireplaces.

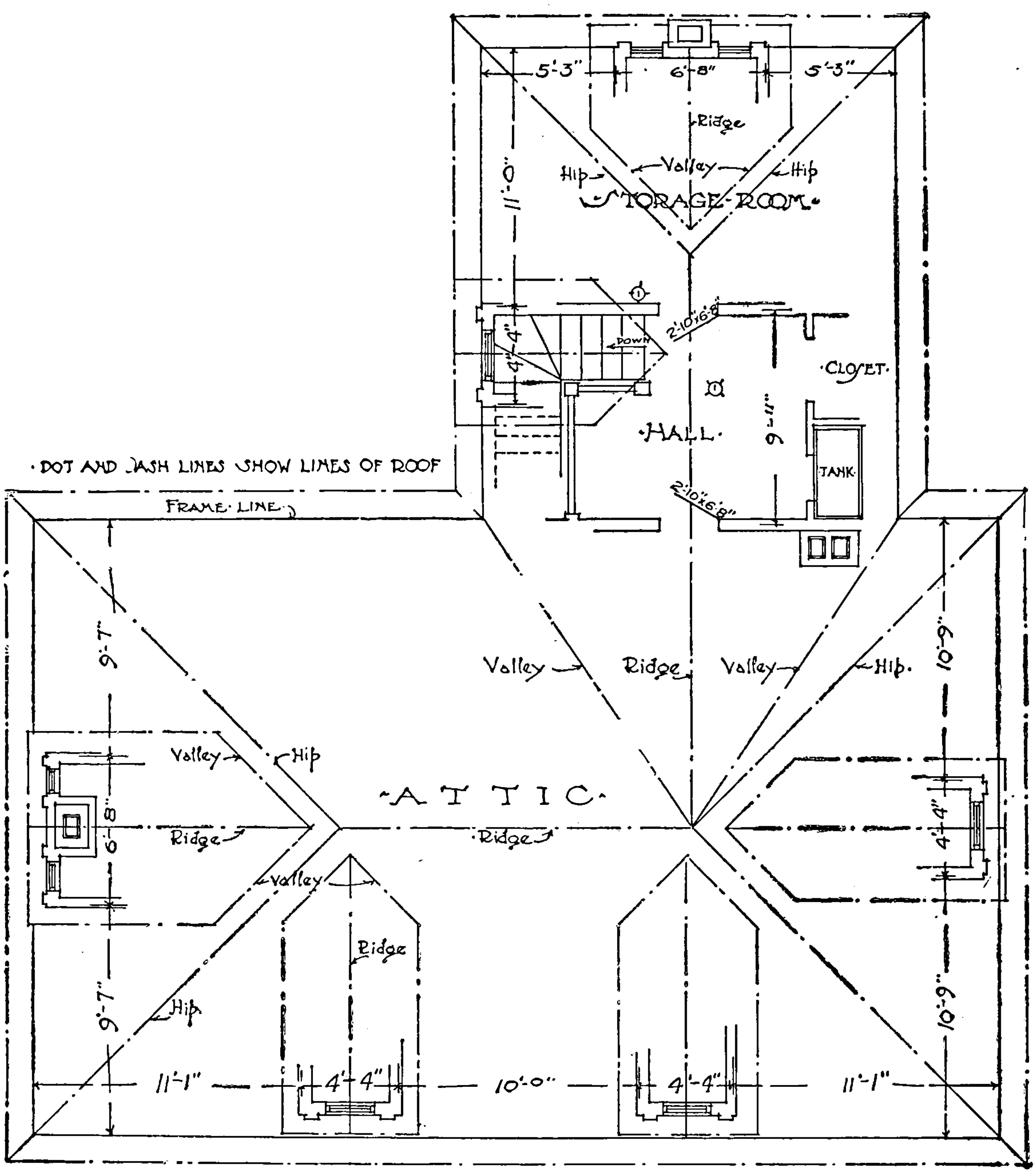
From the rear of the hall a door opens on the rear porch, and another door leads to the passage connecting with the kitchen and the back stairs. Between the dining room and the kitchen is a large china closet, having glazed shelving and also a counter shelf on which is dotted the location for a china-closet sink—which, shown in this way, would not be considered a part of a contract, but could be put in later. From the kitchen a staircase leads down to the basement. The kitchen has windows on both sides, giving a cross-draft for ventilation, which is very agreeable in summer.

In the rear of the kitchen is a pantry, with cupboards, drawers, and shelving. The large back entry is planned for a refrigerator, which has an ice door on the rear, to be put in according to the directions furnished by the refrigerator maker.

This plan should be laid out like all the others, from a center axis, the dimensions being figured to outside of studs for outside walls, and to the center of partitions for inside walls, and to the centers of the window openings.

The sill line is $\frac{7}{8}$ inch inside the outside line of the walls shown, while the inner line representing the plaster surface is $4\frac{3}{4}$ or $4\frac{7}{8}$ inches inside the sill line. The dimensions being given in this way, it is a simple matter for the carpenter on the building to run his measuring stick between the outside studding and against the outside boarding, and to measure across, thus locating the center of an interior partition or the center of one of the windows. The location of gas and electric fixtures is shown by circles on the plans.

Second-Floor Plan. This is shown in Fig. 30. Only those dimensions are given on these plans which are not indicated on the first floor, as all second-floor partitions are supposed to rest on the



PLAN OF THIRD FLOOR & ROOF

Scale of 0 1 2 3 4 5 6 7 8 feet

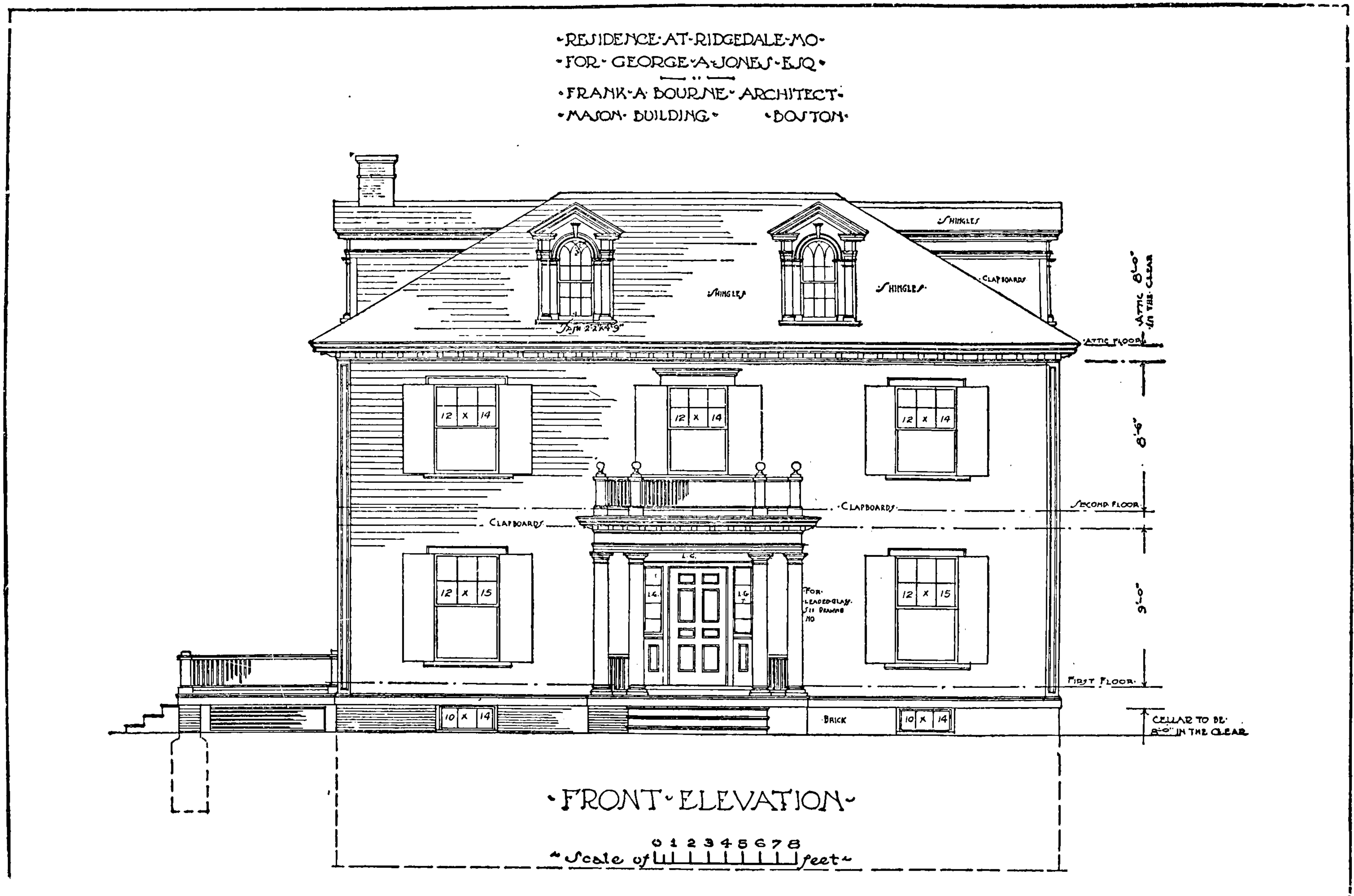
Fig 31.

partitions below, if possible. The roofs of the porch and piazza are shown. These may be covered with painted canvas or with tin, and, if they are to be much used, should be provided also with a floor of wood slats. The staircase and hall are shown with an alcove opening toward the front, lighted from the window over the front porch. This alcove is separated from the hall by an arch resting on small columns, making an attractive sitting room. There are doors from it into the adjacent bedrooms. Instead of the arched opening, a partition may be put in, making a convenient dressing room. The bedrooms are 11 by 14 feet, and are provided with closets.

One bedroom has a fireplace, and the two bedrooms on the left of the house have access to a chimney. There is a small linen closet, provided with wide shelves, opening out of the hall. Sometimes the lower part of this closet is provided with drawers, and the upper part with wide lockers having drop fronts. The opening between the front hall and the rear hall can be closed with a door, if desired; or the door can be placed opposite the partition between the bathroom and the rear bedroom. The bathroom comes directly over the butler's pantry, so that the plumbing is all very compactly arranged. The staircase to the attic goes up over the back stairs that lead down to the kitchen. The rear bedroom, which could be used as a servants' room, is provided with a large closet. A large linen closet, with shelves and drawers, opens into the rear hall.

Attic and Roof Plan. The attic, as shown in Fig. 31, is left unfinished, with the exception of the hall at the top of the back stairs. The location of the tank is shown near a chimney, and a small closet opens off the hall. The roof lines are shown by dot-and-dash lines, which are frequently drawn in red on the working drawings. The frame line (*i. e.*, the line of the outside of the sill and the studding)—which should appear on all the working drawings—is shown here in full, with all dimensions noted thereon.

Front and Side Elevations. As shown in Figs. 32 and 33, the character of the house is "Colonial," of about the period of the beginning of the nineteenth century. The treatment is very simple and the details should be worked out delicately to obtain the Colonial character. The construction is comparatively simple, the base being of brick, sometimes with a granite course at grade, and sometimes the whole underpinning being of split granite. The wall is covered with

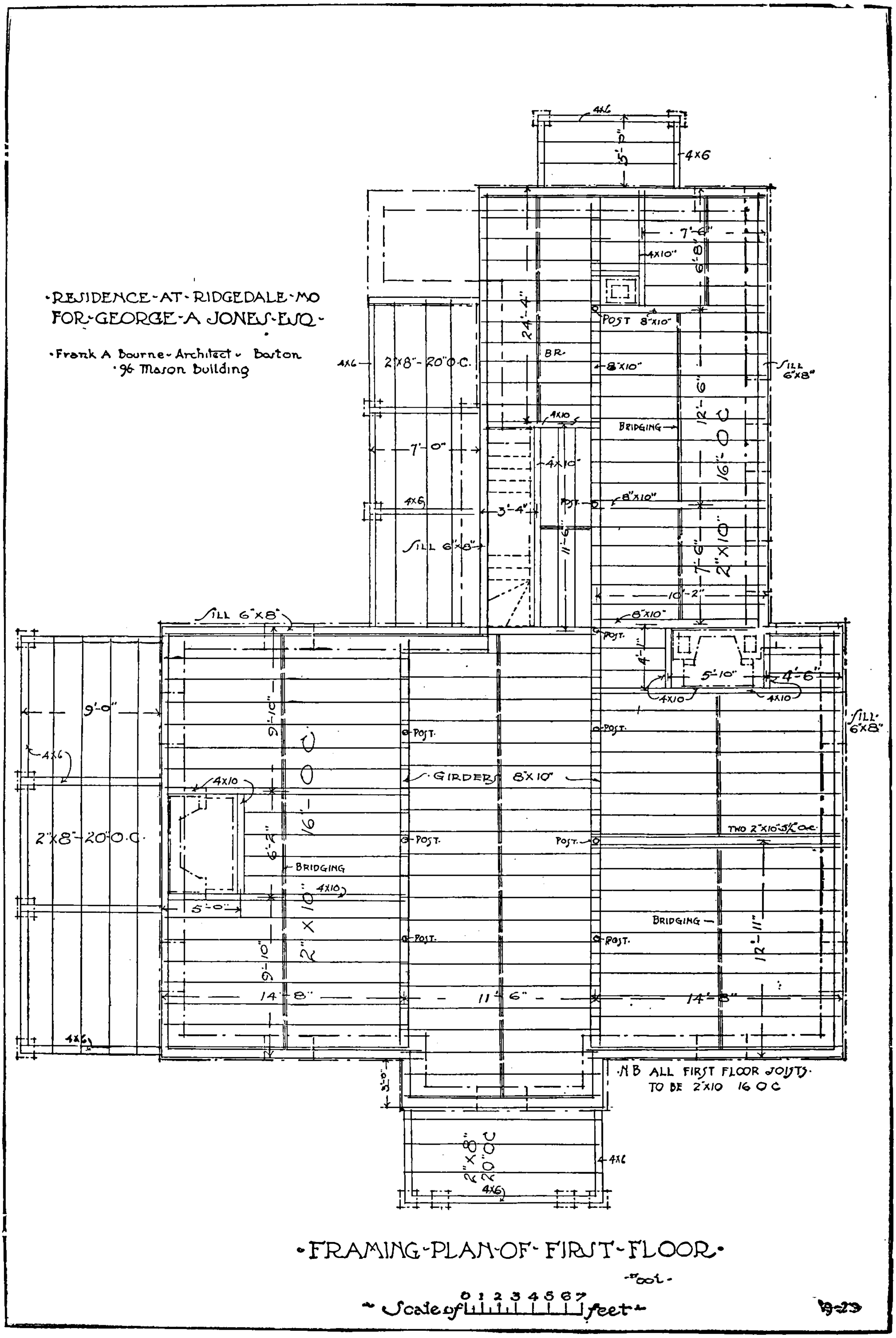

·RESIDENCE·AT·RIDGEDALE·MO·
·FOR·GEORGE·A·JONES·ESQ·
·FRANK·A·BOURNE·ARCHITECT·
·MASON·BUILDING· ·BOSTON·
SHINGLES
CLAPBOARDS
SHINGLES
SHINGLES
SASH 2'2"X4'9"
ATTIC 8'0" IN THE CLEAR
ATTIC FLOOR
12 X 14
12 X 14
12 X 14
8'6"
CLAPBOARDS
CLAPBOARDS
SECOND FLOOR
12 X 15
12 X 15
9'-0"
FOR LEADED GLASS SEE DRAWING NO
FIRST FLOOR
10 X 14
BRICK
10 X 14
CELLAR TO BE 8'-0" IN THE CLEAR
·FRONT·ELEVATION·
0 1 2 3 4 5 6 7 8
Scale of feet


·RESIDENCE·AT·RIDGEDALE·MISSOURI·FOR·
GEORGE·A·JONES· ·ESQUIRE·
·Frank A. Bourne·Architect Mason Building·Boston·
SHINGLES
CLAPBOARDS
SHINGLES
CLAPBOARDS
T.B
TURNED·BALUSTERS
T.B
BRICK
DETAIL·OF·FRONT·ELEVATION·
Scale of 0 1 2 3 4 5 6 feet

Fig. 34.

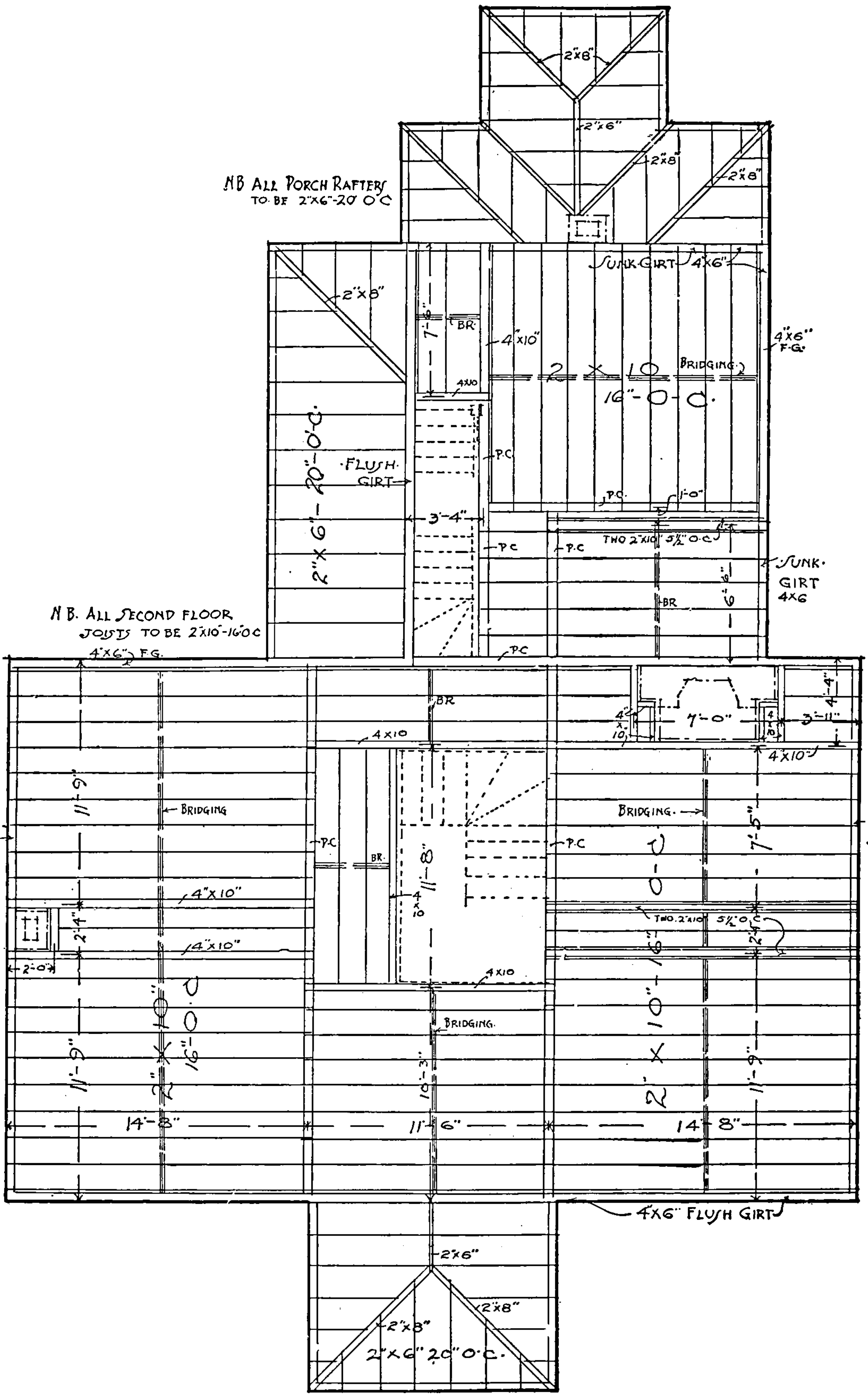
clapboards, with cypress or pine finish. The roof is covered with shingles. The location of the floors is shown by a dot-and-dash line, which in working drawings is frequently put in in red ink. The height of the floors is 9 feet for the first story, 8 feet 6 inches for the second story, with an attic 8 feet in the clear. The cellar is to be 8 feet high in the clear.

Detail of Front Elevation. Fig. 34, showing detail of the front elevation, is reduced from a drawing made at a scale of one-half inch to the foot. This is sufficiently large to show very clearly to the workmen the relation and character of the mouldings, which must, of course, be worked out at full size. The cornice and the front entrance are here shown, the cornice consisting of the Roman Doric Order, as treated in the Colonial period, the column having a modified Attic base, and a shaft with the customary entasis. This entasis or swelling of the column extends one-third of its height without diminution, and tapers slightly until it comes to the necking. The cap is very simple, consisting of astragal, necking, fillet, and echinus, all turned; a square abacus, consisting of a fascia, ogee, and fillet. The architrave consists of a fascia, small bead, another fascia, ogee, and fillet. The frieze in this type of building is usually plain; and the cornice, which may be greatly varied, consists, in this case, of a great quarter-hollow, fillet, quarter-round, fascia with brackets, and a corona consisting of fascia, fillet, and cyma. Between the columns is a balustrade with turned balusters. The cornice is surmounted by another balustrade with posts, top and bottom rail, and turned balusters. The doorway is worked out in old Colonial style, with paneling peculiar to that period. The sash may be made either according to the design shown, in wood, or with wide leads, which may be painted white. Windows are shown with outside casing and back band; and the center window has a small cap to accent the central portion of the house. The water-table is formed to take up the slight projections of the brick underpinning beyond the outside boarding. It consists of a wide fascia, an astragal, and a splayed member. The corner is paneled, as shown. Sometimes a plain corner-board is employed, and at other times it is made larger and finished with a Classic capital and base. The cornice of the house is similar to the cornice of the porch, the frieze and architrave being omitted, as is quite customary on Colonial houses, although there are examples of Colonial houses where the complete en-



RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
Frank A Bourne Architect Boston
96 Mason Building
FRAMING PLAN OF FIRST FLOOR
N B ALL FIRST FLOOR JOISTS TO BE 2"x10 16 O C
GIRDERS 8"x10"
SILL 6"x8"
BRIDGING
POST
2"x8" 20" O.C.
2"x10" 16" O C
TWO 2"x10" 5½ O.C.
Scale of 0 1 2 3 4 5 6 7 feet

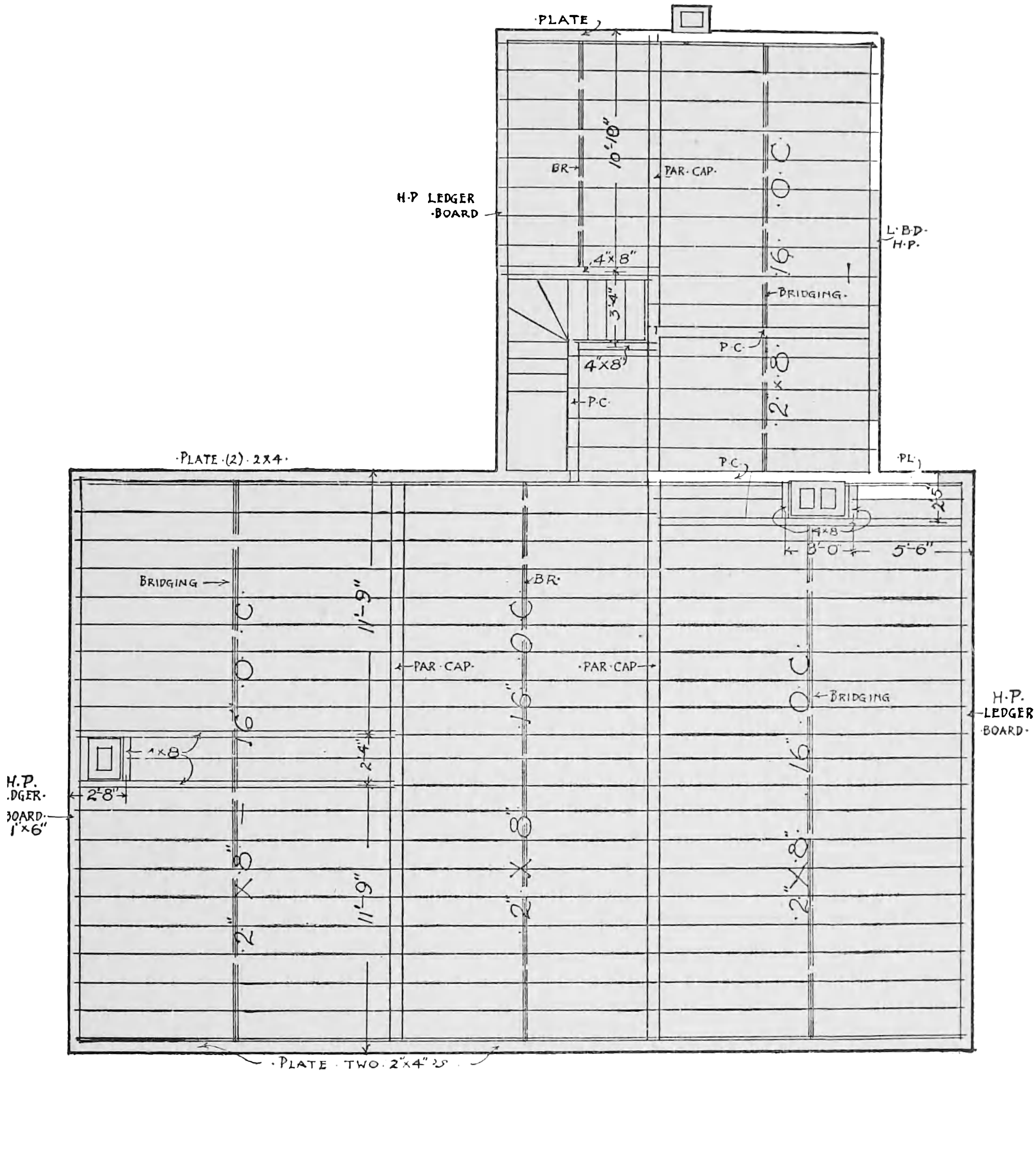
Fig. 35.



FRAMING-PLAN-OF-SECOND-FLOOR-

Scale of 0 1 2 3 4 5 6 feet

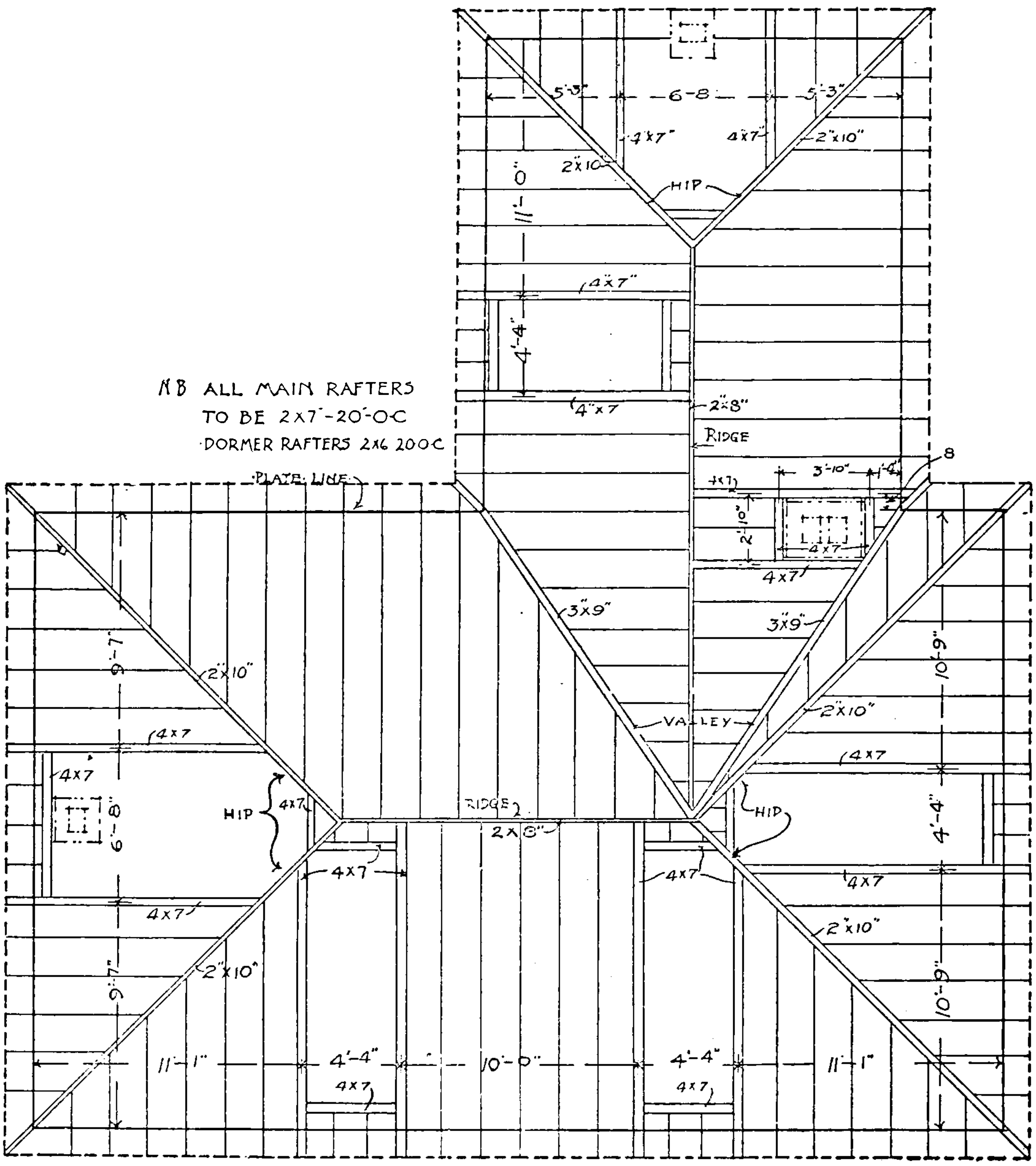
Fig. 36.



·FRAMING·PLAN·OF·THIRD·FLOOR·

Scale of 0 1 2 3 4 5 6 7 8 feet

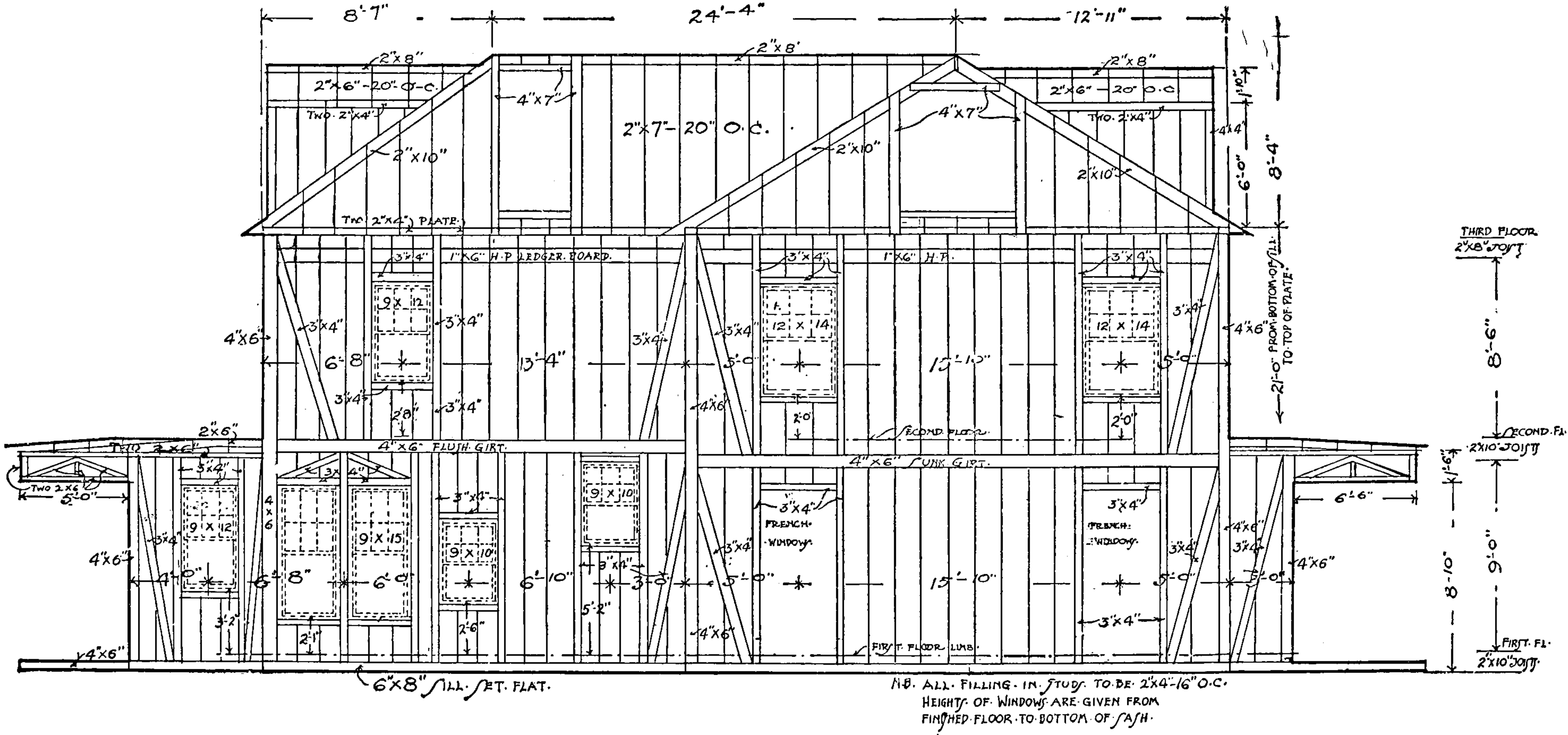
Fig. 37.



-FRAMING-PLAN-OF-ROOF-

-Scale of 0 1 2 3 4 5 6 7 8 feet.-

Fig. 38.



·FRAMING·OF·LEFT·SIDE·ELEVATION·

~Scale of 0 1 2 3 4 5 6 7 8 9 feet~

partition caps of the story below, on which the joists rest, are shown. The joists in the attic floor are 2 by 8, placed 16 inches on centers.

Roof Framing Plan. The rafters and hips are shown (Fig. 38) 2 by 10; the valley rafters, 3 by 9; the ridge, 2 by 8 inches. The rafters either side of the dormer openings are 4 by 7, and the headers for the dormers are also 4 by 7 inches. All the other main rafters are 2 by 7 inches, placed 20 inches on centers; and the dormer rafters, 2 by 6, placed 20 inches on centers. The plate line, which is the same as the first-floor sill line, is shown as a full line, and the dimensions are given from this line.

Framing of Front Elevation. The framing of the front elevation of the house above the foundation is shown in Fig. 39. The sill is 6 by 8, resting on its 8-inch face. The corner posts are 4 by 6, framed into the sill; and a 4 by 6 flush girt is shown running around the house. It will be noticed that the girt stops on the side elevations where it is marked "4 by 6 sunk girt" (Fig. 40). The plate is formed of 2 by 4 joists, which break joints all around the building. The frame is braced by 3 by 4 studs, these braces being as long as possible, which is considered better construction than the former short-brace system. In cheaper work, 2 by 4 braces, halved into the studding, are sometimes used in the same position. The filling-in studs are 2 by 4, set 16 inches on centers. The door and window studs are 3 by 4 inches, set 5 inches clear of the sash opening.

The dimensions are given to the centers of the openings. The heights are generally given to the finished floor, which would be 2 inches above the joist line. The large openings are trussed, as shown over the front door opening. The rafters are 2 by 7, set 20 inches on centers, the hips being 2 by 10, and the valley rafters 3 by 4. The dormers are built up of 4 by 4 corner posts and 4 by 7 rafters each side of the opening. The ridge is 2 by 8, the distance to the top of ridge being given above the top of the plate, and all the points on the ridge rafters and ridge may be located on the sill line to the junction of the hip.

Framing of Side Elevation. The sill, girts, corner posts, studding, plate, and rafters (Fig. 40), are similar to those already described on the front elevation. The framing of the front and rear porches is also shown, with the dimensions given similarly. The attic floor joists

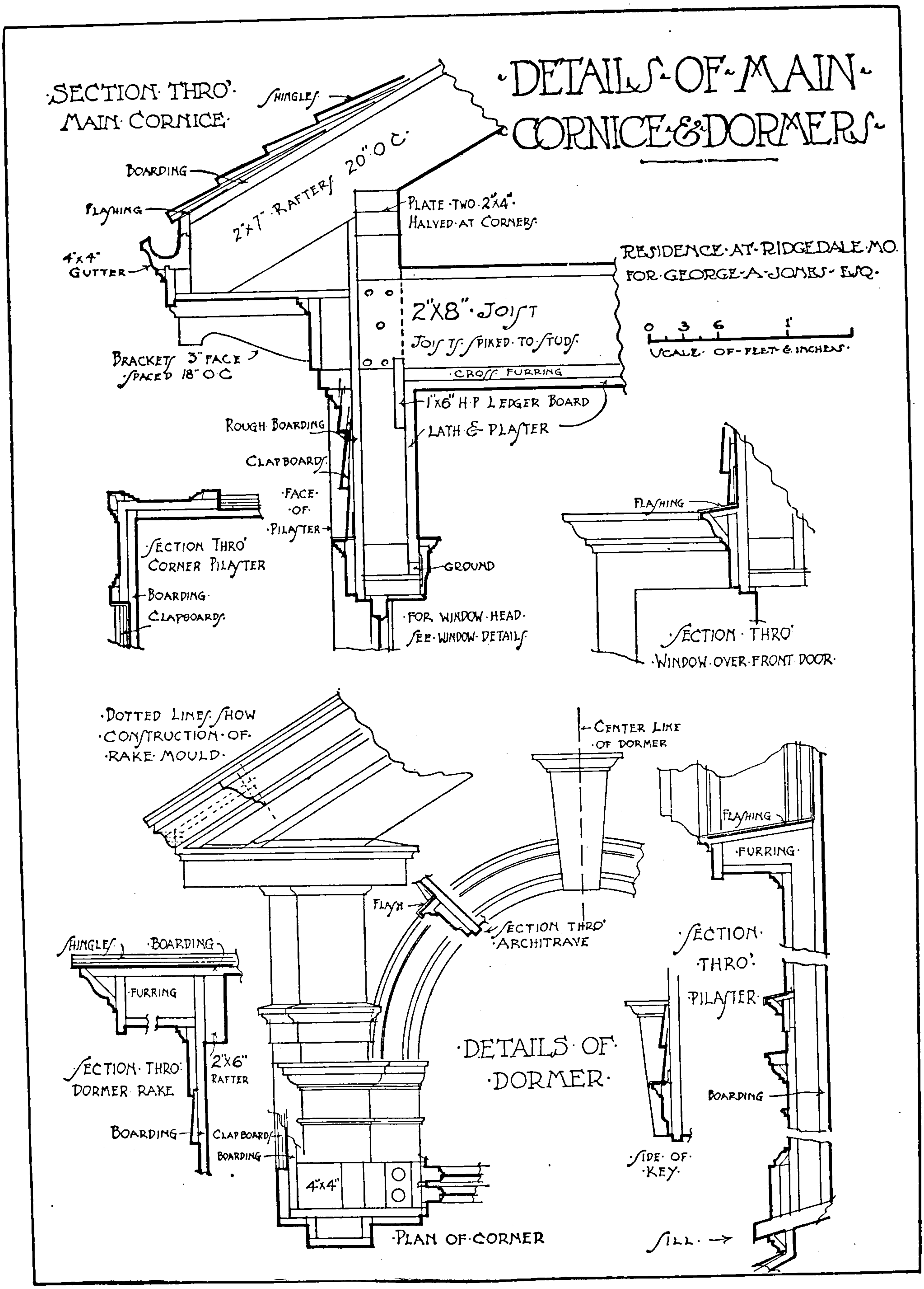
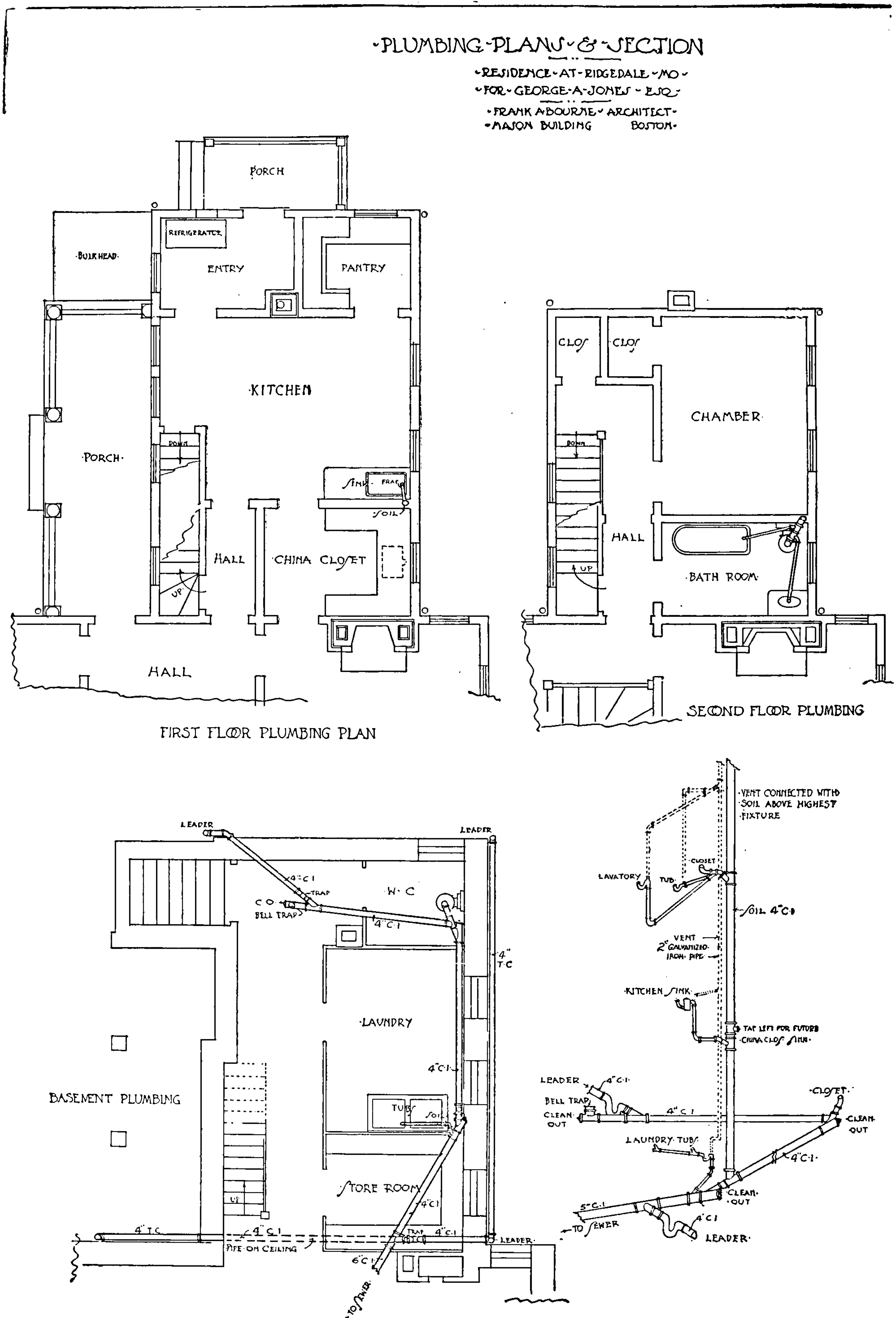

DETAILS OF MAIN CORNICE & DORMERS
SECTION THRO' MAIN CORNICE
SHINGLES
BOARDING
FLASHING
4"x4" GUTTER
2"x7" RAFTERS 20" O.C.
PLATE TWO 2"x4" HALVED AT CORNERS
RESIDENCE AT RIDGEDALE MO. FOR GEORGE A JONES ESQ.
0 3 6 1'
SCALE OF FEET & INCHES
2"X8" JOIST
JOISTS SPIKED TO STUDS
CROSS FURRING
BRACKETS 3" FACE SPACED 18" O.C.
1"x6" H.P. LEDGER BOARD
LATH & PLASTER
ROUGH BOARDING
CLAPBOARDS
FACE OF PILASTER
GROUND
FOR WINDOW HEAD SEE WINDOW DETAILS
SECTION THRO' CORNER PILASTER
BOARDING
CLAPBOARDS
FLASHING
SECTION THRO' WINDOW OVER FRONT DOOR
DOTTED LINES SHOW CONSTRUCTION OF RAKE MOULD
CENTER LINE OF DORMER
FLASH
SECTION THRO' ARCHITRAVE
FLASHING
FURRING
SECTION THRO' PILASTER
SHINGLES
BOARDING
FURRING
SECTION THRO' DORMER RAKE
2"x6" RAFTER
BOARDING
CLAPBOARDS
BOARDING
4"x4"
DETAILS OF DORMER
BOARDING
SIDE OF KEY
PLAN OF CORNER
SILL

Fig. 41.



PLUMBING PLANS & SECTION
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A BOURNE ARCHITECT
MASON BUILDING BOSTON
PORCH
REFRIGERATOR
BULKHEAD
ENTRY
PANTRY
KITCHEN
PORCH
DOWN
SINK
TRAP
SOIL
HALL
CHINA CLOSET
UP
HALL
FIRST FLOOR PLUMBING PLAN
CLOS
CLOS
CHAMBER
DOWN
HALL
UP
BATH ROOM
SECOND FLOOR PLUMBING
LEADER
LEADER
4" C I
TRAP
C O
BELL TRAP
W C
4" C I
4" T C
LAUNDRY
4" C I
TUBS
SOIL
BASEMENT PLUMBING
STORE ROOM
4" C I
UP
4" T C
4" C I
PIPE ON CEILING
TRAP
4" C I
LEADER
6" C I
TO SEWER
VENT CONNECTED WITH SOIL ABOVE HIGHEST FIXTURE
CLOSET
LAVATORY
TUB
SOIL 4" C I
VENT
2" GALVANIZED IRON PIPE
KITCHEN SINK
TAP LEFT FOR FUTURE CHINA CLOS SINK
LEADER
4" C I
BELL TRAP
CLEAN OUT
4" C I
CLOSET
CLEAN OUT
LAUNDRY TUBS
4" C I
CLEAN OUT
5" C I
TO SEWER
4" C I
LEADER

Fig. 43.

are supported on a 1 by 6 hard pine ledger-board, which is cut into the studding after the manner of balloon framing.

Main Cornice and Dormer. Fig. 41 is reduced from a drawing made at a scale of three-fourths inch to the foot. This plate should be drawn out at the original scale mentioned; and a full-size pencil study should be made for comparison.

Kitchen, Pantry, and China Closet. Fig. 42 shows the details of kitchen, pantry, and china closet reduced from a drawing made at a scale of one-half inch to the foot, and larger details at a scale of one and one-half inches to the foot, showing shelving, lockers, and doors. These are all included in the interior finish, and should follow the specifications as to sizes. The mouldings should all be full-size.

Plumbing. Fig. 43 shows the plumbing details for this building, These details are carried somewhat further than is usually done on plans, but no further than advisable, as they will be found of great assistance in carrying out and superintending the work. The basement plan shows the direction of the sewer connection, which is a horizontal pipe, six inches in diameter, of cast iron, located either on the basement ceiling or in a trench on the cellar floor. In this case it must be below the cellar-floor level in order to take the laundry tubs. The section shows the elevations of the pipe carried up through the house.

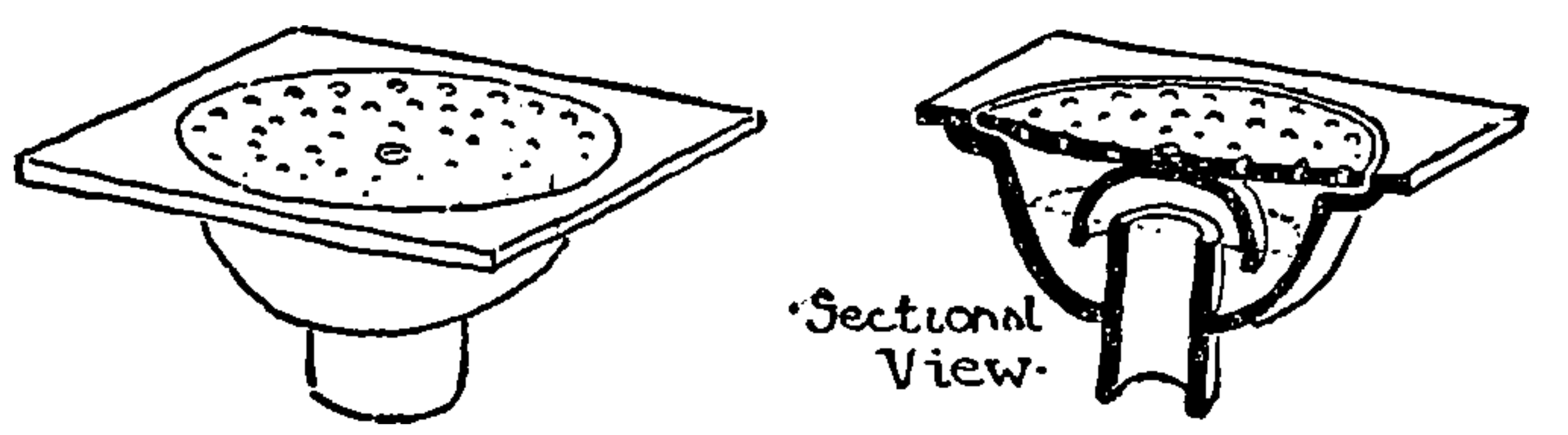


Fig. 44.

There will be a trap between the point shown and the sewer, just outside the wall of the house. The leader connections are 4-inch cast-iron pipe inside the house in cellar floor, and 4-inch terra-cotta outside the house, to take the water from the gutters and conductors. On the first connection there is a cleanout, and the size of the pipe is reduced from 6 inches to 4 inches. There should be cleanouts at every bend, and also at about every fifteen feet of horizontal run. There should be a bell trap (Fig. 44) to take the cellar surface water, also branches for general fixtures through the house, as shown. The vertical pipe of 4-inch cast iron would rest on a brick pier at the bottom built by the mason.

The vent pipes from the trap of every fixture are shown in dotted lines, and are carried up beyond the highest fixture, where they may be

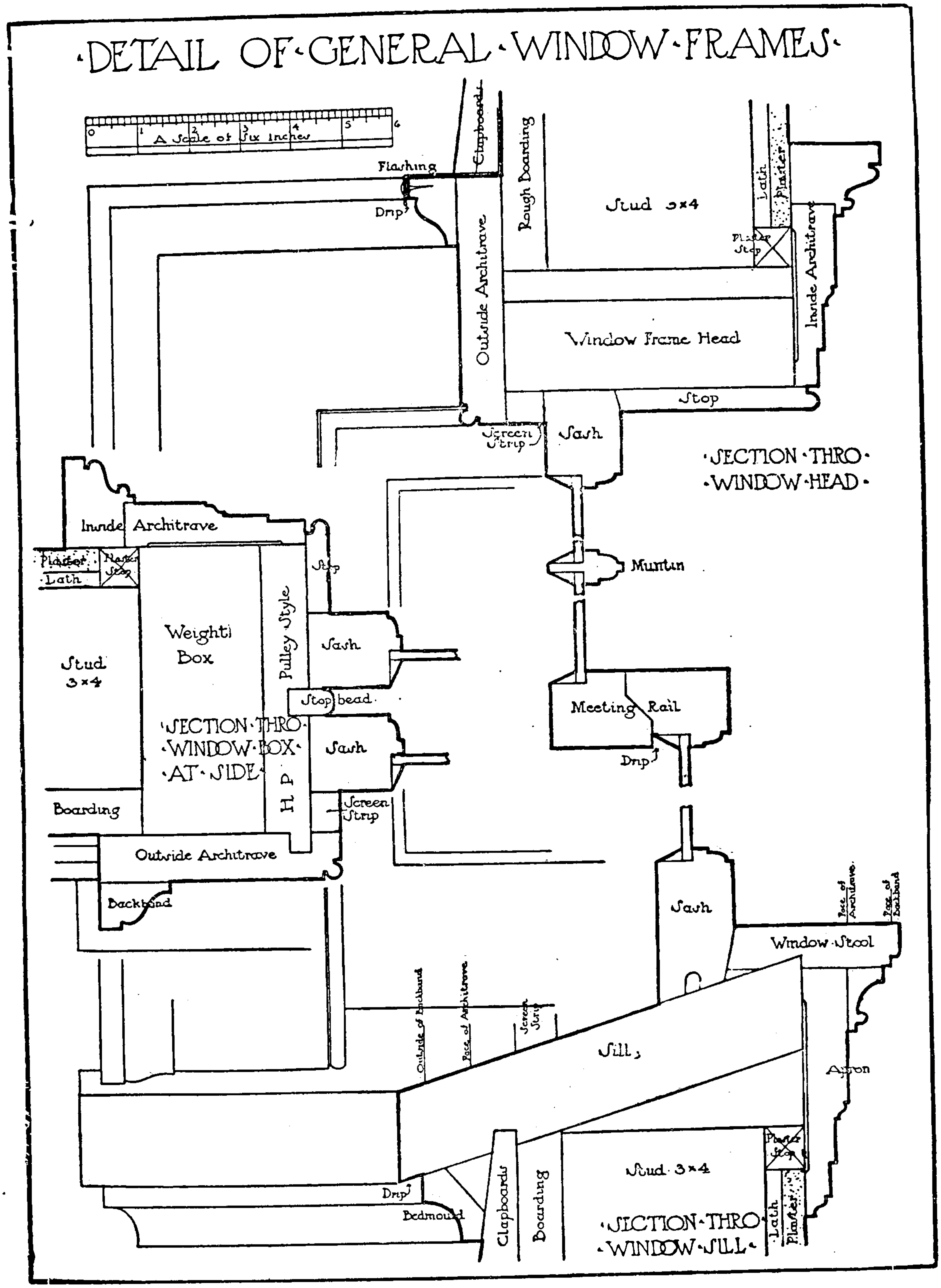

DETAIL OF GENERAL WINDOW FRAMES
A Scale of Six Inches
0
1
2
3
4
5
6
Flashing
Clapboards
Rough Boarding
Drip
Outside Architrave
Stud 3×4
Lath
Plaster
Plaster Stop
Inside Architrave
Window Frame Head
Stop
Screen Strip
Sash
SECTION THRO WINDOW HEAD
Muntin
Inside Architrave
Plaster
Lath
Plaster Stop
Stop
Weights Box
Pulley Style
Stud 3×4
Sash
Stop bead
Meeting Rail
SECTION THRO WINDOW BOX AT SIDE
Sash
Drip
H P
Boarding
Screen Strip
Outside Architrave
Backband
Sash
Face of Architrave
Face of Backband
Window Stool
Outside of Backband
Face of Architrave
Screen Strip
Sill
Apron
Plaster Stop
Stud 3×4
Drip
Bedmould
Clapboards
Boarding
SECTION THRO WINDOW SILL
Lath
Plaster

Fig. 45.

The pulley stile is of hard pine; and the parting strip, or stop-bead between the two sashes, is also hard pine. Between the outside architrave and the sash is put in a small screen strip, to give space enough for a mosquito screen between blinds and sash. On the inside of the sash is a stop-bead, which forms a part of the interior finish and covers the rough part of the window frame.

The upper part of the drawing shows a section through the window head. Sometimes the window frame head is made of thinner stock than that shown. This completes the rough window box as it is shipped from the sash factory to the building. At the building, it is nailed in place against the rough boarding; and later the sash, which come a little too large for their position, are fitted into place. Sections horizontally and vertically are shown through the sash, including meeting rail and muntins. The sash at the sill is wider than elsewhere, and underneath is usually beveled where it comes against the finished window stool, so that it will shut tight. There is also usually a groove underneath, to intercept any water that may blow in. The meeting-rail may be made on the outside sash, to drop below the meeting-rail on the inside sash, forming a drip which will prevent the water washing down on the glass of the lower sash.

The inside finish is frequently included on the general interior-finish drawings of the building, and is not always sent out with the window-frame details. The window stool is shown on the drawing, with a small space underneath where it comes against the sash, which forms a slight interruption for any water that may pass the other groove. The apron is nailed onto the sill and plaster stop; and a moulding is generally run under the window stool where it joins the apron. A back band may be laid around the inside architrave, against the plastering; or the inside architrave may be all one piece.

Fig. 46 shows several variations from the details of window frames illustrated in Fig. 45; and these can be still further varied if desired; or a combination of the parts may be made, taking certain details from each detail given.

The frames, unless otherwise shown, are usually made of white pine. Pulley stiles and parting beads are made of hard pine.

The pulley stiles are seven-eighths inch thick, tongued into the outside casings, as shown in the section through the side of the window box. The parting or stop beads are seven-eighths by one-half inch in

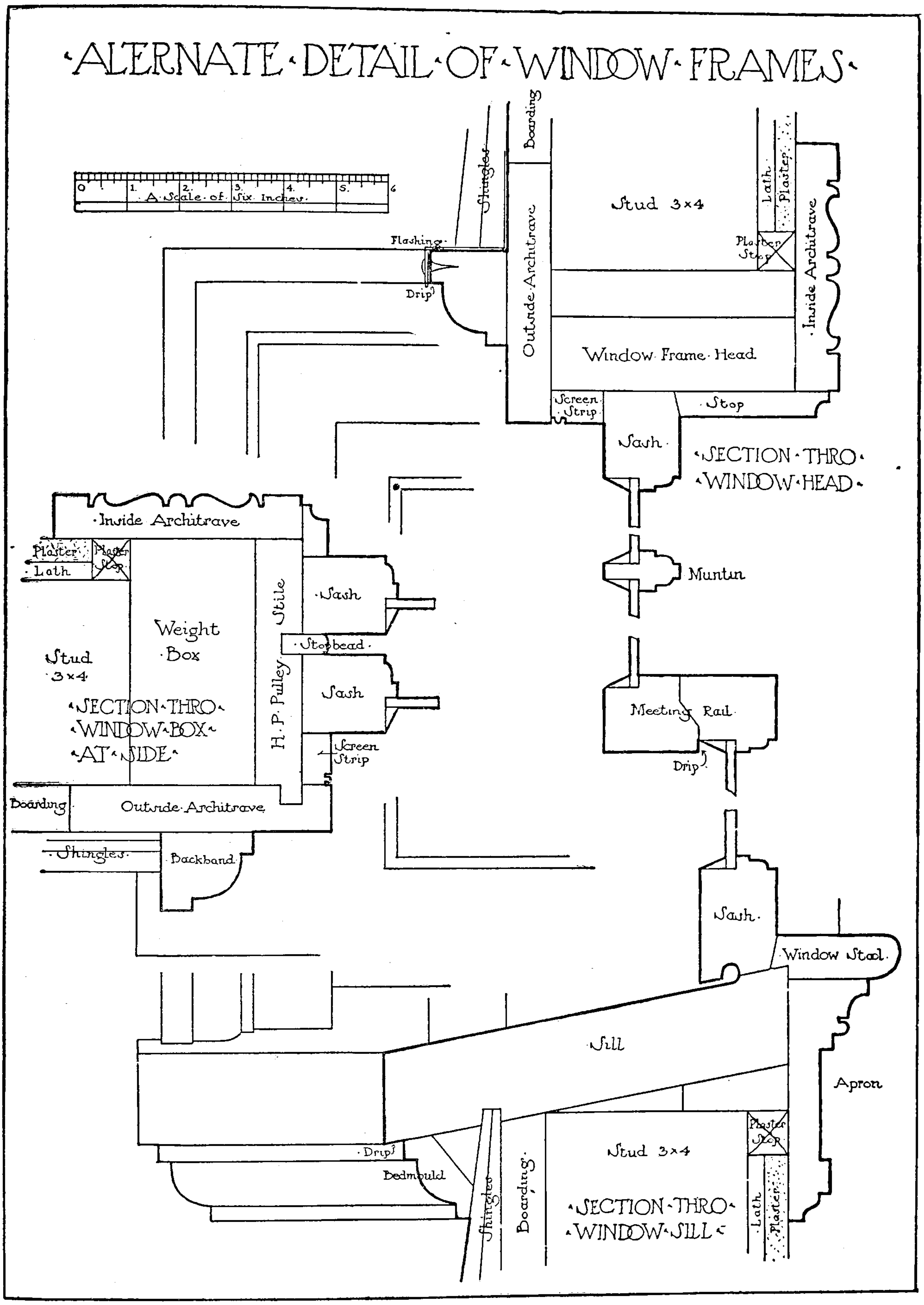

ALTERNATE DETAIL OF WINDOW FRAMES
0 1. 2. 3. 4. 5. 6
A Scale of Six Inches
Boarding
Shingles
Flashing
Drip
Outside Architrave
Stud 3×4
Lath
Plaster
Plaster Stop
Inside Architrave
Window Frame Head
Screen Strip
Stop
Sash
SECTION THRO WINDOW HEAD
Muntin
Inside Architrave
Plaster
Plaster Stop
Lath
Weight Box
Stile
Sash
Stopbead
Stud 3×4
H. P. Pulley
SECTION THRO WINDOW BOX AT SIDE
Screen Strip
Meeting Rail
Drip
Boarding
Outside Architrave
Shingles
Backband
Sash
Window Stool
Sill
Apron
Plaster Stop
Stud 3×4
Drip
Bedmould
Shingles
Boarding
SECTION THRO WINDOW SILL
Lath
Plaster

Fig. 46.

size; sometimes they are made seven-eighths by three-eighths inch, the latter giving more room for the screen strip.

When two-coat work is specified for plaster, the plaster stops are generally three-quarters inch thick; when three-coat work is used, generally seven-eighths inch thick. Very often the window box is completed by ground-casing either three-quarters or seven-eighths inch thick, as shown in Fig. 47; in this case no ground or plaster stops are necessary around the window frames. The yoke or window-frame head is generally made one and three-eighths or one and one-half inches thick. The sills are set to pitch one and one-half inches. Care must be taken to see that the blinds are made sufficiently long to fit, as stock frames are frequently made with a slope of not over one-half inch in four inches. The outside casing—or outside architrave, as it is sometimes called—may be set either flush with the boarding or outside the boarding. When it is set flush with the boarding, the shingles may be carried directly across the joint, and finished against a back band, which comes around the outside of the window frame. The outside casing is generally seven-eighths inch thick, and five inches or sometimes four and one-half inches in width. In certain cases it is made of one and one-eighth inch stock, when it is to be set outside the boarding. Sometimes, instead of the back-band shown, an architrave made from one and one-eighth to one and three-quarter inch stock is planted on the outside casing. This would show the distinction between the outside casing and the outside architrave. The method of using a ground casing and outside casing flush with the boarding is inexpensive, and therefore in quite common use. It does not give sufficient room for a screen strip, and does not make a very tight casing where the pulley stile connects with the sill.

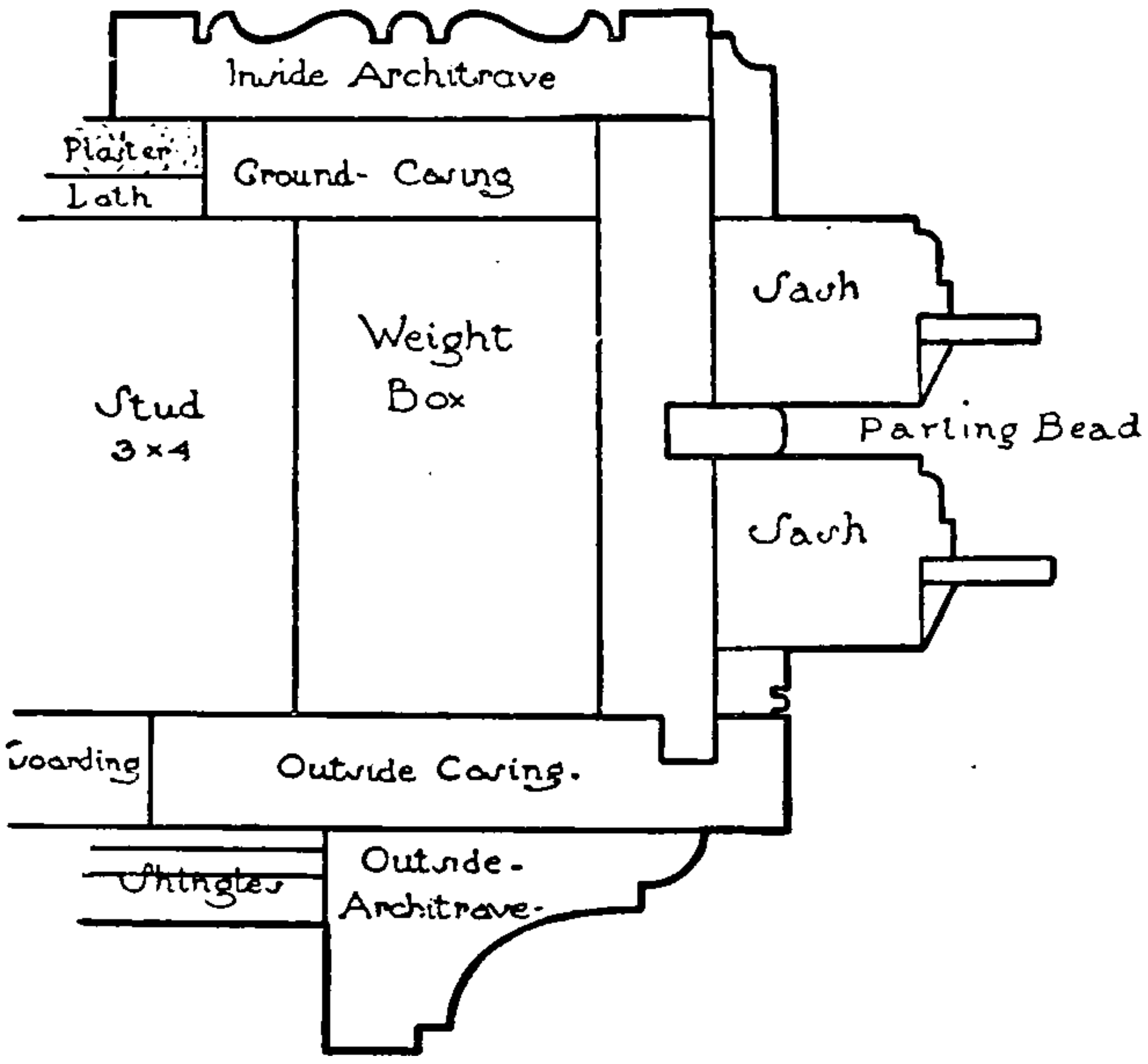


Fig. 47.

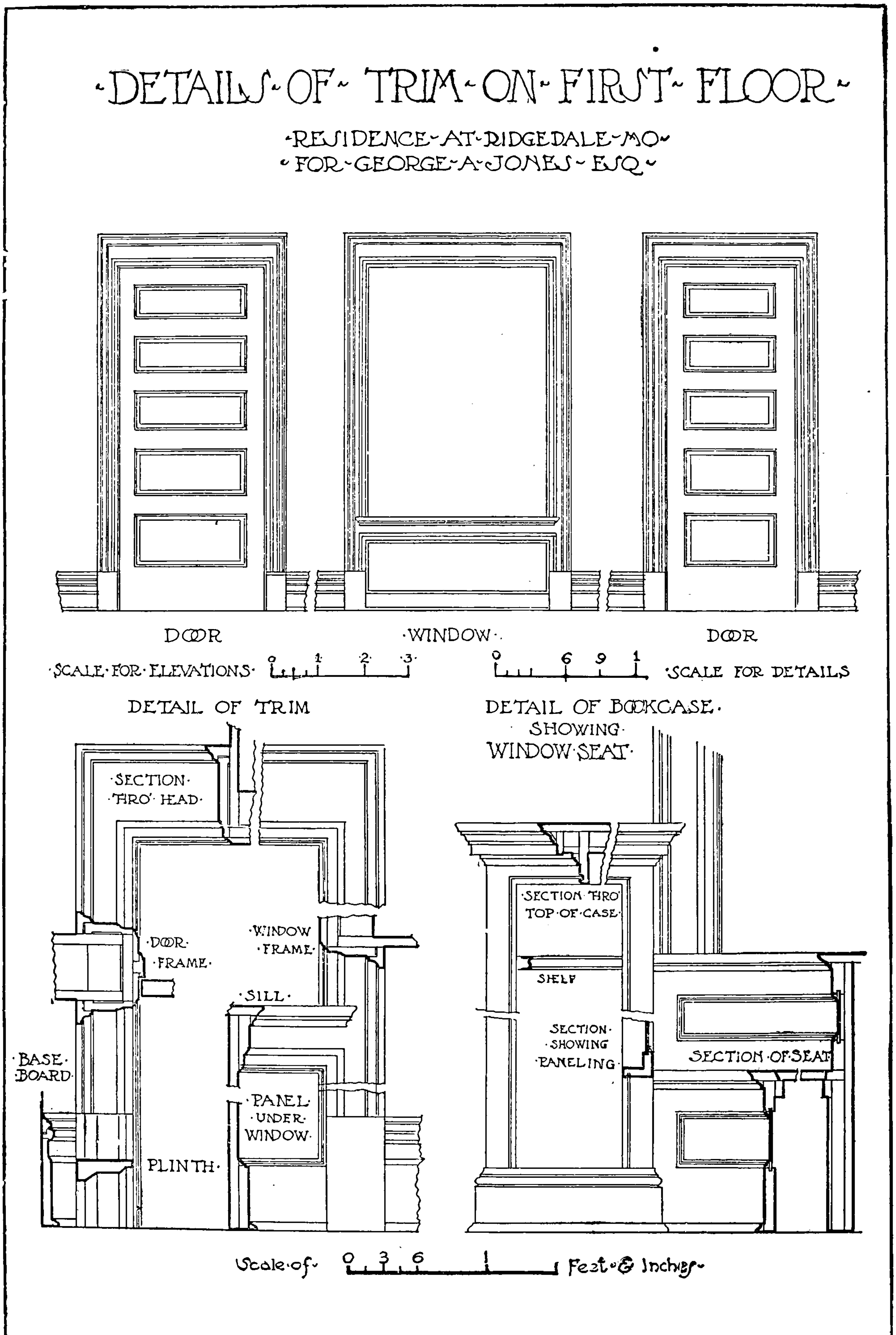

DETAILS OF TRIM ON FIRST FLOOR
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
DOOR
WINDOW
DOOR
SCALE FOR ELEVATIONS 0 1 2 3
0 6 9 1 SCALE FOR DETAILS
DETAIL OF TRIM
DETAIL OF BOOKCASE SHOWING WINDOW SEAT
SECTION THRO' HEAD
DOOR FRAME
WINDOW FRAME
SILL
BASE BOARD
PANEL UNDER WINDOW
PLINTH
SECTION THRO' TOP OF CASE
SHELF
SECTION SHOWING PANELING
SECTION OF SEAT
Scale of 0 3 6 1 Feet & Inches

Fig. 49.

The sash are usually made one and three-quarters inches thick, for house construction; sometimes, in less expensive work, they are made one and one-half inches thick, and, for cheap cellar windows, one and one-quarter inches thick. For plate glass they should not be less than one and three-quarter inches thick; and for important work, they are usually two and one-quarter inches thick. Frames may be veneered on the inside, to match the other interior finish.

Porch and Front Entrance. For detail of these, see Fig. 48.

Trim on First Floor. For detail, see Fig. 49.

Uniform Titles for Drawings. Fig. 50 shows a scheme for a uniform title to be use on working drawings. This may be made as a rubber stamp, the name of the drawing being lettered in, the name of the

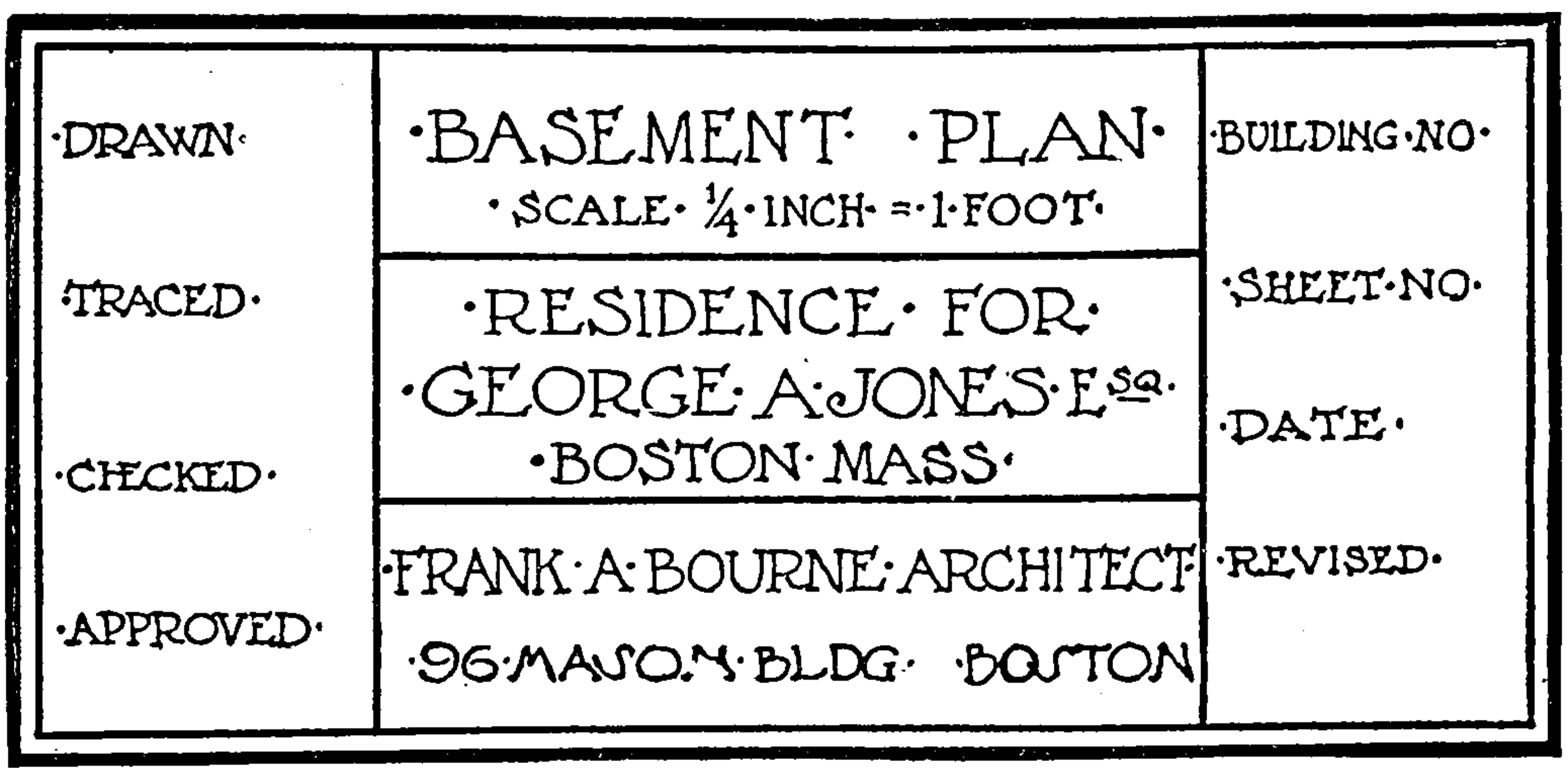


Fig. 50.

building being set up in rubber type, and the remainder being permanent. This stamp should be put on the drawing whenever it is started, a rubber dating stamp being used to give the date of beginning; the building number and sheet number should be recorded in the drawing book. The architect or draftsman who lays out the drawing puts his initials under the word "Drawn;" the draftsman who finishes it puts his initials under the word "Traced;" another puts his initials under the word "Checked," with the date; and finally the architect adds his initials and date after the drawings are ready to go out of the office. On the lower right-hand corner is a space where date of any revision may be entered. This stamp may be made four and seven-eighths inches long, so that it can be used on a 3 by 5 index card, for the drawing record; and also on a postal card, for a receipt to be signed by the con-

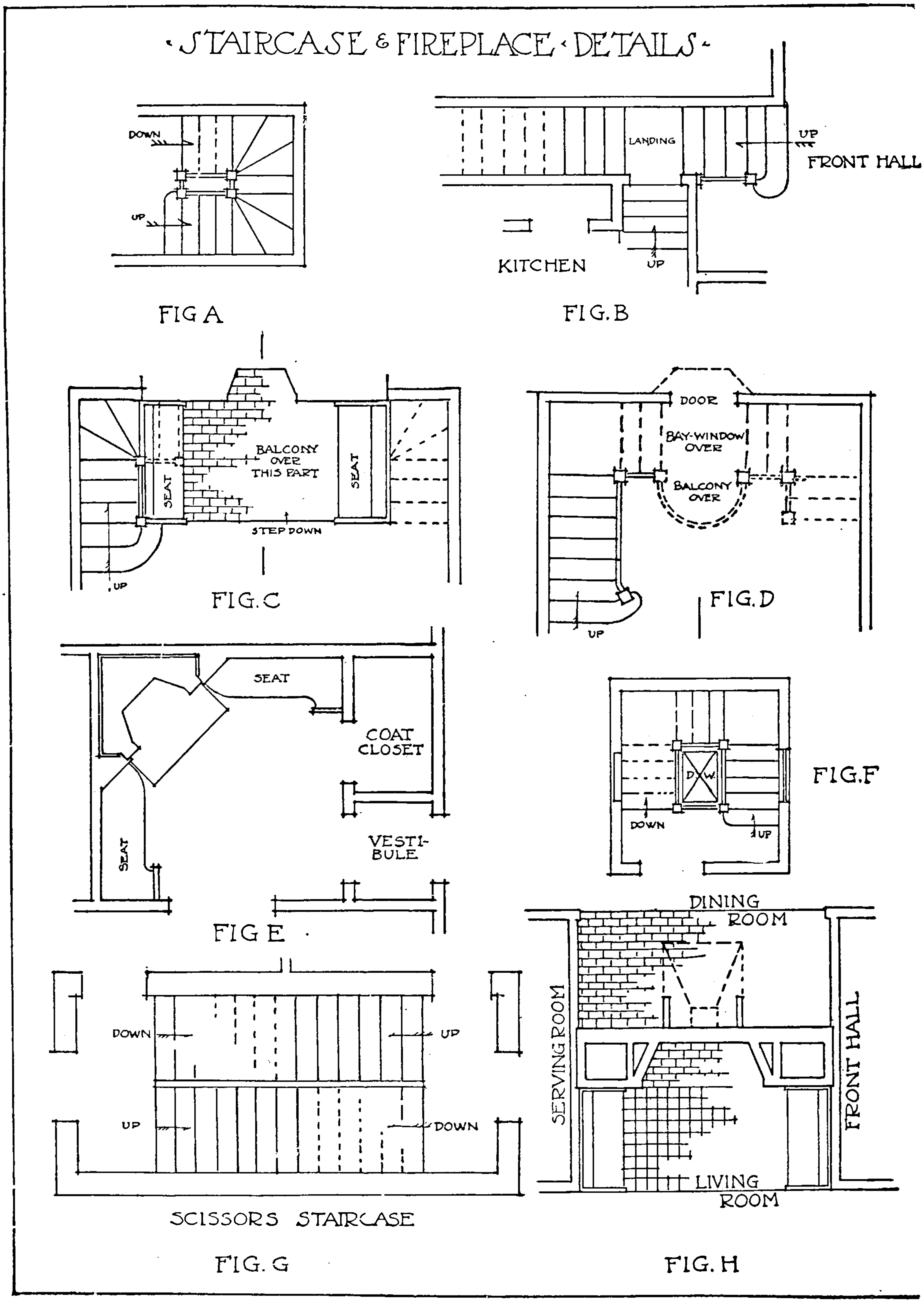
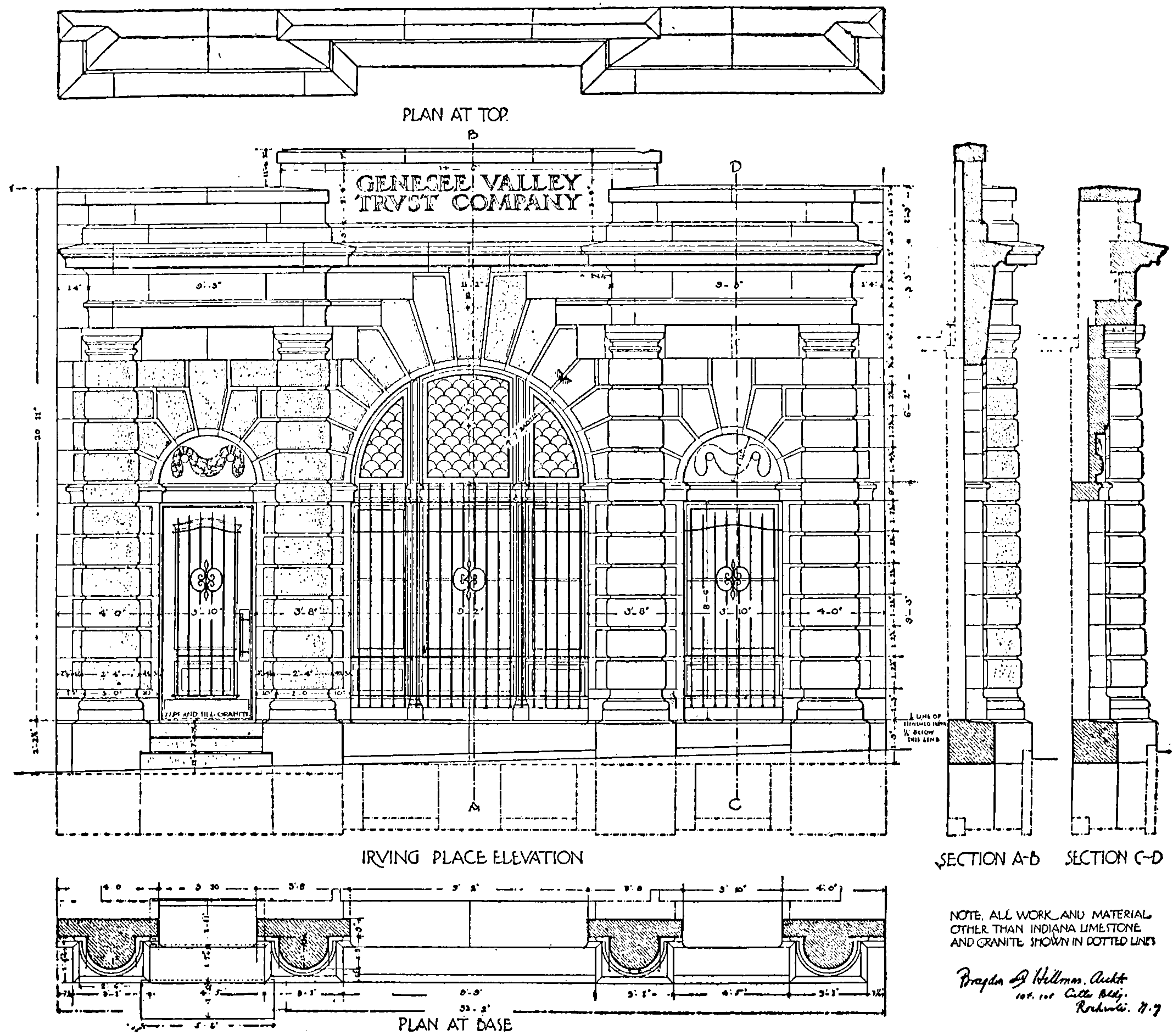

STAIRCASE & FIREPLACE DETAILS
DOWN
UP
FIG A
LANDING
UP
FRONT HALL
KITCHEN
UP
FIG. B
BALCONY OVER THIS PART
SEAT
SEAT
STEP DOWN
UP
FIG. C
DOOR
BAY-WINDOW OVER
BALCONY OVER
UP
FIG. D
SEAT
COAT CLOSET
VESTI-BULE
SEAT
FIG E
D.W.
DOWN
UP
FIG. F
DOWN
UP
UP
DOWN
SCISSORS STAIRCASE
FIG. G
DINING ROOM
SERVING ROOM
FRONT HALL
LIVING ROOM
FIG. H

Fig. 51.



BILL OF INDIANA LIMESTONE—GENESEE VALLEY TRUST CO'S BUILDING

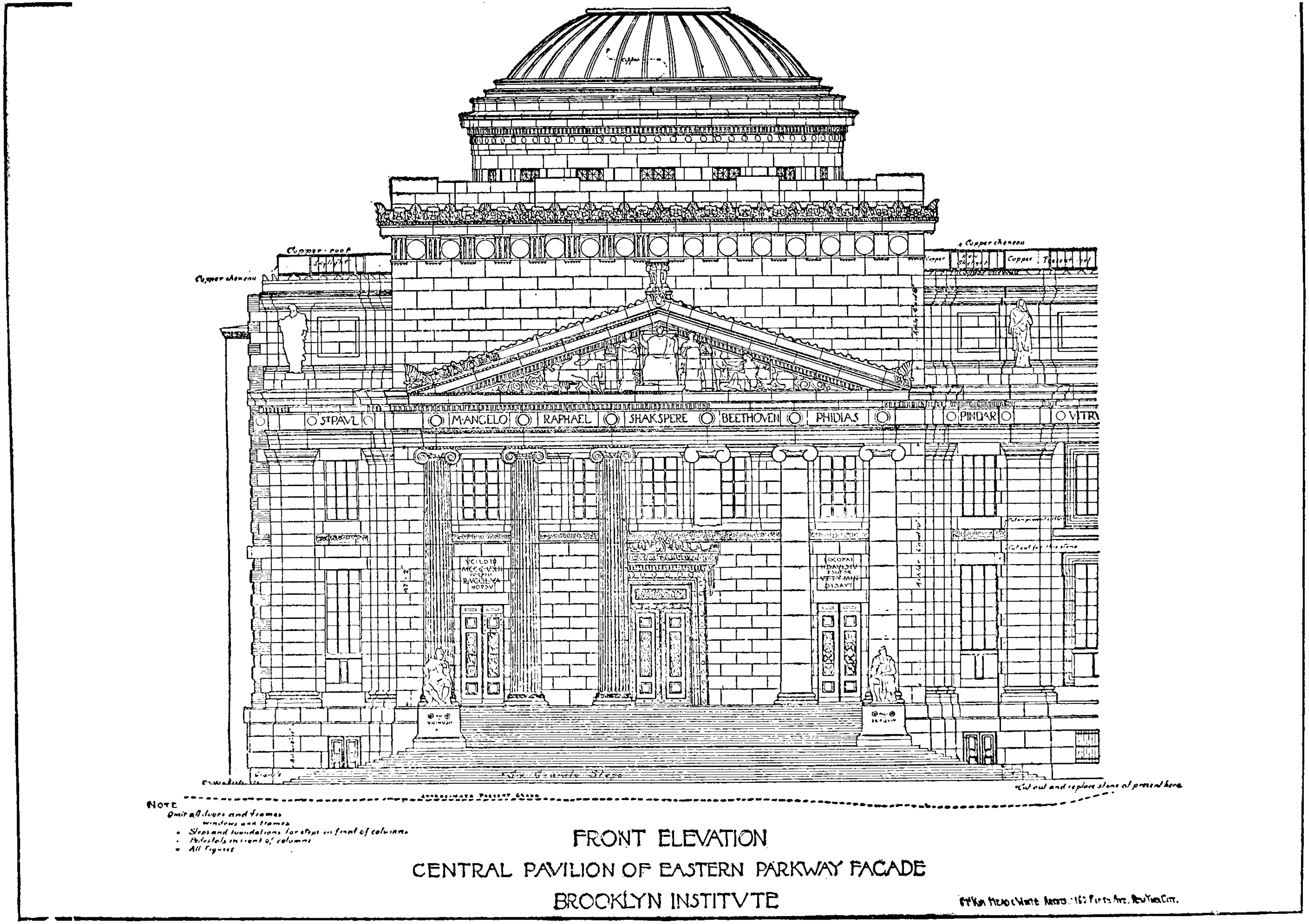

ST PAUL
M·ANGELO
RAPHAEL
SHAKSPERE
BEETHOVEN
PHIDIAS
PINDAR
FRONT ELEVATION
CENTRAL PAVILION OF EASTERN PARKWAY FACADE
BROOKLYN INSTITVTE
NOTE

Fig. 53.

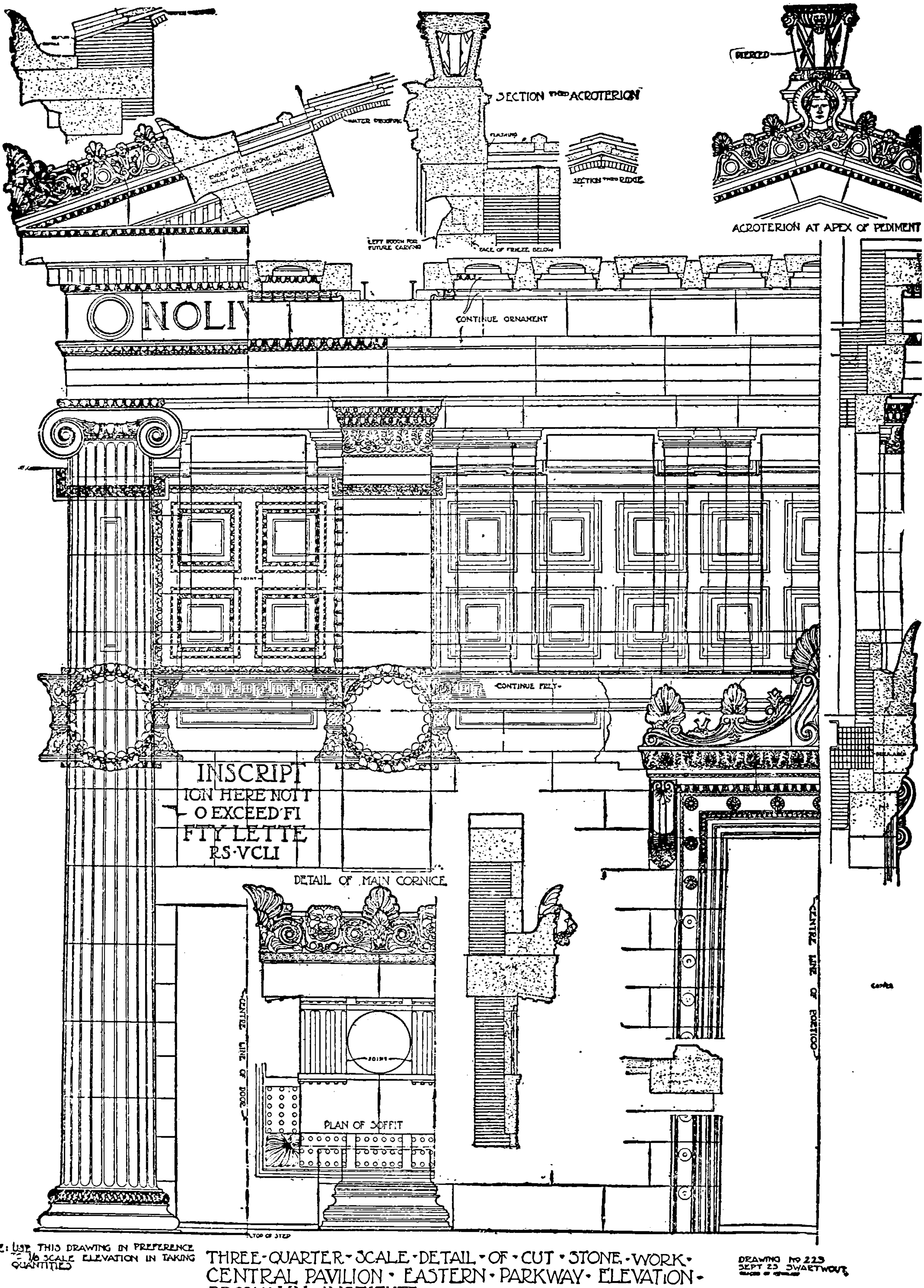

SECTION THRO ACROTERION
SECTION THRO RIDGE
PIERCED
ACROTERION AT APEX OF PEDIMENT
EVERY OTHER STONE SLAB THRO WALL AS HERE SHOWN
LEFT ROUGH FOR FUTURE CARVING
FACE OF FRIEZE BELOW
CONTINUE ORNAMENT
CONTINUE FRET
NOLI
INSCRIPT
ION HERE NOTT
O EXCEED FI
FTY LETTE
RS·VCLI
DETAIL OF MAIN CORNICE
PLAN OF SOFFIT
CENTRE LINE OF DOOR
CENTRE LINE OF PORTICO
TOP OF STEP
USE THIS DRAWING IN PREFERENCE TO 1/8 SCALE ELEVATION IN TAKING QUANTITIES
THREE-QUARTER-SCALE-DETAIL-OF-CUT-STONE-WORK-
CENTRAL PAVILION-EASTERN-PARKWAY-ELEVATION-
BROOKLYN-INSTITUTE-
McKIM-MEAD-AND-WHITE-ARCHTS-
DRAWING No 223
SEPT 23 SWARTWOUT

Fig. 54.

side vestibule, with an interesting arrangement of the ingle-nook and fireplace, and seats each side.

Fig. F shows another arrangement of circular staircase differing from that shown in Fig. A, as it contains space for a service elevator or lift.

Fig. G shows a scissors staircase, which is sometimes used in double houses occupied by different families on each floor. This construction makes a saving of space, as the staircases may be placed under each other, while each family is able to go from floor to floor by its own private staircase. This arrangement is also sometimes used in schoolhouses, where there is height enough to have mezzanine toilet rooms at the landings, with separate stairways for boys and girls in the same given space on plan.

Fig. H shows an arrangement for the fireplace between dining room and living room where space is desired for closets or serving room between. On one side is built the ordinary fireplace with seats on each side, the tiling being carried out to the end of the seats; on the other side the hearth is carried out with brick floor, and the hood is carried out over this so that a basket of coals can be set directly on the brick floor. Sometimes the fire-basket is placed below the floor level, so that the surface comes about on a level with the floor.

Figs. 52 to 55 show working drawings of prominent architectural firms. It should be noted how carefully and clearly everything is drawn—from the lettering to the sculptured parts.

The preliminaries to starting a drawing, are:

Stretch half a sheet of Whatman's Imperial cold-pressed paper, 22 by 15 inches in size. While this is drying, sketch out rapidly with pencil, T-square, and triangles, on a piece of manila detail paper, the main lines of the proposed drawing. This will show the proper placing of the drawing, and save much erasing on the final sheet.

Sometimes tracing paper may be mounted over the Whatman's paper, and a place cut for making the final drawing; or the study may be made directly on the tracing paper over the final sheet, and then cut out and redrawn or transferred.

The paper required for the first drawing is, therefore:

One sheet Whatman's "Imperial" drawing paper.

One yard manila detail paper.

Several yards of Rowney's English tracing paper.

"IITTLE ORCHARD FARM," A COUNTRY RESIDENCE AT CAMP HILL, PENNSYLVANIA

Wilson Eyre, Architect, Philadelphia, Pennsylvania

Built of Buff-Colored Stone, Laid Up and Partly Dashed with Mortar. Roof is of Split Cypress Shingles. For Floor Plans See Page 392

Catalogues. Catalogues and price lists of all standard articles are easily obtained and should be kept at hand, properly indexed, for ready reference, as they contain a great deal of specific information. For close figuring, however, it will not do to rely upon these prices, as the amounts of trade discounts are not always included. These vary greatly from time to time, and often there are two or more discounts, a trade discount, a cash discount, and a variation in discounts made by different merchants, all of which the contractor must become aware of to obtain bottom prices.

All data of this sort should be carefully tabulated for constant reference, in such a form that it may be easily revised and kept, so far as possible, up to date.

The manner and time of payments is a matter to be considered in this connection, as it will permit the contractor to take advantage of cash discounts, which often make a great difference in the cost of certain materials.

Profit. To the actual price of labor and materials must be added the profit and this will need careful consideration. A common method is to add a lump sum to the estimated cost of labor and materials, varying with locality and customer, with the probable sharpness of competition and the circumstances of the contractor. This is a careless method, as it leaves no means for future comparison and no certain knowledge of just what the profits of a given job are.

Percentage. A better way is to base the profits upon a percentage of the estimated cost. This will vary, in ordinary cases, from ten to fifteen per cent, ten per cent being the least that should be expected on any work, and this is not enough for small contracts of two or three thousand dollars; but for large work, where there is a great duplication of parts and processes, it will be enough in most cases. Some contractors, whose workmen are required to perform especially skilful labor, figure fifteen per cent on all labor and ten per cent on materials.

Duplicate Parts. The matter of duplication is an important factor in estimating, as a considerable saving is often made if large quantities of material, either worked or unworked, are required; this is especially true in manufactured parts, such as doors and windows, columns, balustrades, etc. Modern machines are capable of duplication with astonishing rapidity, and workmen can put together similar parts more quickly and cheaply than variable members.

Transportation. The distance of the work from the shop of the contractor, or from centers of manufacture, will affect the cost to a marked degree, as much time is consumed in teaming and especially in handling material a number of times.

If communication between the works and the building site can be established by water, it will usually save considerable expense for freight and handling, with perhaps less risk of damage, and consequently less expense for crating and boxing. A careful study should be made of the means of transportation to each different building site from the shop, the office, and the mill, and the data kept for future reference, subject to varying rates and conditions, to change of seasons, and amounts to be transported.

These are some of the more important matters which require preliminary consideration as affecting all estimates, and are only a small part of the real questions involved, as different localities and customs require different treatment, and numerous questions will arise to confront the contractor, all of which may be successfully met, as we have seen, by the exercise of care and judgment.

Methods. Estimates are formed by many and varying methods, depending upon the degree of accuracy required, the capability of the contractor, and the character of the building. A broad division may be made between approximate estimates and accurate detailed estimates, only the latter of which should be considered when it is the intention to actually carry out the work under a definite contract.

Approximate Estimates. Approximate estimates are obtained with varying degrees of accuracy by several methods, the most convenient and reliable of which is the system of *cubing*; i.e., the cubical contents of the proposed building is obtained and multiplied by a given price per cubic foot. This rate is obtained by careful comparison of the plans and requirements with similar buildings which have been erected under conditions as like as possible to the conditions under which the proposed building can be erected.

Several methods are used to determine the cubical units, depending upon the size and shape of the proposed building. One method is to multiply the square feet in the plan of the building by the height from half-way the depth of foundations to half-way up the roof. Another system uses the height from the bottom of the foundation, and another obtains the actual cubical contents. Any of these may be used if the data for comparison is obtained in the same way, but all are subject to important variations which experience and judgment alone will determine. For instance, if the contour of the building is very uneven, with low portions, such as porches and sheds, and high portions, such as towers and cupolas, these must either be omitted from the whole and compared separately, or a lump sum be added or subtracted according to the size and elaboration of these members.

Another variation arises in the size of rooms, giving a ratio of partitions and division walls which is not constant, and of course a large building with many duplicate parts will require a different rating from a smaller one, so that the method of estimating by cubing is at best approximate, and its degree of accuracy depends largely upon the experience and judgment of the contractor. Even long experience will afford no safe-guard against unusual elaboration of interior or exterior, so that cube rates can only be applied to buildings of ordinary character, and comparisons are only reliable between buildings of like description and uses, as the treatment of even the same materials will vary largely in buildings of varying uses.

The height of the building will not increase the cube rate proportionately, unless the internal voids are alike, although it is certain that the higher one builds from the ground, the more time and expense it requires to put the material in place, to say nothing of thicker walls and necessarily heavier construction.

Estimating by the Square. A convenient method of estimating is by the square of one hundred surface feet. This is especially applicable to office buildings, schools, mills, stables, and all buildings where the floors are few in number or similar in plan. For one story buildings the price per square is taken to include the roof, walls, floor, and foundations, but for buildings of two or more stories the price per square should be taken separately for each floor, the lower floor being priced to include the foundations and the top floor to include the roof.

This method of estimating by the square is not so accurate as by cubical contents, but the results are often more convenient and adaptable, because the tabulation of the square area of the various floors may be easily reduced to terms of accommodation for public

the sub-soil, the presence of ledges or water below the surface which will require especial or costly treatment, etc. Often a deposit of sand will be found upon the site which will not only save carting away of material excavated, but, if of proper quality, it may be used for the work. Such items are constantly occurring so that a knowledge of existing conditions will be of great advantage to the estimator.

Regarding underground conditions, there is always an element of chance, as the most thorough examination will not always reveal hidden perils; the author knows of a case where a mason had contracted for the building of a sewer, and was in a fair way to make a good profit, when a narrow vein of quicksand was uncovered, to overcome which not only took away all the anticipated profit but caused a severe loss to the contractor besides.

Ground water is another source of danger and it will be well for the contractor to closely examine his contract, to see to what extent he is to furnish protection from this source, as a vein of water which may have been temporarily stopped or diverted by the operation of building, will sometimes unexpectedly make its presence known during or after the completion of the work, when it may become a source of great annoyance and expense to the contractor if he has agreed to insure a waterproof job. Numerous illustrations could be given of the danger from unforeseen causes which can at best be only partially obviated by the most careful examination.

In order to accurately take off a building either by quantities, square or cube, a good knowledge of arithmetic is necessary; and, while we may assume that the reader already possesses this knowledge, it may be well to include some of the essential rules of that branch of arithmetic which is known as mensuration.

This consists primarily in the science of obtaining definite data regarding given figures or surfaces, such as areas, solids, capacity, linear dimensions, and comparisons of bodies.

Definitions. The *area*, or superficial dimension of any figure is the measure of its surface, without regard to its thickness or any other dimension.

The *cubical contents* of any figure is the measure of its solidity, or whole capacity, and has reference to the three dimensions, length, breadth, and thickness.

If the figure is considered as hollow, then the cubical contents becomes its *capacity* or capability of containing matter.

The *linear dimension* of a figure is expressed by its length in a direct line in any direction and has no regard to breadth or thickness.

Units. The application of these dimensions is made by fixing a unit by which the figure may be compared and the required dimension obtained; thus, for calculating the area of a figure the unit is usually a square, one side of which is the unit of length, and the area becomes the square measure of the figure.

This is expressed in common terms by square inch, square foot, square yard, or any other given unit and the measure of the surface is computed by obtaining the number of these square units which are contained in the figure, the process being called squaring.

In a similar manner the cubical contents or solidity of a figure is obtained by computing the number of cubical units which it contains, which is called cubing it.

Rules. Numerous rules have been adopted for obtaining these dimensions when given dimensions are known, and a tabulation of some of the more important and useful of these follows, by means of which it is hoped that the student may be able to solve most of the ordinary problems which will arise in common practice.

RULES AND TABLES

TABLE OF MULTIPLES

Circumference	of a circle	=	diameter × 3.1416
Area	of a circle	=	square of the radius × 3.1416
Area	of a circle	=	square of the diameter × 0.7854
Area	of a circle	=	square of the circumference × 0.07958
Area	of a circle	=	half the circumference × half the diameter
Radius	of a circle	=	circumference × 0.159155
Radius	of a circle	=	square root of the area × 0.56419
Diameter	of a circle	=	circumference × 0.31831
Diameter	of a circle	=	square root of area × 1.12838
Side of an inscribed square		=	diameter × 0.7071
Side of an inscribed square		=	circumference × 0.2251
Side of an equal square		=	diameter × 0.8862
Area of a triangle		=	base by $\frac{1}{2}$ the altitude

Area of an ellipse	= product of both diameters × .7854
Surface of a sphere	= circumference × diameter
Surface of a sphere	= square of the diameter × 3.1416
Surface of a sphere	= square of the circumference × 0.3183
Solid contents of a sphere	= surface × $\frac{1}{6}$ of its diameter
Solid contents of a sphere	= cube of diameter × 0.5236
Diameter of a sphere	= square root of surface × 0.56419
Diameter of a sphere	= cube root of solidity × 1.2407
Circumference of a sphere	= cube root of solidity × 3.8978
Solid contents of a cone or pyramid	= area of base × $\frac{1}{3}$ altitude
Surface of a cube	= six × area of one side
Area of trapezoid	= altitude × $\frac{1}{2}$ sum of parallel sides

NOTE—Volumes of similar solids are to each other as the cubes of their similar lines

MEASURE OF LINES AND SURFACE

1. To find the area of a parallelogram: *Rule*—Multiply the length by the breadth or perpendicular height. See Fig. 1

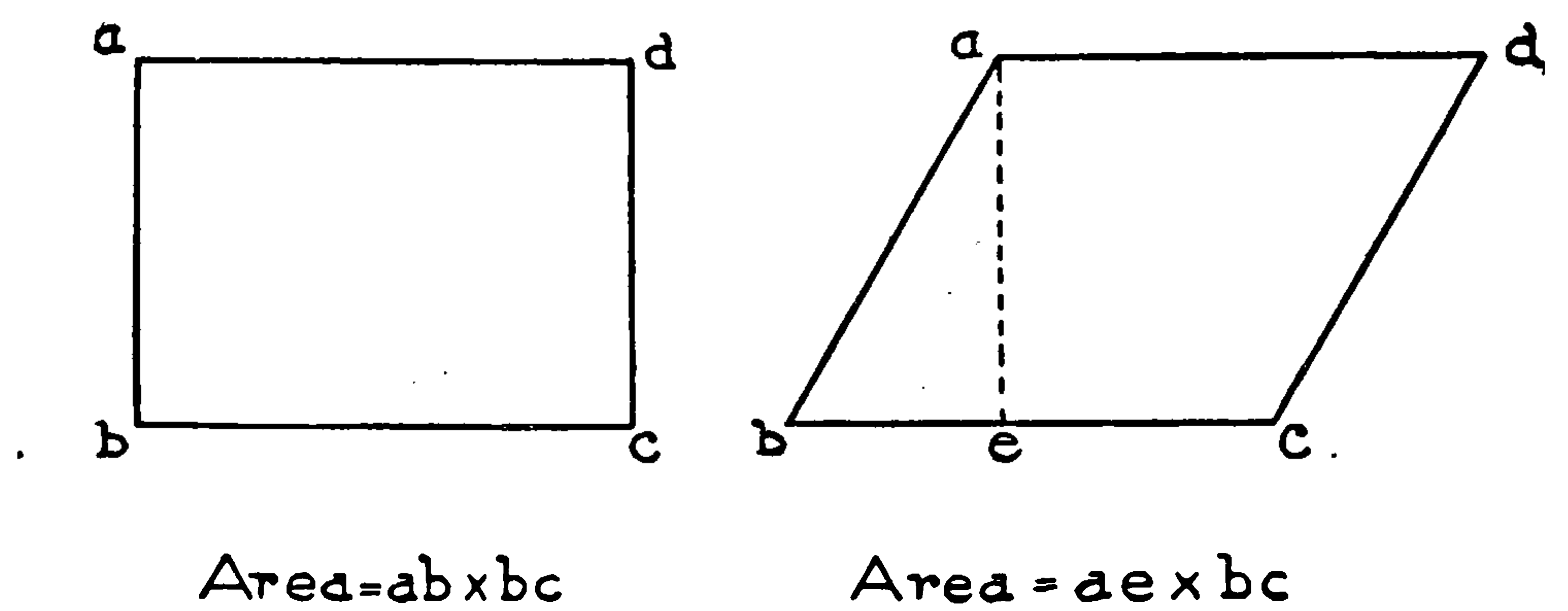


Fig. 1.

2. To find the area of a triangle: *Rule*—Multiply the base by half the altitude. See Fig. 2.

3. To find the hypothenuse of a right-angled triangle when the base and perpendicular are known: *Rule*—Add together the square of the known sides and extract the square root of the sum. See Fig. 3.

4. To find one side of a right-angled triangle when the hypothenuse and the other side are known: *Rule*—From the square of the hypothenuse subtract the square of the given side, and

the square root of the remainder will be the other side. See Fig. 4.

5. To find the area of a trapezium: *Rule*—Divide the figure into triangles by drawing a diagonal and the sum of the areas of these triangles will be the area of the trapezium. See Fig. 5.

6. To find the area of a trapezoid: *Rule*—Add the two parallel sides and mutliply by one-half the perpendicular distance between them. See Fig. 6.

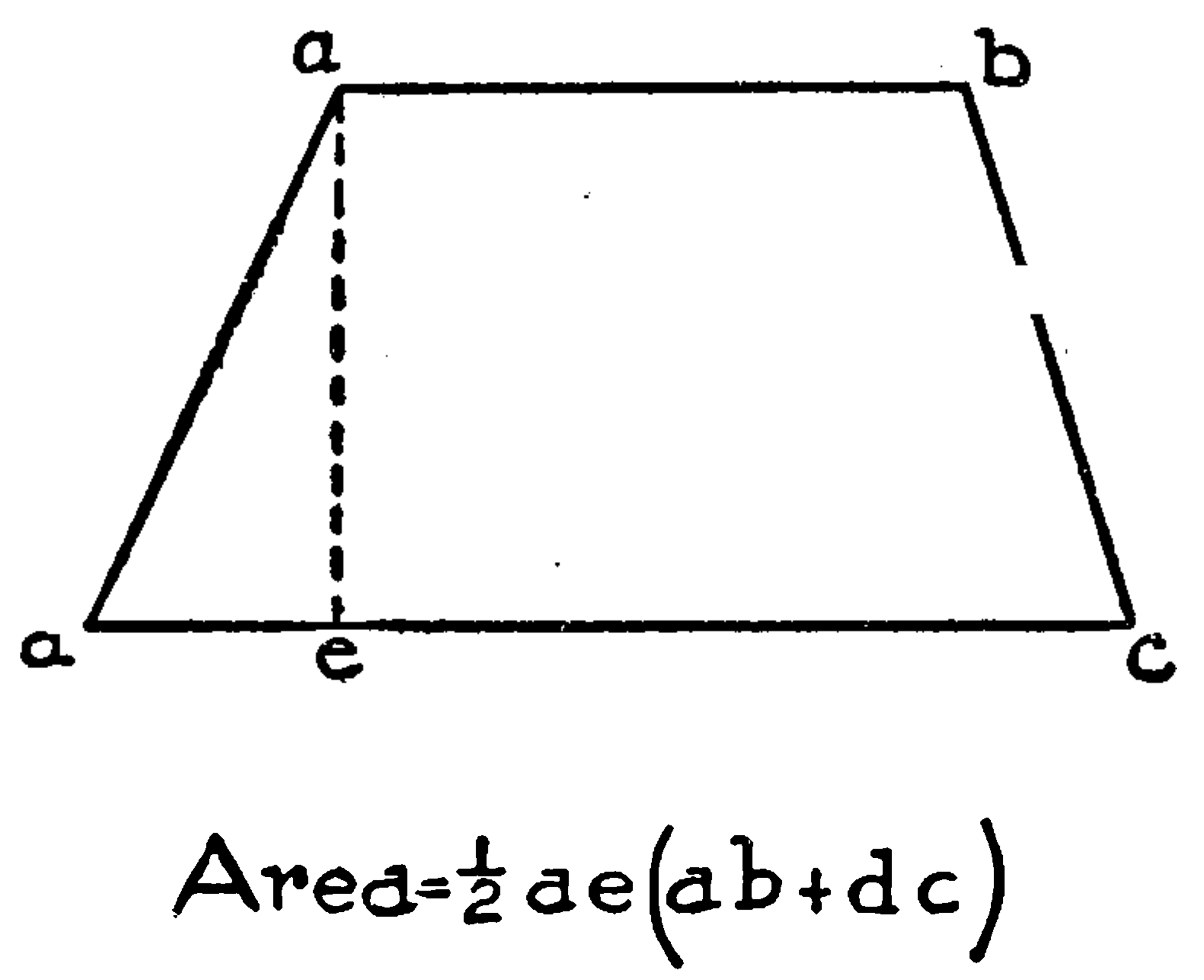


Fig. 6.

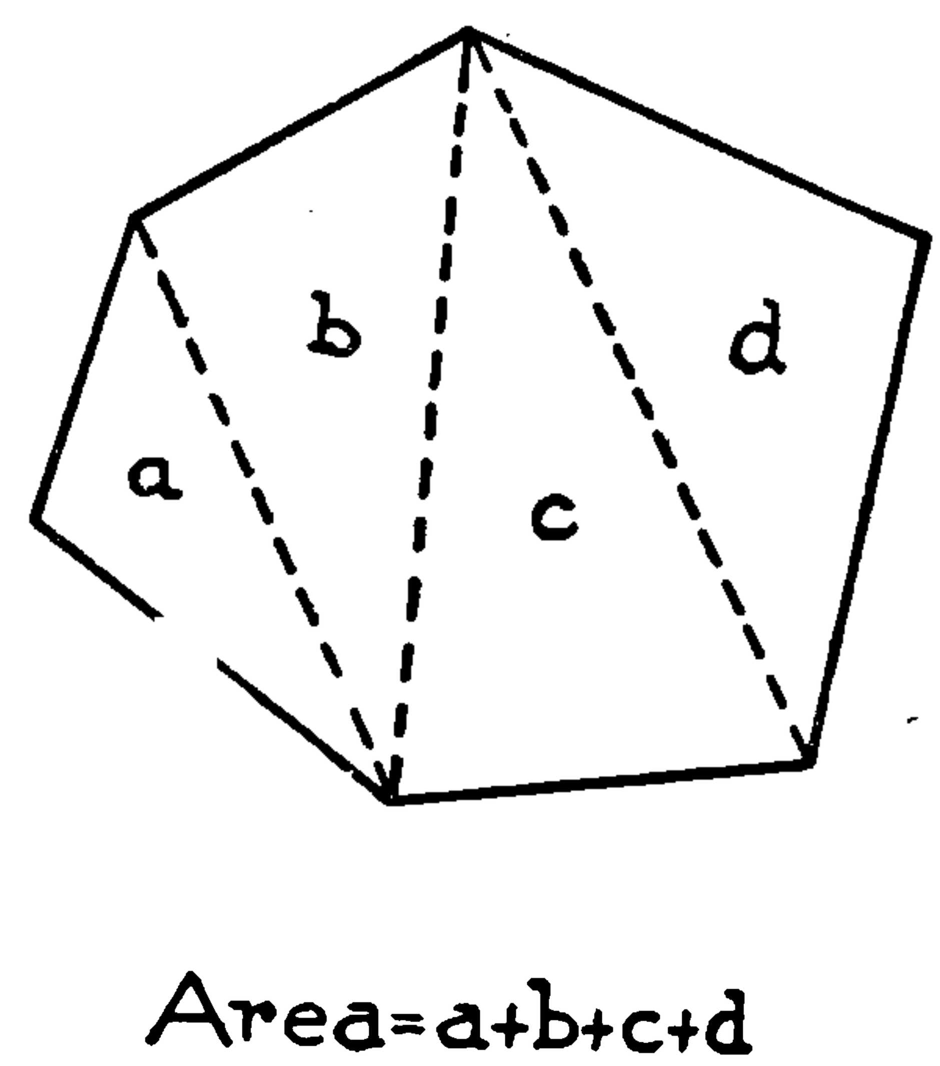


Fig. 7.

7. To find the area of a regular polygon: *Rule*—Multiply one side by half its perpendicular distance from the center, and this product by the number of sides.

Table of Multiples to Compute Measurements of Regular Polygons, the Side of the Polygon Being Unity

Name of Polygon	No. of Sides	A Area	B Radius of Circum-scribing Circle	C Length of the Side.	D Radius of Inscribed Circle
Triangle	3	0 433013	0.5773	1.732	0.2887
Tetragon	4	1	0.7071	1.4142	0.5
Pentagon	5	1.720477	0.8506	1.1756	0.6882
Hexagon	6	2.598076	1	1	0.866
Heptagon	7	3 633912	1.1524	0.8677	1.0383
Octagon	8	4.828427	1.3066	0.7653	1.2071
Nonagon	9	6.181824	1.4619	0.684	1.3737
Decagon	10	7.694209	1.618	0.618	1.5383
Undecagon	11	9 36564	1.7747	0.5634	1.7028
Dodecagon	12	11 196152	1.9319	0.5176	1.866

8. To find the area of a regular polygon when the length of a side only is given: *Rule*—Multiply the square of the side by the number opposite the name of the polygon in Column A.

9. To find the radius of a circumscribing circle when the

length of a side only is given: *Rule*—Multiply the length of a side of the polygon by the number in Column B.

10. To find the length of side of a polygon that is contained in a given circle, when the radius of the circle is known: *Rule*—Multiply the radius of the circle by the number opposite the name of the polygon in Column C.

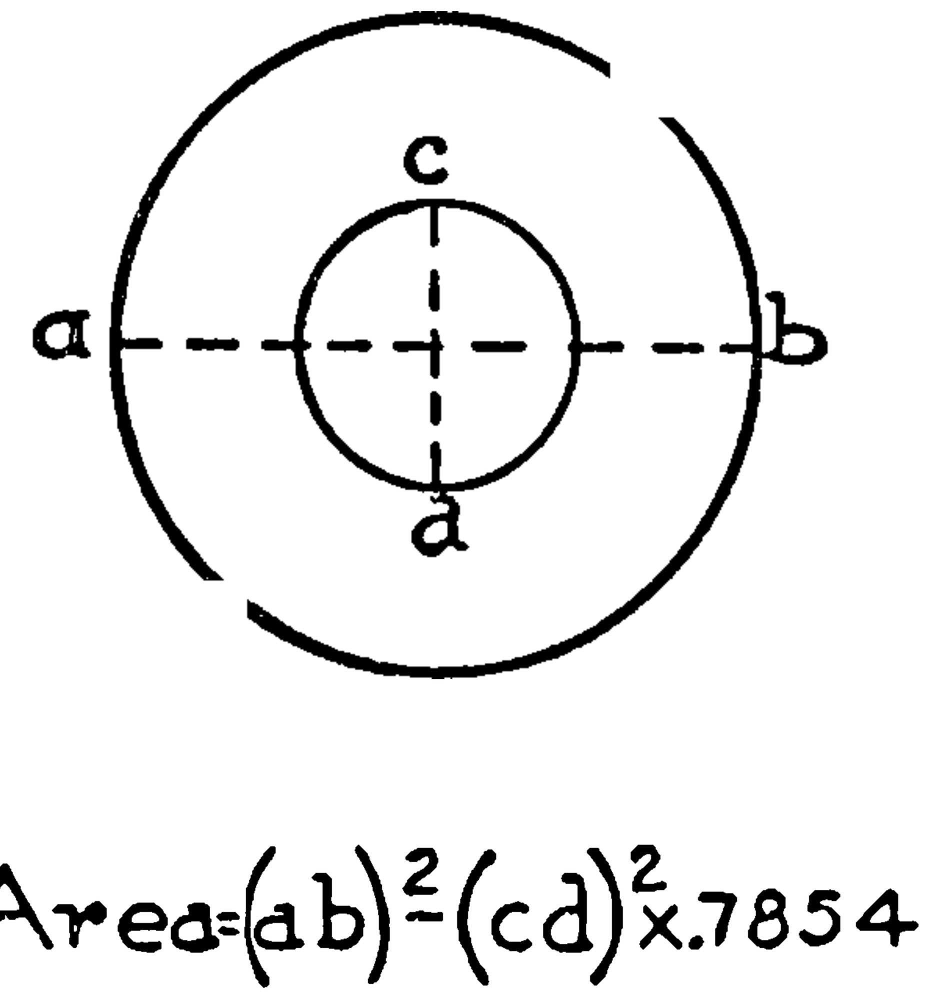


Fig 8.

11. To find the radius of a circle that can be inscribed in a given polygon, when the length of a side is given: *Rule*—Multiply the length of a side of the polygon by the number opposite the name of the polygon in Column D.

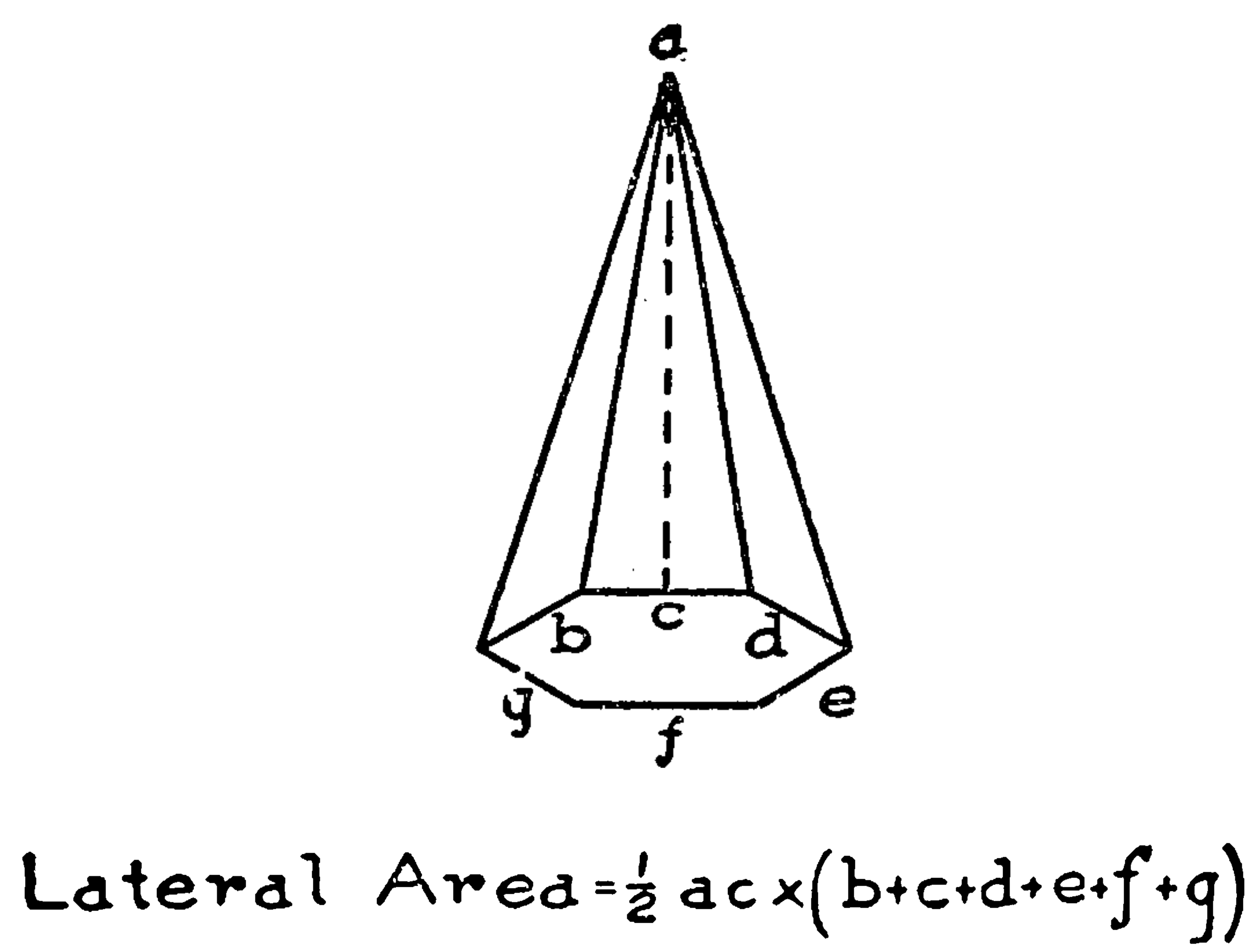


Fig. 9.

12. To find the area of an irregular polygon: *Rule*—Divide the polygon into triangles and add the areas of all the triangles. Fig. 7.

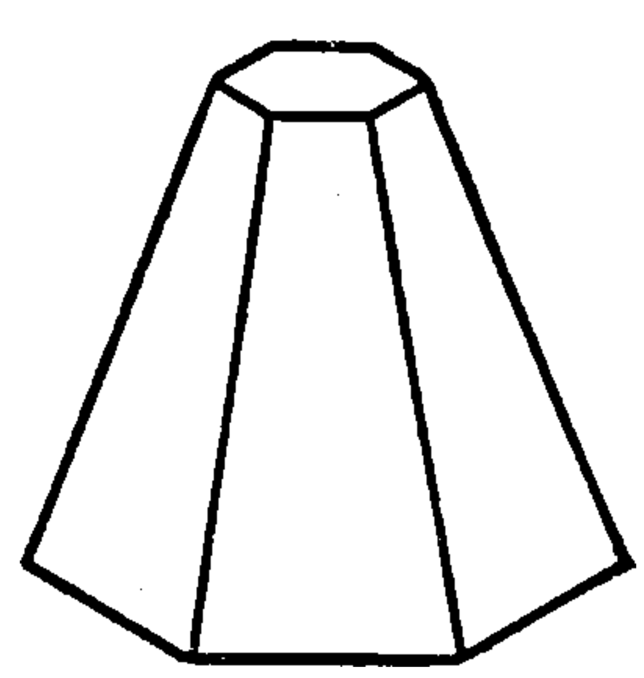


Fig 10 Frustrum of Pyramid.

13. To find the area of a ring included between the circumferences of two concentric circles: *Rule*—Square the diameters and multiply difference between the squares by .7854. Fig. 8.

14. To find the area of an ellipse: *Rule*—Multiply the two axes together and the product multiplied by .7854 will be the area.

15. To find the circumference of an ellipse: *Rule*—Square

AREAS OF CIRCLES

Size	Area	Size	Area	Size	Area	Size	Area
1/8	0 0123	10	78 54	30	706.86	65	3318 3
1/4	0 0491	1/2	86.59	31	754.76	66	3421.2
3/8	0.1104	11	95 03	32	804.24	67	3525 6
1/2	0 1963	1/2	103 86	33	855.30	68	3631.6
5/8	0 3067	12	113 09	34	907.92	69	3739 2
3/4	0.4417	1/2	122.71	35	962.11	70	3848 4
7/8	0 6013	13	132 73	36	1017.8	71	3959 2
1	0.7854	1/2	143.13	37	1075.2	72	4071 5
1/8	0 9940	14	153 93	38	1134.1	73	4185 3
1/4	1.227	1/2	165 13	39	1194.5	74	4300 8
3/8	1.484	15	176.71	40	1256 6	75	4417.8
1/2	1.767	1/2	188 69	41	1320 2	76	4536.4
5/8	2.073	16	201 06	42	1385 4	77	4656 0
3/4	2.405	1/2	213 82	43	1452 2	78	4778 3
7/8	2.761	17	226 98	44	1520 5	79	4901.6
2	3.141	1/2	240.52	45	1590 4	80	5026.5
1/4	3.976	18	254 46	46	1661.9	81	5153.0
1/2	4.908	1/2	268 80	47	1734.9	82	5281.0
3/4	5.939	19	283 52	48	1809.5	83	5410 6
3	7 068	1/2	298 64	49	1885.7	84	5541 7
1/4	8.295	20	314 16	50	1963.5	85	5674 5
1/2	9 621	1/2	330 06	51	2042 8	86	5808.8
3/4	11 044	21	346 36	52	2123 7	87	5944 6
4	12 566	1/2	363 05	53	2206 1	88	6082.1
1/2	15.904	22	380.13	54	2290 2	89	6221 1
5	19 635	1/2	397 60	55	2375 8	90	6361.7
1/2	23 758	23	415 47	56	2463.0	91	6503 8
6	28.274	1/2	433 73	57	2551.7	92	6647 6
1/2	33.183	24	452 39	58	2642 0	93	6792 9
7	38.484	1/2	471.43	59	2733 9	94	6939.7
1/2	44.178	25	490.87	60	2827.4	95	7088 2
8	50.265	26	530 93	61	2922 4	96	7238 2
1/2	56 745	27	572 55	62	3019 0	97	7389'8
9	63 617	28	615 75	63	3117 2	98	7542 9
1/2	70 882	29	660 52	64	3216 9	99	7697 7

To find the circumference of a circle when diameter is given, multiply the given diameter by 3 1416

To find the diameter of a circle when circumference is given, multiply the given circumference by 31831

the two axes and multiply the square root of half their sum by 3.1416.

AREAS OF SOLIDS

16. To find the lateral surface of a prism: *Rule*—Multiply the perimeter of the base by the altitude.

17. To find the lateral surface of a regular pyramid: *Rule*—Multiply the perimeter of the base by one-half the slant height. Fig. 9.

18. To find the lateral surface of the frustrum of a regular pyramid: *Rule*—Multiply the perimeters of the two ends by one-half the slant height. Fig. 10.

Roofers	$3.50..........
Roofers' Helpers	2.25..........
Steam Fitters	4.40..........
Steam Fitters' Helpers	2.25..........
Plumbers	4.40..........
Plumbers' Helpers	1.50..........
Gas Fitters	4.40..........
Gas Fitters' Helpers	2.25..........
Electricians	3.60..........
Painters	3.00..........

EXCAVATION

Many considerations, seen and unforeseen, enter into the cost of excavations, of which the unforeseen conditions can, at best, be only judged of, making it more important that known circumstances should be carefully considered. Among these may be mentioned the varying kinds of soil and rock, the depth to which the excavation can be carried without shoring, the distance to which the excavated material is to be carried, and whether pumping or bailing will be necessary. Material excavated to a depth of six feet can be thrown on to the surface, but below this depth a stage will be necessary, or else it must be carted or wheeled out.

In taking off quantities for excavation, work in trenches should be kept separate from large areas, as the cost will be greater on account of lack of room for working.

Where the nature of the soil is uncertain, borings should be made or test pits dug, not only to reveal the character of the material, but to determine the depth at which "hard pan" is to be found. This is especially necessary when the specifications call for the foundations of any structure to be carried to hard pan, without reference to the drawings, or when no definite depth of footing is shown.

In the absence of full instructions, it is best to figure to excavate a foot outside of all walls or footings, to give ample working room; and trenches for pipes, etc., should be enough wider than the pipe to allow of working all around. Hollows should be made where hubs rest, so as to give a full bearing for the pipe.

In taking quantities in irregular ground, the plot should be divided into a number of definite squares and the contents of each square taken separately. See Fig. 11.

Cost of Excavating. The cost of excavating varies in different localities and under differing conditions, no two cases agreeing in details or in execution. The governing factors are experience and judgment. Excavating is usually priced by the cubic yard and will average about as follows:

Picking—12 cu. yds. per day at $2.40	$0.20
Throwing out—12 cu. yds. per day at $2.40	.20
Wheeling 50 ft. away	.10
	$0 50

Excavations in clay or very hard soil may cost from $0.50 to $1.00 while rock excavations will cost from $2.00 to $10.00, or more, according to the nature and position of the rock. Re-filling and packing around walls will cost usually from $\frac{1}{4}$ to $\frac{1}{2}$ of the price of earth excavations. Excavation of sand or loose gravel, which can be done by means of a horse scraper, will cost $0.30 per cu. yd.

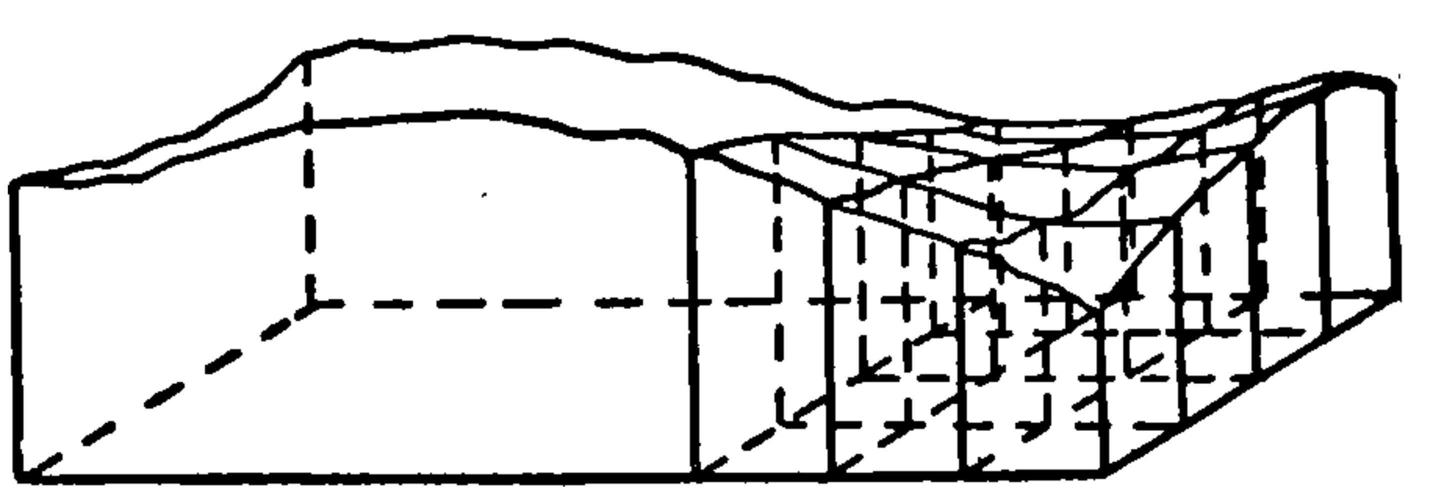


Fig 11 Division of plot

Pile Foundations. The cost of piling varies with the nature of the soil and the length of pile necessary. Taking a 30-ft. pile as an average length, then piles 30 ft. long, driven and cut off level to receive footings, will cost $3.50 to $4.00 per pile.

STONE WORK

Stone walls are figured either by the perch or the cubic yard.

In taking off a stone foundation, it is customary to take the corners twice, that is, each different face of the wall is measured from out to out, thus doubling the corners. This makes up for the extra labor of laying up the corners.

The cost of a perch of rubble foundations laid in Rosendale cement mortar, 1 to 3, may be taken as follows:

1 perch of stone		$1.25
½ barrel cement	at $1.20	.60
⅙ load sand	at 1.75	.29
⅓ day, mason	at 4.50	1.50
¼ day, laborer	at 2.40	.60
Total cost per perch		$4.24

A perch of rubble wall laid in Portland cement mortar, 1 to 3, will cost:

1 perch of stone		$1.25
½ barrel Portland cement	at $2.10	1.05
⅙ load sand	at $1.75	.29
⅓ day, mason	at 4 50	1.50
⅓ day, laborer	at 2.40	.80
Total cost per perch		$4.89

Cut Stone. Cut stonework is figured by the cubic foot, the prices differing according to the amount of labor involved in the cutting; and this will depend somewhat upon the nature of the stone, a hard stone being more expensive to prepare than a soft one. The principal kinds of stone used in building are granite, limestone, sandstone, marble, and bluestone.

Granite. Granite is one of the hardest stones to quarry and prepare, and, on account of its cost it is not so freely used as limestone or marble. Granite in rough blocks from the quarry will cost 45 to 60 cents a cubic foot, the cutting of beds and joints will cost 25 cents for each square foot of surface so treated. If the face is pitched off to a line with rock face, it will cost 25 cents per square foot, while hammering in 8-cut work will cost 70 cents per square foot. Quincy granite will cost, in the rough, about double this, or $1.20 per cubic foot; the cutting will cost one-third more.

From this data we may deduce the following scale:

Granite, in rough blocks at quarry,	per cu. ft.	$0.60
Add for beds and joints	per sq. ft.	.25
Add for rock face, pitched off to a line,	per sq. ft.	.25
Add for 8-cut work	per sq. ft.	.70

Hence the facing of an average wall with 8 inches of granite

The rise of these caps is about 10 inches, and the rise of the sill 5 inches. These sets for an average sized window, say 4-foot opening, will cost for a 4-inch reveal $10, and for an eight-inch reveal $15.

Sandstone. The cost of dressed sandstone is about 10 per cent more than that of limestone.

Setting. The cost of setting cut stone may be taken at 15 cents a running foot for window trimmings and ashlar work, and

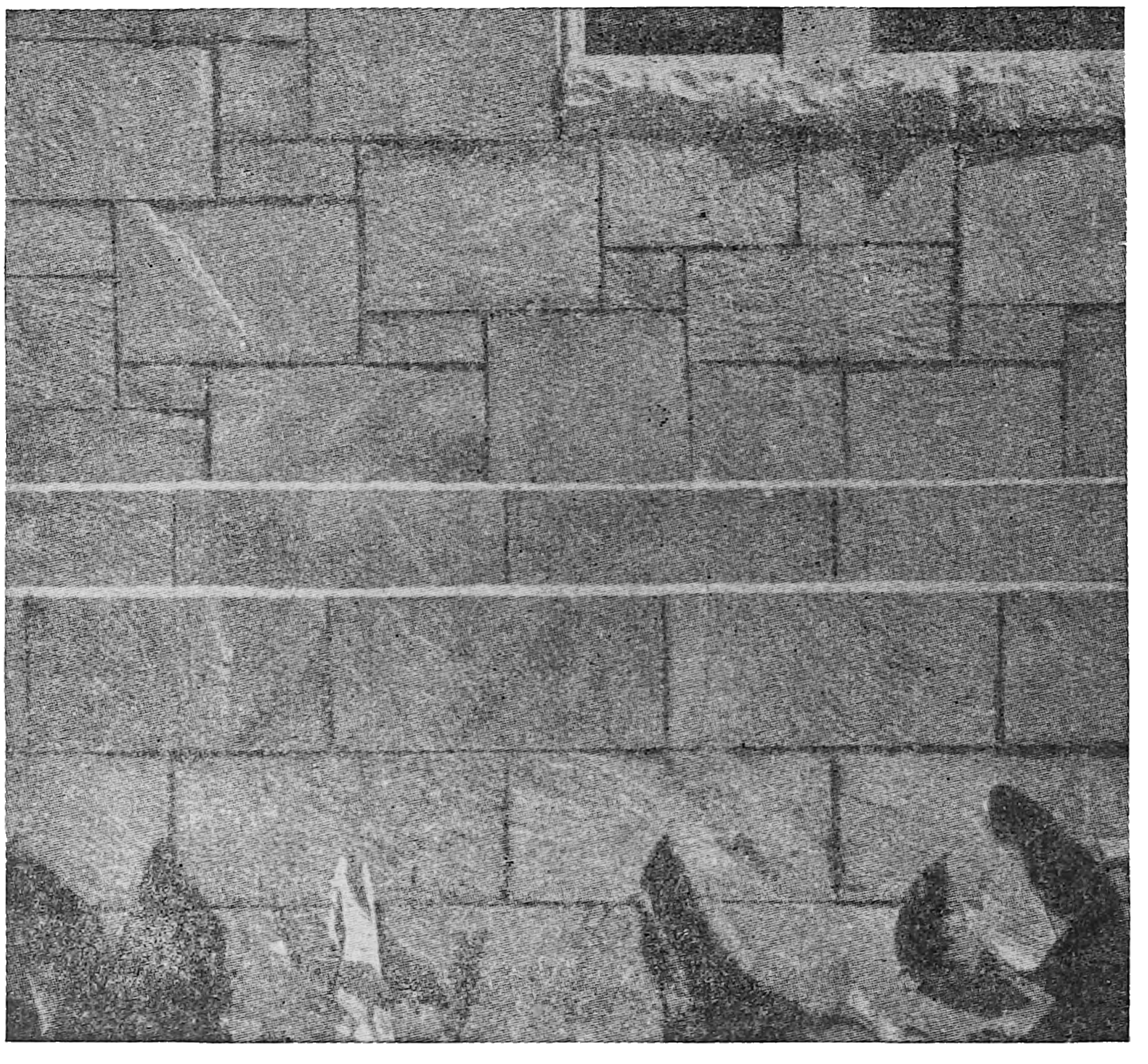


Fig 13 Seam-Faced Granite Wall.

20 cents for platforms, water table, steps, etc. Trimming and fitting at the building will cost about 10 cents per cubic foot.

The foregoing prices are based upon quarry-men's wages at $2.50 per day, and stone cutters' wages at $4.00 per day.

Much of the cutting and finishing of stone is done by machinery, so that the question of wages will not enter into the preparation of the stock so largely as in many other branches.

Marble. A more expensive stone to use is marble, which can be obtained in a variety of colors, in different parts of the country. The price of marble differs in different localities but for general purposes may be taken as about double the figures which we have quoted for limestone.

Bluestone. Bluestone is used in the East mainly for flagging, copings, etc., but is used to a considerable extent for building, in Central and Western sections. The price of bluestone flagging 3 inches thick with trimmed joints and face planed and dressed, will be 65 cents a square foot; with natural face, 35 cents to 45 cents. Bluestone ashlar 8 inches thick with natural face and dressed joints, will cost $1.00 per square foot, and 15 cents a square foot for setting.

Seam-Faced Granite. In some localities granite, lying in upturned strata with open weathered seams, is to be obtained. This is used for facing walls in ashlar work, being set on edge in the wall with the seam-face showing; this will cost, in place, 4-inch to 8-inch thick, from 60 cents to 75 cents a superficial foot. See Fig. 13.

BRICKWORK

Brickwork is usually estimated by the thousand bricks, but is sometimes priced by the cubic foot at 40 cubic feet to a thousand. A mason in one day will lay from 800 to 1,000 common bricks, or 300 to 400 face bricks.

The number of bricks in a wall may be found by multiplying the superficial area by $7\frac{1}{2}$ for each 4 inches of the thickness of the wall. Openings of the size of ordinary windows are generally deducted, but very small openings will cost more to make than the deduction. An allowance for breakage should be made of 5 per cent.

Mortar. Bricks are laid in mortar made of *lime* or *cement*, according to the strength required. Lime mortar should not be used in damp situations, or where great strength is required. The difference in cost of lime and cement mortar is so little that cement mortar is generally used.

The building laws of some cities require brick work to be laid in cement mortar for a certain part of the height.

Cement mortar makes a darker joint, but where a white joint is required it can be obtained, without loss of strength, by using Portland cement and lime mortar.

Cost. The cost of brickwork by the thousand in various kinds of mortar may be analyzed as follows:

In 1 – 3 lime mortar,

1,000 bricks	$ 9.00
3 bu. lime at $.36 per bu.	1.08
½ load of sand at $1.75 per load	.88
10 hours, mason at $.60 per hour	6.00
10 hours, tender at $.30 per hour	3.00
	$19.96

In 1 – 3 Rosendale cement mortar:

1,000 bricks	$9.00
1½ bbl. Rosendale cement at $1.20	1.80
½ load sand	.88
10 hours, mason at $.60 per hour	6.00
10 hours, tender at $.30 per hour	3.00
	$20.68

In 1 – 3 Portland cement mortar:

1,000 bricks	$ 9.00
1¼ bbl. Portland cement at $2.10	2.62
½ load sand at $1.75	.88
10 hours, mason at $.60 per hour	6.00
10 hours, tender at $.30 per hour	3.00
	$21.50

From these tables we may deduce an approximate estimate in round numbers as follows:

1,000 bricks laid in 1 – 3 lime mortar	$20.00
1,000 bricks laid in 1 – 3 cement mortar	21.00
1,000 bricks laid in 1 – 3 Portland cement mortar	22.00

So that, on a job of ordinary size, the difference between lime and cement mortar ought not to be considered, where cement mortar will give assurance of greater stability.

Face Bricks. Face bricks in great variety, are to be had either plain or moulded, and in a variety of colors. On ordinary face brickwork a mason with tender will lay about 300 to 400 bricks in a day.

MISCELLANEOUS DATA

CHIMNEYS

Chimneys may be quickly estimated by the lineal foot of height, as follows:

1 flue 8 in. x 8 in. per foot	$0.90	with flue lining	$1.10
1 " 8 in. x 12 in. per foot	1.00	" " "	1.25
1 " 12 in. x 12 in. per foot	1.20	" " "	1.50
2 flues 8 in. x 8 in. per foot	1.40	" " "	1.80
2 " 8 in. x 12 in. per foot	1.75	" " "	2.20

FLUE LINING

Net price per foot, outside dimensions.

4½ in. x 8½ inches	$.10	8½ in. x 17½ inches	$.32
4½ in. x 13 "	.16	13 in. x 13 "	.30
8½ in. x 8½ "	.16	13 in. x 18 "	.42
8½ in. x 13 "	.22	18 in. x 18 "	.70

For openings add one-third.

MASONS' SUPPLIES

Portland Cement	$ 2 10 per bbl.
Rosendale Cement	1.20 " "
Extra Lime for Skimming	1.15 " "
No. 1 Lime for Mortar	1 05 " "
Vermont Lime	1.20 " "
Plaster, 250 lb. bbls.	1.60 " "
Mortar Color, Red, in bbls.	.01¼ per lb.
Mortar Color, Red, in 100 or 200 lb. keg	.01½ " "
Mortar Color, black	.03½ " "
Philadelphia Pressed Brick, for fireplaces	35.00 per M.
Fire Brick	35.00 " "
Best Plastering Hair	.25 per bush.
Mortar Hods	1.50 each
Brick Hods	1 25 "
10-in. Mortar Hoes	.50 "
Good No. 2 Shovels, square point, plain back	.75 "
Sand Screens, wood leg	6.00
Bolted Dump Barrows	2.00

Metal Corner Bead		$0.04 per ft.
Iron Rim and Cover, 20 in. diameter		3.50 each
" " "	18 in. "	3.00 "
" " "	15 in. "	2.50 "

CELLAR COLUMNS

For cellar supports, in place of brick piers, pipe columns consisting of a steam pipe filled with cement, under a patent, are coming into general use in many localities.

These columns cost less, and take up less room than a brick pier of equal strength. The prices are as follows:

Size.	7 Ft.	8 Ft.	9 Ft.	10 Ft.
3 in.	$1.65	$1.90	$2.20	$2.65
3½ in.	1.90	2.20	2.65	3.15
4 in.	2.75	3.25	3.80	4.40
4½ in.	4.00	5.00	5.50	6.00
5 in.	5.00	5.85	6.65	7.55
6 in.	6.00	6.95	8.00	9.30

EARTHEN DRAIN PIPE

For sewer and cesspool connections and general drainage, earthen vitrified drain pipes are used. These are laid in cement and, if well below frost or danger of breaking, make a more durable pipe than cast iron, besides being much less costly.

Net Price of Standard Vitrified Pipe

Inside Diameter	Price per Foot	Bends and Curves	Weight per Foot
2 in.	$0.05	$0.17	6 lbs.
3 in.	.05	.17	8 "
4 in.	.07	.23	10 "
5 in.	.08¾	.30	12 "
6 in.	.10	.38	16 "
8 in.	.17	.70	24 "
10 in.	.26	1.00	34 "
12 in.	.35	1.40	45 "
15 in.	.47	1.90	67 "
18 in.	.60	2.38	86 "

CARPENTRY

The Carpenter-Work of a building includes, in general, the skeleton or frame, if a wooden building, the floor timbers, studs of partitions and walls, rafters, the covering in of the frame, with its exterior finish and clapboards, siding or shingles, the flooring, furring, grounds, and beads. This practically covers the constructive woodwork or carpentry proper, while to the term joinery belongs the outside and inside finish, windows and doors, sheathing and dado, stairs and fixtures.

In many sections the general term carpentry covers all woodworking and covering, while in others the distinction between the carpenter and the joiner is more distinctly drawn.

For the purposes of this work it will not be necessary to hold this distinction, and so for convenience, the term carpentry will be used to cover all branches of woodworking.

Two distinct elements enter into the carpenter-work of any structure; the *Material* and the *Labor*, and the cost of both is subject to fluctuation to a great extent. The trend in both is in the direction of increased cost in varying degrees in different localities, but the state of the market in both labor and materials is never quiescent, so that any printed prices must be considered as comparative only, and must be carefully compared with local and known data before being accepted as accurate or final.

The material with which the carpenter works, consists in the main of three principal divisions, the *Frame*, the *Covering*, and the *Finish*, and each of these has further subdivisions as will be noted.

Board Measure. All lumber which has not been wrought or moulded, is sold by "board measure" that is, the stock in each piece is reduced to a unit of a square foot of board one inch thick. This is called board measure and is expressed by the abbreviation B. M. Prices of lumber are usually rated by the thousand feet, so that the expression "Twenty-five dollars a thousand" means twenty-five dollars for a thousand square feet of stock one inch thick. To reduce stock of greater thickness than one inch, to its equivalent in board measure, several rules may be used.

A convenient method is to divide the product of the width and thickness in inches by 12, and multiply by the length in feet.

Example. How many feet, B. M., are there in a joist 2 in. x 9 in., 20 ft. long?

$$\frac{2 \times 9}{12} \times 20 = 30 \text{ ft. B. M.}$$

When the sizes are fractional, or produce a product not easily divided by 12, the operation may sometimes be simplified by varying the process and multiplying the length in feet, and the thickness and width in inches together, and dividing the whole product by 12.

Example. How many feet are there in a joist $2\frac{1}{2}$ in. x 9 in., 16 ft. long?

$$\frac{16 \times 2\frac{1}{2} \times 9}{12} = 30 \text{ ft. B. M.}$$

MISCELLANEOUS PRICES OF LUMBER

LUMBER

Dimension spruce lumber up to 9 inches of depth will cost at present per M., board measure. $26.00

10–inch stock, per M.	30.00
For long lengths, add per M.	2.00
Hemlock boarding	24.00
Spruce boarding	25.00
Spruce boarding matched	27.00
Spruce upper floor	45.00
Extra shingles	4.00
Clear shingles	3.50
Spruce clapboards	50.00
Siding cypress	30.00
Drop or novelty siding	55.00
Laths	5.00
Georgia pine timbers 12 in.	35.00
Georgia pine timbers 14 in.	40.00
Georgia pine timbers 16 in.	50.00

FLOORS AND FINISH

Georgia pine, heart face rift	$70.00
Georgia pine, common rift	45.00

Maple flooring		$ 55.00
Quartered oak flooring	125.00 to	150.00
North Carolina pine, rift stock		40.00
North Carolına pine, slash stock		33.00

FINISH

Georgia pine	$ 45.00
Cypress No. 1	80.00
Cypress No. 2	75.00
Oak, plain	90.00
Oak, quartered	120.00
Birch	65.00
Whitewood	52.00
Ash	55.00
Elm	40.00

INSIDE DOOR FRAMES

2 ft. 8 in. x 6 ft. 8 in.	$1.00
2 ft. 10 in. x 6 ft. 8 in.	1.10
3 ft. 0 in. x 7 ft. 0 in.	1.15
For transom bars add	.75

Calculating the Frame. In taking off the rough frame of a house for the purposes of estimating, the most accurate method is to take a schedule of every piece of timber from the framing plans, but as it often happens that the estimates are asked for from the general drawings, before framings are made, it has become the custom in many sections to estimate the cost of the walls and floors by the square of 100 superficial feet, making separate allowance for sills, girders, plates, and other large timbers.

If it is desired to take off the frame separately in the absence of framing plans the following data may be of use.

The sills of an ordinary house will usually be from 6 in. x 6 in. to 6 in. x 10 in., girders from 6 in. x 8 in. to 8 in. x 10 in., and floor joists from 2 in. x 8 in. to 3 in. x 12 in. generally 16 in. on centers. Wall studding of outside frame and bearing partitions will usually be 2 in. x 4 in. – 16 in. on centers. Studding of closets and light walls will usually be 2 in. x 3 in., plates 4 in. x 4 in. and 4 in. x 6 in., sometimes two 2 in. x 4 in. doubled, rafters from 2 in. x 6 in. to 2 in. x 12 in. and 18 in. to 24 in. on centers.

In taking off the frame, the sills and plates will of course be measured by the linear feet in the outside wall. The position of the main bearing partitions will usually give the number and location of the girders. Studs are doubled at openings and at corners, and fireplaces and stair openings will call for timbers of a large size, say from 6 in. to 8 in. width.

Assuming that the joists are 16 in. on centers, the number of joists on a floor will be given by taking $\frac{3}{4}$ of the length of the building in feet, and adding one joist. The number of studs in the outside frame at 16 in. on centers may be found by taking $\frac{3}{4}$ of the number of lineal feet in the outside of the building, adding one stud for each corner, and one for each door and window. To this must be added any gables or bay windows or other projections. Three quarters of the number of lineal feet of partitions will give the number of studs in the inside frame at 16 in. on centers. This allows for doubling of studs at openings and corners.

For the number of rafters take the length of the building divided by the distance of the rafters apart and add 1, this gives the number of pairs of rafters if a plain gable roof, while the number of rafters in a hip roof can be found by dividing the whole distance around the building by the distance apart.

Cost of Frame. Spruce lumber is generally used for framing, but Georgia pine must sometimes be used for large girders.

The cost of spruce lumber is from $26.00 to $28.00 per M., for sizes 9 in. and under; $30.00 for 10 in. stock, with a corresponding increase for large sizes. Hard pine lumber, 12 in. and under, will cost $35.00 per M.; 14 in. sizes $40.00; 16 in. sizes $50.00, and so on. Hard pine from the South by shipload will cost about $5 00 less per M.

The labor of framing sills, girders, etc., will cost about $10.00 per M.; plates, rafters, etc. $12.00. From this we estimate that a section of sill 30 ft. long, containing 90 ft. B. M. will cost as follows:

Stock, 90 ft. B. M. of 6 in. x 6 in. spruce at $26.00 per M.	$2.34
Labor of framing at $10.00 per M.	.90
	$3.24

Shingling the outside walls will cost:

Shingles, 850 at $4.25	$3.61
Paper and laying	.50
Nails	.25
Labor on shingling per square	2.18
Total cost of shingling	$6.54

Roofing with 2 in. x 6 in. rafters spaced 20 in. on centers will cost:

2 in. x 6 in. rafters 20 in. on centers at $26.00	$1.56
Waste ¼	.39
Labor	2.00
Nails	.10
Boarding	2.40
Waste	.60
Labor	1.00
Nails	.15
Total cost per square	$8.20

Inside studding ready for lathing will cost:

Studs, 2 in. x 4 in., 16 in. on centers, 50 ft. B. M. at $26.	$1.30
Waste ½ stock	.65
Nails	.15
Labor, per square	1.50
Beads and grounds	.40
Total cost per square	$4.00

Windows of average size in place will cost approximately:

Window frame	$1.20
Sashes 3 ft. x 5 ft.	1.75
Blinds	1.00
Blind fastenings	.15
Weight, 30 lbs. at 1¼ cents per lb.	.38
Sash cord, 20 ft. at 1 cent per ft.	.20
Sash fast	.25
Inside casings, 20 ft. at 3½ cents per ft.	.70
Stop beads, 16 ft. at 1¾ cents per ft.	.28
Labor, 8 hours at 41 cents per hour	3.28
Total cost of window in place	$9.19

Inside doors of average size will cost, complete:

Door 2 ft. 8 in. x 6 ft. 8 in. x $1\frac{1}{2}$ in. pine, to paint	$2.40
Frame	1.00
Casings	1.33
Threshold	.15
Nails	.05
Hardware	1.25
Labor, 8 hours at 41 cents	3.28
Total cost of door in place	$9.46

Rift hard pine upper floors will cost, per square of 100 square feet:

Rift hard pine flooring, 100 ft. B. M. at $65.00	$ 6.50
Waste and matching $\frac{1}{3}$ of stock	2.16
Labor	2.00
Nails, 5 lbs. at 3 cents per lb.	.15
Paper	.25
Total cost of floor per square	$11.06

Approximate cost per square ft.	11 cents
Finishing with shellac and wax	3 cents
Total per square foot finished	14 cents

Quartered oak floor, per square ft.	25 cents
Finishing with shellac	4 cents
Total cost per square foot	29 cents

A common front door will cost:

Door 3 ft. 4 in. x 7 ft. 0 in. x $1\frac{7}{8}$ in.	$ 5.75
Frame	4.50
Plate glass	2.50
Casings, 20 ft. at 4 cents	.80
Hinges	.68
Lock and knobs	4.50
Labor	4.00
Total cost of door	$22.73

A pair of sliding doors, fitted complete, will average about as follows:

2 doors 3 ft. 0 in. x 7 ft. 0 in. x $1\frac{3}{4}$ in. each	\$6.00
44 feet casings, at $4\frac{1}{2}$ cents	1.98
40 feet grounds, at 1 cent	.40
40 feet stop beads, at 2 cents	.80
Astragal	1.00
Chafing strip	.20
Lock	4.50
Hangers and track	4.50
Sheathing pocket, 84 ft. at 40 cents	3.36
Labor, 40 hours at 41 cents	16.40
Total cost of doors	\$39.14

These are some of the principal parts of a house analyzed and will serve to show how the cost of any portion may be obtained by dividing it into parts and pricing each portion by itself.

Following are some miscellaneous details of carpenter work: Two carpenters working in pairs can put up in a day about

300 ft. B. M. of studding.
300 ft. B. M. of rafters.
600 ft. B. M. of floor joist.
800 ft. B. M. of wall or roof boarding.
600 ft. B. M. of matched boarding.
500 ft. B. M. of diagonal matched boarding.

MISCELLANEOUS ITEMS

CELLAR WINDOW

Frame	\$1.50
Sash	1.20
Hardware	.15
Labor	.50
	\$3.35

CELLAR DOORS

Stock door, 2 ft. 8 in. x 6 ft. 8 in. x $1\frac{1}{2}$ in.	\$2.25
Frame	1.00
Finish, 36 ft. $4\frac{1}{2}$ in. finish	1.62

Inside Doors five cross panels in pine to paint

2 ft. 8 in. x 6 ft. 8 in. x $1\frac{1}{2}$ in.	$2.40
2 ft. 10 in. x 6 ft. 10 in. x $1\frac{1}{2}$ in.	2.50
3 ft. 0 in. x 7 ft. 0 in. x $1\frac{1}{2}$ in.	2.80

Window Frames

$2\frac{1}{2}$ ft. x $4\frac{1}{2}$ ft.	$1.10
3 ft. x 5 ft.	1.20

STAIRS

The trade of stair-building, while a part of the general work of joinery, is usually taken up as a separate trade and is done by men who do nothing else. For this reason it is better, if possible, to have the stairs figured and built by a regular stair-builder, who will have the special tools, moulds, and stock necessary for this branch of carpenter work.

There are usually in every house, two sets of stairs, one in the front part of the house and one in the back part. Sometimes the stairs are so arranged as to land together in the second story, but divide somewhere in their height upon a common landing, one part, the more ample and elaborate, running from the front hall, and the other from the back hall or kitchen. This is called a combination staircase and is often an economical solution of the problem of front and back stairs. See Fig. 14.

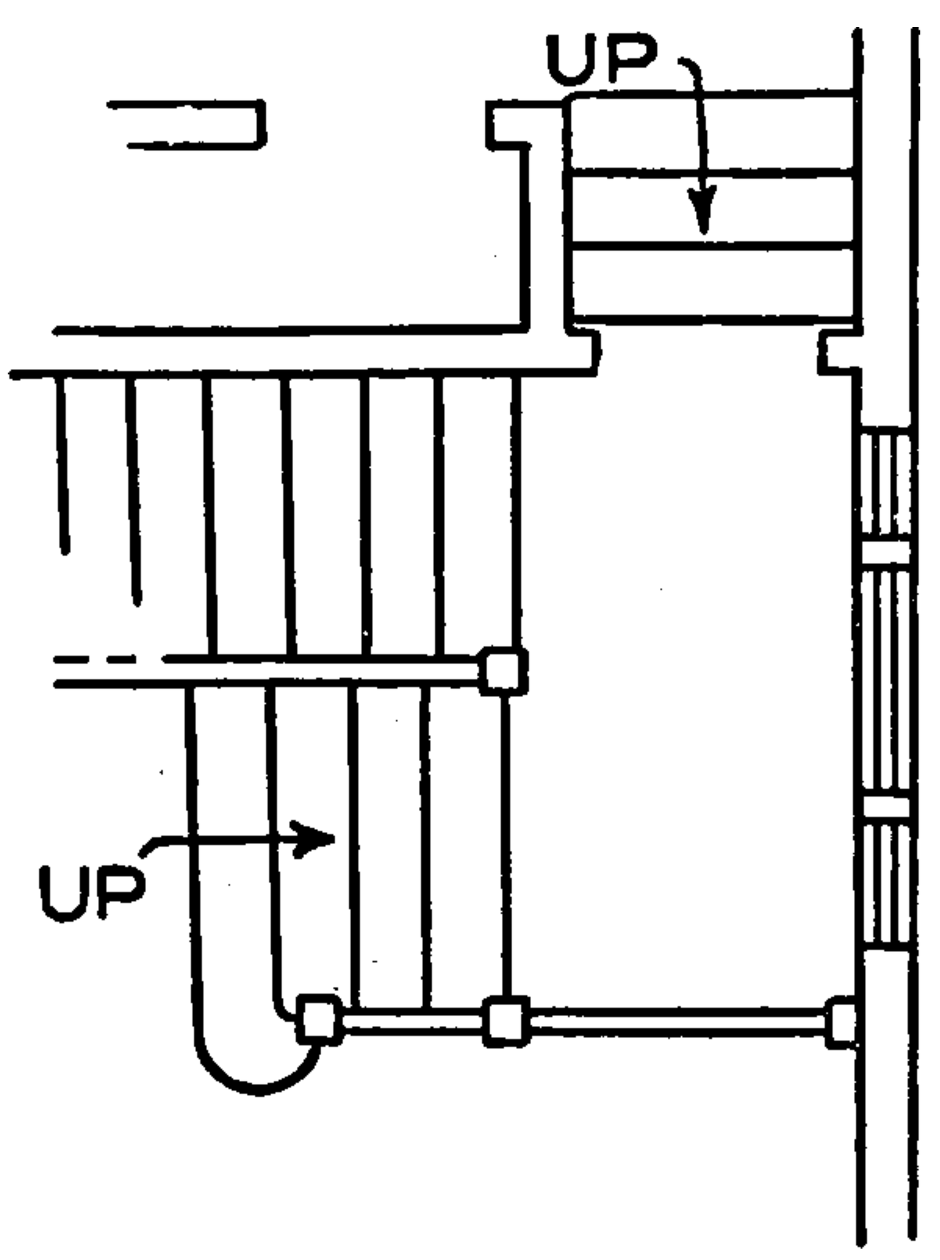


Fig. 14 Combination Staircase

When two separate staircases are put in, each will have a distinct character, and it is this condition that we shall consider.

Front Stairs. The front stairs of ordinary width and elaboration, say from 3 ft. to 4 ft. wide with turned balusters and moulded rails and posts, in white wood or North Carolina pine, may be approximated at $3.50 to $4.50 per step, complete. This is on the basis $1.50 per step for labor, the remainder for the stock. Panelling in connection with the stairs should be figured at $.40 to $.50 per sq. ft. of which one-half will be labor and the other half the stock. For ash add 50 per cent, for oak 75 per cent.

Winding steps will cost about double the price of straight steps for material, but the labor will be increased only about 50 per cent. This price will allow of hard pine treads and plain moulded rail with $1\frac{1}{2}$ in. turned balusters, two to a tread.

No more definite data can be given as to front stairs, as there is such a wide variation in design and finish, and such a wide range in selection of posts, rails, and balusters.

In general a good moulded and panelled newel may be had for \$5.00 to \$8.00, landing posts \$3.00 to \$4.00, rail 15 to 18 cents per lineal foot, balusters 9 to 12 cents each. Balusters turned in colonial pattern with an upper shaft, a square, and an urn-shaped turning at the base, will cost, turned to detail, about 18 cents; if twisted, add 30 cents. See Fig. 15.

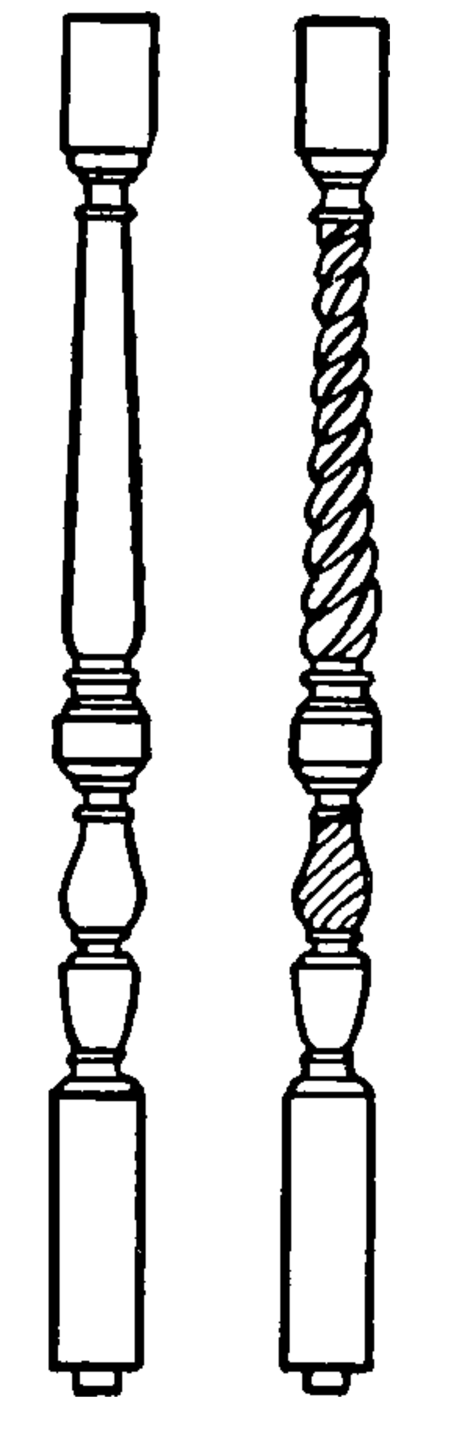


Fig 15 Balusters in Colonial Pattern.

These prices are for open string stairs, if brackets are used on the outside stringer, it will add 12 to 15 cents per step.

Back Stairs. Common box stairs, for general use in the back and attic portions of a house, will cost about \$1.60 per step, this includes 85 cents for stock and 75 cents for labor. Winders will be used more frequently here than in front stairs and will cost about double the price of a straight step. Open cellar stairs of plank with no risers will cost about 65 cents per step, giving 20 cents for labor and 45 cents for stock.

Summary. From the foregoing it will be found that a flight of front stairs in white wood will cost, at the average run of 16 steps, about \$64.00; and the same in ash \$96.00; in oak \$112.00. This is a fair price for good plain work and will give a satisfactory result.

The back stairs at 15 steps would cost \$24.00 and the cellar stairs \$7.80. Under conditions where much of the handrailing could be done away with, the prices could be reduced considerably.

DAY'S WORK

A carpenter in one day can do any one of the following items:

400 running feet of plaster grounds

40 pairs of bridging

1 window, complete, frame, sash, and fittings

1 door, setting frame, hanging, casing, and fitting with hardware
Casing windows, 4 per day
Hanging and fitting blinds, 10 pairs per day
Hanging and fitting doors, 5 per day
Casing doors, 5 per day

Cost of labor per square of 100 feet:

Framing of floors, per square	$1.50
Framing of walls	1.50
Framing of plain roofs	1.50
Framing of hip and valley roofs	2.00
Heavy framing	1.20
Boarding walls	.75
Boarding walls with matched boards	1.00
Boarding walls diagonally	1.00
Boarding roofs	1.00
Laying rough floor	.75
Laying rough floor diagonally	1.00
Bridging floors	.50
Furring brick walls 12 in. on centers	1.50
Furring brick walls 16 in. on centers	1.00
Laying spruce upper floor, 6 in. stock	1.50
Laying spruce upper floor, 4 in. stock	2.00
Laying hardwood floors, $2\frac{1}{2}$ in. stock	2.50
Shingling walls and roofs	2.18
Clapboarding walls	2.18
Papering walls under shingle or clapboards	.25

Work by the piece; labor:

Making window frames	$1.25
Making door frames	1.00
Door frame with transom	1.50
Setting window frames, each	.30
Setting window frames in brickwork, each	.50
Hanging blinds, per pair	.32
Fitting and hanging sashes per pair	.50
Hanging transoms	.40
Casing windows	.80

A simple balustrade of straight square balusters $1\frac{1}{8}$ in. will cost per running foot:

Top rail	3 in. x 4 in.	$0.12
Bottom rail	2 ft. x 4 in.	.08
Balusters, four to a foot		.12
Labor		.32
		$0.64

Piazza ceiling per square:

Sheathing	$4.00
Waste	1.25
Furring	1.50
Nails	.25
Labor	1.50
	$8.50

Piazza Finish:

Stock pattern, 5 in. turned columns	8 ft. long	$ 2.00
Stock pattern, 6 in. turned columns	8 ft. long	2.75
Stock pattern, 8 in. Colonial columns	9 ft. long	3.50
Stock pattern, 10 in. Colonial columns	9 ft. long	5.50
8 in. Doric Column from detail	9 ft. long	6.50
10 in. Doric Column from detail	9 ft. long	8.50
10 in. Fluted Column from detail	9 ft. long	15.00
Short Posts, 5 in. x 5 in. x 4 ft. 0 in.		1.00
Short Posts, 6 in. x 6 in. x 4 ft. 0 in.		1.50
Piazza balusters $1\frac{3}{4}$ in., 14 in. to 16 in. long, .06 to		.10
Piazza rail $1\frac{3}{4}$ x $3\frac{3}{4}$ in. per ft.		.06
Piazza rail $2\frac{1}{4}$ x $3\frac{3}{4}$ in. per ft.		.07
Tin roof per square		10.00 to 12.00

Conductors:

15 ft. pipe at 15 cents	$2.25
Gooseneck and labor	.65
Putting up	.50
	$3.40

HARDWARE

The best way to get at the cost of hardware is to get a schedule and price for each job from the dealer. The price of hardware is constantly changing. Prices are given here for a few staple articles of ordinary value.

Nails per cwt.	$2.50 to $4.00
Front door set (bronze metal)	7.00 to 10.00
Vestibule door set	6.00 to 8.00
Inside door set	1.00 to 1.50
Store door set	6.00 to 10.00
Single sliding door set	1.50 to 2.00
Double sliding door	2.00 to 3.00
Double acting floor hinge per pair	3.50 up
Double acting spring hinge "	2.00 up
Window fixture, weights, etc.	1.10 up
Sash fast each	.25 to .35
Transom fixture	.30 to .50
Cupboard door set	.60
Folding door bolts	1.25 to 3.00
Flush bolts per pair	1.50
Butts, small size per pair	.25
Butts, ordinary size, per pair	.30 to .40
Double coat and hat hooks, per dozen	2.50
Screws, per gross, bronze	.85
Single sliding door hanger	2.50 to 3.75
Double sliding door hanger	3.50 to 5.50

NAILS

Nails are priced from a base price per hundred weight adopted by the manufacturers, which includes certain sizes of the more common kinds. From this base the different kinds of nails are priced by means of extras, as agreed upon. The present base includes common, fence, and sheathing nails in sizes from 20 penny to 60 penny.

Following is a schedule of all kinds of cut and wire nails in general use and the extra price of each kind per cwt. above the base, which is $2.50 per cwt., for cut nails and $2.45 per cwt. for wire nails.

National List of Extras per cwt. for Cut Nails in Fair Assortment. Adopted Dec. 1, 1896

Common, Fence, and Sheathing

Base 20d to 60d	$2.50*

*(Variable. July, 1907, $2 65)

	Extras
10d to 16d	$0.05
8d and 9d	.10
6d and 7d	.20
4d and 5d	.30
3½d	.40
3d	.45
3d fine	.65
2d	.70
Spikes, all sizes	.10

Fine Finishing	Extras
10d and larger	$0.25
8d and 9d	.35
6d and 7d	.45
4d and 5d	.65

Barrel, Roofing, and Cottage	
1½ inch	$0.30
1⅜ inch	.40
1¼ inch	.50
1⅛ inch	.60
1 inch	.70
⅞ inch	.85
¾ inch	1.00

Casing, Box, and Floor	
10d and larger	$0.15
8d and 9d	.25
6d and 7d	.35
4d and 5d	.50
3d	.70
2d	1.00

Clinch	
3 in. and larger	$0.45
2¾ and 2½ in.	.55
2¼ and 2 in.	.65
1¾ and 1½ in.	.75
1¼ in.	.95
1 in.	1.15

10 cents for each ½ keg

Slating	
6d	$0.40
4d and 5d	.50
3d	.75
2d	1.00

4d Swedes Genuine	$1.30
4d Swedes Common	.80

Galvanizing	2½ cts. per lb.
Tinning	3 cts. per lb.

Size	2d	3d	3½d	4d	5d	6d	7d	8d	9d	10d
Length	1	1¼	1⅜	1½	1¾	2	2¼	2½	2¾	3

Size	12d	20d	30d	40d	50d	60d
Length	3½	4	4½	5	5½	6

Earthen drains 4 in. diam. per foot	$ .20
Arch brick laid in wall per M.	100.00
Marble mosaic per sq. ft.	.75
Marble threshold, exterior	5.00
Marble base per foot	.50
Granolithic per sq. ft.	.25
Steel beams per lb.	.03
Cast iron per lb.	.02
Copper skylights per sq. ft., heavy	1.75 to 2.50
Plastering 2 coats on wire lath	.65
Wooden balustrade per ft.	1.50
Outside blinds for a house will average per pair	.85
Inside doors, 5 cross panels, pine to paint, average	3.25
Store sash $1\frac{3}{4}$ in. per lineal foot	.30
Storm sash for house will average	1.55
Outside door frame with transom	3.50
Inside door frames will average	1.10
Same with transoms	1.85
Factory window complete 4 ft. 0 in. × 8 ft. 0 in.	13.00
Framing heavy lumber per M.	12.00
Planing lumber per M.	2.00
Laying plank floors per M.	9.00
Common bricks per M.	9.00
Common bricks laid in wall per M.	20.00
Concrete foundations per cu. yd.	7.25
Shingling on roof per square	6.54
Slating	11.80
Tar and gravel roof per square	6.00
Tin roofing per square, average	11 00

ROOFING

Description. Many kinds of material are used for covering roofs, depending upon the nature of the work, the pitch of the roof, the desired appearance, and the availability of material.

Shingles. The roof covering of an ordinary wooden house is generally of shingles. These are either shaved or sawed, but sawed shingles are generally used. Sawed shingles come in bundles of 250, or four bundles to the thousand. These quantities are based on a width of 4 in. to each shingle so that if they are wider they will be numerically less and consequently, if narrower, there will be more in number. Common shingles are 16 in. to 18 inches in length.

Measuring. In measuring for shingles the quantities are usually taken by the square; equal to 100 sq. ft., and the number of shingles required will depend upon the lap or exposure which is given to the shingles. On roofs the exposed length is usually 4½ inches, and on walls 5 or 6 inches is the usual exposure, although in the carrying out of special designs a greater or less exposure may be given.

Quantities. The covering capacity of 1000 shingles at various exposures is as follows:

4 inches to the weather	111 sq. ft.	= 900 per square
4½ inches to the weather	125 sq. ft.	= 800 per square
5 inches to the weather	139 sq. ft.	= 720 per square
6 inches to the weather	167 sq. ft.	= 600 per square
7 inches to the weather	194 sq. ft.	= 514 per square
8 inches to the weather	222 sq. ft.	= 450 per square

Cost. Sawed cedar shingles of best quality marked "Extra" will cost from $4.00 to $5.00 per thousand, and clear shingles, that is, having the exposed lower third of clear stock, will cost $3.50 to $4.00 per thousand, and it will require 5 pounds of 4 penny nails. These will cost 3 cents a pound if plain, or 5 cents, galvanized.

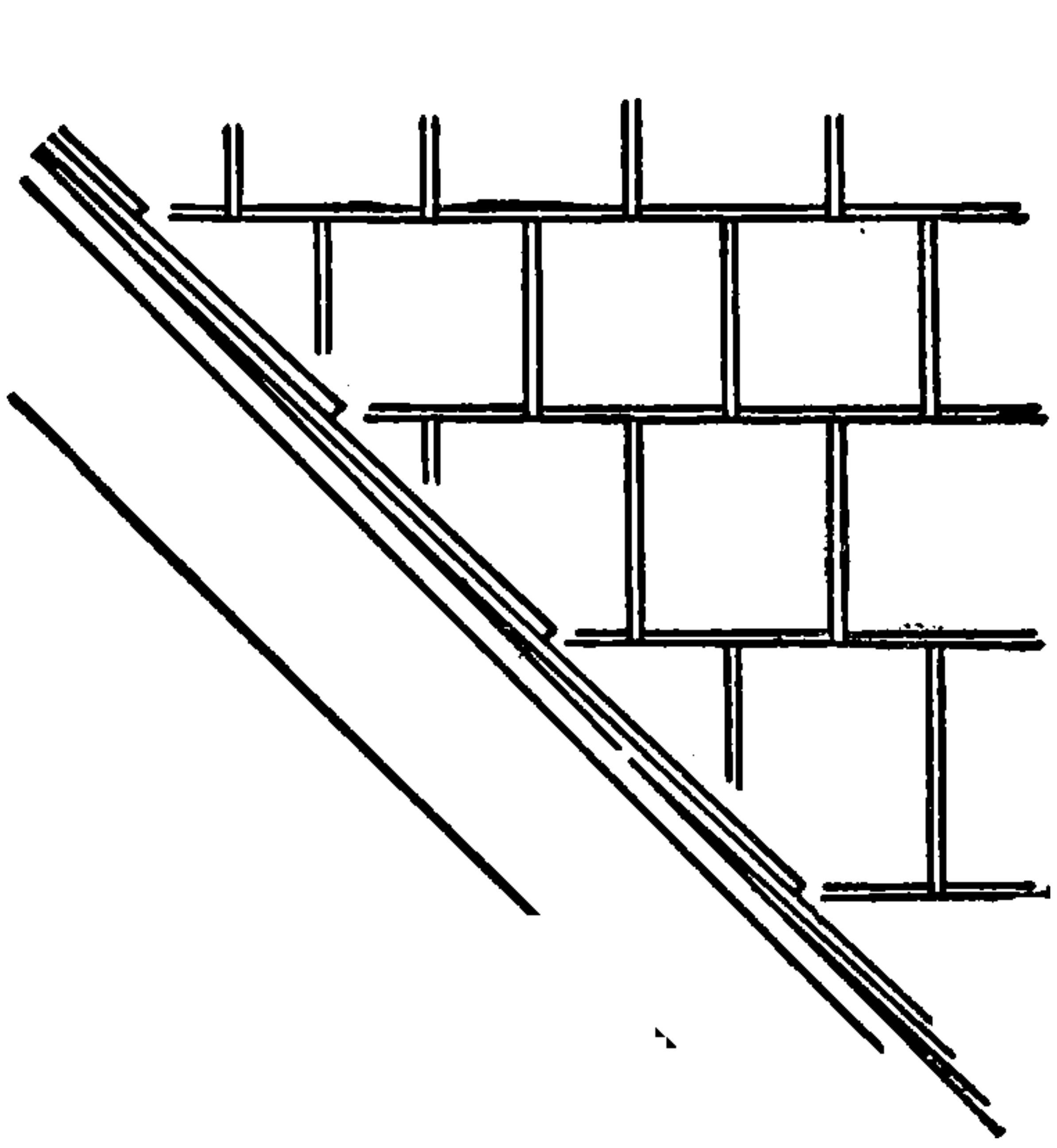


Fig 16. Slating

A carpenter in one day of 8 hours will lay 1500 shingles on plain work or 1000 if surface is much cut up. This will cost at $3.20 per day from $2.14 to $3.00.

In estimating shingling an allowance will be necessary for waste; this should be about 5 per cent on plain roofs and 8 to 10 per cent on roofs with many hips, valleys, or dormers.

Slating. Slates are made in different sizes from 6 x 12 up to 16 x 24 and larger sizes for special work. They are laid with reference to head-cover rather than exposure, that is: the lap of cover of each course by the second above it, gives the gauge to which slates should be laid, Fig. 16; this lap is usually 3 inches, so that the exposed length of any slate may be found by subtracting this lap from the length of the slate and dividing by 2. This exposure multiplied by the width of the slate gives the exposed area of the slate, and the number of slates in a given area may be found by dividing the area in square inches by the exposed area of the slate.

Example. How many slates will be required per square to cover a roof if 8-in. x 14-in. slates are used?

$$\frac{(14 \text{ in.} - 3 \text{ in.})}{2} = 5\tfrac{1}{2} \text{ in.}\ ;\ 8 \text{ in.} \times 5\tfrac{1}{2} \text{ in.} = 44 \text{ sq. in.};\ \frac{14400 \text{ sq. in.}}{44 \text{ sq. in.}} = 327.$$

In measuring a slate roof it is usual to allow an extra width of from 6 inches to a foot, according to localities, on hips, valleys, eaves, and wall cuttings, to allow for the extra work involved.

Extra charge should be made for towers and all varied forms of roof.

Quantities. The number of slates required to cover a square of roofing is given for various sizes in the following table:

6 x 12	533	10 x 20	165
7 x 14	377	11 x 22	138
8 x 16	277	12 x 24	114
9 x 18	214	14 x 28	83

The cost of slating per square is as follows:

Slates	10 in. x 16 in.	$ 7.50
Labor 1 day, slater		3.50
Nails		.15
Roofing paper		.50
Labor on paper		.15
		$11.80

Tin roof per sq. ft., average	$0.11
Gutters per ft., galv. iron	.90
Galv. iron conductors per ft., put up	.18 to .25
Copper roof, plain per square	40 00
Copper roof, with battens per square	50.00
Gravel roofing, 5-ply per square	6 00

Zinc flashing, $1\frac{1}{2}$ cents per inch of width, per foot.

In some localities no openings are deducted unless more than 7 yards in area, but in close figuring this is not generally followed.

Narrow strips, such as chimney breasts, if less than a foot wide, are generally called a foot. Round corners, beads, and arrises must be taken separately by the lineal foot.

Raking surfaces require additional work and should be taken at about one-half more than plain work. Circular or elliptical work should be charged at two prices and domes, groins, and intersecting soffits, at three prices. Cornices are taken by the square foot of girth with enrichments charged separately by the lineal foot.

Lathing. Lathing is generally included in the plasterer's price although put up by a different set of men. Lathing is estimated by the square yard or by the thousand laths, the price being $2.75 to $3.25 a thousand.

Labor. Two plasterers requiring one helper will do from 40 to 50 square yards of three-coat plastering, or 60 to 70 square yards of two-coat work, in a day of 8 hours, and 1,200 to 1,500 laths makes a day's work for one lather. 100 sq. yds. of lath and plaster will cost about as follows, for two-coat work:

1,500 laths at $4.75 per M	$ 7.12
10 lbs. 3d. nails at $3.20 per cwt.	.32
Labor on laths	4.50
10 bushels lime at .48 per bu.	4.80
6 lbs. hair at .04	.24
1 load sand	1.80
Plasterer 3 days at $5.00	15.00
Helper 1½ days at $3.00	4.50
Cartage	1.00
	$39.28

Cost of a square yard of two-coat work, $39.28 ÷ 100 = 39 to 40 cents.

This is a price which is on the increase and, while plastering is done in the country towns as low as 35 cents per yard it will not be safe to use this price any length of time.

For three-coat work we may take the following schedule:

Laths and putting on, as above	$11.94
13 bush. lime at .48	6.24
8 lbs. hair at .04	.32
$1\frac{1}{2}$ loads sand at $1.80	2.70
1 bbl. plaster Paris	1.70
Plasterer 4 days at $5.00	20.00
Helper 2 days at $3.00	6.00
Cartage	1.00
	$49.90

Cost of a sq. yd. of three-coat work, $49.90 ÷ 100 = 50 cents.

Rules. In some portions of the country a set of rules has been adopted governing the valuing of plasterer's work which are in the main as follows:

"*First.* Measure on all walls and ceilings the surface actually plastered, without deducting any grounds or any openings of less extent than seven superficial yards.

Second. Returns of chimney-breasts, pilasters, and all strips of plastering less than twelve inches in width, measure as twelve inches wide; and where the plastering is finished down to the base, surbase, or wainscoating, add six inches to height of walls.

Third. In closets, add one-half to the measurement. Raking ceilings and soffits of stairs, add one-half to the measurement; circular or elliptical work, charge two prices; domes or groined ceilings, three prices.

Fourth. For each twelve feet of interior work done farther from the ground than the first twelve feet, add five per cent; for outside work, add one per cent for each foot that the work is done above the first twelve feet."

Stucco-work is generally governed by the following rules; viz., "Mouldings less than one foot girt are rated as one foot, over one foot, to be taken superficial. When work requires two moulds to run same cornice, add one-fifth. For each internal angle or mitre, add one foot to length of cornice, and, for each external angle, add two feet. All small sections of cornice less than twelve inches long measure as twelve inches. For raking cornices, add one-half; circular or elliptical work double price; domes and groins, three prices.

For enrichments of all kinds a special price must be charged. The higher the work is above ground, the higher the charge must be; add to it at the rate of five per cent for every twelve feet above the first twelve feet."

PAINTING

Painting is estimated by the yard, doors and windows being taken solid to make up for the extra labor of cutting in the sashes and mouldings.

Railings, fences, grilles, and similar surfaces are taken solid.

A painter in one day will cover 100 yds. of outside work one priming coat, or 80 yds. of the second coat. Ten pair of blinds will make a day's work.

On first coat, one pound of paint will cover about 4 sq. yds. and 6 sq. yds. on the subsequent coats. One pound of putty for stopping will cover 20 yds.

Shingle stains require a gallon for every 500 shingles if dipped two-thirds in, and for a brush coat after laying, a gallon will cover about 200 feet of surface, or 1500 shingles.

1 gallon of priming color	will cover 50 yards
1 gallon of zinc white	will cover 50 yards
1 gallon of white paint	will cover 44 yards
1 gallon of black paint	will cover 50 yards
1 gallon of stone color	will cover 44 yards
1 gallon of yellow paint	will cover 44 yards
1 gallon of green paint	will cover 45 yards
1 gallon of emerald green	will cover 25 yards
1 gallon of bronze green	will cover 75 yards

The following table gives the comparative covering of paints by weight on various surfaces.

COVERING OR SPREADING POWER OF TYPICAL PAINTS* ON WOOD

	First Coat	Second Coat
Red lead	112	252
White lead	221	324

*The figures represent square feet covered by 100 lbs. of paint of the usual consistency, applied evenly with a brush.

Tinting walls in distemper will cost 15 cents per sq. yd. for small amounts and 10 cents per sq. yd. for 50 yds. or more. Finishing hard wood floors with filler, shellac, and 2 coats of varnish or wax finish will cost 30 cents per sq. yd.

OUTSIDE PAINTING

1 coat new work per sq. yard	$0.10
2 coats new work per sq. yard	.18
3 coats new work per sq. yard	.25

SANDING

2 coats paint, 1 coat sand per sq. yd.	$0.28
3 coats paint, 1 coat sand per sq. yd.	.35
3 coats paint, 2 coats sand per sq. yd.	.50

Painting on brick will cost 12 cents per yard for the first coat, but subsequent coats will cost no more than on wood. Tin roofs can be painted one coat for 5 cents a yard.

1000 shingles dipped two-thirds of their length will cost $3.00 and a brush coat in addition costs 50 cents. Blinds are rated at $1.50 per pair for an average size.

HEATING

The heating of a building is generally made the subject of a special contract.

The three usual methods for house heating are, the Hot Air Furnace, the Hot Water Boiler, or the Steam Boiler. Sometimes a combination system of hot air and steam, or hot air and hot water is used.

Estimates of the cost of heating should be obtained from contractors who follow this particular branch of construction.

In general, for an ordinary class of building such as residences, apartments, stores, etc., the heating will range according to the system used, from 6% to 12% of the cost of the building, as follows:

Hot air furnace	6 to 7 per cent.
Steam	8 to 10 per cent.
Hot water	10 to 12 per cent.

These figures are approximate and the only reliable way to obtain the actual cost is by taking off the items and figuring each job by itself.

Quantities. The hot air heating of an ordinary house can be approximated closely by the builder on the basis of cubic contents to be heated; and the area of piping and capacity of the furnace can be approximated by means of the following general rules:

To determine the size of pipe for any room, find the cubic contents of the room in cubic feet and divide this by 25 for rooms on the first floor, and by 35 for rooms on the second and third floors.

Make the cold air box at least $\frac{3}{4}$ of the combined area of pipes, none of which should be smaller than 7 inches in diameter.

Example. For a small house of seven rooms the quantities may be as follows:

FIRST FLOOR

Parlor 12 x 15 x 9 ft. high 1624 cu. ft. divided by 25 = 65 sq. in. or 9 in. pipe

Hall 8 x 20 x 9 ft. high 1440 cu. ft. divided by 25 = 58 sq. in. or 9 in. pipe

Add 40% for second story hall space making 81 sq. in. = 10 in. pipe

Dining Room 14 x 15 x 9 ft. high 1890 cu. ft. divided by 25 = 76 sq. in. or 10 in. pipe

SECOND FLOOR

Chamber	13 x 15 x 8½ =	1658 cu. ft. ÷ 35 =	48 sq. in.	or 8 in. pipe
Chamber	11 x 12 x 8½ =	1122 cu. ft. ÷ 35 =	32 sq. in.	or 7 in. pipe
Chamber	14 x 16 x 8½ =	1904 cu. ft. ÷ 35 =	55 sq. in.	or 8 in. pipe
Bath Room	8 x 10 x 8½ =	680 cu. ft. ÷ 35 =	20 sq. in.	or 7 in. pipe

Total pipe area:

2 – 10 in. pipes 78 sq. in. each	156 sq. in.
1 – 9 in. pipe 64 sq. in.	64 sq. in.
2 – 8 in. pipes 50 sq. in.	100 sq. in.
2 – 7 in. pipes 38 sq. in.	76 sq. in.
Total pipe area	396

From this scale we can determine the size of the furnace and the cost of piping.

A furnace to carry say 400 to 500 sq. feet of pipe area would cost, set in place, from $100 to $125. The labor on pipes, registers, and furnace $20 to $24.

The cost of piping will depend on the distances to run but the material can be estimated as follows:

Round tin pipes will cost; from A. A. charcoal plates, as follows:

Size of Pipe	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"	16"	18"
Per Foot........................	.09	.10	.12	.14	.16	.18	.23	.25	.27	.28	.30	.32
Hot Air Damper................	.12	.12	.12	.15	.15	.15	.18	.18	.18	.20	.20	.25
Furnace Collars................	.10	.10	.10	.12	.12	.14	.18	.18	.18	.20	.20	.25
Tin Elbows.....................	.12	.15	.18	.20	.25	.30	.35	.40	.45	.50	.60	.70

* REGISTERS

Size	6x10	7x10	8x10	8x12	9x12	10x14	12x15	12x16	14x18	16x20
Black Register..........	.50	.52	.52	.58	.64	1.08	1.37	1.70	2.74	3.75
Slate Stone	.38	.42	.44	.50	.63	.70	.93	1.00	1.50	2.35
Register Box............	.14	.16	.17	.20	.23	.27	.33	.35	.38	.50
Netting..................	.05	.05	.06	.06	.07	.07	.08	.08	.10	.12
Totals...................	1.07	1.15	1.19	1.34	1.57	2.12	2.71	3.13	4.72	6.72

* July, 1906 —Add one-third.

Galvanized smoke pipe will cost 9c per lb. and will weigh per lineal foot as follows:

Size No.	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"
22	1¾	2⅛	2⅝	3	3⅜	3¼	4⅛	4½	5	5¼	5¾
24	1¼	1⅝	1⅞	2⅛	2½	2¾	3	3⅜	3⅝	3⅞	4¼

GALVANIZED ELBOWS

Size	4"	4½"	5"	5½"	6"	7"	8"
Pound	1	1¼	1½	1¾	2¼	2¾	3¼
Cost..................................	.18	.20	.23	.25	.28	.32	.35

Tin, per Sheet

DC	12½ x 17	.05
IX	14 x 20	.07
IXX	14 x 20	.08
IX	20 x 23	.12
IX	20 x 26	.13
IX	20 x 29½	.16
IX	20 x 32½	.17

Miscellaneous Data

Galvanized sheet iron per lb.	$0.05
Common sheet iron per lb.	.04

from the cubic contents of the rooms to be heated by the following tables which give the proportions of one square foot of radiating surface to the cubic contents of the various rooms in cubic feet.

STEAM

One Square Foot of Radiation Will Heat	Dwellings, Cubic Feet	Halls, Stores, Etc. Cubic Feet	Churches and Auditoriums, Cubic Feet
By direct radiation—			
On first floor	35 to 60	75 to 100	125 to 200
On upper floors....................	50 to 80	....	....
By indirect radiation—			
On first floor	25 to 40	50 to 70	80 to 135
On upper floors............... ...	40 to 50	....	....

HOT WATER

One Square Foot of Radiation Will Heat	Dwellings, Cubic Feet	Halls, Stores, Etc Cubic Feet	Churches and Auditoriums, Cubic Feet
By direct radiation—			
On first floor......................	15 to 25	30 to 45	50 to 85
On upper floors.	25 to 40		
By indirect radiation—			
On first floor...........	17 to 40	45 to 65	80 to 125
On upper floors..........	25 to 35		

Having determined the amount of radiation, piping, and fittings, the labor may be obtained by adding about 20 per cent to the cost of materials.

PLUMBING

So wide a range is possible in the selection and price of plumbing fixtures that no very useful data can be given for a complete installation.

For instance, in one house the price of a single bathroom, fitted up to meet the fancies and purse of the owner, may cost more than the whole plumbing outfit of his more modest neighbor.

Nevertheless, it is a fact that the plumbing of a house is a poor place to practice economy, as no part of the construction of a building needs more careful attention in execution or in selection.

In general, a good job of plumbing will cost about 10 per cent of the cost of the building, and of this outlay about 30 per cent will represent the labor.

In taking off plumbing the contractor should begin at the sewer or cesspool, if the drains are included, or, if not, at the outer end of the soil pipe, and take off carefully every pipe with its fittings, which should be itemized carefully as this data will be useful in getting at the amount of caulking, fitting, etc.

Soil Pipes. Soil pipes should be estimated by the lineal foot, allowing in each joint $\frac{3}{4}$ of a pound of lead for every inch in diameter of the pipe.

List prices of pipe and fittings can be obtained from the dealers, which are subject to discount; these vary from time to time, but the present discounts will be found to bring the prices of the more common materials about as follows:

DRAINAGE

4-in. extra heavy soil pipe per ft.	$ .30
3-in. extra heavy soil pipe per ft.	.22
2-in. extra heavy soil pipe per ft.	.15½
For fittings add 35 per cent to the cost of pipe.	
4-in. running trap	2.00
4-in. brass ferrule cleanout	.50
4-in. lead bend	1.50
4-in. brass ferrule	.50
2-in. brass ferrule	.20
Solder per lb.	.22

WATER SUPPLY

40 gal. galvanized boiler and stand	$15.00
1-in. brass pipe per ft.	.60
1-in. galvanized pipe per ft.	.09
¾-in. galvanized pipe per ft.	.06
½-in. galvanized pipe per ft.	.05
1-in. stop and waste cock	1.50
¾-in. stop and waste cock	.90
½-in. stop and waste cock	.80
Sill cock	1.00
For fittings, add 30 per cent to cost of pipes.	

WATER

1 cu. ft.	7.48 gallons
1 cu. ft.	29.92 quarts

1 cu. ft., 62.321 lbs.	1004 oz.
1 cu. yd.	1692 lbs.
1 gal., 231 cu. in.	$8\frac{1}{3}$ lbs.
1-foot cylinder	49.1 lbs.
1-inch cylinder	.028 lbs.

Pressure per sq. in. = depth in feet x 433.

Each 27.72 inches of depth gives a pressure of 1 lb. to a square inch.

A barrel $31\frac{1}{2}$ gal.

Contents in cu. ft. x 2375 = barrels.

Head of water = pressure in lbs, per sq. in. x 2.31.

Number of gallons in a foot of pipe = Diam. in. inches 2 x .04.

Supply for one person is 15 gallons a day.

Actual use 6 gallons to 12 gallons.

Water 34 feet high has a pressure of 15 lbs. per sq. in. equal to atmosphere.

CAPACITY OF CISTERNS

In Gallons, for Each Foot in Depth

Diameter in Feet	Gallons	Diameter in Feet	Gallons
2	23 5	9	475.87
2 5	36 7	9.5	553.67
3	52 9	10.	587.5
3 5	71 96	11.	710.9
4.	94 02	12.	846.4
4 5	119	13.	992 9
5.	146 8	14.	1,151.5
5 5	177 7	15.	1,321.9
6	211 6	20.	2,350 0
6 5	248 22	25	3,570.7
7.	287.84	30.	5,287.7
7 5	330 48	35.	7,189.
8	376	40.	9,367.2
8 5	424 44	45.	11,893 2

The American Standard gallon contains 231 cubic inches, or $8\frac{1}{3}$ pounds of pure water A cubic foot contains 62 3 pounds of water, or 7 48 gallons Pressure per square inch is equal to the depth or head in feet multiplied by 433 Each 27 72 inches of depth gives a pressure of one pound to the square inch

For tanks that taper, take diameter $\frac{4}{10}$ from large end.

FIXTURES

3-ft. soapstone sink complete	\$30.00 to \$40.00
14-in. x 17-in. lavatory with marble slab and back piece fitted complete	\$35.00 to \$50.00

In general, the rough wiring of a house may be reckoned at $4.00 per outlet for conduit work, and $2.00 per outlet for knob and tube work.

This is for every time the wires are brought to the surface, whether for switches, cutouts, or fixtures. Another way is to allow $1.50 for each lamp or switch.

Switches. Various kinds of switches are used, the two principal kinds being the push button, and the rotary switch.

These vary in price according to make and finish.

A good rotary switch can be had at from 90 cents to $1.00.

Push button switches from $1.00 to $1.10.

Snap switches from 30 to 40 cents.

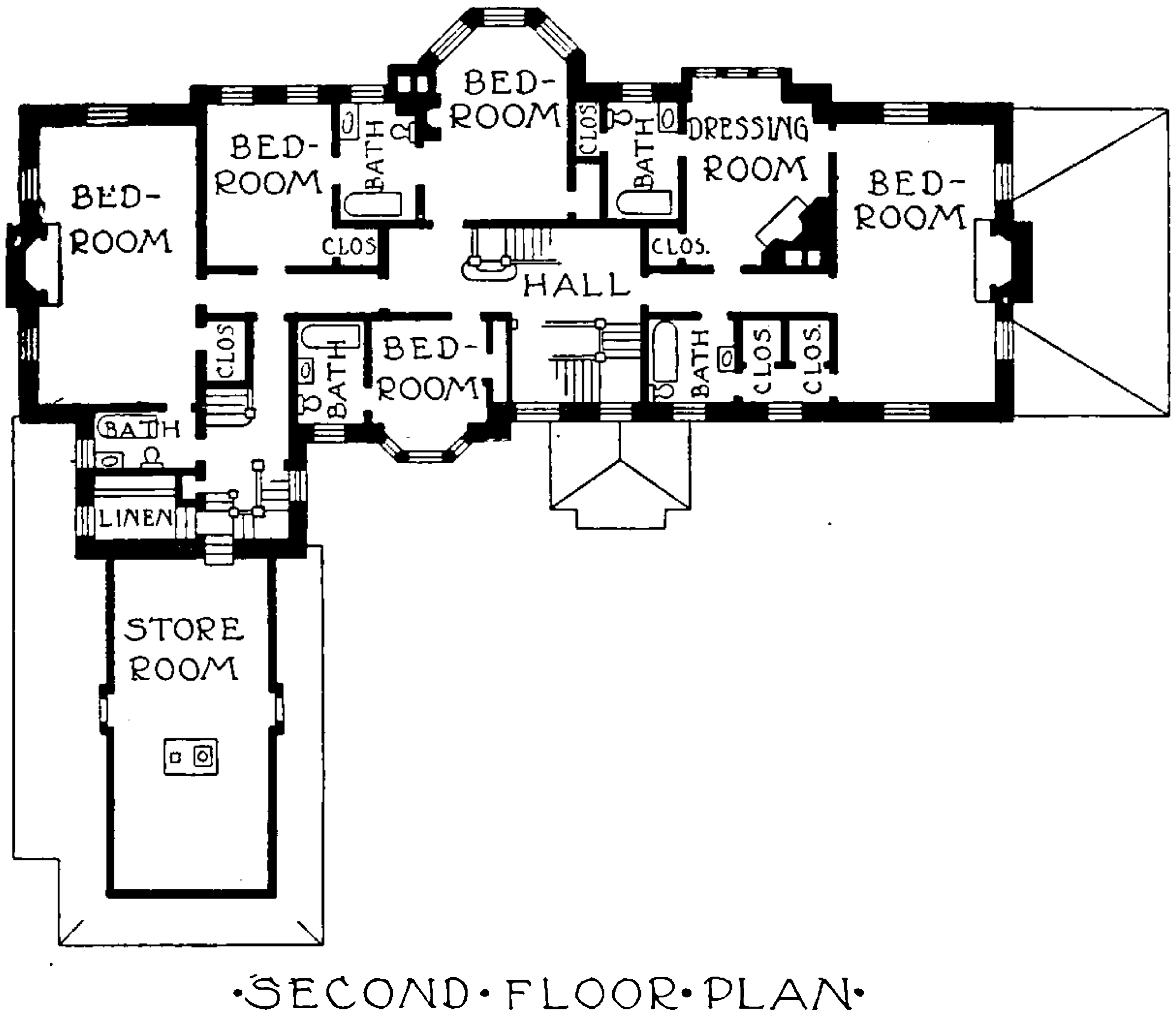
Wires are sold in coils which are marked with the gauge and manufacturer, and should bear the label of inspection acceptable to the local Insurance board.

The cost of wire will vary with the gauge and the insulation but for usual house work should cost, for No. 14 wire, 2 cents a foot.

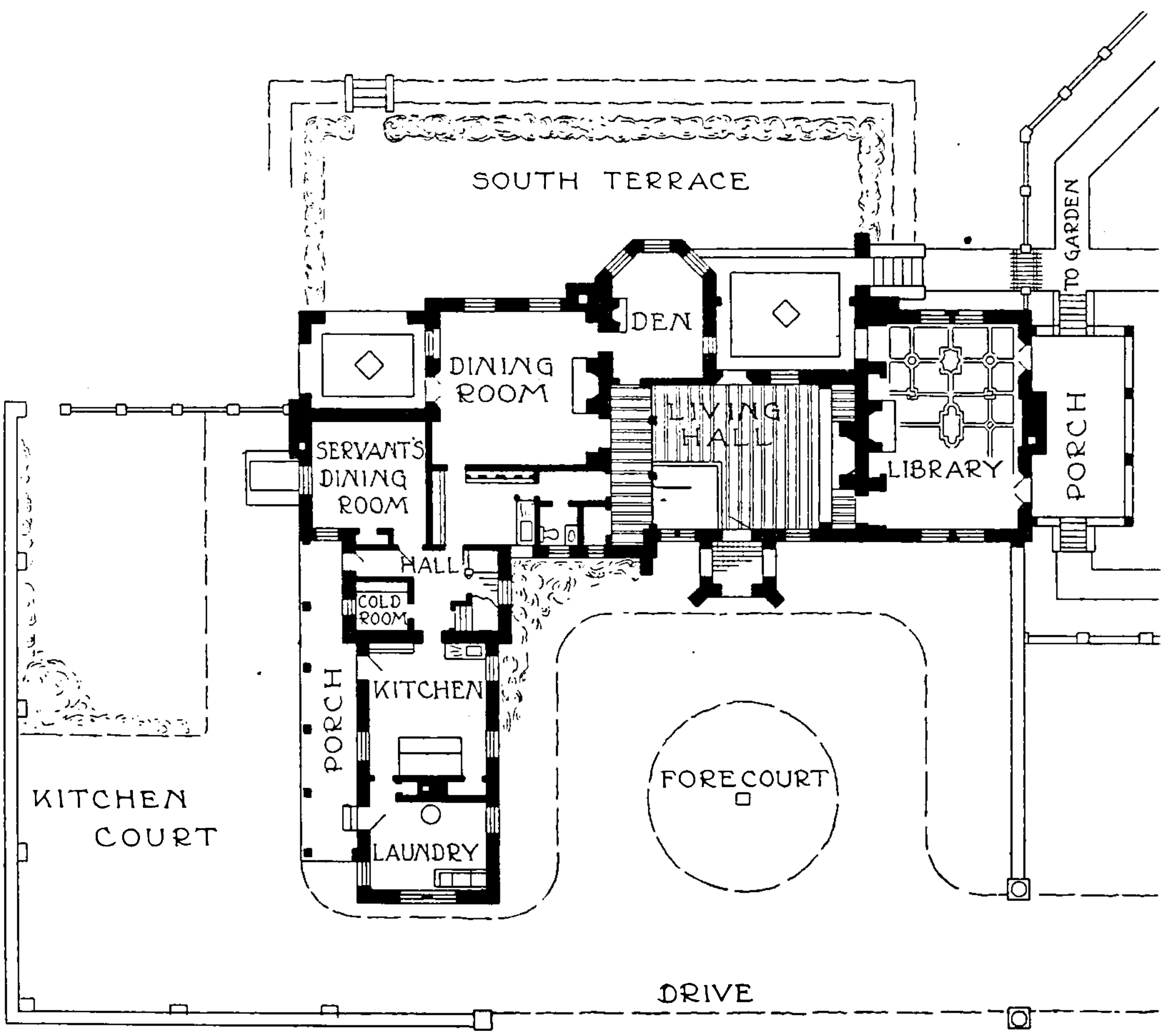
It is well to remember that, in electric wiring, the larger the house, the more per outlet the wiring will cost. This seems contrary to expectation but is occasioned by the smaller percentage of lights to length of wire.

Bells. The number of call bells in a dwelling will vary according to the plan and choice of the owner.

For an ordinary house the number would range from six to ten, and the cost should be from $18.00 to $25.00 or about $3.00 per bell.



·SECOND·FLOOR·PLAN·



·FIRST·FLOOR·PLAN·

FLOOR PLANS OF "LITTLE ORCHARD FARM" AT CAMP HILL, PENNSYLVANIA

Wilson Eyre, Architect, Philadelphia, Pennsylvania

For Exterior See Page 332

RESIDENCE AT RIDGEDALE MO.
FOR GEORGE A. JONES ESQ.

FRANK A. BOURNE ARCHITECT.
MASON BUILDING BOSTON

FRONT ELEVATION

Scale of 0 1 2 3 4 5 6 7 8 feet


SHINGLES
SHINGLES
9 X 12
12 X 14
12 X 14
SECOND FLOOR LINE
CLAPBOARDS
9 X 12
9 X 15
9 X 15
9 X 10
9 X 10
12 X 15
12 X 15
12 X 15
12 X 15
FRENCH WINDOWS
CLAPBOARDS
FIRST FLOOR LINE
LATTICE
LATTICE
BRICK
BULKHEAD
4'-6" Below Grade
LEFT SIDE ELEVATION
Scale of 0 1 2 3 4 5 6 7 8 feet

Fig. 2

ESTIMATE

OF

RESIDENCE AT RIDGEDALE, MO.

FOR GEORGE A. JONES, ESQ.

Staking-out and setting batter-boards.	$15.00
Water supply during construction	10.00
	$25.00

EXCAVATION

NOTE.—Excavation is priced by the cubic yard; and in this regard, the distance to which the excavated material must be carted will be an important consideration. In the present case, the material is to be carried only a short distance, so that no unusual conditions will have to be considered.

As before mentioned, it is usually well to dig a cellar at least a foot larger all around than the sill line, so that plenty of room may be afforded to the mason to plaster the outside of the wall. This should be done without regard to the specifications. As this extra excavation lies entirely outside the line of the house, it may be well to take it off separately, remembering that it will extend down into the trench below the wall, making about 8 feet of height.

QUANTITIES—					CU. FT.
42 ft. 0 in.	×	8 ft. 0 in.	×	1 ft. 0 in.	336
34 ft. 0 in.	×	8 ft. 0 in.	×	1 ft. 0 in.	272
10 ft. 4 in.	×	8 ft. 0 in.	×	1 ft. 0 in.	83
17 ft. 6 in.	×	8 ft. 0 in.	×	1 ft. 0 in.	140
68 ft. 0 in.	×	8 ft. 0 in.	×	1 ft. 0 in.	544
41 ft. 0 in.	×	8 ft. 0 in.	×	1 ft. 0 in.	328
CELLAR EXCAVATIONS—					
28 ft. 0 in.	×	43 ft. 0 in.	×	5 ft. 6 in.	6,622
12 ft. 6 in.	×	3 ft. 0 in.	×	5 ft. 6 in.	206
26 ft. 0 in.	×	20 ft. 6 in.	×	5 ft. 6 in.	2,931
9 ft. 0 in.	×	6 ft. 6 in.	×	5 ft. 6 in.	322
				Carried forward	11,784 cu. ft.

Brought forward 11,784 cu. ft.

MISCELLANEOUS QUANTITIES—

Piers	
2 ft. 0 in. × 2 ft. 0 in. × 3 ft. 6 in. × 12	168
Trench	
185 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in.......	308
Area	
14 ft. 0 in. × 2 ft. 8 in. × 3 ft. 6 in.......	129
Drains	
123 ft. 0 in. × 3 ft. 6 in. × 1 ft. 6 in.	645
Cesspools	
5 ft. 6 in. × 5 ft. 6 in. × 8 ft. 0 in.......	242
10 ft. 0 in. × 10 ft. 0 in. × 8 ft. 0 in........	800
Dry Wells	
6 × 2 ft. 0 in. × 2 ft. 0 in. × 5 ft. 0 in.	120
Total,	14,196 cu. ft.

Total, 14,196 cu. ft., or 525 cu. yds., at 50 cents $262.50

STONEWORK

DRY WALLS IN TRENCH—	CU. FT.
16 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in........	27
16 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in.	27
12 ft. 6 in. × 1 ft. 8 in. × 1 ft. 0 in.	20.8
3 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in. ...	5
23 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in.	38
16 ft. 6 in. × 1 ft. 8 in. × 1 ft. 0 in.......	27.5
28 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in.	46
28 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in.	46
14 ft. 6 in. × 1 ft. 8 in. × 1 ft. 0 in.	24
4 ft. 6 in. × 1 ft. 8 in. × 1 ft. 0 in..	7.5
23 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in.	38
Total,	306.8 cu. ft.

307 cu. ft. ÷ 25 = 12 perches of dry wall.

MORTAR WALLS—	
16 ft. 0 in. × 6 ft. 7 in. × 1 ft. 8 in.	175
16 ft. 0 in. × 6 ft. 7 in. × 1 ft. 8 in.	175
9 ft. 6 in. × 8 ft. 3 in. × 1 ft. 8 in.	130
Carried forward	480 cu. ft.

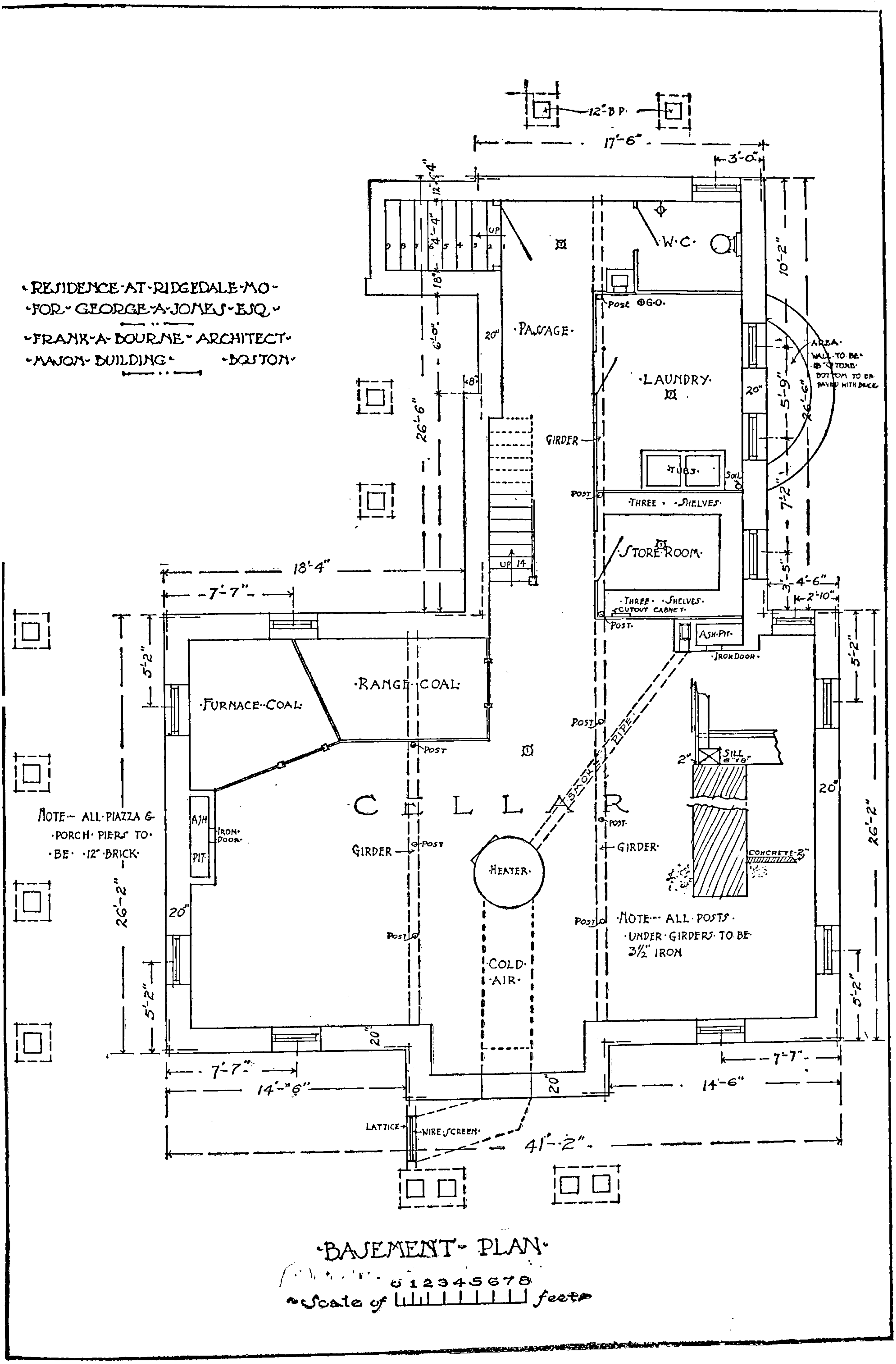

·RESIDENCE·AT·RIDGEDALE·MO·
·FOR·GEORGE·A·JONES·ESQ·
·FRANK·A·BOURNE·ARCHITECT·
·MASON·BUILDING· ·BOSTON·
NOTE— ALL·PIAZZA & ·PORCH·PIERS TO· ·BE· ·12"·BRICK·
·PASSAGE·
·W·C·
·LAUNDRY·
·TUBS·
·THREE· ·SHELVES·
·STORE·ROOM·
·THREE· ·SHELVES·
CUTOUT CABNET
ASH·PIT·
IRON DOOR
·RANGE·COAL·
·FURNACE·COAL·
C E L L A R
·HEATER·
COLD· ·AIR·
SMOKE PIPE
GIRDER
POST
SILL
CONCRETE
NOTE— ALL·POSTS· ·UNDER·GIRDERS·TO·BE· 3½" IRON
AREA· WALL·TO BE· STONE· BOTTOM TO BE PAVED WITH BRICK
LATTICE
WIRE SCREEN
12" B P
·BASEMENT· PLAN·
Scale of feet

Fig. 4.

			Brought forward	480 cu. ft.
	23 ft. 0 in. ×	8 ft. 3 in. ×	1 ft. 8 in.	316
	12 ft. 0 in. ×	6 ft. 7 in. ×	1 ft. 8 in.	132
	28 ft. 0 in. ×	8 ft. 3 in. ×	1 ft. 8 in.	385
	6 ft. 0 in. ×	6 ft. 7 in. ×	1 ft. 6 in.	59
	10 ft. 0 in. ×	6 ft. 7 in. ×	1 ft. 0 in.	66
	8 ft. 6 in. ×	6 ft. 7 in. ×	1 ft. 8 in.	93
	9 ft. 0 in. ×	8 ft. 3 in. ×	1 ft. 8 in.	123
	25 ft. 0 in. ×	6 ft. 7 in. ×	1 ft. 8 in.	274
	6 ft. 0 in. ×	6 ft. 7 in. ×	1 ft. 8 in.	66
	23 ft. 0 in. ×	6 ft. 7 in. ×	1 ft. 8 in.	252
PIERS—				
	2 ft. 6 in. ×	5 ft. 6 in. ×	1 ft. 0 in.	14
	2 ft. 6 in. ×	5 ft. 6 in. ×	1 ft. 0 in....	14
	2 ft. 0 in. ×	2 ft. 0 in. ×	1 ft. 0 in.	4
	12 ft. 0 in. ×	3 ft. 6 in. ×	2 ft. 0 in.	84
	12 ft. 0 in. ×	3 ft. 6 in. ×	2 ft. 0 in. ..	84
AREA—				
	14 ft. 0 in. ×	3 ft. 6 in. ×	1 ft. 6 in.	73
			Total,	2,519 cu. ft.

2,519 cu. ft ÷ 25 = 101 perches of mortar wall.

UNDERPINNING—				CU. FT.
	16 ft. 0 in. ×	1 ft. 8 in. ×	1 ft. 8 in.......	45
	16 ft. 0 in. ×	1 ft. 8 in. ×	1 ft. 8 in.	45
	6 ft. 0 in. ×	1 ft. 8 in. ×	1 ft. 8 in.	17
	12 ft. 0 in. ×	1 ft. 8 in. ×	1 ft. 8 in.	34
	6 ft. 0 in. ×	1 ft. 0 in. ×	1 ft. 0 in.	6
	8 ft. 6 in. ×	1 ft. 8 in. ×	1 ft. 8 in.	23
	25 ft. 0 in. ×	1 ft. 8 in. ×	1 ft. 8 in.	70
	6 ft. 0 in. ×	1 ft. 8 in. ×	1 ft. 8 in.	17
	23 ft. 0 in. ×	1 ft. 8 in. ×	1 ft. 8 in.	64
	14 ft. 0 in. ×	2 ft. 0 in. ×	1 ft. 6 in.	42
			Total,	363 cu. ft.

363 cu. ft. ÷ 25 = 14½ perches of underpinning.

Summary of Stonework—

12 perches of dry wall, at $3.00 .... $ 36.00

Carried forward $ 36.00

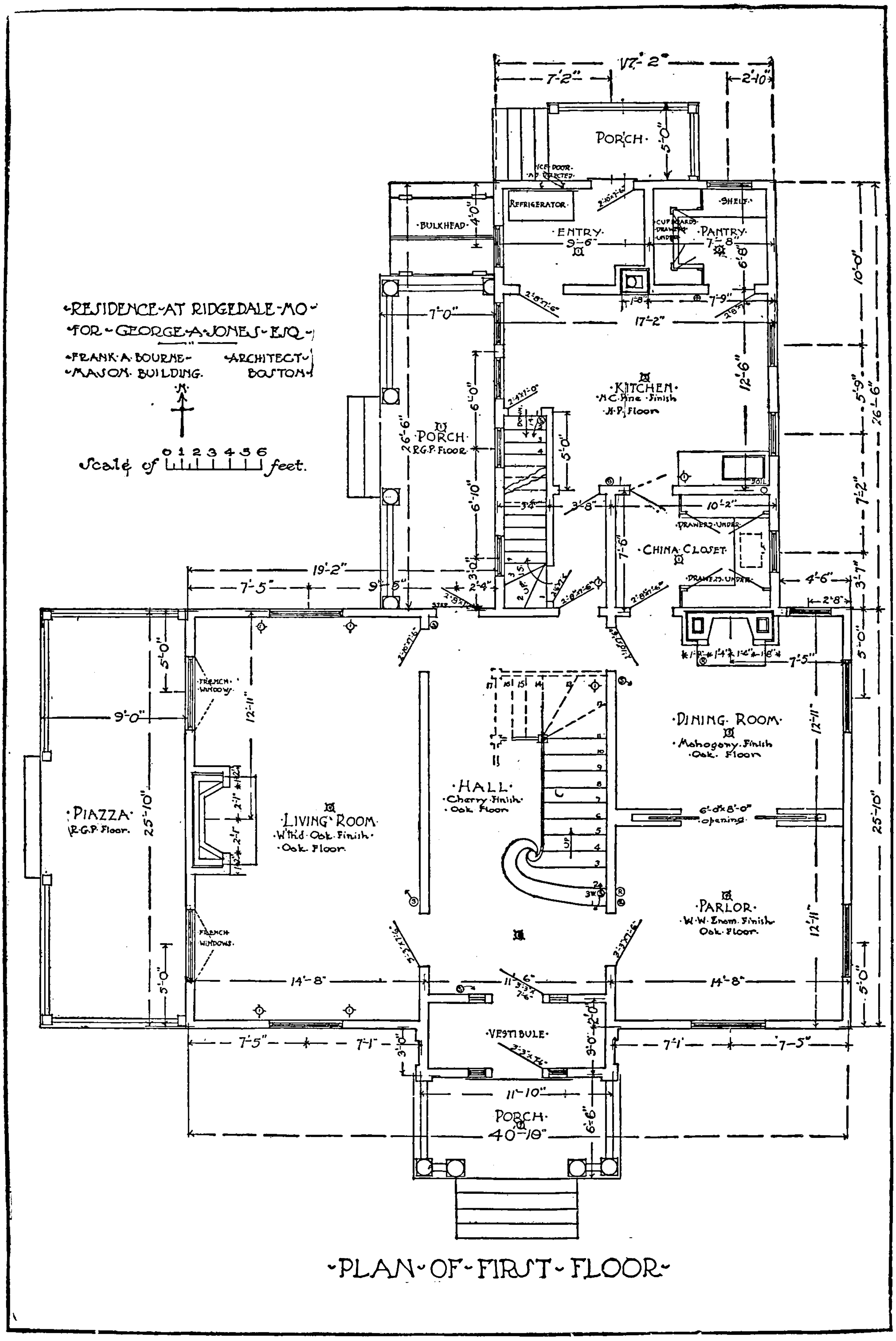

RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A. BOURNE ARCHITECT
MASON BUILDING BOSTON
Scale of 0 1 2 3 4 5 6 feet.
PORCH
REFRIGERATOR
BULKHEAD
ENTRY
PANTRY
SHELF
KITCHEN
H.C. Pine Finish
H.P. Floor
PORCH
R.G.P. Floor
CHINA CLOSET
DRAWERS UNDER
PIAZZA
R.G.P. Floor.
LIVING ROOM
W'th'd Oak Finish
Oak Floor
FRENCH WINDOWS
HALL
Cherry Finish
Oak Floor
DINING ROOM
Mahogany Finish
Oak Floor
6'-0"x8'-0" opening
PARLOR
W.W. Enam. Finish
Oak Floor
VESTIBULE
PORCH
40'-10"
PLAN OF FIRST FLOOR

Fig. 5.

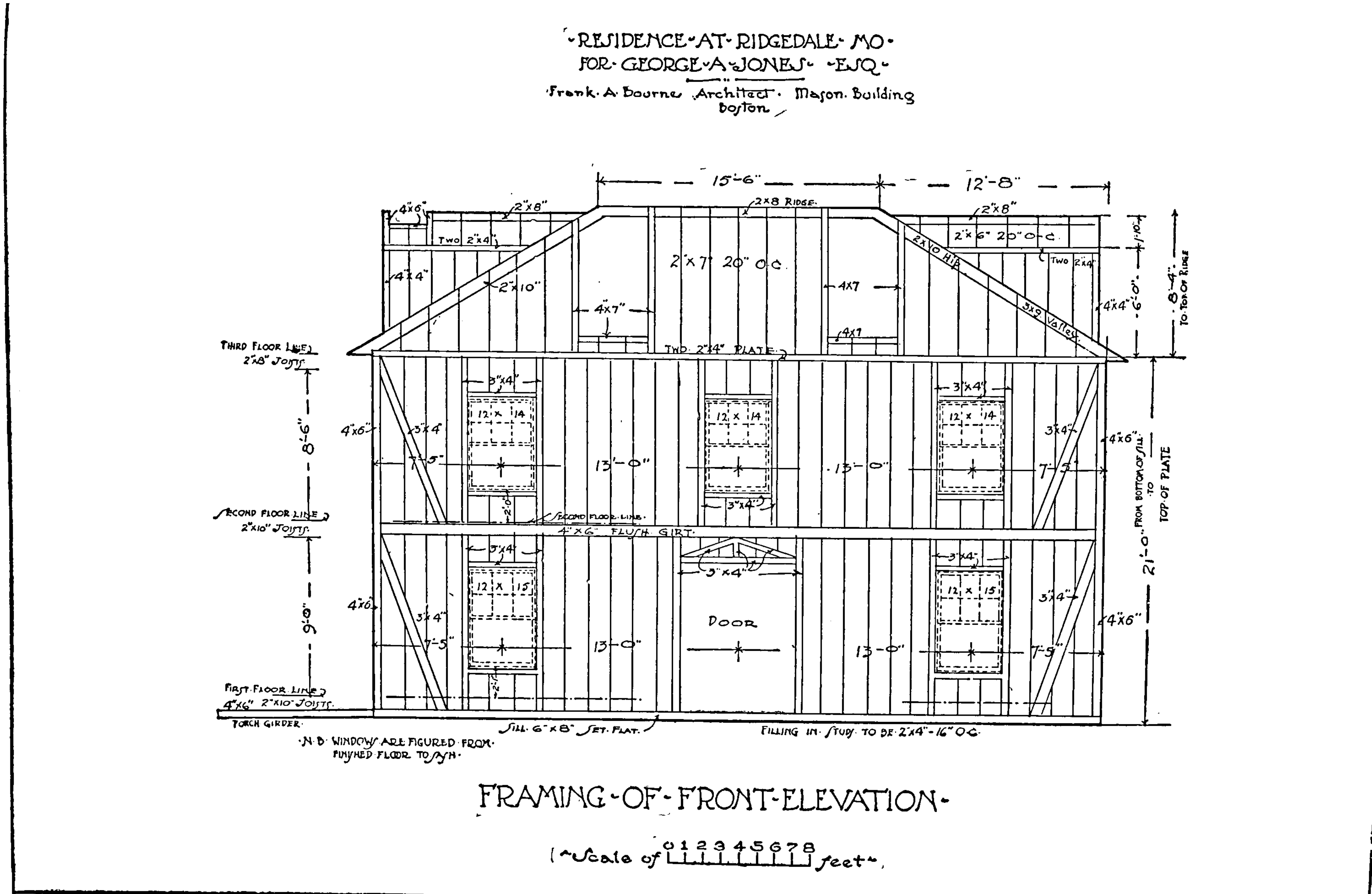
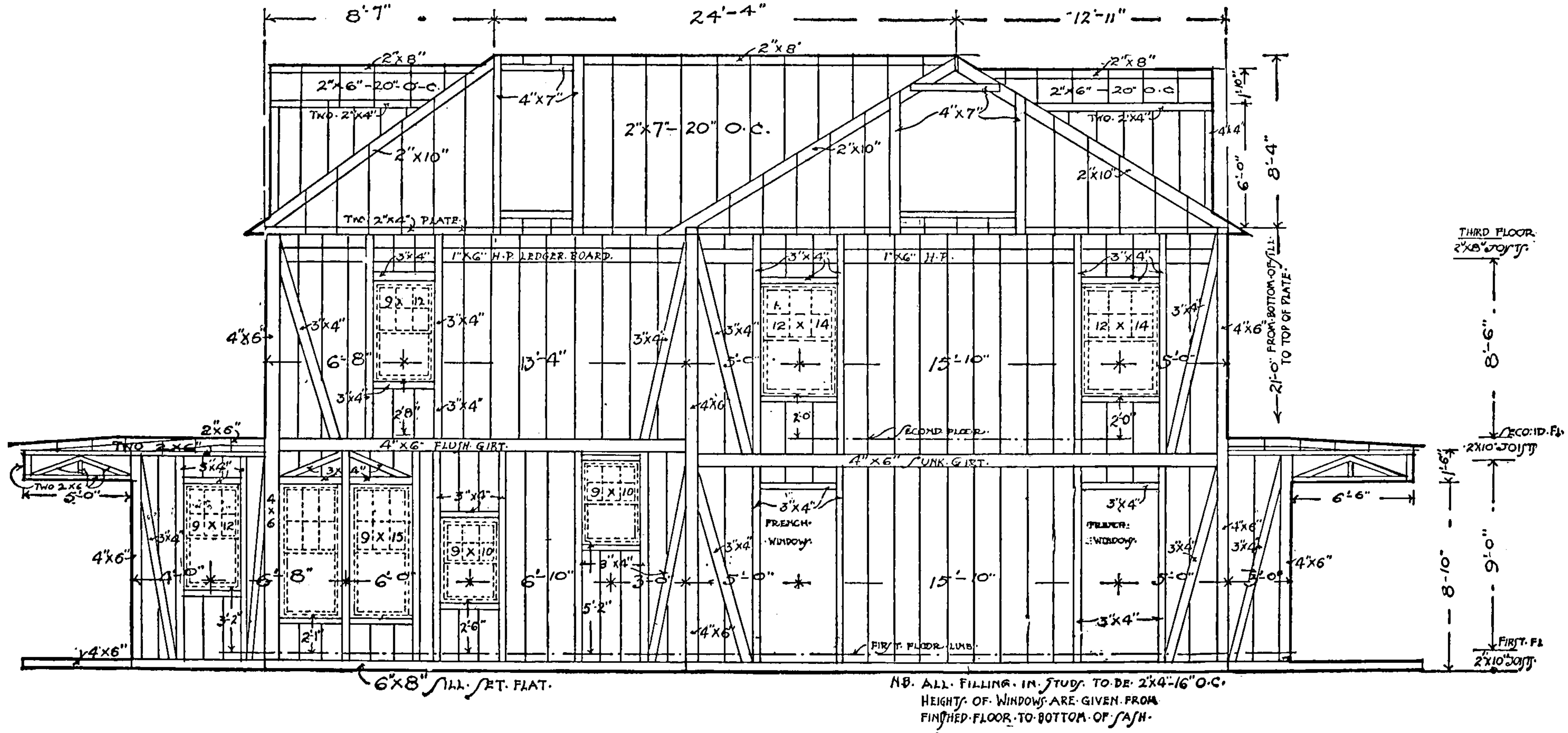

RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
Frank A Bourne Architect Mason Building Boston
15'-6"
12'-8"
2x8 RIDGE
4"x6"
2"x8"
Two 2"x4"
2"x6" 20" O.C.
2"x7" 20" O.C.
4"x4"
2"x10"
2x10 HIP
3x9 Valley
4x7
4"x7"
TWO 2"x4" PLATE
1'-10"
6'-0"
8'-4" TO TOP OF RIDGE
THIRD FLOOR LINE
2"x8" JOISTS
8'-6"
SECOND FLOOR LINE
2"x10" JOISTS
9'-0"
FIRST FLOOR LINE
4"x6" 2"x10" JOISTS
PORCH GIRDER
3"x4"
12 x 14
12 x 15
13'-0"
7'-5"
2'-0"
4"x6" FLUSH GIRT
DOOR
21'-0" FROM BOTTOM OF SILL TO TOP OF PLATE
SILL 6"x8" SET FLAT
FILLING IN STUDS TO BE 2"x4" 16" O.C.
N.B. WINDOWS ARE FIGURED FROM FINISHED FLOOR TO SASH
FRAMING OF FRONT ELEVATION
Scale of 0 1 2 3 4 5 6 7 8 feet

Fig. 6.



·FRAMING·OF·LEFT·SIDE·ELEVATION·

~Scale of 1/8" 0 1 2 3 4 5 6 7 8 9 feet~

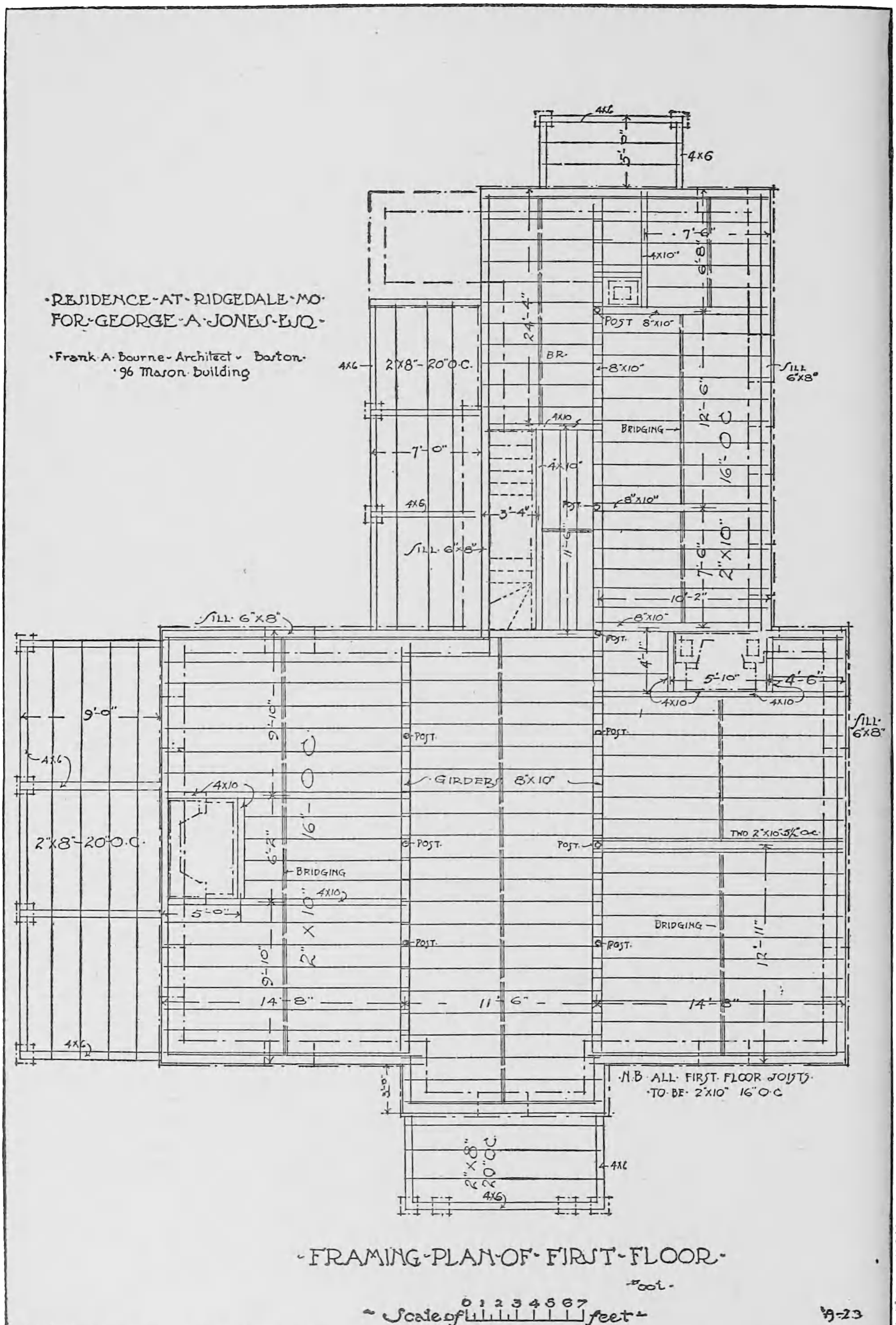

RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
Frank A. Bourne Architect Boston
96 Mason Building
2"x8" 20" O.C.
7'-0"
SILL 6"x8"
4x6
BR.
POST 8"x10"
BRIDGING
SILL 6"x8"
24'-4"
16'-0"
12'-6"
7'-6"
2"x10"
10'-2"
9'-0"
GIRDERS 8"x10"
POST
TWO 2"x10" 5½" O.C.
14'-8"
11'-6"
N.B. ALL FIRST FLOOR JOISTS TO BE 2"x10" 16" O.C.
FRAMING PLAN OF FIRST FLOOR
Scale of feet
A-23

Fig. 8.

	Brought forward	902 sq. ft.
15 ft. 6 in. × 26 ft. 0 in.		403
30 ft. 0 in. × 8 ft. 0 in.		240
		1,545 sq. ft.

First Story—

25 ft. 0 in. × 40 ft. 0 in.	1,000
11 ft. 0 in. × 3 ft. 0 in.	33
25 ft. 6 in. × 16 ft. 6 in.	420
490 ft. 0 in. × 9 ft. 0 in.	4,410
	5,863 sq. ft.

Second Story—

	Sq. Ft.
25 ft. 0 in. × 40 ft. 0 in.	1,000
16 ft. 6 in. × 19 ft. 0 in.	313
520 ft. 0 in. × 8 ft. 6 in.	4,420
	5,733 sq. ft.

Total amount of plastered surfaces, 13,141 sq. ft.

Outs—

32 doors, average 40 sq. ft.	1,280
34 windows, average 15 sq. ft.	510
	1,790 sq. ft.

1,790 sq. ft. ÷ 2 = 895 sq. ft.

13,141 sq. ft. less 895 sq. ft. = 12,246 sq. ft. = 1,361 sq. yds.

Total cost of Plastering 1,361 sq. yds., at $.40 . . . . $ 544.40

CARPENTER WORK

Frame—

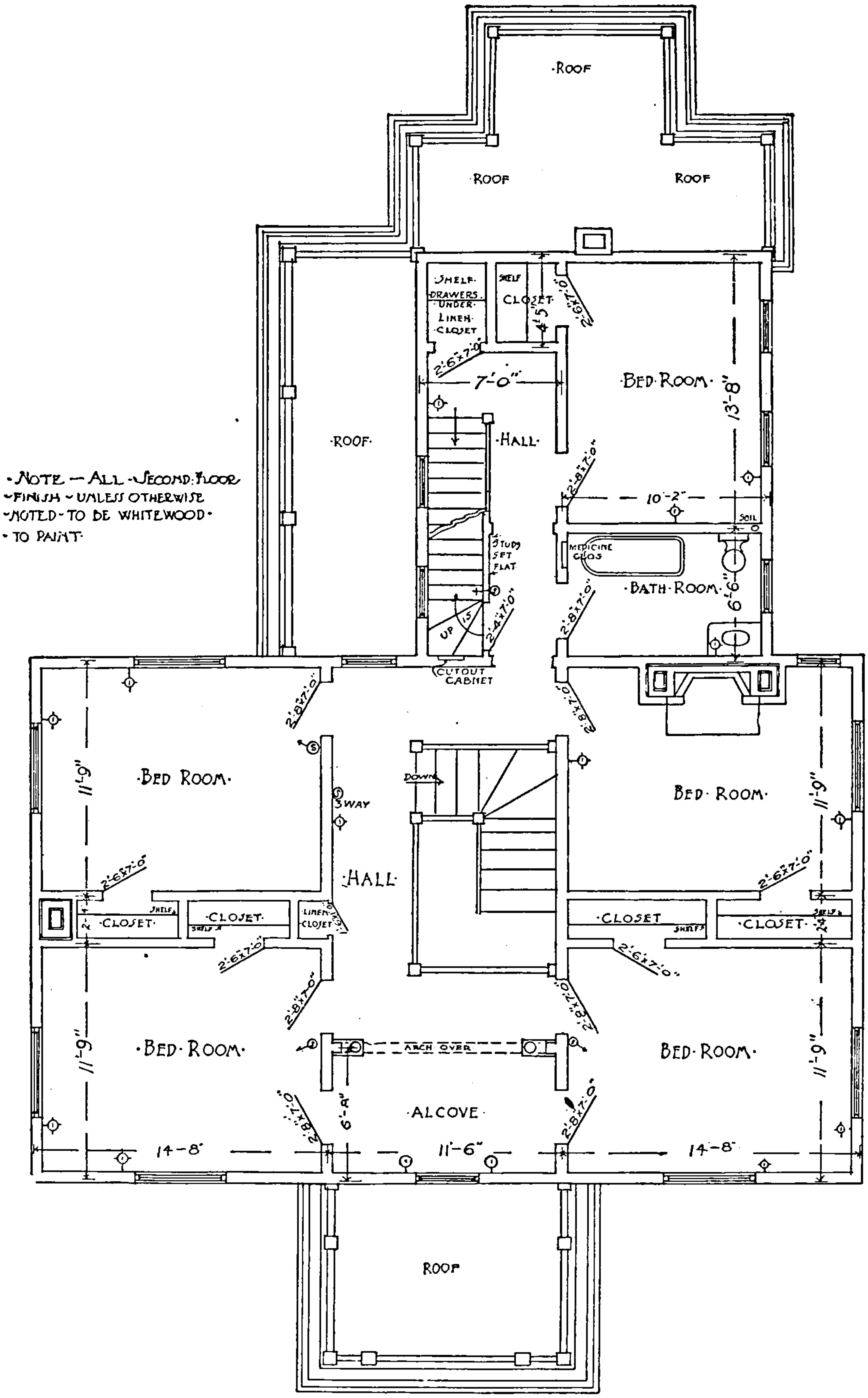
			Ft. B. M.
188 linear ft.,	6 × 6 in.	sill	564
136 " "	4 × 6 in.	"	272
74 " "	8 × 10 in.	girders	494
250 " "	4 × 6 in.	posts	500
188 " "	4 × 6 in.	girts	376
			2,206

2,206 ft. B. M. at $38.00 per M. . . . . $ 83.82

First-Story Frame, Bridging and Under Floor—

25 ft. 0 in. × 40 ft. 0 in. 1,000

Carried forward $ 83.82



-PLAN- OF-SECOND-FLOOR-

~Scale of 0 1 2 3 4 5 6 7 8 9 feet~

Fig. 9.

	Brought forward	$ 83.82
11 ft. 0 in. × 3 ft. 0 in.	33	
26 ft. 0 in. × 16 ft. 6 in.	429	
	1,462 sq. ft.	
1,462 sq. ft. = 14.62 squares, at $9.35 per square		$ 136.70

UPPER FLOOR—

Hard Pine

25 ft. 6 in. × 16 ft. 6 in. = 421 sq. ft., at $10.50 per square .... $ 44.21

Oak

25 ft. 0 in. × 40 ft. 0 in. = 1,000 sq. ft.
11 ft. 0 in. × 3 ft. 0 in. = 33 "
1,033 sq. ft.

1,033 sq. ft. at $20.00 per square .... $ 206.60

PORCH FLOOR—

6 ft. 0 in. × 11 ft. 0 in. = 66 sq. ft.
9 ft. 0 in. × 5 ft. 0 in. = 45 "

PIAZZA FLOOR—

26 ft. 0 in. × 9 ft. 0 in. = 234 "
20 ft. 6 in. × 7 ft. 0 in. = 144 "
489 sq. ft.

489 sq. ft. at $12.35 per square .... $ 60.39

SECOND-STORY FRAME, BRIDGING AND STRAPPING FLOORS—

40 ft. 0 in. × 25 ft. 0 in. .... 1,000 sq. ft.
20 ft. 0 in. × 17 ft. 0 in. .... 340 " "
1,340 sq. ft.

1,340 sq. ft. at $18.00 per square .... $ 241.20

THIRD STORY—

1,340 sq. ft. at $10.10 per square .... $ 135.34

ROOF FRAME, BOARDING AND SHINGLES–

30 ft. 0 in. × 16 ft. 6 in. × 2 sides .. 990 sq. ft.
34 ft. 0 in. × 16 ft. 6 in. × 2 sides .. 1,122 " "
2,112 sq. ft.

2,112 sq. ft. at $16.67 per square .... $ 352.07

FLASHING .... $ 40.00

TIN ROOF, FRAME AND BOARDING—

21 ft. 0 in. × 7 ft. 6 in. .... 157 sq. ft.

Carried forward $1,300.33

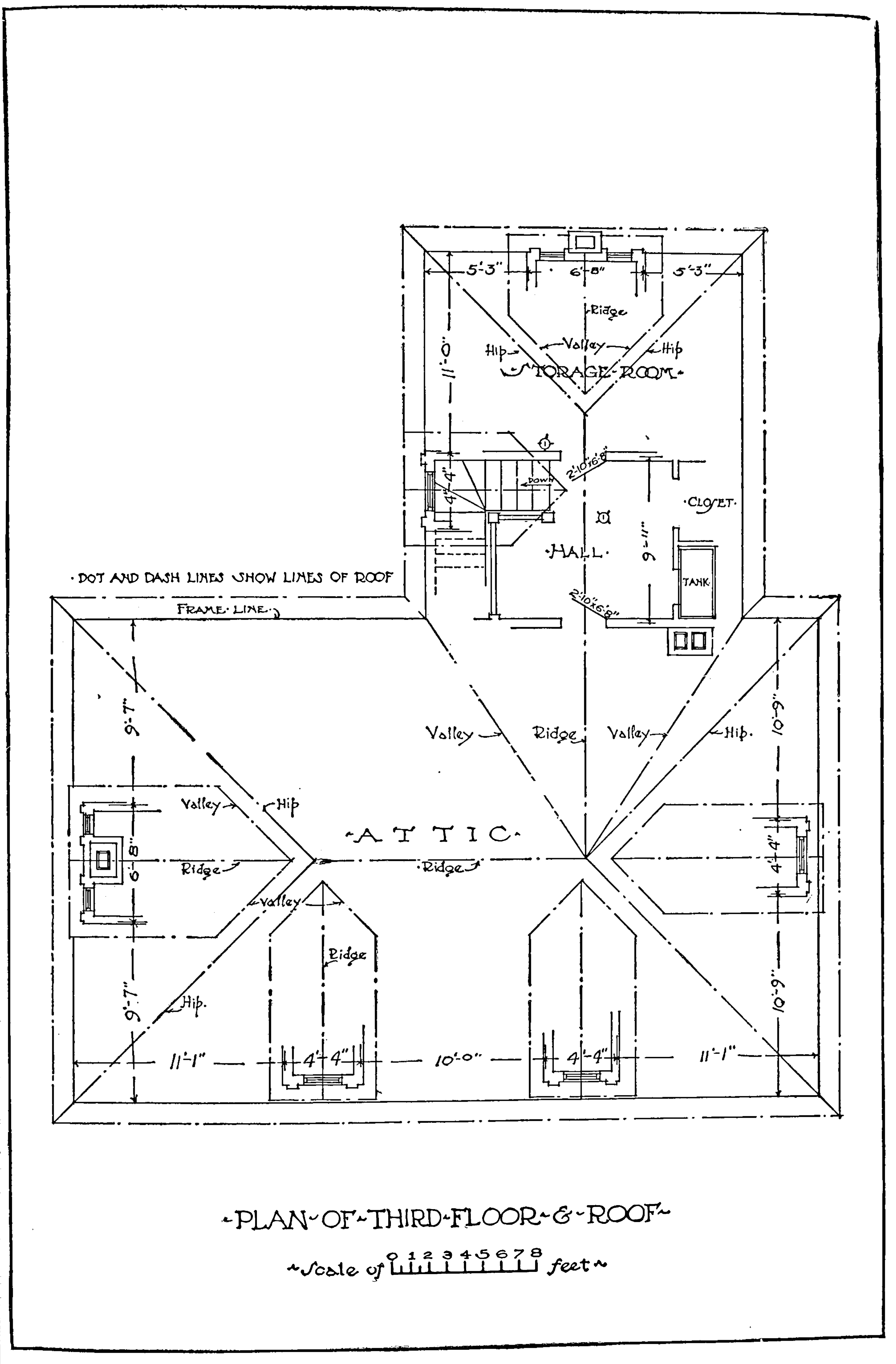
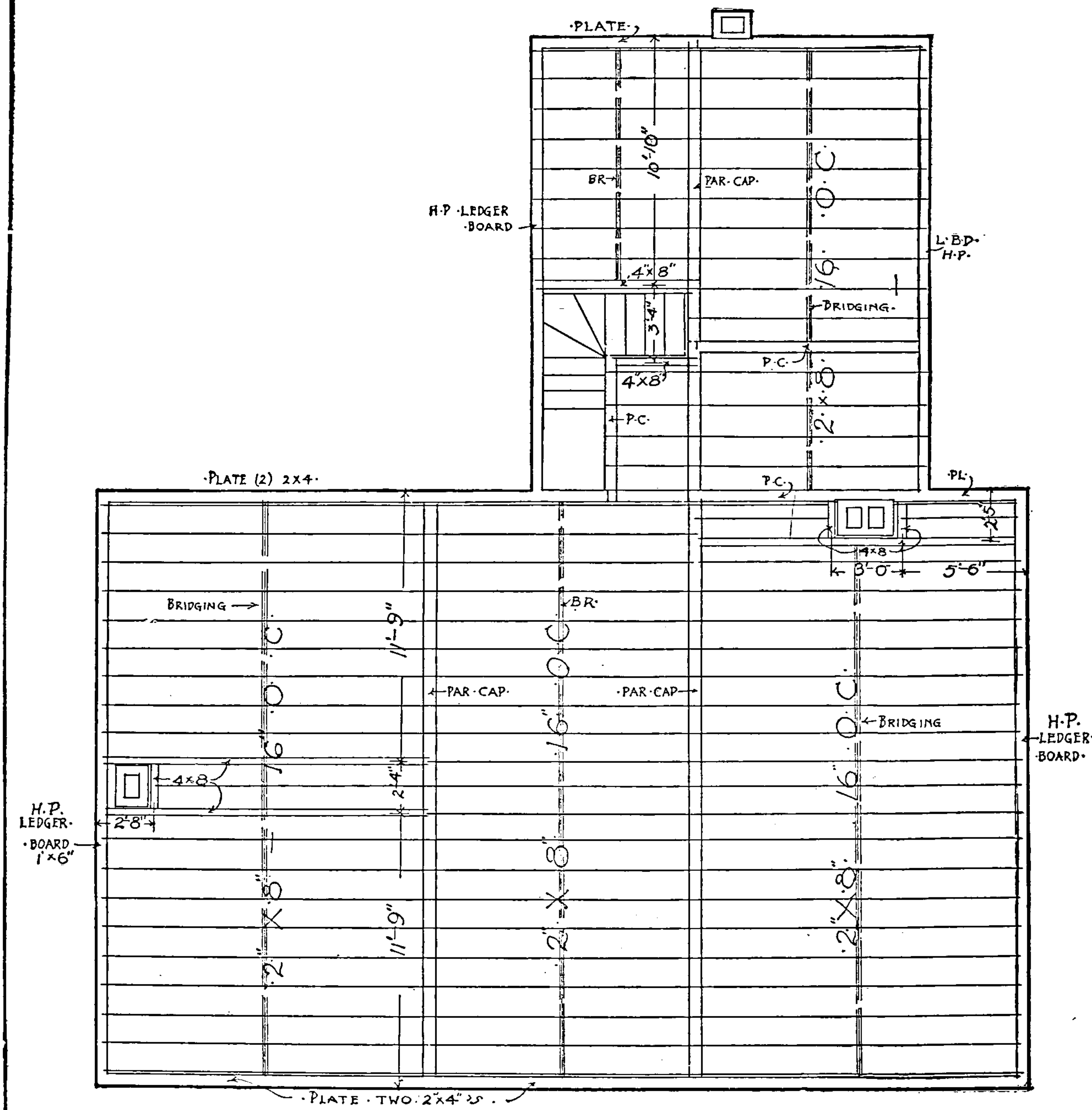

5'-3"
6'-8"
5'-3"
Ridge
Hip
Valley
Hip
STORAGE ROOM
11'-0"
DOWN
2'-10"x6'-8"
4'-4"
CLOSET
HALL
9'-11"
TANK
2'-10"x6'-8"
DOT AND DASH LINES SHOW LINES OF ROOF
FRAME LINE
9'-7"
Valley
Ridge
Valley
Hip
10'-9"
Valley
Hip
ATTIC
6'-8"
Ridge
Ridge
Valley
4'-4"
Ridge
9'-7"
Hip
10'-9"
11'-1"
4'-4"
10'-0"
4'-4"
11'-1"
PLAN OF THIRD FLOOR & ROOF
Scale of 0 1 2 3 4 5 6 7 8 feet

Fig. 11

Brought forward			$1,300.33
19 ft. 0 in. × 6 ft. 6 in.	124 sq. ft.		
11 ft. 0 in. × 5 ft. 6 in.	60 " "		
14 ft. 0 in. × 9 ft. 6 in.	133 " "		
	474 sq. ft.		
474 sq. ft. at $20.92 per square			$ 99.16
OUTSIDE WALLS, STUDDING AND BOARDING—			
172 ft. 0 in. × 20 ft 0 in.	3,440 sq. ft.		
6 ft. 6 in. × 10 ft. 0 in. × 2 sides	130 " "		
3 ft. 0 in. × 9 ft. 0 in. × 2 sides	54 " "		
	3,624 sq. ft.		
3,624 sq. ft. at $8.30 per square			$ 300.79
INSIDE STUDDING—			
180 ft. 0 in. × 9 ft. 0 in.	1,620 sq. ft.		
196 ft. 0 in. × 8 ft. 6 in.	1,666 " "		
28 ft. 0 in. × 8 ft. 0 in.	224 " "		
	3,510 sq. ft.		
3,510 sq. ft., at $4.00 per square			$ 140.40
CLAPBOARDING—			
44 ft. 0 in. × 19 ft. 0 in. × 2 sides.	1,672 sq. ft.		
6 ft. 0 in. × 8 ft. 0 in. × 2 sides.	96 " "		
2 ft. 0 in. × 9 ft. 0 in. × 2 sides.	36 " "		
39 ft. 0 in. × 19 ft. 0 in. × 2 sides.	1,482 " "		
	3,286 sq. ft.		
3,286 sq. ft. at $7.95 per square . . .		$261.23	
Deduct for stock only, 36 windows = 540 sq. ft., at $4.70 per square		25.38	$ 235.85

MISCELLANEOUS

DORMERS—		
6, at $50 each.		$ 300.00
MAIN CORNICE—		
180 ft., at $1.25 per ft.		225.00
BALUSTRADE ON ROOF—		
96 ft., at $0.50 per ft.	$48.00	
18 posts, at $1.50 each	27.00	75.00
Carried forward		$2,676.53



·FRAMING·PLAN·OF·THIRD·FLOOR·

Scale of 0 1 2 3 4 5 6 7 8 feet

Fig. 12.

Brought forward		$3,550.91
1 window, 3 ft. 4 in. × 5 ft. 6 in. (birch finish) ..		16.57
1 window, 2 ft. 6 in. × 5 ft. 6 in. (birch finish) ..		14.45
2 windows, 3 ft. 4 in. × 5 ft. 5 in. (whitewood), at .... $13.33 each		26.66
4 windows, 2 ft. 6 in. × 4 ft. 6 in. (N. C. pine), at ....$11.44 each		45.76
FRONT DOOR, with side and top lights—		
3 ft. 3 in. × 7 ft. 6 in.		56.33
REAR DOOR—		
2 ft. 10 in. × 7 ft. 6 in..........................		13.46
CELLAR SASHES—		
12, at $3.25 each..............................		39.00
INSIDE FINISH—		
Coal bins in basement, 240 sq. ft.		
Studding 240 sq. ft. at $3.00 per square	$ 7.20	
Boarding 240 " " $4.75 " "	11.40	
Labor on 2 doors, one day............	3 25	21.85
COLD-AIR BOX—		
3 ft. 0 in. × 1 ft. 0 in., 25 ft. long, at $.62 per linear ft. ...		15.50
BASEMENT PARTITIONS—		
46 ft. 0 in. × 8 ft. 0 in., 368 sq. ft., at $8.75 per square...		32.20
3 doors, at $8.87 each............................		26.61
67½ ft. shelving, at $.15 per ft.......................		10.12
1 door to bulkhead............................ ...		10.00
FIRST STORY—		
1 door, 2 ft. 8 in. × 7 ft. 6 in. (whitewood and birch finish)		20.67
1 pair sliding doors (whitewood and birch finish)		53.52
40 ft. birch base at $.20 per ft......................		8.00
1 door, 3 ft. 3 in. × 7 ft. 6 in. (whitewood and oak)		22.67
1 door, 2 ft. 10 in. × 7 ft. 6 in. (whitewood and oak)		20.67
WOOD CORNICE IN DINING ROOM—		
56 ft., 6 in. × 6 in. (birch), at $.48 per ft.	$26.88	
56 ft. picture moulding, at $.06 per ft.	3.36	30.24
WOOD CORNICE IN LIBRARY—		
82 ft., 6 in. × 6 in. (oak), at $.48 per ft......	$39 36	
Carried forward	$39.36	$4,035.19

Brought forward	$39.36	$4,035.19
82 ft. picture moulding, at $.06 per ft.	4.92	44.28
OAK BASE—		
72 ft. at $.20 per ft.		14.40
1 door, 3 ft. 0 in. × 7 ft. 6 in (whitewood)		12.59
VESTIBULE DOOR, side lights and top light, same as front door.		56.33
WHITEWOOD BASE, 101 ft., at $.10 per ft.		10.10
5 doors (N. C. pine), at $9.48 each		47.40
CHINA CLOSET FINISH		100.00
PANTRY		50.00
KITCHEN AND BACK ENTRY SHEATHING—		
65 linear ft., at $.40 per ft.		26.00
MANTELS—		
Allowance	$125.00	
Labor of setting	6 50	$131.50
SECOND STORY—		
16 doors stock, at $9.48 each		$151.68
1 arch in hall		10.00
2 wood columns, at $10.00 each		20.00
5 closets, at $3.50 each		17.50
1 linen closet		25.00
1 linen closet		20.00
THIRD STORY—		
2 doors, finished one side, at $7.04 each		$ 14.08
1 closet door		7.04
Tank		10.00
Finished floor, 100 sq. ft.		7.25
Base, 14 ft., at $.10 per ft.		1.40
CONDUCTORS—		
120 ft., at $.13 per ft., put up	$15.60	
6 goosenecks, at $1.00 each	6.00	$ 21.60
CUTTING AND FITTING FOR PLUMBING AND HEATING		35.00
FREIGHT, FARES AND EXPENSES		50.00
INSURANCE		10.00
Total cost of Carpenter Work		$4,928.34

STAIRS

Front Stairs—		
128 ft. spruce, at $30 per M.	3.84	
120 ft. whitewood, at $70 per M.	8.40	
85 ft. quartered oak, at $150 per M.	12.75	
30 ft. mahogany rail and turn	24.00	
5 paneled posts at $5.00 each	25.00	
105 balusters at $.15 each	15.75	
11 nosings at $.06 each	.66	
25 scotias at $.03 each	.75	
Nails, glue, etc.	1.00	
Labor	56.00	$148.15
Back Stairs—		
First Flight—		
55 ft. spruce, at $30 per M.	$ 1.65	
105 ft. N. C. pine, at $60 per M	6.30	
16 scotias at $.03 each	.48	
Nails, etc.	.75	
Labor	16.00	25.18
Second Flight—		
54 ft. spruce, at $30 per M.	$ 1.62	
110 ft. N. C. pine, at $60 per M	6.60	
17 scotias at $.03 each	.51	
Nails, etc.	.75	
1 post	.75	
4 ft. rail, at $.12½ per ft.	.50	
12 balusters at $.06¼ each	.75	
Labor	17.00	28.48
Cellar Stairs—		
40 ft. spruce, at $30 per M.	$ 1.20	
75 ft. N. C. pine, at $60 per M.	4.50	
Post	.50	
Rail	1.20	
Labor	5.00	12.40
		$214.21
Framing		2.00
Total cost of Stairs		$216.21

HARDWARE

NOTE.—This estimate is based upon a fair quality of hardware, the butts being of bronze plated steel, the knobs of struck-up bronze metal, with rose and escutcheon combined; the sash fasts of solid bronze metal, also lifts and catches.

BASEMENT

BULKHEAD, OUTSIDE—			
2 pairs extra heavy galv. T hinges, 8-inch at $.85 each		$1.70	
2 hooks and staples, 5 inch, at	$.10 each	.20	
Labor		1.00	
BULKHEAD, INSIDE—			
1 pair heavy T hinges, 8-inch		.15	
1 thumb-latch		.10	
Labor		.50	
THREE DOORS—			
3 pairs butts, $3\frac{1}{2} \times 3\frac{1}{2}$-inch, at	$.15 each	.45	
3 sets locks at	$.45 each	1.35	
Labor		1.50	
HINGED WINDOWS—			
12 pairs butts, $1\frac{1}{4}$-inch, at	$ 06 each	.72	
12 hooks and eyes, at	$.02 each	.24	
12 buttons, at	$.02 each	.24	
Labor		1.50	$ 9.65

FIRST FLOOR

ENTRANCE DOOR—			
$1\frac{1}{2}$ pairs butts, $4\frac{1}{2} \times 4\frac{1}{2}$-inch, at	$.38 each	$ .57	
1 set locks, bronze metal		9 50	
Labor		2.00	
SEVEN INSIDE DOORS, FRONT—			
7 pairs butts, $3\frac{1}{2} \times 3\frac{1}{2}$-inch, at	$.30 each	2.10	
7 sets locks at	$1.00 each	7.00	
Labor		5.25	
	Carried forward	$26.42	$9.65

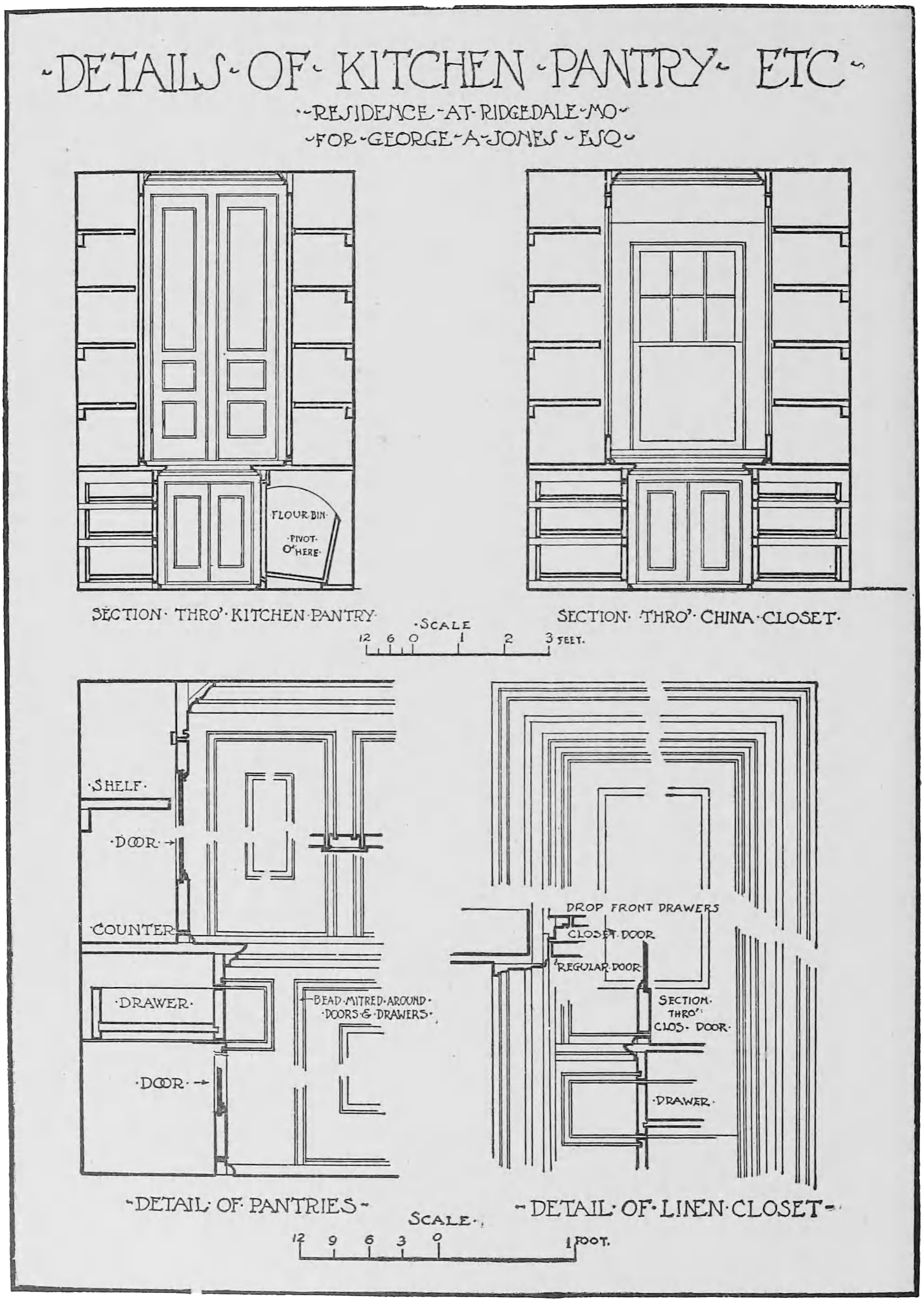

DETAILS OF KITCHEN PANTRY ETC
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FLOUR BIN
PIVOT HERE
SECTION THRO' KITCHEN PANTRY
SCALE
12 6 0 1 2 3 FEET.
SECTION THRO' CHINA CLOSET
SHELF
DOOR
COUNTER
DRAWER
BEAD MITRED AROUND DOORS & DRAWERS
DOOR
DROP FRONT DRAWERS
CLOSET DOOR
REGULAR DOOR
SECTION THRO' CLOS. DOOR
DRAWER
DETAIL OF PANTRIES
SCALE
12 9 6 3 0 1 FOOT.
DETAIL OF LINEN CLOSET

Fig. 14.

	Brought forward	$57.84	$9.65
4 cupboard catches, at	$.15 each	.60	
1 bbl. swing		.75	
10 drawer-pulls, at	$.06 each	.60	
Labor		2.00	
WINDOWS—			
15 sash fasts, at	$.30 each	4.50	
30 sash lifts, at	$.06 each	1.80	
Labor		7.50	
CASEMENT WINDOWS,			
4 pairs butts, 3 × 3-inch, at	$.50 each	2.00	
2 pairs flush bolts, at	$1.00 each	2.00	
2 casement fasts, at	$.45 each	.90	
Labor		1.00	$81.49

SECOND FLOOR

SIXTEEN DOORS—			
16 pairs butts, $3\frac{1}{2} \times 3\frac{1}{2}$-inch, at	$.30 each	$ 4.80	
16 sets locks, at	$.90 each	14.40	
Labor		10.40	
WINDOWS—			
14 sash fasts, at	$.30 each	4.20	
1 sash fast		.35	
28 sash lifts, at	$.06 each	1.68	
2 sash lifts, at	$.10 each	.20	
Labor		7.00	
SIX DRAWERS IN LINEN CLOSET—			
12 drawer-pulls, at	$.06 each	.72	
Labor		.25	$44.00
BATHROOM—			
1 pair butts, $3\frac{1}{2} \times 3\frac{1}{2}$-inch (nickel-plate)		.40	
1 set locks (nickel-plate)		1.25	
Labor		.75	$ 2.40

ATTIC

TWO DOORS—			
2 pairs butts, $3\frac{1}{2} \times 3\frac{1}{2}$-inch, at	$.12 each	$.24	
2 sets locks, at	$.45 each	.90	
Labor		1.00	
	Carried forward	$2.14	$137.54

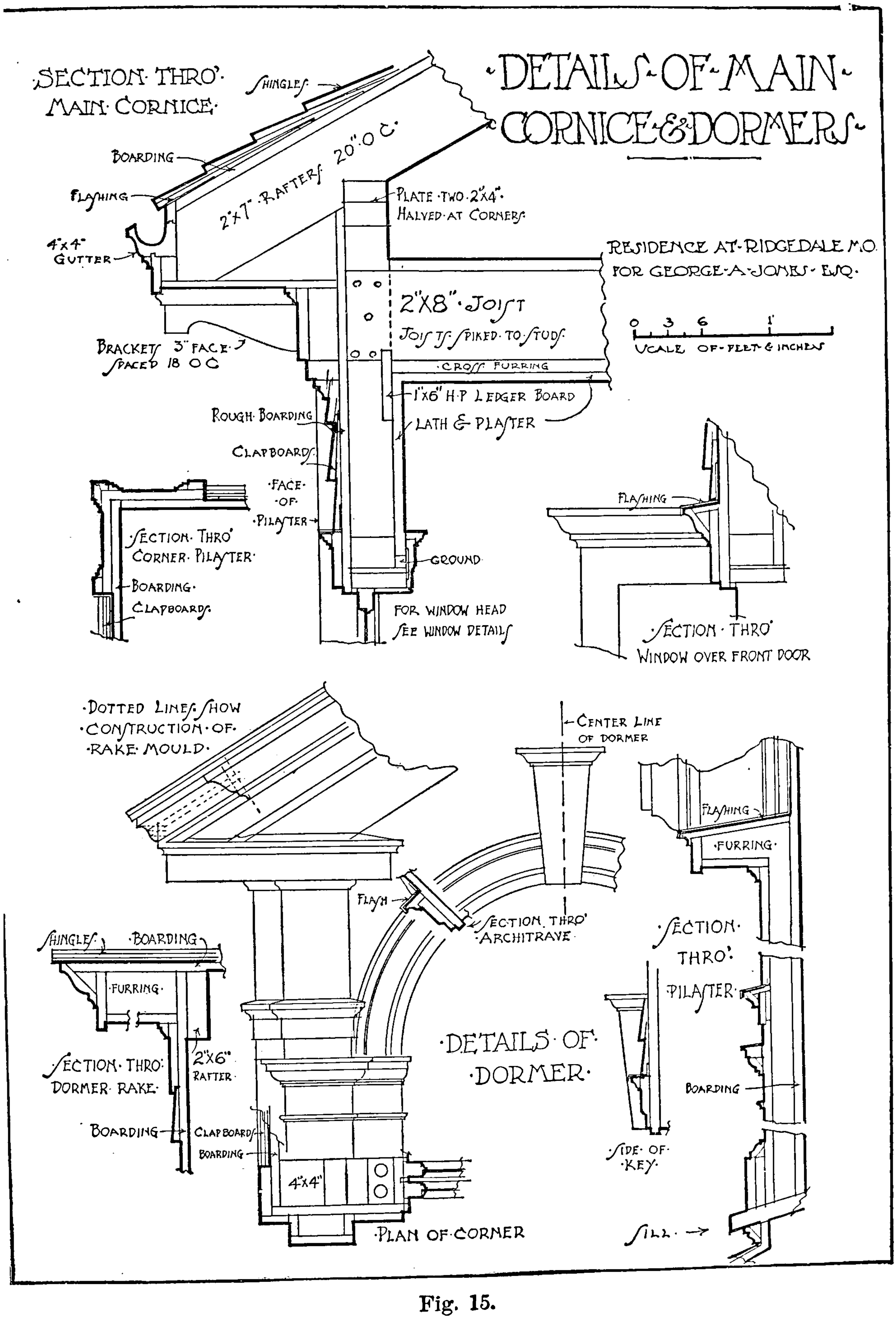

DETAILS OF MAIN CORNICE & DORMERS
SECTION THRO' MAIN CORNICE
SHINGLES
BOARDING
FLASHING
4"x4" GUTTER
2"x7" RAFTERS 20" O C
PLATE TWO 2"x4" HALVED AT CORNERS
RESIDENCE AT RIDGEDALE MO.
FOR GEORGE A JONES ESQ.
2"X8" JOIST
JOISTS SPIKED TO STUDS
0 3 6 1'
SCALE OF FEET & INCHES
BRACKETS 3" FACE SPACED 18 O C
CROSS FURRING
1"x6" H P LEDGER BOARD
LATH & PLASTER
ROUGH BOARDING
CLAPBOARDS
FACE OF PILASTER
SECTION THRO' CORNER PILASTER
BOARDING
CLAPBOARDS
GROUND
FOR WINDOW HEAD SEE WINDOW DETAILS
FLASHING
SECTION THRO' WINDOW OVER FRONT DOOR
DOTTED LINES SHOW CONSTRUCTION OF RAKE MOULD
CENTER LINE OF DORMER
FLASH
SECTION THRO' ARCHITRAVE
FLASHING
FURRING
SHINGLES
BOARDING
FURRING
SECTION THRO' DORMER RAKE
2"X6" RAFTER
BOARDING
CLAPBOARDS
BOARDING
4"x4"
PLAN OF CORNER
DETAILS OF DORMER
SECTION THRO' PILASTER
BOARDING
SIDE OF KEY
SILL

Fig. 15.

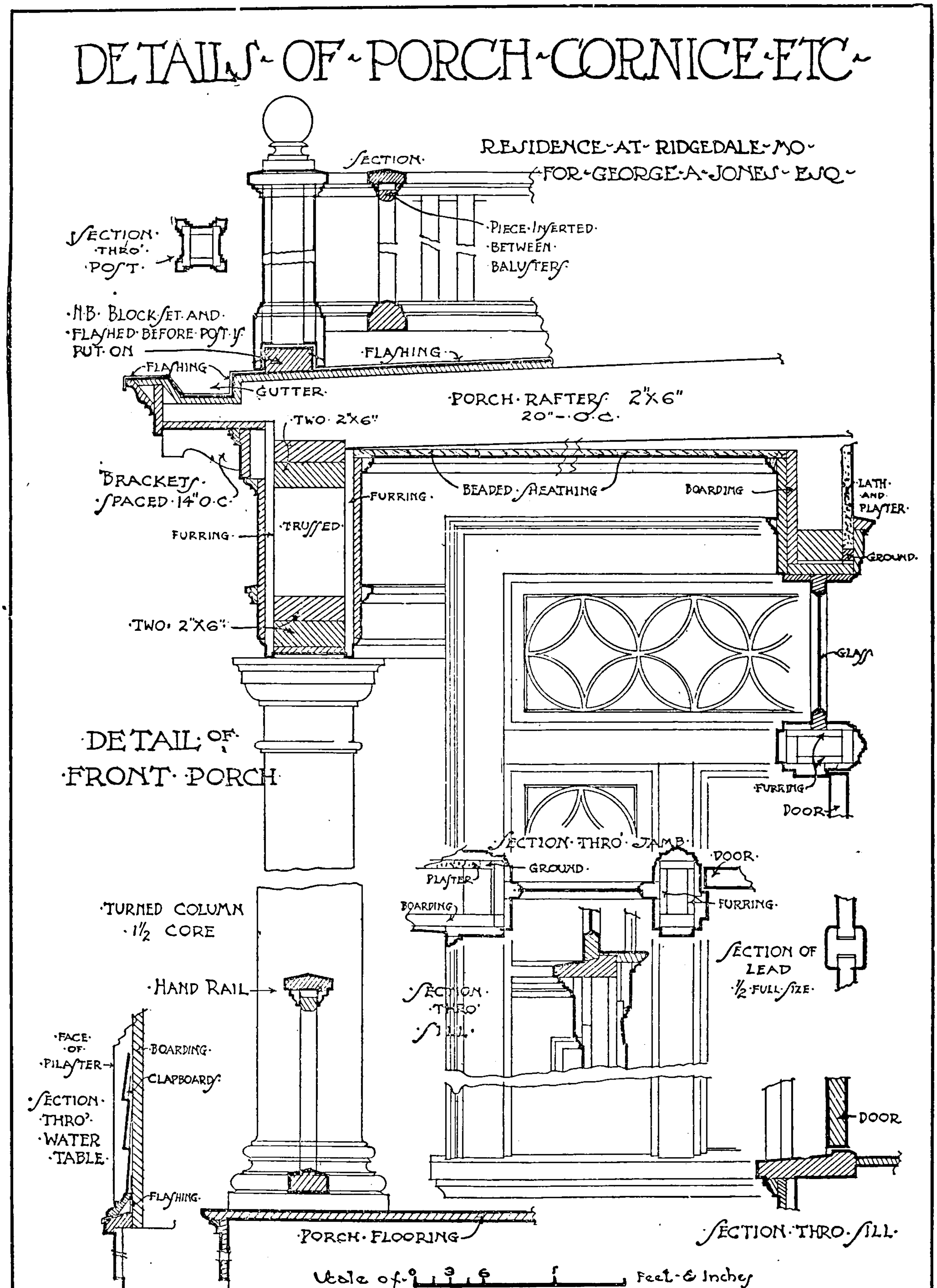

DETAILS OF PORCH CORNICE ETC
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
SECTION
SECTION THRO' POST
PIECE INSERTED BETWEEN BALUSTERS
N.B. BLOCK SET AND FLASHED BEFORE POST IS PUT ON
FLASHING
FLASHING
GUTTER
PORCH RAFTERS 2"X6" 20"-O.C.
TWO 2"X6"
BRACKETS SPACED 14" O.C.
FURRING
BEADED SHEATHING
BOARDING
LATH AND PLASTER
GROUND
FURRING
TRUSSED
TWO 2"X6"
GLASS
DETAIL OF FRONT PORCH
FURRING
DOOR
SECTION THRO' JAMB
DOOR
PLASTER
GROUND
BOARDING
FURRING
TURNED COLUMN 1½ CORE
SECTION OF LEAD ½ FULL SIZE
HAND RAIL
SECTION THRO' SILL
FACE OF PILASTER
BOARDING
CLAPBOARDS
SECTION THRO' WATER TABLE
FLASHING
DOOR
PORCH FLOORING
SECTION THRO SILL
Scale of 0 3 6 1 Feet & Inches

Fig. 16.

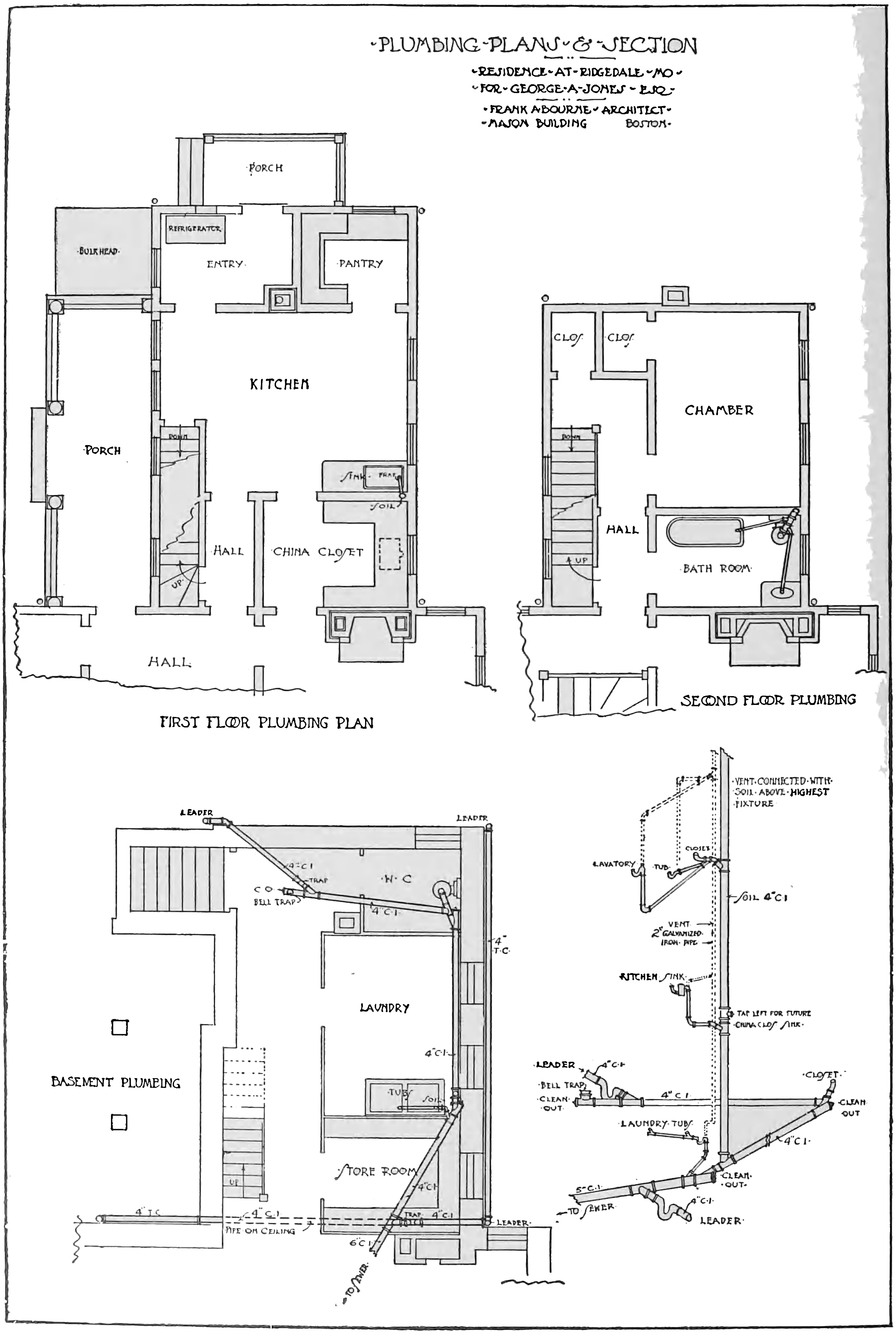

PLUMBING PLANS & SECTION
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A BOURNE ARCHITECT
MASON BUILDING BOSTON
PORCH
BULKHEAD
REFRIGERATOR
ENTRY
PANTRY
KITCHEN
PORCH
SINK
TRAP
SOIL
HALL
CHINA CLOSET
UP
HALL
FIRST FLOOR PLUMBING PLAN
CLOS
CLOS
CHAMBER
HALL
BATH ROOM
UP
SECOND FLOOR PLUMBING
LEADER
LEADER
4" C I
TRAP
C O
BELL TRAP
W C
4" C I
4" T C
LAUNDRY
4" C I
TUBS
SOIL
STORE ROOM
4" C I
UP
BASEMENT PLUMBING
4" T C
4" C I
PIPE ON CEILING
TRAP
4" C I
LEADER
6" C I
TO SEWER
VENT CONNECTED WITH SOIL ABOVE HIGHEST FIXTURE
CLOSET
LAVATORY
TUB
SOIL 4" C I
VENT 2" GALVANIZED IRON PIPE
KITCHEN SINK
TAP LEFT FOR FUTURE CHINA CLOS SINK
LEADER
4" C I
BELL TRAP
CLEAN OUT
4" C I
CLOSET
CLEAN OUT
LAUNDRY TUBS
4" C I
CLEAN OUT
5" C I
TO SEWER
4" C I
LEADER

Fig. 17.

Brought forward		$244.61
LABOR—		
Measuring and laying out risers, man 1 day	$4.80	
Erecting risers, man 2 days, helper 1 day	12.00	
Laying out and erecting cellar pipes and furnace, man 3 days, helper 2 days	19.20	
Finishing, man 1 day	4.80	
Carting and expenses	10.00	50.80
Total cost of Heating Apparatus		$ 295.41

PLUMBING

WASTE AND SOIL PIPES—		
2 4-in. lead bends, at $1.10 each	$2.20	
2 4-in. sleeves, at $.65 each	1.30	
5 2-in. " at $.28 each	1.40	
2 3 × 2-in. sleeves, at $.45 each	.90	
1 1½-in. Pemberton trap	6.80	
30 lbs. solder, wiping, at $.25 lb.	7.50	
2 trap plugs, at $.42 each	.84	
2 6-in. traps, at $2.35 each	4.70	
1 6-in. cesspool	3.00	
4 1½-inch solder nipples, at $.15 each	.60	
1 4-in. roof flashing	1.35	
Soil pipe	47.87	
15 ft. 1½-in. lead pipe, No. 55	3.24	
50 ft. 2-in. iron pipe / 40 ft. 1½-in. " "	8.96	
Soil fittings, ⅓ cost of pipe	15.96	
Cast-iron fittings, 20 per cent	1.79	$ 108.41
MISCELLANEOUS FITTINGS—		
3 4-in. brass C. O.	$ 2.70	
1 5-in. brass C. O.	1.50	
Refrigerator waste	12.50	
Local vents	12.00	
1 ball-cock	1.25	
2 sill cocks	2.00	
Tank overflow	6.50	
4 ¾-inch S. & W. cocks	3.24	
Carried forward	$41.69	$108.41

Brought forward		$ 41.69	$ 108.41
1 boiler valve and chain		.70	
25 lbs. tinned copper, at $.32 lb.		8.00	
6 3-part hangers, brass		6.30	
2 ¾-in. hose bibs		1.50	
3 ¾-inch plain bibs		2.10	
Street connections		55.00	
1 lb. putty		.05	
2 lbs. grafting wax		.50	
Calking lead, 380 lbs.		22.80	
Oakum		1.60	$ 140.24
Fixtures—			
1 36 x 24 x 8-in. sink, 12-in. back		$11.40	
1 24 x 14-in. pantry sink		14.00	
1 pair pantry cocks		3.60	
2 24 x 48-in. trays, 12-in. back		14.10	
1 5-ft. bathtub, complete		41.00	
1 lavatory, complete		32.50	
1 water-closet, complete		60.00	
1 40-gallon boiler		16.75	
1 " " " stand		.85	
12 lbs. fine solder		3.12	
Clamps and hooks		2.70	
Tinned tacks		.15	
Fuel		1.95	$ 202.12
Supplies and Labor—			
126 ft. ¾-inch galv. water pipe		$4.41	
22 ft. ½-inch " " "		.62	
Fittings, ⅓ cost of pipe		1.67	
74 ft. ¾-in. brass	$23.49		
56 ft. ½-in. "	16.24	39.73	
Fittings, 20 per cent		7.95	
Painting of iron pipes		9.75	
Stop-cocks		3.54	
Sink and tray legs		4.72	
Lead, oil, etc.		.65	
Carried forward		$ 73.04	$ 450.77

NOTE.—This estimate is figured on outlet boxes at all outlets; and includes a main cabinet and main switch to connect with the meter and to cover the meter, on an eight-circuit panel-board, which allows one spare circuit. The panel-board is to be made of slate, with slate gutters and linings, with good wood door and trim.

The labor is estimated on wages being $3.60 per day for a journeyman, and $2.00 per day for helper. This price is above that paid in small places, but is below what is paid in some cities.

ELECTRIC LIGHTING FIXTURES

NOTE.—While the electric lighting fixtures are not generally made a part of the building contract, it may be worth while to consider them in relation to the cost of the house; although, as has been stated, there is such a wide range in design and cost, as well as in personal preference, that any data given can be at best only approximate.

The following estimate is based upon simple designs of moderate cost in "old brass" finish:

FIRST STORY

LIVING ROOM—	
1 4-light electrolier	$17.50
4 1-light wall brackets, at $3.25 each	13.00
HALL—	
2 2-light ceiling pieces, at $2.50 each	5.00
VESTIBULE—	
1 3-light cluster	5.00
PORCH—	
1 1-light ceiling-piece	1.75
PARLOR—	
1 4-light electrolier	17.50
2 1 " wall brackets	6.50
DINING ROOM—	
1 4-light electrolier	10.00
2 1 " wall brackets	5.00
CHINA CLOSET, REAR HALL, KITCHEN—	
3 1-light ceiling-pieces, at $.75 each	2.25
2 1 " wall brackets, at $1.35 each	2.70
Carried forward	$86.20

Brought forward	$ 86.20
PANTRY—	
1 1-light ceiling-piece	.75
ENTRY—	
1 1 " " "	1.35
PIAZZA—	
1 1 " " "	1.75

SECOND STORY

HALL—	
2 1-light ceiling-pieces, at $1.50 each	$3.00
ALCOVE—	
2 1-light ceiling pieces, at $2.50 each	5.00
BEDROOMS—	
13 1-light brackets, at $2.50 each	32.50
BATHROOM—	
1 1-light ceiling-piece	1.35
REAR HALL—	
1 1-light bracket	1.35

THIRD STORY

HALL—	
1 1-light wall bracket	$1.35
ATTIC—	
1 3-ft. drop-cord	.85

BASEMENT

LAUNDRY—	
1 1-light wall bracket	$1.15
CELLAR—	
4 3-ft. drop-cords, at $.85 each	3.40
	$ 140.00

LABOR

Installing above fixtures with all necessary trimmings	$ 12.00
Total cost of Electric Lighting Fixtures in place	$152.00

PAINTING

OUTSIDE PAINTING—	
17 pairs blinds, three coats painting, at $1.50 pair	$ 25.50
1,068 yds. three coats painting, windows and wood-work, at $.20 yd.	213.60
Carried forward	$239.10

Brought forward	$239.10
54 yds. two coats metallic paint, upper side tin roofs, at $.15 yd.	8.10
62 yds. two coats oiling on floors, porch, and piazza, at $.10 yd.	6.20
INTERIOR PAINTING—	
166 yds. filling, staining, and shellacing, and two coats hard oil finish, at $.20 yd.	$33.20
245 yds. filling and two coats spar varnish, first coat rubbed, at $.25 yd.	61.25
403 yds. one coat shellac, three of paint, two coats zinc and white varnish. Rubbed with pumice and water, ivory white finish, at $.80 yd.	322.40
294 yds. treat with potash, one oil filler, clean, four coats shellac, last coat rubbed with pumice and oil, oak and birch, at $.35 yd.	102.90
109 yds. filling, four coats shellac, last coat rubbed with pumice and oil, floors at $.30 yd.	32.70
114 yds. size and three coats paint, last coat with varnish, walls, at $.20 yd.	22.80
5 yds. three coats paint and one enamel gloss, bath-tub, at $.25 yd.	1.25
100 yds. three coats paint, last with zinc, flat, white-wood, at $.25 yd.	25.00
10 yds. one coat shellac on pipes, at $.10 yd.	1.00
299 yds. size and tint in water-colors, ceilings, at $.15 yd.	44.85
Total cost of Painting	$ 900.75

GENERAL SUMMARY

Batter-Boards and Water Supply	$ 25.00
Excavation	262.50
Stonework, Cesspools, and Drains	754.15
Chimneys and Brickwork	281.50
Concreting	88.20
Plastering	544.40
Carpenter Work	4,928.34
Carried forward	$6,884.09

Brought forward	$6,884.09
Stairs	216.21
Hardware	155.49
Heating	295.41
Plumbing	845.96
Electric Wiring	297.61
Electric Fixtures	152.00
Painting	900.75
Total,	$9,747.52

SCHEDULES

ANALYSIS OF CARPENTER WORK

Following is a section devoted to the analysis of the different portions of carpenter work in the foregoing estimate. These show how the prices are obtained, and will be very useful for comparison, as the changes in cost of parts can be noted and kept up to date.

First Floor, price per square of 100 sq. ft., including the floor beams, bridging, and under floors, but no furring for plaster—

Joists, 2 × 10-in., 16 inches on centers	$3.25	
Labor	1.50	
Nails	.10	
Bridging	.50	
Under floor, hemlock, at $24.00	2.30	
Waste, one-third	.80	
Labor	.75	
Nails	.15	$ 9.35

Hard Pine Upper Floor, per square of 100 sq. ft.—

Stock	$6.00	
Waste, one-third	2.00	
Labor	2.25	
Nails	.25	$10.50

Quartered Oak Upper Floor, per square of 100 sq. ft.—

Stock	$10.00	
Waste	3.30	
Labor	6.50	
Nails	.25	$20.05

Porch or Veranda Floor, per square of 100 sq. ft.—

Joists, 2 × 8-in., 16 inches on centers	$2.60	
Labor	1.00	
Hard pine flooring, at $55.	5.50	
Waste	1.80	
Labor	1.25	
Nails	.20	$12.35

Second Floor, per square of 100 sq. ft.—

Joists, 2 × 10-in., 16 inches on centers	$3.25	
Labor	1.50	
Bridging	.50	
Furring	1.50	
Under-floor stock	2.30	
Waste, one-third	.80	
Labor	.75	
Nails	.15	
Upper-floor stock	4.00	
Waste	1.30	
Labor	1.75	
Nails	.20	$18.00

Third Floor, per square of 100 sq. ft.—

Joists, 2 × 8-in., 16 inches on centers	$ 2.60	
Labor	1.50	
Under floor	4.00	
Furring	1.50	
Bridging	.50	$10.10

Shingled Roof, per square of 100 sq. ft—

Rafters, 2 × 7-in, 20 inches on centers.	$ 2.17	
Labor	2.25	
Matched spruce boarding	2.50	
Waste, one-third	.80	
Labor	1.25	
Nails	.20	
Shingles	4.00	
Labor	3.25	
Nails	.25	$16.67

Tinned Roof, per square of 100 sq. ft.—		
Rafters, 2 × 7-in., 20 inches on centers	$ 2.17	
Labor	1.50	
Matched boarding, as above	4.75	
Paper	.50	
Tinning	12.00	$20.92
Wall Frame and Boarding, per square of 100 sq. ft.—		
Studding, 2 × 4-in., 16 inches on centers	$ 4.00	
Boarding	2.30	
Waste	.80	
Labor	1.00	
Nails	.20	$ 8.30
Inside Studding, per square of 100 sq. ft.—		
Stock, 2x4-in., 16 inches on centers	$ 1.30	
Waste, one-half stock	.65	
Labor	1.50	
Nails	.15	
Grounds and beads	.40	$ 4.00
Clapboarding, per square of 100 sq. ft.—		
Clapboards, 80, at $.05 each	$ 4.00	
Labor	3.25	
Paper	.50	
Nails	.20	$ 7.95
Main Cornice, per linear foot—		
Gutter, per ft.	$ .12	
Upper fascia	.03	
Fillet	.01	
Lower fascia	.04	
Planceer	.08	
Bed-mould	.02	
Frieze	.06	
Architrave moulding	.04	
Brackets	.25	
Labor	.50	
Rough furring	.10	$ 1.25
Piazza Cornice, per linear foot—		
Upper fascia	$ .03	
Carried forward	$ .03	

Brought forward	$ .03	
Gutter	.10	
Lower fascia	.03	
Fillet	.01	
Planceer	.08	
Bed-mould	.02	
Brackets	.25	
Frieze	.15	
Architrave mould	.03	
Soffit	.05	
Inside frieze	.10	
Labor	1.00	
Rough furring	.15	$ 2.00
Attic Windows, circular top, each—		
Frame	$ 6.00	
Sash	2.50	
Inside finish	1.00	
Weights and cord	.45	
Labor	1.25	$11.20
Second-Story Windows, 3 ft. 6 in. × 5 ft., each—		
Frame	$ 3.50	
Sashes, 17½ sq. ft., at $.20 per sq. ft.	$ 3.50	
Blinds	1.00	
Blind fasts	.15	
Inside finish	1.19	
Nails and screws	.10	
Weights and cord	.64	
Labor, 1 day	3.25	$13.33
Inside Finish for Window, as above—		
Architrave, 21 ft., at $.03½ per ft.	$ .73	
Back-band, 21 ft., at $.03 " "	.63	
Beads, 17 ft., at $.02 " "	.34	$ 1.70
30 per cent off		.51
		$ 1.19
Weights and Cord for Window, as above—		
Weights, 17½ ft., 2 lbs. per ft., 35 lbs., at $.01¼ per lb.	$ .44	
Cord, 20 ft., at $.01 per ft.	.20	$ .64

Cost of Window, 2 ft. 6 in. x 4 ft. 6 in., each—

Frame	$ 3.50	
Window, 11¼ sq. ft., at $.20 per sq. ft	2.25	
Blinds	.75	
Blind fastenings	.15	
Screws and nails	.10	
Weight, 22½ lbs., at $ 01¼ per lb.	.28	
Cord	.15	
Inside Casing, 18 ft., at $.03½ per ft.	.63	
Back-band, 18 ft., at $.03 per ft.	.54	
Stop-beads, 14 ft., at $ 02 per ft.	.28	
Labor	3.25	$11.88

French Windows, 4 ft. 6 in × 7 ft. 6 in., each—

Frame	$ 5.00	
Sash, 4 ft. 6 in. × 7 ft. 6 in., 34 sq. ft., at $.20 per sq. ft.	6.80	
Astragal	.50	
Nails and screws	.10	
Inside finish	.96	
Labor	4.88	$18.24

Window, 3 ft. 4 in. × 5 ft. 6 in. (oak finish), each—

Frame	$ 3.50	
Window, 18 sq. ft., at $ 20 per sq. ft.	3.60	
Blinds	1.00	
Blind fasts	.15	
Nails and screws	.10	
Weights	.70	
Finish (oak)	2.64	
Labor, 1½ days	4.88	$16.57

Rear Door, 2 ft. 10 in. × 7 ft. 6 in.—

Frame	$4.00	
Door, 21 sq. ft., at $ 25 per sq. ft.	5.25	
Finish	.91	
Labor	3.25	
Nails	05	$13.46

Front Door, 3 ft. 3 in. × 7 ft. 6 in., with top and side lights—		
Frame—		
Sill, 7 ft., at $.25 per ft.	$1.75	
Jambs, 23 ft.. at $.07 per ft.	1.61	
Mullions and transom bar, 20 ft., at $.10½ per ft.	2.10	
Outside casing, 23 ft., at $.03½ per ft.	.81	
Mullion casing, 20 ft., at $ 02$\frac{1}{10}$ per ft.	.42	
Labor, ½ price of stock	3.32	
	$10.01	
Door, 3 ft., 3 in. × 7 ft. 6 in.—		
21 sq. ft., at $.25 per sq. ft.	$5.25	
Side-light panels, 6 ft., at $.25 per ft.	1.50	
3 sash rims, at $.50 each	1.50	
Leaded glass, 10⅝ sq. ft., at $2.50 per sq. ft.	27.00	
	$35.25	
Inside Finish—		
Stop-beads	$ .28	
Architrave, 24 ft., at $.04½ per ft.	1.08	
Labor, 3 days	9.75	
	$11.11	
Total cost of front door and frame		$56.37
Door, 2 ft. 8 in. × 7 ft. 6 in. (N. C. pine)—		
Stock door	$3.00	
Frame	1.25	
Threshold	.15	
Nails	.05	
Finish, 39½ ft., at $ 04½ per ft.	1.78	
Labor	3.25	$9.48
Pair of Sliding Doors, 6 ft. × 8 ft. (whitewood and birch)—		
Doors, 48 sq ft., at $.50 per sq. ft.	$24.00	
Architrave, 24 ft., birch	2.34	
" 24 ft., whitewood	1.05	
Jambs, 22 ft., birch	1.82	
" 22 ft., whitewood	.85	
Grounds, 22 ft., birch	.50	
Carried forward	$30.56	

Location Sheet of Electric Outlets

Location	Ceiling	Bracket	Sw.	Total Outlets	Total Lights
Basement—					
Passage	1				1
Furnace	1			1	1
Laundry		1		1	1
Furnace Room	2			2	2
	4	1		4	5
First Floor—					
Entry		1		1	1
Pantry	1			1	1
Kitchen	1	2	2	5	3
Porch	1		1	2	1
China Closet	1			1	1
Dining Room	1	2		3	8
Parlor	1	2		3	10
Hall	1			1	1
Hall	1		2	3	2
Vestibule	1			1	1
Porch	1			1	1
Living Room	1	4	2	7	13
	11	11	7	29	43
Second Floor—					
Back Hall		1	2	3	1
Bedroom		1		1	1
Bath		1		1	1
Bedroom		3		3	3
"		3		3	3
Alcove		2		2	2
Front Hall	2		2	4	2
Bedroom		3		3	3
"		3		3	3
	2	17	4	23	19
Attic—					
Hall		1		1	1
Attic	1			1	1
	1	1		2	2

REVIEW QUESTIONS.

PRACTICAL TEST QUESTIONS.

In the foregoing sections of this Cyclopedia numerous illustrative examples are worked out in detail in order to show the application of the various methods and principles. Accompanying these are examples for practice which will aid the reader in fixing the principles in mind.

In the following pages are given a large number of test questions and problems which afford a valuable means of testing the reader's knowledge of the subjects treated. They will be found excellent practice for those preparing for College, Civil Service, or Engineer's License. In some cases numerical answers are given as a further aid in this work.

17. Draw from memory guide squares showing indications of material as shown on plans, sections and elevations.

18. Describe the usual methods of letting a contract.

19. State briefly the general requirements for an office building.

20. At a scale of $\frac{1}{4}$ inch = 1 foot, lay out in pencil on brown paper, the plans shown on Figs. 28, 29, 30, 31, 32, 33, and, at a scale of $\frac{1}{2}$ inch = 1 foot, Fig. 34.

21. Trace the first and second floor plans which you have drawn on tracing paper in ink, and also the front elevation.

22. Put thin bond or tracing paper over the drawings you have made and lay out in pencil the framing plans as shown in Figs. 35, 36, 37, 38, 39, and 40.

23. Ink in the framing plans of the first floor and of the front elevation.

24. Lay out in pencil, at a scale of $1\frac{1}{2}$ inches = 1 foot, the details shown on Fig. 41, comparing the mouldings with larger size drawings of window frames, etc., given elsewhere.

25. Lay out in pencil from memory on detail paper a full size detail of the window frame shown in Fig. 45. Then without changing this first drawing, take a sheet of tracing paper, put it over your drawing, and draw out the corrections (if you have made any mistakes), or make a complete corrected copy.

26. Lay out a $1\frac{1}{2}$ inch scale detail of the porch cornice as shown in Fig. 48 in pencil on detail paper.

REVIEW QUESTIONS

ON THE SUBJECT OF

ESTIMATING.

PART I

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1. (a) What will a walk of bluestone flagging 4 ft. wide and 19 ft. long cost, complete? (b) Give cost of limestone coping for an 18-inch wall on one side of the path.

2. (a) About how many square yards of surface will four pounds of paint cover in two coats? (b) How much will it cost to paint a brick wall 8 ft. high and 15 ft. long with three coats of paint?

3. (a) How many feet B. M. in a 4-in. x 10-in. stick 22 ft. long? (b) How much lumber will it take to stud up a wall 12 ft. long and 9 ft. high with two windows in it?

4. Give an analysis of one cubic yard of concrete.

5. What percentage of the cost of a building should be allowed for heating by furnace? How much of this goes to the labor?

6. What will a square of slating cost?

7. Analyze the cost of a square of flooring.

8. (a) What will be the cost of a plain copper roof for a store 30 ft. x 40 ft.? (b) What will be the cost of a tin roof?

9. How many cubic feet of wall will a thousand bricks lay?

10. Give an analysis of the cost of 100 square yards of 2-coat plastering.

11. What special data besides plans and specifications are necessary to figure a job for a contract?

12. How many square feet will 1000 shingles lay at 5 in. to the weather?

13. What will be the approximate cost of a house 20 ft. $\times$ 30 ft. with an 8 ft. cellar and a half-pitch gable roof, at 12 cents per cubic foot?

14. How large a furnace pipe must be run to a room 15 ft. × 20 ft. and 10 ft. high, and what will be the size of register?

15. Give a rule for finding the number of studs in a front if set 16 in. on centers. If set 12 in. on centers.

16. What will be the cost of an ordinary flight of stairs of 17 risers for a $3000 house? How much should be allowed for the cellar stairs of 14 risers?

17. How much studding can two men set in one day? How much boarding? Shingles? Diagonal boarding?

18. (a) How many square yards of 2-coat plastering can a mason and helper put on in one day? (b) What will it cost?

19. (a) What will the newel of an ordinary staircase cost? (b) How much will the balusters of first run cost at two to a tread if the run is 8 risers high?

20. (a) How many bricks will be required to build a wall 10 ft. high, 30 ft. long, and 1 ft. thick. (b) What will it cost in 1 to 3 lime mortar?

21. What will it cost to put on 1000 laths?

22. In making repairs a man required the services of a carpenter for 5 hours, a plumber and helper 2 days, and an electrician for a day and a half, what was his bill for labor?

23. What will it cost to dig out a cellar 18 ft. × 30 ft.; 4 ft. below grade at one end and 6 ft. the other?

24. (a) At a base price of $2.45 per cwt. what will three cwt. of 6-penny box nails cost? (b) What will 1 cwt. of 4-penny slating nails cost?

25. (a) What per cent of the cost of a house will usually go to the plumbing? (b) What portion of this will represent the labor?

26. (a) What is the relative cost of marble as compared with limestone? (b) Of sandstone as compared with limestone?

27. (a) What is the usual cost of moulded finish in white wood or cypress? (b) What will the casings for both sides of a door 3 ft × 7 ft. cost, using a 5-inch casing with corner blocks?

28. (a) About how many cubic feet will one square foot of direct steam radiation heat, in the first story of a dwelling? (b) Direct hot water radiation?

29. What will be the area of a pyramidal roof 20 ft. square at the base and 15 ft. on the rafter line?

10. What will it cost to excavate a cellar 30 ft. by 40 ft., and 5 ft. deep, at 50 cents per cu. yd.?

11. What will be the cost of a chimney with two 8 by 12-inch flues, 35 ft. high, brickwork costing $20 per M. laid?

12. What will be the cost of a stucco cornice for a room 12 ft. by 16 ft., at 25 cents per foot?

13. If furnace layout consists of five 7-in. pipes, three 9-in. pipes, and two 14-in. pipes, what should be the area of the cold-air box?

14. Give analysis of cost of a square of clapboarding, using clapboards at $50 per M.

15. (*a*) Show by analysis the approximate cost and method of figuring a piazza cornice.

(*b*) A rear door and frame.

16. Give analysis and approximate cost of a window complete, without hardware; sash 3 ft. 6 in. by 5 ft. 0 in.

17. Give analysis and approximate price, per square, of a shingled roof, using matched boards on 2 ft. 7 in. rafters.

18. (*a*) How many bricks, per foot of height, will be required in a chimney of two 8 by 12 in. fines, with 4-in. walls and withes?

(*b*) In a chimney with three 8 by 12-in. flues?

(*c*) In an ashpit, 12 in. by 3 ft. 8 in. inside measurement, with 4-in. back and front walls and 8-in. end walls? Make sketch plan of each, showing bricks.

19. (*a*) Give a reasonable cost for hardware of seven inside doors put on.

(*b*) Of fifteen windows with sash-fasts and lifts.

20. What is a fair price for building lattice under a piazza 9 ft. 0 in. by 36 ft. 0 in., showing 1 ft. 6 in. at one end and 3 ft. 6 in. at the other end, with a 6-foot flight of steps taken out at the center?

INDEX

Note —For page numbers see foot of pages

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