HOME FOR KNIGHTS OF PYTHIAS, DECATUR, ILL.

H. V. von Holst and Lorin A. Rawson, Architects, Chicago, Ill. Reproduced from competition drawing. For plan, see next succeeding plate.

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, STEEL CONSTRUCTION, ARCHITECTURAL DRAWING, SHEET METAL WORK, HEATING, VENTILATING, ETC.

Prepared by a Staff of

ARCHITECTS, BUILDERS, AND EXPERTS OF THE HIGHEST PROFESSIONAL STANDING

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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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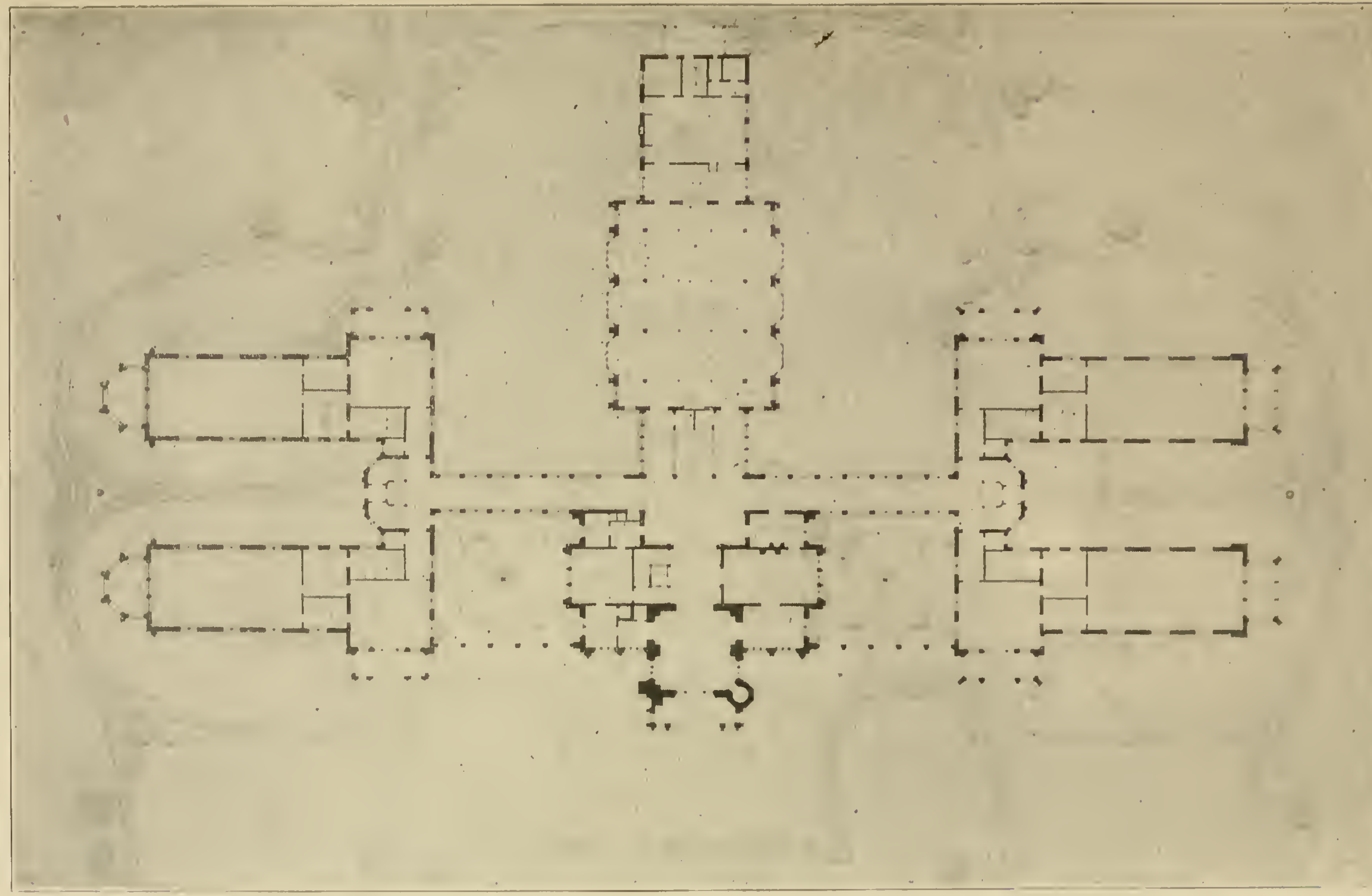
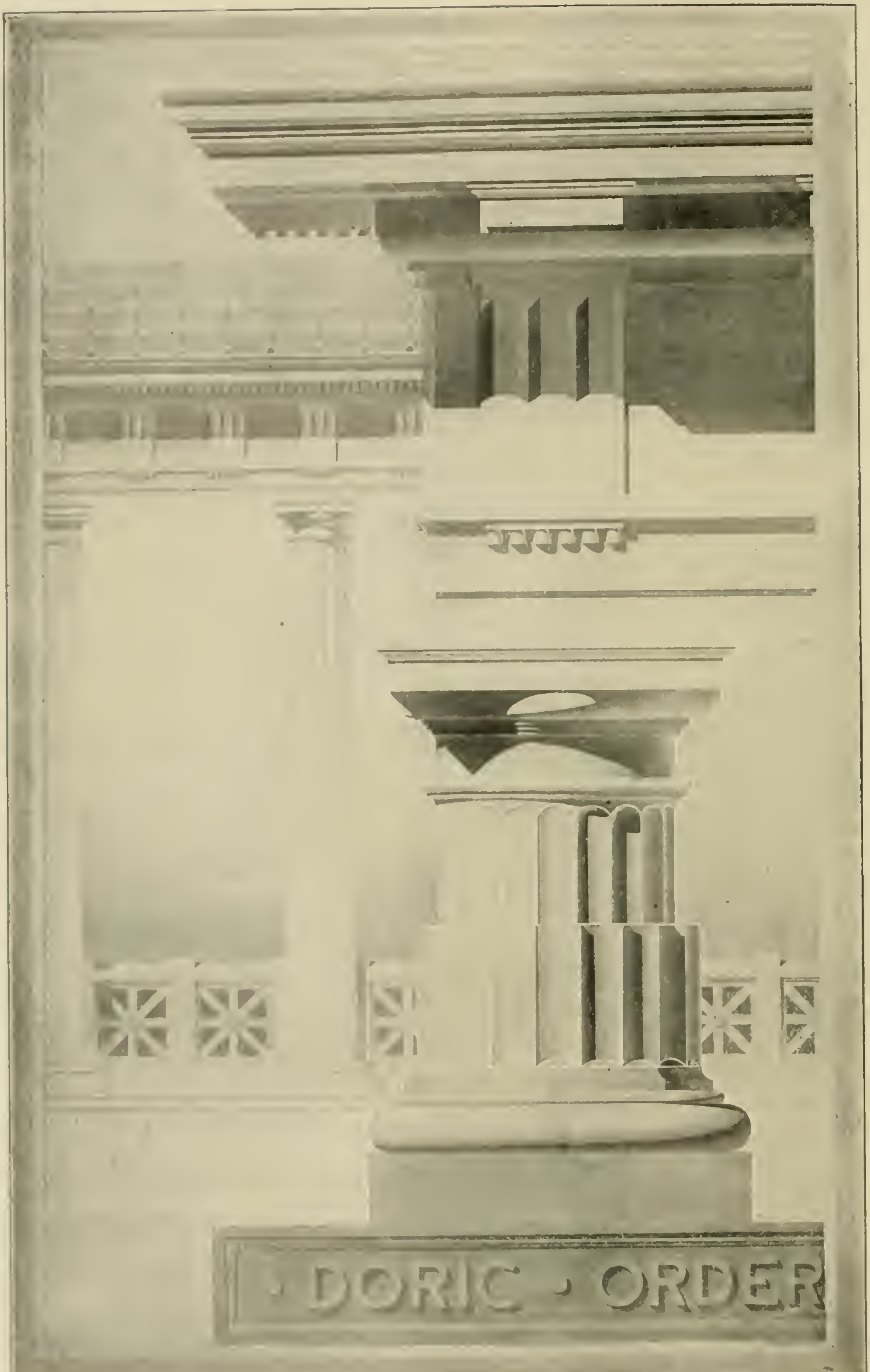


PLAN FOR HOME OF THE KNIGHTS OF PYTHIAS AT DECATUR, ILL.

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 257.

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Foreword

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 to-day 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.

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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 "Rendering Elevations" Page 269.

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MECHANICAL DRAWING

PART I

The subject of mechanical drawing is of great interest and importance to all mechanics and engineers. Drawing is the method used to show graphically the small details of machinery; it is the language by which the designer speaks to the workman; it is the most graphical way to place ideas and calculations on record. Working drawings take the place of lengthy explanations, either written or verbal. A brief inspection of an accurate, well-executed drawing gives a better idea of a machine than a large amount of verbal description. The better and more clearly a drawing is made, the more intelligently the workman can comprehend the ideas of the designer. A thorough training in this important subject is necessary to the success of everyone engaged in mechanical work. The success of a draftsman depends to some extent upon the quality of his instruments and materials. Beginners frequently purchase a cheap grade of instruments. After they have become expert and have learned to take care of their instruments they discard them for those of better construction and finish. This plan has its advantages, but to do the best work, strong, well-made and finely finished instruments are necessary.

INSTRUMENTS AND MATERIALS.

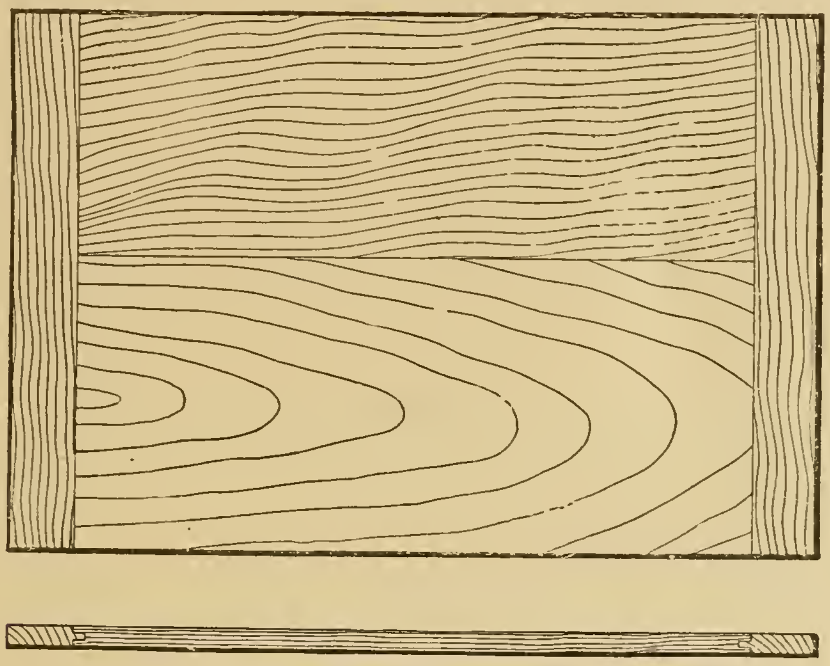
Drawing Paper. In selecting drawing paper, the first thing to be considered is the kind of paper most suitable for the proposed work. For shop drawings, a manilla paper is frequently used, on account of its toughness and strength, because the drawing is likely to be subjected to considerable hard usage. If a finished drawing is to be made, the best white drawing paper should be obtained, so that the drawing will not fade or become discolored with age. A good drawing paper should be strong, have uniform thickness and surface, should stretch evenly, and should neither repel nor absorb liquids. It should also allow considerable erasing without spoiling the surface, and it should lie smooth when stretched or when ink or colors are used. It is, of course, impossible to find all of these qualities in any one paper, as for instance great strength cannot be combined with fine surface.

In selecting a drawing paper the kind should be chosen which combines the greatest number of these qualities for the given work. Of the better class Whatman's are considered by far the best. This paper is made in three grades; the *hot pressed* has a smooth surface and is especially adapted for pencil and very fine line drawing, the *cold pressed* is rougher than the hot pressed, has a finely grained surface and is more suitable for water color drawing; the *rough* is used for tinting. The cold pressed does not take ink as well as the hot pressed, but erasures do not show as much on it, and it is better for general work. There is but little difference in the two sides of Whatman's paper, and either can be used. This paper comes in sheets of standard sizes as follows:—

Cap,	13 × 17 inches.	Elephant,	23 × 28 inches.
Demy,	15 × 20 "	Columbia,	23 × 34 "
Medium,	17 × 22 "	Atlas,	26 × 34 "
Royal,	19 × 24 "	Double Elephant,	27 × 40 "
Super-Royal,	19 × 27 "	Antiquarian,	31 × 53 "
Imperial,	22 × 30 "	Emperor,	48 × 68 "

The usual method of fastening paper to a drawing board is by means of thumb tacks or small one-ounce copper or iron tacks. In fastening the paper by this method first fasten the upper left hand corner and then the lower right pulling the paper taut. The other two corners are then fastened, and sufficient number of tacks are placed along the edges to make the paper lie smoothly. For very fine work the paper is usually stretched and glued to the board. To do this the edges of the paper are first turned up all the way round, the margin being at least one inch. The whole surface of the paper included between these turned up edges is then moistened by means of a sponge or soft cloth and paste or glue is spread on the turned up edges. After removing all the surplus water on the paper, the edges are pressed down on the board, commencing at one corner. During this process of laying down the edges, the paper should be stretched slightly by pulling the edges towards the edges of the drawing board. The drawing board is then placed horizontally and left to dry. After the paper has become dry it will be found to be as smooth and tight as a drum head. If, in stretching, the paper is stretched too much it is likely to split in drying. A slight stretch is sufficient.

Drawing Board. The size of the drawing board depends upon the size of paper. Many draftsmen, however, have several boards of various sizes, as they are very convenient. The drawing board is usually made of soft pine, which should be well seasoned and straight grained. The grain should run lengthwise of the board, and at the two ends there should be pieces about $1\frac{3}{4}$ or 2 inches wide fastened to the board by nails or screws. These end pieces should be perfectly straight for accuracy in using the T-square. Frequently the end pieces are fastened by a glued



DRAWING BOARD

matched joint, nails and screws being also used. Two cleats on the bottom extending the whole width of the board, will reduce the tendency to warp, and make the board easier to move as they raise it from the table.

Thumb Tacks. Thumb tacks are used for fastening the paper to the drawing board. They are usually made of steel either pressed into shape, as in the cheaper grades, or made with a head of German silver with the point screwed and riveted to it. They are made in various sizes and are very convenient as they can be easily removed from the board. For most work however, draftsmen use small one-ounce copper or iron tacks, as they can be forced flush with the drawing paper, thus offering no obstruction to the T-square. They also possess the advantage of cheapness.

Pencils. In pencilling a drawing the lines should be very fine and light. To obtain these light lines a hard lead pencil must be used. Lead pencils are graded according to their hardness, and are numbered by using the letter H. In general a lead pencil of 5H (or HHHHH) or 6H should be used. A softer pencil, 4H, is better for making letters, figures and points. A hard lead pencil should be sharpened as shown in Fig. 1. 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. It should be ground to a chisel edge and the corners slightly rounded. In making the straight lines the chisel edge should be used by placing it against the T-square or triangle, and because of the chisel edge the lead will remain sharp much longer than if sharpened to a point. This chisel edge enables the draftsman 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, as the lines will then be somewhat thicker and heavier. The lead for compasses may also be sharpened to a point although some draftsmen prefer to use a chisel edge in the compasses as well as for the pencil.

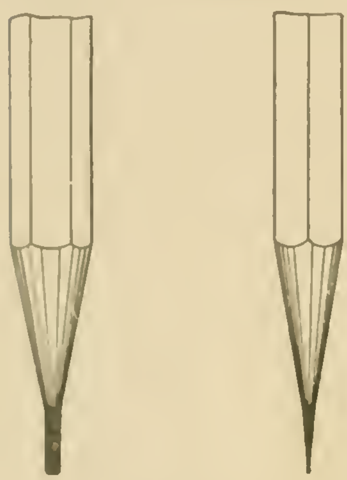


Fig. 1.

In using a very hard lead pencil, the chisel edge will make a deep depression in the paper if much pressure is put on the pencil. As this depression cannot be erased it is much better to press lightly on the pencil.

Erasers. In making drawings, but little erasing should be necessary. However, in case this is necessary, a soft rubber should be used. In erasing a line or letter, great care must be exercised or the surrounding work will also become erased. To prevent this, some draftsmen cut a slit about 3 inches long and $\frac{1}{8}$ to $\frac{1}{4}$ inch wide in a card as shown in Fig. 2. The card is then placed over the work and the line erased without erasing the rest of the drawing. An erasing shield of a form similar to that shown in Fig. 3 is very convenient, especially in erasing letters. It is made of thin sheet metal and is clean and durable.

For cleaning drawings, a sponge rubber may be used. Bread crumbs are also used for this purpose. To clean the drawing

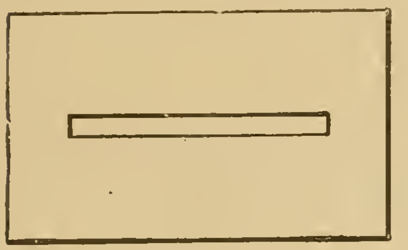


Fig. 2.

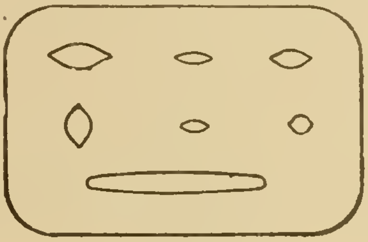


Fig. 3.

scatter *dry* bread crumbs over it and rub them on the surface with the hand.

T-Square. The T-square consists of a thin straight edge called the blade, fastened to a head at right angles to it. It gets

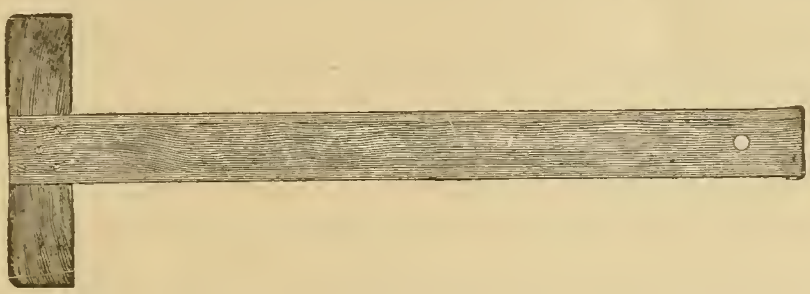


Fig. 4.

its name from the general shape. T-squares are made of various materials, wood being the most commonly used. Fig. 4 shows an ordinary form of T-square which is adapted to most work. In Fig. 5 is shown a T-square with edges made of ebony or mahogany, as these woods are much harder than pear wood or maple, which is generally used. The head is formed so as to fit against the left-hand edge of the drawing board, while the blade extends over the surface. It is desirable to have the blade of the T-square form a right angle with the head, so that the lines drawn with the T-square will be at right angles to the left-hand edge of the board. This, however, is not absolutely necessary, because the lines drawn with the T-square are always with reference to one edge of the board only, and if this edge of the board is straight, the lines drawn with the T-square will be parallel to each other. The T-square should never be used except with the left-hand edge of the board, as it is almost impossible to find a drawing broad with the edges parallel or at right angles to each other.

The T-square with an adjustable head is frequently very convenient, as it is sometimes necessary to draw lines parallel to each

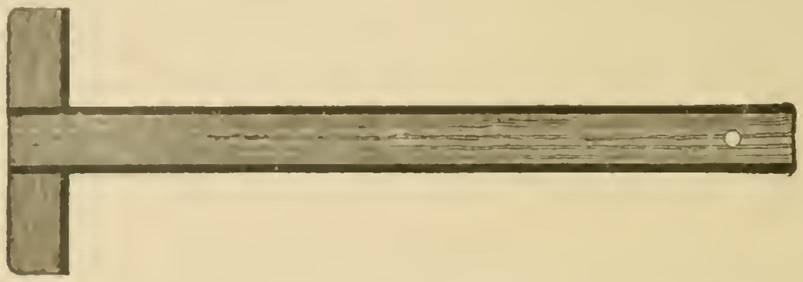


Fig. 5.

other which are not at right angles to the left-hand edge of the board. This form of T-square is similar to the ordinary T-square already described, but the head is swiveled so that it may be clamped at any desired angle. The ordinary T-square as shown in Figs. 4 and 5 is, however, adapted to almost any class of drawing.

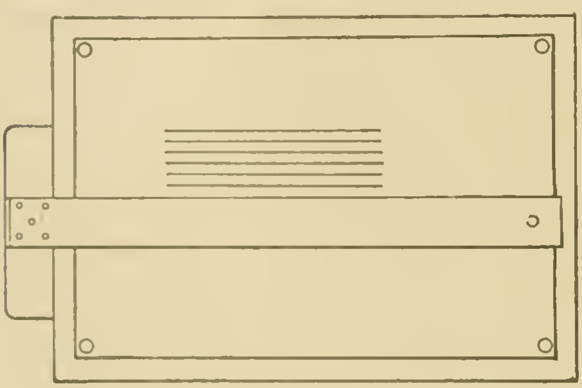


Fig. 6.

Fig. 6 shows the method of drawing parallel horizontal lines with the T-square. With the head of the T-square in contact with the left-hand edge of the board, the lines may be drawn by moving the T-square to the desired position. In using the T-square the upper edge should always be used for drawing as the two edges may not be exactly parallel and straight, and also it is more convenient to use this edge with the triangles. If it is necessary to use a straight edge for trimming drawings or cutting the paper from the board, the lower edge of the T-square should be used so that the upper edge may not be marred.

For accurate work it is absolutely necessary that the working edge of the T-square should be exactly straight. To test the straightness of the edge of the T-square, two T-squares may be placed together as shown in Fig. 7. This figure shows plainly that the edge of one of the T-squares is crooked. This fact, however, does not prove that either one is straight, and for this determination a third blade must be used and tried with the two given T-squares successively.

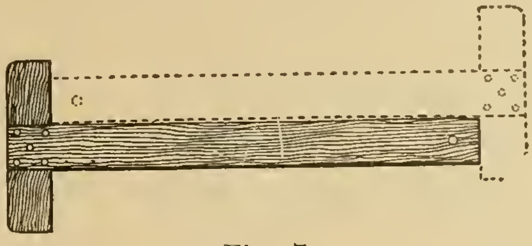
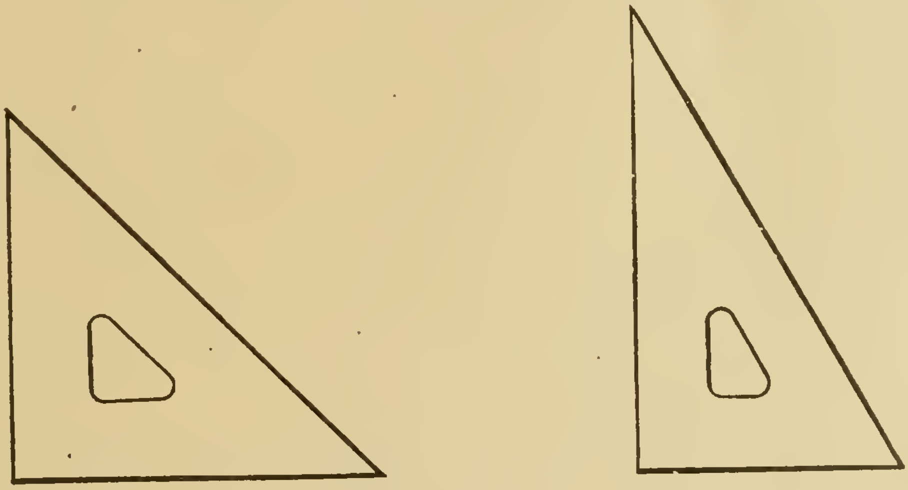


Fig. 7.

Triangles. Triangles are made of various substances such as wood, rubber, celluloid and steel. Wooden triangles are cheap but are likely to warp and get out of shape. The rubber triangles are frequently used, and are in general satisfactory. The transparent celluloid triangle is, however, extensively used on account of its transparency, which enables the draftsmen to see the work already done even when covered with the triangle. In using a rubber or celluloid triangle take care that it lies perfectly flat or



TRIANGLES.

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 are made in various sizes, and many draftsmen have several constantly on hand. A triangle 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. Two triangles are necessary for every draftsman, one having two angles of 45 degrees each and one a right angle; and the other having one angle of 60 degrees, one of 30 degrees and one of 90 degrees.

The value of the triangle depends upon the accuracy of the angles and the straightness of the edges. To test the accuracy of the right angle of a triangle, place the triangle with the lower edge resting on the edge of the T-square, as shown in Fig. 8. Now draw the line C D, which should be perpendicular to the edge of the T-square. The same triangle should then be placed in the position shown at B. If the right angle of the triangle is exactly 90 degrees the left-hand edge of the triangle should exactly coincide with the line C D.

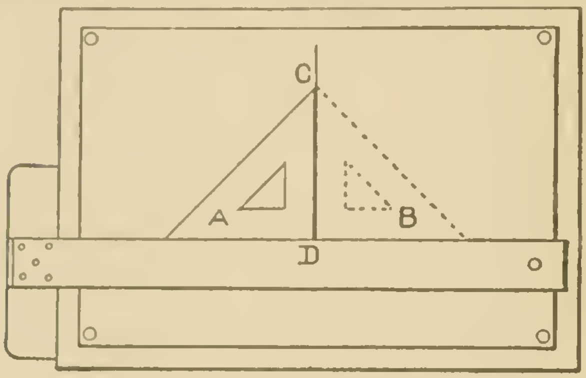


Fig. 8.

To test the accuracy of the 45-degree triangles, first test the right angle then place the triangle with the lower edge resting on the working edge of the T-square, and draw the line E F as shown in Fig. 9. 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.

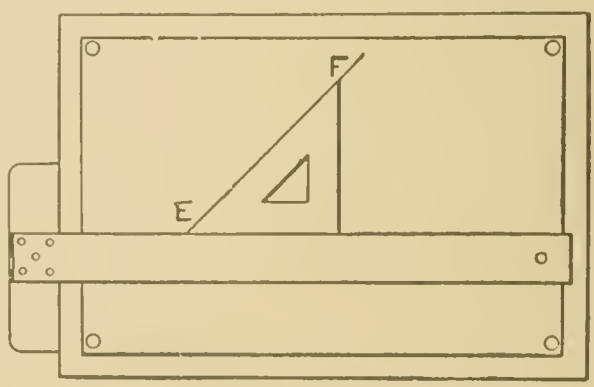


Fig. 9.

Triangles are very convenient in drawing lines at right angles to the T-square. The method of doing this is shown in Fig. 10. Triangles are also used in drawing lines at an angle with the horizontal, by placing them on the board as shown in Fig. 11. Suppose the line E F (Fig. 12) is drawn at any angle, and we wish to draw a line through the point P parallel to it.

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

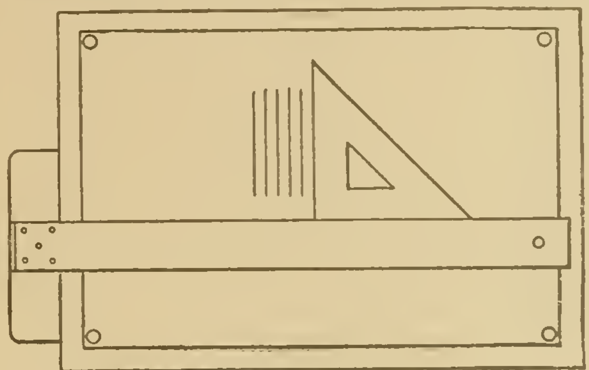


Fig. 10.

A line can be drawn perpendicular to another by means of the triangles as follows. Let E F (Fig. 13) be the given line, and suppose we wish to draw a line perpendicular to E F through the point D. Place the longest side of one of the triangles so that it coincides with the line E F, as the triangle is shown in position at A. Place the other triangle (or any straight edge) in the position of the triangle as shown at B, one edge resting against the edge of the triangle A. Then holding B with the left hand, place the triangle A in the position shown at C, so that the longest side passes through the point D. A line can then be drawn through the point D perpendicular to E F.

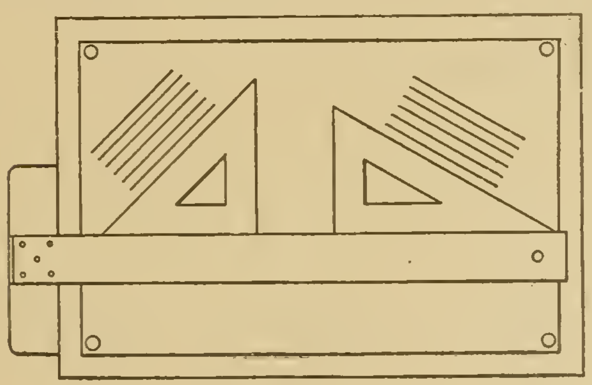


Fig. 11.

In previous figures we have seen how lines may be drawn making angles of 30, 45, 60 and 90 degrees with the horizontal. If it is desired to draw lines forming angles of 15 and 75 degrees the triangles may be placed as shown in Fig. 14.

In using the triangles and T-square almost any line may be drawn. Suppose we wish to draw a rectangle having one side horizontal. First place the T-square as shown in Fig. 15. By moving the T-square up or down, the sides A B and D C may be drawn, because they are horizontal and parallel. Now place one of the triangles resting on the T-square as shown at E, and having the left-hand edge passing through the point D. The vertical

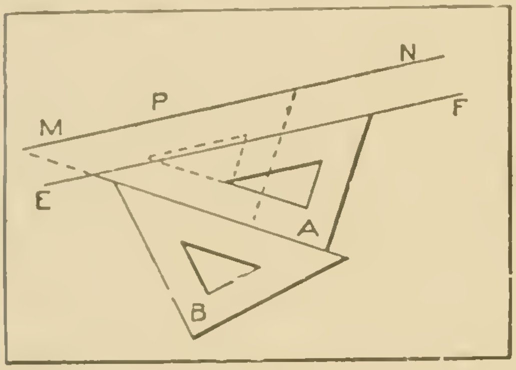


Fig. 12.

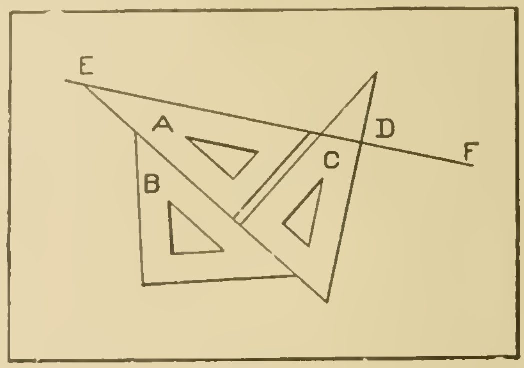


Fig. 13.

line D A may be drawn, and by sliding the triangle along the edge of the T-square to the position F the line B C may be drawn by using the same edge. These positions are shown dotted in Fig. 15.

If the rectangle is to be placed in some other position on the drawing board, as shown in Fig. 16, place the 45-degree triangle F so that one edge is parallel to or coincides with the side D C. Now holding the triangle F in position place the triangle H so that its upper edge coincides with the lower edge of the triangle F. By holding H in position and sliding the triangle F

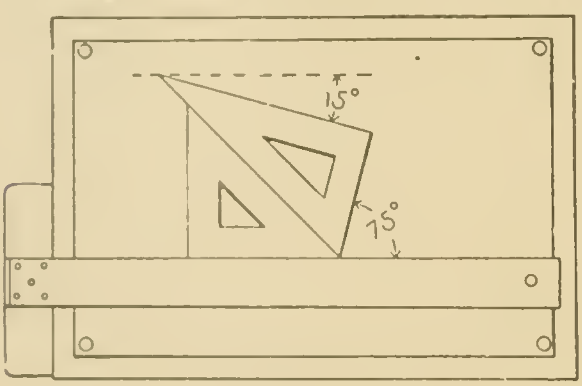


Fig. 14.

along its upper edge, the sides A B and D C may be drawn. To draw the sides A D and B C the triangle should be used as shown at E.

Compasses. Compasses are used for drawing circles and arcs of circles. They are made of various materials and in various sizes. 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. It does not soil readily, it has no odor, and is easy to keep clean. Aluminum instruments possess the advantage of lightness, but on account of the soft metal they do not wear well.

The compasses are made in the form shown in Figs. 17 and 18. Pencil and pen points are provided, as shown in Fig. 17. Either pen or pencil may be inserted in one leg by means of a shank and socket. The other leg is fitted with a needle point which is placed at the center of the circle. In most instruments the needle point is separate, and is made of a piece of round steel wire having a square shoulder at one or both ends. Below this shoulder the needle point projects. The needle is made in this form so that the hole in the paper may be very minute.

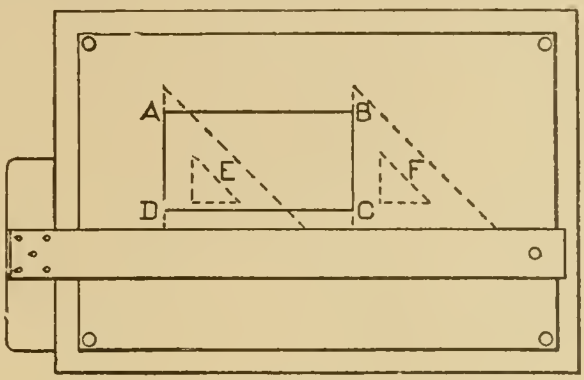


Fig. 15.

In some instruments lock nuts are used to hold the joint firmly in position. These lock nuts are thin discs of steel, with notches for using a wrench or forked key. Fig. 19 shows the detail of the joint of high grade instruments. Both legs are alike at the joint, and two pivoted screws are inserted in the yoke. This permits ample movement of the legs, and at the same time gives the proper stiffness. The flat surface of one of the legs is faced with steel, the other being of German silver, in order 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 dust and dirt and to prevent rusting of the steel face.

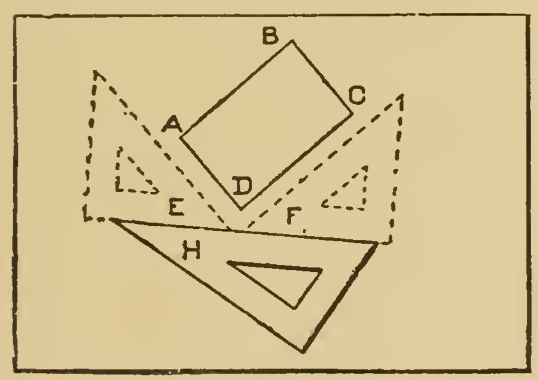


Fig. 16.

Figs. 20, 21 and 22 show the detail of the socket; in some instruments the shank and socket are pentagonal, as shown in Fig. 20. The shank enters the socket loosely, and is 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.

In Fig. 21 is shown another form of shank. This is round, having a flat top. A set screw is also used to hold this in position. A still better form of socket is shown in Fig. 22; the hole

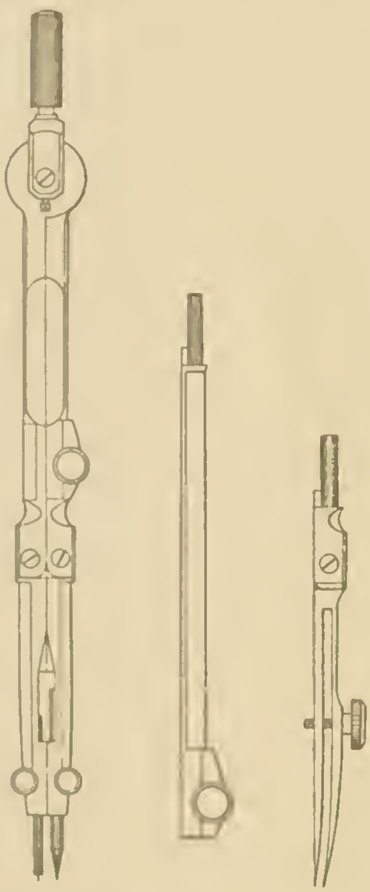


Fig. 17.

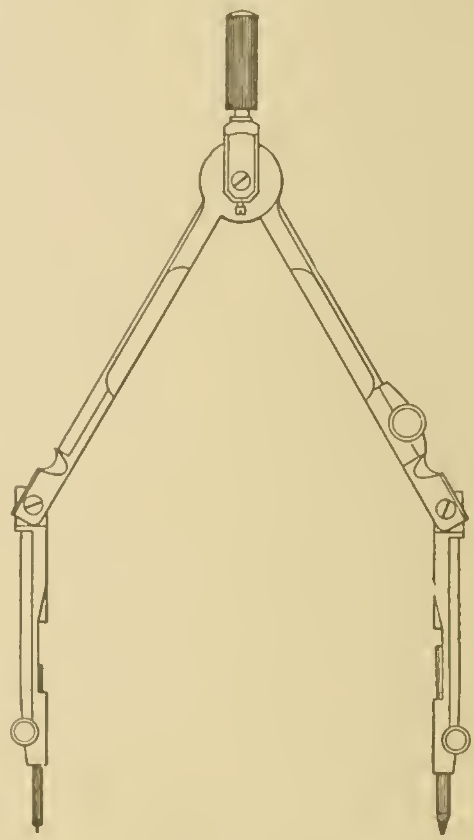


Fig. 18.

is made tapered and is circular. The shank fits accurately, and is held in perfect alignment by a small steel key. The clamping screw is placed upon the side, and keeps the two portions of the split socket together.

Figs. 17 and 18 show that both legs of the compasses 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 pencilling circles it is not as necessary that the pencil should be kept vertical; it is a good plan, however, to learn to use them in this way both in pencilling 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.

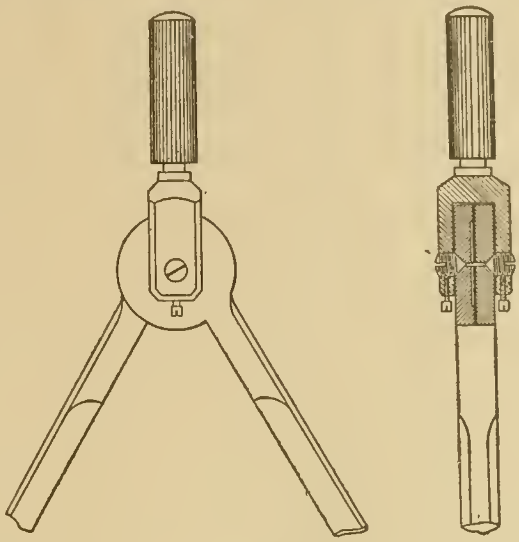


Fig. 19.

In removing the pencil or pen, it should be pulled out straight. If bent from side to side the socket will become enlarged and the shank worn; this will render the instrument inaccurate. For drawing large circles the lengthening bar shown in Fig. 17 should be used. When using the lengthening bar the

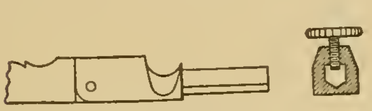


Fig. 20.

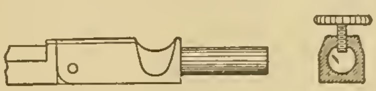


Fig. 21.

needle point should be steadied with one hand and the circle described with the other.

Dividers. Dividers, shown in Fig. 23, are made similar to the compasses. They are used for laying off distances on the drawing, either from scales or from other parts of the drawing. They may also be used for dividing a line into equal parts. When dividing a line into equal parts the dividers should be turned in the opposite direction each time, so that the moving point passes alternately to the right and to the left. The instrument can then be operated readily with one hand. The points of the dividers should be very sharp so that the holes made in the paper will be small. If large holes are made in the paper, and the distances between

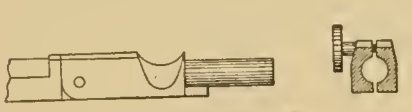


Fig. 22.

the points are not exact, accurate spacing cannot be done Sometimes the compasses are furnished with steel divider points in addition to the pen and pencil points. The compasses may then be used either as dividers or as compasses. Many draftsmen use a *needle point* in place of dividers for making measurements from a scale. The eye end of a needle is first broken off and the needle then forced into a small handle made of a round piece of soft pine. This instrument is very convenient for indicating the intersection of lines and marking off distances.

Fig. 23.

Bow Pen and Bow Pencil. Ordinary large compasses are too heavy to use in making small circles, fillets, etc. The leverage of the long leg is so great that it is very difficult to draw small circles accurately. For this reason the bow compasses shown in Figs. 24 and 25 should be used on all arcs and circles having a radius of less than three-quarters inch. The bow compasses are also convenient for duplicating small circles such as those which represent boiler tubes, bolt holes, etc., since there is no tendency to slip.

The needle point must be adjusted to the same length as the pen or pencil point if very small circles are to be drawn. The adjustment for altering the radius of the circle can be made by turning the nut. If the change in radius is considerable the points should be pressed together to remove the pressure from the nut which can then be turned in either direction with but little wear on the threads.

Fig. 26 shows another bow instrument which is frequently used in small work in place of the dividers. It has the advantage of retaining the adjustment.

Drawing Pen. For drawing straight lines and curves that are not arcs of circles, the line pen (sometimes called the ruling pen) is used. It consists of two blades of steel fastened to a handle as shown in Fig. 27. The distance between the pen points can be adjusted by the thumb screw, thus regulating the width of line to be drawn. The blades are given a slight curvature so that there will be a cavity for ink when the points are close together.

The pen may be filled by means of a common steel pen or with the quill which is provided with some liquid inks. The pen should not be dipped in the ink because it will then be necessary to wipe the outside of the blades before use. The ink should fill the pen 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 the pen should be carefully wiped with

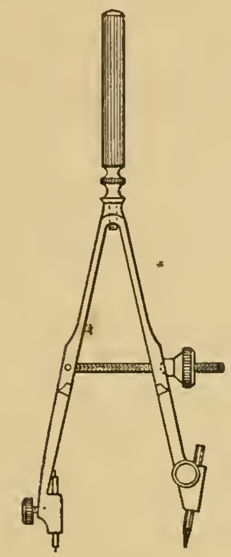


Fig. 24.

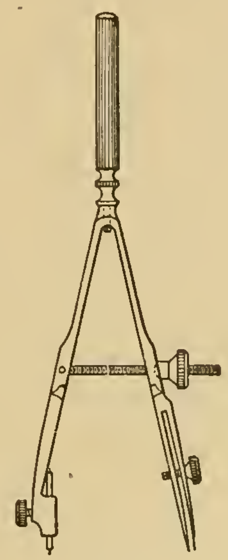


Fig. 25.

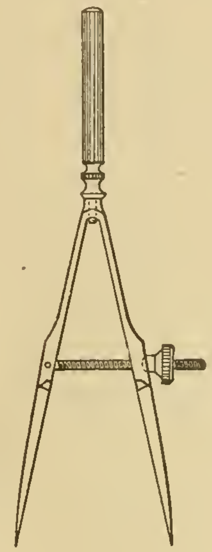


Fig. 26.

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. If the points do not bear equally the line will be ragged. If both points touch, and the pen is in good condition the line will be smooth. The pen is usually inclined slightly in the direction in which the line is drawn. The pen

Fig. 27.

should *touch* the triangle or T-square which serve as guides, but it should not be pressed against them because the lines will then be uneven. The points of the pen should be close to the edge of the triangle or T-square, but should not touch it.

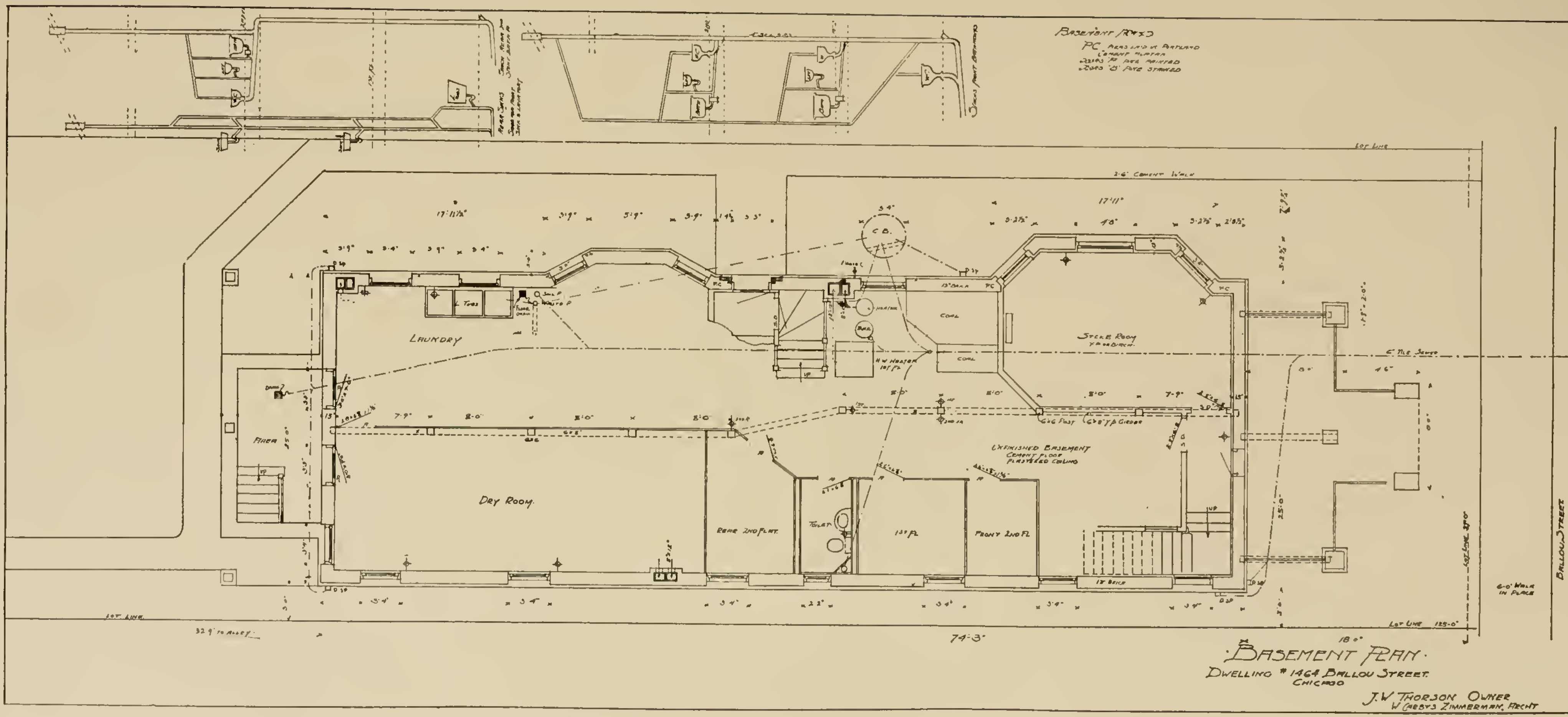
To Sharpen the Drawing Pen. After the pen has been used for some time the points become worn, and it is impossible to make smooth lines. This is especially true if rough paper is used. The pen can be put in proper condition by sharpening it. To do this take a small, flat, close-grained oil-stone. The blades should first be screwed together, and the points of the pen can be given the proper shape by drawing the pen back and forth over the stone changing the inclination so that the shape of the ends will be parabolic. This process dulls the points but gives them the proper shape, and makes them of the same length.

To sharpen the pen, separate the points slightly and rub one of them on the oil-stone. While doing this keep the pen at an angle of from 10 to 15 degrees with the face of the stone, and give it a slight twisting movement. This part of the operation requires great care as the shape of the ends must not be altered. After the pen point has become fairly sharp the other point should be ground in the same manner. All the grinding should be done on the *outside* of the blades. The burr should be removed from the inside of the blades by using a piece of leather or a piece of pine wood.

Ink should now be placed between the blades and the pen tried. The pen should make a smooth line whether fine or heavy, but if it does not the grinding must be continued and the pen tried frequently.

Ink. India ink is always used for drawing as it makes a permanent black line. It may be purchased in solid stick form or as a liquid. The liquid form is very convenient as much time is saved, and all the lines will be of the same color; the acid in the ink, however, corrodes steel and makes it necessary to keep the pen perfectly clean.

Some draftsmen prefer to use the India ink which comes in stick form. To prepare it for use, a little water should be placed in a saucer and one end of the stick placed in it. The ink is ground by giving it a twisting movement. When the water has become black and slightly thickened, it should be tried. A heavy line should be made on a sheet of paper and allowed to dry. If the line has a grayish appearance, more grinding is necessary. After the ink is thick enough to make a good black line, the grinding should cease, because very thick ink will not flow freely from the pen. If, however, the ink has become too



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

W. Carbys Zimmerman, Architect, Chicago, Ill.

For First and Second Story Plans, See Page 42; for Elevations, See Page 58.

thick, it may be diluted with water. After using, the stick should be wiped dry to prevent crumbling. It is well to grind the ink in small quantities as it does not dissolve readily if it has once become dry. If the ink is kept covered it will keep for two or three days.

Scales. Scales are used for obtaining the various measurements on drawings. They are made in several forms, the most convenient being the flat with beveled edges and the triangular. The scale is usually a little over 12 inches long and is graduated for a distance of 12 inches. The triangular scale shown in Fig. 28 has six surfaces for graduations, thus allowing many graduations on the same scale.

The graduations on 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.

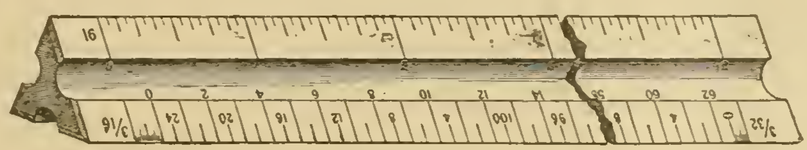


Fig. 28.

Thus we make drawings full size, half 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, civil engineers, and for measuring on indicator cards.

The scale should never be used for drawing lines in place of triangles or T-square.

Protractor. The protractor is an instrument used for laying off and measuring angles. It is made of steel, brass, horn and paper. If made of metal the central portion is cut out as shown in Fig. 29, so that the draftsman can see the drawing. The outer edge is divided into degrees and tenths of degrees. Sometimes the graduations are very fine. In using a protractor a very sharp hard pencil should be used so that the lines will be fine and accurate.

The protractor should be placed so that the given line (produced if necessary) coincides with the two O marks. The center of the circle being placed at the point through which the desired line is to be drawn. The division can then be marked with the pencil point or needle point.

Irregular Curve. One of the conveniences of a draftsman's

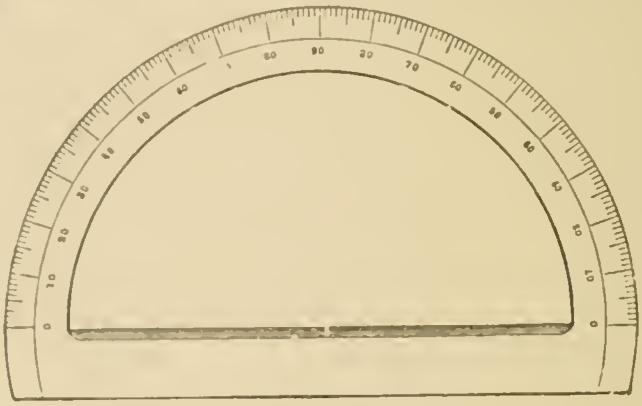


Fig. 29.

outfit is the French or irregular curve. It is made of wood, hard rubber or celluloid, the last named material being the best. It is made in various shapes, two of the most common being

Fig. 30.

shown in Fig. 30. This instrument is used for drawing curves other than arcs of circles, and both pencil and line pen can be used.

To draw the curve, a series of points is first located and then the curve drawn passing through them by using the part of the irregular curve that passes through several of them. The curve is shifted for this work from one position to another. 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

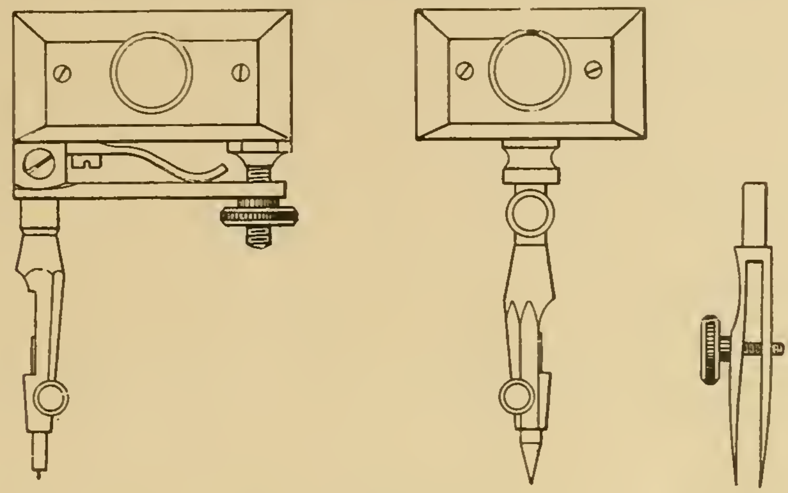


Fig. 31.

tangent to the curve, thus necessitating a continual change of direction.

Beam Compasses. The ordinary compasses are not large enough to draw circles having a diameter greater than about 8 or 10 inches. A convenient instrument for larger circles is found in the beam compasses shown in Fig. 31. The two parts called channels carrying the pen or pencil and the needle point are clamped to a wooden beam; the distance between them being equal to the radius of the circle. Accurate adjustment is obtained by means of a thumb nut underneath one of the channel pieces.

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 well. Lettering requires time and patience; and if one wishes to letter rapidly and well he must practice.

Usually a beginner cannot letter well, and in order to produce a satisfactory result, considerable practice is necessary. Many think it a good plan to practice lettering before commencing a drawing. A good writer does not always letter well; a poor writer need not be discouraged and think he can never learn to make a neatly lettered drawing.

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

There are many styles of letters used by draftsmen. For titles, large Roman capitals are frequently used, although Gothic and block letters also look well and are much easier to make.

ABCDEFGHIJ
KLMNOPQR
STUVWXYZ
1234567890

Fig. 32.

Almost any neat letter free from ornamentation is acceptable in the regular practice of drafting. Fig. 32 shows the alphabet of vertical Gothic capitals. These letters are neat, plain and easily made. The inclined or italicized Gothic type is shown in Fig. 33. This style is also easy to construct, and possesses the advantage that a slight difference in inclination is not apparent. If the vertical lines of the vertical letters incline slightly the inaccuracy is very noticeable.

The curves of the inclined Gothic letters such as those in the *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 shown in Fig. 34, the letters are made almost wholly of straight lines, the corners only being curved. These letters are very easy to make and are clear cut.

The first few plates of this work will require no titles; the only lettering being the student's name, together with the date and plate number. Later, the student will take up the subject of

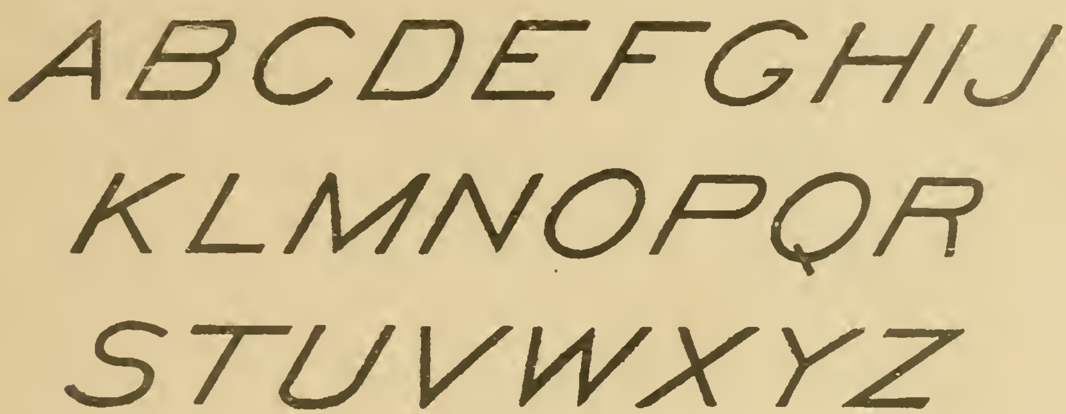


Fig. 33.

lettering again in order to letter titles and headings for drawings showing the details of machines. For the present, however, inclined Gothic capitals will be used.

To make the inclined Gothic letters, first draw two parallel lines having the distance between them equal to the desired height of the letters. If two sizes of letters are to be used, the smaller should be about two-thirds as high as the larger. For the letters

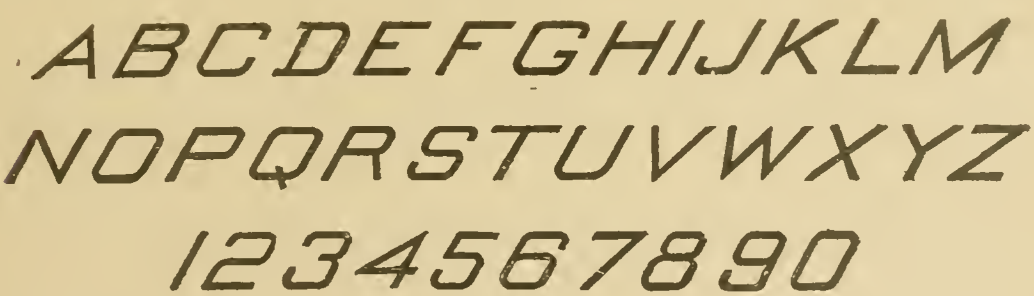


Fig. 34.

to be used on the first plates, draw two parallel lines $\frac{5}{32}$ inch apart. This is the height for the letters of the date, name, also the plate number, and should be used on all plates throughout this work, unless other directions are given.

In constructing the letters, they should extend fully to these lines, both at the top and bottom. They should not fall short of the guide lines nor extend beyond them. As these letters are inclined they will look better if the inclination is the same for all. As an aid to the beginner, he can draw light pencil lines, about $\frac{1}{4}$ inch apart, forming the proper angle with the parallel lines already drawn. The inclination is often made about 70 degrees; but as a 60-degree triangle is at hand, it may be used. To draw these lines place the 60-degree triangle on the T-square as shown in Fig. 36. In making these letters the 60-degree lines will be found a great aid as a large proportion of the back or side lines have this inclination.

Capital letters such as *E*, *F*, *P*, *T*, *Z*, etc., should have the top lines coincide with the upper horizontal guide line. The bottom lines of such letters as *D*, *E*, *L*, *Z*, etc., should coincide with the lower horizontal guide line. If these lines do not coincide with the guide lines the words will look uneven. Letters, of which *C*, *G*, *O*, and *Q*, are types, can be formed of curved lines or of straight lines. If made of curved lines, they should have a little greater height than the guide lines to prevent their appearing smaller than the other letters. In this work they can be made of straight lines with rounded corners as they are easily constructed and the student can make all letters of the same height.

To construct the letter *A*, draw a line at an angle of 60 degrees to the horizontal and use it as a center line. Then from the intersection of this line and the upper horizontal line drop a vertical line to the lower guide line. Draw another line from the vertex meeting the lower guide line at the same distance from 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 are the horizontal 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*, draw the center line 60 degrees to the horizontal; the diverging lines are similar to those of the *V* but are shorter and form a larger angle. The diverging lines should meet the center line a little below the middle.

The lower-case letters are shown in Fig. 35. In such letters as *m*, *n*, *r*, etc., make the corners sharp and not rounding. The letters *a*, *b*, *c*, *e*, *g*, *o*, *p*, *q*, should be full and rounding. The figures (see Fig. 32) are made as in writing — except the *4*, *6*, *8* and *9*.

The Roman numerals are made of straight lines as they are largely made up of *I*, *V* and *X*.

At first the copy should be followed closely and the letters drawn in pencil. For a time, the inclined guide lines may be used.

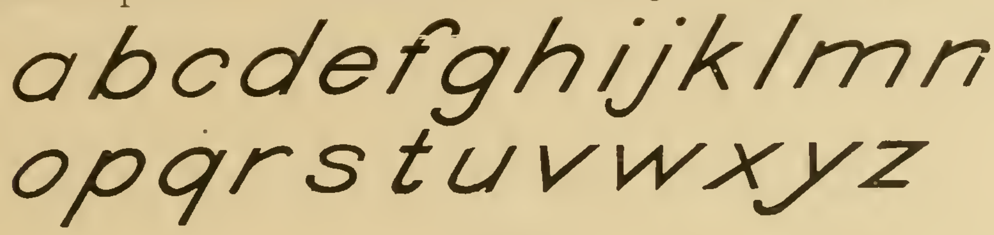


Fig. 35.

but after the proper inclination becomes firmly fixed in mind they should be abandoned. The horizontal lines are used at all times by most draftsmen. After the student has had considerable practice, he can construct the letters in ink without first using the pencil. Later in the work, when the student has become proficient in the simple inclined Gothic capitals, the vertical, block and Roman alphabets should be studied.

PLATES.

To lay out a sheet of paper for the plates of this work, the sheet, A B G F, (Fig. 36) is placed on the drawing board 2 or 3 inches from the left-hand edge which is 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 the T-square will be more accurate. In placing the paper on the board, always true it up according to the long edge of the sheet. First fasten the paper to the board with thumb tacks, using at least 4 — one at each corner. If the paper has a tendency to curl it is better to use 6 or 8 tacks, placing them as shown in Fig. 36. Thumb tacks are commonly used; but many draftsmen prefer one-ounce tacks as they offer less obstruction to the T-square and triangles.

After the paper is fastened in position, find the center of the

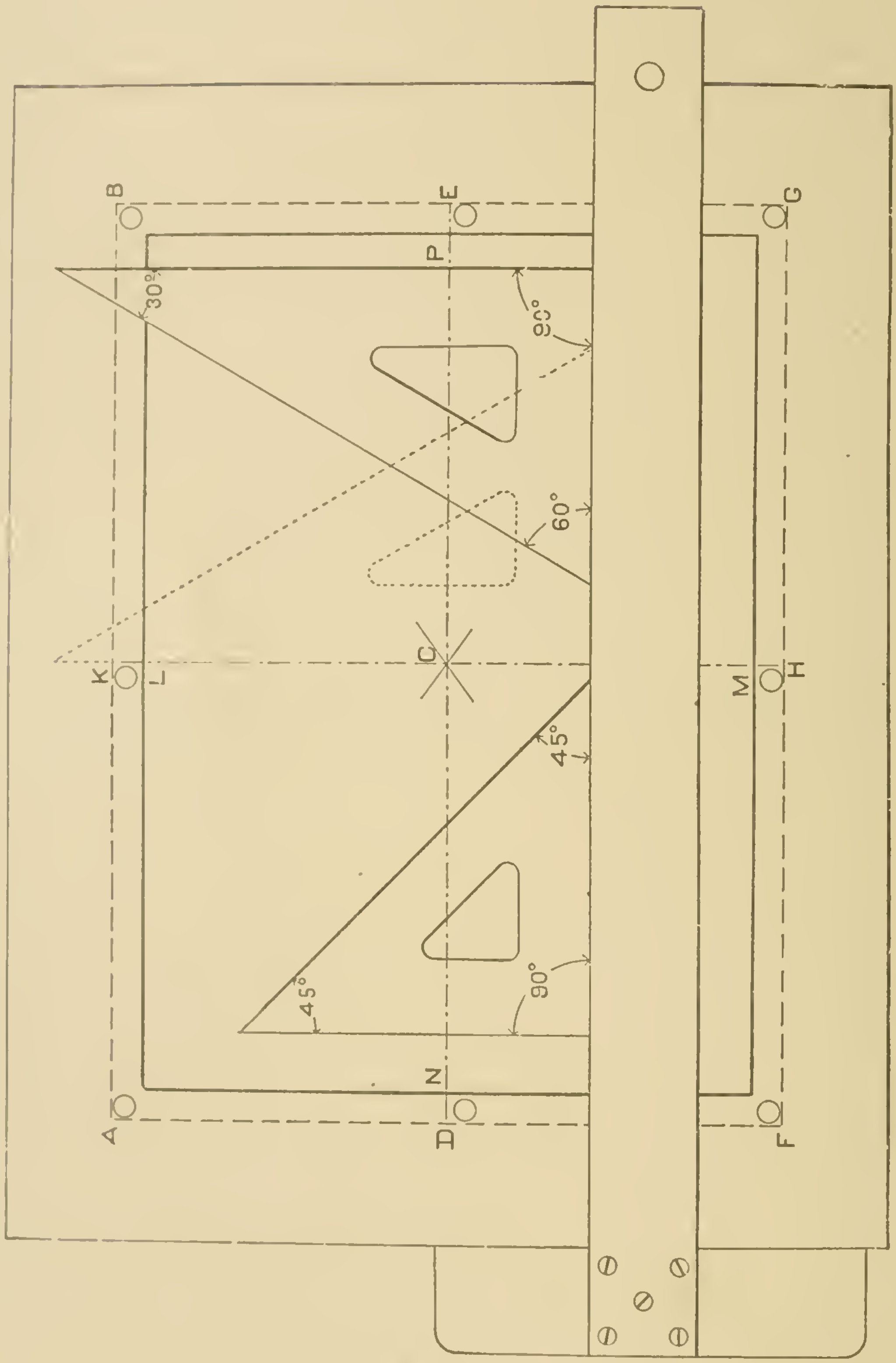


Fig. 36.

sheet by placing the T-square so that its upper edge coincides with the diagonal corners A and G and then with the corners F and B, drawing short pencil lines intersecting at C. Now place the T-square so that its upper edge coincides with the point C and draw the dot and dash line D E. With the T-square and one of the triangles (shown dotted) in the position shown in Fig. 36, draw the dot and dash line H C K. In case the drawing board is large enough, the line C H can be drawn by moving the T-square until it is entirely off the drawing. If the board is small, produce (extend) the line K C to H by means of the T-square or edge of a triangle. In this work always move the pencil from the left to the right or from the bottom upward; never (except for some particular purpose) in the opposite direction.

After the center lines are drawn measure off 5 inches above and below the point C on the line H C K. These points L and M may be indicated by a light pencil mark or by a *slight* puncture of one of the points of the dividers. Now place the T-square against the left-hand edge of the board and draw horizontal pencil lines through L and M.

Measure off 7 inches to the left and right of C on the center line D C E and draw pencil lines through these points (N and P) perpendicular to D E. We now have a rectangle 10 inches by 14 inches, in which all the exercises and figures are to be drawn. The lettering of the student's name and address, date, and plate number are to be placed *outside* of this rectangle in the ½-inch margin. In all cases lay out the plates in this manner and keep the center lines D E and K H as a basis for the various figures. The border line is to be inked with a heavy line when the drawing is inked.

Pencilling. In laying out plates, all work is first done in pencil and afterward inked or traced on tracing cloth. The first few plates of this course are to be done in pencil and then inked; later the subject of tracing and the process of making blue prints will be taken up. Every beginner should practice with his instruments until he can use them with accuracy and skill, and until he understands thoroughly what instrument should be used for making a given line. To aid the beginner in this work, the first three plates of this course are designed to give the student practice; they do not involve any problems and none of the work is difficult. The student is strongly advised to draw these plates two or three times before making the one to be sent to us for correction. Diligent practice is necessary at first; especially on *PLATE I* as it involves an exercise in lettering.

PLATE I.

Pencilling. 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. 36. 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 *Figs. 1* and *2* and the top lines A B of *Figs. 3* and *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. 36. The lines thus drawn, form the sides B C of *Figs. 1* and *3* and the sides A D of *Figs. 2* and *4*. Next draw the line A B A B with the T-square, $4\frac{5}{8}$ inches above the horizontal center line. This line forms the top lines of *Figs. 1* and *2*. Now draw the line D C D C $4\frac{5}{8}$ inches below the horizontal center line. The rectangles of the four figures are completed by drawing vertical lines $6\frac{5}{8}$ inches from the vertical center line. We now have four rectangles each $6\frac{1}{4}$ inches long and $4\frac{1}{4}$ inches wide.

Fig. 1 is an exercise with the 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 the 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 be careful to have the pencil point 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 pencilling insure an accurate drawing. Some beginners think that they can correct inaccuracies while

PLATE I

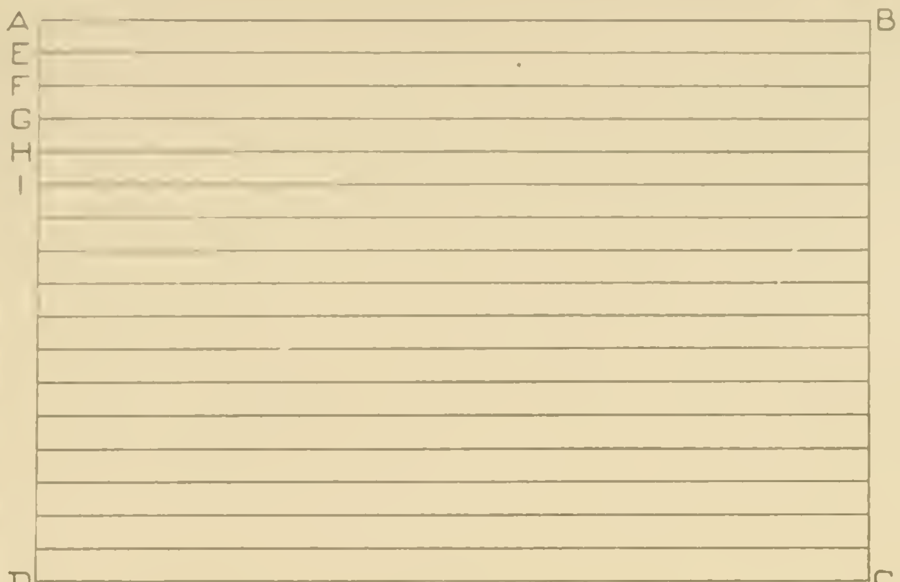


FIG. 1

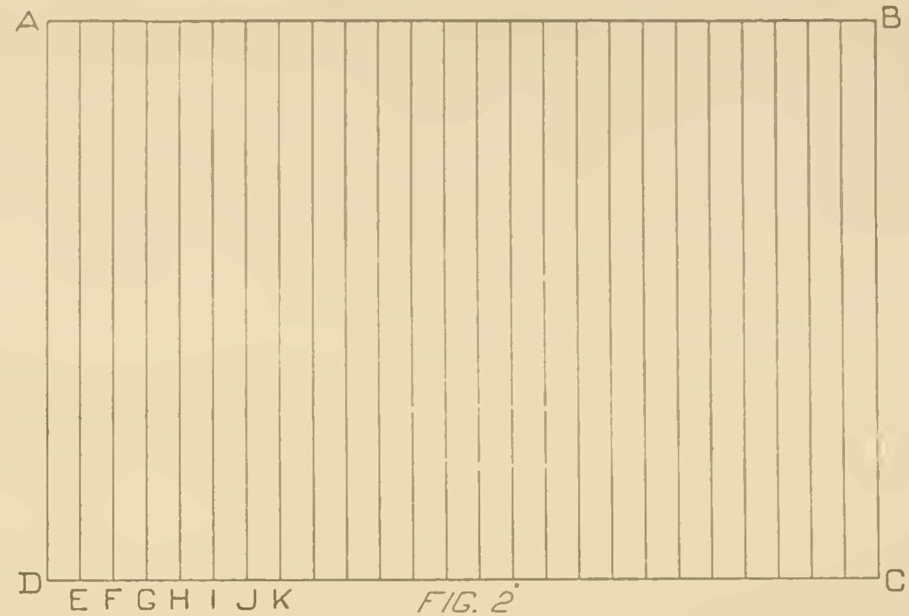


FIG. 2

FIG. 3

LETTERING

THE SUBJECT OF LETTERING IS OF GREAT IMPORTANCE TO THE MECHANICAL DRAUGHTSMAN. MANY WELL EXECUTED DRAWINGS HAVE BEEN DISFIGURED BY POOR LETTERING.

Proficiency can be acquired only by practice. Practice lettering. Practice.

ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijklmnopqrstuvwxyz

1234567890

I II III IV V VI VII VIII IX X

FIG. 4

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inking; but experience soon teaches them that they cannot do so.

Fig. 2 is an exercise with the line pen, T-square and triangle. First 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 with the head at the left-hand edge of the drawing board and the upper edge in about the position shown in Fig. 36. Place either triangle with one edge on the upper edge of the T-square and the 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. To do this keep the T-square

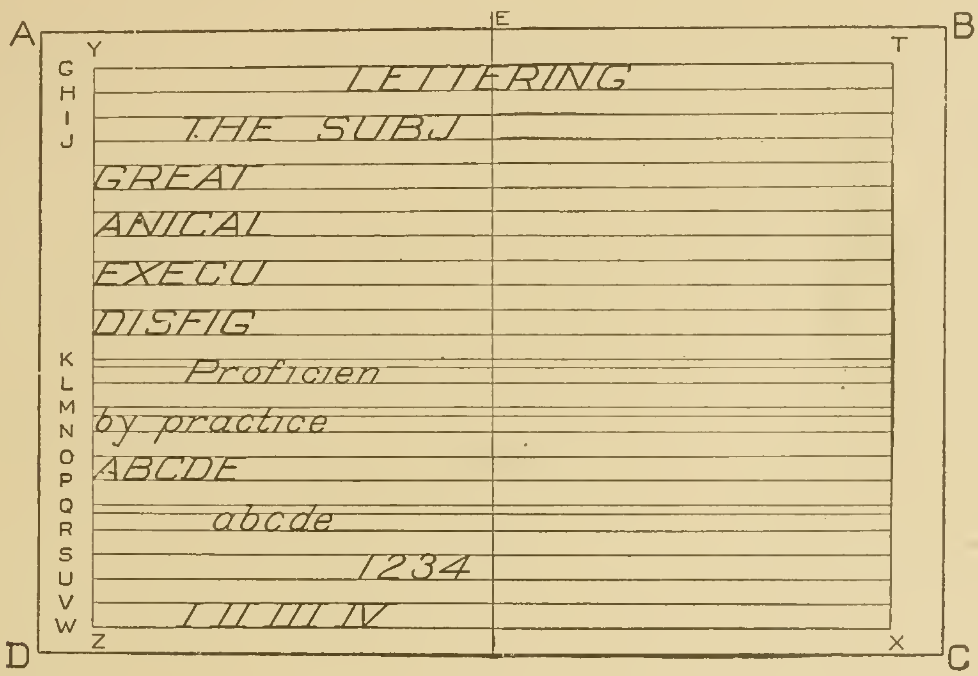


Fig. 37.

rigid and slide the triangle toward the right, being careful to have the edge coincide with the division marks in succession.

Fig. 3 is an exercise with the line pen, T-square and 45-degree triangle. First lay off the distances A E, E F, F G, G H, H I, I J, J K, etc., each $\frac{1}{4}$ inch long. Then lay off the distances B L, L M, M N, N O, O P, P Q, Q R, etc., also $\frac{1}{4}$ inch long. Place the T-square so that the upper edge will be below the line D C of *Fig. 3.* With the 45-degree triangle draw lines from A D and D C to the points E, F, G, H, I, J, K, etc., as far as the point B. Now draw lines from D C to the points L, M, N, O, P, Q, R, etc., as far as the point C. In drawing these lines move the pencil away from the body, that is, from A D to A B and from D C to B C.

Fig. 4 is an exercise in free-hand lettering. The finished exercise, with all guide lines erased, should have the appearance shown in *Fig. 4* of *PLATE I.* The guide lines are drawn as shown in Fig 37. First draw the center line E F and light pencil lines Y Z and 1 X, $\frac{3}{8}$ inch from the border lines. Now, 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, $\frac{3}{16}$ inch below H. The lines I, J, etc., to K are all $\frac{5}{32}$ inch apart.

We now practice the lower-case letters. Draw the line L, $\frac{3}{16}$ inch below K and a light line $\frac{1}{8}$ inch above L to limit the height of the small letters. The space between L and M is $\frac{5}{32}$ inch. The lines M and N are drawn in the same manner as K and L. The space between N and O should be $\frac{1}{4}$ inch. The line P is drawn $\frac{5}{32}$ inch below O. Q is also $\frac{5}{32}$ inch below P. The lines Q and R are drawn $\frac{3}{16}$ inch apart as are M and N. The remainder of the lines S, U, V and W are drawn $\frac{5}{32}$ inch apart.

The center line is a great aid in centering the word "*LETTERING*," the alphabets, numerals, etc. The words "*THE*" and "*Proficiency*" should be indented 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. The letters should be sketched in pencil, the ordinary letters such as E, F, H, N, R, etc. being made of a width equal to about $\frac{3}{4}$ the 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 near them and that greater space should be left on each side of an I or between letters whose sides are parallel; for instance there should be more space between an N and E than between an E and H. 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 the letter L follows an L they should be placed near together. In all lettering the letters should be placed so that the general effect is pleasing. After the four figures are completed, the lettering for name, address and date should be pencilled. With the T-square draw a pencil line $\frac{5}{32}$ inch above the top border line at the right-hand end. This line should be 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.* The letters should be pencilled free hand and the student may use the 60-degree guide lines if he desires.

The guide lines of the date, name and address are similarly drawn in the lower margin. The date of completing the drawing should be 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. He may leave them out if he desires ; but we would advise him to do this extra lettering for the practice and for convenience in reference. First draw with the T-square two parallel line $\frac{5}{32}$ 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 pencilling of *PLATE I* has been completed the exercises should be inked. The pen should first be examined to make sure that the nibs are clean, of the same length and come together evenly. To fill the pen with ink use an ordinary steel pen or the quill in the bottle, if Higgin's Ink is used. Dip the quill or pen into the bottle and then inside between the nibs of the line pen. The ink will readily flow from the quill into the space between the nibs as soon as it is brought in contact. Do not fill the pen too full, if the ink fills about $\frac{1}{4}$ the distance to the adjusting screw it usually will be sufficient. If the filling has been carefully done it will not be necessary to wipe the outsides of the blades. However, any ink on the outside should be wiped off with a soft cloth or a piece of chamois.

The pen should now be tried on a separate piece of paper in order that the width of the line may be adjusted. In the first work where no shading is done, a firm distinct line should be used. The beginner should avoid the extremes; a very light line makes the drawing have a weak, indistinct appearance, and very heavy lines detract from the artistic appearance and make the drawing appear heavy.

In case the ink does not flow freely, wet the finger and touch it to the end of the pen. If it then fails to flow, draw a slip of thin paper between the nibs (thus removing the dried ink) or clean thoroughly and fill. Never lay the pen aside without cleaning.

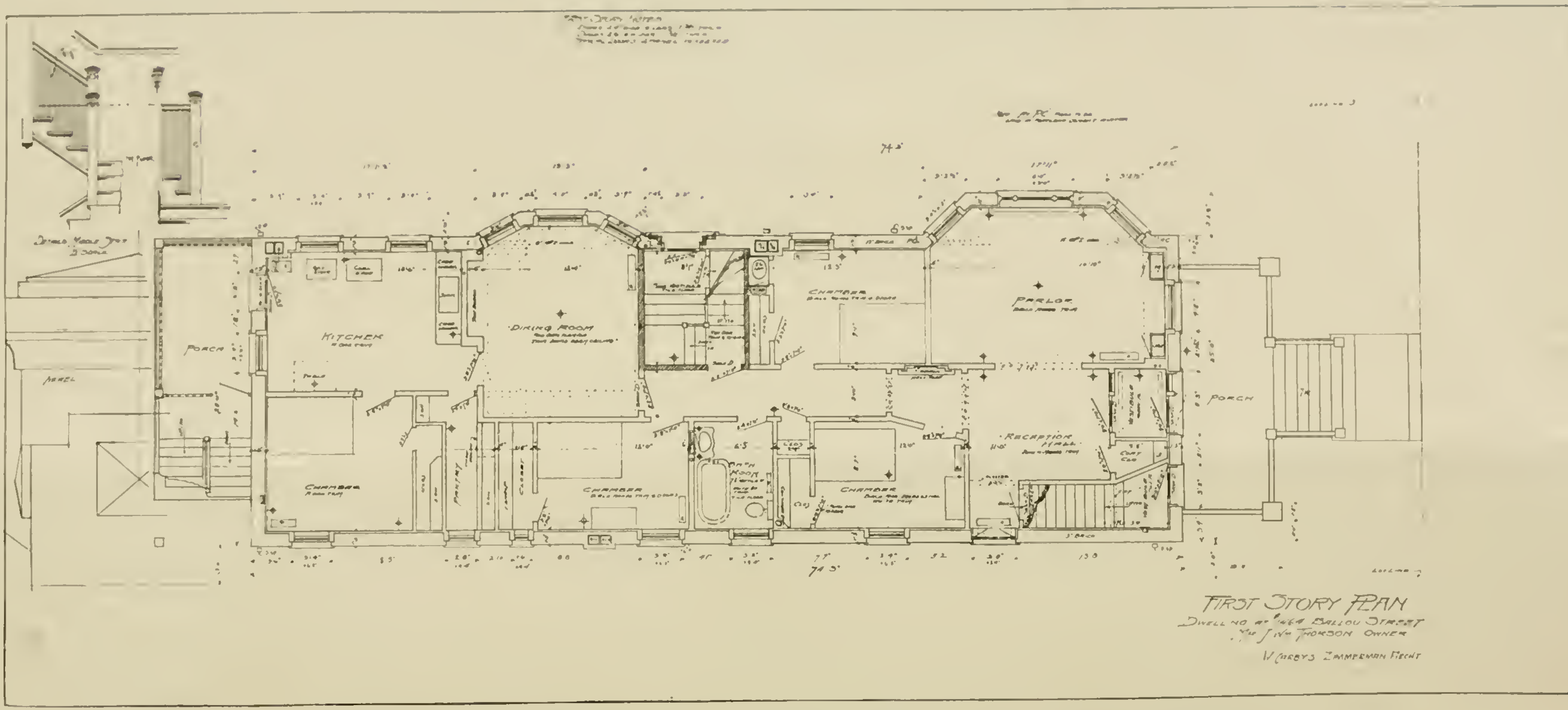
In ruling with the line pen it should be held firmly in the right hand almost perpendicular to the paper. If grasped too firmly the width of the line may be varied and the draftsman soon becomes fatigued. The pen is usually held so that the adjusting screw is away from the T-square, triangles, etc. Many draftsmen incline the pen slightly in the direction in which it is moving.

To ink *Fig. 1*, place the T-square with the head at the working edge as in pencilling. First ink all of the horizontal lines moving the T-square from A to D. In drawing these lines considerable care is necessary; both nibs should touch the paper and the pressure should be uniform. Have sufficient ink in the pen to finish the line as it is difficult for a beginner to stop in the middle of the line and after refilling the pen make a smooth continuous line. While inking the lines A, E, F, G, H, I, etc., greater care should be taken in starting and stopping than while pencilling. Each line should start *exactly* in the pencil line A D and stop in the line B C. The lines A D and B C are inked, using the triangle and T-square.

Fig. 2 is inked in the same manner as it was pencilled; the lines being drawn, sliding the triangle along the T-square in the successive positions.

In inking *Fig. 3*, the same care is necessary as with the preceding, and after the oblique lines are inked the border lines are finished. In *Fig. 4* the border lines should be inked in first and then the border lines of the plate. The border lines should be quite heavy as they give the plate a better appearance. The intersections should be accurate, as any running over necessitates erasing.

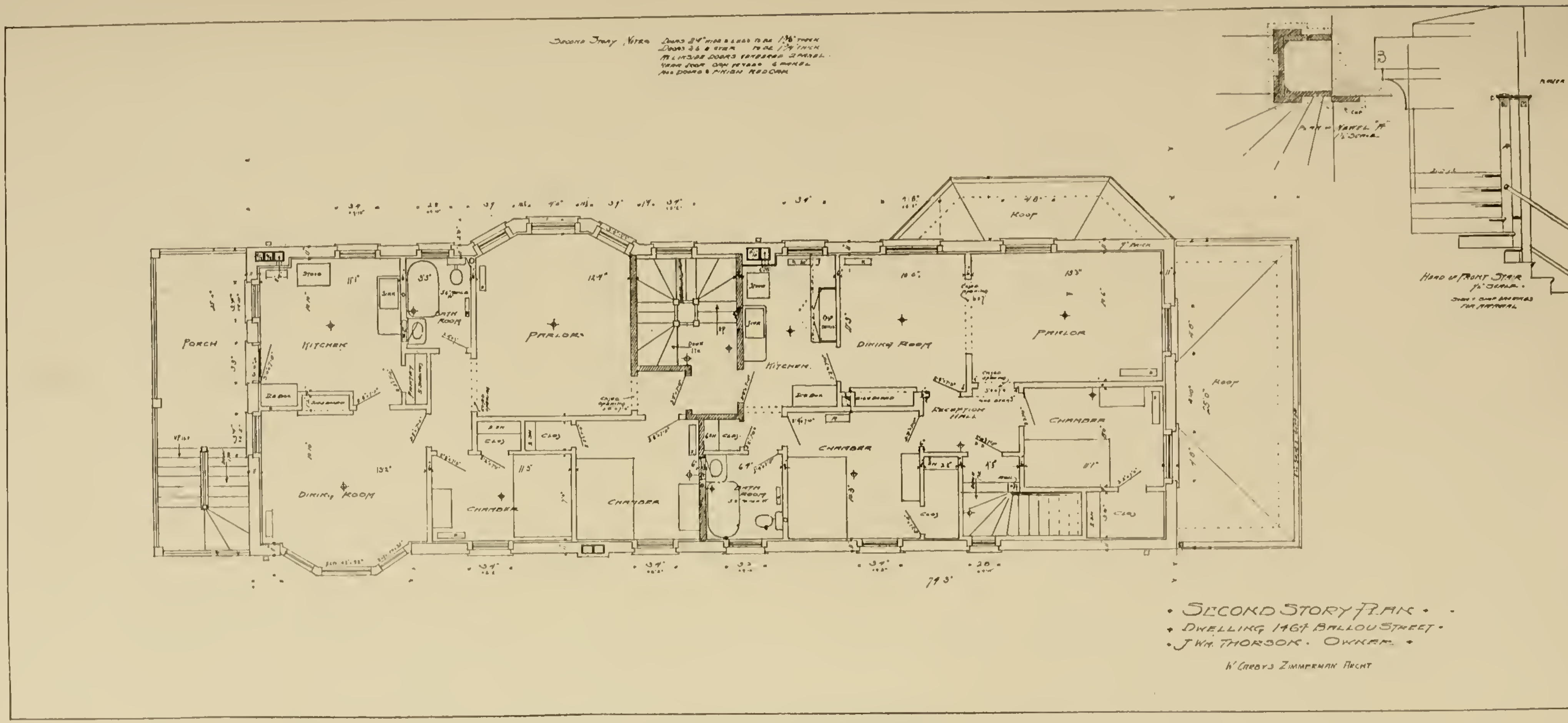
The line pen may now be cleaned and laid aside. It can be



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.

cleaned by drawing a strip of blotting paper between the nibs or by means of a piece of cloth or chamois. The lettering should be done free-hand using a steel pen. If the pen is very fine, accurate work may be done but the pen is likely to catch in the paper, especially if the paper is rough. A coarser pen will make broader lines but is on the whole preferable. Gillott's 404 is as fine a pen as should be used. After inking *Fig. 4*, the plate number, date and name should be inked, also free-hand. After inking the words "*Fig. 1*," "*Fig. 2*," etc., all pencil lines should be erased. **In the finished drawing there should be no center lines, construction lines or letters other than those in the name, date, etc.**

The sheet should be cut to a size of 11 inches by 15 inches, the dash line outside the border line of *PLATE I* indicating the edge.

PLATE II.

Pencilling. The drawing paper used for *PLATE II* should be laid out as described with *PLATE I*, that is, the border lines, center line and rectangles for *Figs. 1* and *2*. To lay out *Figs. 3*, *4* and *5* proceed as follows: Draw a line with the T-square parallel to the horizontal center line and $\frac{3}{8}$ inch below it. Also draw another similar line $4\frac{5}{8}$ below the center line. The two lines will form the top and bottom of *Figs. 3*, *4* and *5*. Now measure off $2\frac{1}{4}$ inches on either side of the center on the horizontal center line and call the points Y and Z. On either side of Y and Z and at a distance of $\frac{1}{4}$ inch draw vertical parallel lines. Now draw a vertical line A D, $4\frac{1}{4}$ inches from the line Y and a vertical line B C $4\frac{1}{4}$ inches from the line Z. We now have three rectangles each 4 inches broad and $4\frac{1}{4}$ inches high. *Figs. 1* and *2* are pencilled in exactly the same way as was *Fig. 1* of *PLATE I*, that is, horizontal lines are drawn $\frac{1}{4}$ inch apart.

Fig. 3 is an exercise to show the use of a 60-degree triangle with a T-square. Lay off the distances A E, E F, F G, G H, etc. to B each $\frac{1}{4}$ inch. With the 60 degree triangle resting on the upper edge of the T-square, draw lines through these points, E, F, G, H, I, J, etc., forming an angle of 30 degrees with the horizontal. The last line drawn will be A L. In drawing these lines move the pencil from A B to B C. Now find the distance between the lines on the vertical B L and mark off these distances on the line B C commencing at L. Continue the lines from A L to N C. Commencing at N mark off distances on A D equal to those on B C and finish drawing the oblique lines.

Fig. 4 is an exercise for intersection. Lay off distances of $\frac{1}{4}$ inch on A B and A D. With the T-square draw fine pencil lines through the points E, F, G, H, I, etc., and with the T-square and triangle draw vertical lines through the points L, M, N, O, P, etc. In drawing this figure draw every line exactly through the points indicated as the symmetrical appearance of the small squares can be attained only by accurate pencilling.

The oblique lines in *Fig. 5* form an angle of 60 degrees with the horizontal. As in *Figs. 3* and *4* mark off the line A B in divisions of $\frac{1}{4}$ inch and draw with the T-square and 60-degree triangle the oblique lines through these points of division moving the pencil from A B to B C. The last line thus drawn will be A L. Now mark off distances of $\frac{1}{4}$ inch on C D beginning at L. The lines may now be finished.

Inking. *Fig. 1* is designed to give the beginner practice in drawing lines of varying widths. The line E is first drawn. This line should be rather fine but should be clear and distinct. The line F should be a little wider than E; the greater width being obtained by turning the adjusting screw from one-quarter to one-half a turn. The lines G, H, I, etc., are drawn; each successive line having greater width. M and N should be the same and quite heavy. From N to D the lines should *decrease* in width. To complete the inking of *Fig. 1*, draw the border lines. These lines should have about the same width as those in *PLATE I.*

In *Fig. 2* the first four lines should be dotted. The dots should be uniform in length (about $\frac{1}{16}$ inch) and the spaces also uniform (about $\frac{1}{32}$ inch). The next four lines are dash lines similar to those used for dimensions. These lines should be drawn with dashes about $\frac{3}{4}$ inch long and the lines should be fine, yet distinct.

The following four lines are called dot and dash lines. The dashes are about $\frac{3}{4}$ inch long and a dot between as shown. In the regular practice of drafting the length of the dashes depends upon the size of the drawing — $\frac{1}{2}$ inch to 1 inch being common. The last four lines are similar, two dots being used between the

PLATE II

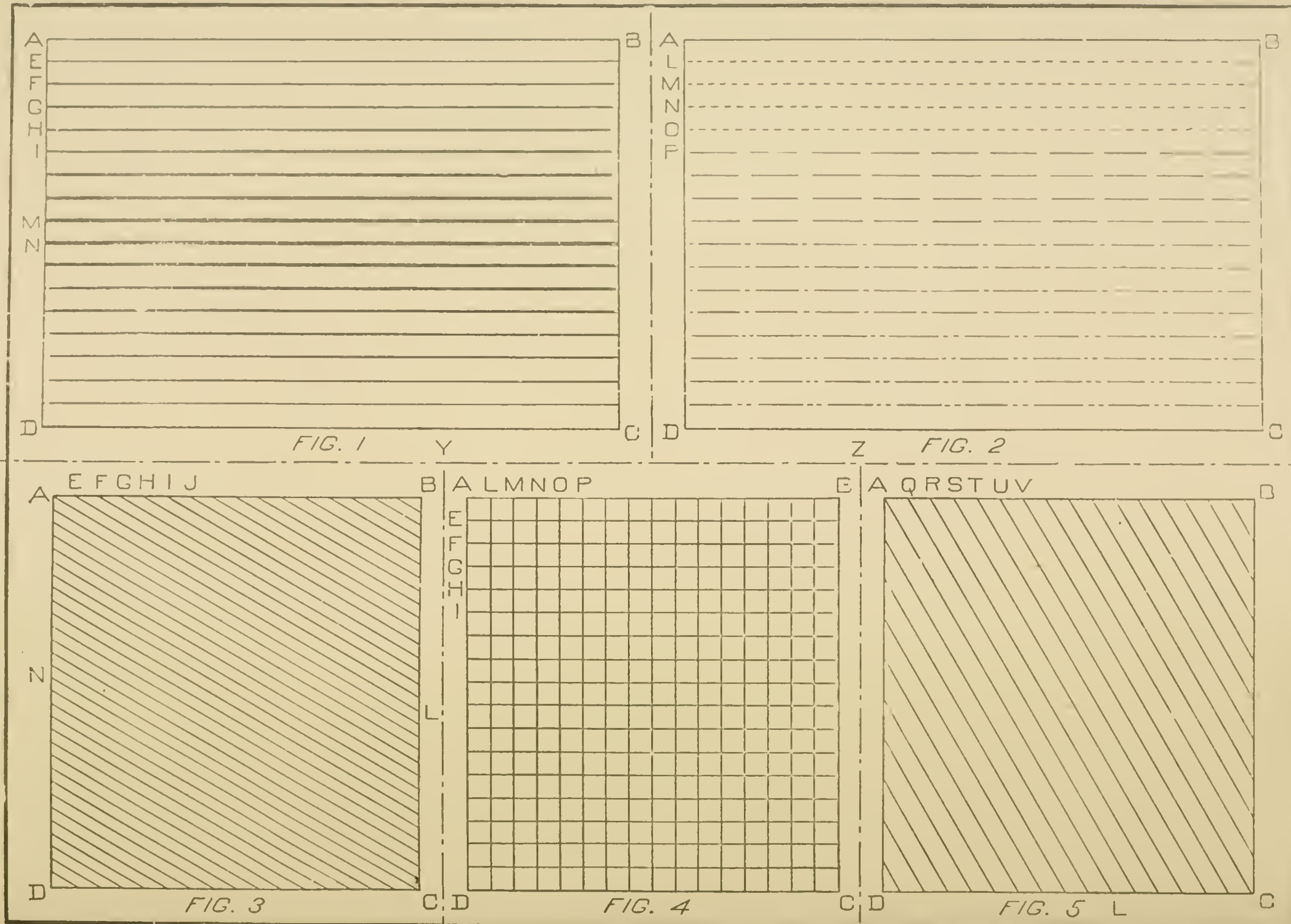


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5

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dashes. After completing the dot and dash lines, draw the border lines of the rectangle as before.

In inking *Fig. 3*. the pencil lines are followed. Great care should be exercised in starting and stopping. The lines should begin in the border lines and the end should not run over.

The lines of *Fig. 4* must be drawn carefully, as there are so many intersections. The lines in this figure should be lighter than the border lines. If every line does not coincide with the points of division L, M, N, O, P, etc., some will appear farther apart than others.

Fig. 5 is similar to *Fig. 3*, the only difference being in the angle which the oblique lines make with the horizontal.

After completing the five figures draw the border lines of the plate and then letter the plate number, date and name, and the figure numbers, as in *PLATE I.* **The plate should then be cut to the required size, 11 inches by 15 inches.**

PLATE III.

Pencilling. The horizontal and vertical center lines and the border lines for *PLATE III* are laid out in the same manner as were those of *PLATE II.* To draw the squares for the six figures, proceed as follows :

Measure off two inches on either side of the vertical center line and draw light pencil lines through these points parallel to the vertical center line. These lines will form the sides A D and B C of *Figs. 2* and *5*. Parallel to these lines and at a distance of $\frac{1}{2}$ inch draw similar lines to form the sides B C of *Figs. 1* and *4* and A D of *Figs. 3* and *6*. The vertical sides A D of *Figs. 1* and *4* and B C of *Figs. 3* and *6* are formed by drawing lines perpendicular to the horizontal center line at a distance of $6\frac{1}{2}$ inches from the center.

The horizontal sides D C of *Figs. 1*, *2* and *3* are drawn with the T-square $\frac{1}{2}$ inch above the horizontal center line. To draw the top lines of these figures, draw (with the T-square) a line $4\frac{1}{2}$ inches above the horizontal center line. The top lines of *Figs. 4*, *5* and *6* are drawn $\frac{1}{2}$ inch below the horizontal center line. The squares are completed by drawing the lower lines D C, $4\frac{1}{2}$ inches below the horizontal center line. The figures of *PLATES I* and *II* were constructed in rectangles; the exercises of *PLATE III* are, however, drawn in squares, having the sides 4 inches long.

In drawing *Fig. 1*, first divide A D and A B (or D C) into 4 equal parts. As these lines are four inches long, each length will be 1 inch. Now draw horizontal lines through E, F and G and vertical lines through L, M and N. These lines are shown dotted in *Fig. 1*. Connect A and B with the intersection of lines E and M, and A and D with the intersection of lines F and L. Similarly draw D J, J C, I B and I C. Also connect the points P, O, I and J forming a square. The four diamond shaped areas are formed by drawing lines from the middle points of A D, A B, B C and D C to the middle points of lines A P, A O, O B, I B etc., as shown in *Fig. 1*.

Fig. 2 is an exercise of straight lines. Divide A D and A B into four equal parts and draw horizontal and vertical lines as in *Fig. 1*. Now divide these dimensions, A L, M N, etc. and E F, G B etc. into four equal parts (each $\frac{1}{4}$ inch). Draw light pencil lines with the T-square and triangle as shown in *Fig. 2*.

In *Fig. 3*, divide A B and A D into eight parts, each length being $\frac{1}{2}$ inch. Through the points H, I, J, K, L, M and N draw vertical lines with the triangle. Through O, P, Q, R, S, T and U draw horizontal lines with the T-square. Now draw lines connecting O and H, P and I, Q and J, etc. These lines can be drawn with the 45-degree triangle, as they form an angle of 45 degrees with the horizontal. Starting at N draw lines from A B to B C at an angle of 45 degrees. Also draw lines from A D to D C through the points O, P, Q, R, etc., forming angles of 45 degrees with D C.

Fig. 4 is drawn with the compasses. First draw the diagonals A C and D B. With the T-square draw the line E H. Now mark off on E H distances of $\frac{1}{4}$ inch. With the compasses set so that the point of the lead is 2 inches from the needle point, describe the circle passing through E. With H as a center draw the arcs F G and I J having a radius of $1\frac{3}{4}$ inches. In drawing these arcs be careful not to go beyond the diagonals, but stop at the points F and G and I and J. Again with H as the center and a radius of $1\frac{1}{2}$ inches draw a circle. The arcs K L and M N are drawn in the same manner as were arcs F G and I J; the

PLATE II

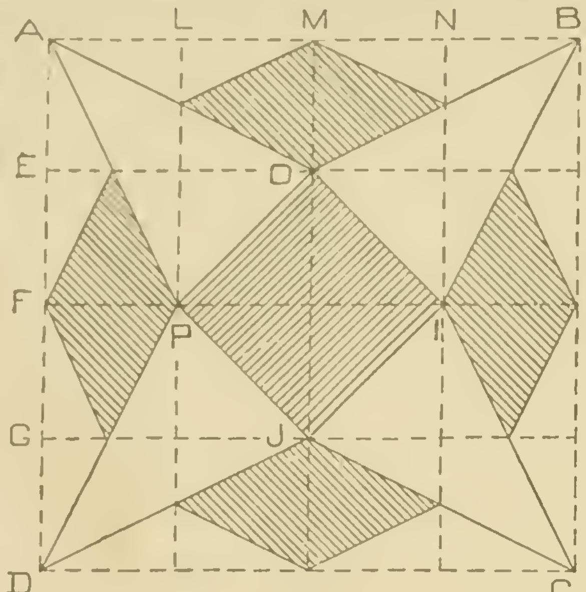


FIG. 1

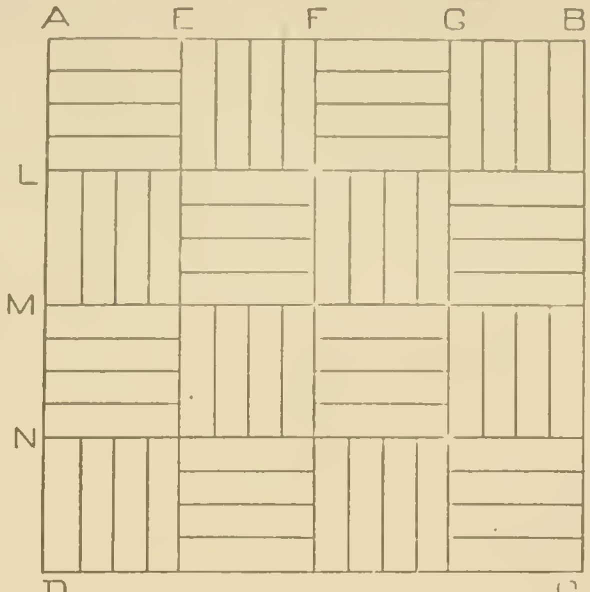


FIG. 2

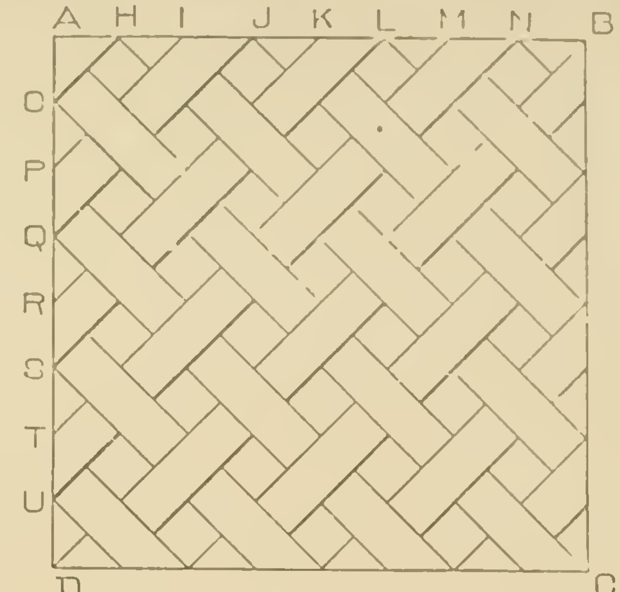


FIG. 3

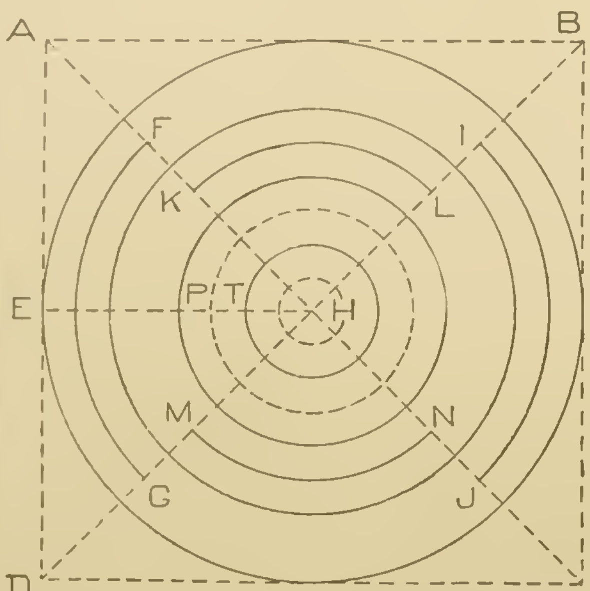


FIG. 4

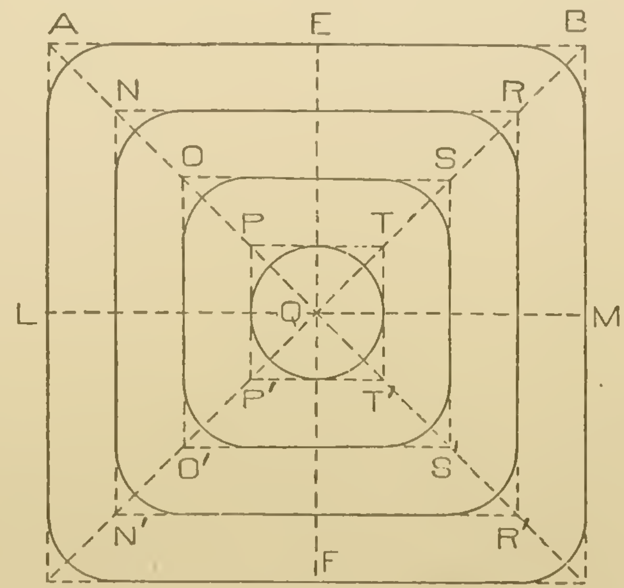


FIG. 5

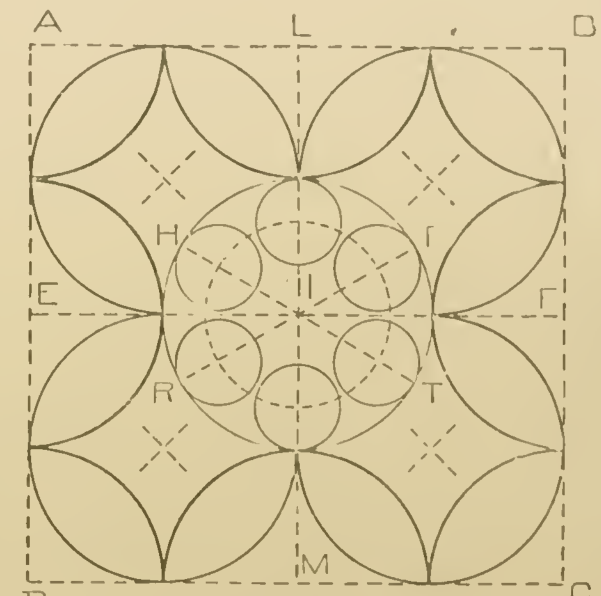


FIG. 6

JANUARY 14, 1907 HERBERT CHANDLER CHICAGO, ILL.

radius being $1\frac{1}{4}$ inches. Now draw circles, with H as the center, of 1, $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$ inch radius, passing through the points P, T, etc.

Fig. 5 is an exercise with the line pen and compasses. First 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 draw the lines N N′ O O′ and N R, O S, etc., through these points, forming the squares N R R′ N′, O S S′ O′, etc. With the bow pencil adjusted so that the distance between the pencil point and the needle point is $\frac{1}{2}$ inch draw the arcs having centers at the corners of the 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 P T, T T′, T′ P′ and P′ P are each 1 inch long and form the square, the arcs drawn with Q as a center will form a circle.

To draw *Fig. 6*, first draw the center lines E F and L M. Now find the centers of the small squares A L I E, L B F I etc. Through the center I draw the construction lines H I T and R I P forming angles of 30 degrees with the horizontal. Now adjust the compasses to draw circles having a radius of one inch. With I as a center, draw the circle H P T R. With the same radius (one inch) draw the arcs with centers at A, B, C and D. Also draw the semi-circles with centers at L, F, M and E. Now draw the arcs as shown having centers at the centers of the small squares A L I E, L B F I, etc. 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 have a radius of $\frac{5}{16}$ inch.

Inking. In inking this plate, the outlines of the squares of the various figures are inked only in *Figs. 2* and *3*. In *Fig. 1* the only lines to be inked are those shown in **full** lines in *PLATE III.* First ink the star and then the square and diamonds. The cross-hatching should be done *without* measuring the distance between the lines and without the aid of any cross hatching device as this is an exercise for practice. The lines should be about $\frac{1}{16}$ inch apart. After inking erase all construction lines.

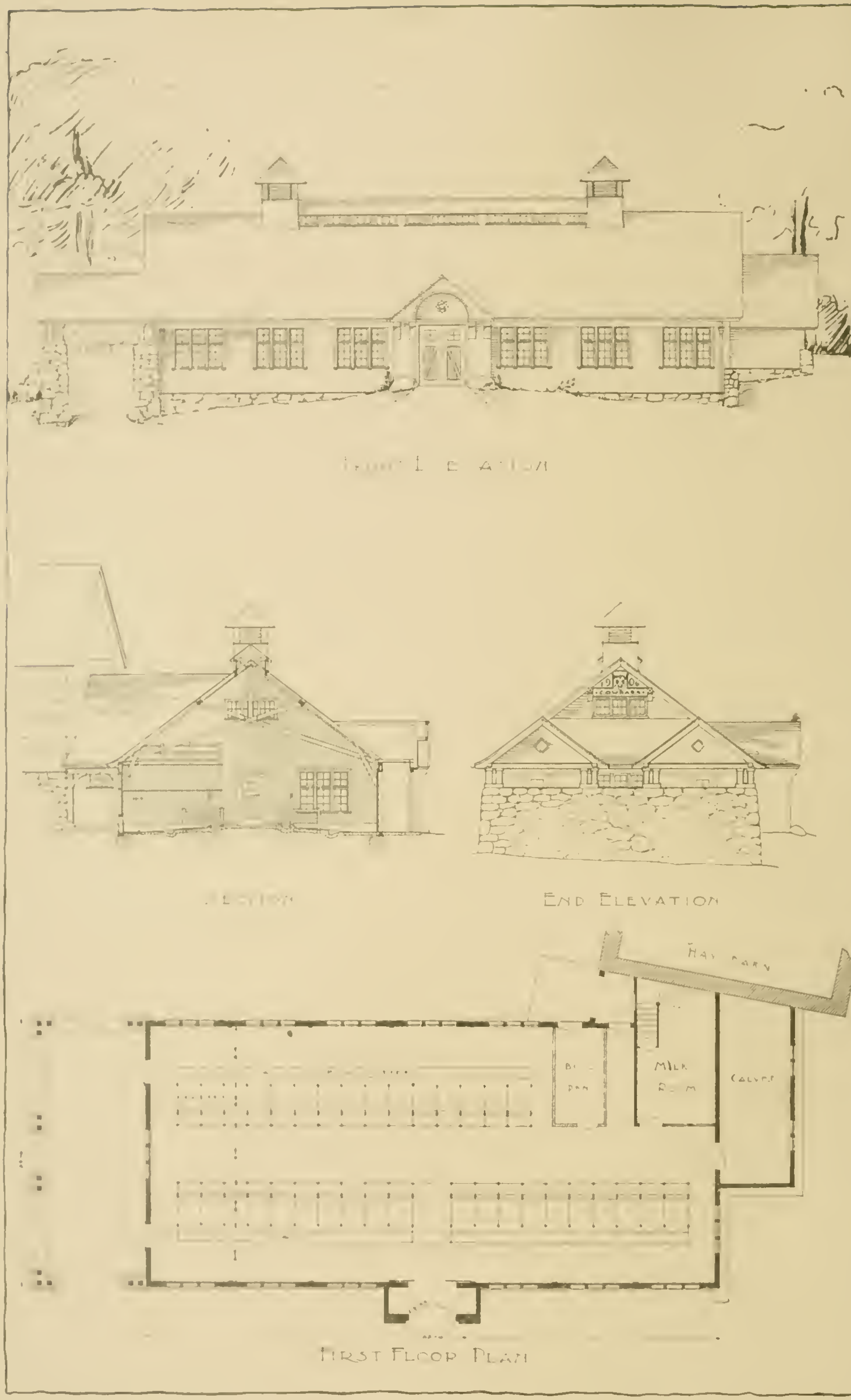
In inking *Fig. 2* be careful not to run over lines. Each line should coincide with the pencil line. The student should first ink the horizontal lines L, M and N and the vertical lines E, F and G. The short lines should have the same width but the border lines, A B, B C, C D and D A should be a little heavier.

Fig. 3 is drawn entirely with the 45-degree triangle. In inking the oblique lines make P I, R K, T M, etc., a light distinct line. 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. After inking *Fig. 3* all horizontal and vertical lines (except the border lines) should be erased. The border lines should be slightly heavier than the light oblique lines.

The only instrument used in inking *Fig. 4* is the compasses. In doing this exercise adjust the legs of the compasses so that the pen will always be perpendicular to the paper. If this is not done both nibs will not touch the paper and the line will be ragged. In inking the arcs, see that the pen stops *exactly* at the diagonals. The circle passing through T and the small inner circle should be dotted as shown in *PLATE III.* After inking the circles and arcs erase the construction lines that are without the outer circles but leave in *pencil* the diagonals inside the circle.

In *Fig. 5 draw all arcs first* and then draw the straight lines meeting these arcs. It is much easier to draw straight lines meeting arcs, or tangent to them, than to make the arcs tangent to straight lines. As this exercise is difficult, and in all mechanical and machine drawing arcs and tangents are frequently used we advise the beginner to draw this exercise several times. Leave all construction lines in pencil.

Fig. 6, like *Fig. 4*, is an exercise with compasses. If *Fig. 6* has been laid out accurately 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.



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.

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 any two of its 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 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.

Lines are *perpendicular* to each other, if when they cross, the four angles formed are equal. If they meet and form two equal angles they are perpendicular.

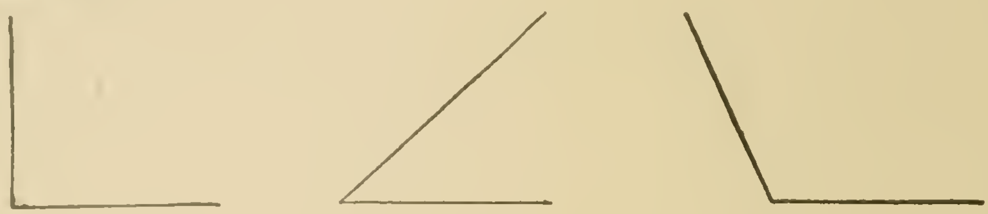
An *oblique line* is one that is neither vertical nor horizontal.

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.

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 formed when two straight lines meet. An angle is often defined as being the difference in direction of two straight lines. The lines are called the *sides* and the point of meeting is called the *vertex*. The size of an angle depends upon the amount of divergence of the sides and is independent of the length of these lines.



RIGHT ANGLE. ACUTE ANGLE. OBTUSE ANGLE.

If one straight line meet another and the angles thus formed are equal they are **right angles**. When two lines are perpendicular to each other the angles formed are right angles.

An **acute angle** is less than a right angle.

An **obtuse angle** is greater than a right angle.

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*.

TRIANGLES.

A **triangle** is a figure enclosed by three straight lines. It is a polygon of three sides. The bounding lines are the *sides*, and the points of intersection of the sides are the *vertices*. The *angles* of a triangle are the angles formed by the sides.

A **right-angled** triangle, often called a *right* triangle, is one that has a right angle.

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

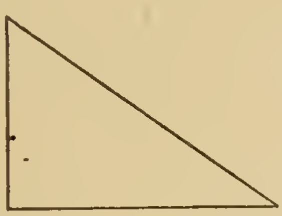
An **obtuse-angled** triangle is one that has an obtuse angle.

In an **equilateral** triangle all of the sides are equal.

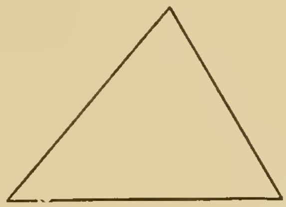
If all of the *angles* of a triangle are equal, the figure is called an **equiangular** triangle.

A triangle is called **scalene**, when no two of its sides are equal.

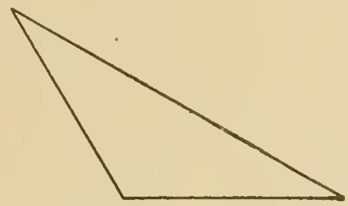
In an **isosceles** triangle two of the sides are equal.



RIGHT ANGLED TRIANGLE.



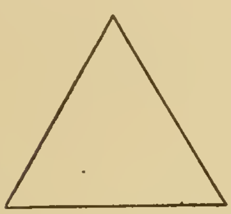
ACUTE ANGLED TRIANGLE.



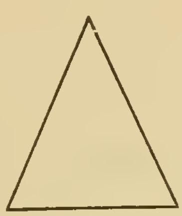
OBTUSE ANGLED TRIANGLE.

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

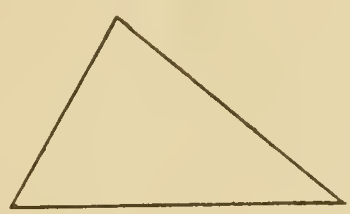
The *altitude* of a triangle is the perpendicular drawn from the vertex to the base.



EQUILATERAL TRIANGLE.



ISOSCELES TRIANGLE.

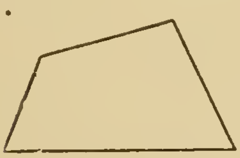


SCALENE TRIANGLE.

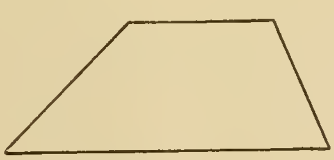
QUADRILATERALS.

A **quadrilateral** is a plane figure bounded by four straight lines.

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



QUADRILATERAL.



TRAPEZOID.

PARALLELOGRAM.

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

A **trapezoid** is a quadrilateral having two sides parallel.

The *bases* of a trapezoid are its parallel sides. The *altitude* is the perpendicular distance between the bases.

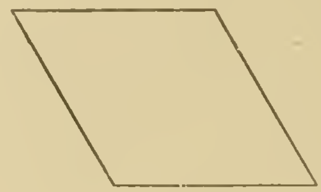
A **parallelogram** is a quadrilateral whose opposite sides are parallel.

The *altitude* of a parallelogram is the perpendicular distance between the bases which are the parallel sides.

There are four kinds of parallelograms:

RECTANGLE.

SQUARE.



RHOMBUS.

A **rectangle** is a parallelogram, all of whose angles are right angles. The opposite sides are equal.

A **square** is a rectangle, all of whose sides are equal.

A **rhombus** is a parallelogram which has four equal sides; but the angles are not right angles.

A **rhomboid** is a parallelogram whose adjacent sides are unequal; the angles are not right angles.

POLYGONS.

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

The 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.

A **hexagon** is a polygon of *six* sides.

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

An **octagon** is a polygon of *eight* sides.

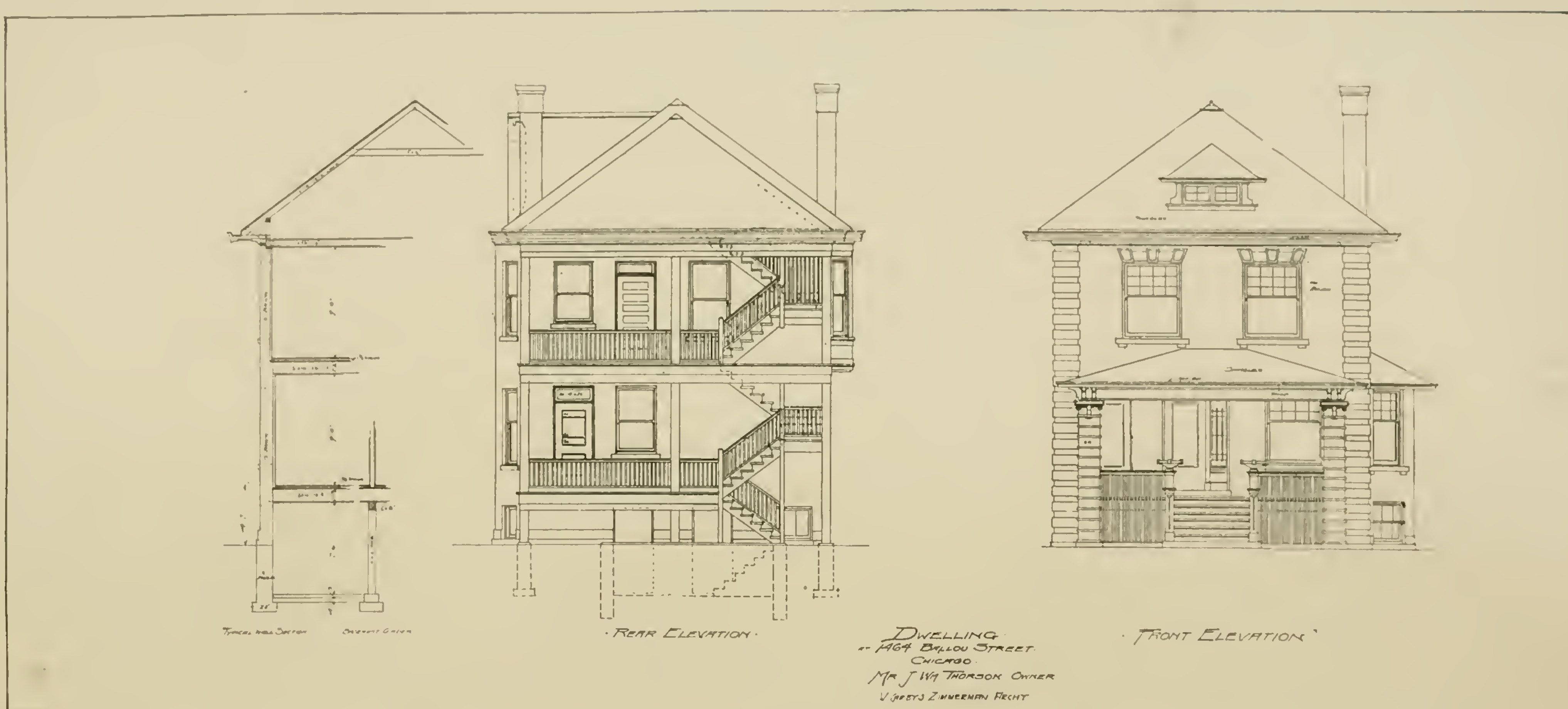
A **decagon** is a polygon of *ten* sides.

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 are equal and all of whose sides are equal.



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 10-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.

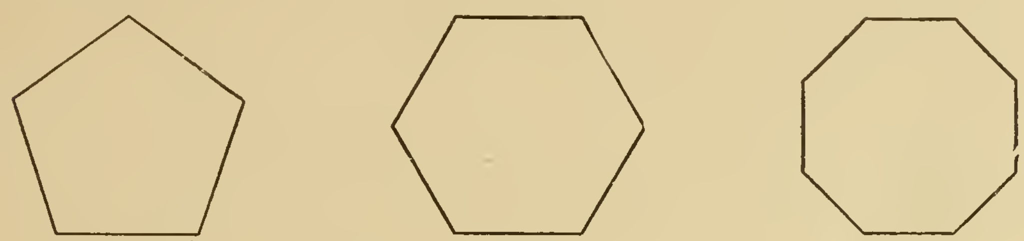
Front and Rear Elevations Shown on Opposite Page. For Plans, See Pages 26 and 42.

CIRCLES.

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

The curve which bounds the circle is called the **circumference** Any portion of the circumference is called an *arc*.

The **diameter** of a circle is a straight line drawn through the center and terminating in the circumference. A **radius** is a straight line joining the center with the circumference. It has a length equal to one half the diameter. All radii (plural of radius) are equal and all diameters are equal since a diameter equals two radii.

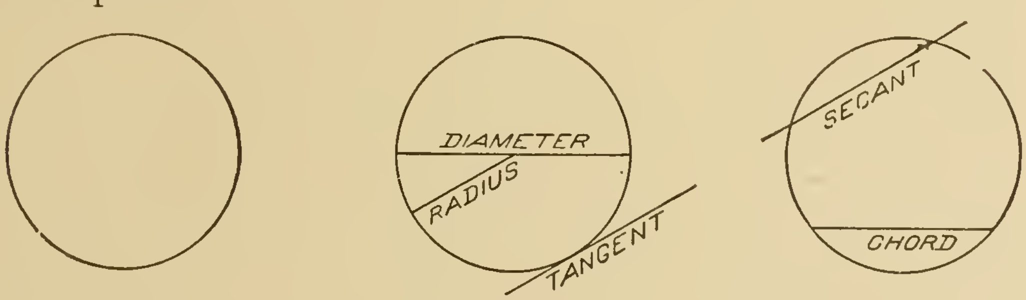


PENTAGON. HEXAGON. OCTAGON.

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*. A quadrant may mean the sector, arc or angle.

A **chord** is a straight line joining the extremities of an arc. It is a line drawn across a circle that does not pass through the center.

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



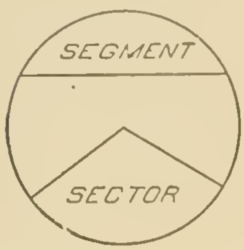
CIRCLE.

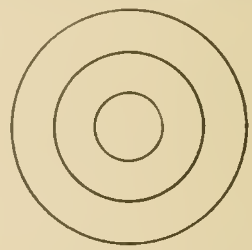
A **tangent** is a straight line which touches the circumference at only one point. It does not intersect the circumference. The point at which the tangent touches the circumference is called the *point of tangency* or *point of contact*.

A **sector** of a circle is the portion or area included between an arc and two radii drawn to the extremities of the arc.

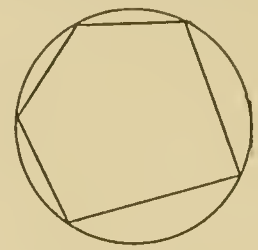
A **segment** of a circle is the area included between an arc and its chord.

Circles are **tangent** when the circumferences touch at only one point and are **concentric** when they have the same center.





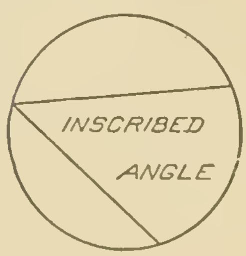
CONCENTRIC CIRCLES.

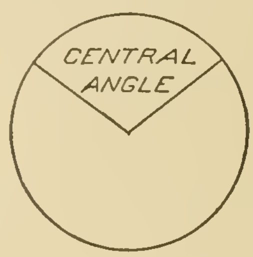


INSCRIBED POLYGON

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.

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



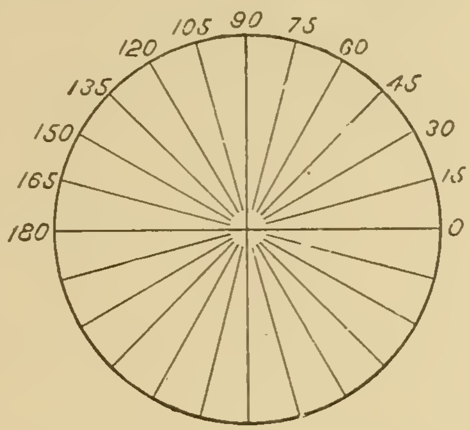


An **inscribed polygon** is one whose vertices lie in the circumference and whose sides are chords.

MEASUREMENT OF ANGLES.

To measure an angle describe an arc with the center at the vertex of the angle and having any convenient radius. 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.

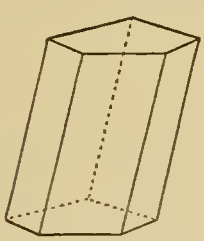
In order that the size of an angle or arc may be stated without saying that it is a certain fraction of a circumference, the circumference is divided into 360 equal parts called degrees. Thus we can say that an angle contains 45 degrees, which means that it is $\frac{45}{360} = \frac{1}{8}$ of a circumference. In order to obtain accurate measurements each degree is divided into 60 equal parts called *minutes* and each minute is divided into 60 equal parts called *seconds*. Angles and arcs are usually measured by means of an instrument called a protractor which has already been explained.

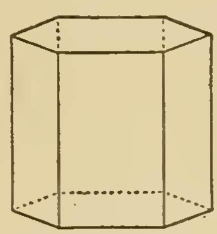


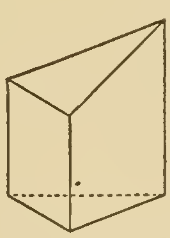
SOLIDS.

A **polyedron** is a solid bounded by planes. The bounding planes are called the *faces* and their intersections *edges*. The intersections of the edges are called *vertices*.

A polygon having four faces is called a **tetraedron**; one having six faces a **hexaedron**; of eight faces an **octaedron**; of twelve faces a **dodecaedron**, etc.


PRISM.


RIGHT PRISM.


TRUNCATED PRISM.

A **prism** is a polyedron, of which two opposite faces, called bases, are equal and parallel; the other faces, called lateral faces are parallelograms.

The area of the lateral faces is called the *lateral area.*

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

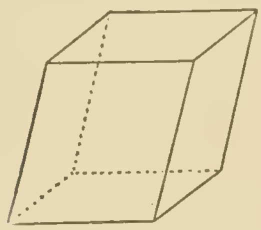
Prisms are *triangular*, *quadrangular*, etc., according to the shape of the base.

A **right** prism is one whose lateral edges are perpendicular to the bases.

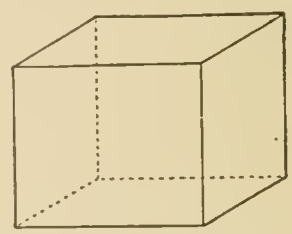
A **regular** prism is a right prism having regular polygons for bases.

A **parallelopiped** is a prism whose bases are parallelograms. If the edges are all perpendicular to the bases it is called a **right** parallelopiped.

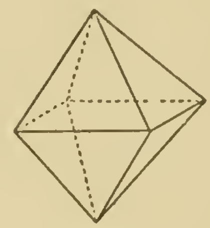
A **rectangular parallelopiped** is a right parallelopiped whose bases are rectangles ; all the faces are rectangles.



PARALLELOPIPED.



RECTANGULAR PARALLELOPIPED.



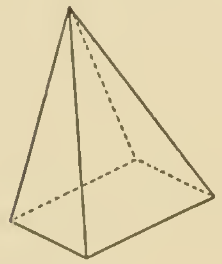
OCTAEDRON.

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

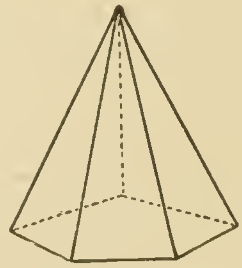
A **truncated prism** is the portion of a prism included between the base and a plane not parallel to the base.

PYRAMIDS.

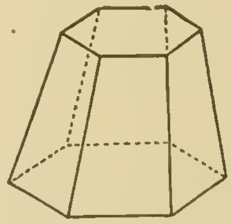
A **pyramid** is a polyedron one face of which is a polygon (called the base) and the other faces are triangles having a common vertex.



PYRAMID.



REGULAR PYRAMID.



FRUSTUM OF PYRAMID.

The vertices of the triangles form the *vertex* of the pyramid.

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

A pyramid is called **triangular, quadrangular**, etc., according to the shape of the base.

A **regular pyramid** is one whose base is a regular polygon and whose vertex lies in the perpendicular erected at the center of the base.

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.

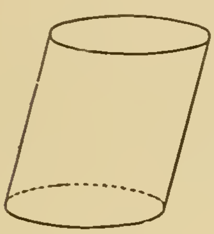
The *altitude* of a frustum of a pyramid is the perpendicular distance between the bases.

CYLINDERS.

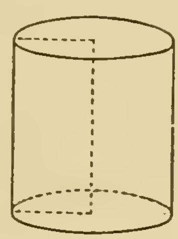
A **cylindrical surface** is a curved surface generated by the motion of a straight line which touches a curve and continues parallel to itself.

A **cylinder** is a solid bounded by a cylindrical surface and two parallel planes intersecting this surface.

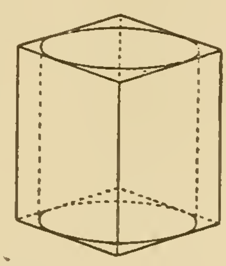
The parallel faces are called *bases*.



CYLINDER.



RIGHT CYLINDER.



INSCRIBED CYLINDER.

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

A **circular cylinder** is a cylinder whose base is a circle.

A **right cylinder** or a *cylinder of revolution* is a cylinder generated by the revolution of a rectangle about one side as an axis.

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

The cylindrical area is call the *lateral area*. The *total area* is the area of the bases added to the lateral area.

CONES.

A **conical surface** is a curved surface generated by the motion of a straight line, one point of which is fixed and the end or ends of which move in a curve.

A **cone** is a solid bounded by a conical surface and a plane which cuts the conical surface.

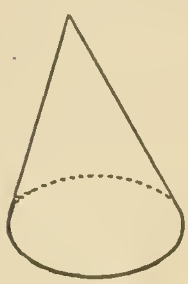
The plane is called the *base* and the curved surface the lateral area.

The *vertex* is the fixed point.

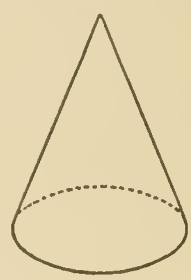
The *altitude* of a cone is the perpendicular distance from the vertex to the base.

An *element* of a cone is a straight line from the vertex to the perimeter of the base.

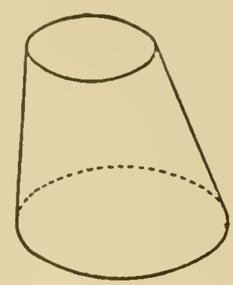
A **circular cone** is a cone whose base is a circle.



CONE.



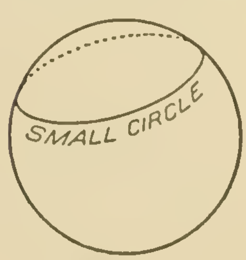
RIGHT CIRCULAR CONE.



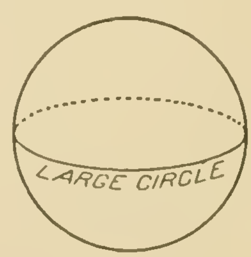
FRUSTUM OF CONE.

A **right circular cone** or **cone of revolution** is a cone whose axis is perpendicular to the base. It may be generated by the revolution of a right triangle about one of the perpendicular sides as an axis.

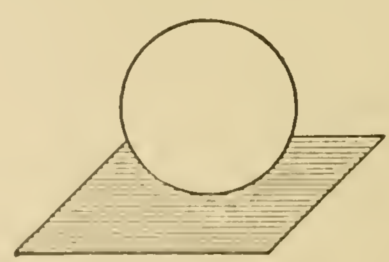
A **frustum** of a cone is the solid included between the base and a plane parallel to the base.



SPHERE.



SPHERE.



TANGENT PLANE.

The *altitude* of a frustum of a cone 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 *radius* of a sphere is a straight line drawn from the center to the surface. The *diameter* is a straight line drawn through the center and having its extremities in the surface.

A sphere may be generated by the revolution of a semi-circle about its diameter as an axis.

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

An *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.

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

A sphere is *tangent* to a plane when the plane touches the surface in only one point. A plane perpendicular to the extremity of a radius is tangent to the sphere.

CONIC SECTIONS.

If a plane intersects a cone the geometrical figures thus formed are called conic sections. A plane perpendicular to the base and 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 surface will be the circumference of a circle.

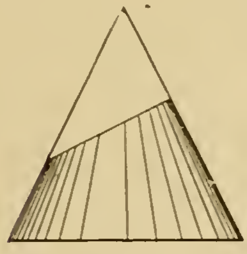


Fig. 1.

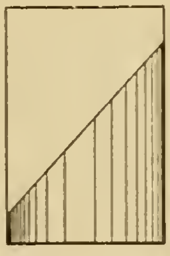


Fig. 2.

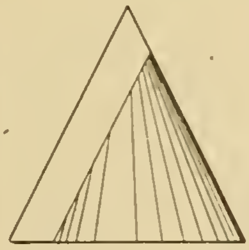


Fig. 3.

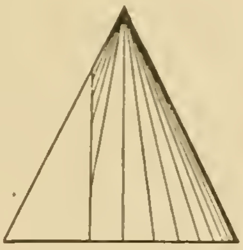


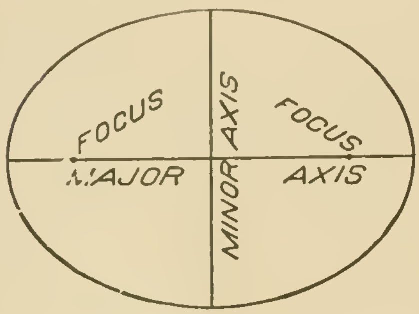
Fig. 4.

Ellipse. The ellipse is a curve formed by the intersection of a plane and a cone, the plane being oblique to the axis but not cutting the base. If a plane is passed through a cone as shown in Fig. 1 or through a cylinder as shown in Fig 2, the curve of intersection will be an ellipse. An ellipse may be defined as being *a curve generated by a point moving in a plane, the sum of the distances of the point to two fixed points being always constant.*

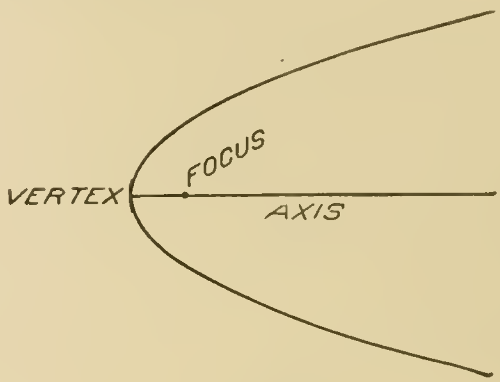
The two fixed points are called the **foci** and lie on the longest line that can be drawn in the ellipse. One of these points is called a *focus*.

The longest line that can be drawn in an ellipse is called the **major axis** and the shortest line, passing through the center, is called the **minor axis**. The minor axis is perpendicular to the middle point of the major axis and the point of intersection is 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.



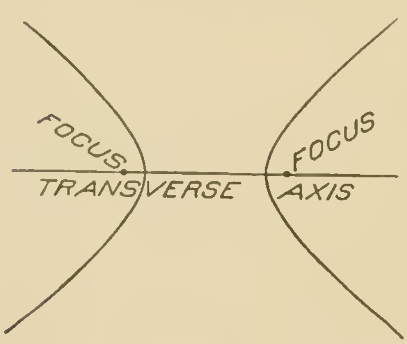
ELLIPSE.



PARABOLA.

Parabola. The parabola is a curve formed by the intersection of a cone and a plane parallel to an element as shown in Fig. 3. The curve is not a closed curve. The branches approach parallelism.

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



HYPERBOLA.

The point is called the **focus** 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**.

Hyperbola. This curve is formed by the intersection of a plane and a cone, the plane being parallel to the axis of the cone as shown in Fig. 4. Like the parabola, the curve is not a closed curve; the branches constantly diverge.

An hyperbola is defined as being *a plane curve such that the difference of 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**.

Rectangular Hyperbola. The form of hyperbola most used in Mechanical Engineering is called the rectangular hyperbola because it is drawn with reference to rectangular co-ordinates. This curve is constructed as follows: In Fig. 5, O X and O Y are the two co-ordinates drawn at right angles to each other. These lines are also called axes or asymptotes. Assume A to be a known point on the curve. In drawing this curve for the theoretical indicator card, this point A is the point of cut-off.

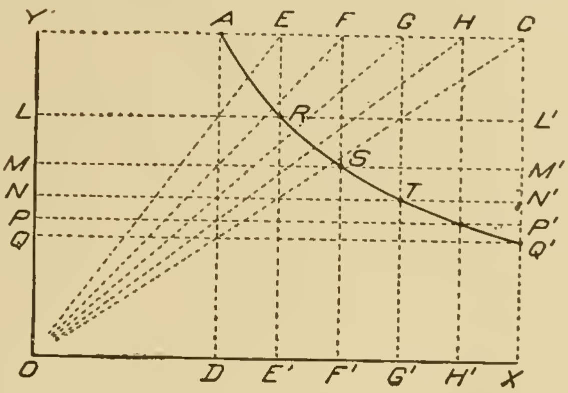


Fig. 5.

Draw A C parallel to O X and A D perpendicular to O X. Now mark off any convenient points on A C such as E, F, G, and H; and through these points draw EE′, FF′, GG′, and HH′ perpendicular to O X. Connect E, F, G, H and C with O. Through the points of intersection of the oblique lines and the vertical line A D 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 fourth is the intersection T of NN′ and GG′. The other points are found in the same way.

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

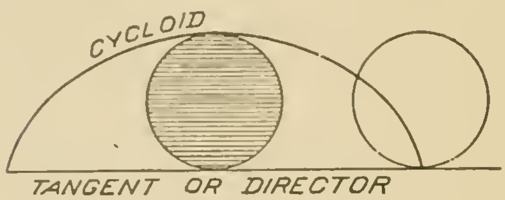
ODONTOIDAL CURVES.

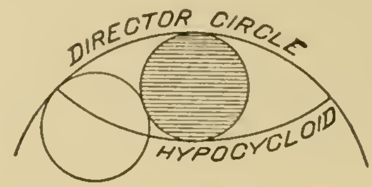
The outlines of the teeth of gears must be drawn accurately because the smoothness of running depends upon the shape of the teeth. The two classes of curves generally employed in drawing gear teeth are the cycloidal and involute.

Cycloid. The cycloid is a curve generated by a point on the circumference of a circle which rolls on a straight line tangent to the circle.

The rolling circle is called the *describing* or *generating circle* and the point, the *describing* or *generating point.* The tangent along which the circle rolls is called the *director.*

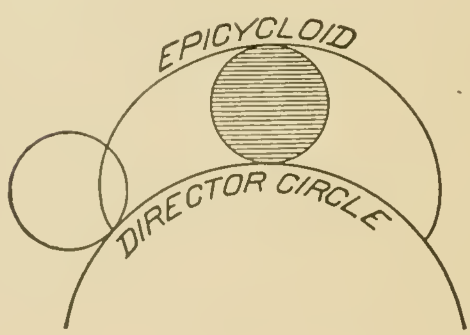
In order that the curve may be a true cycloid the circle must roll without any slipping.

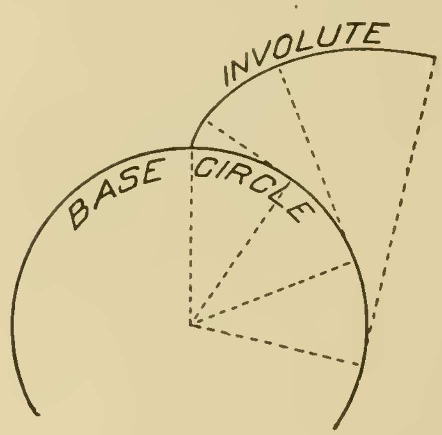




Epicycloid. If the generating circle rolls upon the *outside* of an arc or circle, called the *director circle*, the curve thus generated is called an epicycloid. The method of drawing this curve is the same as that for the cycloid.

Hypocycloid. In case the generating circle rolls upon the inside of an arc or circle, the curve thus generated is called the hypocycloid. The circle upon which the generating circle rolls is





called the *director circle.* If the generating circle has a diameter equal to the radius of the director circle the hypocycloid becomes a straight line.

Involute. If a thread or fine wire is wound around a cylinder or circle and then unwound, the end will describe a curve called an involute. The involute may be defined as being *a curve generated by a point in a tangent rolling on a circle known as the base circle.*

The construction of the ellipse, parabola, hyperbola and odontoidal curves will be taken up in detail with the plates.

PLATE IV.

Pencilling. The horizontal and vertical center lines and the border lines for *PLATE IV* should be laid out in the same manner as were those for *PLATE I.* There are to be six figures on this plate and to facilitate the laying out of the work, the following lines should be drawn: measure off $2\frac{1}{4}$ inches on both sides of the vertical center line and through these points draw vertical lines as shown in dot and dash lines on *PLATE IV.* In these six spaces the six figures are to be drawn, the student placing them in the centers of the spaces so that they will present a good appearance. In locating the figures, they should be placed a little above the center so that there will be sufficient space below to number the problem.

The figures of the problems should first be drawn lightly in pencil and after the entire plate is completed the lines should be inked. In pencilling, all intersections must be formed with great care as the accuracy of the results depends upon the pencilling. Keep the pencil points in good order at all times and draw lines *exactly* through intersections.

GEOMETRICAL PROBLEMS.

The following problems are of great importance to the mechanical draughtsman. The student should solve them with care; he should not do them blindly, but should understand them so that he can apply the principles in later work.

PROBLEM I. **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 short arcs above and below A C 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 cuts the line A C at F which is the middle point.

$$A F = F C$$

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.

PROBLEM 3. **To Draw Through a Given Point a Line Parallel to a Given Line.**

First Method. Draw the horizontal 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 with A C. (Make the angle about 60 degrees). Now construct an angle equal to P F C having the vertex at P and one side the line E P. (See problem 2). This may be done as follows: With F as a center and any convenient radius, describe the arc L M. With the same radius draw the indefinite arc N O using P as the center. With N as a center and a radius equal to the chord L M, draw an arc cutting the arc N O at O. Through the points P and O draw a straight line which will be parallel to A C.

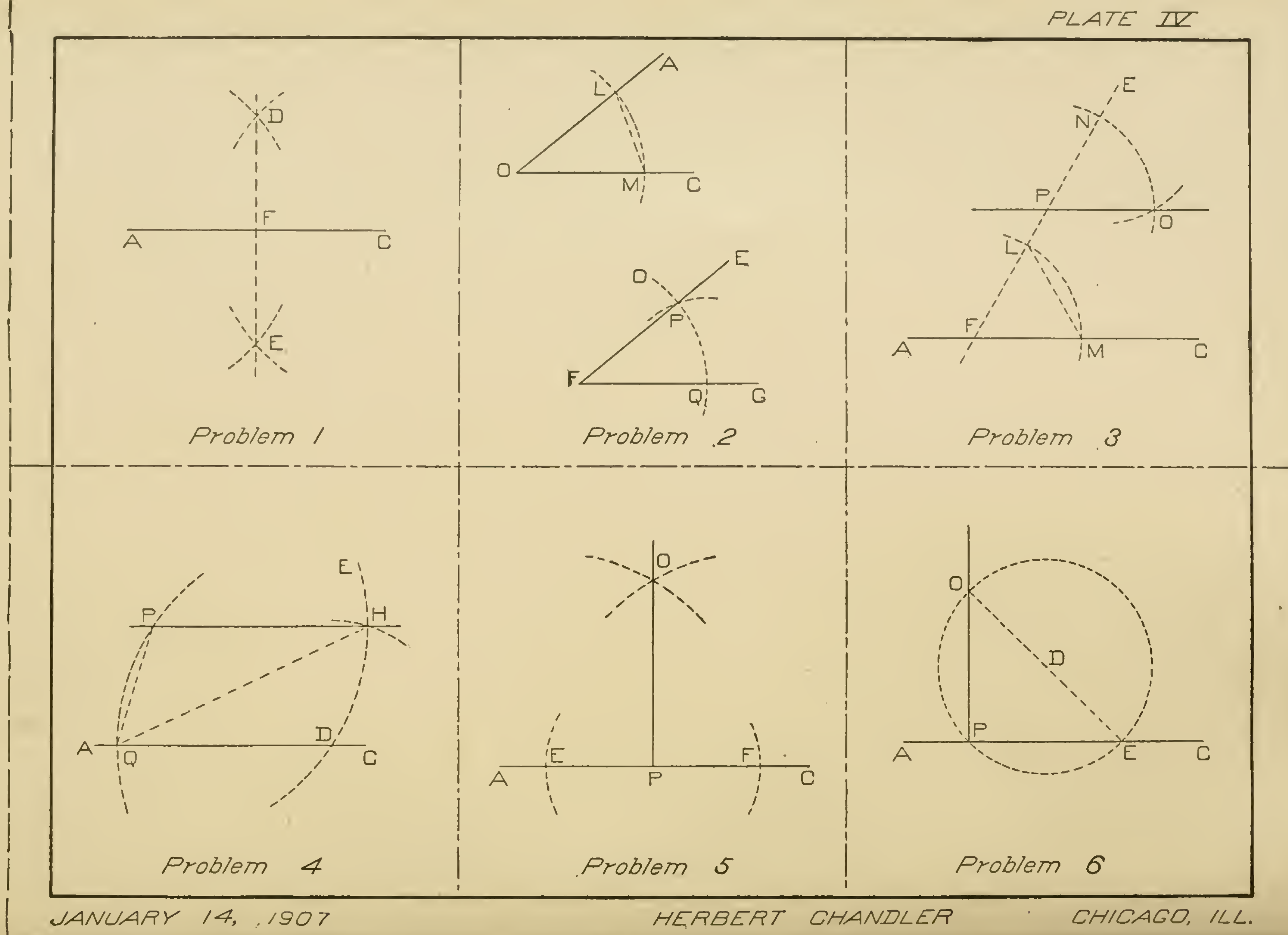


PLATE IV
Problem 1
Problem 2
Problem 3
Problem 4
Problem 5
Problem 6
JANUARY 14, 1907
HERBERT CHANDLER
CHICAGO, ILL.

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

PROBLEM 4. **To Draw Through a Given Point a Line Parallel to a Given Line.**

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.

PROBLEM 5. **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 horizontal 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 equally distant from E and F. Hence a line drawn through them is perpendicular to the middle point of E F which is P.

PROBLEM 6. **To Draw a Perpendicular to a Line from a Point in the Line.**

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 semi-circle; hence it is a right angle, and the sides O P and P E are perpendicular to each other.

After completing these figures draw pencil lines for the lettering. The words "*PLATE IV*" and the date and name should be placed in the border, as in preceding plates. To letter the words "Problem 1," "Problem 2," etc., draw horizontal lines $\frac{1}{4}$ inch above the horizontal center line and the lower border line. Draw another line $\frac{3}{16}$ inch above, to limit the height of the P, *b* and *l*. Draw a third line $\frac{1}{8}$ inch above the lower line as a guide line for the tops of the small letters.

Inking. In inking *PLATE IV* the figures should be inked first. The line A C of Problem 1 should be a full line as it is the given line; the arcs and line D E, being construction lines should be dotted. In Problem 2, the sides of the angles should be full lines. Make the chord L M and the arcs dotted, since as before, they are construction lines.

In Problem 3, the line A C is the given line and P O is the line drawn parallel to it. As E F and the arcs do not form a part of the problem but are merely construction lines, drawn as an aid in locating P O, they should be dotted. In Problems 4, 5 and 6, the assumed lines and those found by means of the construction lines should be full lines. The arcs and construction lines should be dotted. In Problem 6, the entire circumference need not be inked, only that part is necessary that is used in the problem. The inked arc should however be of sufficient length to pass through the points O, P and E.

After inking the figures, the border lines should be inked with a heavy line as before. Also, the words "*PLATE IV*" and the date and the student's name. Under each problem the words "Problem 1," "Problem 2," etc., should be inked; lower case letters being used as shown.

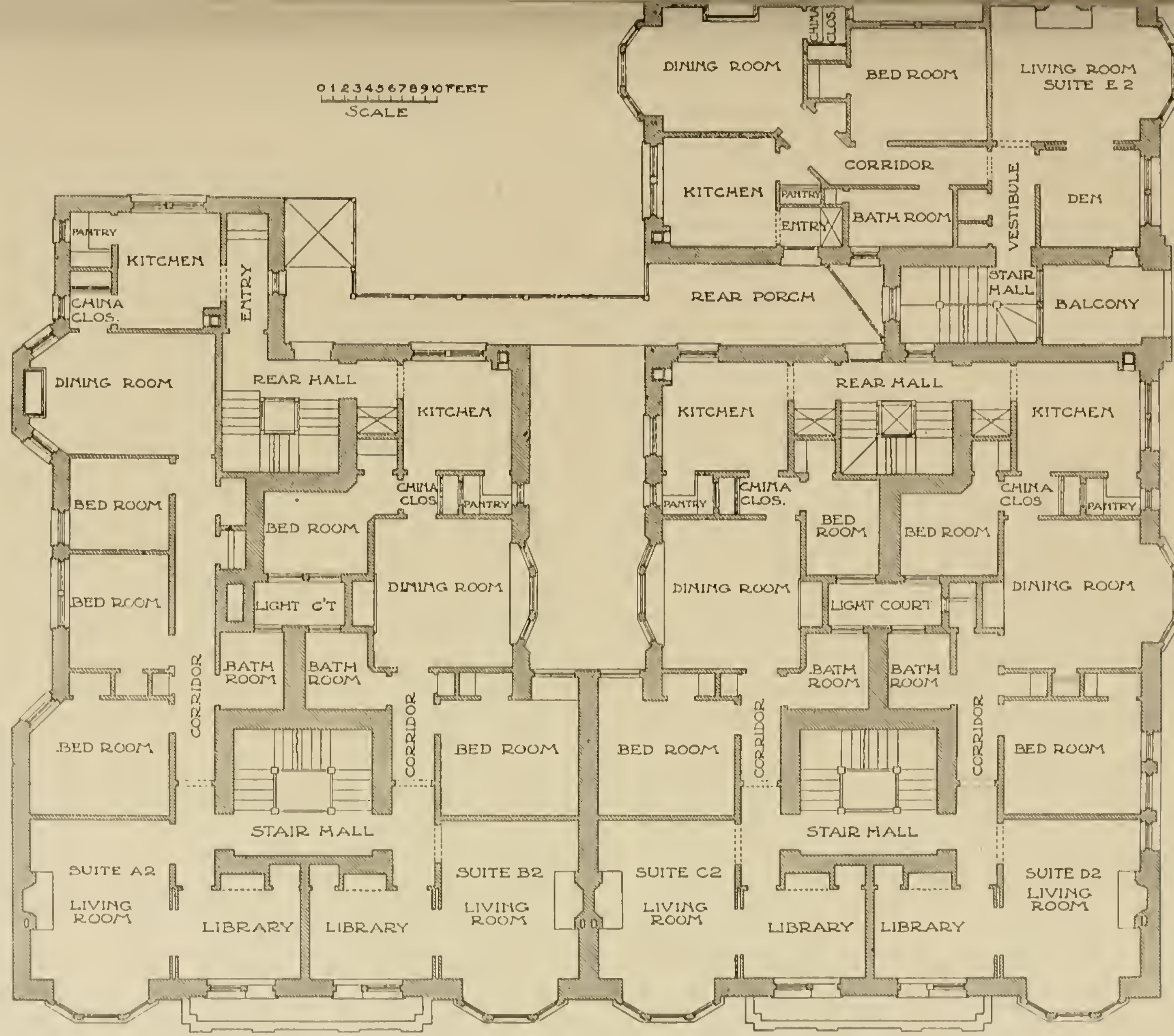
PLATE V.

Pencilling. In laying out the border lines and centre lines follow the directions given for *PLATE IV.* The dot and dash lines should be drawn in the same manner as there are to be six problems on this plate.

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 Iron. Composition Roof. All Public Halls and All Living Rooms of Oak Finish; Bedrooms, Poplar, for Enamel; Kitchen, Cypress Finish. Second-Story Plan Shown on Opposite Page.



SECOND-STORY PLAN OF MARLBORO FLAT BUILDING, MILWAUKEE, WIS.

Fernekes & Cramer, Architects, Milwaukee, Wis.

Exterior View Shown on Opposite Page.

PROBLEM 7. **To Draw a Perpendicular to a Line from a Point without the Line.**

Draw the horizontal straight line A C about $3\frac{1}{4}$ inches long. 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 equally distant from E and F, the line P T is perpendicular to A C.

PROBLEM 8. **To Bisect a Given Angle.**

First Method. When the sides intersect.

Draw the lines O C and O A forming any angle (from 45 to 60 degrees). These lines should be about 3 inches long. 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.

PROBLEM 9. **To Bisect a Given Angle.**

Second Method. When the lines do not intersect.

Draw the lines A C and E F about 4 inches long and in the positions as shown on *PLATE V.* 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 of Problem 8. Draw the arc G H and with G and H as centers draw the arcs intersecting at R. The line O R bisects the angle.

Proof. Since A′ C′ is parallel to A C and E′ F′ 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 Given Line into any Number of Equal Parts.**

Let A C, about $3\frac{3}{4}$ inches long, be the given line. Let us divide it into 7 equal parts. 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 as follows:

A C, $2\frac{3}{4}$ inches long.
E F, $1\frac{15}{16}$ inches long.
M N, $2\frac{3}{16}$ inches long.

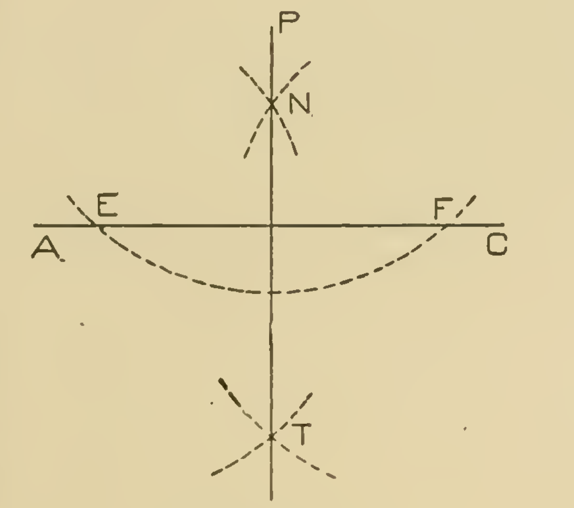
Draw R S equal in length to A C. With R as a center and a radius equal to E F describe an arc. With S as a center and a radius equal to M N draw an arc cutting the arc previously drawn, at T. Connect T with R and S to form the triangle.

PROBLEM 12. **To Construct a Triangle having given One Side and the Two Adjacent Angles.**

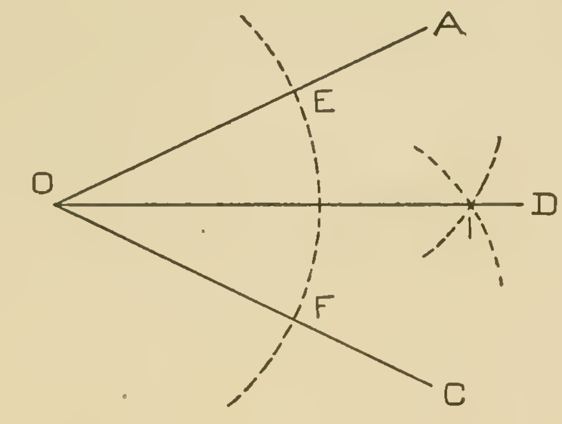
Draw the line M N $3\frac{1}{4}$ inches long and draw two angles A O D and E F G. Make the angle A O D about 30 degrees and E F G about 60 degrees.

Draw R S equal in length to M N and at R construct an

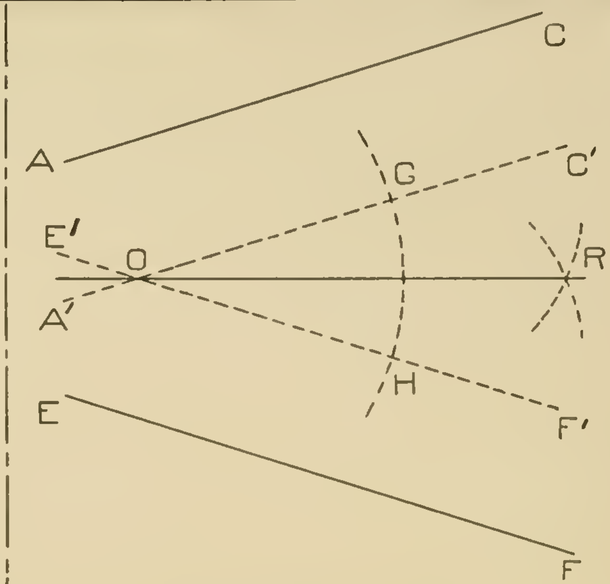
PLATE V



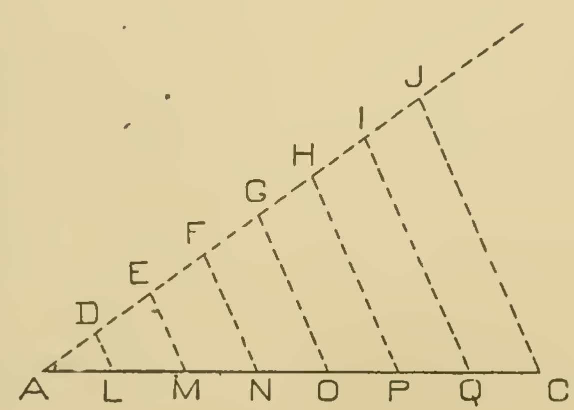
Problem 7



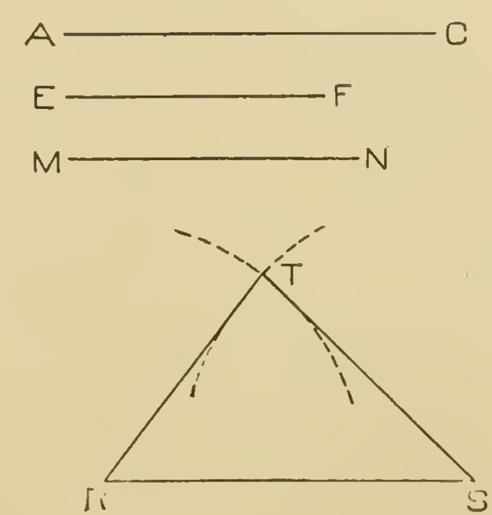
Problem 8



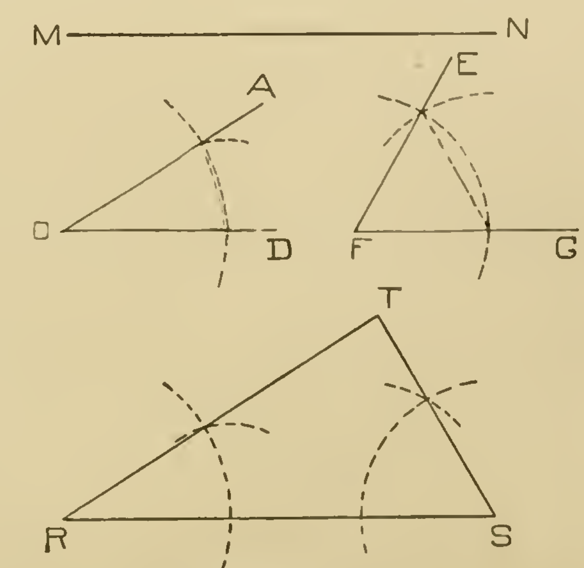
Problem 9



Problem 10



Problem 11



Problem 12

JANUARY 19, 1907 HERBERT CHANDLER CHICAGO, ILL.

angle equal to A O D. At S construct an angle equal to E F G by the method used in Problem 2. *PLATE V* shows the necessary arcs. Produce the sides of the angles thus constructed until they meet at T. The triangle R T S will be the required triangle.

After drawing these six figures in pencil, draw the pencil lines for the lettering. The lines for the words "*PLATE V*," date and name, should be pencilled as explained on page 20. The words "Problem 7," "Problem 8," etc., are lettered as for *PLATE IV*.

Inking. In inking *PLATE V*, the same principles should be followed as stated with *PLATE IV*. The student should apply these principles and not make certain lines dotted just because they are shown dotted in *PLATE V*.

After inking the figures, the border lines should be inked and the lettering inked as already explained in connection with previous plates.

PLATE VI.

Pencilling. Lay out this plate in the same manner as the two 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. Let the distance between A and B be about 2 inches and the distance between A and C be 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. This may be done as explained with Problem 1. With A and B as centers and a radius of about $1\frac{1}{2}$ inches, describe the arcs intersecting at I and J. With A and C as centers and with a radius of about $1\frac{3}{4}$ inches draw the arcs, intersecting at E and F. 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. The bisectors M I and L J may be drawn by the method used in Problem 8. Describe the arcs A C and E F, having centers at L and M respectively. The arcs intersecting at I and J are drawn as already explained. The bisectors of the angles 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. These lines should be perpendicular to each other and pass through O. Bisect one of the radii, such as O C, and with this point H 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 a center at L, draw the arc, cutting the circumference at M. To find the point N, use either M or Q as a center and the distance E P as a radius.

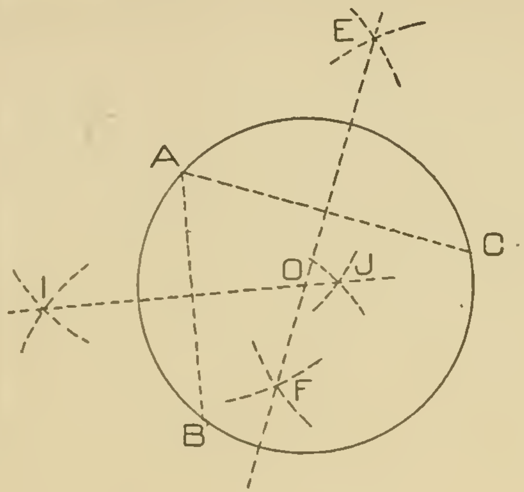
The pentagon is completed by drawing the chords E L, L M, M N, N Q and Q E.

PROBLEM 16. **To inscribe a Regular Hexagon in a given Circle.**

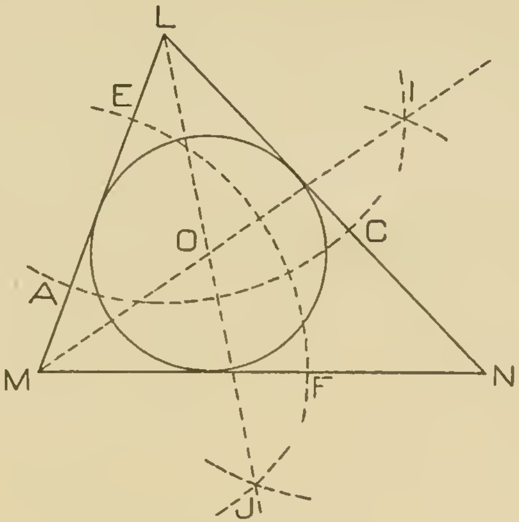
With O as a center and a radius of $1\frac{3}{8}$ inches draw the given circle. With the T square draw the diameter A D. With D as a center, and a radius equal to O D, describe arcs cutting the circumference at C and E. Now with C and E as centers and the same radius, draw the arcs, cutting the circumference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

To inscribe a regular hexagon in a circle mark off chords equal in length to the radius.

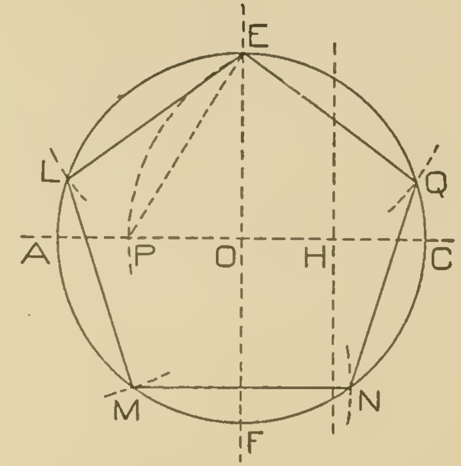
PLATE VI



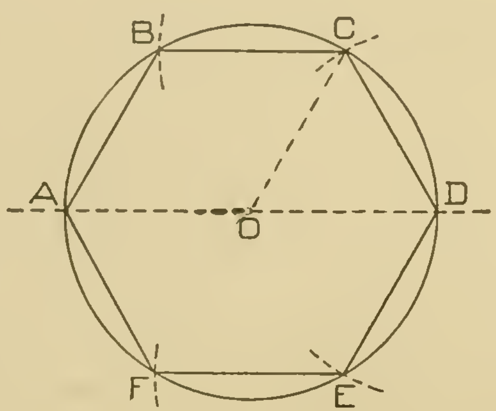
Problem 13



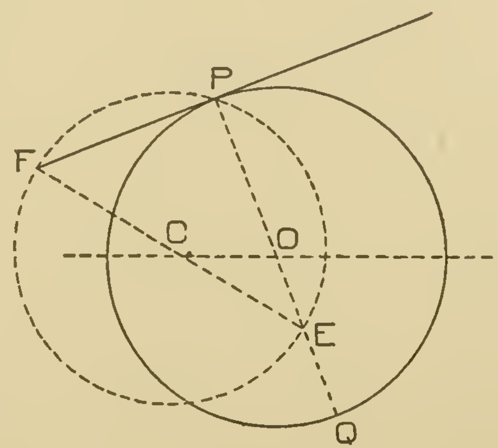
Problem 14



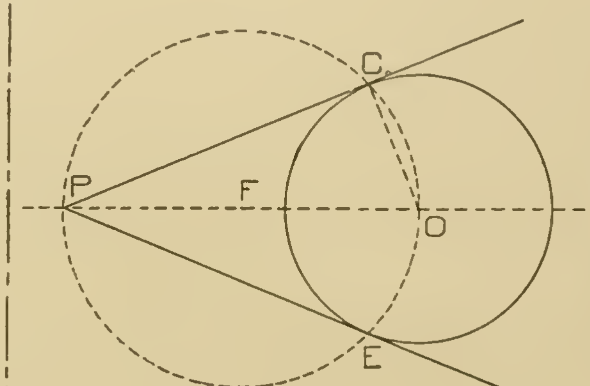
Problem 15



Problem 16



Problem 17



Problem 18

JANUARY 29. 1907 HERBERT CHANDLER CHICAGO. ILL.

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

Proof. The triangle O C D is an equilateral triangle by construction. Then 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 Join the point P with the center O and through P draw a line F P perpendicular to P O. This may be done in any one of several methods. Since P is the extremity of O P the method given in Problem 6 of *PLATE IV*, may be used.

Produce P O to Q. With any center C, and a radius C P draw an arc or circumference passing through P. Draw E F a diameter of the circle whose center is C and through F and P draw the tangent.

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 of the circle. 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 through P and 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.

Proof. The angle P C O is inscribed in a semi-circle and hence is a right angle. Since P C O is a right angle P C is perpendicular to C O. The perpendicular to a radius at its extremity is tangent to the circumference.

Inking. In inking *PLATE VI* the same method should be followed as in previous plates. The name and address should be lettered in inclined Gothic capitals as before.

PLATE VII.

Pencilling. *PLATE VII* should be laid out in the same manner as previous plates. Six problems on the ellipse, spiral, parabola and hyperbola are to be constructed in the six spaces.

PROBLEM 19. **To draw an Ellipse when the Axes are given.**

Draw the lines L M and C D about $3\frac{1}{4}$ and $2\frac{1}{4}$ inches long respectively. Let C D be perpendicular to M N at its middle point P. Make C P = P D. These two lines are the axes. With C as a center and a radius equal to one-half the major axis or equal to L P, draw the arc, cutting the major axis at E and F. These two points are the foci. Now mark off any convenient distances on P M, such as A, B and G.

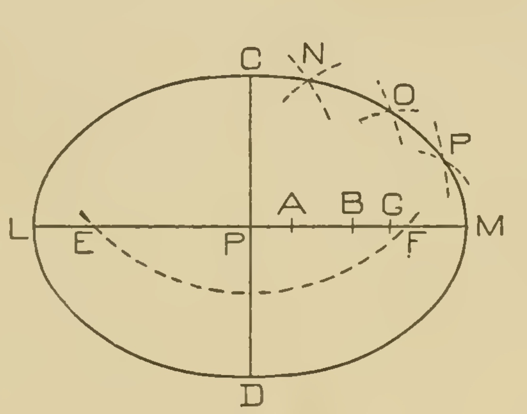
With E as a center and a radius equal to L A, draw arcs above and below L M. With F as a center, and a radius equal to A M describe short arcs cutting those already drawn as shown at N. With E as a center and a radius equal to L B draw arcs above and below L M as before. With F as a center and a radius equal to B M, draw arcs intersecting those already drawn as shown at O. The point P and others are found by repeating the process. The student is advised to find at least 12 points on the curve — 6 above and 6 below L M. These 12 points with L, C, M and D will enable the student to draw the curve.

After locating these points, a free hand curve passing through them should be sketched.

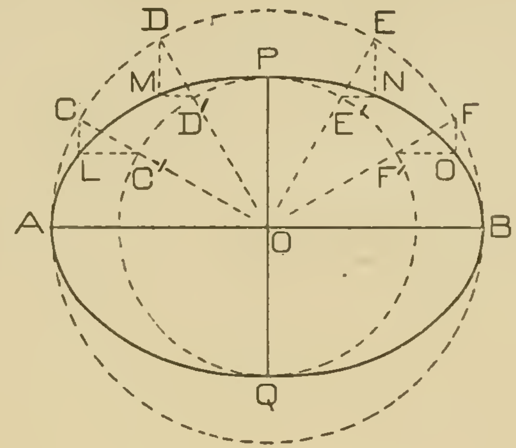
PROBLEM 20. **To draw an Ellipse when the two Axes are given.**

Second Method. Draw the two axes A B and P Q in the same manner as for Problem 19. With O as a center and a radius equal to one-half the major axis, describe the circumference A C D E F B. Similarly with the same center and a radius equal to one-half the minor axis, describe a circle. Draw any radii such as O C, O D, O E, O F, etc., cutting both circumferences. These radii may be drawn with the 60 and 45 degree triangles. At the

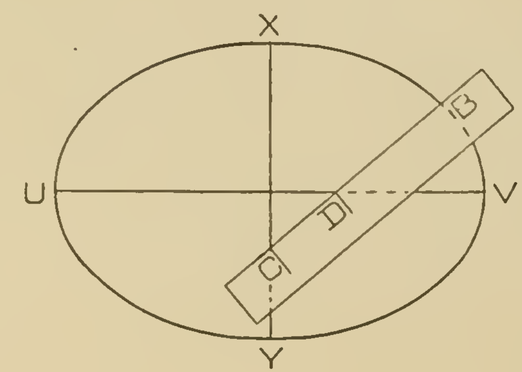
PLATE VII



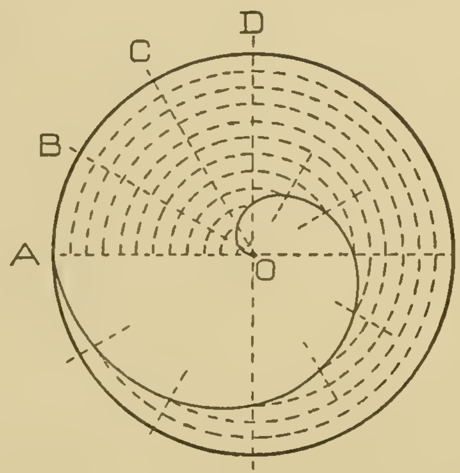
Problem 19



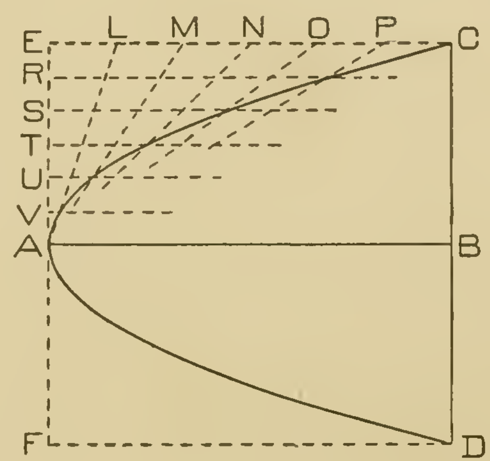
Problem 20



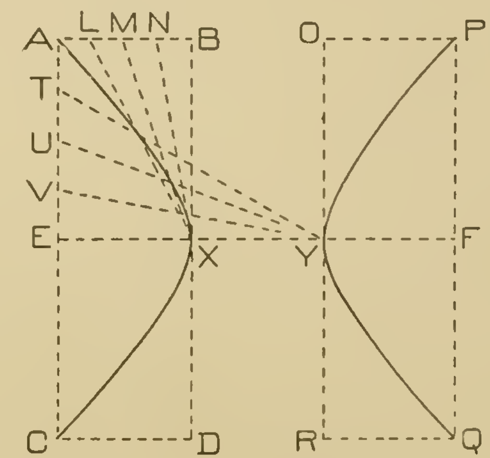
Problem 21



Problem 22



Problem 23



Problem 24

FEBRUARY 4, 1907 HERBERT CHANDLER CHICAGO, ILL.

points of intersection of the radii with the large circle C D E and F, draw *vertical* lines and from the intersection of the radii with the small circle C′, D′, E′, and F′, draw *horizontal* lines intersecting the vertical lines. The intersections of these lines are points on the curve.

As in Problem 19, a free hand curve should be sketched 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 the two preceding problems, 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 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 curve.

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. Mark off on the radius O A, distances of one-eighth inch. As O A is $1\frac{1}{2}$ inches long there will be 12 of these distances. Draw circles through these points. Now draw radii O B, O C, O D, etc. each 30 degrees apart (use the 30 degree triangle). This will divide the circle into 12 equal parts. The curve starts at the center O. The next point is the intersection of the line O B and the first circle. The third point is the intersection of O C and the second circle. The fourth point is the intersection of O D and the third circle. Other points are found in the same way. Sketch in pencil the 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. This line is the axis or as it is sometimes called the abscissa. At A and B draw lines perpendicular to A B. Also with the T square draw E C and F D, $1\frac{1}{2}$ inches above and below A B. Let A be the vertex of the parabola. Divide A E into any number of equal parts and divide E C into the same number of equal parts. Through the points of division, 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 the same manner.

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

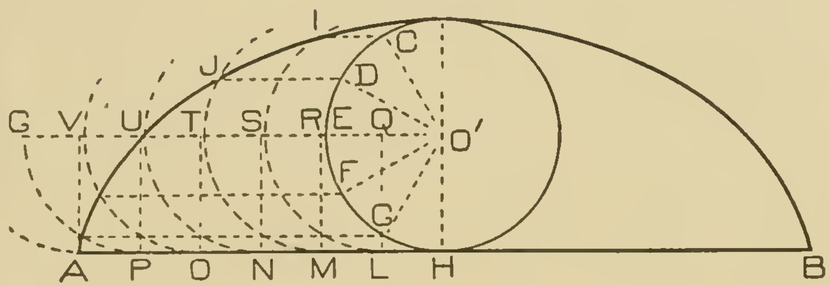
Draw E F about 3 inches long and mark the point X, 1 inch from E and the point Y, 1 inch from X With the triangle and T square, draw the rectangles A B D C and O P Q R such that A B is 1 inch in length and A C, 3 inches in length. Divide A E into any number of equal parts and A B into the same number of equal parts. Draw L X, M X and N X; also connect T, U and V with Y. The first point on the curve is the intersection A; the next is the intersection of T Y and L X; the third the intersection of U Y and M X. The remaining points are found in the same manner. The curve X C and the right-hand curve P Y Q are found by repeating the process.

Inking. In inking the figures on this plate, use the French or irregular curve and make full lines for the curves and their axes. The construction lines should be dotted. Ink in all the construction lines used in finding one-half of a curve, and in Problems 19, 20, 23 and 24 leave all construction lines in *pencil* except those inked. In Problems 21 and 22 erase all construction lines not inked. The trammel used in Problem 21 may be drawn in the position as shown, or it may be drawn outside of the ellipse in any convenient place.

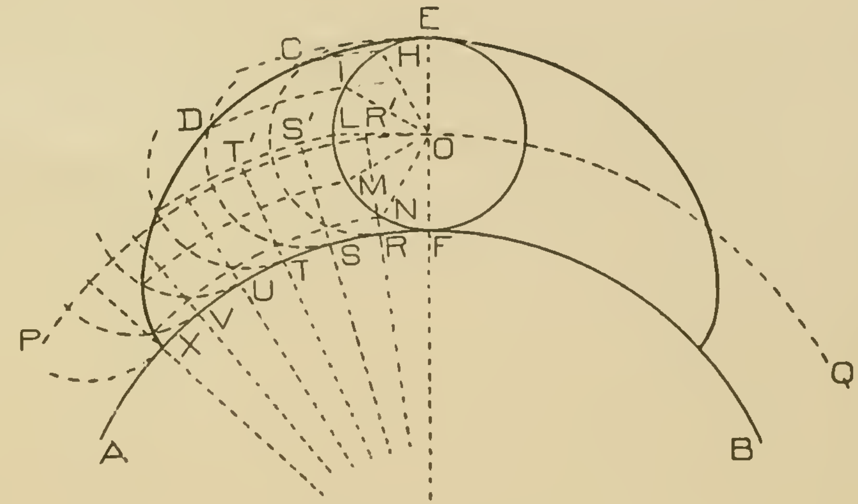
The same lettering should be done on this plate as on previous plates.

PLATE VIII.

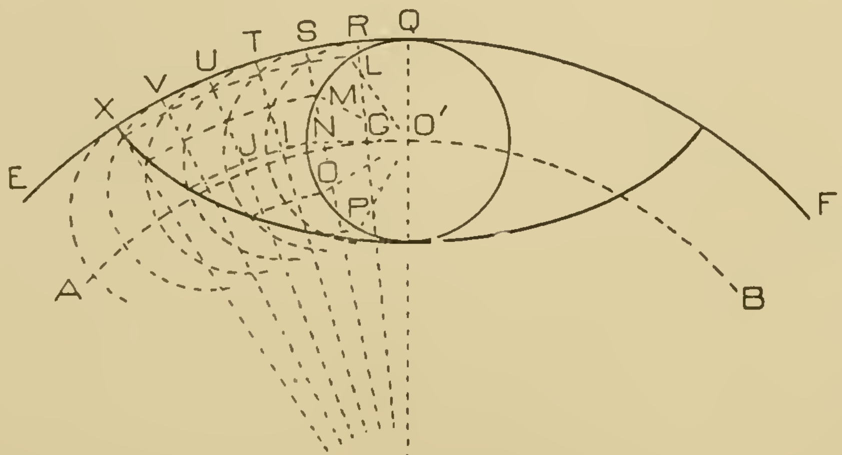
Pencilling. In laying out Plate VIII, draw the border lines and horizontal and vertical center lines as in previous plates, to divide the plate into four spaces for the four problems.



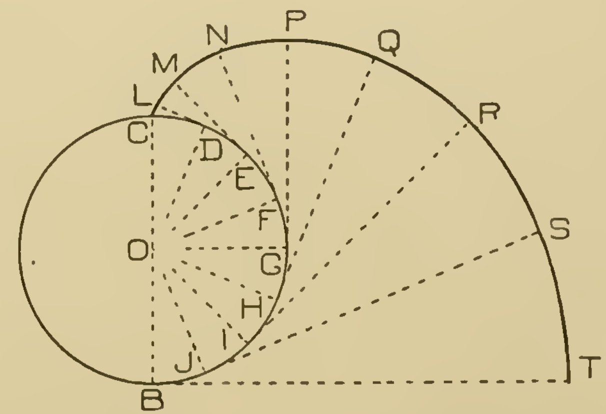
Problem 25



Problem 26



Problem 27



Problem 28

FEBRUARY 12, 1907 HERBERT CHANDLER CHICAGO, ILL.

APARTMENT HOUSE IN ASHMONT, MASS.
Edwin J. Lewis, Architect, Boston, Mass.
For Plans, See Opposite Page.
(Reproduced by Courtesy of "The Brickbuilder.")

FIRST FLOOR PLAN.

SECOND FLOOR PLAN.

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.")

PROBLEM 25. **To construct a Cycloid when the diameter of the generating circle is given.**

With O′ as a center and a radius of $\frac{7}{8}$ inch draw a circle, and tangent to it draw the indefinite horizontal straight line A B. Divide the circle into any number of equal parts (12 for instance) and through these points of division C, D, E, F, etc., draw horizontal lines. Now with the dividers set so that the distance between the points is equal to the chord of the arc C D, mark off the points L, M, N, O, P on the line A B, commencing at the point H. At these points erect perpendiculars to the center line G O′. This center line is drawn through the point O′ with the T square and is the line of centers of the generating circle as it rolls along the line A B. Now with the intersections Q, R, S, T, etc., of these verticals with the center line as centers describe arcs of circles as shown. The points on the curve are the intersections of 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 another point J on the curve. The remaining points, as well as those on the right-hand side, 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 of 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 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 $2\frac{3}{4}$ inches long. With G as a center and a radius of $2\frac{3}{4}$ inches 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 curve. 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 O 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 curve. 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.**

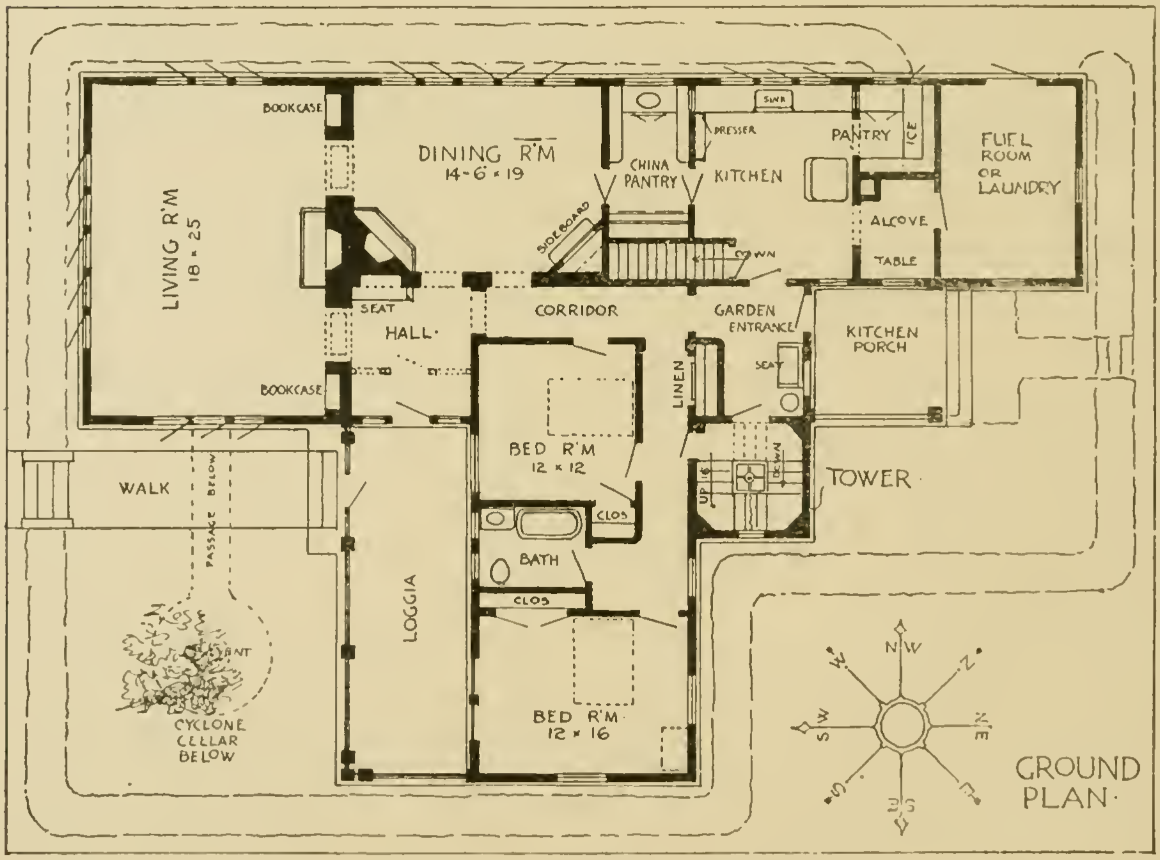
With point O as a center and a radius of 1 inch, describe the base circle. Now divide the circle into any number of equal parts 16 for instance) and connect the points of division with the center of the circle by drawing the radii O C, O D, O E, O F, etc., to O B. At the point D, draw a light pencil line perpendicular to the radius O D. This line will be tangent to the circle. Similarly at the points E, F, G, H, etc., draw tangents to the circle. Now 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. Beginning with the point E, measure on the tangent a distance equal to two of these chords, from the point F measure on the tangent three divisions, and from the point G measure a distance equal to four divisions on the tangent G P. Similarly, measure distances on the remaining tangents, each time adding the length of the chord. This will give the points Q, R, S and T. Now sketch a light pencil line through the points L, M, N, P, etc., to T. This curve will be the involute of the circle.

Inking. The same rules are to be observed in inking *PLATE VIII* as were followed in the previous plates, that is, the curves should be inked in a full line, using the French or irregular curve. All arcs and lines used in locating the points on one-half of the curve should be inked in dotted lines. The arcs and lines used in locating the points of the other half of the curve may be left in pencil in Problems 25 and 26. 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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MECHANICAL DRAWING.

PART III.

PROJECTIONS.

ORTHOGRAPHIC PROJECTION.

Orthographic Projection is the art of representing objects of three dimensions by views on two planes at right angles to each other, in such a way that the forms and positions may be completely determined. The two planes are called planes of projection or co-ordinate planes, one being vertical and the other horizontal, as shown in Fig. 1. These planes are sometimes designated V and H respectively. The intersection of V and H is known as the ground line G L.

The view or projection of the figure on the plane gives the same appearance to the eye placed in a certain position that the object itself does. This position of the eye is at an infinite distance from the plane so that the rays from it to points of a limited object are all perpendicular to the plane. Evidently then the view of a point of the object is on the plane and in the ray through the point and the eye or where this perpendicular to the plane pierces it.

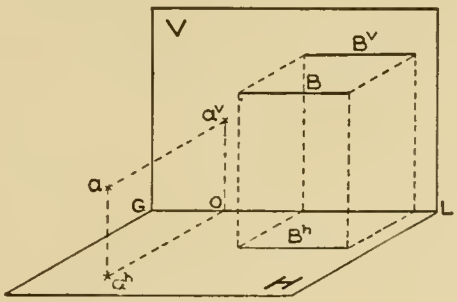


Fig. 1.

Let a, Fig. 1, be a point in space, draw a perpendicular from a to V. Where this line strikes the vertical plane, the projection of a is found, namely at a^v. Then drop a perpendicular from a to the horizontal plane striking it at a^h, which is the horizontal projection of the point. Drop a perpendicular from a^v to H; this will intersect G L at o and be parallel and equal to the line $a\,a^h$. In the same way draw a perpendicular from a^h to V, this also will intersect G L at o and will be parallel and equal to $a\,a^v$. In other words, the perpendicular to G L from the projection of a point on either plane equals the distance of the point from the other plane. B in Fig. 1, shows a line in space. B^v is its V projection, and B^h

its H projection, these being determined by finding views of points at its ends and connecting the points.

Instead of horizontal projection and vertical projection, the terms **plan** and **elevation** are commonly used.

Suppose a cube, one inch on a side, to be placed as in Fig. 2, with the top face horizontal and the front face parallel to the vertical plane. Then the plan will be a one-inch square, and the elevation also a one-inch square. In general the plan is a representation of the top of the object, and the elevation a view of the front. The plan then is a top view, and the elevation a front view.

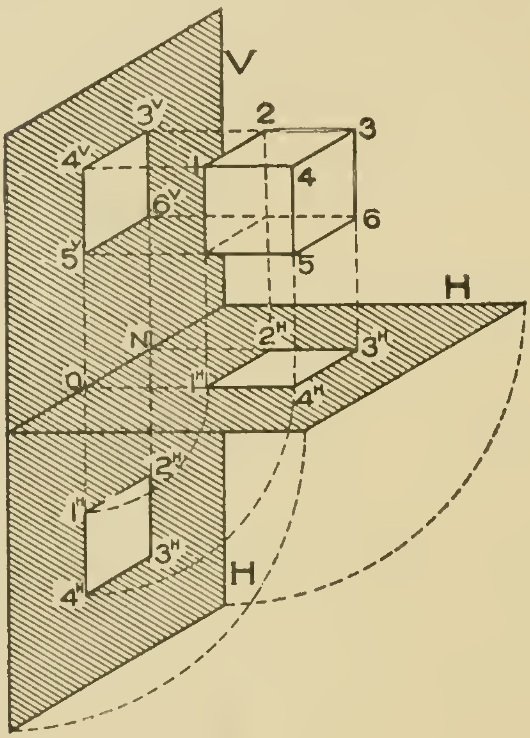


Fig. 2.

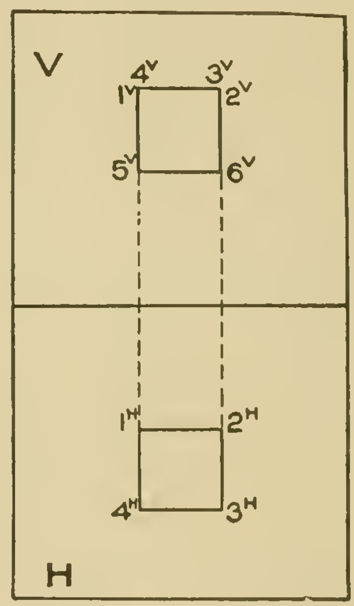


Fig. 3.

Thus far the two planes have been represented at right angles to each other, as they are in space. In order that they may be shown more simply and on the one plane of the paper, H is revolved about G L as an axis until it lies in the same plane as V as shown in Fig. 2. The lines 1^h O and 2^h N, being perpendicular to G L, are in the same straight line as 5^v O and 6^v N, which also are perpendicular to G L. That is—*two views of a point are always in a line perpendicular to G L.* 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, we get a true orthographic projection of the cube as shown in Fig. 3.

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. 3, 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 $\frac{3^v}{2^v}$. 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 or 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 the same figure 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*

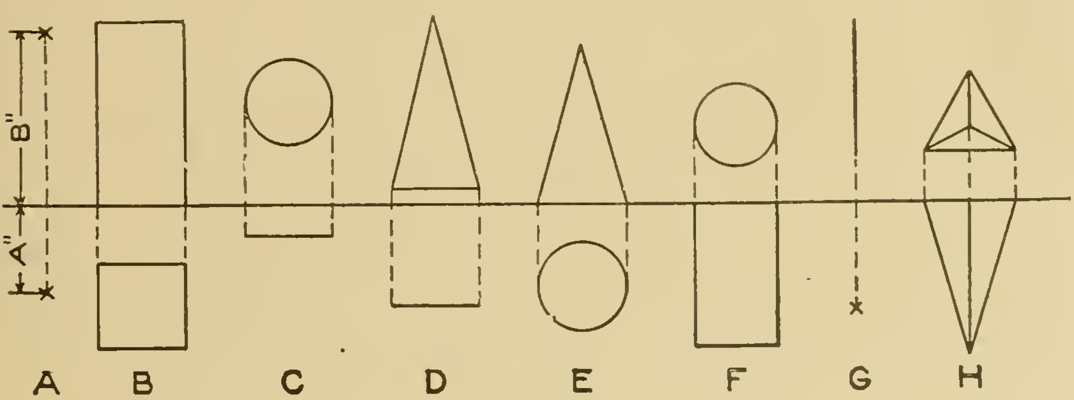


Fig. 4.

straight line is perpendicular 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.

Fig. 4 is given as an exercise to help 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 disc 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. 5, 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

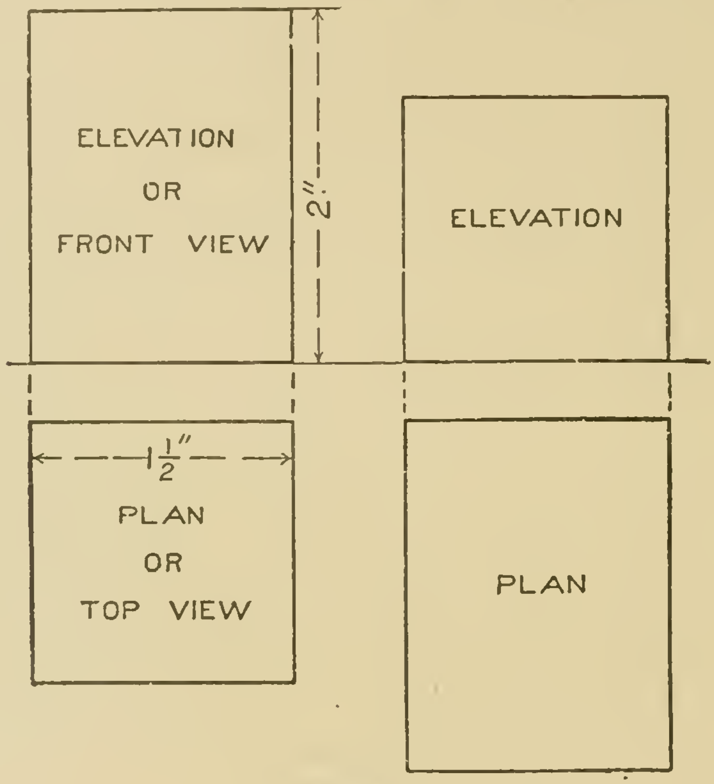


Fig. 5.

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.

The second drawing in Fig. 5 represents a prism of the same size lying on one side on the horizontal plane, and with the ends parallel to V.

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 line, and distance in front of the vertical plane is shown in plan as distance from the ground line.

3. If a line is parallel to either plane, its actual length is shown on that plane, and its other projection is parallel to the ground line. A line oblique to either plane has its projection on that plane shorter than the line itself, and its other projection oblique to the ground line. No projection can be longer than the line itself.

4. A plane surface if parallel to either plane, is shown on

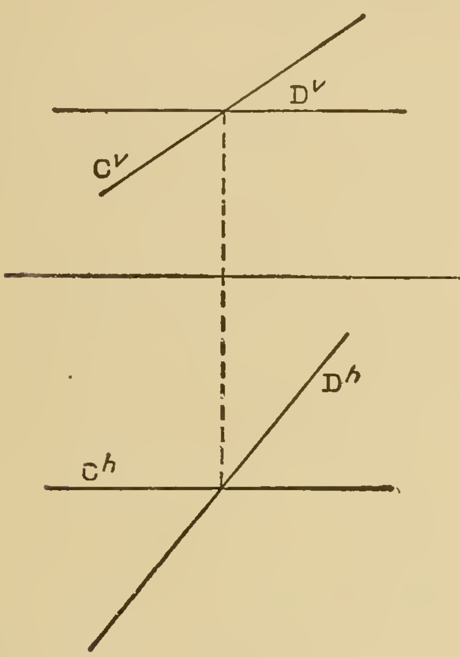


Fig. 6.

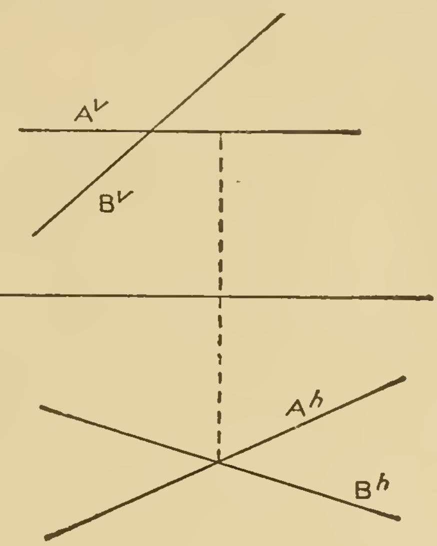


Fig. 7.

that plane in its true size and shape; if oblique it is shown smaller than the true size, and if perpendicular it is shown as a straight line. Lines parallel in space must have their V projections parallel to each other and also their H projections.

If two lines intersect, their projections must cross, since the point of intersection of the lines is a point on both lines, and therefore the projections of this point must be on the projections of both lines, or at their intersection. In order that intersecting lines may be represented, the vertical projections must intersect in a point vertically above the intersection of the horizontal projections. Thus Fig. 6 represents two lines which do intersect as C^v crosses D^v at a point vertically above the intersection of C^h and D^h. In Fig. 7, however, the lines do not intersect since the intersections of their projections do not lie in the same vertical line.

In Fig. 8 is given the plan and elevation of a square pyramid standing on the horizontal plane. The height of the pyramid is the distance A B. The slanting edges of the pyramid, A C, A D, etc., must be all of the same length, since A is directly above the 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.

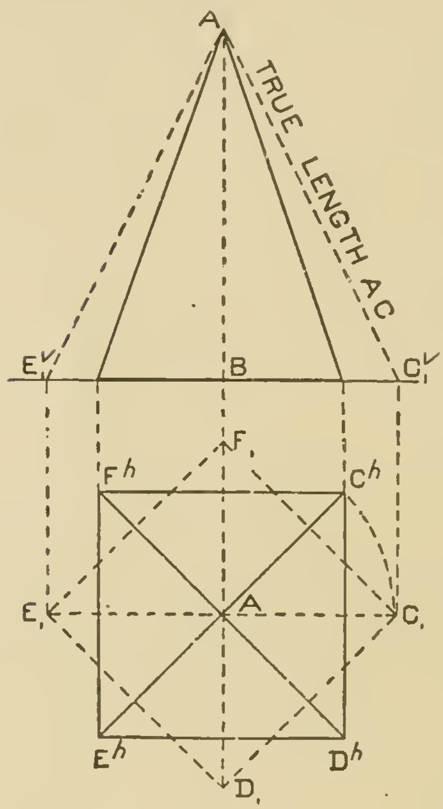
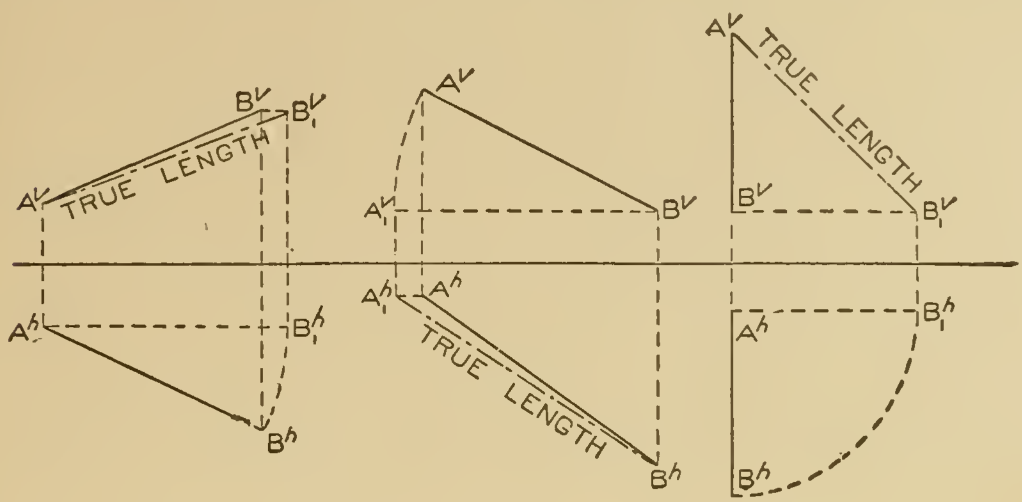


Fig. 8.

Suppose that the pyramid be turned around into the dotted position C_1 D_1 E_1 F_1 where the horizontal projections of two of the slanting edges, A C_1 and A E_1 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 A C. Now if we wish to find simply the true length of A C, it is unnecessary to turn the whole pyramid around, as the one line A C will be sufficient.

The principle of finding the true length of lines is this, and can be applied to any case: 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. See the three Figures at the top of page 9.

Third plane of projection or profile plane. A plane perpendicular to both co-ordinate 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.

A projection on this plane is found in the same way as on the

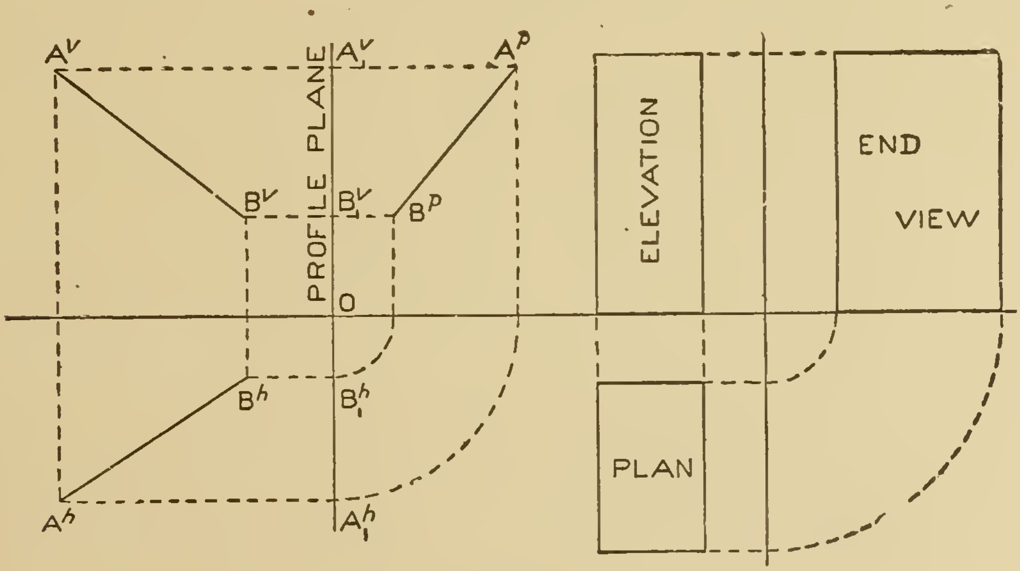


Fig. 9.

V plane, that is, 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 in Fig. 9, the line A B 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 in the same figure, we see 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 by taking one point at a time.

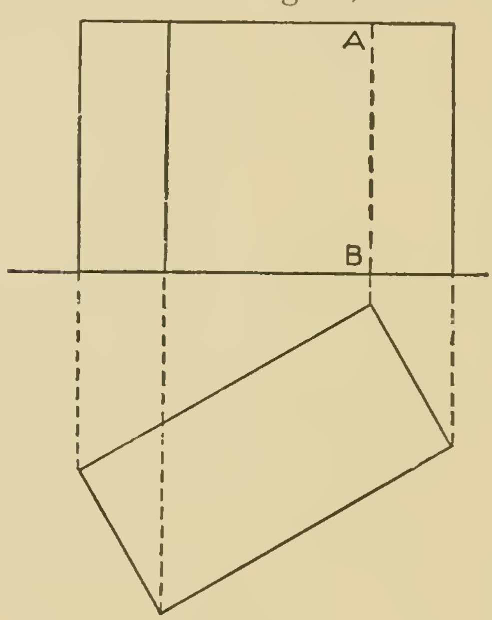


Fig. 10.

In Fig. 10 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, the fourth one being invisible.

In mechanical drawing lines or edges which are invisible are drawn *dotted*. The edges which in projection form a part of the outline or contour of the figure must always be visible, hence always *full lines*. The plan shows what lines are visible in elevation, and the elevation determines what are visible in plan. In Fig. 10, the plan shows that the dotted edge A B is the back edge, and in Fig. 11, the dotted edge C D is found, by looking at the elevation, to be the lower edge of the triangular prism. In general, if in elevation an edge projected *within* the figure is a back edge, it must be dotted, and in plan if an edge projected within the outline is a lower edge it is dotted.

Fig. 12 is a circular cylinder with the length vertical and

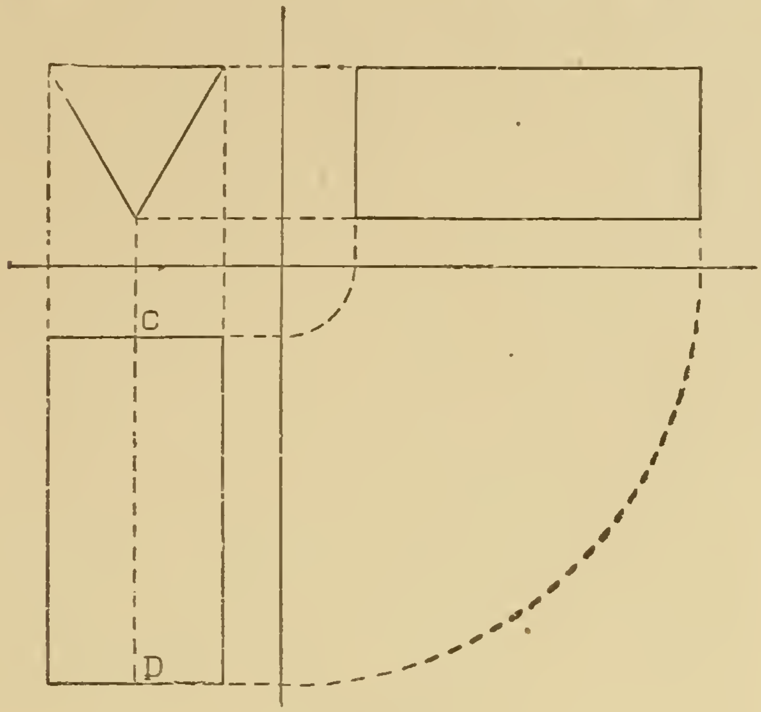


Fig. 11.

with a hole part way through as shown in elevation. Fig. 13 is plan, elevation and end view of a triangular prism with a square hole from end to end. The plan and elevation alone would be insufficient to determine positively the shape of the hole, but the end view shows at a glance that it is square.

In Fig. 14 is shown 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. 15, 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 elevation as before in Fig. 14. 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, because the height does not change.

The same principle is further illustrated in Figs. 16 and 17. The elevation of Fig. 16 shows a square prism resting on one edge, and raised up at an angle of 30° on the right-hand side. The plan gives the width or thickness, $\frac{5}{8}$ in. Notice that the length of the plan is greater than 2 in. and that varying the angle at

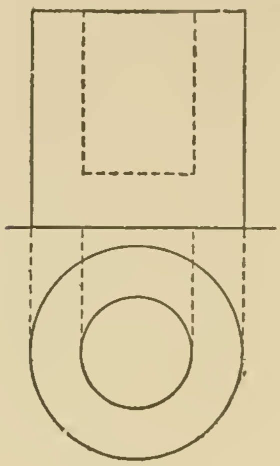


Fig. 12.

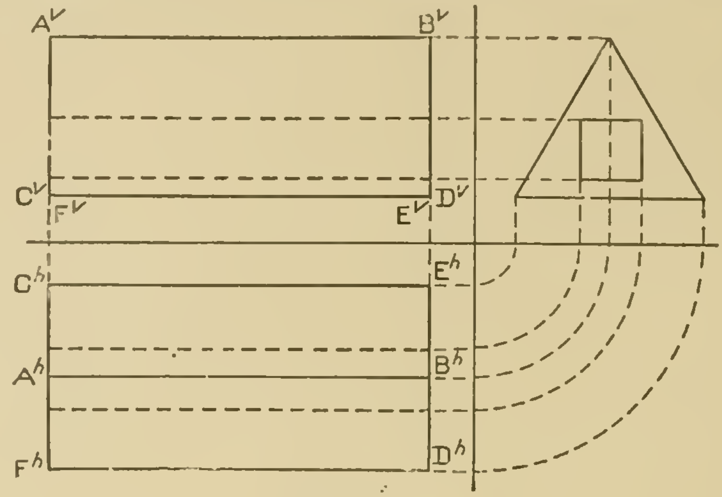


Fig. 13.

which the prism is slanted would change the length of the plan. Now if the prism be turned around through any angle with the vertical plane, the lower edge still being on H, and the inclination

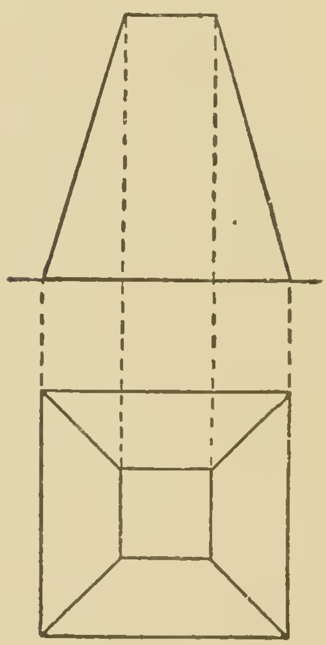


Fig. 14.

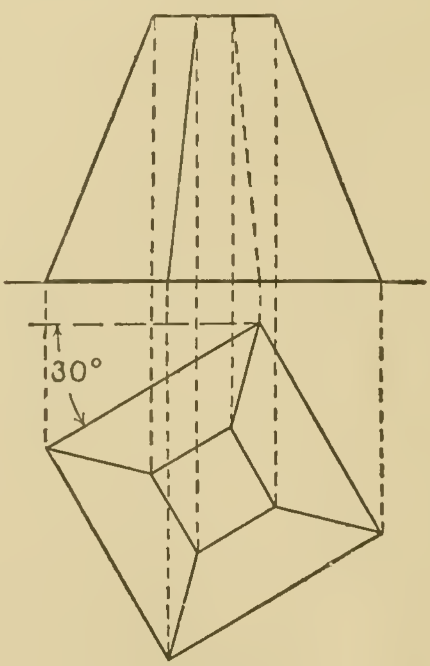


Fig. 15.

of 30° with H remaining the same, the plan must remain the same size and shape.

If the angle through which the prism be turned is 45°, we have the second plan, exactly the same shape and size as the first. The elevation is found by projecting the corners of the prism ver-

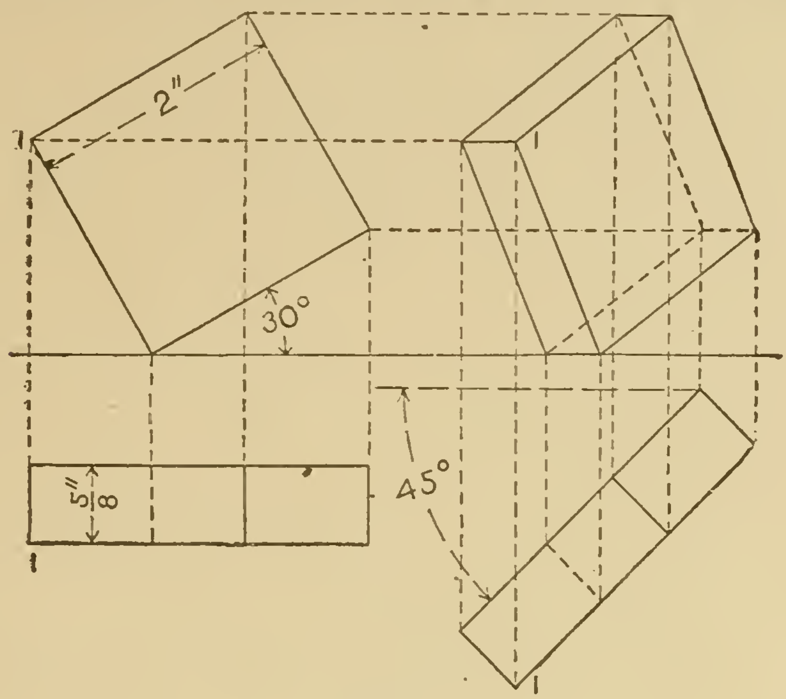


Fig. 16.

tically up to the heights of the same points in the first elevation. All the other points are found in the same way as point No. 1.

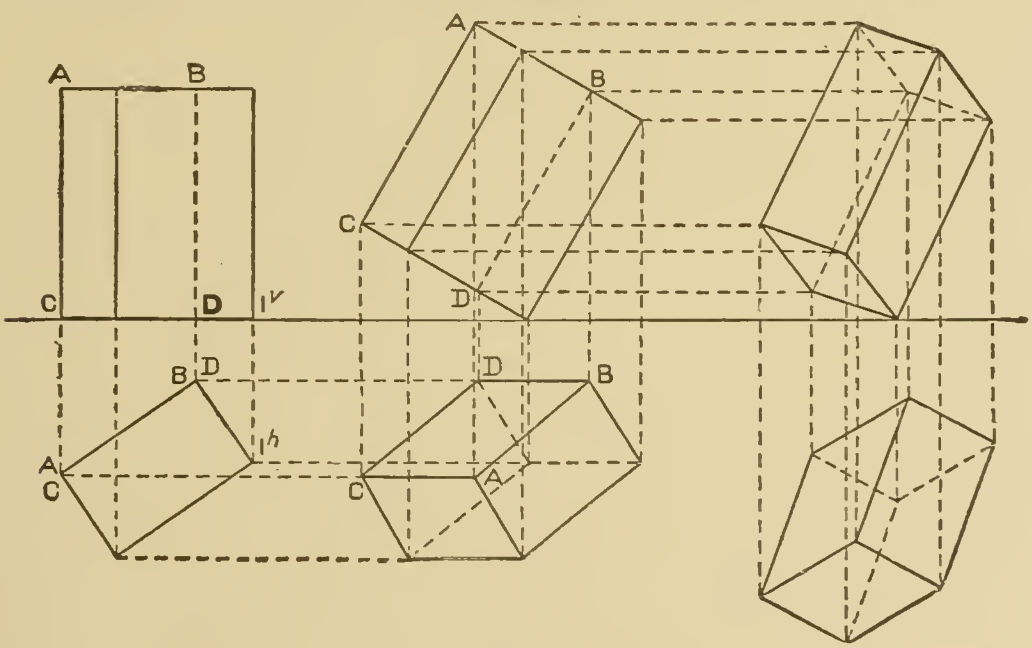


Fig. 17.

Three positions of a rectangular prism are shown in Fig. 17. In the first view, the prism stands on its base, 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. The prism has been turned as if 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 C D 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 preceeding elevation. This principle may be applied to any solid, whether bounded by plane surfaces or curved.

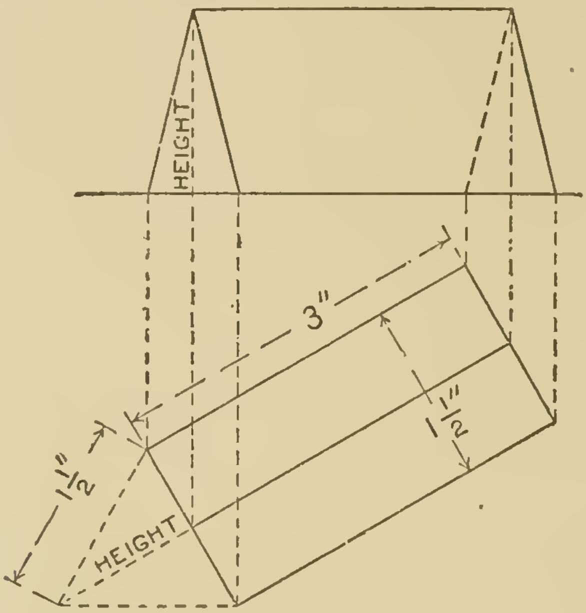
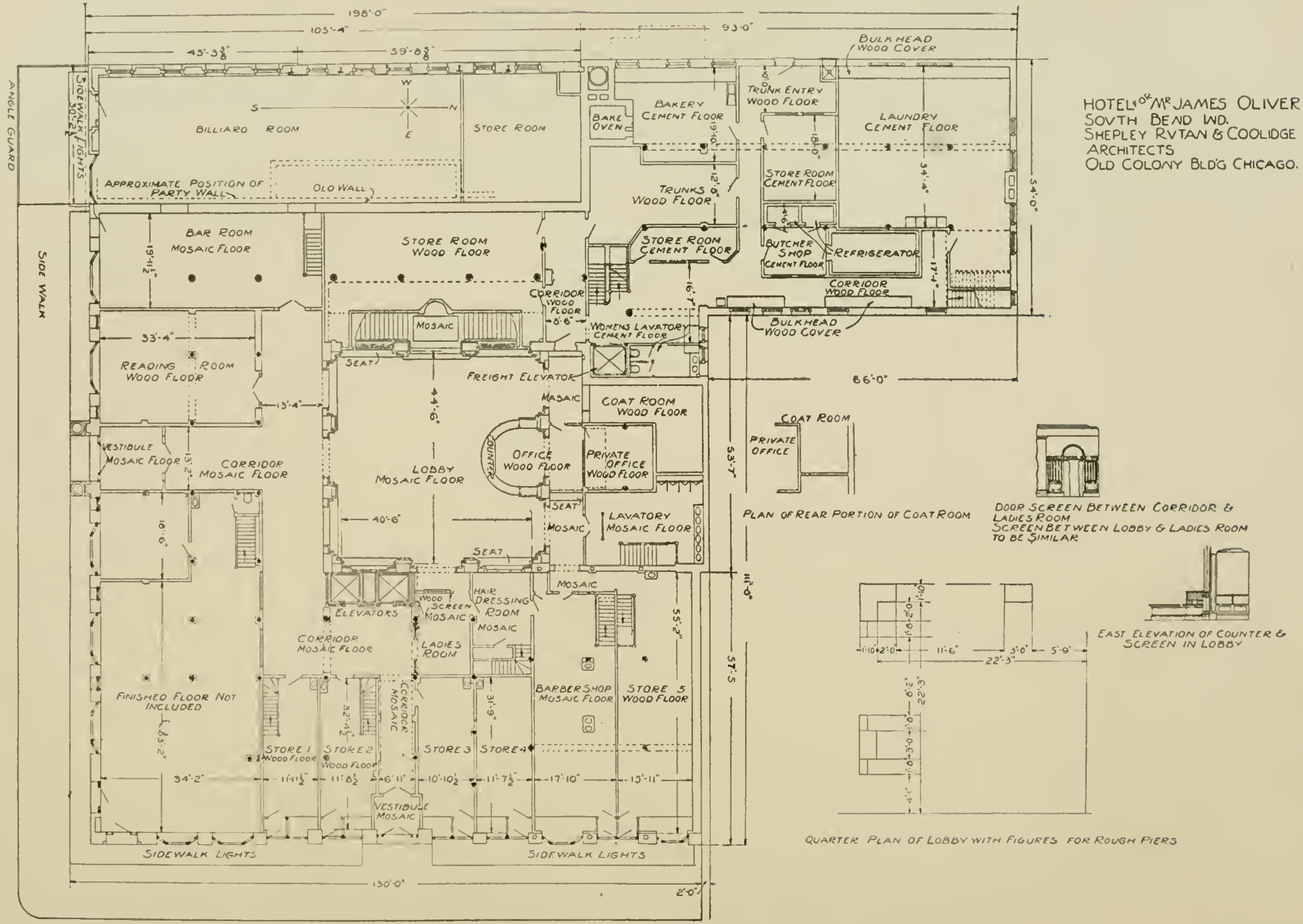


Fig. 18.

This principle as far as it relates to heights, is the same that was used for profile views. An end view is sometimes necessary before the plan or elevation of an object can be drawn. Suppose that in Fig. 18 we wish to draw the plan and elevation of a triangular prism 3″ long, the end of which is an equilateral triangle



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 and Elevation, See Page 122; for Details of Main Cornice, See Page 138.

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.

$1\frac{1}{2}''$ 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°. We are able to draw the plan 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 we can draw the elevation, we must find the height of the top edge. This height, however, must be equal to the altitude of the triangle forming the end of the prism. All that is necessary, then, is to construct an equilateral triangle $1\frac{1}{2}''$ on each side, and measure its altitude.

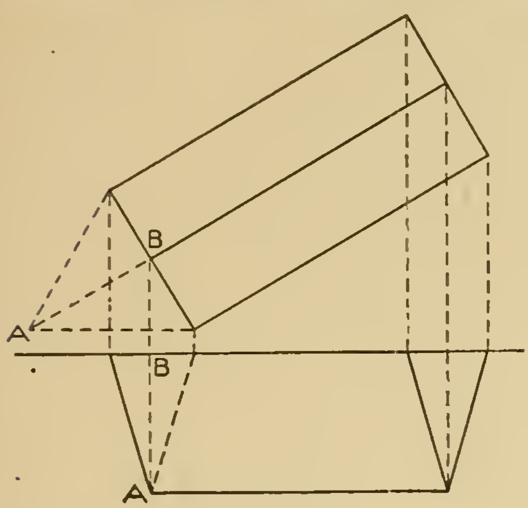


Fig. 19.

A very convenient way to do this is shown in the figure by laying one end of the prism down on H. A similar construction is shown in Fig. 19, but with one face of the prism on V instead of on H.

In all the work thus far the plan has been drawn below and the elevation above. This order is sometimes inverted and the plan put above the elevation, but the plan still remains a top view no matter where placed, so that after some practice it makes but little difference to the draughtsman which method is employed.

SHADE LINES.

It is often the case in machine drawing that certain lines or edges are made heavier than others. These heavy lines are called shade lines, and are used to improve the appearance of the drawing, and also to make clearer in some cases the shape of the object. The shade lines are not put on at random, but according to some system. Several systems are in use, but only that one which seems most consistent will be described. The shade lines are lines or edges separating light faces from dark ones, assuming the light always to come in a direction parallel to the dotted diagonal of the cube shown in Fig. 20. The direction of the light, then, may be represented on H by a line at 45° running backward to the right and on V by a 45° line sloping downward and to the right. Considering the cube in Fig. 20, if the light comes in the direction indicated, it is evident that the front, left-hand side and top will be light, and the bottom, back and right-hand side dark. On the plan, then, the shade lines will be the back edge 1 2 and the right-hand edge 2 3, because these edges are between light faces and dark ones. On the elevation, since the front is light, and the right-hand side and bottom dark, the edges 3 7 and 8 7 are shaded. As the direction of the light is represented on the plan by 45° lines and on the elevation also by 45° lines,

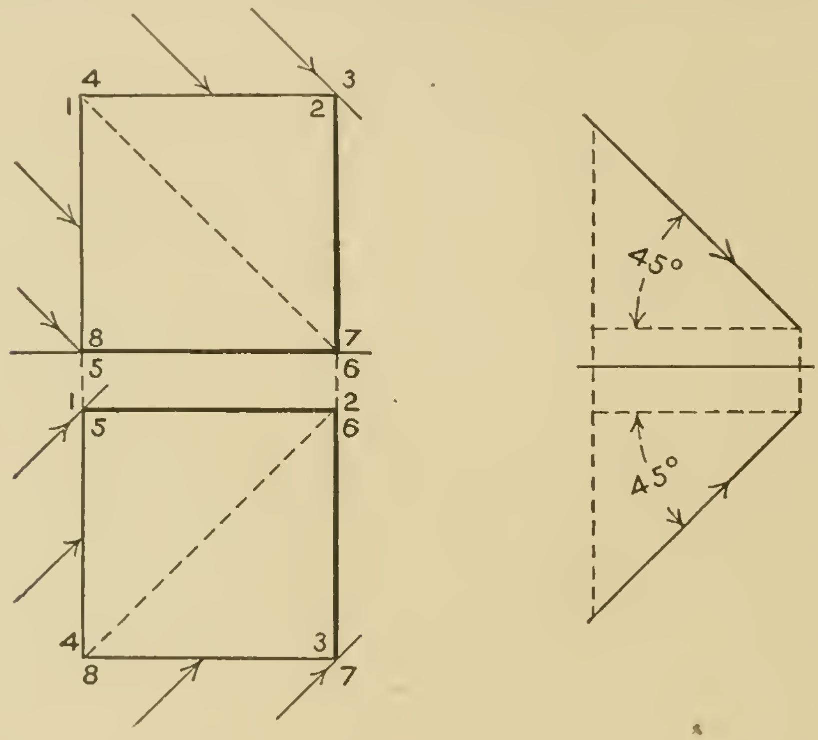


Fig. 20.

we may use the 45° triangle with the T-square to determine the light and dark surfaces, and hence the shade lines. If the object stands on the horizontal plane, the 45° triangle is used on the plan, as shown in Fig. 21, but if the length is perpendicular to the vertical plane, the 45° triangle is used on the elevation, as shown in Fig. 22. This is another way of saying that the 45° triangle is used on that projection of the object which shows the end. By applying the triangle in this way we determine the light and dark surfaces, and then put the shade lines between them. Dotted lines, however, are never shaded, so if a line which is between a light and a dark surface is invisible it is not shaded. In Fig. 21 the plan shows the end of the solid, hence the 45° triangle is used in the direction indicated by the arrows.

This shows that the light strikes the left-hand face, but not the back or the right-hand. The top is known to be light with-

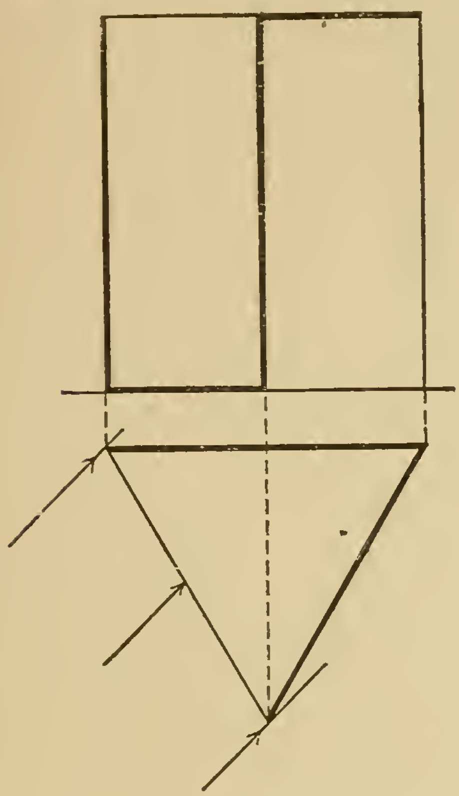


Fig. 21.

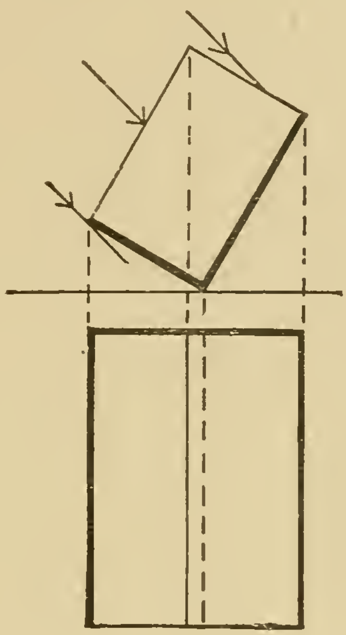


Fig. 22.

out the triangle, as the light comes downward, so the shade edges on the plan are the back and right-hand. On the elevation two faces of the prism are visible; one is light, the other dark, hence the edge between is shaded. The left-hand edge, being between a light face and a dark one is a shade line. The right-hand face is dark, the top of the prism is light, hence the upper edge of this face is a shade line. The right-hand edge is not shaded, because by referring to the plan, it is seen to be between two dark surfaces. In shading a cylinder or a cone the same rule is fol lowed, the only difference being that as the surface is curved, the light is tangent, so an element instead of an edge marks the separation of the dark from the light, and is *not* shaded. The elements of a cylinder or cone should *never* be shaded, but the bases may. In Fig. 23, Nos. 3 and 4, the student should carefully notice the difference between the shading of the cone and cylinder.

If in No. 4 the cone were inverted, the opposite half of the base would be shaded, for then the base would be light, whereas it is now dark. In Nos. 7 and 8 the shade lines of a cylinder and a circular hole are contrasted.

In No. 7 it is clear that the light would strike inside on the further side of the hole, commencing half way where the 45° lines

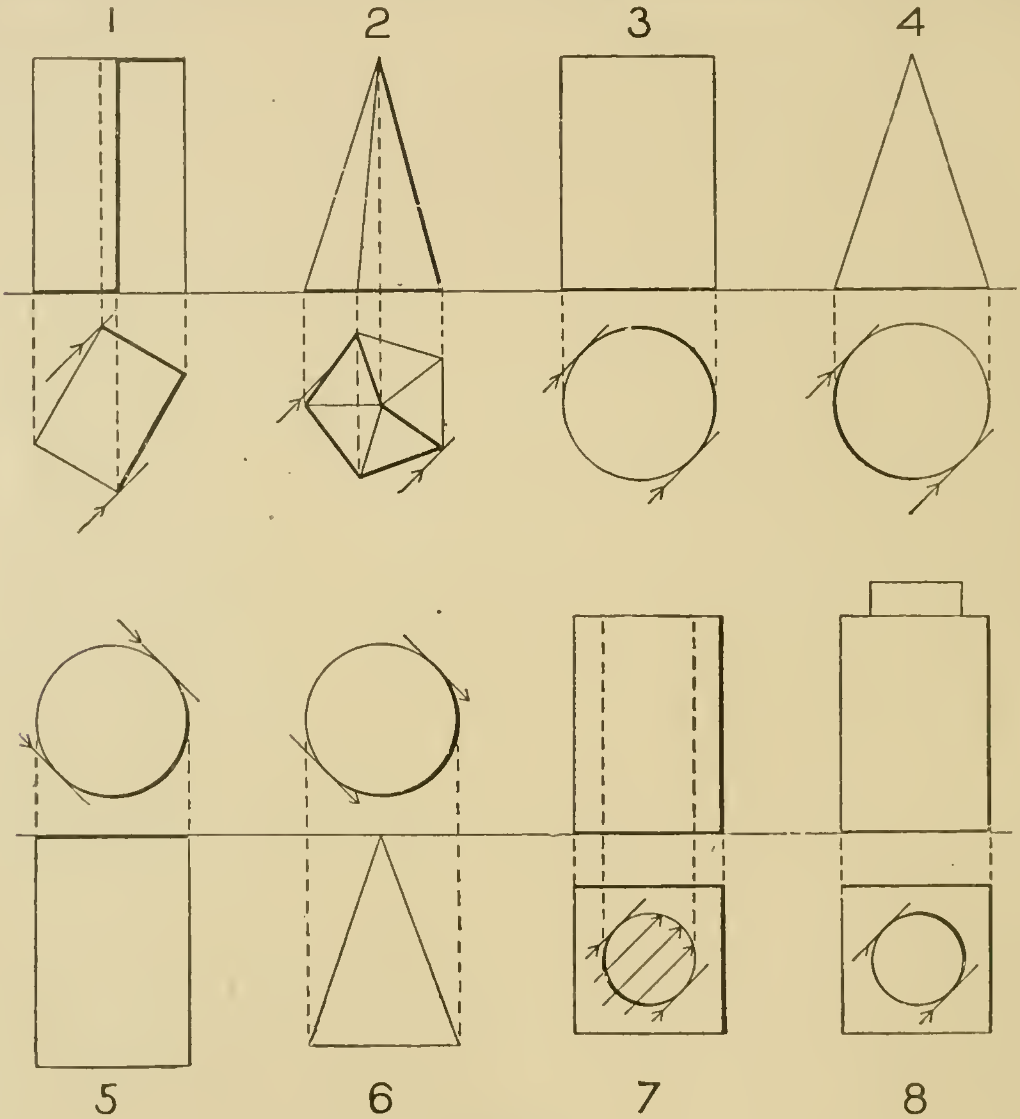


Fig. 23.

are tangent. The other half of the inner surface would be dark, hence the position of the shade line. The shade line then enables us to tell at a glance whether a circle represents a hub or boss, or depression or hole. Fig. 24 represents plan, elevation and profile view of a square prism. Here as before, the view showing the end is the one used to determine the light and dark surfaces, and then the shade lines put in accordingly.

In putting on the shade lines, the extra width of line is put *inside* the figure, not outside. In shading circles, the shade line is made of varying width, as shown in the figures. The method of obtaining this effect by the compass is to keep the same radius, but to change the center slightly in a direction parallel to the rays of light, as shown at A and B in No. 2 of Fig. 24.

No. 2.

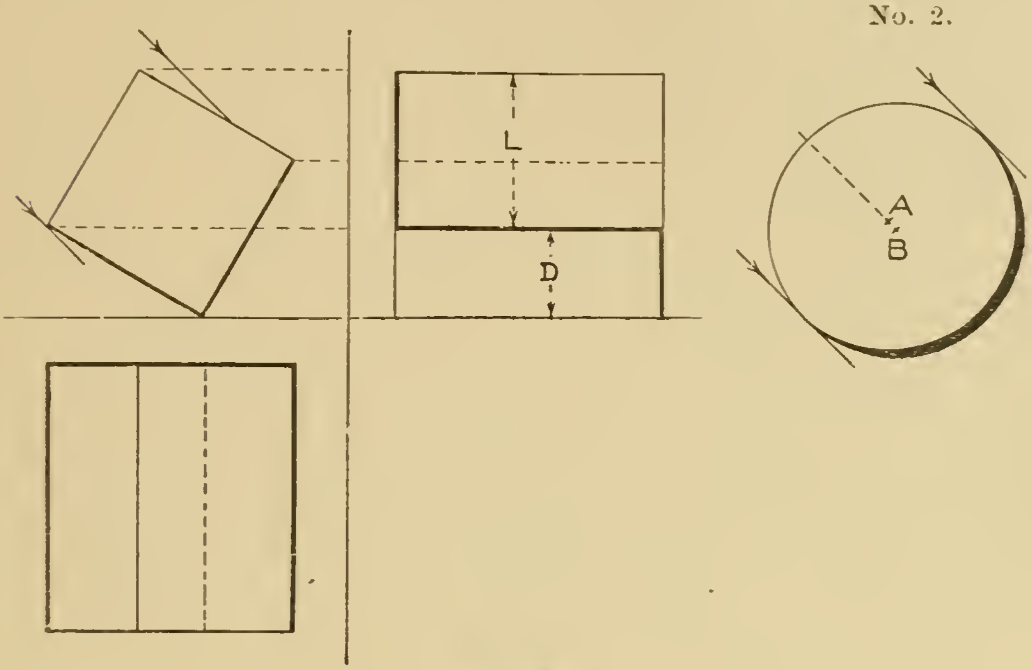


Fig. 24.

INTERSECTION AND DEVELOPMENT.

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.

In Fig. 25 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 sections are found in Figs. 26 and 27. 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.

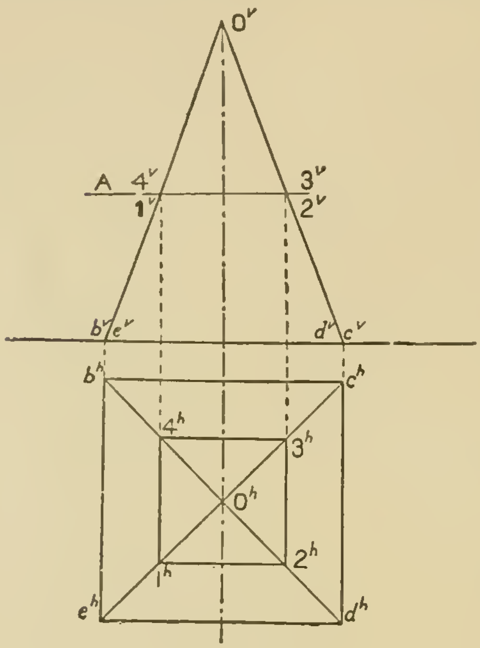


Fig. 25.

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. 28 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 Figs. 29 and 30 the cutting plane is not parallel to the base, hence the intersection will not be of the same shape as the base. The sections 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.

INTERSECTION OF PLANES WITH CONES OR CYLINDERS.

Sections cut by a plane from a cone have already been defined as *conic sections*. These sections may be either 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

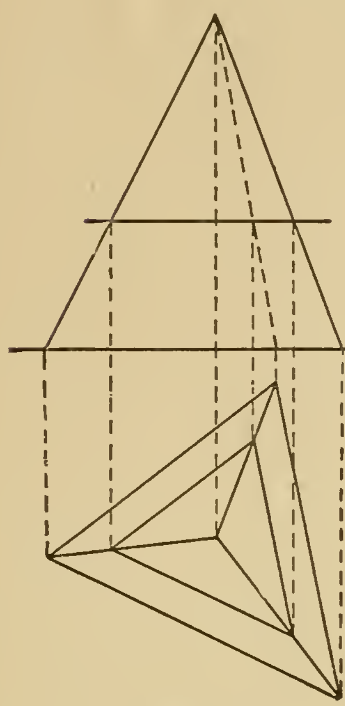


Fig. 26.

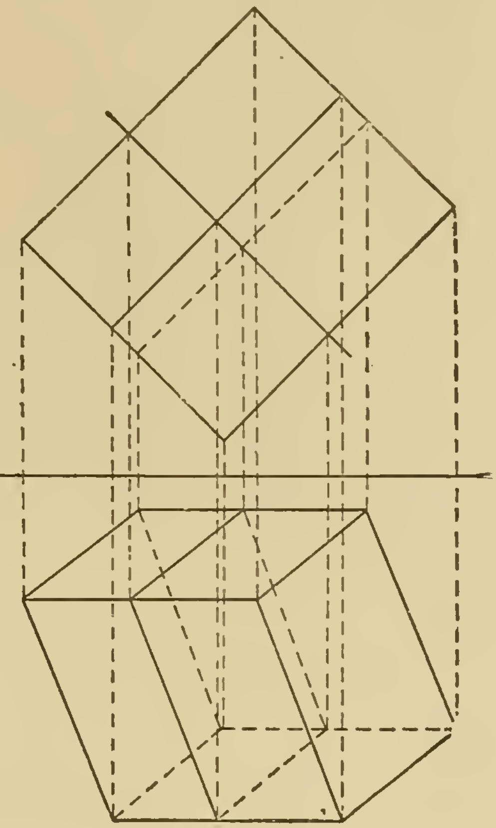


Fig. 27.

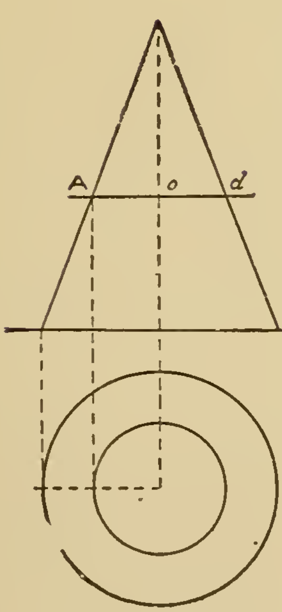


Fig. 28.

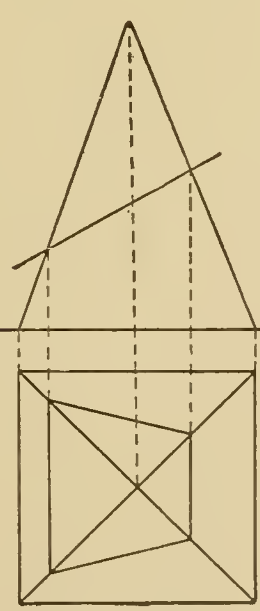


Fig. 29.

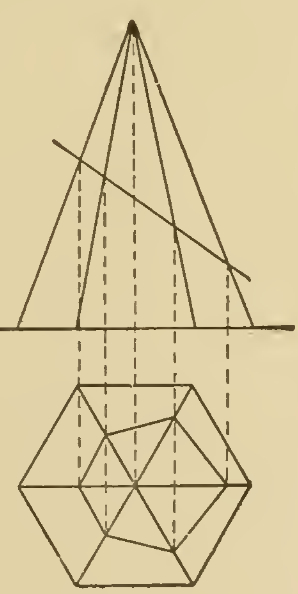


Fig. 30.

ellipse, parabola and hyperbola without projections; it will now be shown that they may be obtained as actual intersections.

In Fig. 31 the plane cuts the cone obliquely. To find points on the curve in plan take a series of horizontal planes

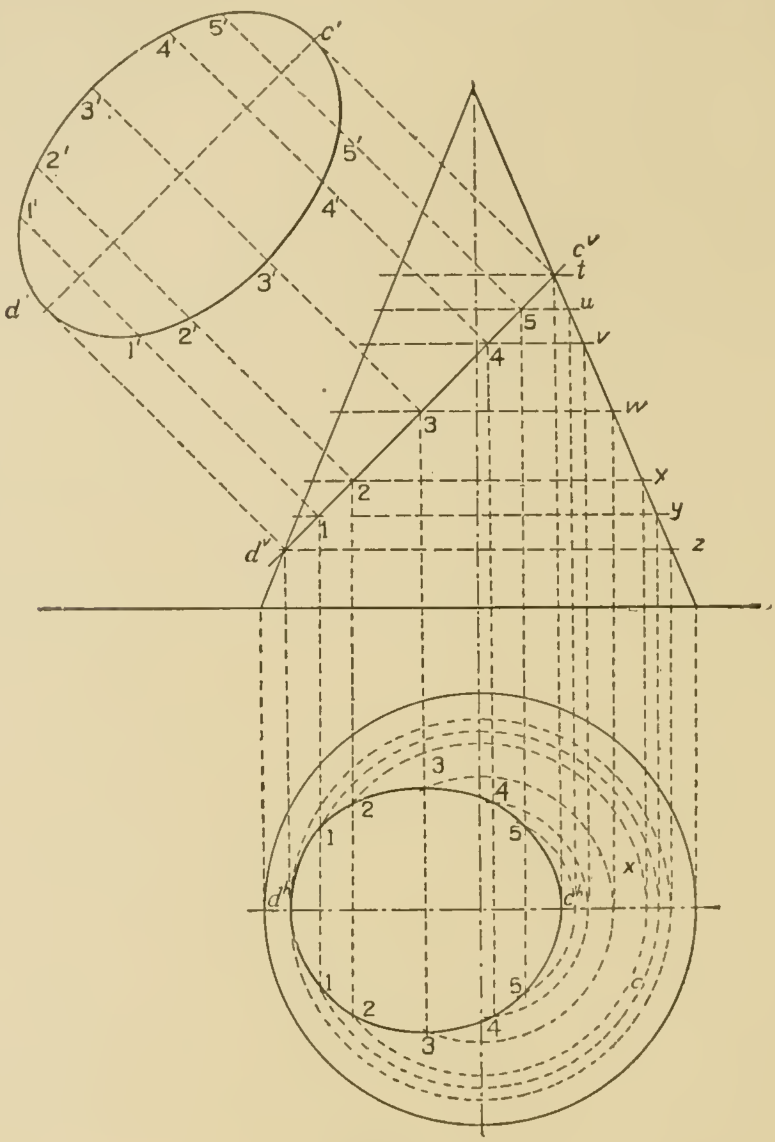


Fig. 31.

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. The horizontal projections of the contour elements will be found 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. Contour elements are those forming the outline.

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 point 2. Also the circle x and the curve must cross twice, once on the front of the cone and once on the back. Point 2 then represents two points which are shown in plan directly beneath on the circle x, and are points on the required intersection. Planes y and z, and as many more as may be necessary to determine the curve accurately, are used in the same way. The curve found is an ellipse. The student will readily see that the true size of this ellipse is not shown in the plan, for the plane containing the curve is not parallel to the horizontal.

In order to find the **actual size** of the ellipse, it is necessary to place its plane in a position parallel either to the vertical or to the horizontal. The actual length of the long diameter of the ellipse must be shown in elevation, $c^v\ d^v$, because the line is parallel to the vertical plane. The plane of the ellipse then may be revolved about $c^v\ d^v$ as an axis until it becomes parallel to V, when its true size will be shown. For the sake of clearness of construction, $c^v\ d^v$ is imagined moved over to the position $c'\ d'$, parallel to $c^v\ d^v$. The lines 1—1, 2—2, 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 will appear perpendicular to $c^v\ d^v$, and the true size of the figure be shown. This construction is made on the left, where $1'$—$1'$, $2'$—$2'$ and $3'$—$3'$ are equal in length to 1—1, 2—2, 3—3 on the plan.

In Fig. 32 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.

If a cone is intersected by a plane which is parallel to only one of the elements, as in Fig. 33, the resulting curve is the parabola, the construction of which is exactly similar to that for the ellipse as given in Fig. 31. If the intersecting plane is parallel to more than one element, or is parallel to the axis of the cone, a hyperbola is produced.

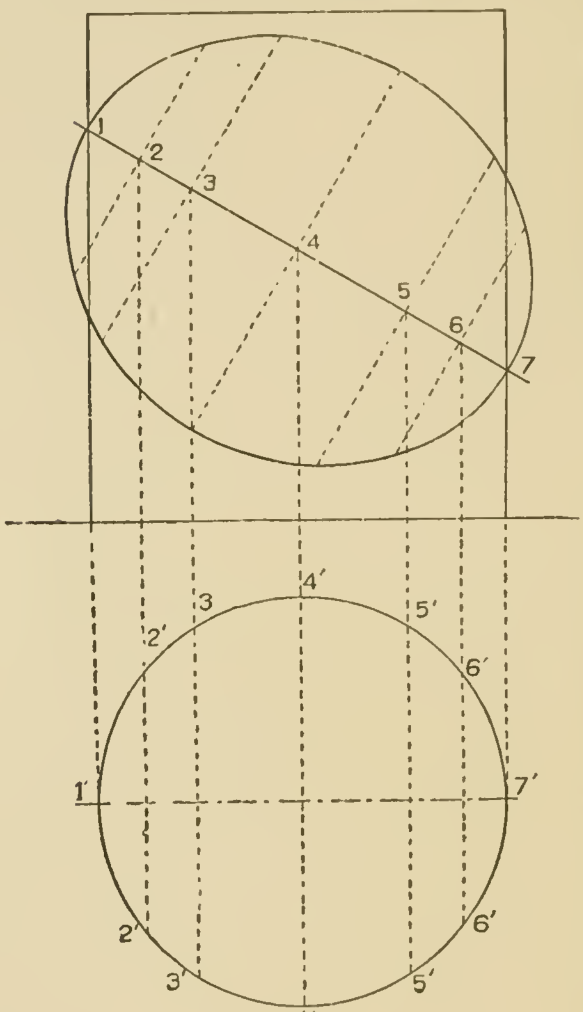


Fig. 32.

In Fig. 34, 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.

DEVELOPMENTS.

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, we obtain an exact development, 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.

In order to find the development of the rectangular prism in Fig 35, the back face, 1 2 7 6, is supposed to be placed in contact

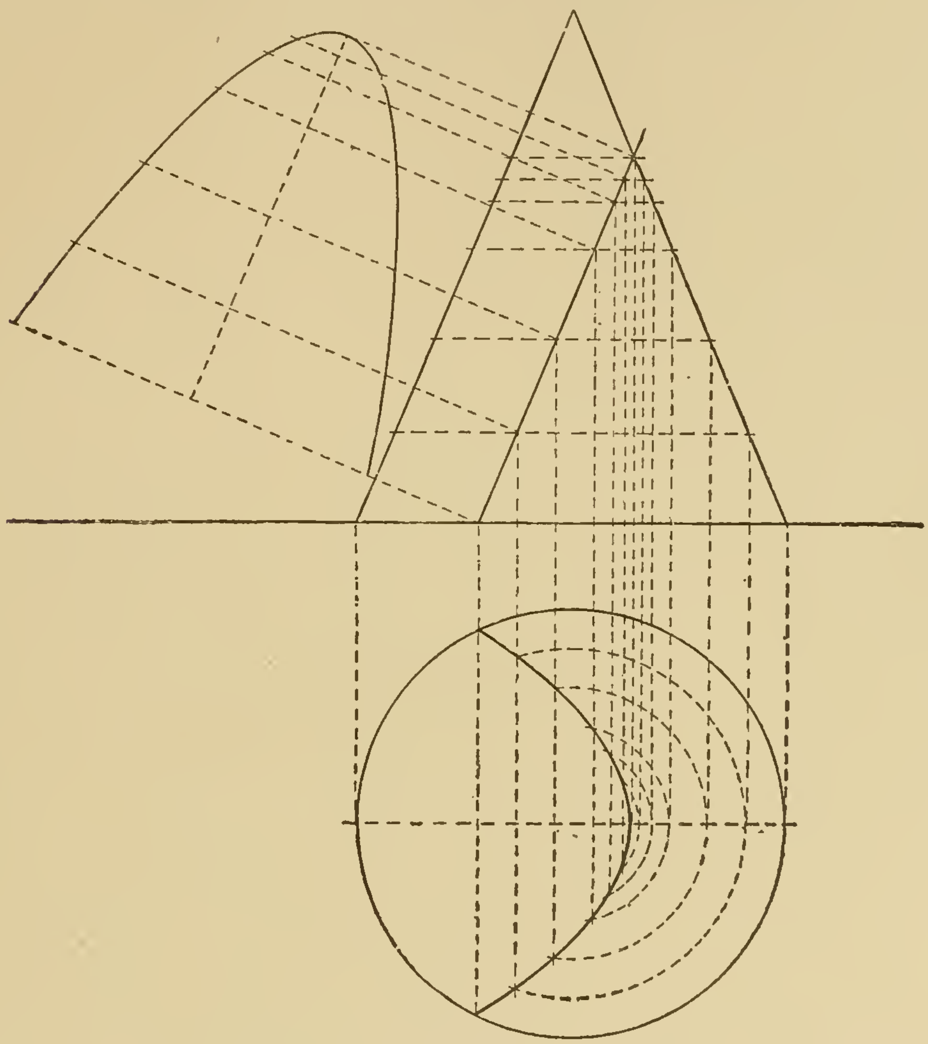


Fig. 33.

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, then this continued until all four faces have been placed on the same plane. The rectangles 1 4 3 2 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.

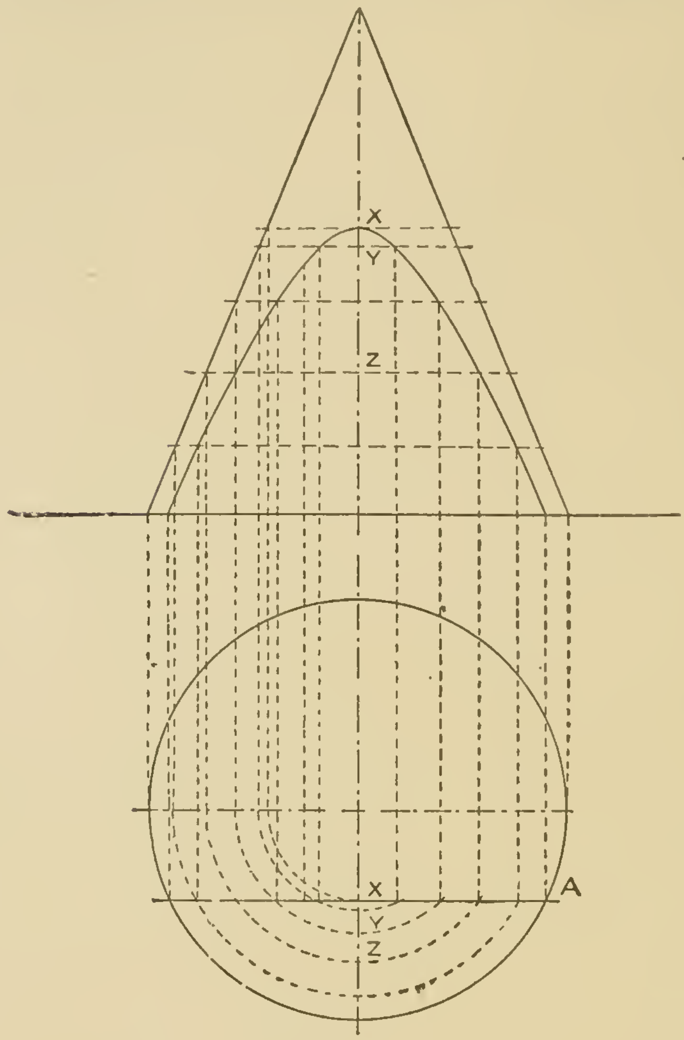


Fig. 34.

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 contact again, the space rolled over will represent the development of the convex surface of the cone. A, Fig. 36, is a cone cut by a plane parallel to the base. In B, let the vertex of the cone be placed at V, and one element of the cone coincide with V A I. The length of this element is taken from the elevation A, of either contour element. All of the elements of the cone are of the same length, so when the cone is rolled each point of the base as it touches the plane will be at the same distance from the vertex. From this it follows that the development of the base will be the arc of a circle of radius equal to the length of an element. To find the length of this arc which is equal to the distance around the base, divide the plan of the circumference of the base into any number of equal parts, as twelve, then with the length of one of these parts as radius, lay off twelve spaces, 1....13, join 1 and 13 with V, and the sector is the development of the cone from vertex to base. To represent on the development

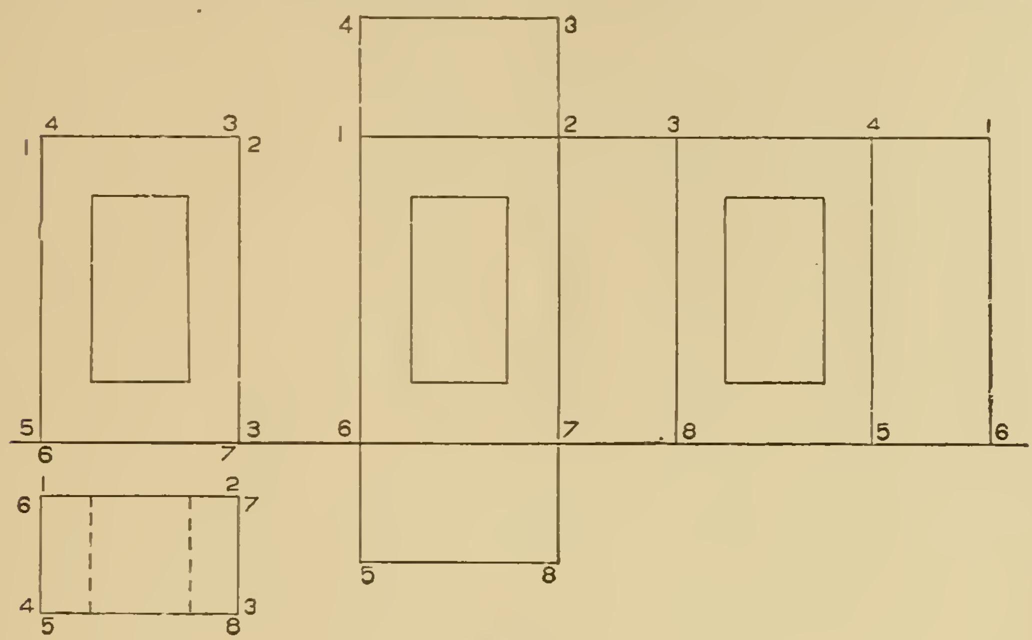


Fig. 35.

the circle cut by the section plane, take as radius the length of the element from the vertex to D, and with V as center describe

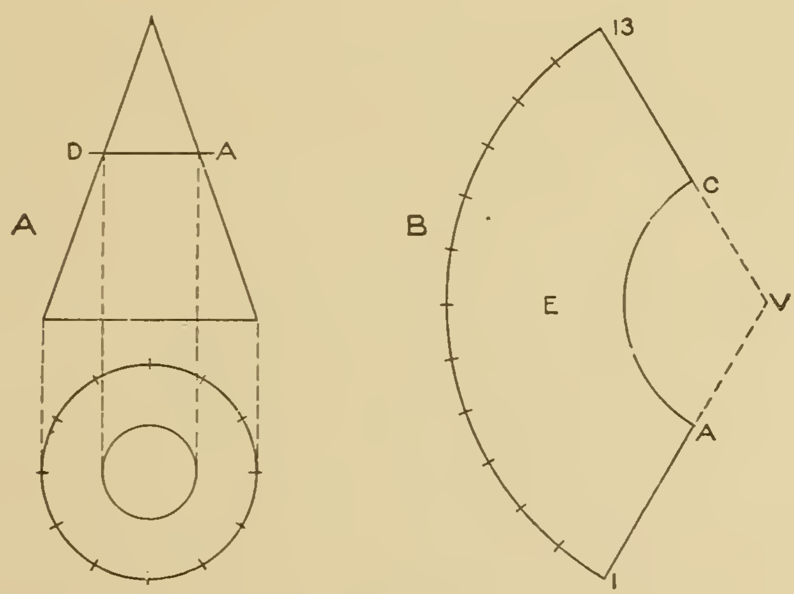


Fig. 36.

an arc. The development of the frustum of the cone will be the portion of the circular ring. This of course does not include the development of the bases, which would be simply two circles the same sizes as shown in plan.

A and B, Fig. 37, represent the plan and elevation of a regular triangular pyramid and its development. If face C is placed on the plane its true size will be shown at C in the development. The true length of the base of triangle C is shown in the plan. The slanting edges, however, not being parallel to the vertical, are not shown in elevation in their true length. It becomes necessary then, to find the true length of one of these edges as shown in Fig. 6, after which the triangle may be drawn in its full size at C in the development. As the pyramid is regular, three equal triangles as shown developed at C, D and E, together with the base F, constitute the development.

If a right circular cylinder is to be developed, or rolled upon a plane, the elements, being parallel, will appear as parallel lines,

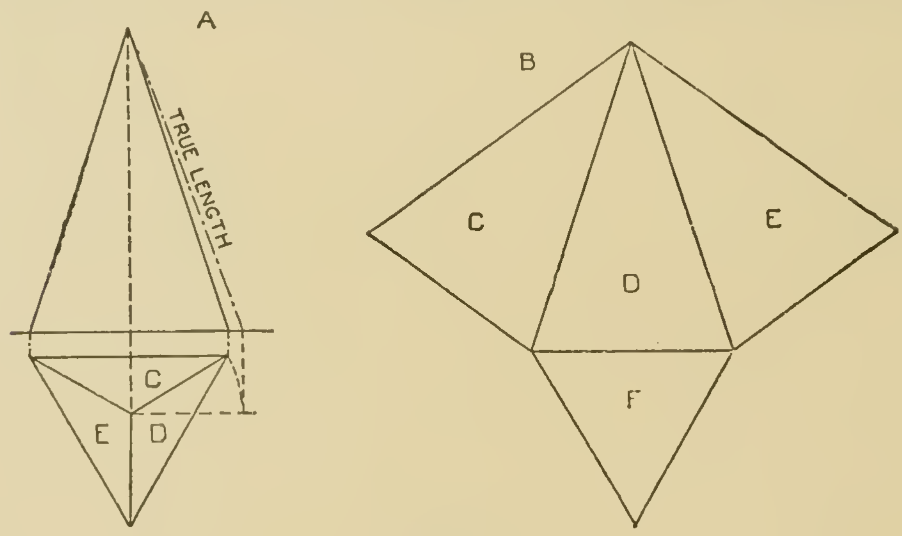


Fig. 37.

and the base, being perpendicular to the elements, will develop as a straight line perpendicular to the elements. The width of the development will be the distance around the cylinder, or the circumference of the base. The base of the cylinder in Fig. 38, is divided into twelve equal parts, 1 2 3, etc. Commencing at point 1 on the development these twelve equal spaces are laid along the straight line, giving the development of the base of the cylinder, and the total width. To find the development of the curve cut by the oblique plane, draw in elevation the elements corresponding to the various divisions of the base, and note the points where they intersect the oblique plane. As we roll the cylinder 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 of the curve is found by projecting horizontally across from 10 in elevation. It will be seen that the curve is symmetrical, the half on the left of 7 being similar to that on the right. The development of any curve whatever on the surface of the cylinder 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. 39 is shown plan and elevation of a three-piece elbow and collar, and develop-

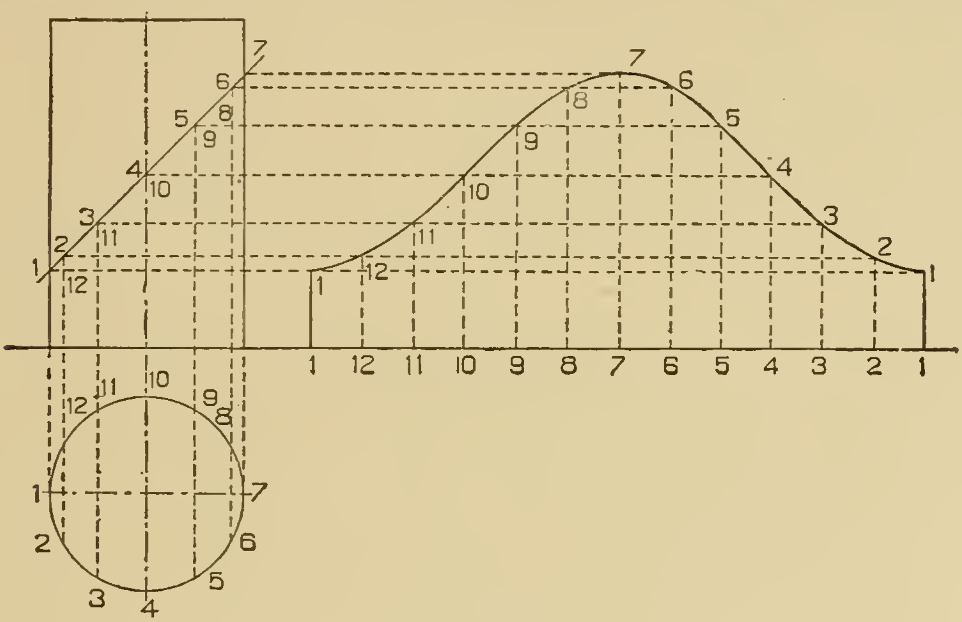


Fig. 38.

ments 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 fitting together as required. Knowing the kind of elbow desired, we 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. 38, and this is also the development of C.

It should be borne in mind that in developing a cylinder we must always have a base 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

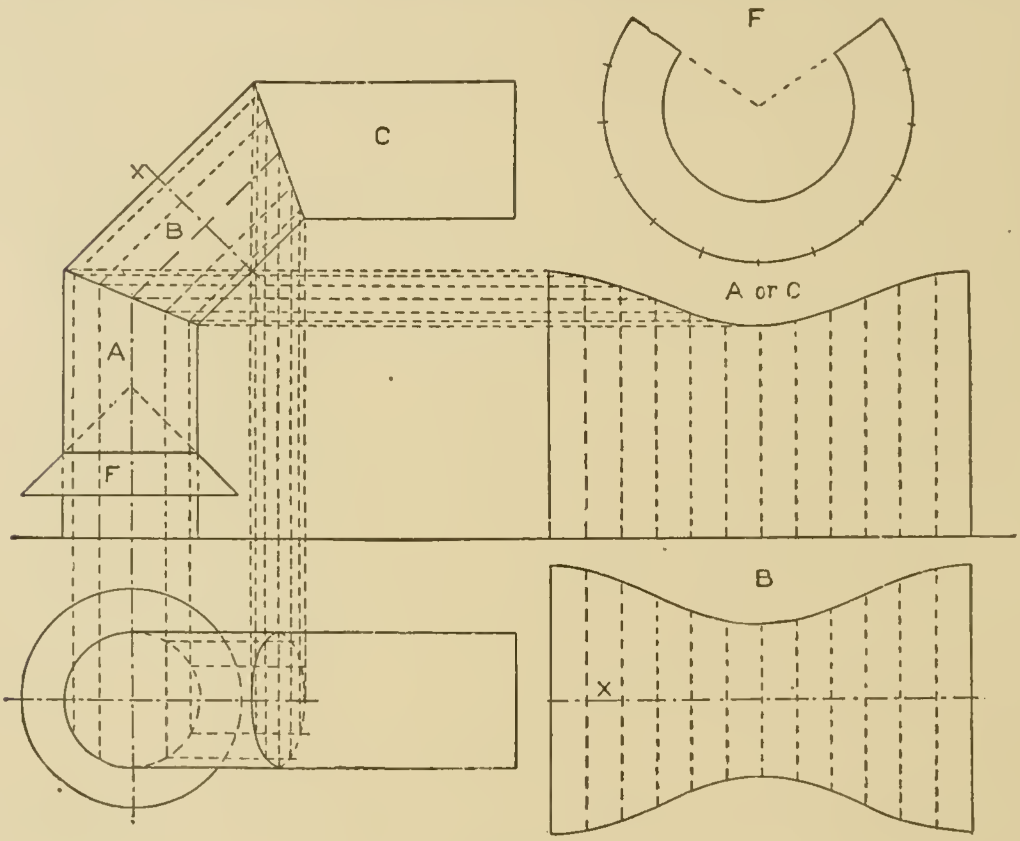
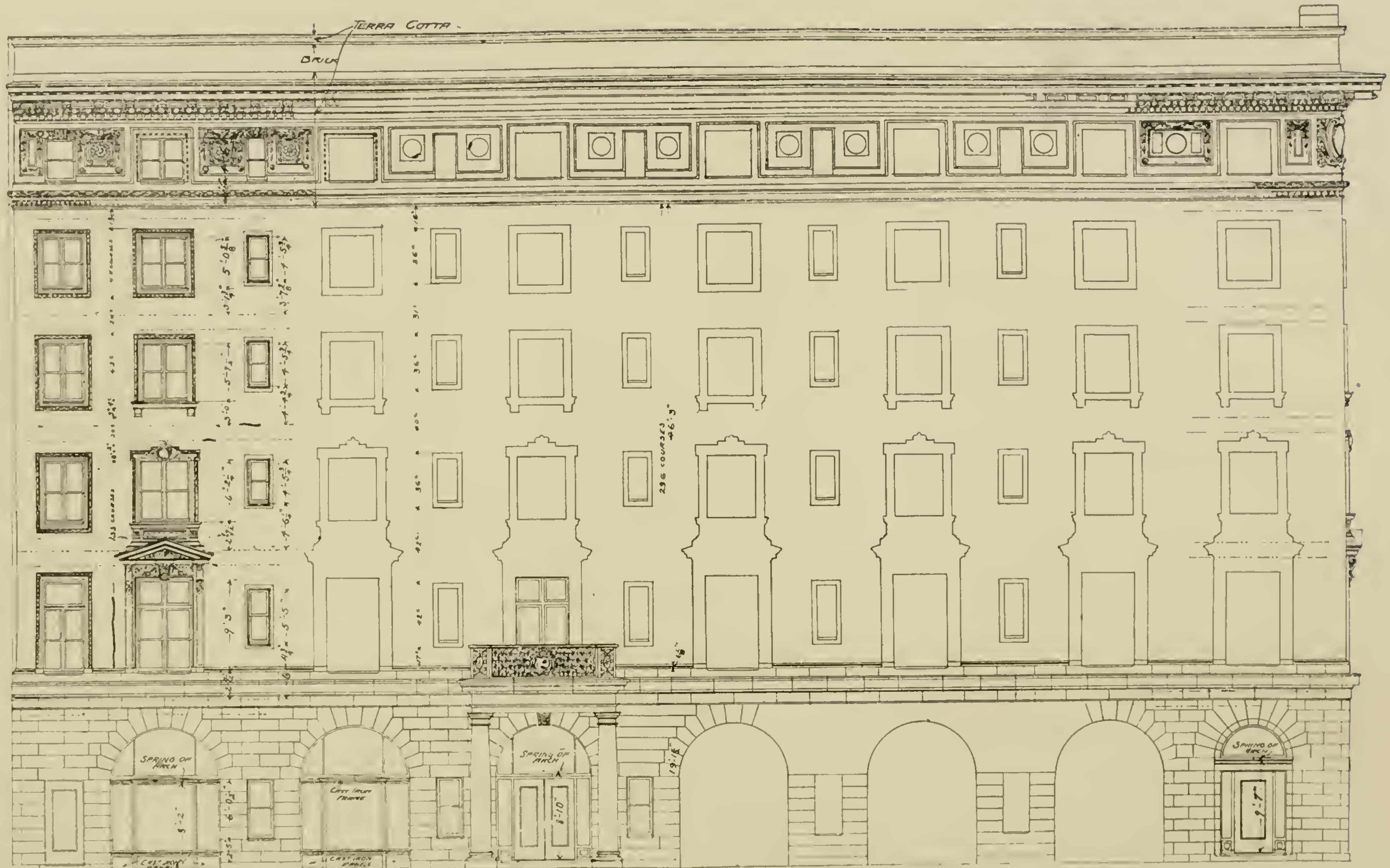


Fig. 39.

straight line, and is therefore the section from which we must work in developing other sections. As B has neither end at right angles to its length, the plane X is drawn at the middle and perpendicular to the length. B is the same diameter pipe as C and A, so the section cut by X will be a circle of the same diameter as the base of A, and its development is shown at X.

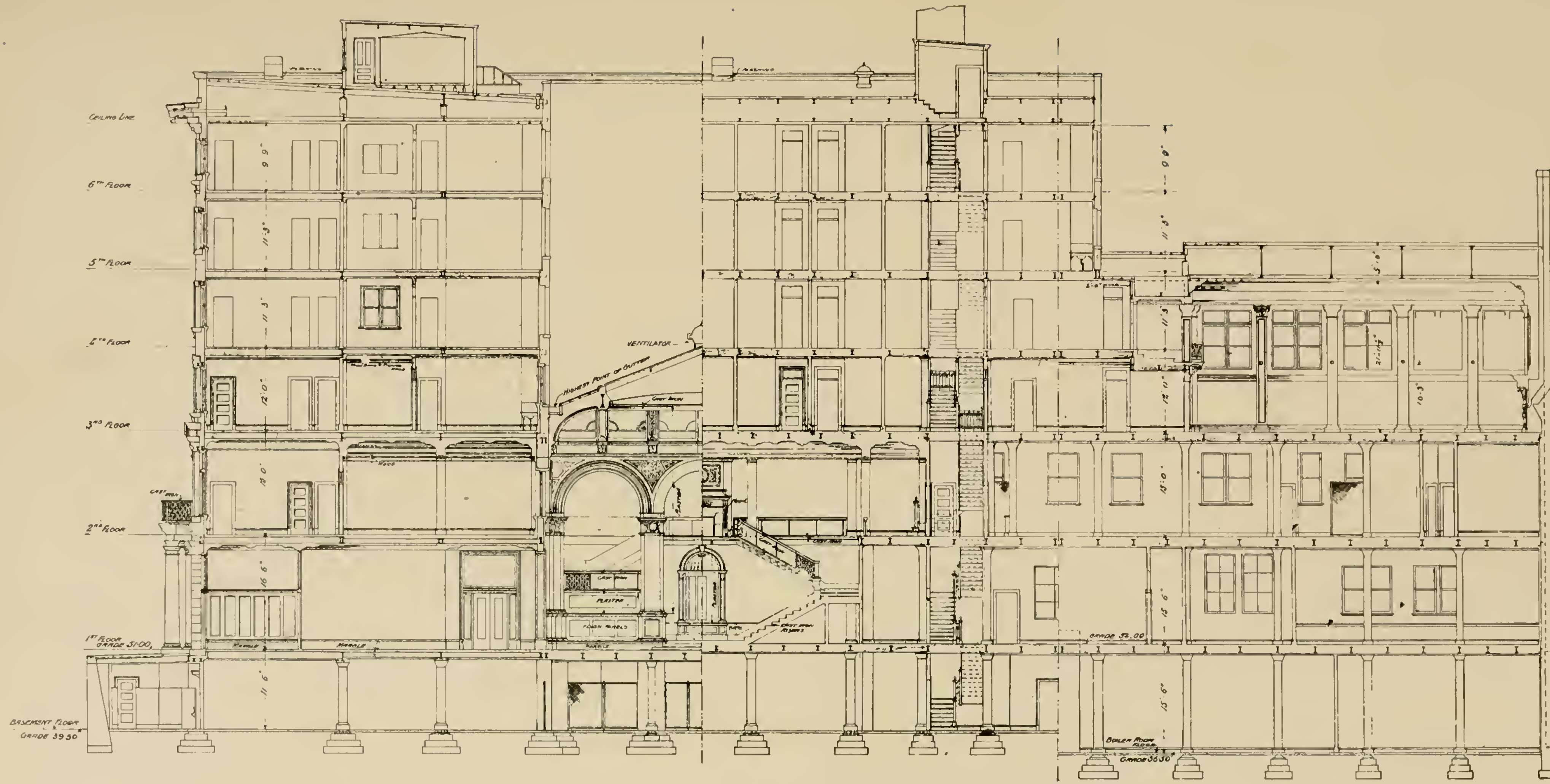
From the points where the elements drawn on the elevation of A meet the joint between A and B, elements are drawn on B,



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

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

Section through Vestibule and Lobby Shown on Opposite Page. For Plans, See Page 106; for Exterior and Details of Main Cornice, See Page 138.



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.

which are equally spaced around B the same as on A. The spaces then laid off along X are the same as given 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. 36. 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.

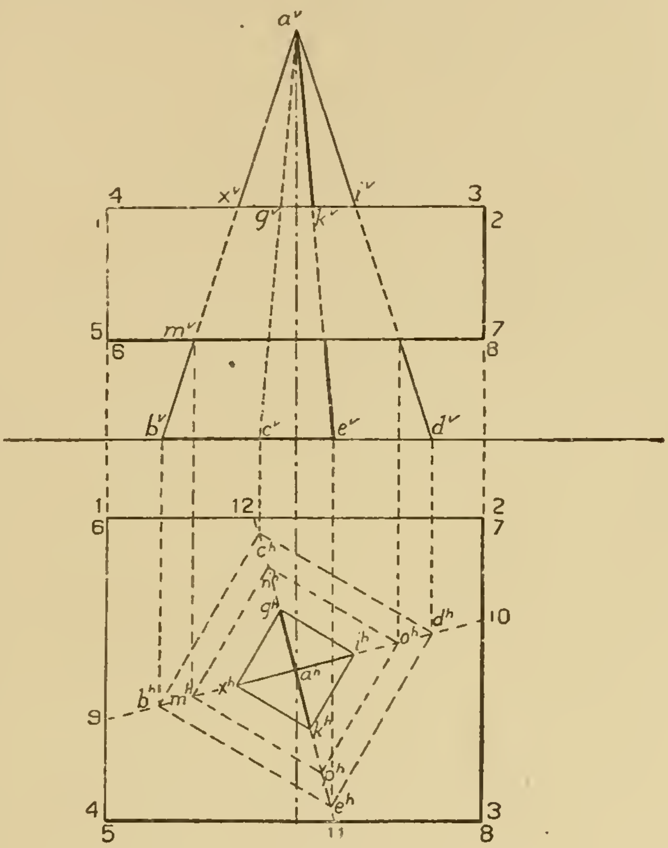


Fig. 40.

The intersection of a rectangular prism and pyramid is shown in Fig. 40. 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 k^v i^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 x^h, and with this as one corner, the square $x^h\ g^h\ i^h\ k^h$ is drawn, its sides parallel to the edges of the base. This square is the intersection of the pyramid with the top of the prism.

The intersection of the pyramid with the bottom of the prism is found in like manner, by taking the point where one edge of the pyramid as $a\ b$ passes through the bottom of the prism shown in elevation as point m^v, projecting down to m^h on $a^h\ b^h$, and drawing the square $m^h\ n^h\ o^h\ p^h$ parallel to the base of the pyramid. These two squares constitute the entire intersection of the two solids, the pyramid going through the bottom and coming out at the top of the prism. As much of the slanting edges of the

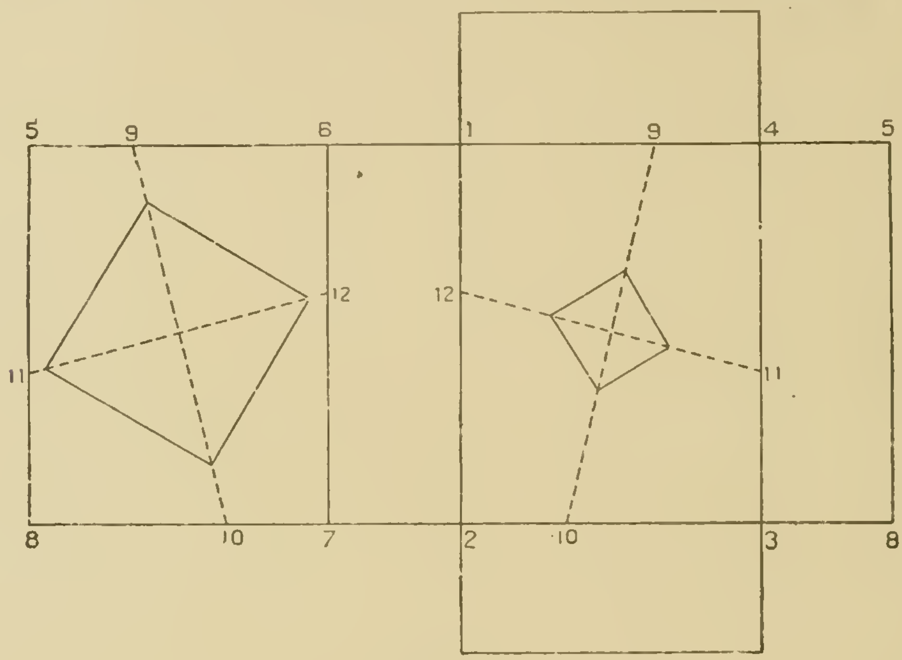


Fig. 41.

pyramid as are above the prism will be seen in plan, appearing as the diagonals of the small square, and the rest of the pyramid, being below the top surface of the prism, will be dotted in plan.

Fig. 41 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 bottom, back and 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 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 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 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, then the square constructed on these diagonals. The same method is used for locating the small square on the top face.

If the intersection of a cylinder and prism is to be found, we may either obtain 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. 42 represents a triangular prism intersecting a cylinder. The axis of the prism is parallel to V and inclined to H. Starting with the size and shape of the base, this is laid off at a_1 b^h c^h, and the altitude of the triangle 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, 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 we can find 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

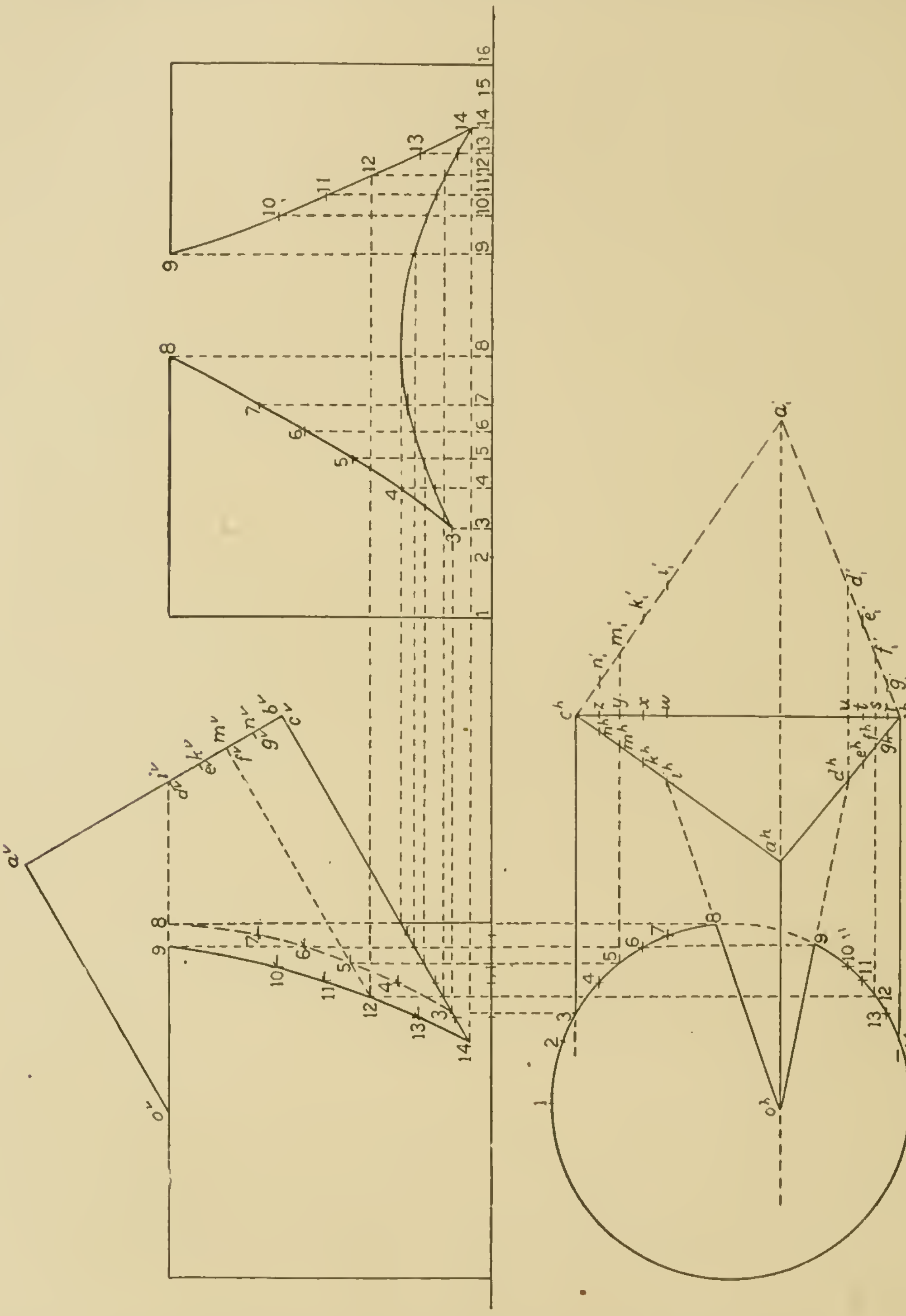


Fig. 43.

Fig. 42.

d, seen in 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, 11.......3. The vertical projections of these points are found on the corresponding lines in elevation, and the curves drawn through. The curve 3, 4....8 must be dotted, as it is on the back of the cylinder. The under face of the prism, which ends with the line b c, is perpendicular to the vertical plane, so the curve of intersection will be projected on V as a straight line. Point 14 is one end of this curve. 3 the other end, and the curve is projected in elevation as the straight line from 14 to the point where the lower edge of the prism crosses the contour element of the cylinder.

Fig. 43 gives the development of the right-hand half of the cylinder, beginning with number 1. As previously explained, the distance between the elements is shown in the plan, as 1—2, 2—3, 3—4 and so on. These spaces are laid off in the development along a straight line representing the development of the base, and from these points the elements are drawn perpendicularly.

The lengths of the elements in the development from the base to the curve are exactly the same as on the elevation, as the elevation gives the true lengths. If then the development of the base is laid off along the same straight line as the vertical projection of the base, the points in elevation may be projected across with the T-square to the corresponding elements in the development. The points on the curve cut by the under face of the prism are on the same elements as the other curves, and their vertical projections are on the under edge of the prism, hence these points are projected across for the development of the lower curve.

In Fig. 44 is given the development of the prism from the right-hand end as far as the intersection with the cylinder, begin-

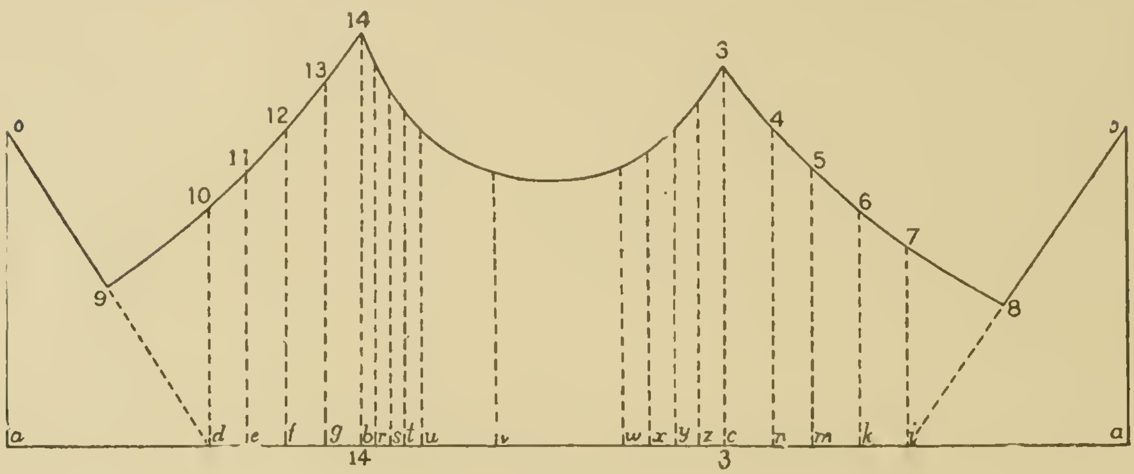


Fig. 44.

ning at the left with the top edge $a\ o$, the straight line $a\ b\ c\ a$ being the development of the base. As this must be the actual distance around the base, the length is taken from the true size of the base, $a_1\ b^h\ c^h$. The parallel lines drawn on the surfaces of the prism must appear on the development their true distances apart, hence the distances $a_1\ d_1$, $d_1\ e_1$, 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, $b^h\ c^h$. Perpendicular lines are drawn from the points of division on the development.

The position of the developed 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 oa on the development is equal to $a^v\ o^v$, d 10 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 o^h9. Number 8 is found in the same way.

ISOMETRIC PROJECTION.

Heretofore an object has been represented by two or more projections. Another system, called **isometrical drawing,** is 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.

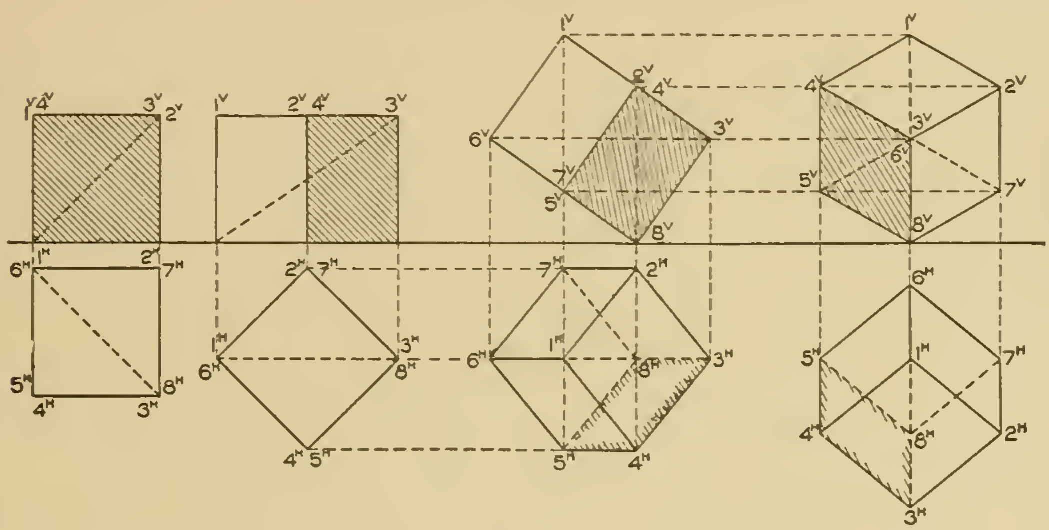


Fig. 45.

To obtain a view which shows the three dimensions in such a way that measurements can be taken from them, draw the cube in the simple position shown at the left of Fig. 45, 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 the 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 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 simplest method. Herein lies the distinction between an isometrical projection and an isometric drawing.

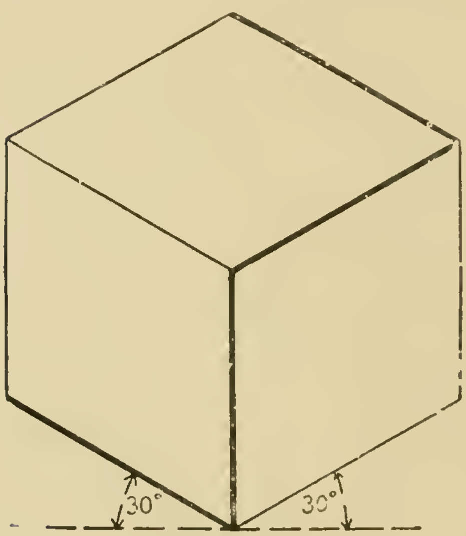


Fig. 46.

It will be noticed that the figure can 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. 46 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, 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. 46 is supposed to be in the position indicated by plan and elevation in Fig. 47, that is, standing on its base, with two faces parallel to the vertical plane.

If the isometric of the cube in the position of Fig. 48 were required, it could not be drawn with the base edges at 30°; neither would these edges appear in their true lengths. It follows, then, that in isometrical drawing, true lengths appear only as 30° lines or as vertical lines. Edges or lines that in actual projection are either parallel to the ground line or perpendicular to V, are drawn in isometric as 30° lines, full length; and those that are actually vertical are made vertical in isometric, also full length.

In Fig. 45, lines such as the front vertical edges of the cube and the two base edges are called the three **isometric axes.** The isometric of objects in oblique positions, as in Fig. 48, can be con-

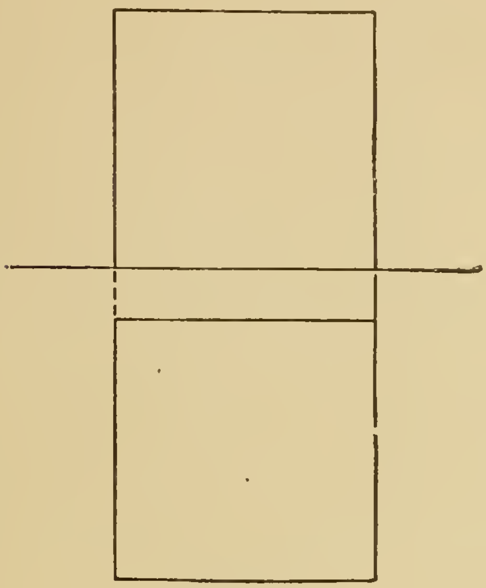


Fig. 47.

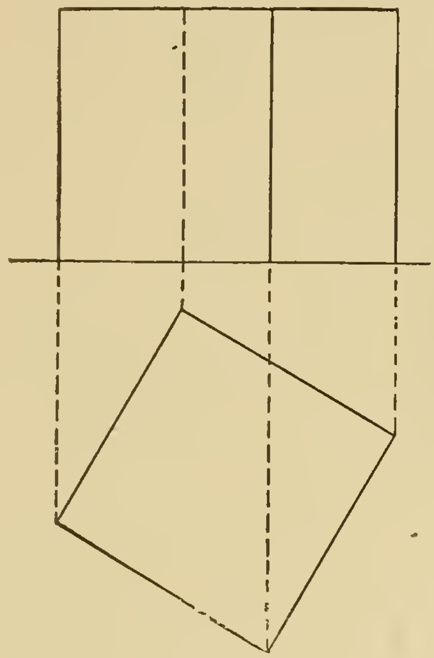


Fig. 48.

structed only by reference to their projections, by methods which will be explained later.

In isometric drawing small rectangular objects are more satisfactorily represented than large curved ones. In woodwork, mortises and joints and various parts of framing are well shown in isometric. This system is used also to give a kind of bird's-eye view of the mills or factories. It is also used in making sketches of small rectangular pieces of machinery, where it is desirable to give shape and dimensions in one view.

In isometric drawing the **direction of the ray of light** is parallel to that diagonal of a cube which runs from the upper left corner to the lower right corner, as 4^v-7^v in the last elevation of Fig. 45. This diagonal is at 30°; hence in isometrical drawing the direction of the light is at 30° downward to the right. From this it follows that the top and two left-hand faces of the cube are light, the others dark. This explains the shade lines in Fig. 45.

In Fig. 45, the top end of the diagonal which is parallel to the ray of light in the first position is marked 4, and traced through to the last or isometrical projection, 4^v. It will be seen that face 3^v 4^v 5^v 8^v of the isometric projection is the front face of the cube in the first view; hence we may consider the left front face of the isometric cube as the front. This is not absolutely necessary, but by so doing the isometric shade edges are exactly the same as on the original projection.

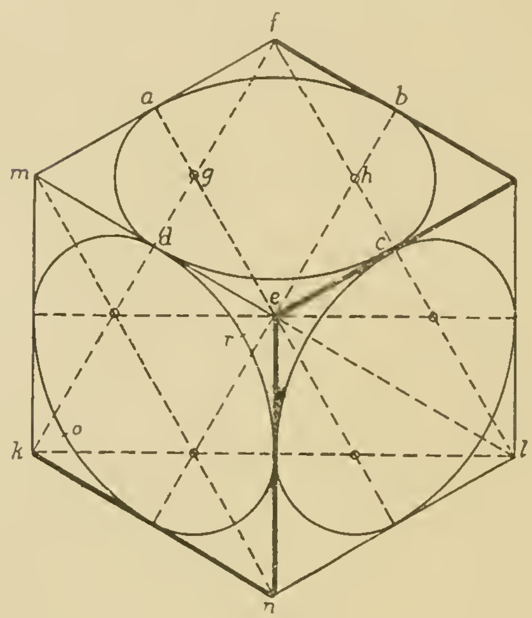


Fig. 49.

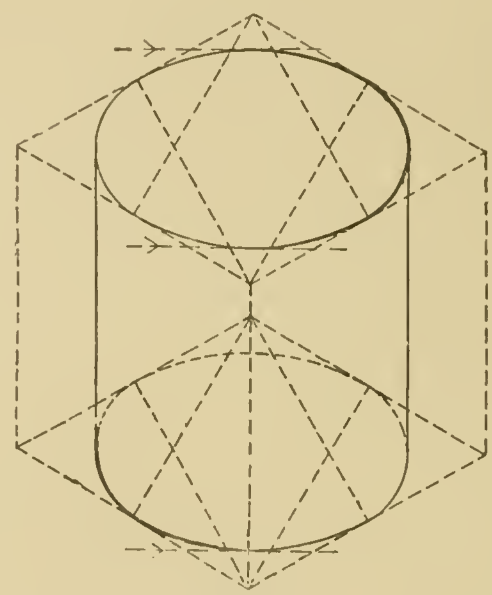


Fig. 50.

Fig. 49 shows a cube with circles inscribed in the top and two side faces. The isometric of a circle is an ellipse, the exact construction of which would necessitate finding a number of points; for this reason an approximate construction by arcs of circles is often made. In the method of Fig. 49, four centers are used. Considering the upper face of the cube, lines are drawn from the obtuse angles *f* and *e*, to the centers of the opposite sides.

The intersections of these lines give points *g* and *h*, which serve as centers for the ends of the ellipse. With center *g* and radius *g a*, the arc *a d* is drawn; and with *f* as center and radius *f d*, the arc *d c* is described, and the ellipse finished by using centers *h* and *e*. This construction is applied to all three faces.

Fig. 50 is the isometric of a cylinder standing on its base.

Notice that the shade line on the top begins and ends where T-square lines would be tangent to the curve, and similarly in the case of the part shown on the base. The explanation of the shade is very similar to that in projections. Given in projections a cylinder standing on its base, the plan is a circle, and the shade line is determined by applying the 45° triangle tangent to the circle. This is done because the 45° line is the projection of the ray of light on the plane of the base.

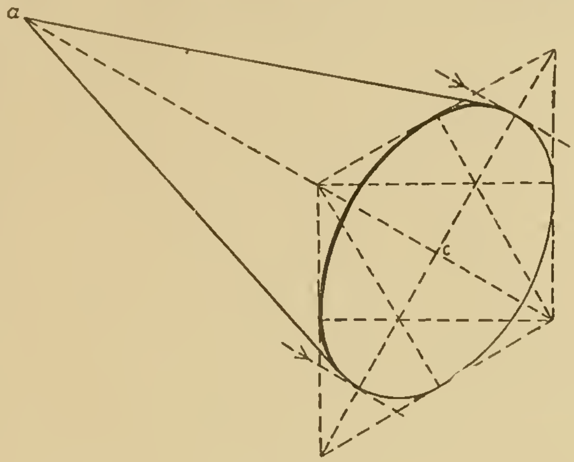


Fig. 51.

In Fig. 49, the diagonal $m\ l$ may represent the ray of light and its projection on the base is seen to be $k\ l$, the diagonal of the base, a T-square line. Hence, for the cylinder of Fig. 50, apply tangent to the base and also to the top a line parallel to the projection of the ray of light on these planes, that is, a T-square line, and this will mark the beginning and ending of the shade line.

In Fig. 49 the projection of the ray of light diagonal $m\ l$ on the right-hand face is $e\ l$, a 30° line; hence, in Fig. 51, where the base is similarly placed, apply the 30° triangle tangent as indicated, determining the shade line of the base. If the ellipse on the left-hand face of the cube were the base of a cone or cylinder extending backward to the right, the same principle would be used.

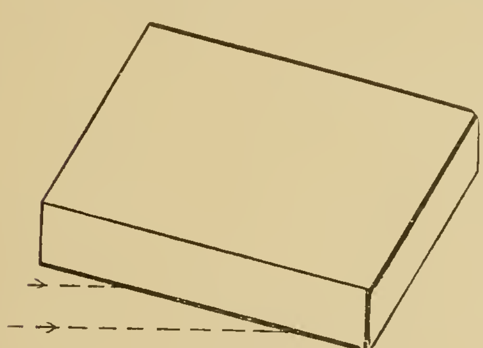


Fig. 52.

The projection of the cube diagonal $m\ l$ on that face is $m\ n$, a 60° line; hence the 60° triangle would be used tangent to the base in this last supposed case, giving the ends of the shade line at points o and r. Figs. 52, 53 and 54 illustrate the same idea with respect to prisms, the direction of the projection of the ray of light on the plane of the base being used in each case to determine the light and dark faces and hence the shade lines.

In Fig. 52 a prism is represented standing on its base, so that the projection of the cube diagonal on the base (that is, a T-square line) is used to determine the light and dark faces as shown The prism in Fig. 53 has for its base a trapezium. The projection of the ray of light on this end is parallel to the diagonal of the face; hence the 60° triangle applied parallel to this diagonal shows that faces *a c d b* and *a g h b* are light, while *c e f d* and *g e f h* are dark, hence the shade lines as shown.

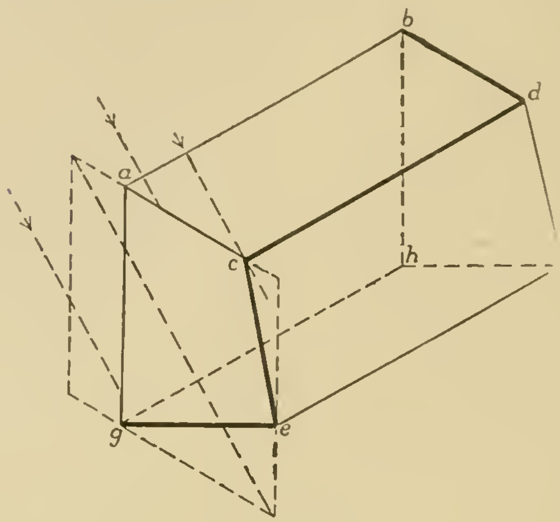


Fig. 53.

The application in Fig. 54 is the same, the only difference being in the position of the prism, and the consequent difference in the direction of the diagonal.

Fig. 55 represents a block with smaller blocks projecting from three faces.

Fig. 56 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. 57 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 *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

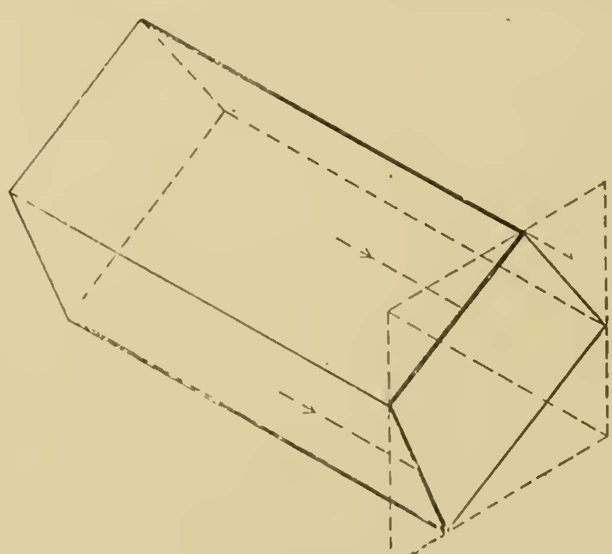


Fig. 54.

the end roof be given at A. This shows that the peak of the roof, 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.

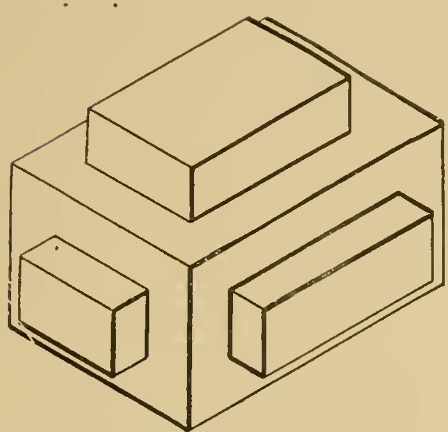


Fig. 55.

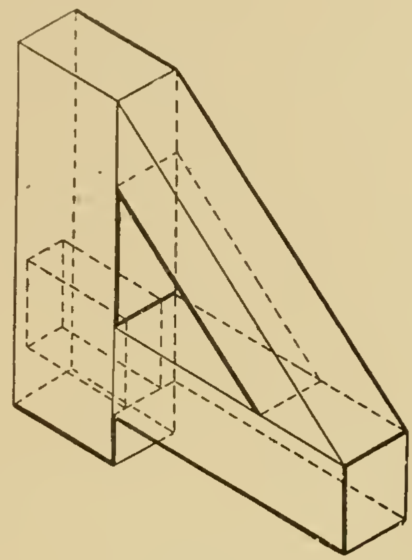


Fig. 56

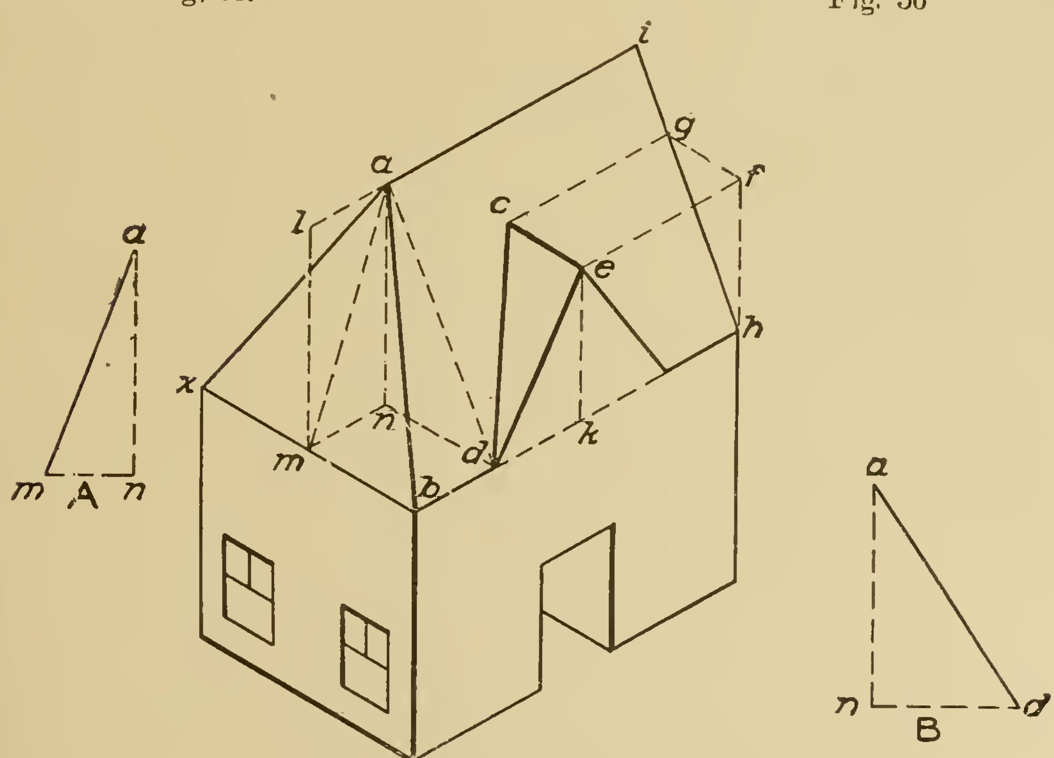


Fig. 57.

The height k e of the ridge of the dormer roof is known, and we must find 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 at 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.

In Fig. 58 a box is shown with the cover opened through 150°.

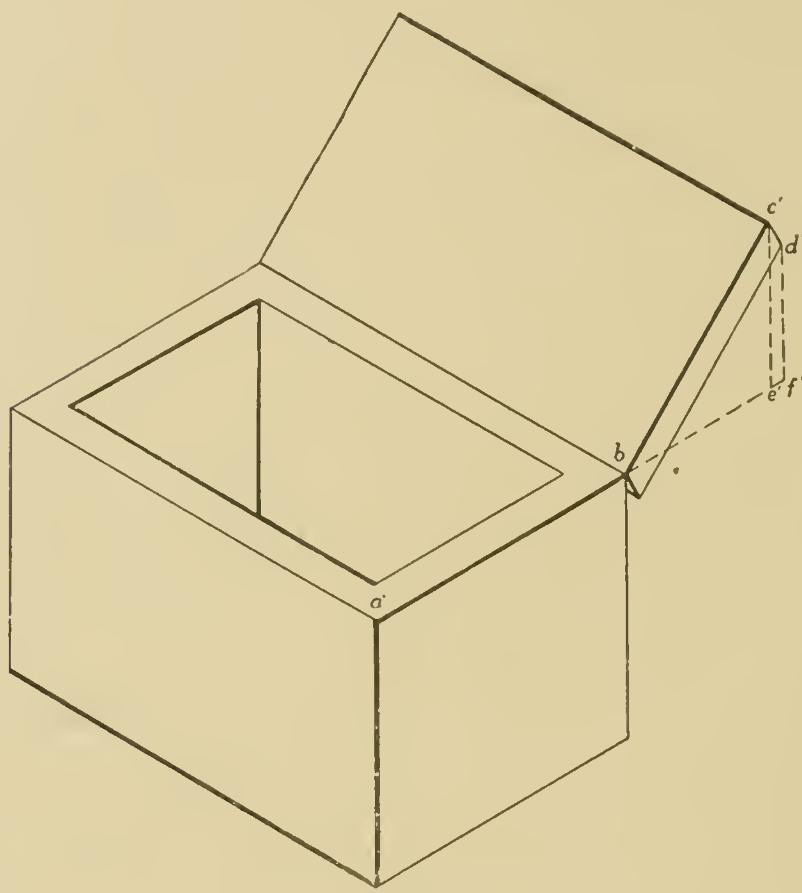


Fig. 58.

The right-hand edge of the bottom shows the width, the left-hand edge the length, and the vertical edge 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 coordinates 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. 59 will be sufficient. Extend the top of the box to the right, and from *c* and *d* let fall perpendiculars or *a b* produced, giving the points *e* and *f*. The point *c* may be located by means of the two distances or co-ordinates *b e* and *e c*,

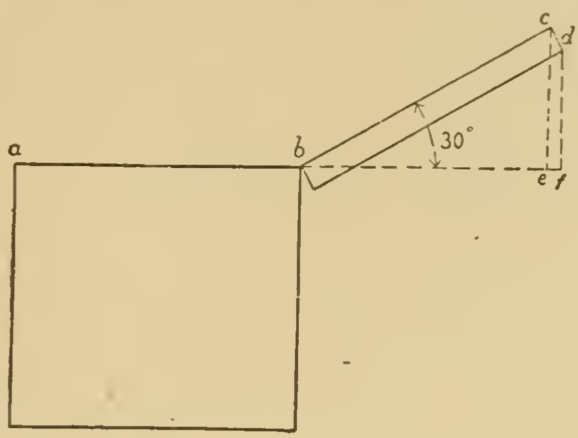


Fig. 59.

and these distances will appear in their true lengths in the isometric view. Hence produce *a′ b′* to *e′* and *f′*; and from these points draw verticals *e′ c′* and *f′ d′*; make *b′ e′* equal to *b e*, *e′ c′* equal to *e c*; and similarly for *d′*. Draw the lower edge parallel to *c′ d′* and equal to it in length, and connect with *b′*.

It will be seen that in isometric drawing parallel lines always appear parallel. It is also true that lines divided proportionally maintain this same relation in isometric drawing.

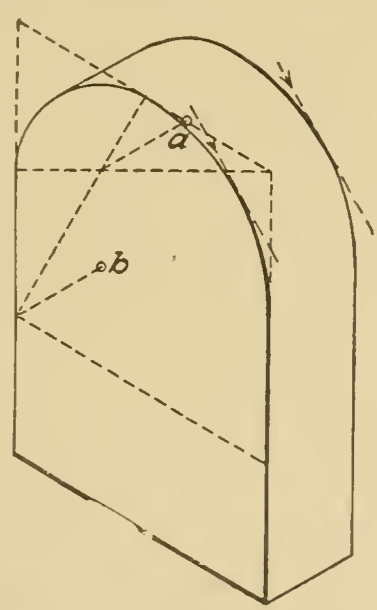


Fig. 60.

Fig. 60 shows a block or prism with a semicircular top. Find the isometric of the square circumscribing the circle, then draw the curve by the approximate method. The centers for the back face are found by projecting the front centers back 30° equal to the thickness of the prism, as shown at *a* and *b*. The plan and elevation of an oblique pentagonal pyramid are shown in Fig. 61. It is evident that none of the edges of the pyramid can be drawn in isometric as either vertical or 30° lines; hence, a system of co-ordinates must be used as shown in Fig. 58. 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 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. 62, *o* being the same point in both figures.

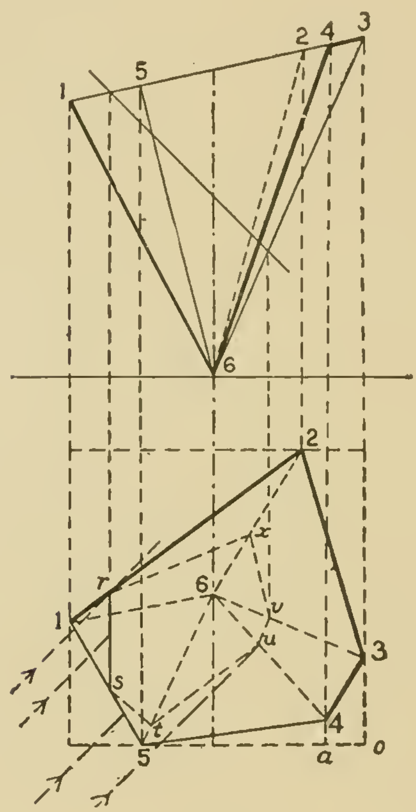


Fig. 61.

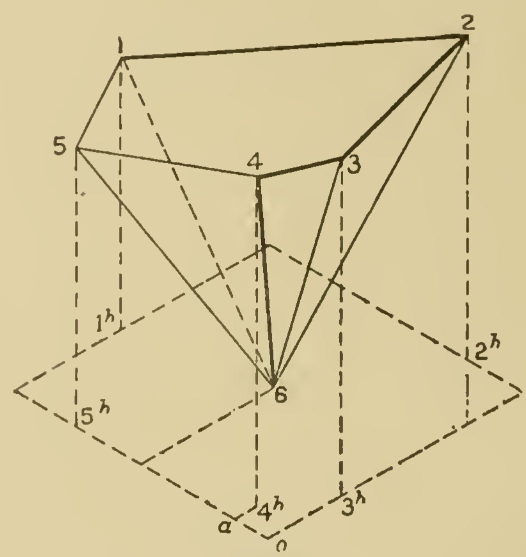


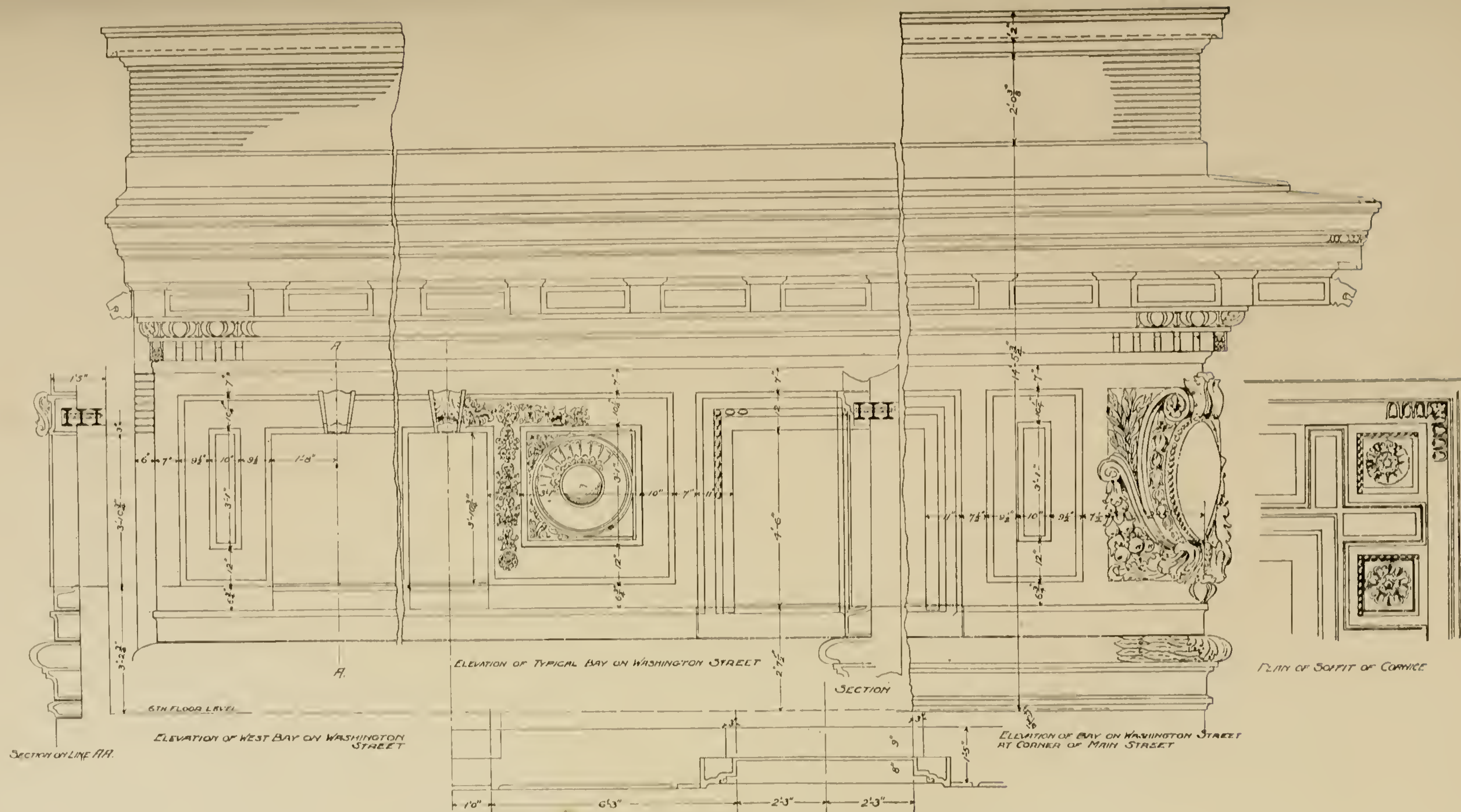
Fig. 62.

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, *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 4, draw 4 *a* parallel to the side of the rectangle; then lay

"THE OLIVER" (HOTEL), SOUTH BEND, IND.

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

For Plans, See Page 106; for Section and Elevation, See Page 122. Details of Main Cornice Shown on Opposite Page.



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.

off $o\ a$ and $a\ 4^h$, giving what may be called the isometric plan of 4 Next, the vertical height taken from the elevation locates the isometric of the point in space.

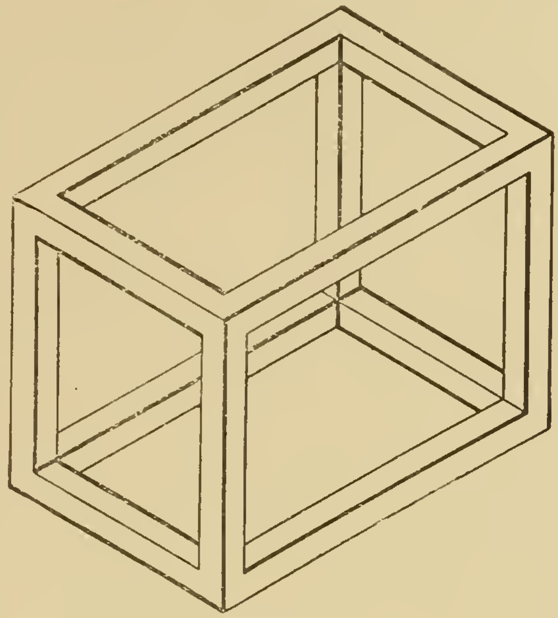


Fig. 63.

In like manner all the corners of the pyramid, including the apex, are located. The rule is, *locate first in isometric the horizontal projection of a point by one or two 30° co-ordinates; then vertically, above this point, its height as taken from the elevation.* The shade lines cannot be determined here by applying the 30° or 60° triangle, owing to the obliquity of the faces. Since the right front corner of the rectangle in plan was made the point o in isometric, the shade lines must be the same in isometric as in actual projection; so that, if these can be determined in Fig. 61, they may be applied at once to Fig. 62.

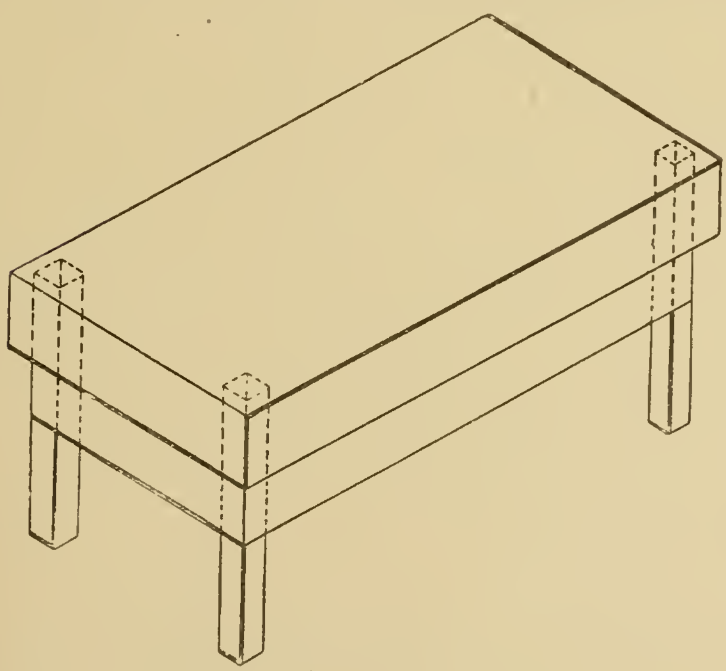


Fig. 64.

The shade lines in Fig. 61 are found by a short method which is convenient to use when the exact shade lines are desired, and when they cannot be determined by applying the 45° triangle. A plane is taken at 45° with the horizontal plane, and parallel to the direction of the ray of light, in such a position as to cut all the surfaces of the pyramid, as shown in elevation. This plane is perpendicular to the vertical plane; hence the section it cuts from the pyramid is readily found in plan by projection. This plane contains some of the rays of light falling upon the pyramid; and we can tell what surfaces these rays strike

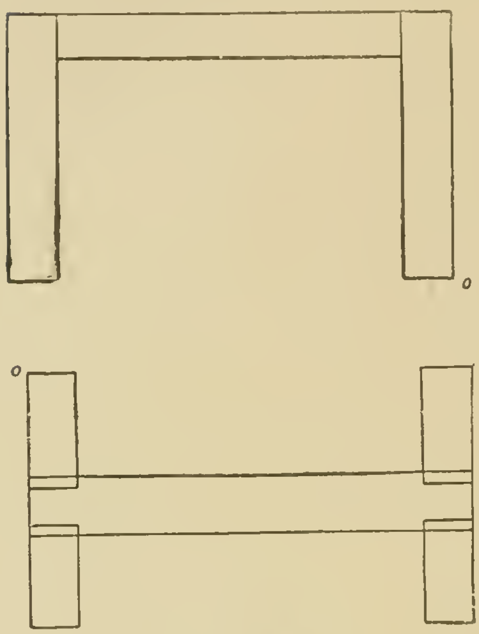


Fig. 65.

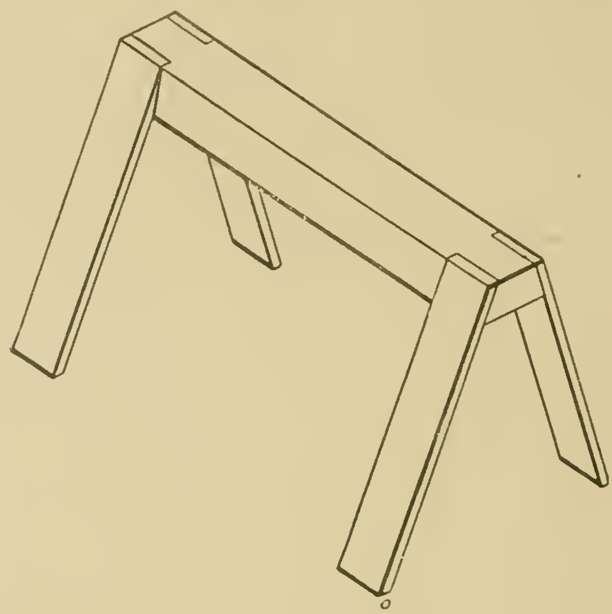


Fig. 66.

Fig. 67.

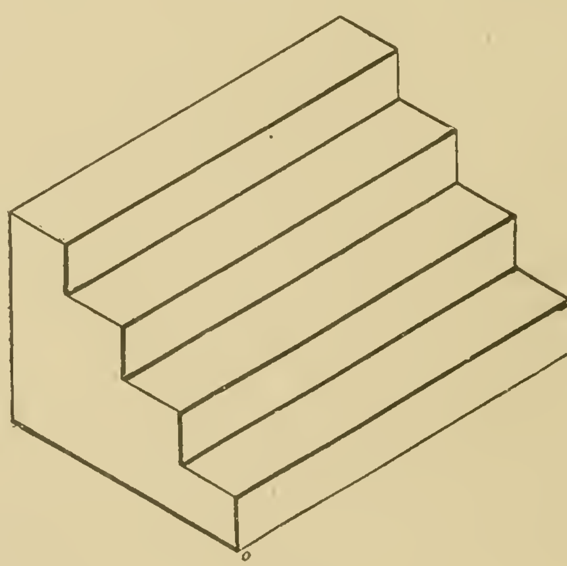


Fig. 68.

and make light, by noticing on the plan what edges of the section are struck by the projections of the rays of light. That is, $r\,s$, $s\,t$, and $t\,u$ receive the rays of light; hence the surfaces on which these lines lie are light. $r\,s$ is on the surface determined by the two lines passing through r and s, namely, 2 — 1 and 1 — 5; in other words, $r\ s$ is on the base; similarly, $s\ t$ is on the surface 1 — 5 — 6; and $t\ u$ on the surface 4 — 6 — 5. The other surfaces are dark; hence the edges which are between the light and dark faces are the shade lines.

Whenever it is more convenient, a plane parallel to the ray of light and perpendicular to H may be taken, the section found in elevation, and the 45° triangle applied to this section. The same method may be used to determine the exact shade lines of a cone or cylinder in an oblique position.

Figs. 63 to 70 give examples of the isometric of various objects. Fig. 65 is the plan and elevation, and Fig. 66 the

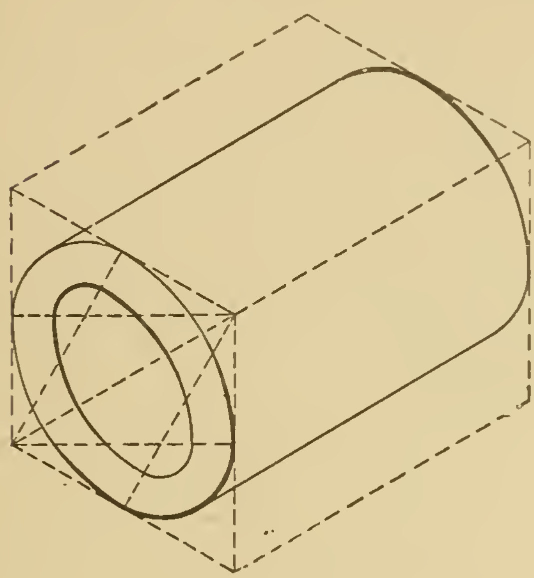


Fig. 69.

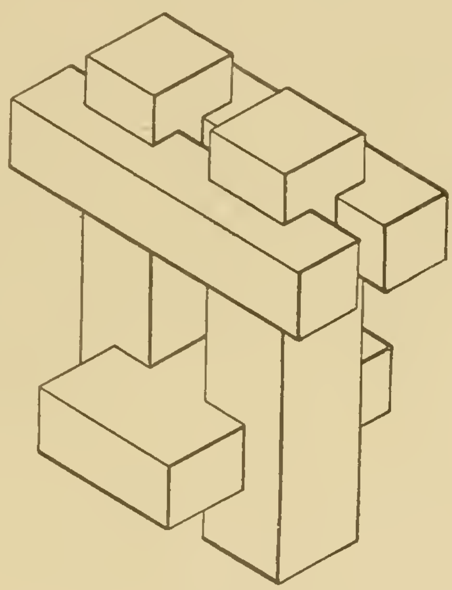


Fig. 70.

isometric, of a carpenter's bench. In Fig. 70, take especial notice of the shade lines. These are put on as if the group were made in one piece; and the shadows cast by the blocks on one another are disregarded. All upper horizontal faces are light, all left-hand (front and back) faces light, and the rest dark.

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 any object. Oblique projection differs from isometric in that one face of the object is represented as if parallel to the vertical plane of projection, the others inclined to it. Another point of difference is that oblique projection cannot be deduced from orthographic projection, as is isometric.

In oblique projection all lines in the front face are shown in their true lengths and in their true relation to one another, and lines which are perpendicular to this front face are shown in their true lengths at any angle that may be desired for any particular case. Lines not in the plane of the front face nor perpendicular

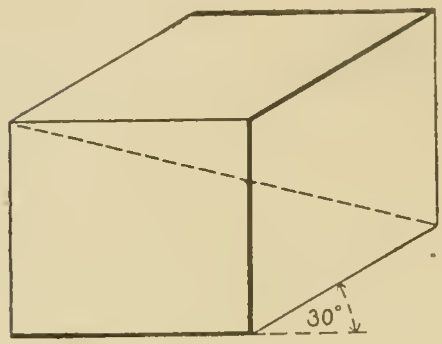


Fig. 71.

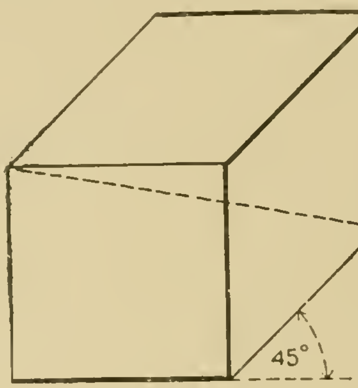


Fig. 72.

to it must be determined by co-ordinates, as in isometric. It will be seen at once that this system possesses some advantages over the isometric, as, for instance, in the representation of circles,

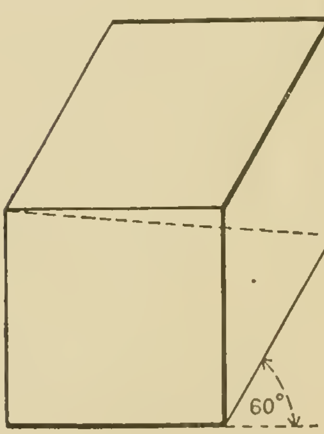


Fig. 73.

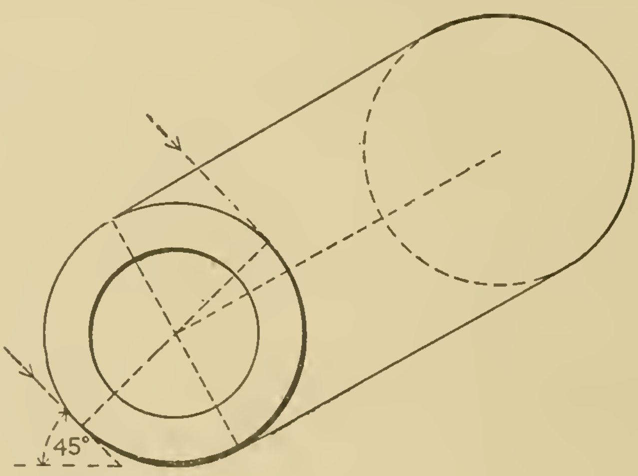


Fig. 74.

as any circle or curve in the front face is actually drawn as such.

The rays of light are still supposed to be parallel to the same diagonal of the cube, that is, sloping downward, toward the plane of projection, and to the right, or downward, backward and to the right. Figs. 71, 72 and 73 show a cube in oblique projection, with the 30°, 45° and 60° slant respectively. The dotted diagonal represents for each case the direction of the light, and the shade lines follow from this.

The shade lines have the same general position as in isometric

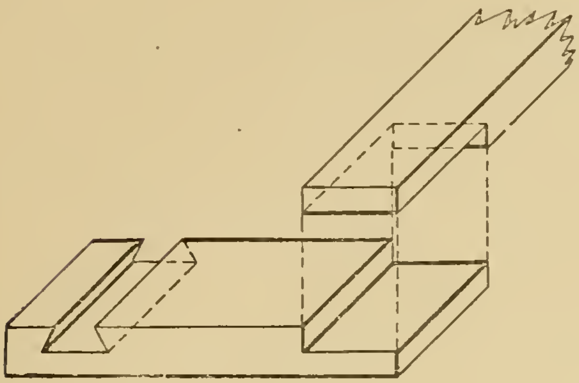


Fig. 75.

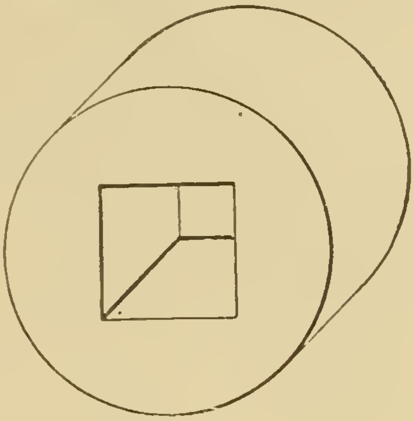


Fig. 76.

drawing, the top, front and left-hand faces being light. No matter what angle may be used for the edges that are perpendicular to the front face, the projection of the diagonal of the cube on this face is always a 45° line; hence, for determining the shade lines on

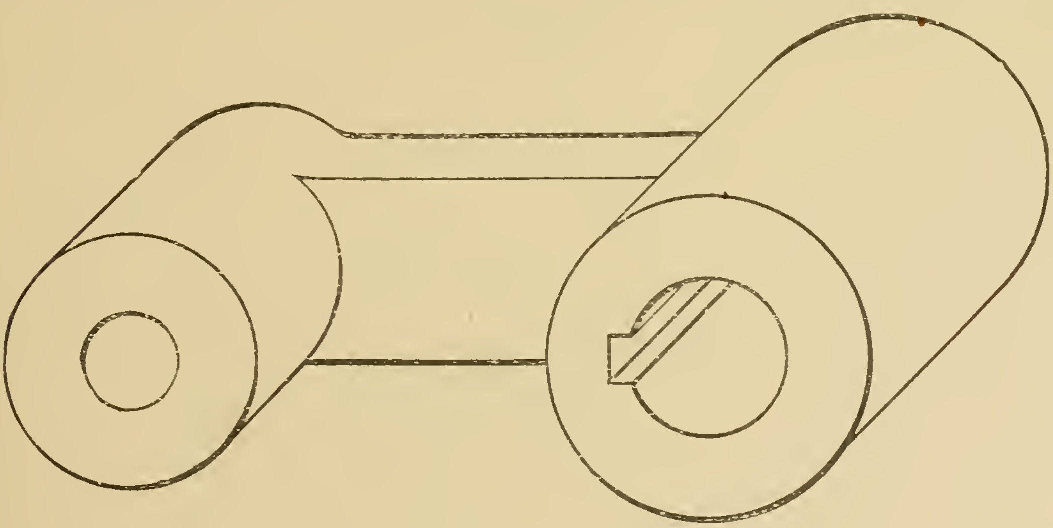


Fig. 77.

any front face, such as the end of the hollow cylinder in Fig. 74, the 45° line is used exactly as in the elevation of ordinary projections.

Figs. 75, 76, 77 and 79 are other examples of oblique projections. Fig. 77 is a crank arm.

The method of using co-ordinates for lines of which the true lengths are not shown, is illustrated by Figs. 78 and 79. Fig. 79 represents the oblique projection of the two joists shown in plan and elevation in Fig. 78. The dotted lines in the elevation (see Fig. 78) 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.

In Fig. 79 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 (see Fig. 78). From this point draw a dotted line parallel to the

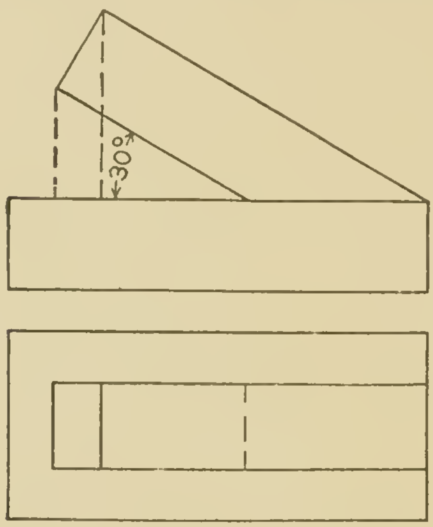


Fig. 78.

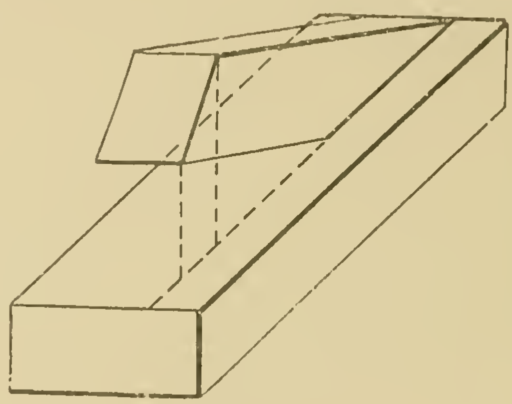


Fig. 79

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. 78, 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 are closer together and heavier on the darker part.

Fig. 80 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, but give the effect of graduation of light. The result is that in elevation the distances between the elements gradually lessen from the 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. 81 to 87.

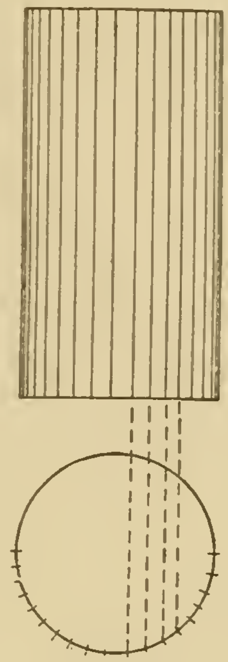


Fig. 80.

Cylinders are often shaded with the light coming in the usual way, the darkest part commencing about where the shade line would actually be on the surface, and the lightest portion a little to the left of the center. Fig. 81 is a cylinder showing the heaviest shade at the right, as this method is often used. Considerable practice is necessary in order to obtain good results; but in this, as in other portions of mechanical drawing, perseverance has its reward. Fig. 82 represents a cylinder in a horizontal position, and Fig. 83 represents a section of a hollow vertical cylinder.

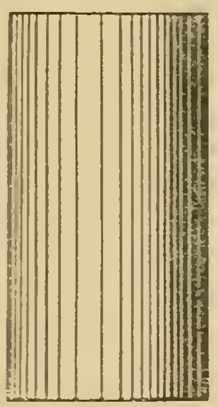


Fig. 81.

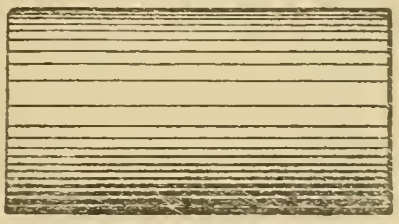


Fig. 82.

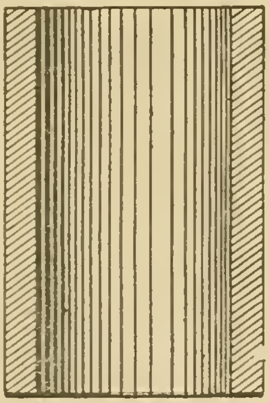


Fig. 83.

Figs. 84 to 87 give other examples of familiar objects.

In the elevation of the cone shown in Fig. 87 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.

All working drawings require more or less lettering, such as titles, dimensions, explanations, etc. In order that the drawing may appear finished, the lettering must be well done. No style of lettering should ever be used which is not perfectly legible. It is generally best to use plain, easily-made letters which present

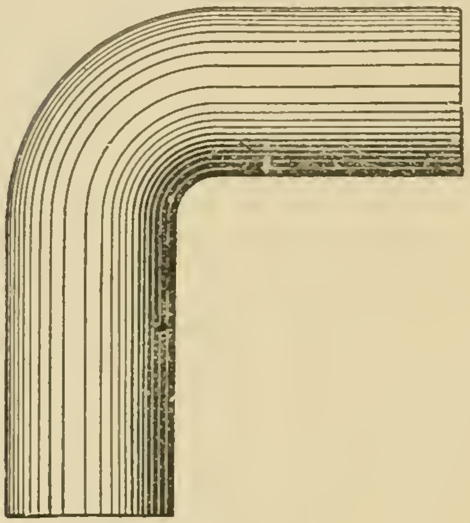


Fig. 84.

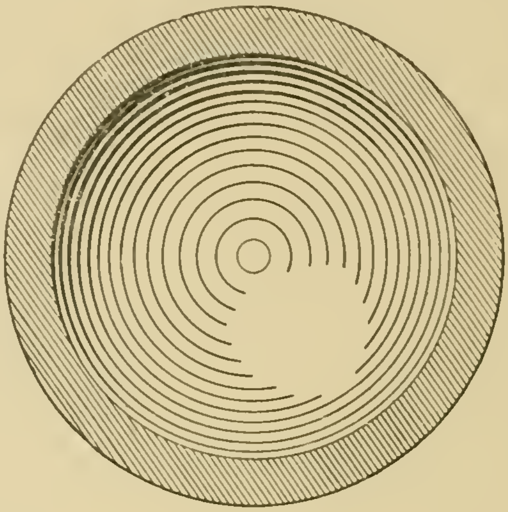


Fig. 85.

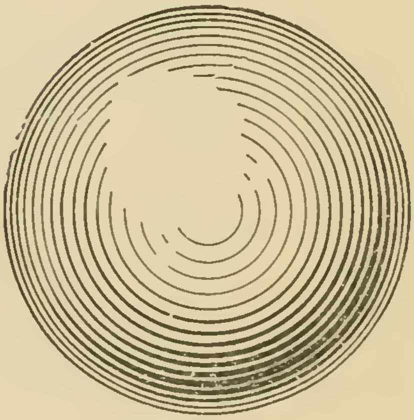


Fig. 86.

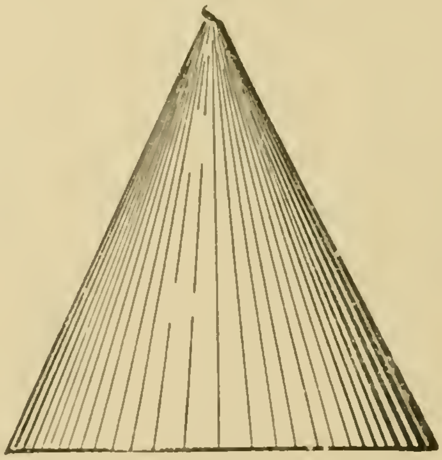


Fig. 87.

a neat appearance. Small letters used on the drawing for notes or directions should be made free-hand with an ordinary writing pen. Two horizontal guide lines should be used to limit the height of the letters; after a time, however, the upper guide line may be omitted.

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. 88. 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.

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 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 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, 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 or inclined, are quite ornamental in effect if well made, the inclined Roman being a particularly attractive letter, although rather difficult to make. The block letter is made on the same general plan as the Gothic, but much heavier. Small squares are taken as

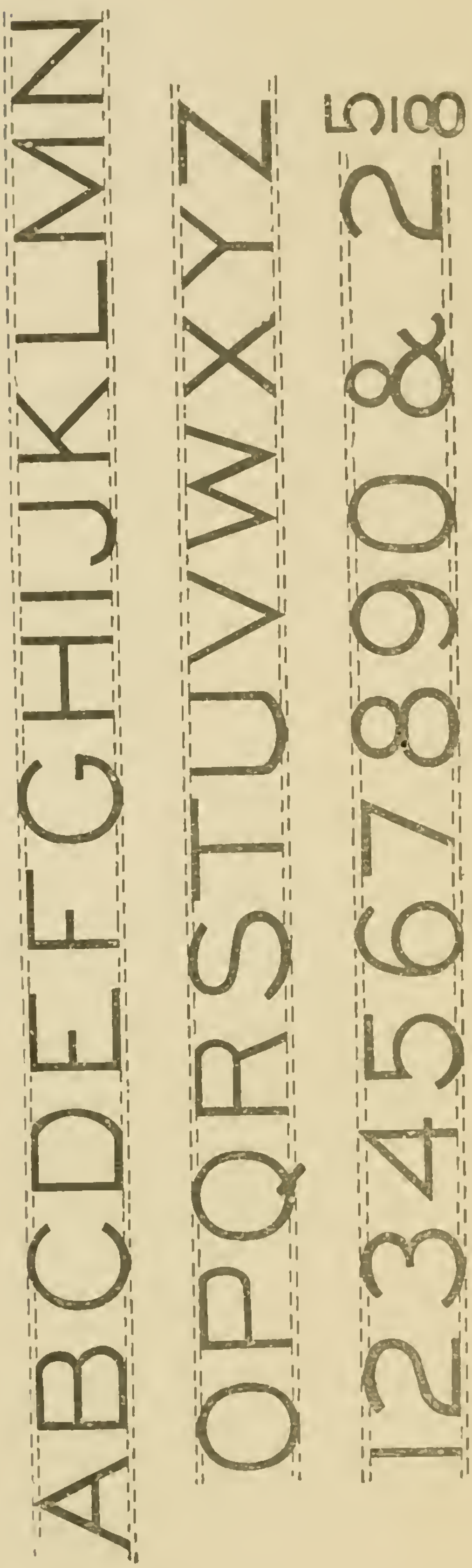
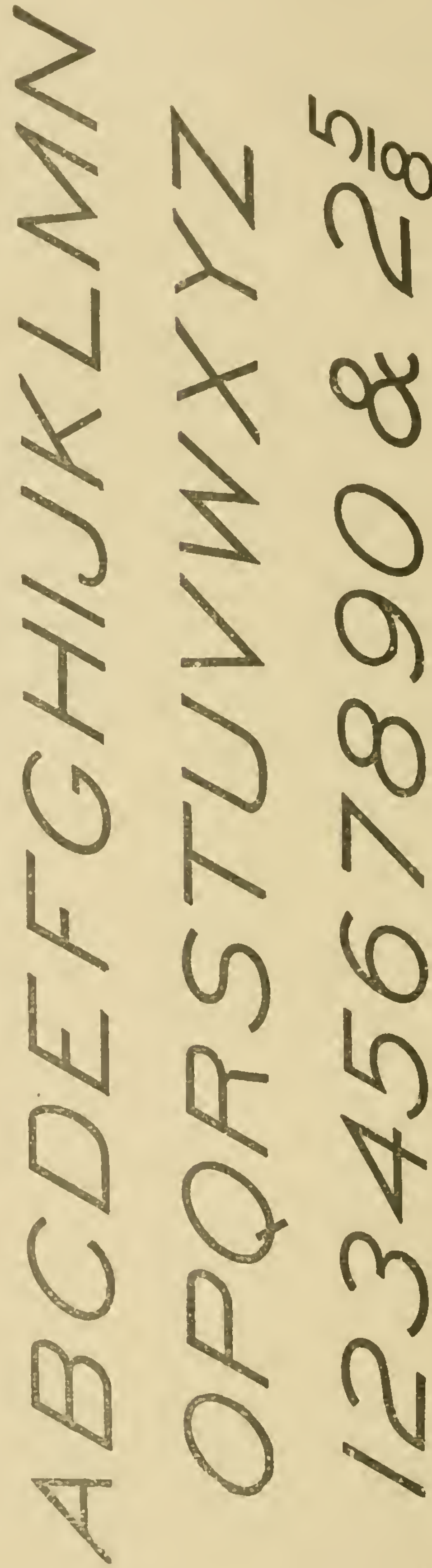


Fig 88. Vertical Gothic Capitals.



Inclined Gothic Capitals.

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 corresponding 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,

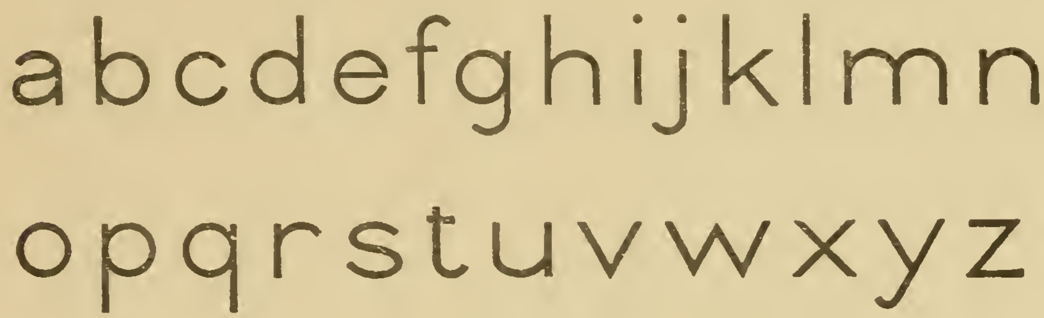


Fig. 89.

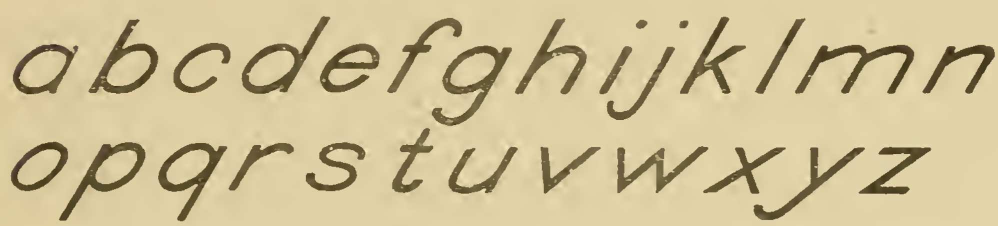


Fig. 90.

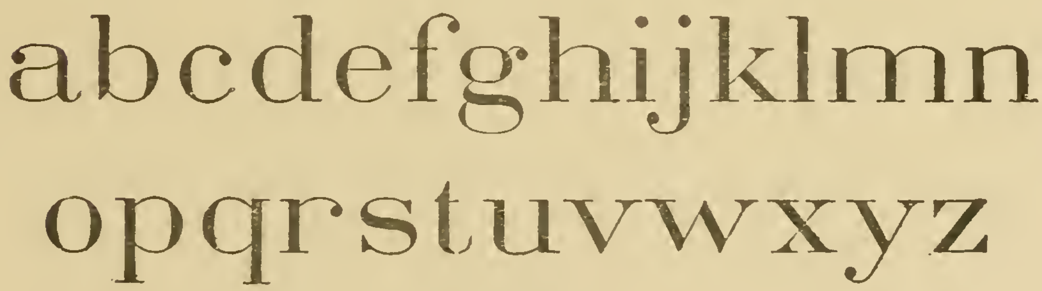


Fig. 91.

the 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. 89, 90, 91 and 92. The Gothic letters shown in Figs. 89 and 90 are much easier to make than the Roman letters in Figs. 91 and 92. These letters, however, do not

ABCDEFGHIJKLMN

OPQRSTUVWXYZ

1234567890 & $2\frac{5}{8}$

Vertical Roman Capitals.

ABCDEFGHIJKLMN

OPQRSTUVWXYZ

1234567890 & $2\frac{5}{8}$

Inclined Roman Capitals.

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.

One of the most important points to be remembered in lettering is the spacing. If the letters are finely executed but poorly spaced, the effect is not good. To space letters correctly and rapidly, requires considerable experience; and rules are of little value on account of the many combinations in which letters are

abcdefghijklmn

opqrstuvwxyz

Fig. 92.

found. A few directions, however, may be found helpful. For instance, take the word TECHNICALITY, Fig. 93. If all the spaces were made equal, the space between the L and the I would appear to be too great, and the same would apply to the space between the I and the T. The space between the H and the N and that between the N and the I would be insufficient. In general, when the vertical side of one letter is followed by the vertical side of another, as in H E, H B, I R, etc., the maximum space

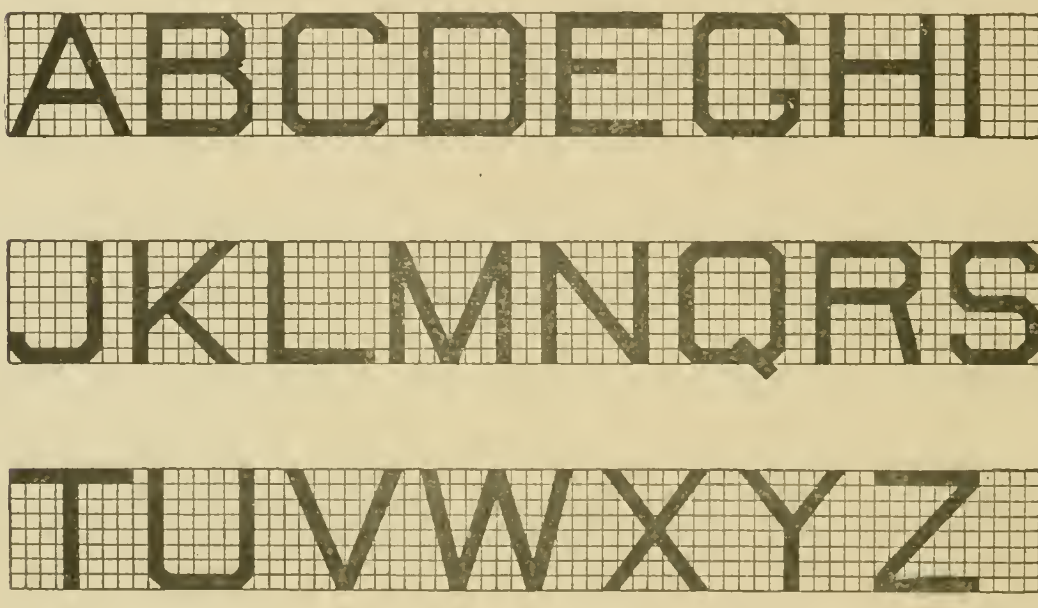
TECHNICALITY

Fig. 93.

should be allowed. Where T and A come together the least space is given, for in this case the top of the T frequently extends over the bottom of the A. In general, the spacing should be such that a uniform appearance is obtained. For the distances between words in a sentence, a space of about $1\frac{1}{2}$ the width of the average letter may be used. The space, however, depends largely upon the desired effect.

For large titles, such as those placed on charts, maps, and some large working drawings, the letters should be penciled before inking. If the height is made equal to the width considerable time and labor will be saved in laying out the work. This is especially true with such Gothic letters as O, Q, C, etc., as these letters may then be made with compasses. If the letters are of sufficient size, 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



Block Letters. .

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 shall be used. 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 we frequently find a portion of the title lettered on an arc of a circle.

In Fig. 94 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. 94. Then draw horizontal lines for the 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.

Fig. 94.

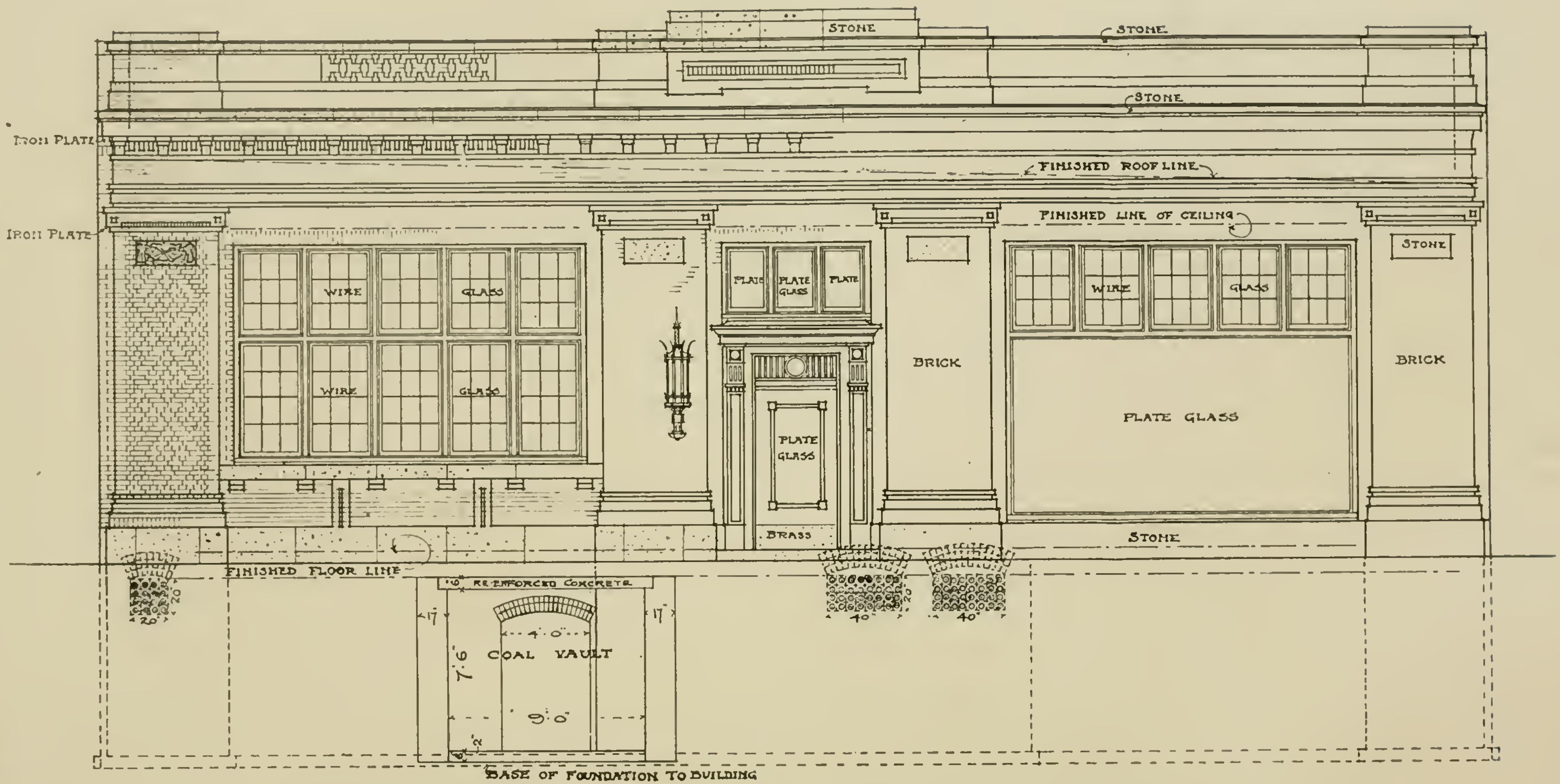
These lines will be the centers of the letters, as shown at A, B, D and E. The vertical lines of the letters should not radiate from the center of the arc, but should be parallel to the center lines already drawn; otherwise the letters will appear distorted. Thus, in the letter N the two verticals are parallel to the line A. The same applies to the other letters in the alphabet.

Tracing. Having finished the pencil drawing, the next step is the inking. In some offices the pencil drawing is made on a thin, tough paper, called board paper, and the inking is done over the pencil drawing, in the manner with which the student is already familiar. It is more common to do the inking on thin, transparent cloth, called tracing cloth, which is prepared for the purpose. This tracing cloth is made of various kinds, the kind in ordinary use being what is known as "dull back," that is, one side is finished and the other side is left dull. Either side may be used to draw upon, but most draftsmen prefer the dull side. If a drawing is to be traced it is a good plan to use a 3H or 4H pencil, so that the lines may be easily seen through the cloth.

The tracing cloth is stretched smoothly over the pencil drawing and a little powdered chalk rubbed over it with a dry cloth, to remove the slight amount of grease or oil from the surface and make it take the ink better. The dust must be carefully brushed or wiped off with a soft cloth, after the rubbing, or it will interfere with the inking.

The drawing is then made in ink on the tracing cloth, after the same general rules as for inking the paper, but care must be taken to draw the ink lines exactly over the pencil lines which are on the paper underneath, and which should be just heavy enough to be easily seen through the tracing cloth. The ink lines should be firm and fully as heavy as for ordinary work. In tracing, it is better to complete one view at a time, because if parts of several views are traced and the drawing left for a day or two, the cloth is liable to stretch and warp so that it will be difficult to complete the views and make the new lines fit those already drawn and at the same time conform to the pencil lines underneath. For this reason it is well, when possible, to complete a view before leaving the drawing for any length of time, although of course on views in which there is a good deal of work this cannot always be done. In this case the draftsman must manipulate his tracing cloth and instruments to make the lines fit as best he can. A skillful draftsman will have no trouble from this source, but the beginner may at first find difficulty.

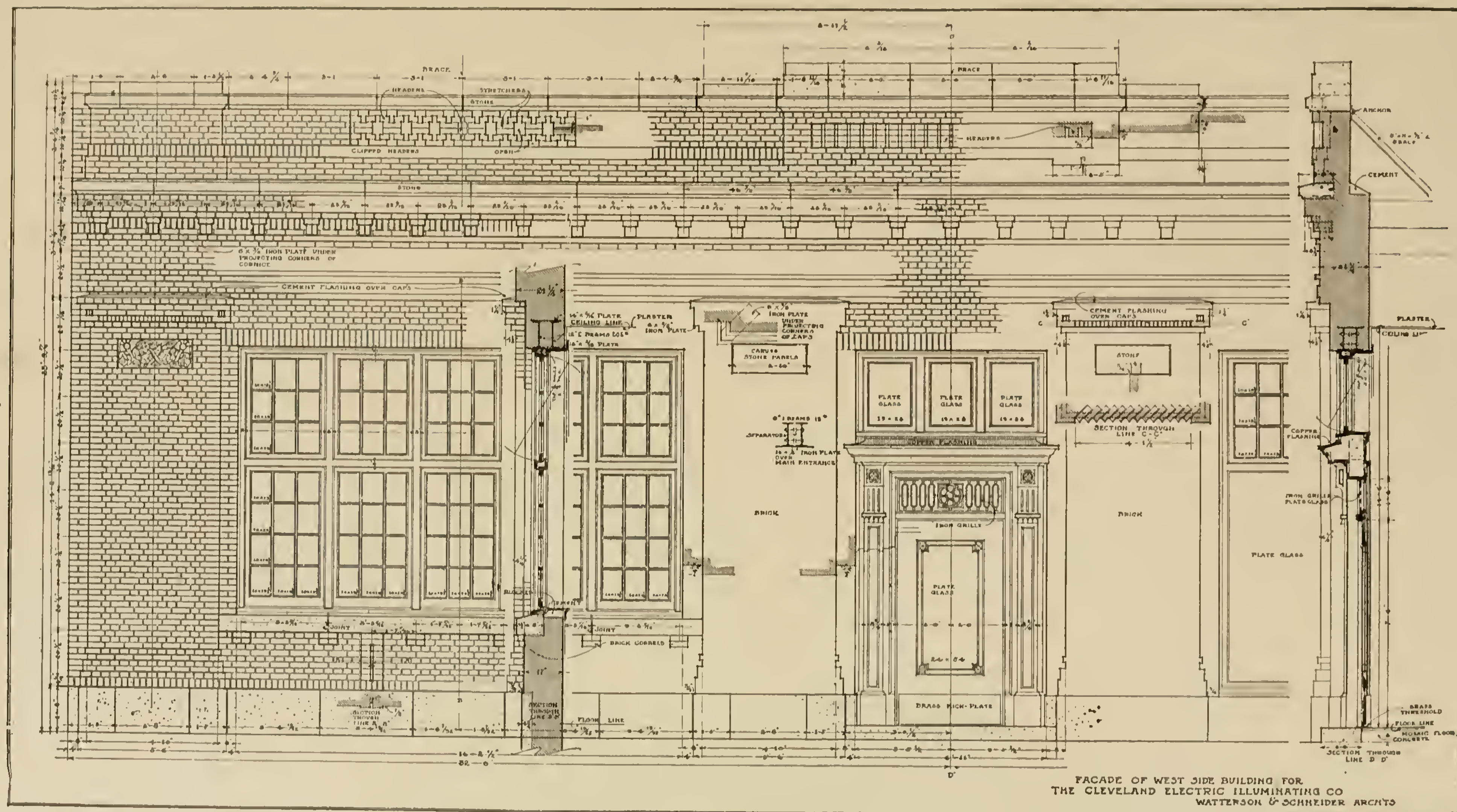
Inking on tracing cloth will be found by the beginner to be quite different from inking on the paper to which he has been accustomed, and he will doubtless make many blots and think at



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.

ABCDEFGHIJKLMN
OPQRSTUVWXYZ

Architectural Capitals.

ABCDEFGHIKLMN
OPQRSTVWXYZ

Architectural Capitals.

first that it is hard to make a tracing. After a little practice, however, he will find that the tracing cloth is very satisfactory and that a good drawing can be made on it quite as easily as on paper.

The necessity for making erasures should be avoided, as far as possible, but when an erasure must be made a good ink rubber or typewriter eraser may be used. If the erased line is to have ink placed on it, such as a line crossing, it is better to use a soft rubber eraser. All moisture should be kept from the cloth.

Blue Printing. The tracing, of course, cannot be sent into the shop for the workmen to use, as it would soon become soiled and in time destroyed, so that it is necessary to have some cheap and rapid means of making copies from it. These copies are made by the process of blue printing in which the tracing is used in a manner similar to the use made of a negative in photography.

Almost all drafting rooms have a frame for the purpose of making blue prints. These frames are made in many styles, some simple, some elaborate. A simple and efficient form is a flat surface usually of wood, covered with padding of soft material, such as felting. To this is hinged the cover, which consists of a frame similar to a picture frame, in which is set a piece of clear glass. The whole is either mounted on a track or on some sort of a swinging arm, so that it may readily be run in and out of a window.

The print is made on paper prepared for the purpose by having one of its surfaces coated with chemicals which are sensitive to sunlight. This coated paper, or blue-print paper, as it is called, is laid on the padded surface of the frame with its coated side uppermost; the tracing laid over it right side up, and the glass pressed down firmly and fastened in place. Springs are frequently used to keep the paper, tracing, etc., against the glass. With some frames it is more convenient to turn them over and remove the backs. In such cases the tracing is laid against the glass, face down; the coated paper is then placed on it with the coated side against the tracing cloth.

The sun is allowed to shine upon the drawing for a few minutes, then the blue-print paper is taken out and thoroughly washed in clean water for several minutes and hung up to dry.

If the paper has been recently prepared and the exposure properly timed, the coated surface of the paper will now be of a clear, deep blue color, except where it was covered by the ink lines, where it will be perfectly white.

The action has been this: Before the paper was exposed to the light the coating was of a pale yellow color, and if it had then been put in water the coating would have all washed off, leaving the paper white. In other words, before being exposed to the sunlight the coating was soluble. The light penetrated the transparent tracing cloth and acted upon the chemicals of the coating, changing their nature so that they became insoluble; that is, when put in water, the coating, instead of being washed off, merely turned blue. The light could not penetrate the ink with which the lines, figures, etc., were drawn, consequently the coating under these was not acted upon and it washed off when put in water, leaving a white copy of the ink drawing on a blue background. If running water cannot be used, the paper must be washed in a sufficient number of changes until the water is clear. It is a good plan to arrange a tank having an overflow, so that the water may remain at a depth of about 6 or 8 inches.

The length of time to which a print should be exposed to the light depends upon the quality and freshness of the paper, the chemicals used and the brightness of the light. Some paper is prepared so that an exposure of one minute, or even less, in bright sunlight, will give a good print and the time ranges from this to twenty minutes or more, according to the proportions of the various chemicals in the coating. If the full strength of the sunlight does not strike the paper, as, for instance, if clouds partly cover the sun, the time of exposure must be lengthened.

Assembly Drawing. We have followed through the process of making a detail drawing from the sketches to the blue print ready for the workmen. Such a detail drawing or set of drawings shows the form and size of each piece, but does not show how the pieces go together and gives no idea of the machine as a whole. Consequently, a general drawing or assembly drawing must be made, which will show these things. Usually two or more views are necessary, the number depending upon the complexity of the machine. Very often a cross-section through some part of the machine, chosen so as to give the best general idea with the least amount of work, will make the drawing clearer.

The number of dimensions required on an assembly drawing depends largely upon the kind of machine. It is usually best to give the important over-all dimensions and the distance between the principal center lines. Care must be taken that the over-all dimensions agree with the sum of the dimensions of the various details. For example, suppose three pieces are bolted together, the thickness of the pieces according to the detail drawing, being one inch, two inches, and five and one-half inches respectively; the sum of these three dimensions is eight and one-half inches and the dimensions from outside on the assembly drawing, if given at all, must agree with this. It is a good plan to add these over-all dimensions, as it serves as a check and relieves the mechanic of the necessity of adding fractions.

FORMULA FOR BLUE-PRINT SOLUTION.

Dissolve thoroughly and filter.

A.	Red Prussiate of potash	2½ ounces,
	Water	1 pint.
B.	Ammonio-Citrate of iron	4 ounces,
	Water	1 pint

Use equal parts of A and B.

FORMULA FOR BLACK PRINTS

Negatives. White lines on blue ground; prepare the paper with

Ammonio-Citrate of iron	40 grains,
Water	1 ounce.

After printing wash in water.

Positives. Black lines on white ground; prepare the paper with:

Iron perchloride	616 grains,
Oxalic Acid	308 grains,
Water	14 ounces.

Develop in	Gallic Acid	1 ounce,
	Citric Acid	1 ounce,
	Alum	8 ounces.

Use $1\frac{1}{4}$ ounces of developer to one gallon of water. Paper is fully exposed when it has changed from yellow to white.

PLATES.

PLATE IX.

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

First draw two ground lines across the sheet, 3 inches below the upper border line and 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. The line should be 1 inch from the vertical plane and the lower end $\frac{1}{2}$ inch above the horizontal.

3 Draw the projections of a line $1\frac{1}{2}$ inches long which is parallel to both planes, 1 inch above the horizontal, and $\frac{3}{4}$ 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, $\frac{1}{2}$ inch from V. The line to be 1 inch above H.

5. Draw the plan and elevation of a line $1\frac{1}{2}$ inches long which is perpendicular to the horizontal plane and 1 inch from the vertical. Lower end of line is $\frac{1}{2}$ inch above H.

6. Draw the projections of a line 1 inch long which is perpendicular to the vertical plane and $1\frac{1}{2}$ inches above the horizontal. The end of the line nearer V, or the back end, is $\frac{1}{2}$ inch from V.

PLATE IX

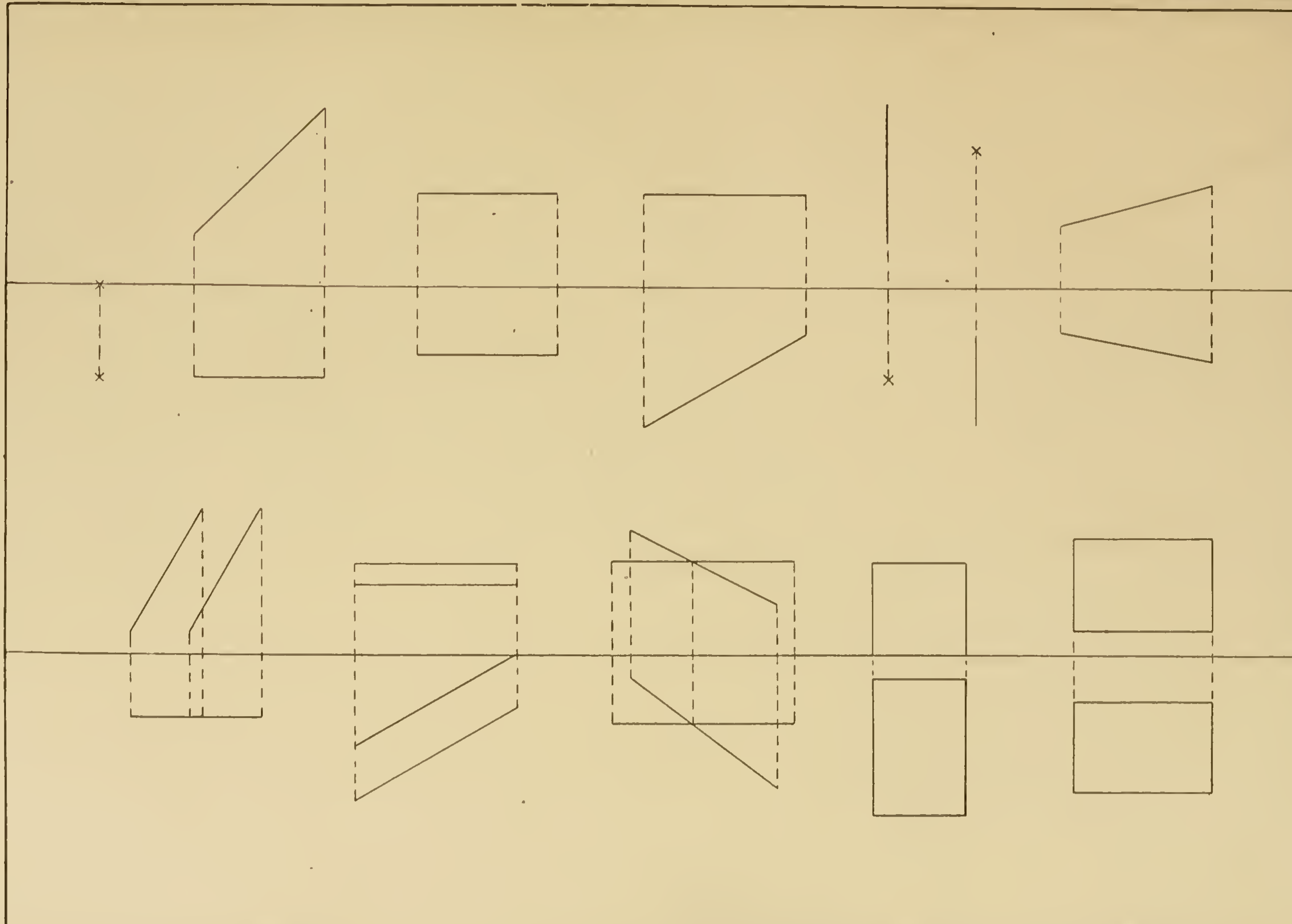


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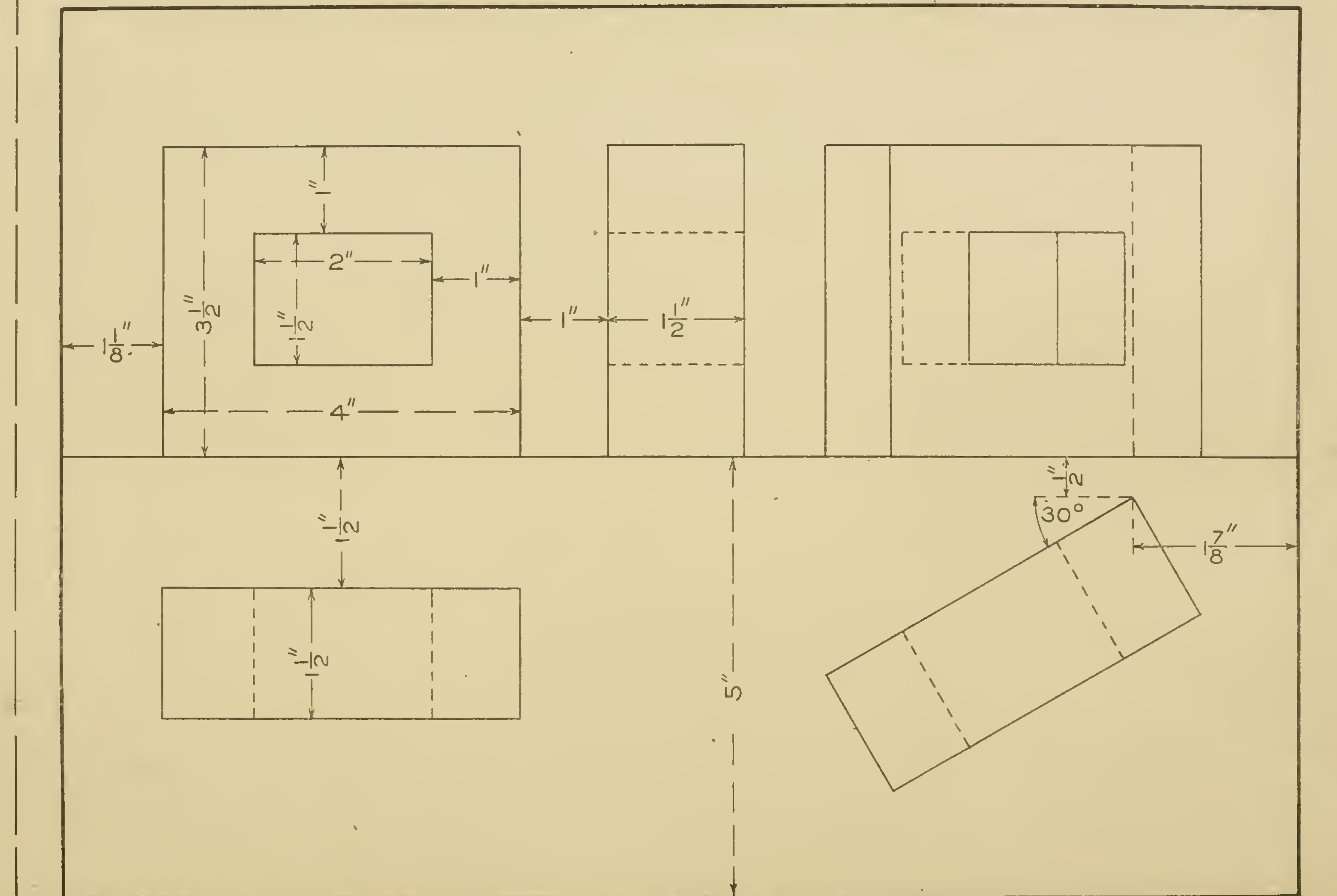
PLATE X



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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 Line:

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. Be careful not to omit the shade lines. 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 $\frac{3}{4}$ 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 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.

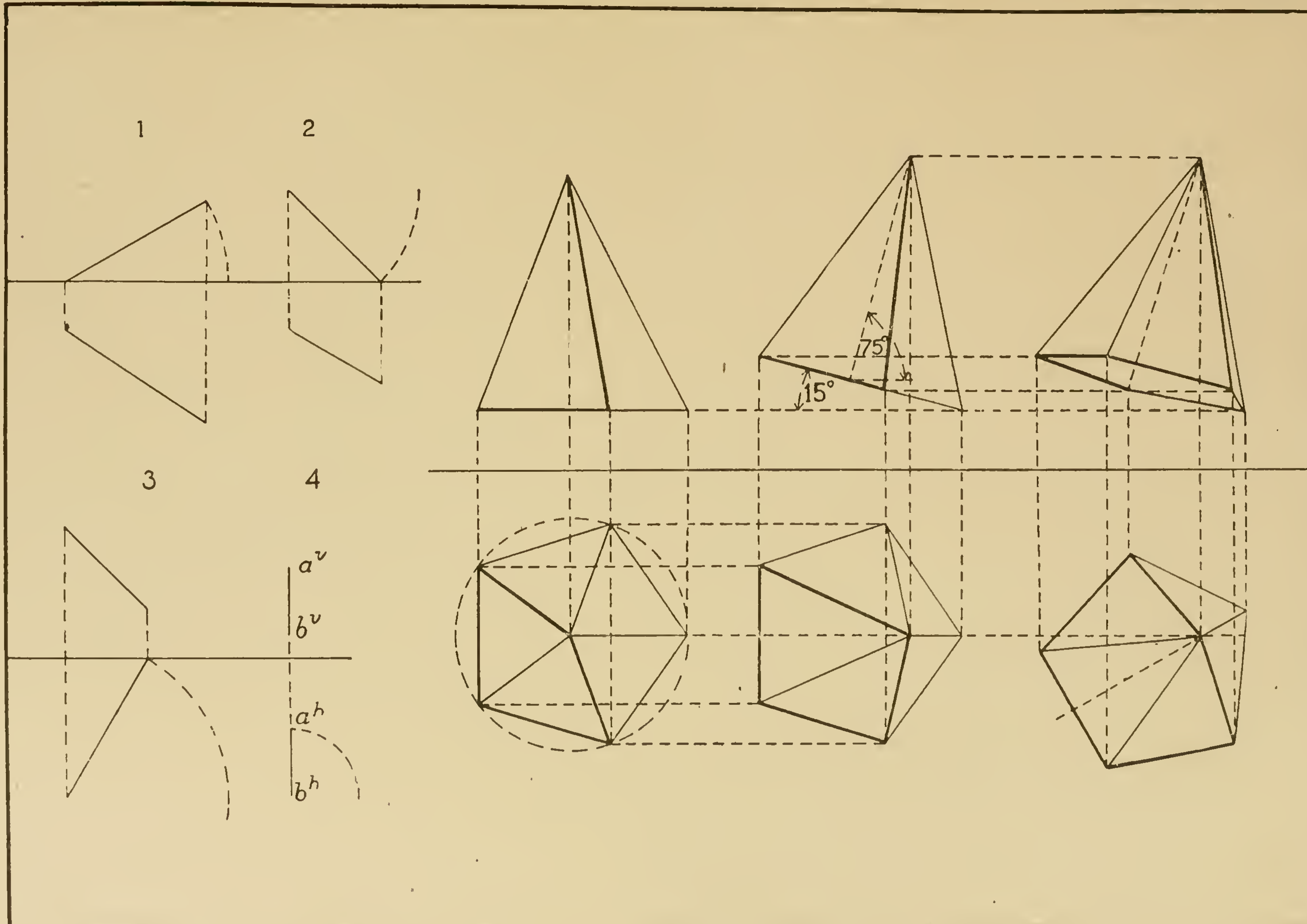
In Figs. 3 and 4, the true lengths are to be found by completing the revolutions indicated. The left-hand end of Fig. 3 is $\frac{3}{4}$ inch from the margin, $1\frac{1}{2}$ inches from V, and $1\frac{5}{8}$ inches above H. The horizontal projection makes an angle of 60° and extends to the ground line, 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

PLATE XI



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Part I. From the way in which the pyramid has been revolved, all angles with V must remain the same as in the first position, hence the vertical projection will be the same shape and size as before. All points of the pyramid remain the same distance from V. The points on the plan are found on T-square lines through the corners of the first plan and directly beneath the points in elevation. In the third position the pyramid has been swung around, about a vertical line through the apex as axis, through 30°. The angle with the horizontal plane remains the same; consequently the plan is the same size and shape as in the

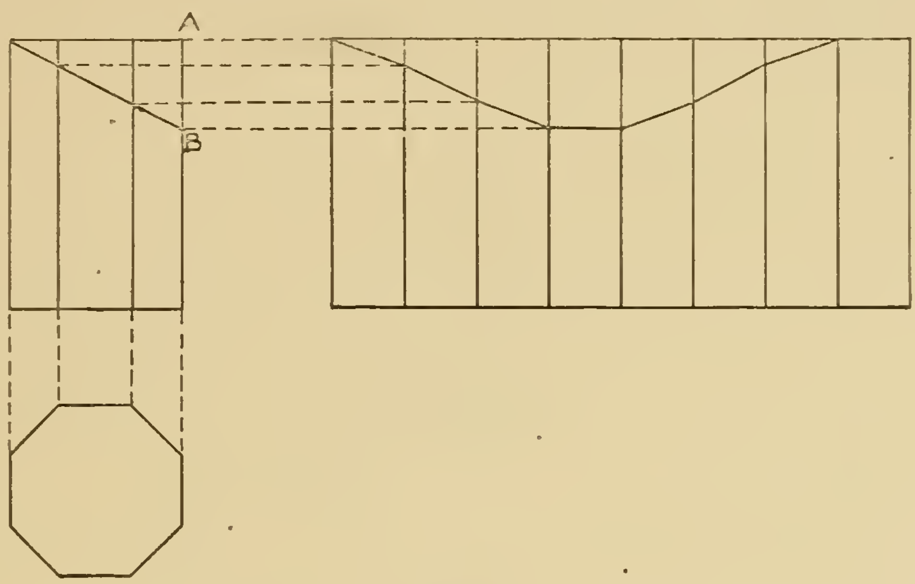


Fig. 96.

second position, but at a different angle with the ground line. Heights of all points of the pyramid have not changed this time, and hence are projected across from the second elevation. Shade lines are to be put on between the light and dark surfaces as determined by the 45° triangle.

PLATE XII.

Developments.

On this plate draw the developments of a truncated octagonal prism, and of a truncated pyramid having a square base. The arrangement on the plate is left to the student; but we should suggest that the truncated prism and its development be placed at the left, and that the development of the truncated pyramid be placed under the development of the prism; the truncated pyramid may be placed at the right.

The prism and its development are shown in Fig. 96. The 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 of construction lines to show clearly the method of finding the development.

The pyramid and its development are shown in Fig. 97. Each side of the square base is 2 inches, and the altitude is $3\frac{1}{2}$ inches.

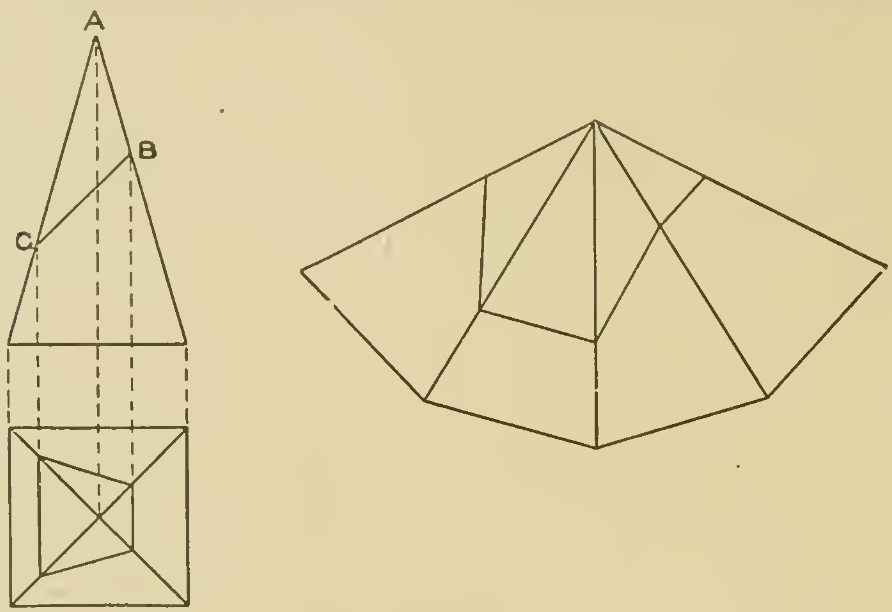


Fig. 97.

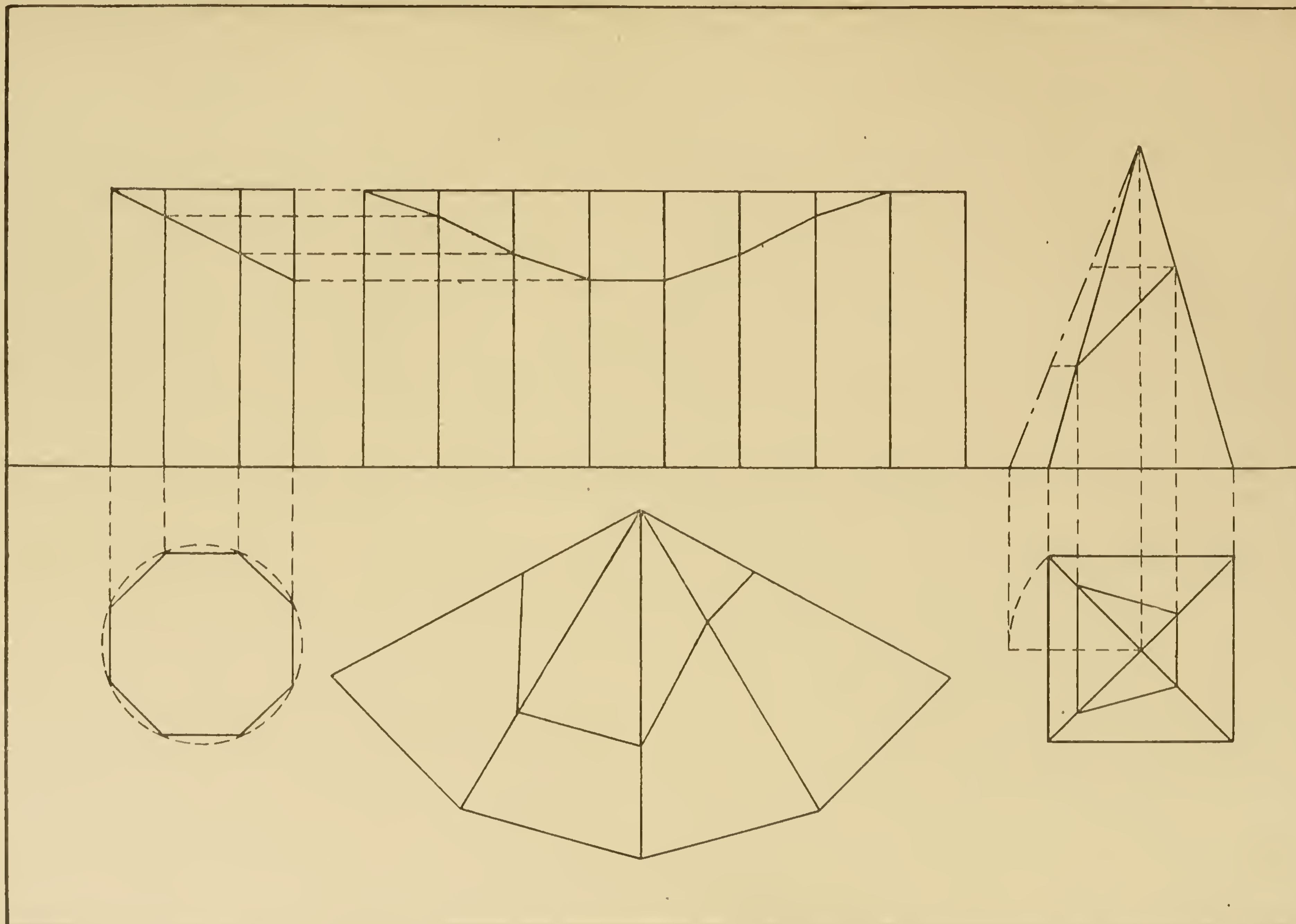
The plane forming the truncated pyramid is passed in such a position that A B equals $1\frac{3}{8}$ inches, and A C equals $2\frac{1}{2}$ inches. In this figure the development may be drawn in any convenient position, but in the case of the prism it is better to draw the development as shown. Indicate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

PLATE XIII.

Isometric and Oblique Projection.

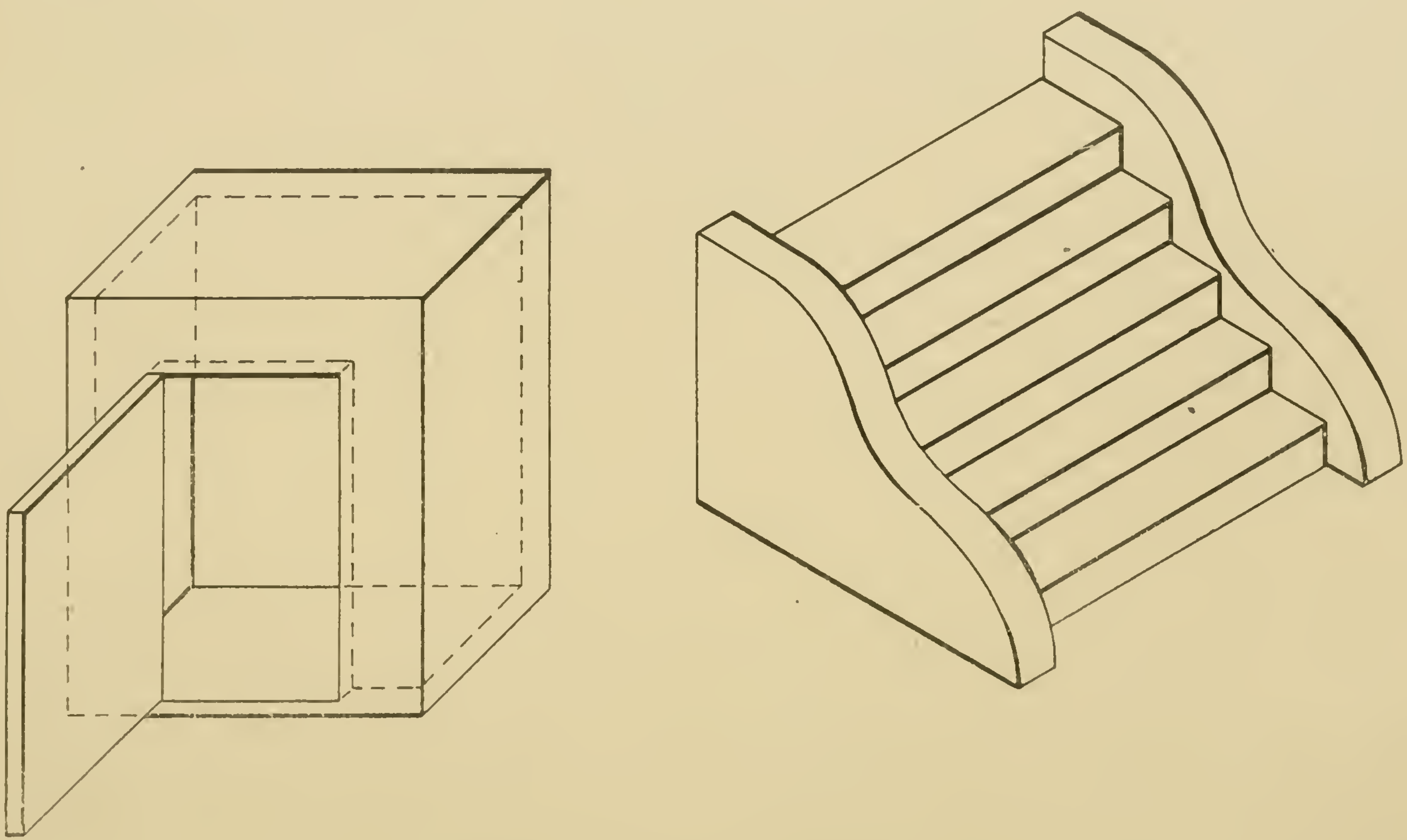
Draw the oblique projection of a portable closet. The angle to be used is 45°. Make the height $3\frac{1}{2}$ inches, the depth $1\frac{1}{2}$ inches, and the width 3 inches. See Fig. 98. The width of the closet

PLATE XII



MARCH 7, 1907 HERBERT CHANDLER CHICAGO, ILL.

PLATE XIII



MARCH 14, 1907 HERBERT CHANDLER CHICAGO, ILL.

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

Watterson & Schneider, Architects, Cleveland, Ohio.

For Front Elevation and Details, See Page 154.

MUSIC BUILDING FOR DOANE COLLEGE, CRETE, NEB.

Dean & Dean, Architects, Chicago, Ill.

For Plans and Section, See Page 186.

is to be shown as the left-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

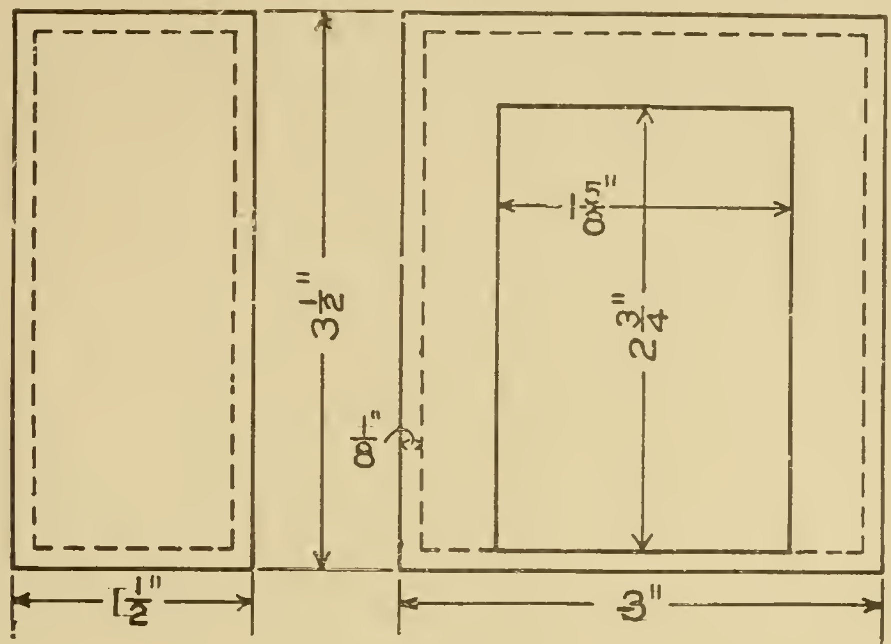


Fig. 98.

centrally in the front of the closet, the bottom edge at the height of the floor of the closet, the hinges of the door to be placed on the left-hand side. In the oblique drawing, show the door opened at an angle of 90 degrees. The thickness of the material of the closet, door, and floor is $\frac{1}{8}$ inch. The door should be hung so that when closed it will be flush with the front of the closet.

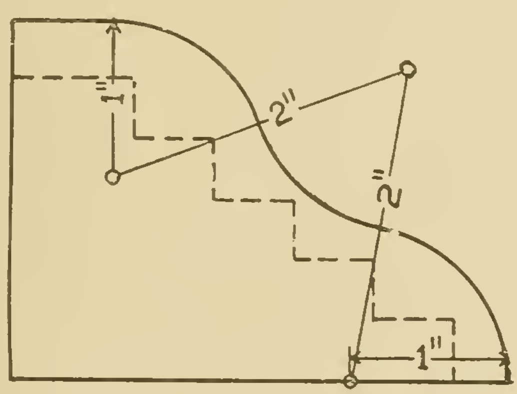


Fig. 99.

Make the isometric drawing of the flight of steps and end walls as shown by the end view in Fig. 99. The lower right-hand corner is to be located $2\frac{1}{4}$ inches from the lower, and 5 inches from the right-hand, margin. The base of the end wall is $3\frac{1}{8}$ inches long, and the height is $2\frac{1}{4}$ inches. Beginning from the back of the wall, the top is horizontal for $\frac{5}{8}$ inch, the remainder of the outline being composed of arcs of circles whose radii and centers are given in the figure. The thickness of the end wall is $\frac{3}{8}$ inch, and both ends are alike. There are to be five steps; each rise is to be $\frac{3}{8}$ inch, and each tread $\frac{1}{2}$ inch, except that of the top step, which is $\frac{3}{4}$ inch. The first step is located $\frac{3}{8}$ inch back from the corner of the wall. The end view of the wall 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 light-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

PLATE XI

COURSE

IN

MECHANICAL DRAWING

AMERICAN SCHOOL

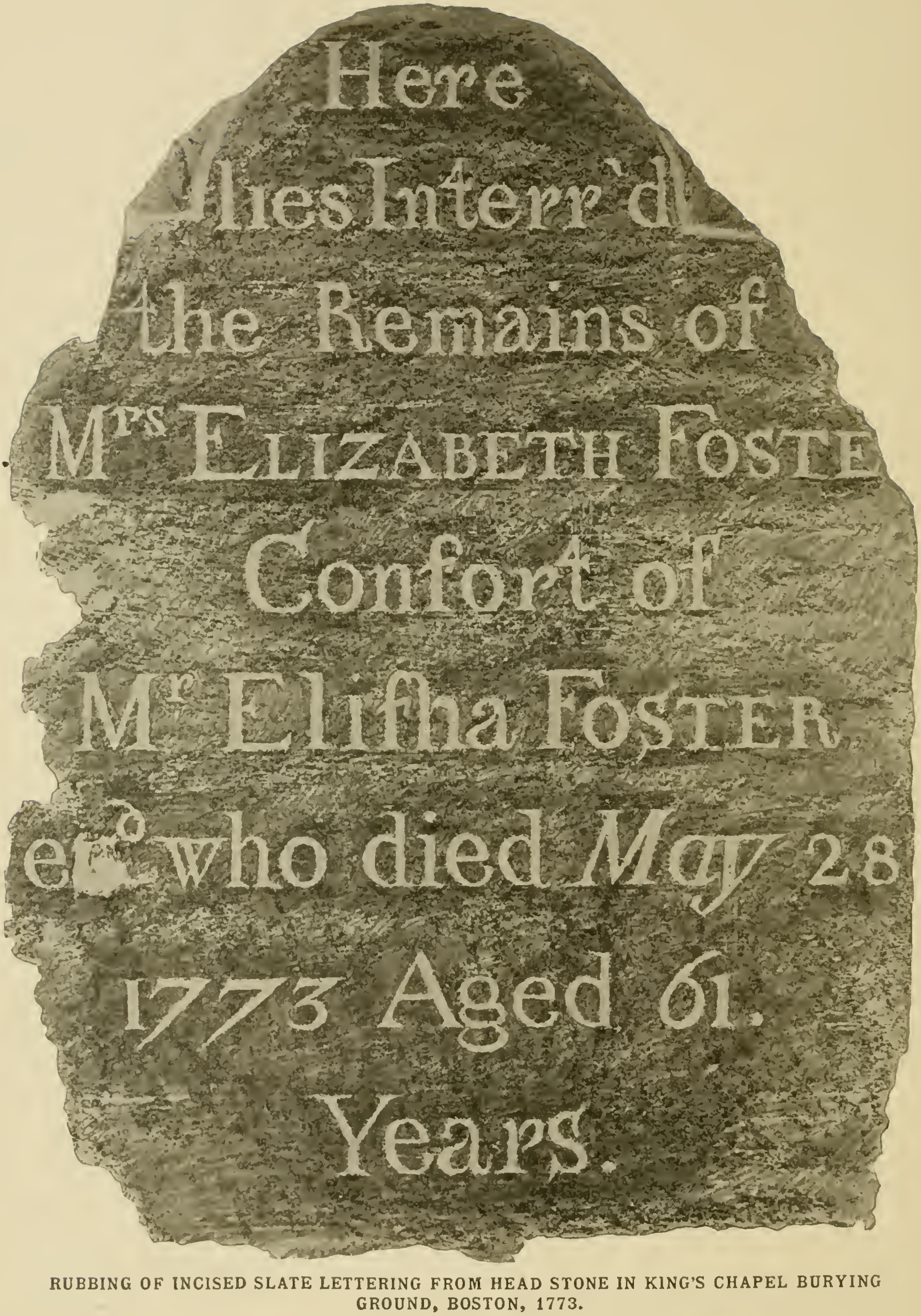
OF

CORRESPONDENCE

CHICAGO, ILL., U.S.A.

APRIL 24. 1907 — HERBERT CHANDLER — CHICAGO. ILL

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.

ARCHITECTURAL LETTERING.

Architectural lettering may be divided into two general classes. The first is for titling and naming drawings, as well as for such notes and explanations as it is usual or necessary to put upon them; this may well be called "Office Lettering." The second includes the use of letters for architectural inscriptions to be carved in wood or stone, or cast in metal: for this quite a different character of letter is required, and one that is always to be considered in its relation to the material in which it is to be executed, and designed in regard to its adaptability to its method of execution. This may be arbitrarily termed "Inscription Lettering," and as a more subtle and less exact subject than office lettering it may better be taken up last.

OFFICE LETTERING.

Architectural office lettering has nothing in common with the usual Engineering letter, or rather, to be more exact, the reverse is true: Engineering lettering has nothing in common with anything else. Its terminology is wrong and needlessly confusing inasmuch as it clashes with well and widely accepted definitions. Therefore it will be necessary to start entirely anew, and if the student has already studied any engineering book on the subject, to warn him that in this instruction paper such terms as Gothic, etc., will be used in their well-understood Architectural meaning and must not be misinterpreted to include the style of letter arbitrarily so called by Engineers.

The first purpose of the lettering on an architectural plan or elevation is to identify the sheet with its name and general descriptive title, and further, to give the names of the owner and architect. The lettering for this purpose should always be rather important and large in size, and its location, weight and 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

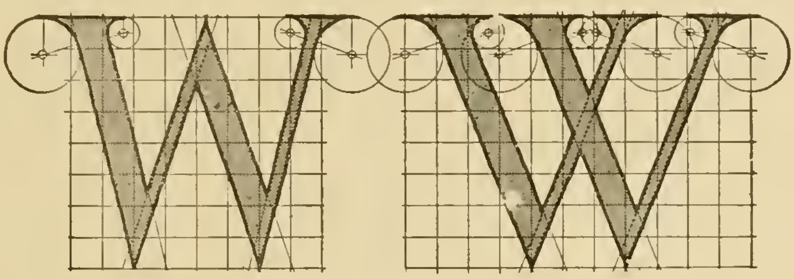


Fig. 1. Two Alternative Forms of the Letter W, to accompany the Alphabet shown in Fig. 2.

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

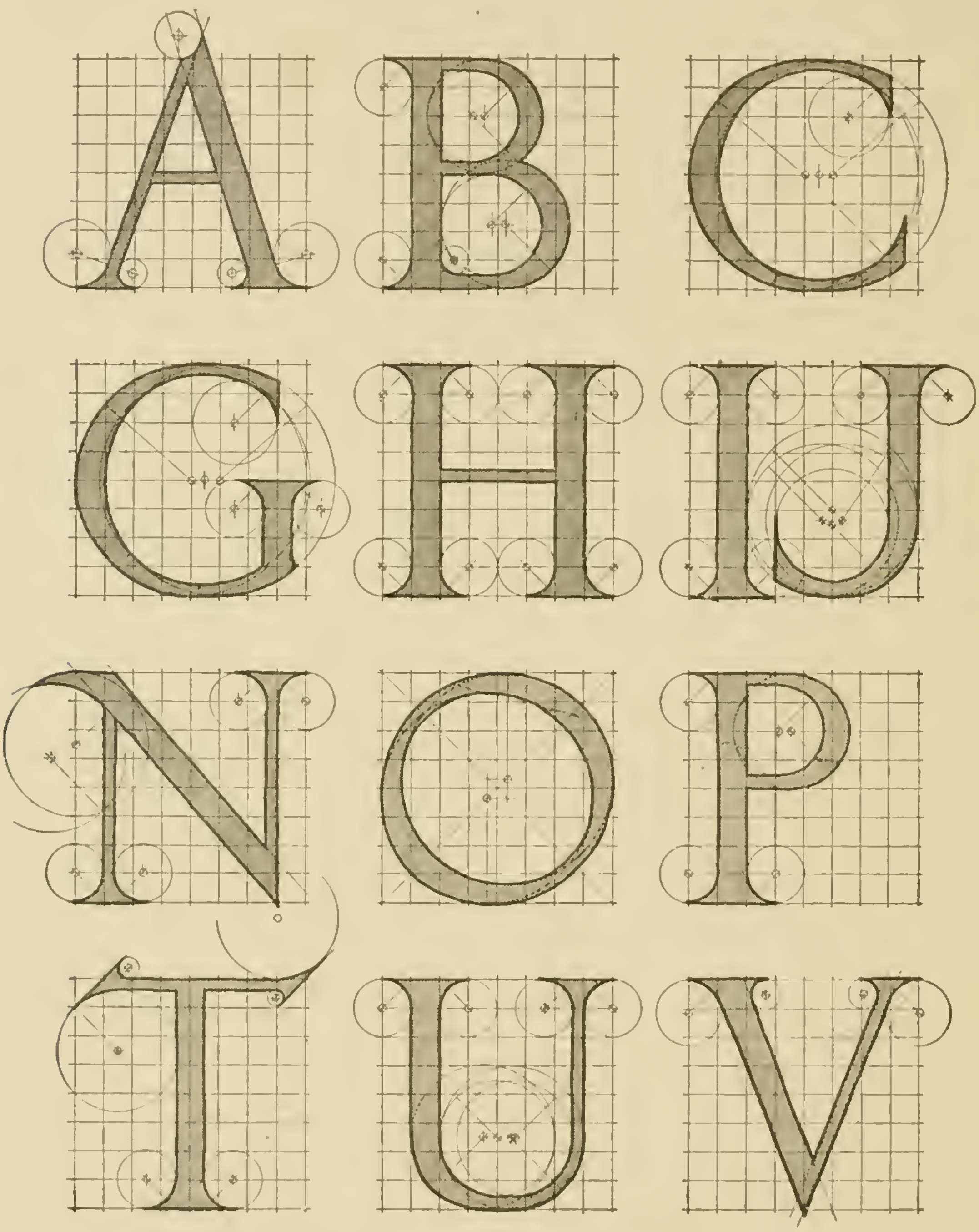


Fig. 2. Alphabet of Classic Renaissance Letters according to Albrecht Dürer, adapted and reconstructed by F. C. Brown. (See Fig. 1.)

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 thoroughly the use of the letters in word combinations, a ready command over this important style of letter will eventually be acquired.

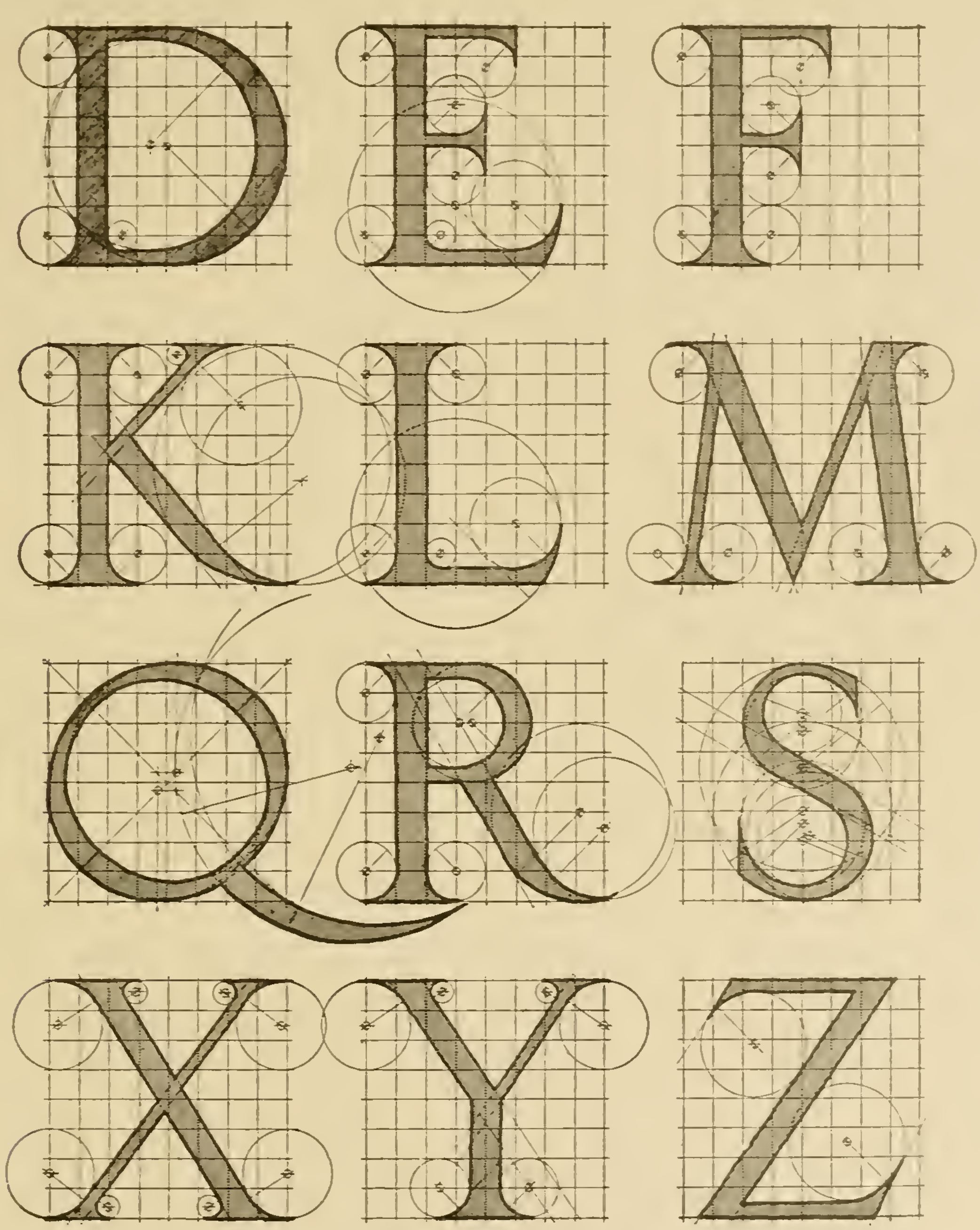


Fig. 2. (Continued)

In practice it will soon be discovered that a letter in outline and of a small size is more difficult to draw than one solidly blacked-in, because the defining outline must be even upon both 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

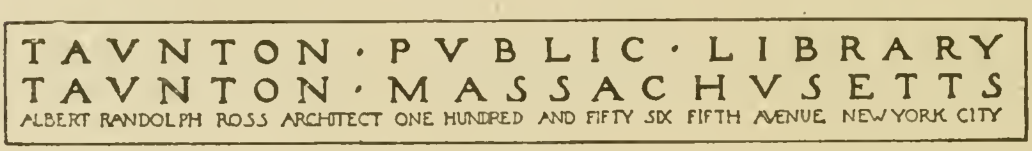


Fig. 3. Title from Competitive Drawings for the Taunton Public Library, Albert Randolph Ross, Architect.

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.

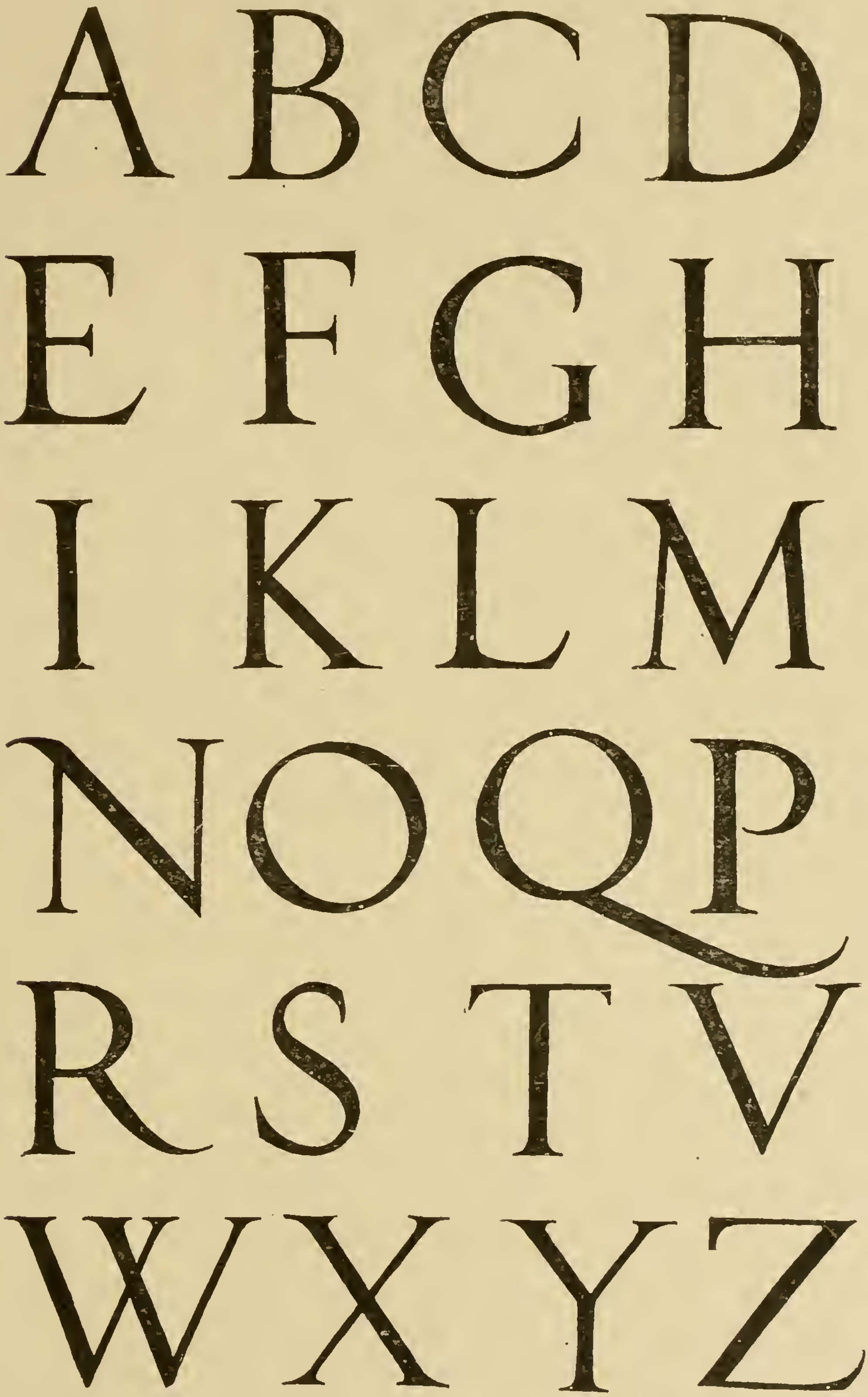


Fig. 4. Italian Renaissance Alphabet, according to Sebastian Serlio.

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

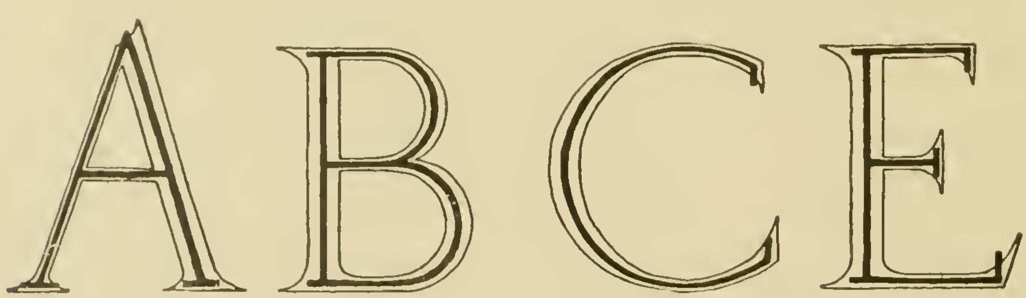


Fig. 6. "Skeleton" Construction of Letters shown in Fig. 2.

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-

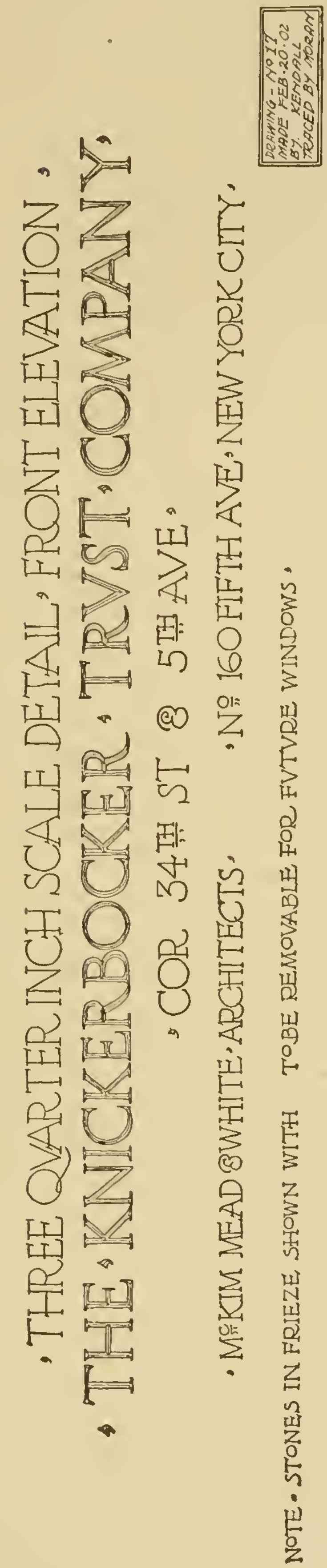


Fig. 7. Title from Drawing of Building for the Knickerbocker Trust Co., New York. McKim, Mead & White, Architects.

necessary to continue this experiment at a greater length, as it is believed the idea is sufficiently developed in these four letters. In addition it is merely the theoretical part of the experiment that it is desirable to impress upon the draftsman. In practice it will be found advisable to make certain further variations from this "skeleton" in order to obtain the most pleasing effect possible with a single-line letter. But the basic relationship of these two forms will amply indicate the propriety of using them in combination or upon the same drawing.

It will be found that the letter more fully shown in Fig. 10 is almost the same as the letter produced by this "skeleton" method, except that it is more condensed. That is, the letters are narrower for their height and a little freer or easier in treatment. This means that they can be lettered more rapidly and occupy less space, and also that they will produce a more felicitous effect.

In actual practice, the free capitals shown in Fig. 10 will be found to be of the shape that can be made most rapidly and easily, and this style or some similar letter should be studied and practiced very carefully.

Other examples of similar one-line capitals will be found 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

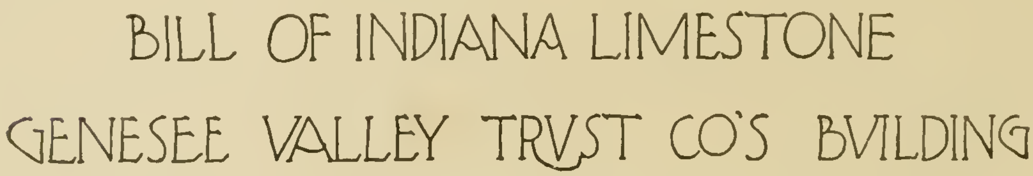


Fig. 8. Title from Architectural Drawing, Claude Fayette Bragdon, Architect.

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

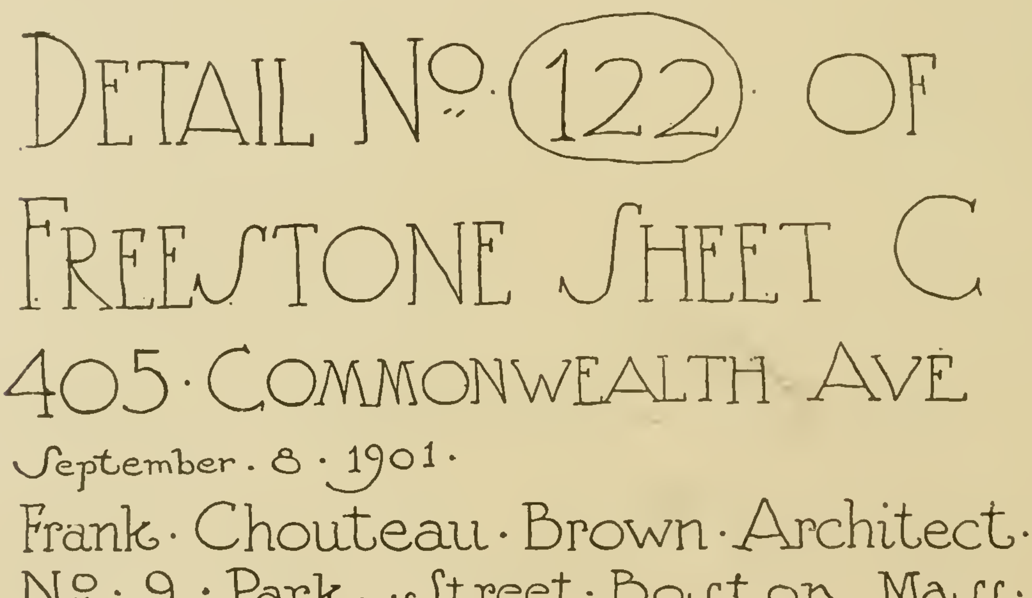
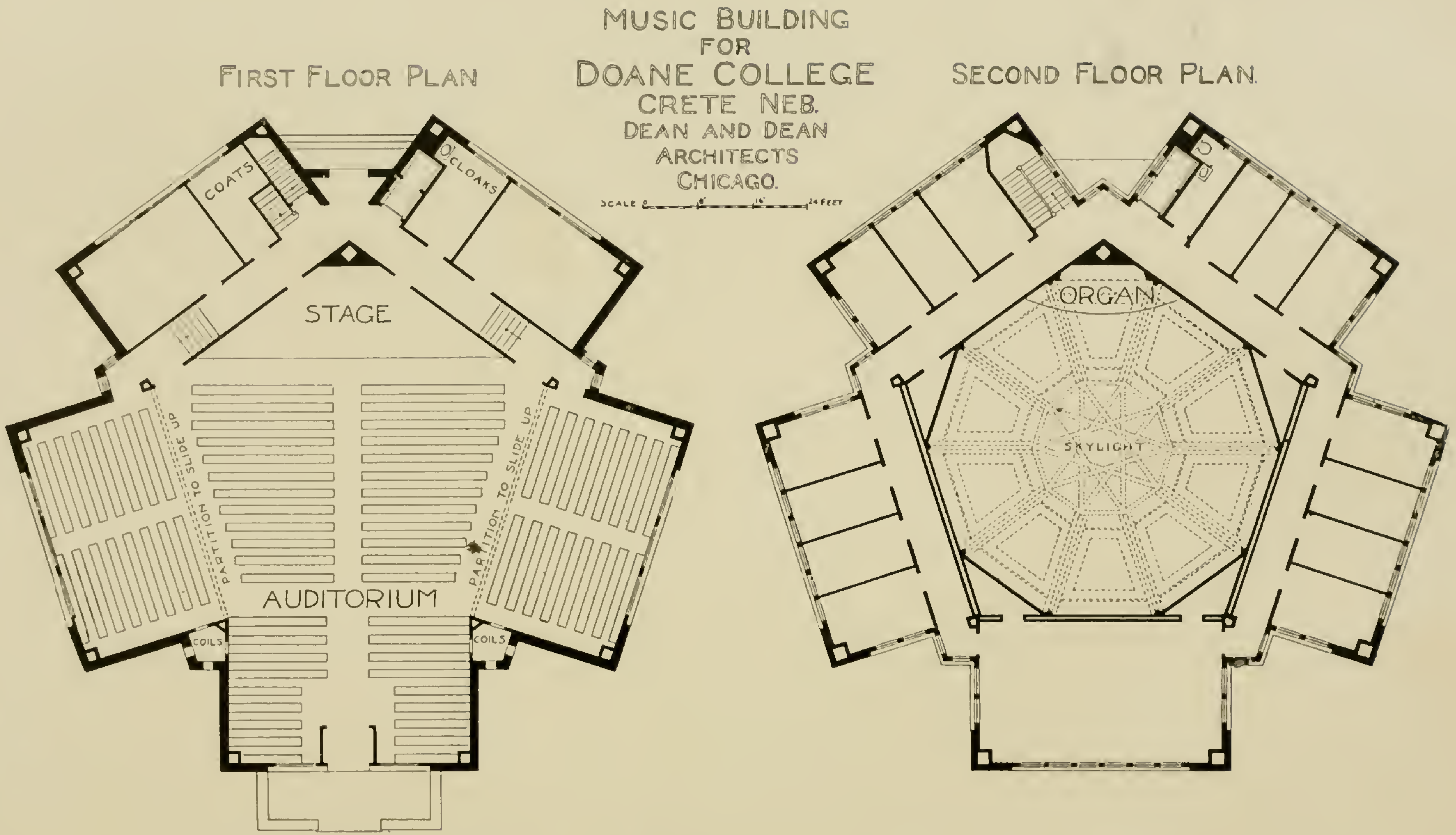


Fig. 9. Title from Detail.

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.

Mr. John

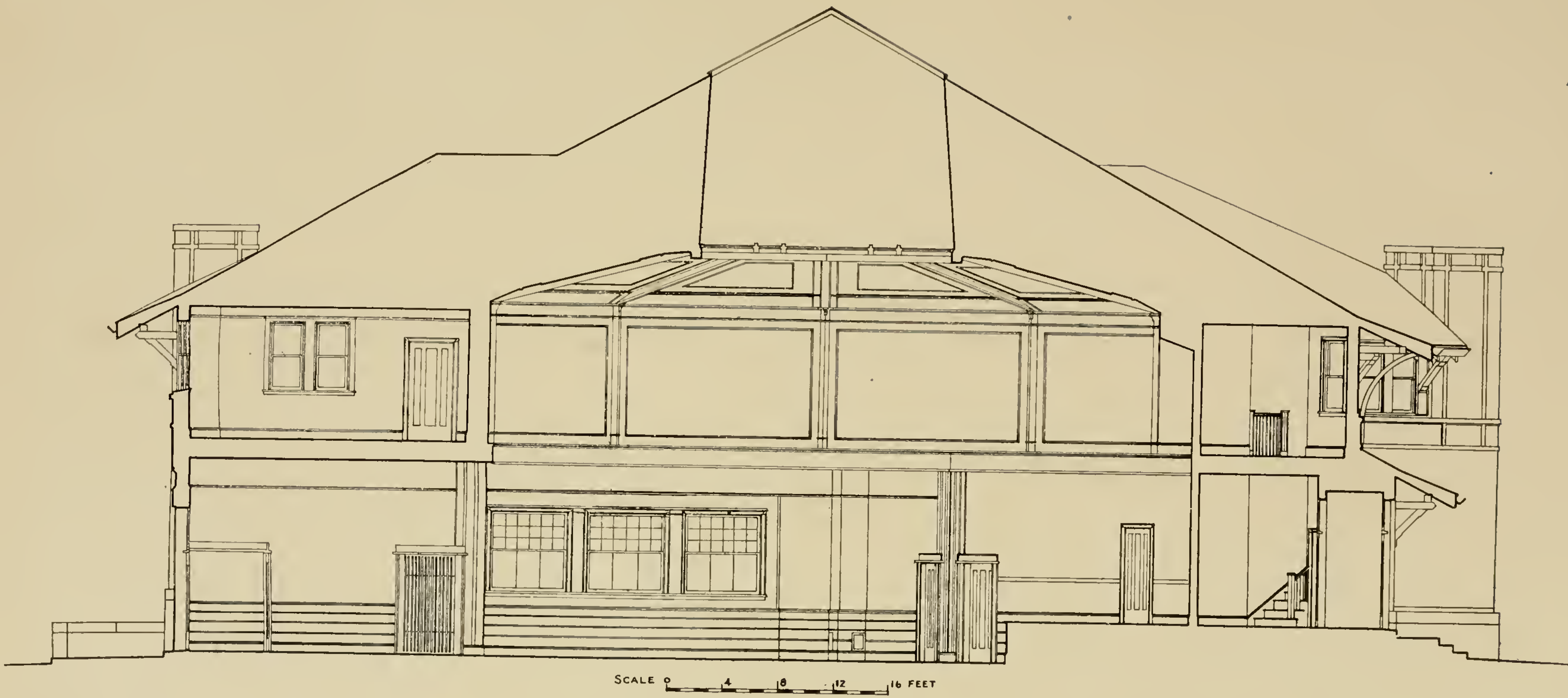
Sikes



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.

H. B. Brown

Johnson

Greensboro

N. C.

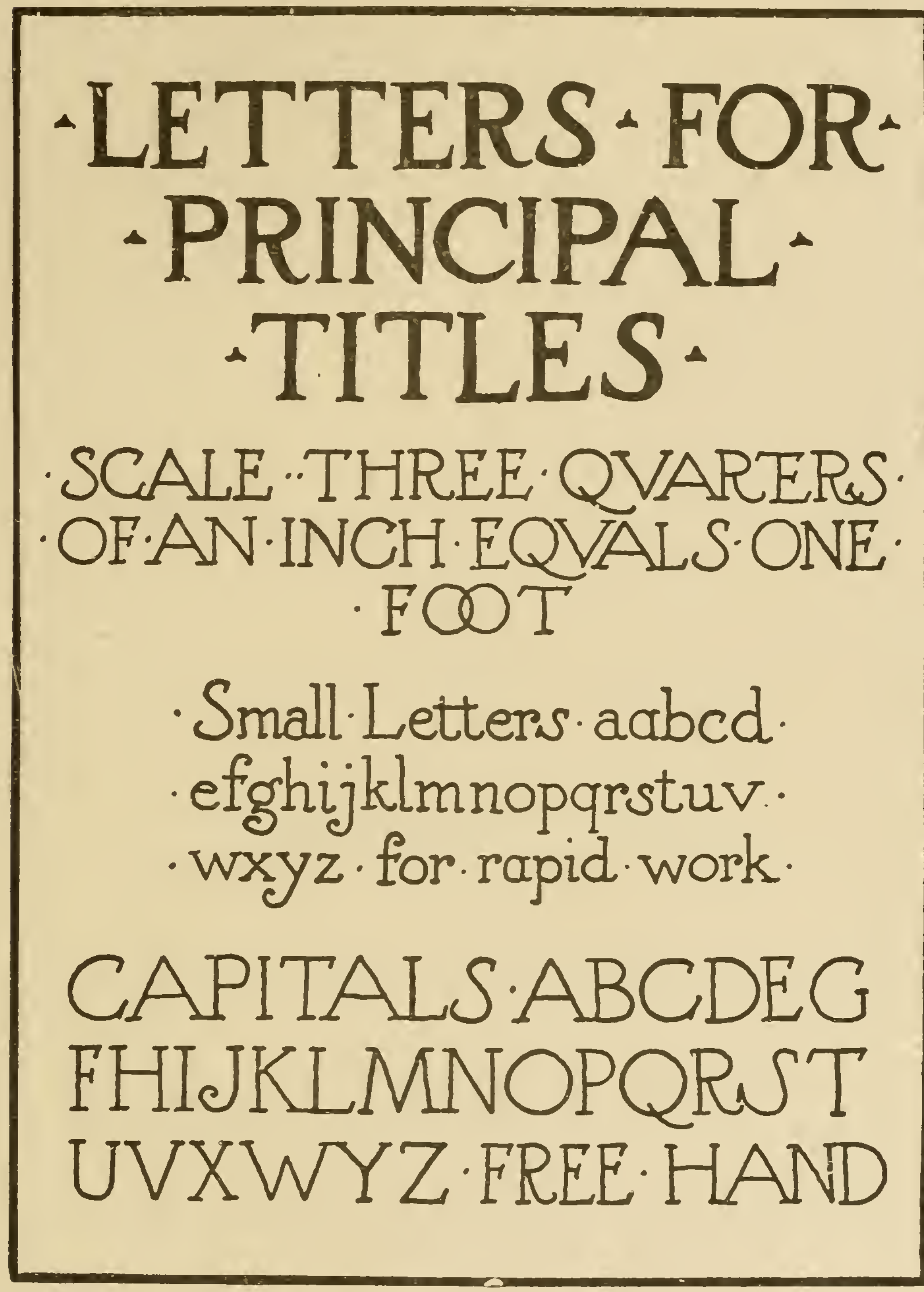


Fig. 10. Letters for Architectural Office use.

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

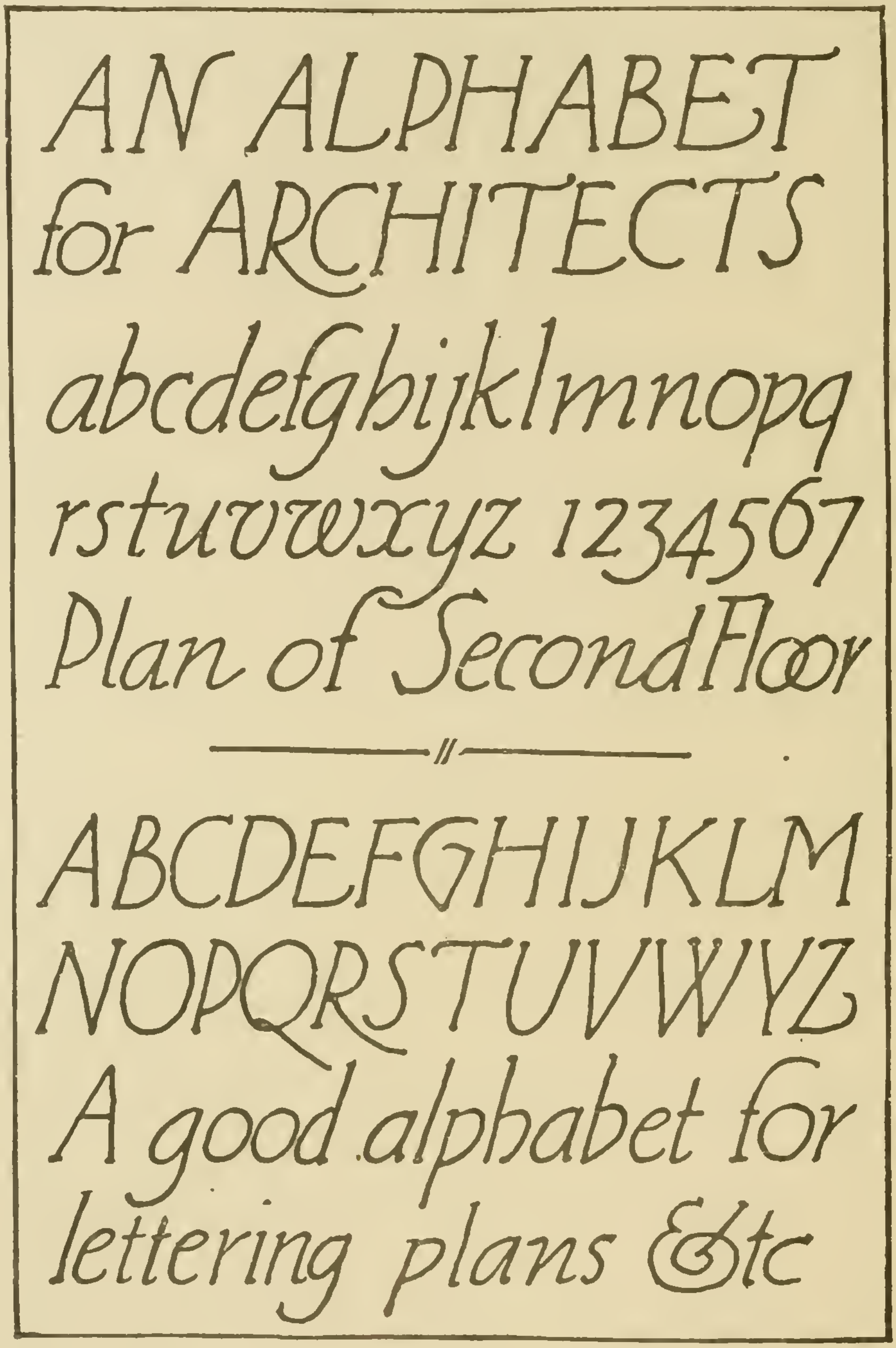


Fig. 11. Single-line Italic Letters, by Claude Fayette Bragdon.

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.

The alphabets of capital and minuscule one-line letters shown in Fig. 11 are similar in general type to those we have just been discussing, except that they are sloped or inclined letters and therefore come under the heading of "Italics." The Italic letter is ordinarily used to emphasize a word or phrase in a sentence where the major portion of the letters are upright;

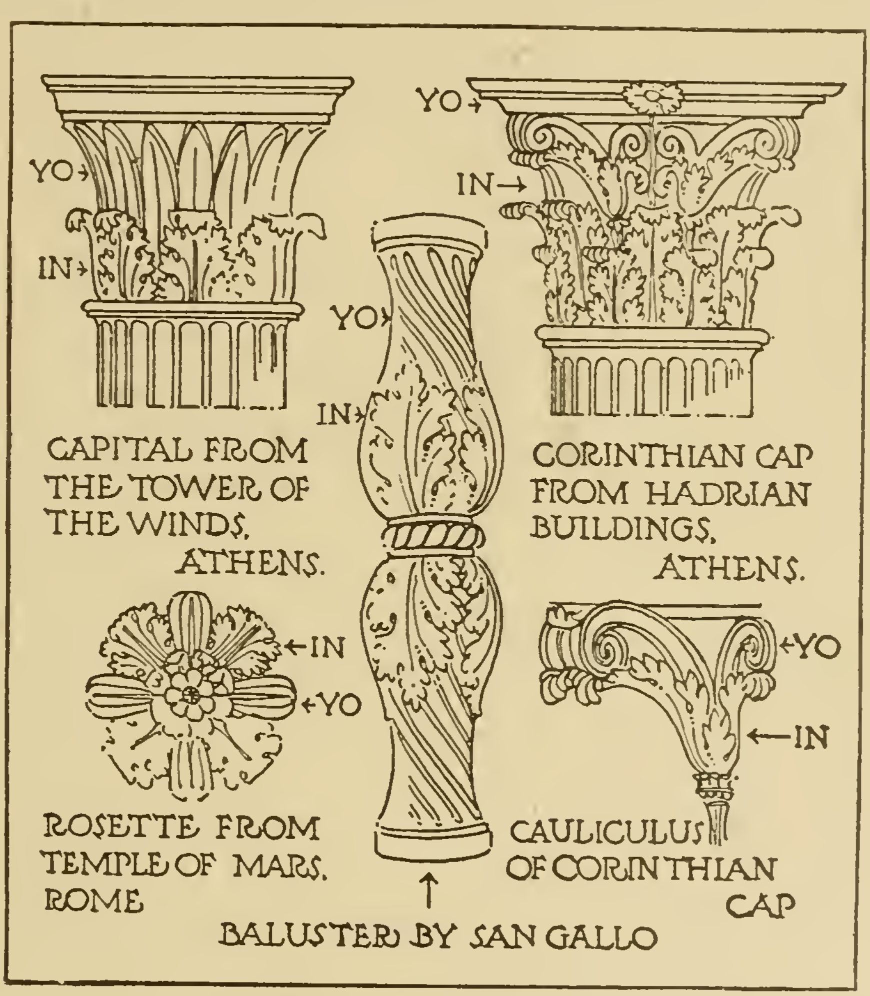


Fig. 12. Drawing, by Claude Fayette Bragdon.

but where the entire legend is lettered in Italics this effect of emphasis is not noticeable, and a pleasing and somewhat more unusual drawing is likely to result. If it is deemed advisable to emphasize any portion of the lettering on such a drawing, it is necessary only to revert to the upright form of letter for that portion.

The single-line capitals and small letters on the usual architectural plan or working drawing are illustrated in Fig. 13, where such a plan is reproduced. This drawing was not one made specially 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.

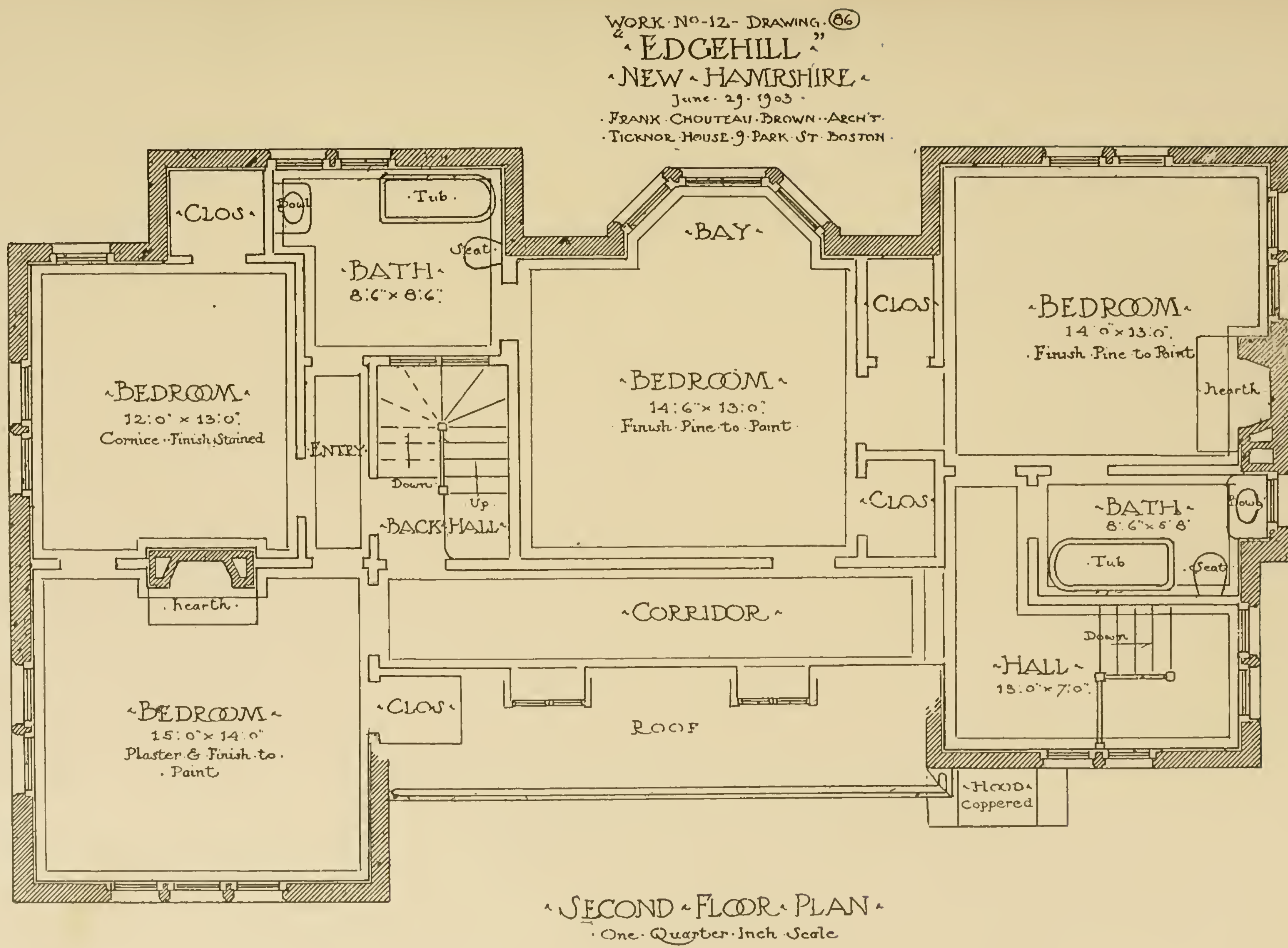

WORK · No-12 - DRAWING · 86
"EDGEHILL"
· NEW · HAMPSHIRE ·
June · 29 · 1903 ·
· FRANK · CHOUTEAU · BROWN · ARCH'T ·
· TICKNOR · HOUSE · 9 · PARK · ST · BOSTON ·
· CLOS ·
Bowl
· Tub ·
Seat
· BATH ·
8' 6" × 8' 6"
· BAY ·
CLOS
· BEDROOM ·
14' 0" × 13' 0"
· Finish · Pine · to · Paint
· BEDROOM ·
12' 0" ×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

Fig. 13.

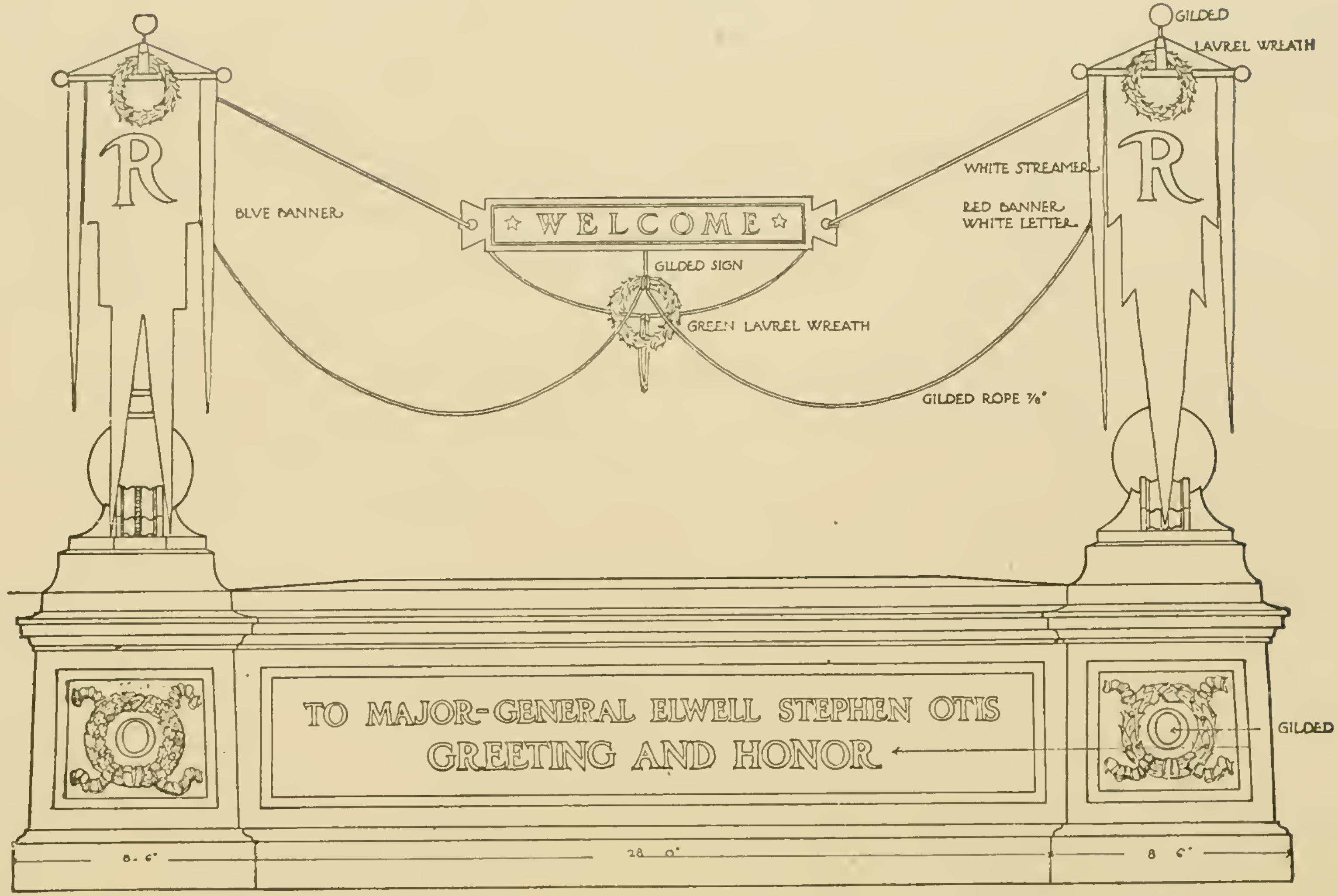


Fig. 14. Upper Portion of Drawing for Otis Memorial Arch, Claude Fayette Bragdon, Architect.

The "skeleton" letter, formed on the classic Roman letter, displays quite as clearly as does the constructive system of Albrecht Dürer, the distinctively *square* effect of the Roman capital. The entire Roman alphabet is built upon this square and its units. The letters shown in Figs. 22 and 23 are redrawn from rubbings of old marble inscriptions in the Roman Forum, and may be taken as representative of the best kind of classic letter

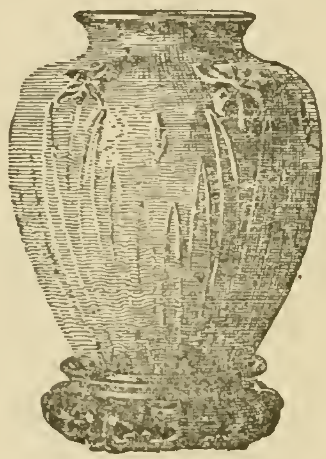
Fig. 15. Advertising Design, by Addison B. Le Boutillier.

for incision in stone. The Dürer letter, while a product of a later period, is fundamentally the same, and differs only in minor, if characteristic, details. However, for purposes of comparison it will serve to show the difference between a letter incised in marble, or in any other material, and one designed for use in lettering in black ink against a white background.

COMPOSITION.

After acquiring a sufficient knowledge of letter forms, the student is ready to begin the study of "lettering." While a knowledge of architectural beauty of form is the first essential, it

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.

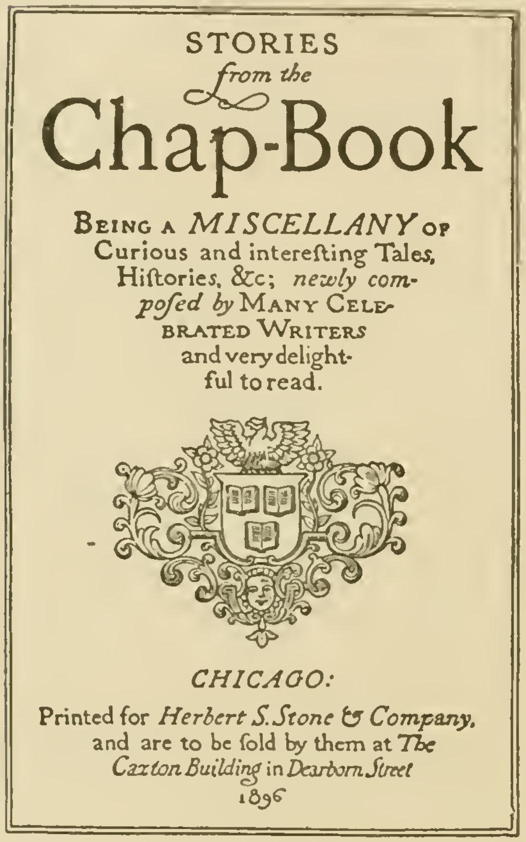
This point of "composition" is so important that a legend of most beautiful individual letter forms, badly placed, will not produce as pleasing an effect as an arrangement of more awkward letters when their composition is good. This quality has been so much disregarded in the consideration of lettering, 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.


STORIES
from the
Chap-Book

BEING A *MISCELLANY* OF
Curious and interefting Tales,
Hiftories, &c; *newly compofed by* MANY CELEBRATED WRITERS
and very delightful to read.

CHICAGO:
Printed for *Herbert S. Stone & Company*,
and are to be fold by them at *The Caxton Building* in *Dearborn Street*
1896

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 some such over-heavy border treatment as has been used. Here, again, in the slight Gothic cusping at the angles a lack of restraint or judgment on the part of the designer is indicated, this Gothic touch being entirely out of keeping with the lettering itself, and only partially demanded by the decorative panel. Of course, it

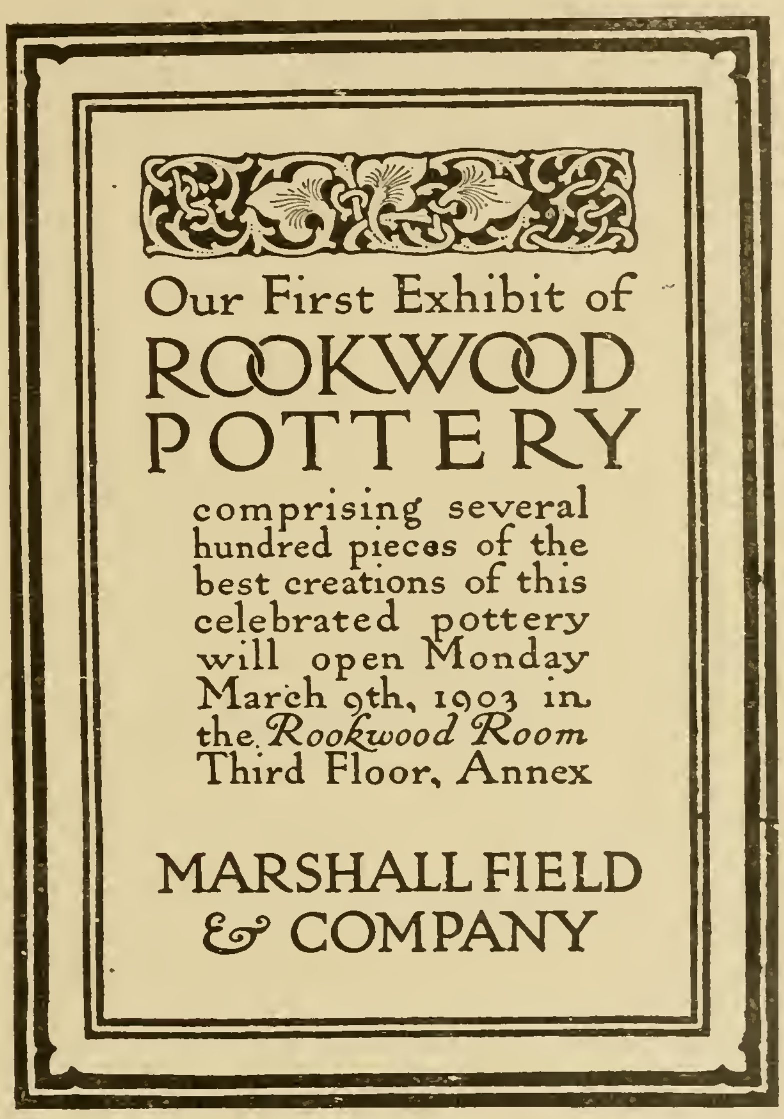


Fig. 18. Advertising Announcement.

is easy to see that these faults are all to be attributed to an attempt to attract and hold the eye and thus add to the value of the design as an advertisement; but a surer taste could have obtained this result and yet not at the expense of the composition as a whole. It is nevertheless an admirable piece of work.

In Fig. 19 is shown an example of the use of lettering in 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.

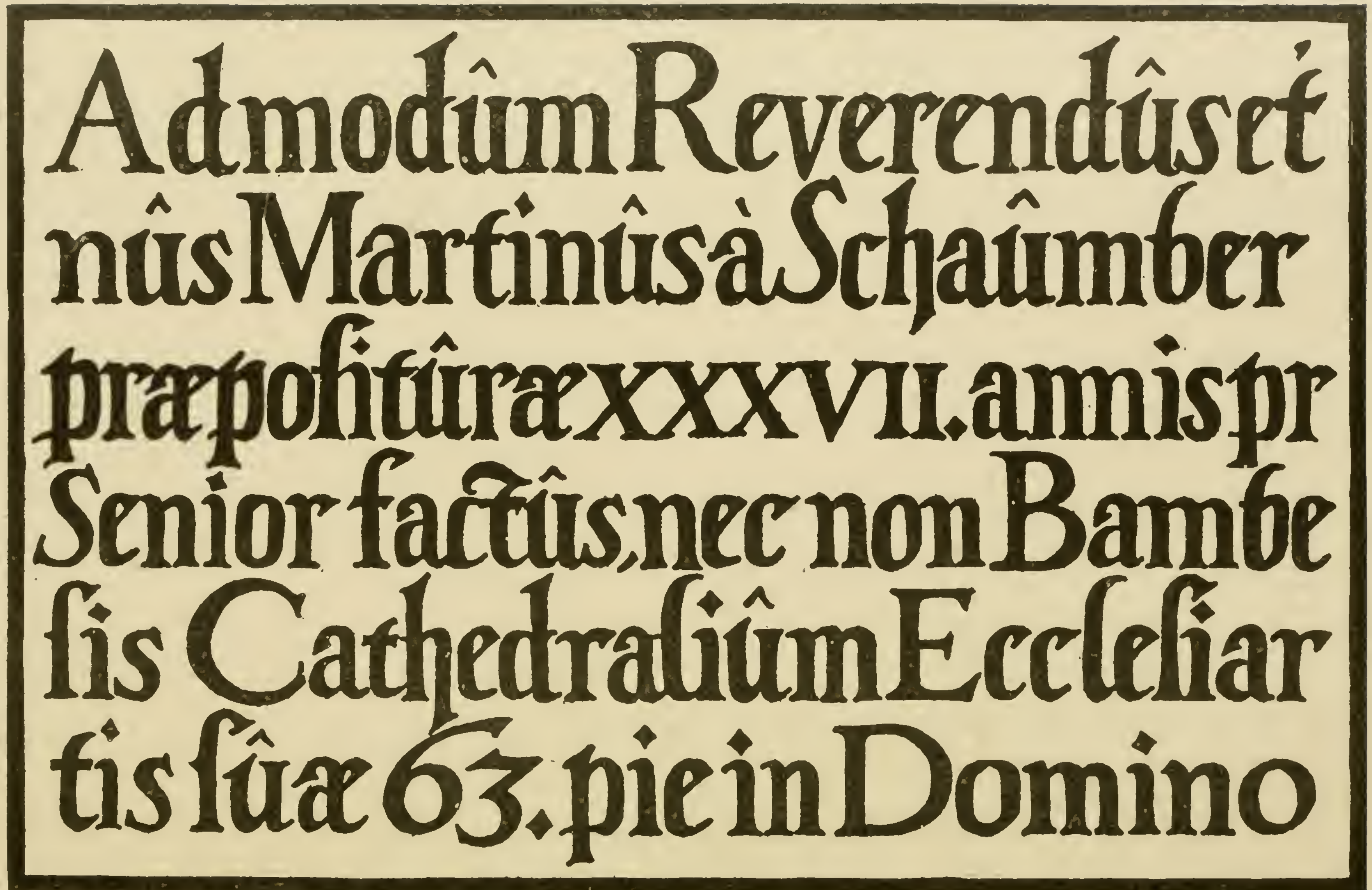
The student will soon find that he unconsciously varies and individualizes the letters that he constantly employs, until they become most natural and easy for him to form. This insures his developing a characteristic letter of his own, even when at the start he bases it upon the same models as have been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

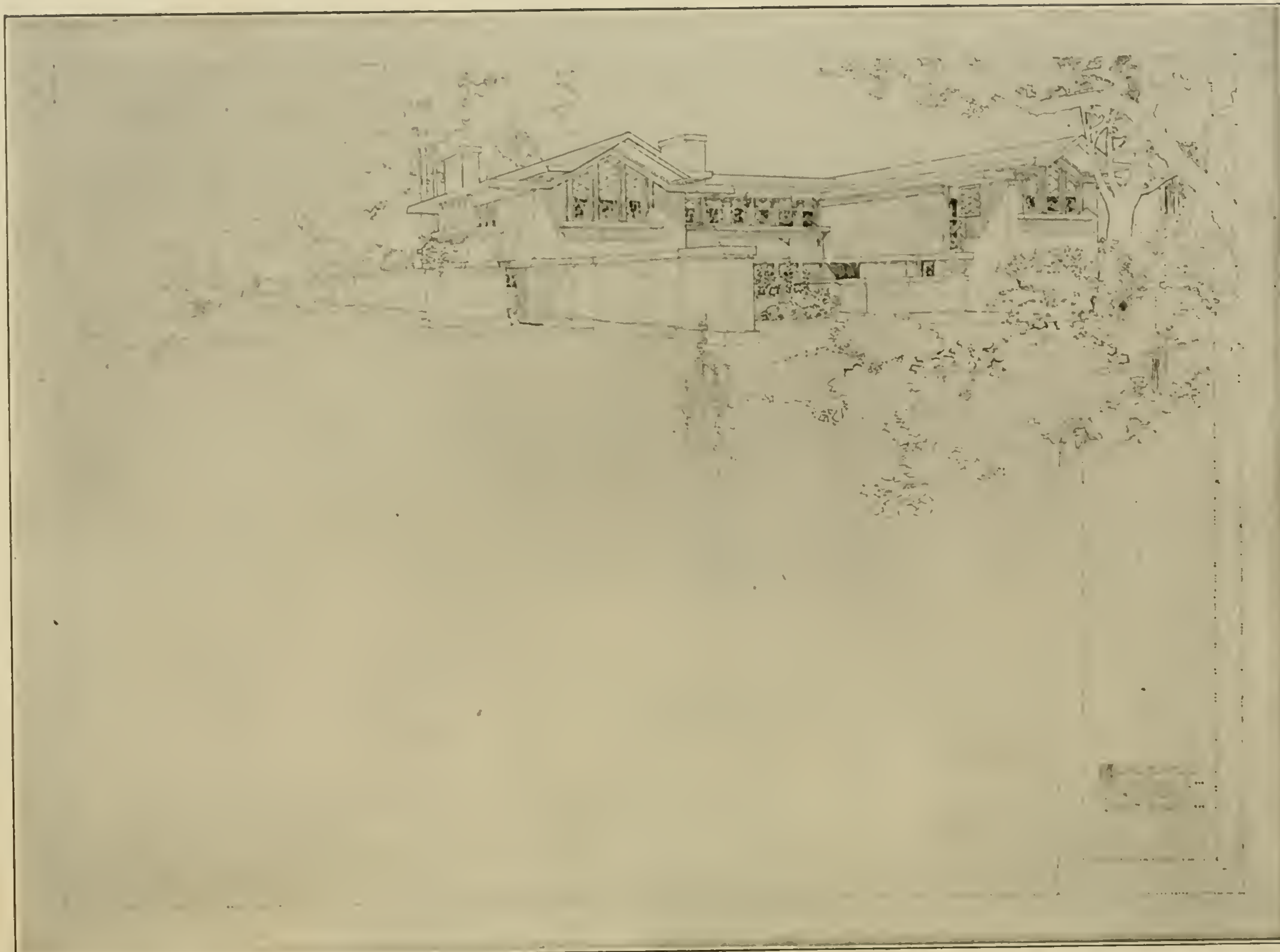
The small letters shown in Figs. 17, 18 and 20 are all adapted from the Caslon or some similar type form, and all exhibit their superiority of spacing over the possible use of any type letter. Fig. 20 is a particularly free and beautiful example indicating the latent possibilities of the minuscule form 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



SMALL OR MINUSCULE LETTERING FROM A HAND LETTERED INSCRIPTION IN BRONZE IN THE CATHEDRAL AT BAUMBERG, 1613.

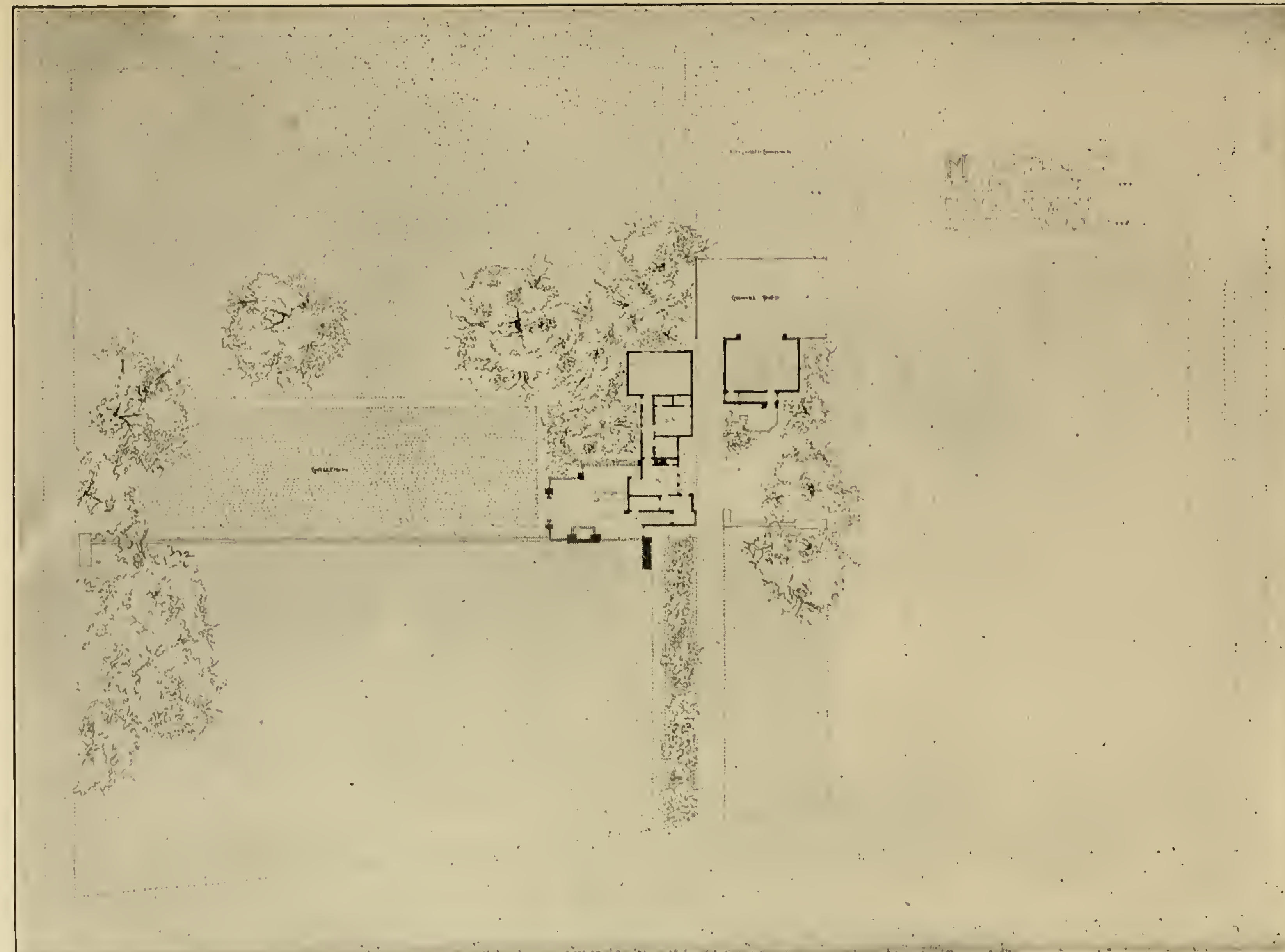
Miss Lessie Johnson



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

Frank Lloyd Wright, Architect, Oak Park, Ill.

For Plan, See Opposite Page.



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.

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

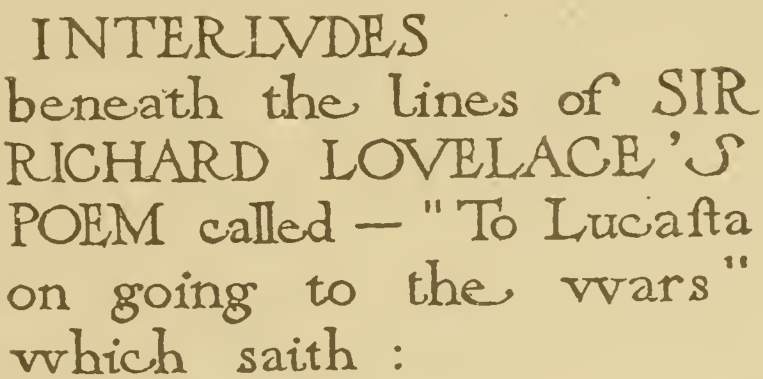


Fig. 20. Pen-drawn Heading, by Harry Everett Townsend.

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

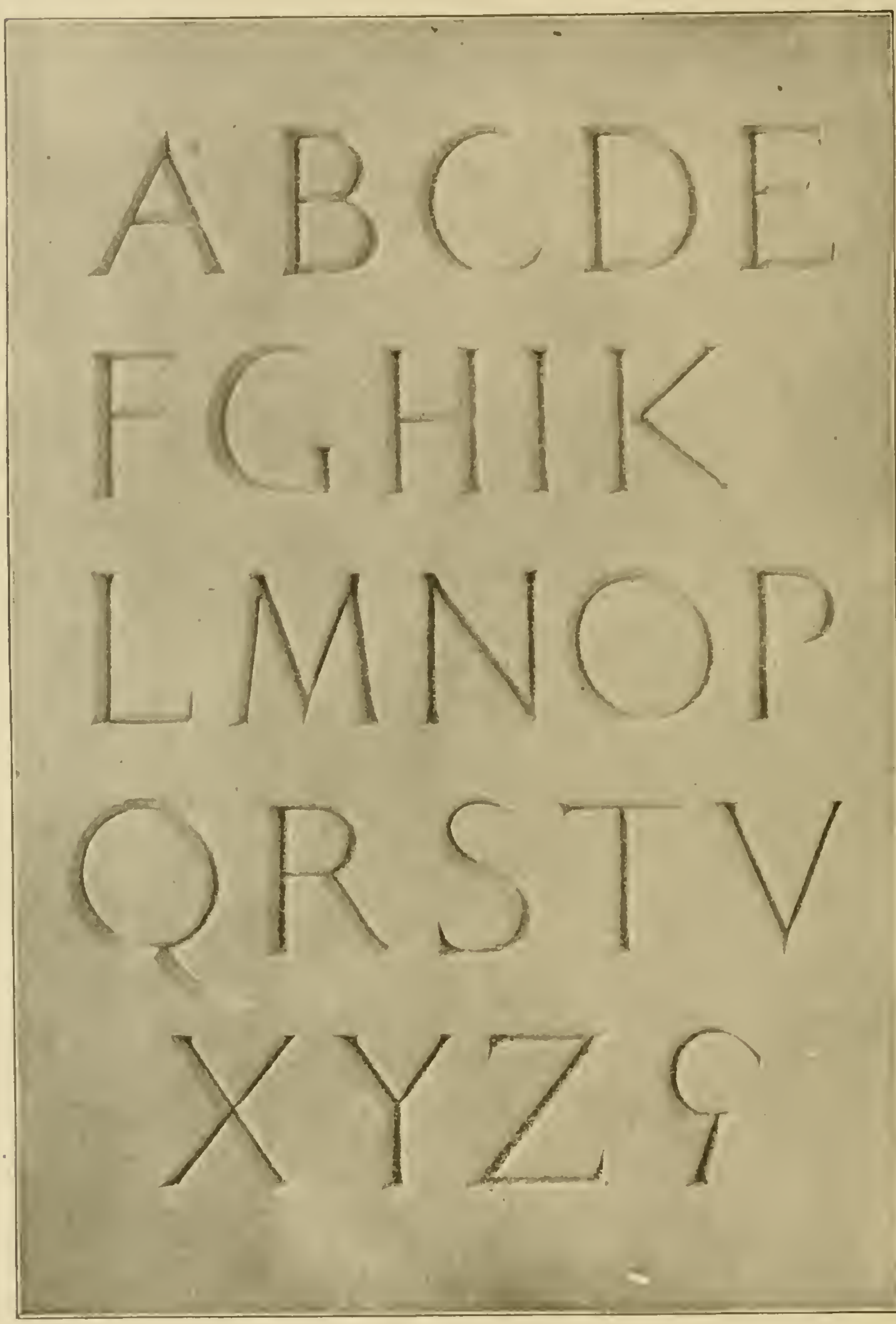


Fig. 21. Study for Lettering on Granite Frieze of Boston Public Library, McKim, Mead & White, Architects.

of a letter in the inscription in place must be carefully studied, its height above or below and relation to the eye of the observer. The fact is that the letter form must in this case be determined solely by the light and shadow cast by the sun on a clear, bright day, or diffused more evenly on a cloudy one. If in an interior location its position in regard to light and view-point is even more important, as the conditions are less variable.

CLASSIC ROMAN LETTERS.

In any letter cut in stone, or cast in metal, it is not the outline of the letter that is seen by the eye of the observer, but the *shadow* cast by the *section used to define the letter*. This at once changes the entire problem and makes it much more complicated. In incising or cutting a letter into an easily carved material, such as stone or marble, we have the examples left us by the inventors, or at least the adapters, of the Roman alphabet. They have generally used it with a V-sunk section, and in architectural and monumental work this is still the safest method and the one most generally followed. One improvement has been made in adapting it to our modern conditions. The old examples were most often carved in a very fine marble which allowed a deep sinkage at a very sharp angle, thus obtaining a well-defined edge and a deep shadow. In most modern work the letters are cut in sandstone or even in such coarse material as granite, where sharp angles and deep sinkage of the letter-section is either impossible, or for commercial reasons influencing both contractors and stonecutters, very hard to obtain. To counterbalance this fault a direct sinkage at right angles to the surface of the stone before beginning the V section has been tried, and is found to answer the purpose very well, as it at once defines the edge of the letter with a sharp shadow. See the two large sections shown in the upper part of Fig. 31.

This section requires a letter of pretty good size and width of section, and, therefore, may be used only on work far removed from the eye, as is indeed alone advisable. An inscription that is to be seen close at hand must rely upon the more correct section and be cut as deeply as possible. For lettering placed at a great height, an even stronger effect may be obtained by making the incised section square, and sinking it directly into the stone.

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

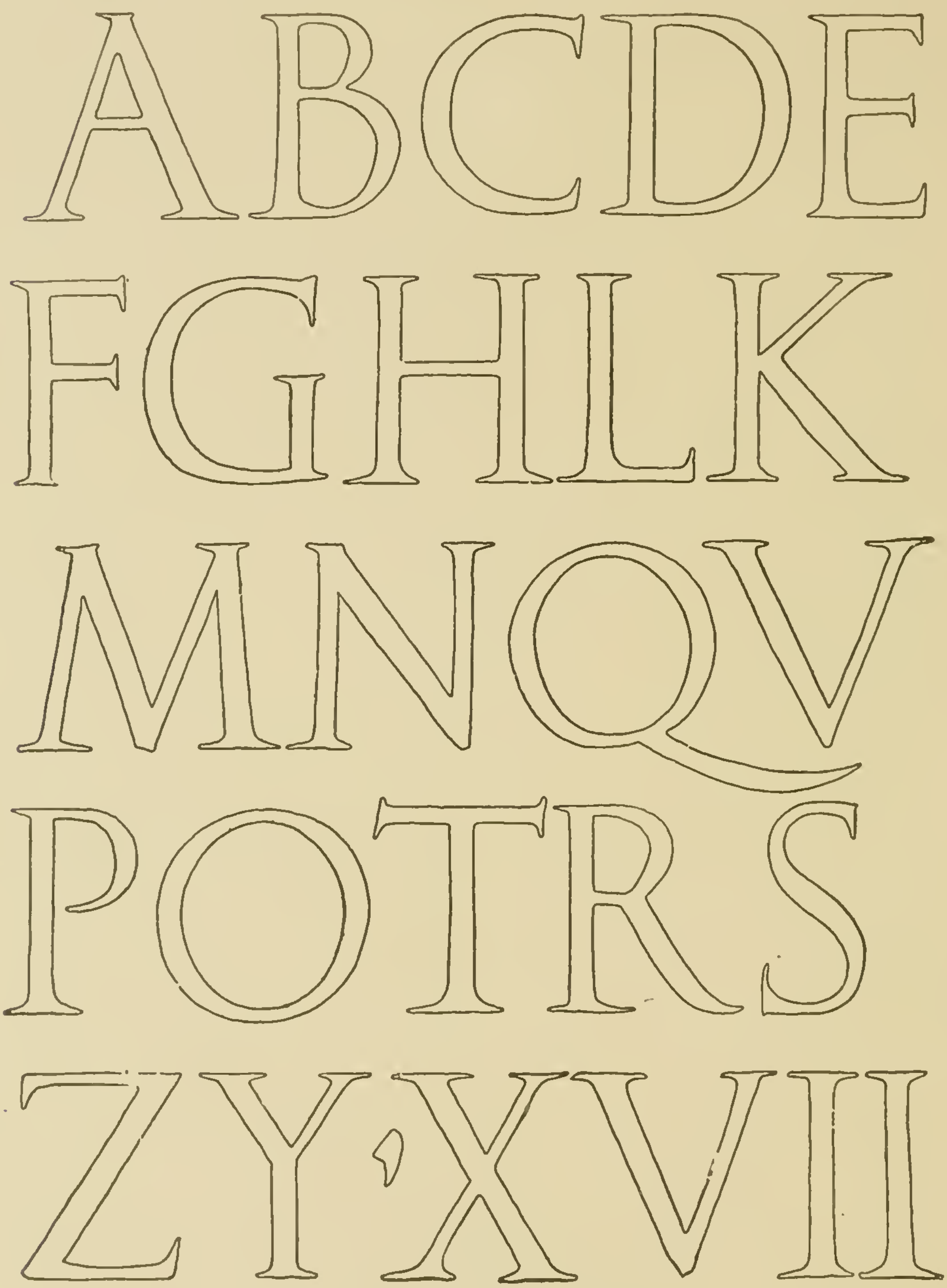


Fig. 22. Classic Roman Alphabet.
From Marble Inscriptions in the Roman Forum.

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

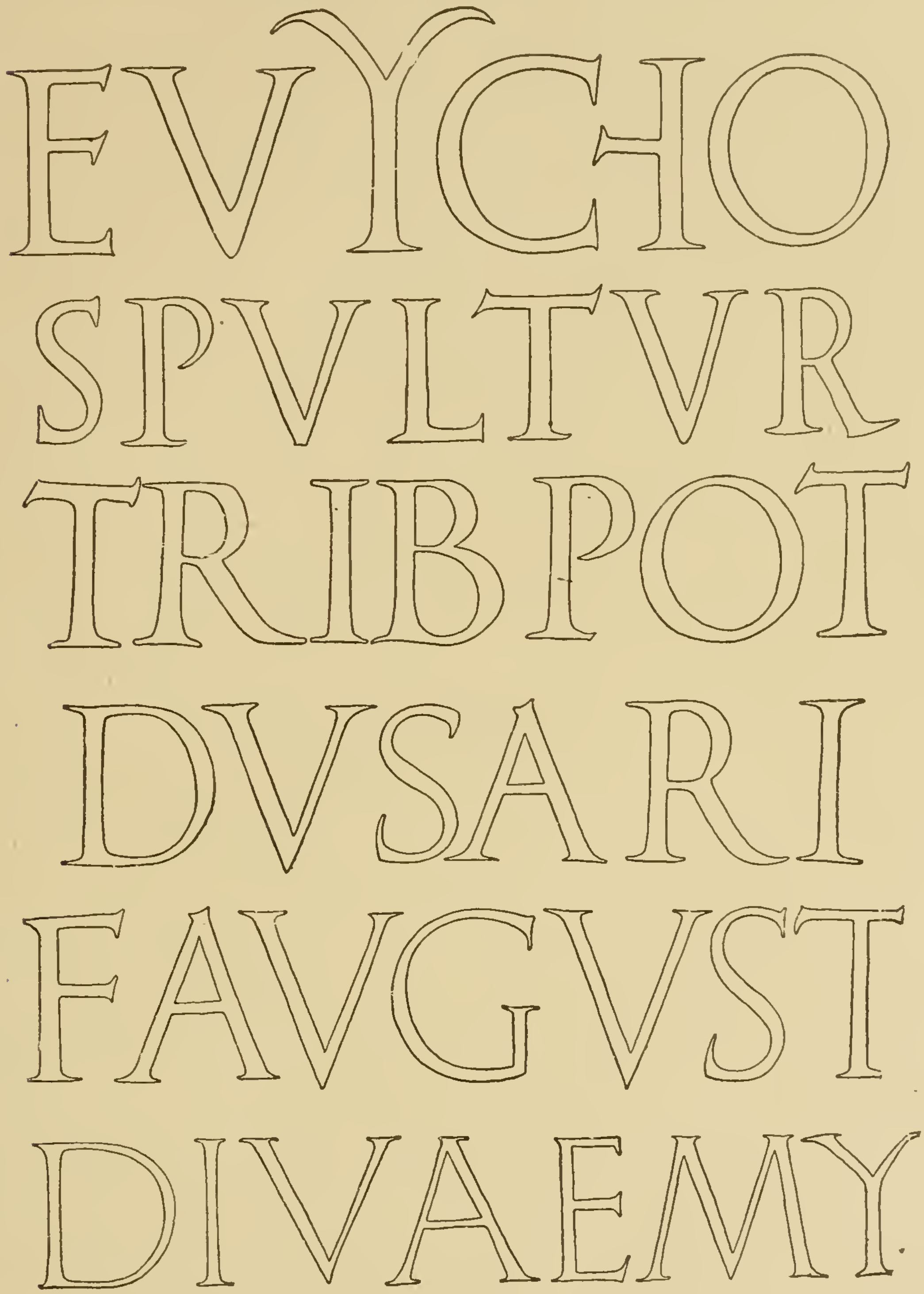


Fig. 23. Fragments of Classic Roman Inscriptions.

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.

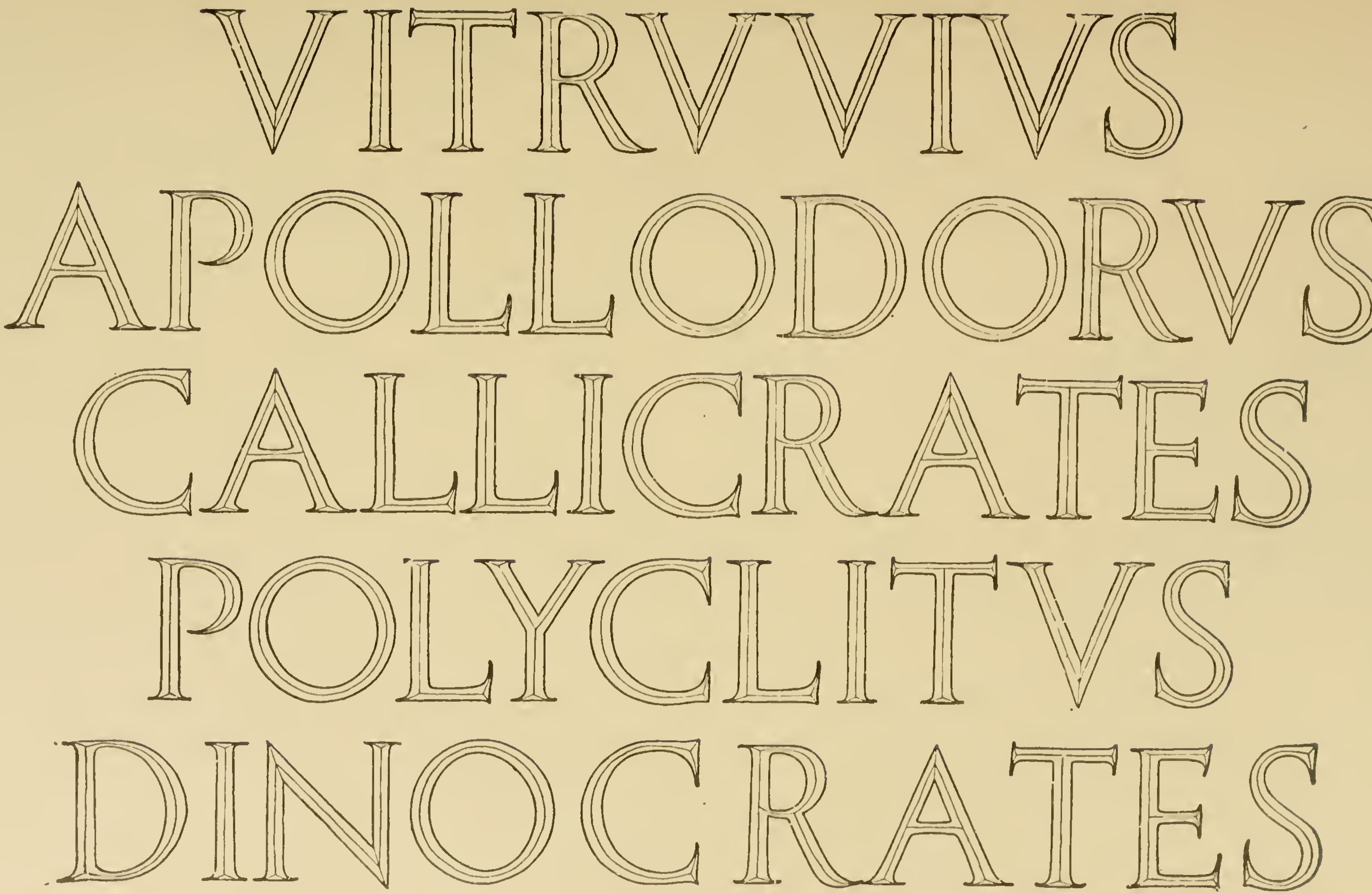


Fig. 24. Lettering from Harvard Architectural Building. McKim, Mead & White, Architects.

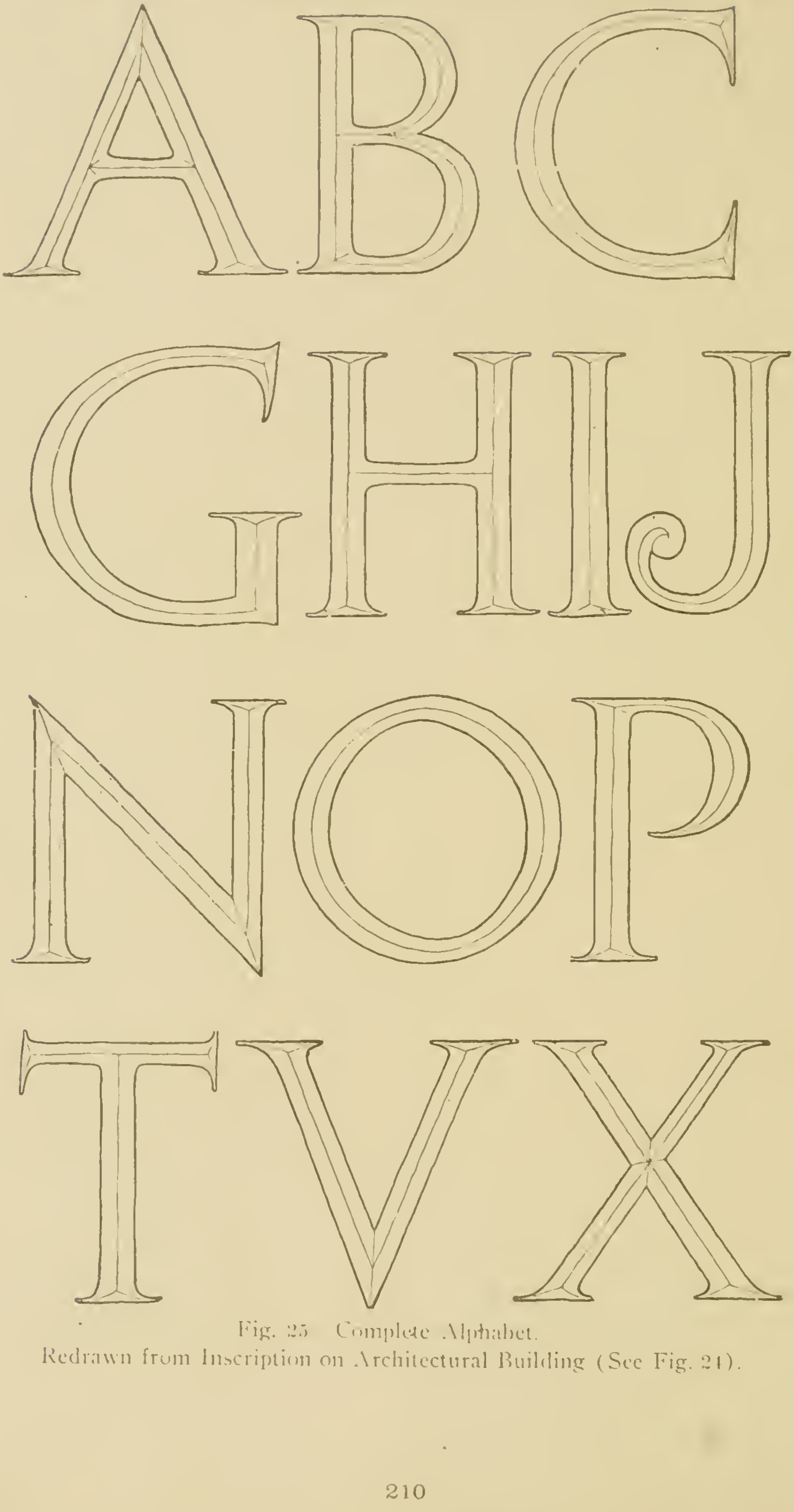


Fig. 25. Complete Alphabet.
Redrawn from Inscription on Architectural Building (See Fig. 24).

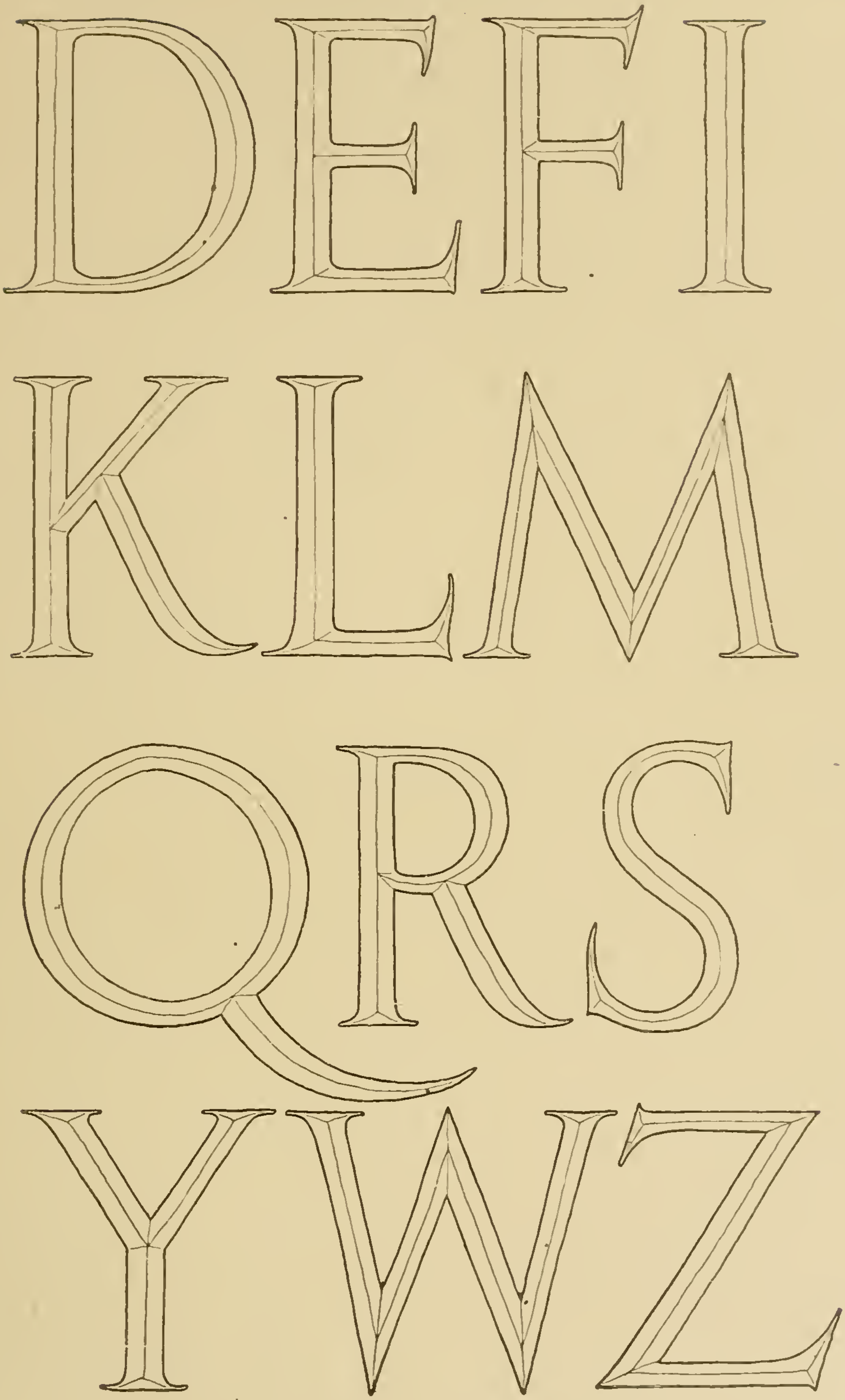


Fig. 25. (Continued)

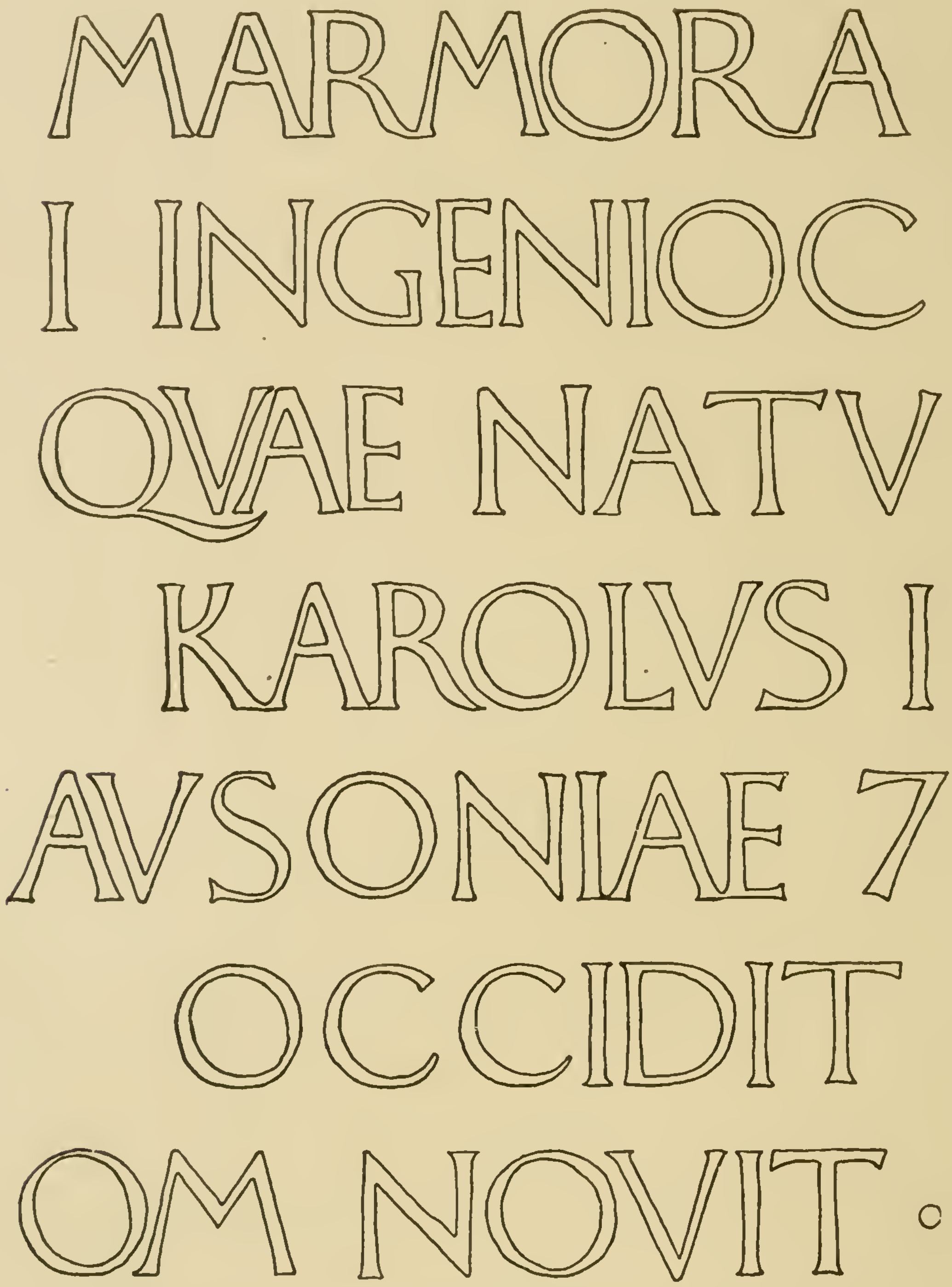
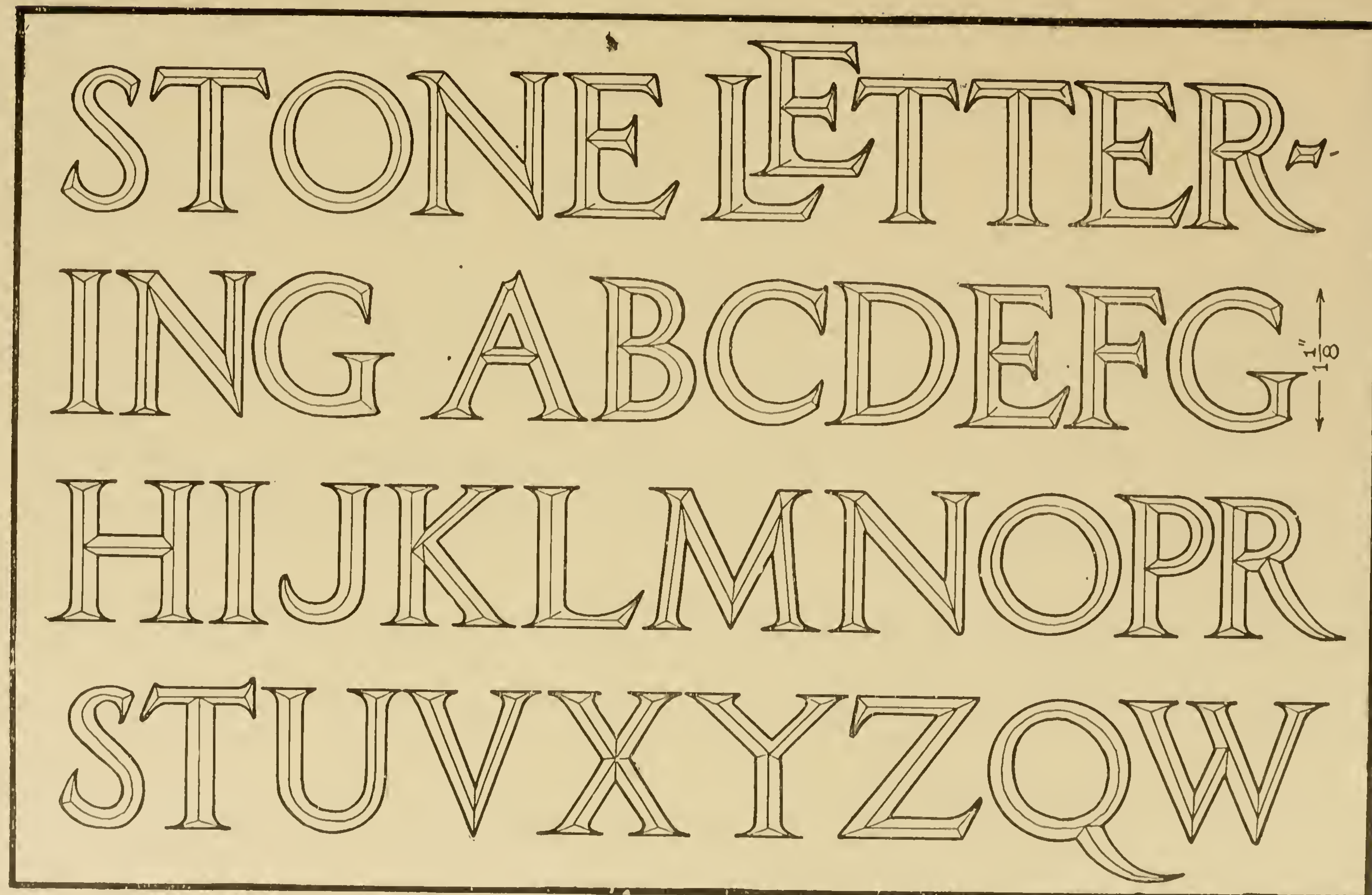
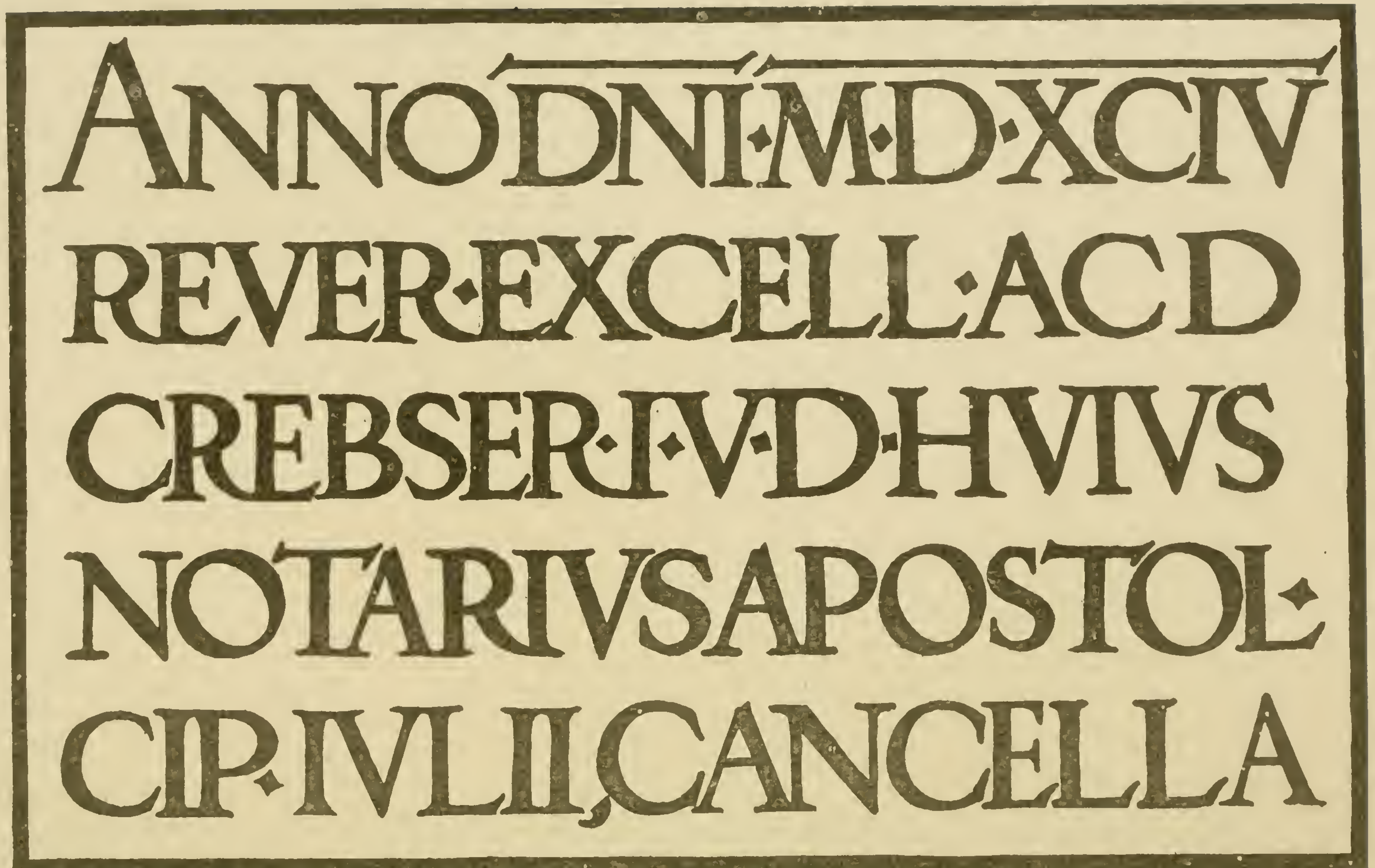


Fig. 26. Fragment of Italian Renaissance Inscription.
From the Marsuppini Tomb in Florence.



ALPHABET OF MODERN CAPITAL LETTERS OF ITALIAN RENAISSANCE CHARACTER.

Suitable for cutting at a small size (i. e. $1\frac{1}{8}$ inches high) in stone.



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

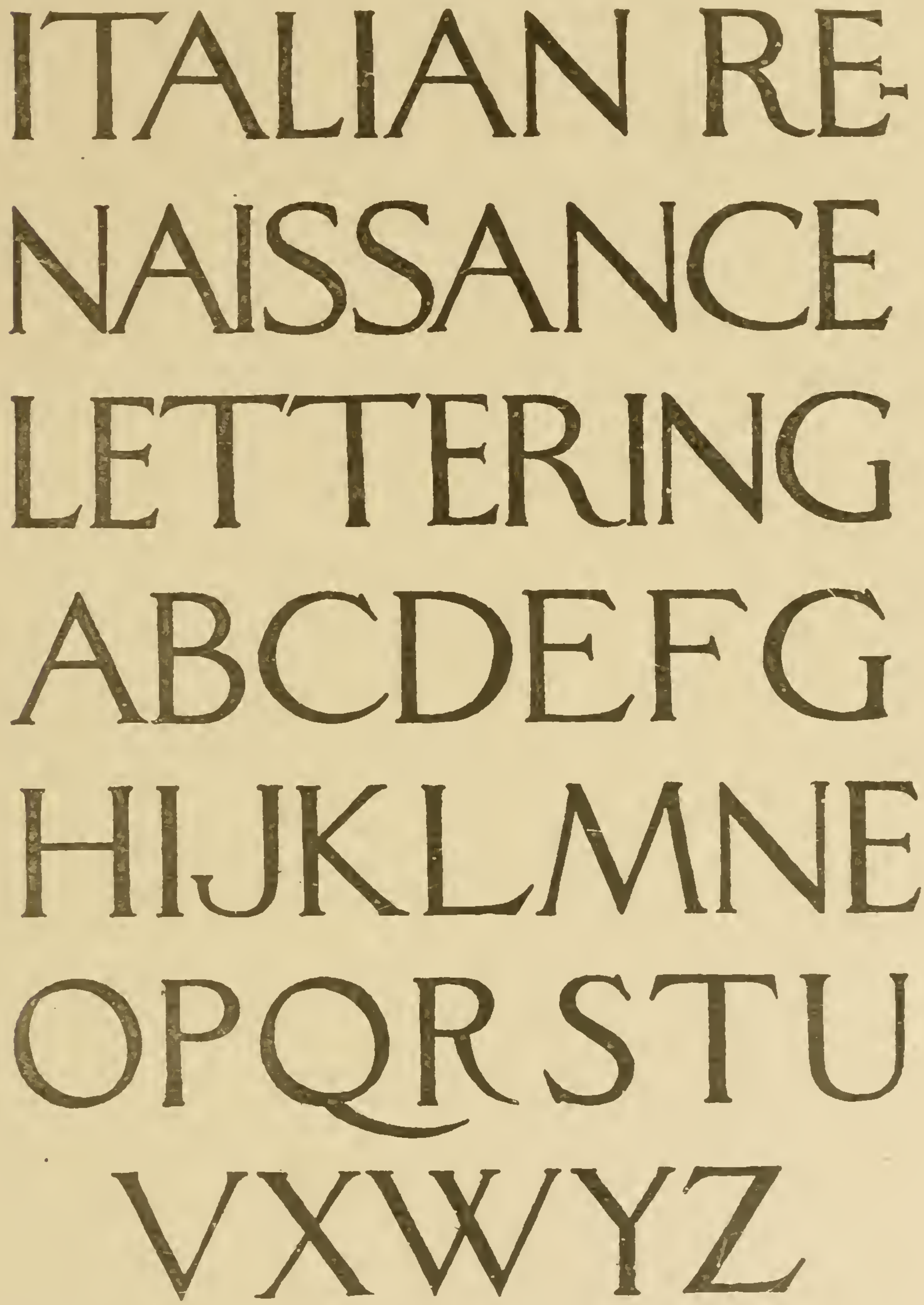


Fig. 27. Italian Renaissance Lettering.
Adapted from Inscription shown in Fig. 26.

In Fig. 26 is shown a fragment of the inscription on the Marsuppini tomb at Florence. This outline letter was traced from a rubbing, and shows very nearly the exact character of the original, a marble incised letter. Fig. 27 is an alphabet devised

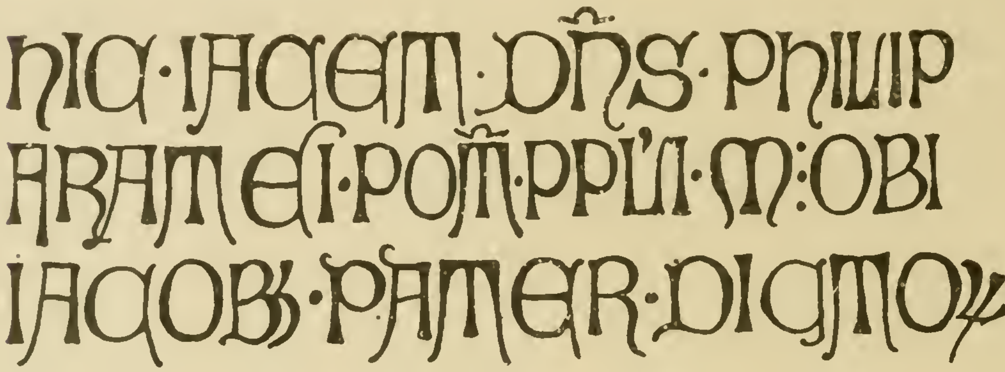


Fig. 28. Italian Renaissance Inscription at Bologna.

from this incised letter for use as a pen-drawn form and redrawn at the same size. It will be noticed that in the letters shown in the four lower lines a quite different serif* treatment has been adopted, and certain of the letters, such as the E's, have been

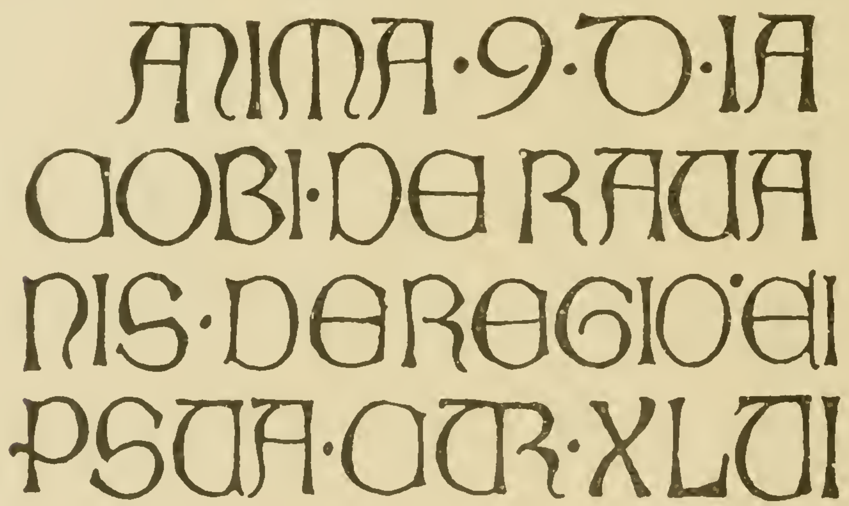


Fig. 29. Italian Renaissance Inscription, Chiaravelle Abbey in Milan.

"extended" or made wider in proportion. These variations are such as modern taste would generally advocate, but in the first three lines of this plate the feeling, serif treatment and letter width of the original have been retained; the only change has

*NOTE. The "serif" is the short spur or cross stroke used to define and end the main upright and horizontal lines of the letter.

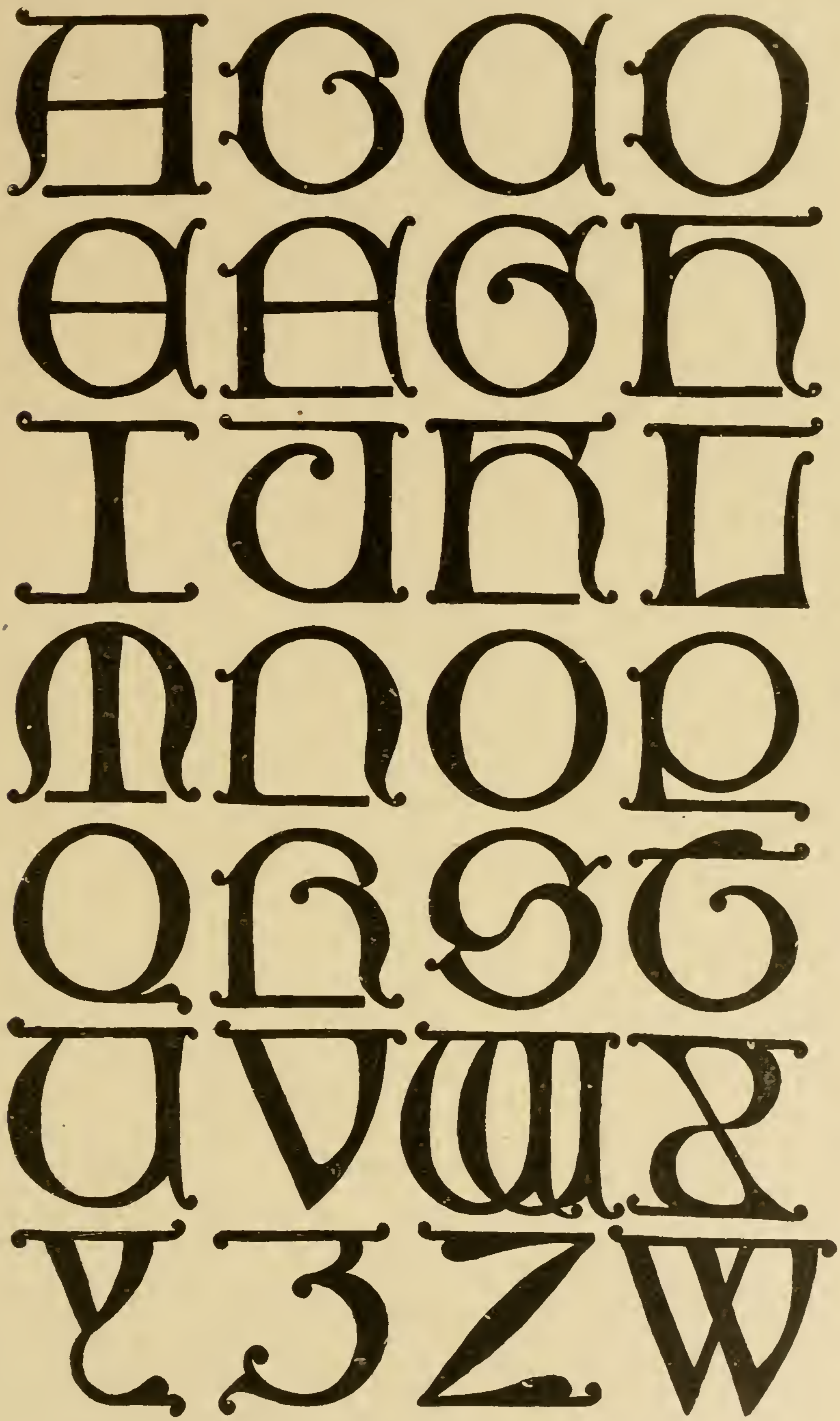


Fig. 30. Alphabet of Uncial Gothic Capital Letters, 16th Century.

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.

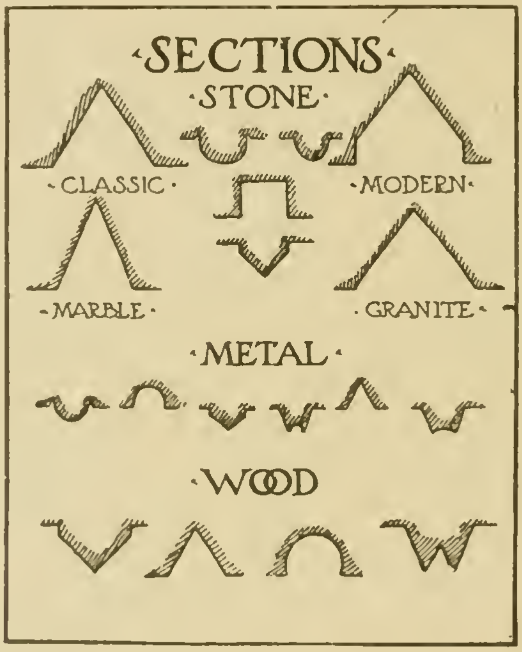


Fig. 31. Inscription Letter Sections.

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

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

Frank Lloyd Wright, Architect, Oak Park, Ill.

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

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 231. Building Completed in 1903.

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

Fig. 33. German Black Letters, from a Brass.

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

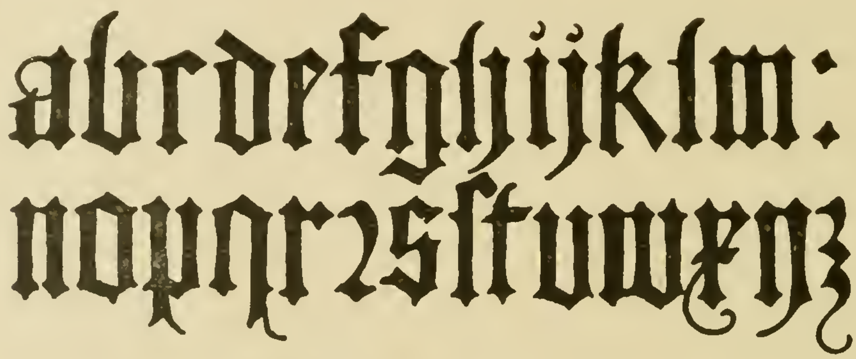


Fig. 34. Black-Letter Alphabet.

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

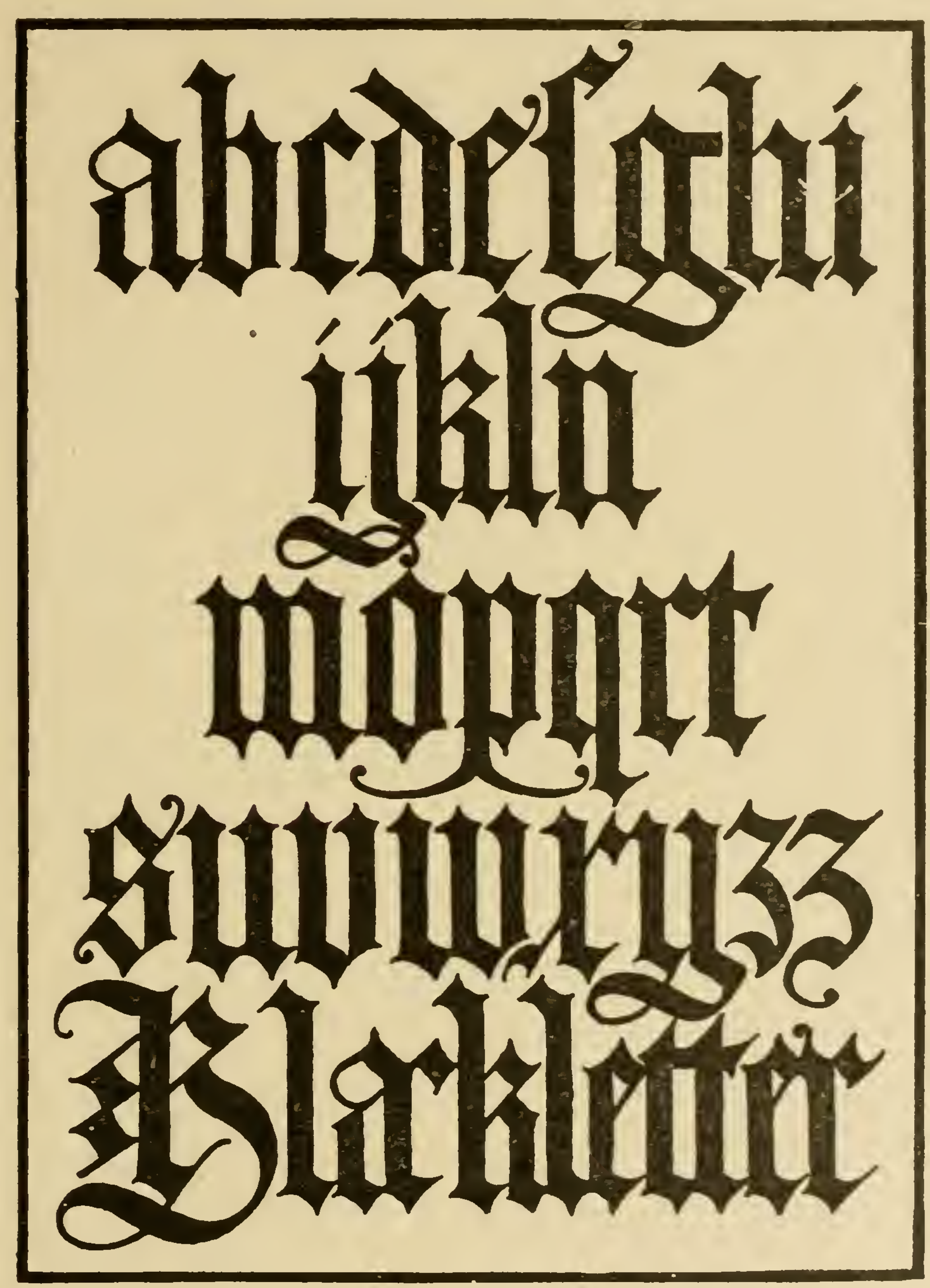


Fig. 35. Italian Black Letters, after Bergomensis.

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

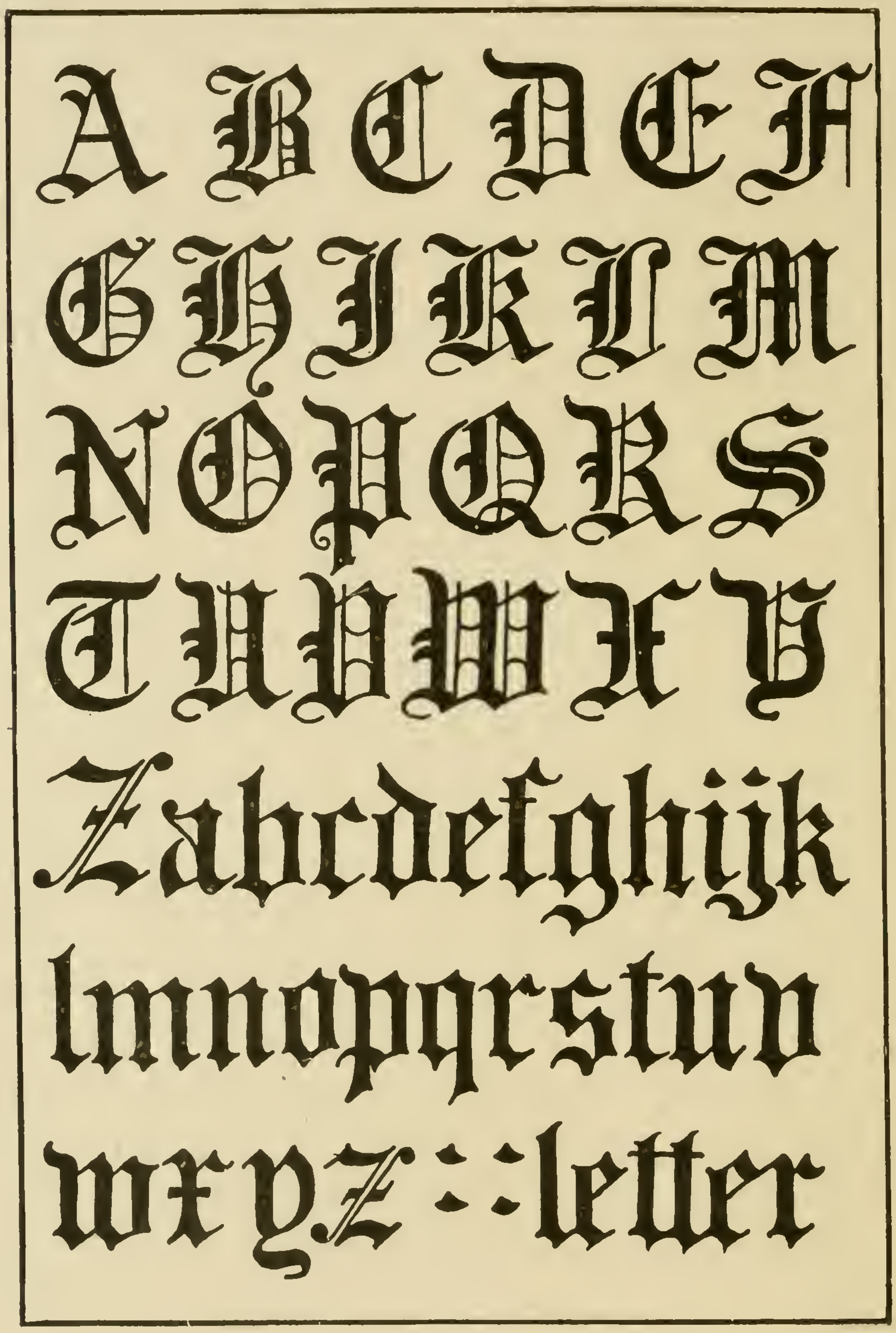


Fig. 36. English Gothic Text.

The alphabet of German black letters shown in Fig. 35 is taken from a very beautiful example of Gothic black letter devised by Jacopus Phillipus Foresti (Bergomensis) and used by him in the title page of "De Claris Mulieribus," etc., published in Ferrara in 1497. Although Italian, this letter is as German in character as any of the examples from the pen of Albrecht Dürer. A German black letter redrawn from a brass is shown in Fig. 33, while an English form of Gothic letter is shown in Fig. 36.

In Fig. 34 is another example of a black-letter alphabet. The entire effect of a black-letter page depends upon the literal interpretation of the title "black letter." That is, the space of white between and among the letters should be overbalanced by the amount of black used in defining the letter form itself.

Inasmuch as this letter is likely to be used but little by architectural draftsmen, and as it is a much more difficult form to compose than even the Roman type, it seems better to refer the student to some treatise where its characteristics are taken up more thoroughly and at greater length.

Any draftsman having occasion to use lettering to any extent should have some fairly elaborate textbook always at hand for reference, and it is believed that "Letters and Lettering," a larger treatise published by the Bates and Guild Company of Boston, from which several of the illustrations reproduced in this pamphlet have been borrowed, contains more material in an easily available form than any other textbook on the subject.

EXAMINATION PLATES.

In addition to the following Examination Plates the student is expected to make careful reproductions of the lettering in the foregoing section.

PLATES I, II, III.

Draw the alphabet, using the same construction as given in Figs. 1 and 2, and making each letter two inches high. Put ten letters on each of the first two plates, and on the third arrange the remainder, including the two forms of W given in Fig. 2.

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.

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ARCHITECTURAL DRAWING.

PART I.

Instruments and Materials. The study of mechanical drawing has acquainted the student with the use of the ordinary drawing instruments and materials. Those required for architectural work are substantially the same.

Pencils. Soft pencils are used; a draftsman cannot have advanced far in ability before becoming familiar with the B B pencil, which will draw any line, from the finest to the coarsest, and give the greatest freedom for all kinds of work, from sketching to full-size details.

In architects' offices it is an almost invariable rule for the new-fledged student and young draftsman to use hard pencils—"nails," as they are called by more experienced men. A soft pencil gives a much more agreeable expression of ideas on paper than a hard pencil; the latter should be reserved for mechanical work. The draftsman must not allow himself to become less accurate as he gains greater freedom, and the use of a soft pencil gives no excuse for a careless or slovenly drawing. H H, F and B B will be found the most useful grades. For laying out work, H H is often used.

Erasers. The noted architect, H. H. Richardson, said that "an eraser is a draftsman's best friend." For work on detail paper, a firm rubber is best, but a soft rubber is most serviceable for removing ordinary pencil marks from all kinds of paper, including the thin tracing papers, without injury to the surface. It will be found that the eraser can be frequently used in studying outlines, and it is the custom for rapid draftsmen to let the pencil lines run where they will, trusting to the eraser to make the outline true. A large size ink eraser will be found easier on the hands than a small one. In making erasures a typewriter's shield of metal with different sizes

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For some of the text and several of the illustrations in ARCHITECTURAL DRAWING the French work, Éléments et Théorie de l'Architecture, Vol. I., by Guadet, has been drawn on freely. The four volumes of this work by Guadet cannot be too highly recommended. Even those not familiar with the French language will find it an excellent reference work on account of the numerous useful illustrations it contains.

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.

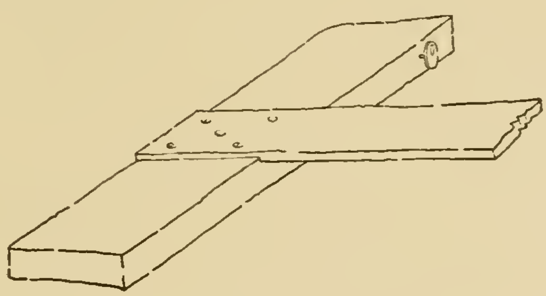


Fig. 1. T-Square with Thumb Tack.

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.

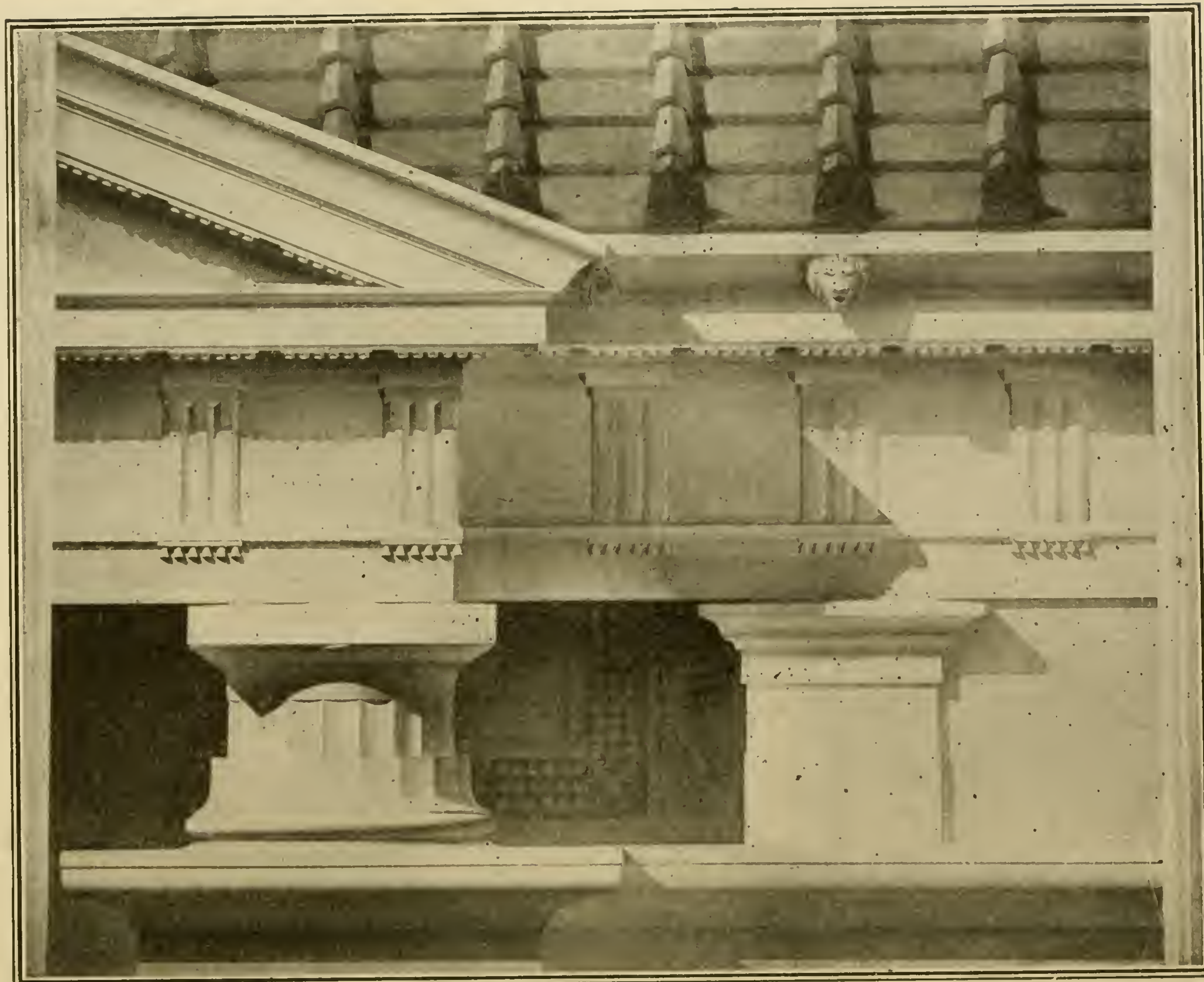
Tinted Papers. Gray or other colored papers are frequently employed, pencil or pen and ink being used for the lines and shadows, and chalk or Chinese white for the high lights. Pastels and water colors are used on special colored papers; "scratch papers" are those on which white is obtained by scratching 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



DETAIL OF GREEK DORIC ORDER.

An example of conventional shadows and rendering.

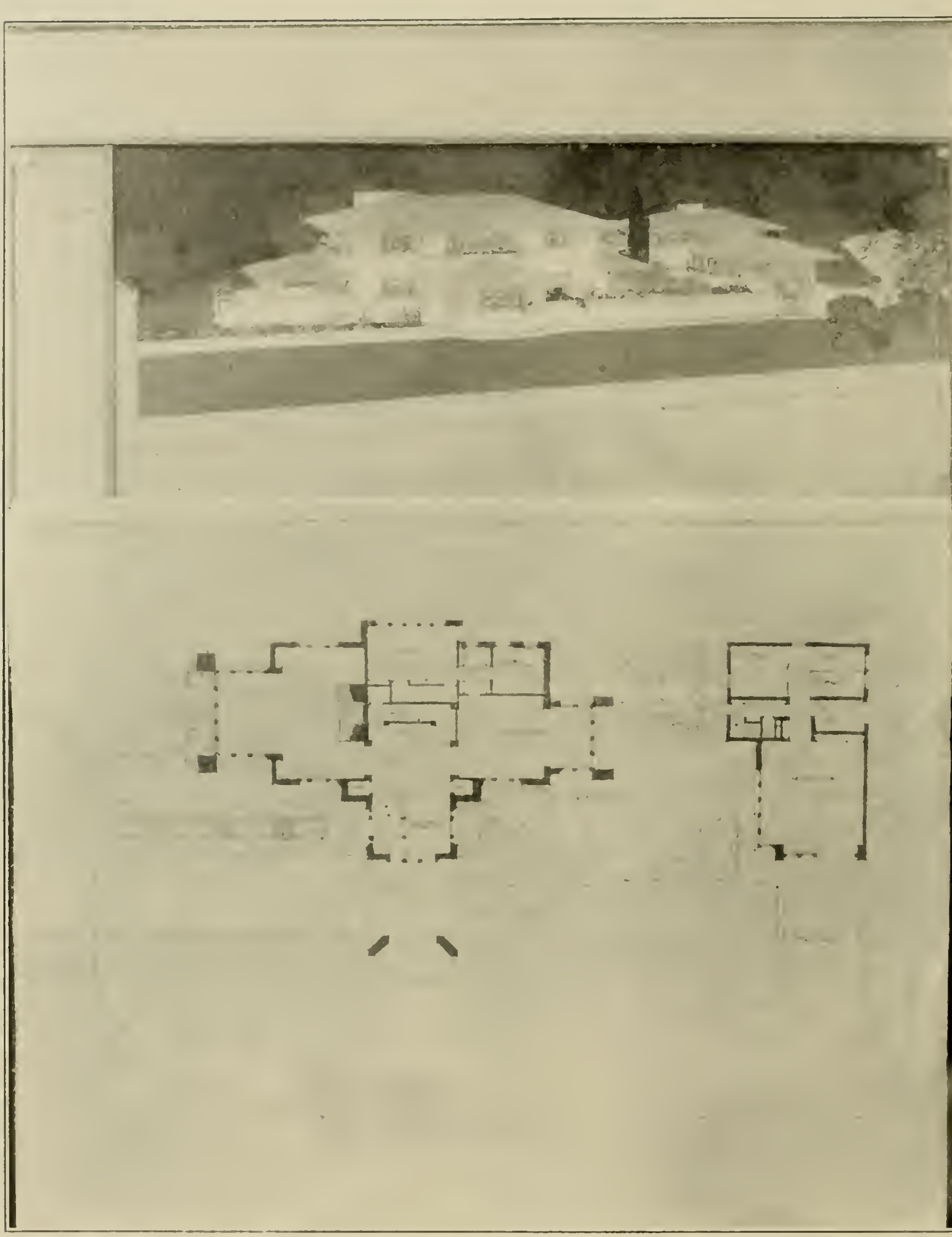
Entrance

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.

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.

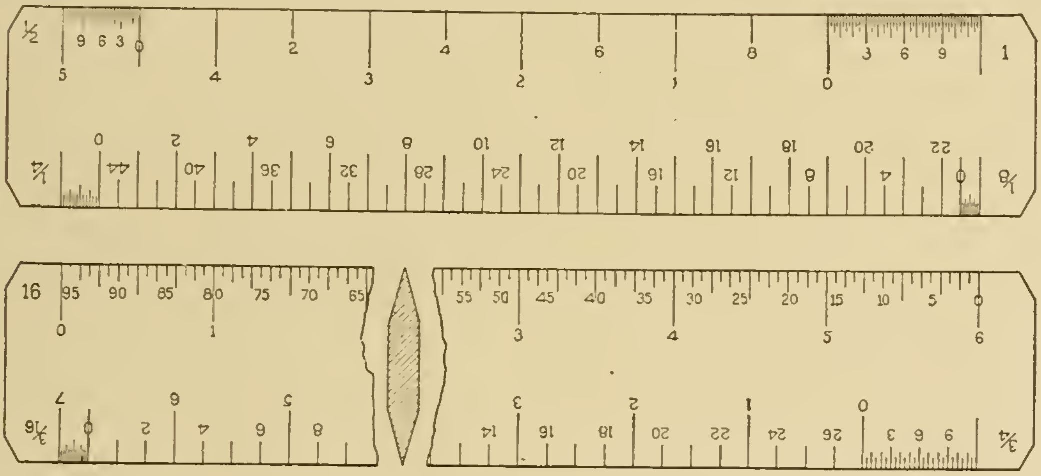


Fig. 2. Architects' Scale.

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

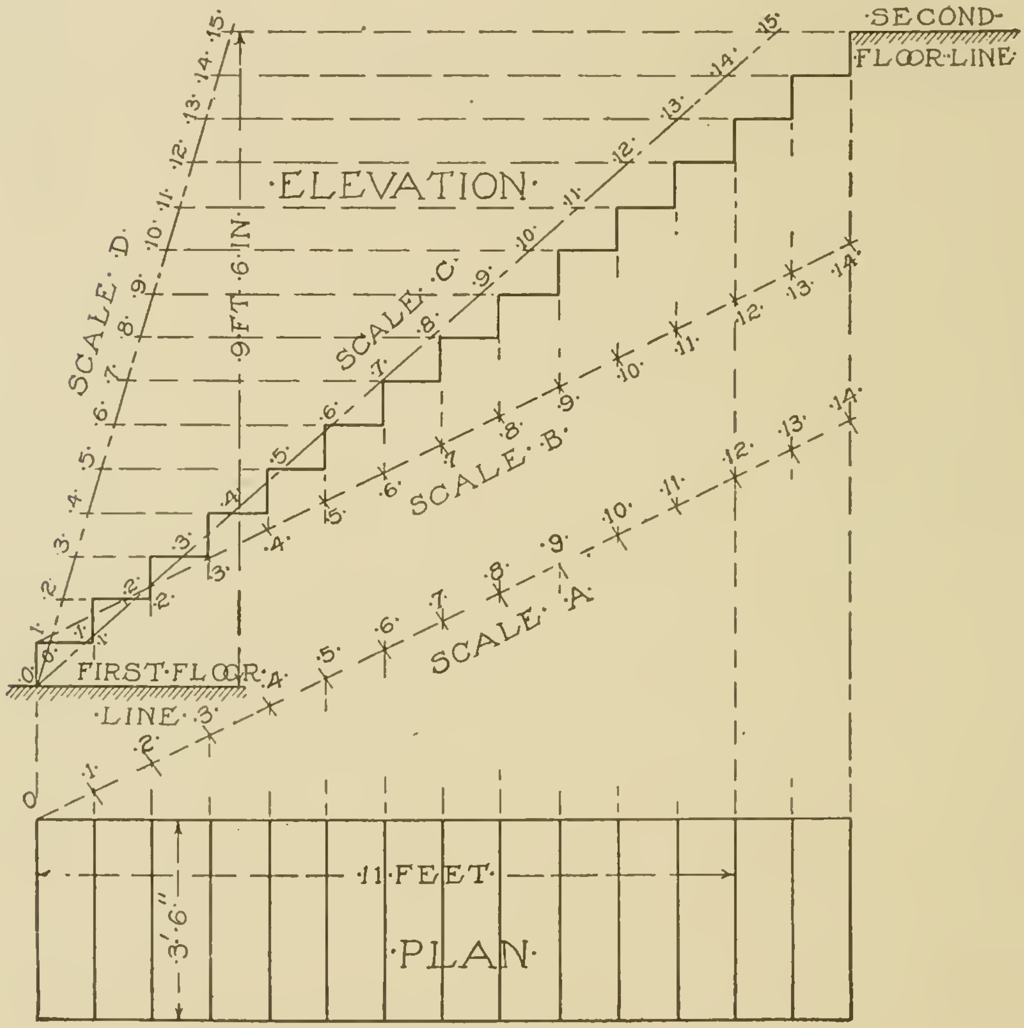


Fig. 3. Use of Scales in Laying out Stairs.

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 coincides with the line just drawn. Each division of the quarter scale marked off as a scale of proportional parts will give us a series of points through which we can draw parallel lines which will locate the risers eleven inches apart. If it is found that the stairs do not arrive at the point desired, the scale can be tipped more or less and each tread decreased or increased. The same method can be followed for laying out the stairs in elevation.

LINE DRAWING.

Character of Line. The thickness of the line in drawing should be the same throughout its length, except occasionally in perspective rendering. The line may vary in different parts of the same drawing, and in different drawings, according to how much or how little detail is to be shown, but in every case the lines should be firm and clear. Those parts of an elevation which are nearest to the spectator should be drawn in heavier lines than the more distant parts. Thick lines generally tend to simplify the design. The outline of the curved mouldings, excepting those circular in section, should be drawn freehand, as they can be given more character in that way than if made with the compass.

The compass should be used in such a way that the point will not make large holes in the paper. The arms of the compass should be bent so that the pencil point and needle point will be perpendicular to the paper. Pencil lines should be made without a heavy pressure so as not to dent the paper. The ruling pen should be held like the pencil and used very lightly, for if too much weight is put upon the pen, the paper will be cut, and if the pen is pressed too hard against the T-square the blades of the pen will be closed and the lines become weaker. It is also necessary that the ink should always flow freely from the drawing pen. It should be renewed frequently and the pen should be cleaned each time it is refilled. If the ink refuses to flow, it frequently can be started by touching the end of the pen to the moistened finger, capillary attraction immediately starting the ink to flow.

Ordinary writing ink should not be used with the drawing pen. After the drawing is inked in, the pencil lines can be erased. The student will eventually become accustomed to making the important lines with the pencil and putting in many of the lines of the drawing immediately in ink, between limiting lines in pencil. But the draftsman should be very sure of himself and his drawing before using this method.

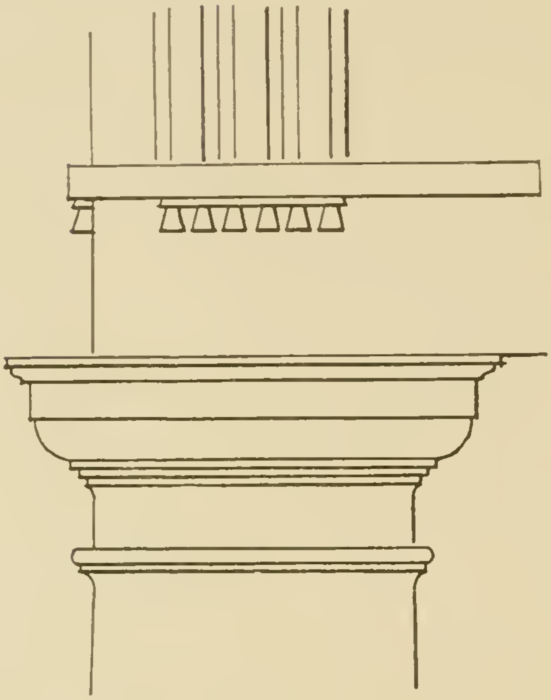


Fig. 4. Shade Lines.

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.

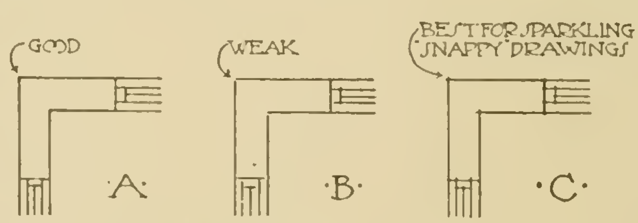
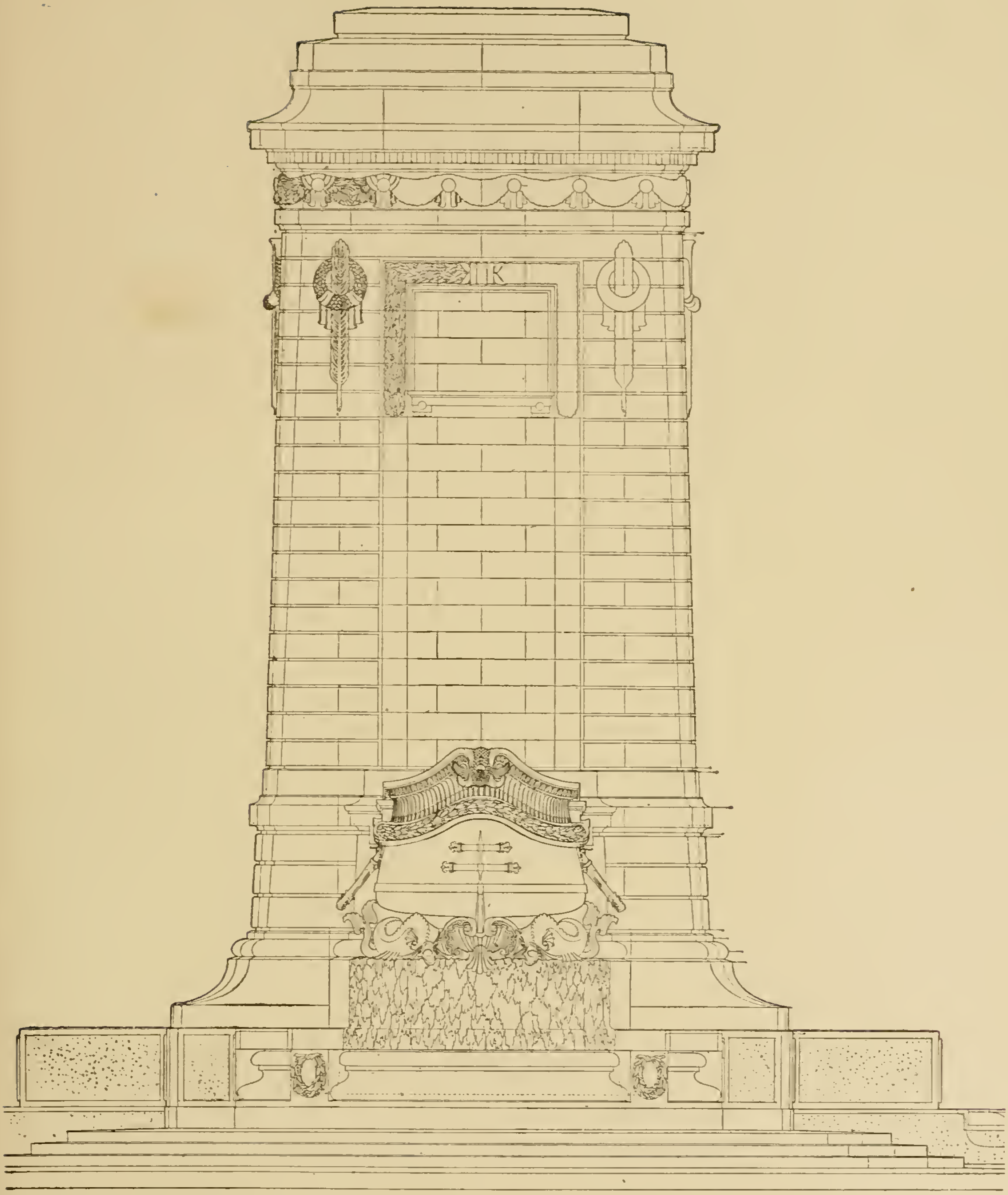


Fig. 5. Junctions of Lines.

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 small section of the front alone is made. This should preferably be called a profile of the front.

Definition of Elevations. The elevations of a building are the projections of the building on vertical planes parallel to the side of the building of which an elevation is desired. Except in the case of complete uniformity, it is necessary to have several elevations in order to show the complete exterior of a building, such as the principal facade, side elevations, and rear elevation.

THE IMPORTANCE OF AXES IN ARCHITECTURAL DRAWING.

The axis is the key of a design or of any composition. An axis in geometry is a line which separates into two equal parts any symmetrical plane figure, or the pole of a surface of revolution or of a regular solid, such as a rectangular prism with a regular base. In architecture the idea of the axis is greater than this. It is in reality a vertical plane through the whole building separating the building into two parts symmetrically, or in such a way that they balance one another.

Although the graphical representation is confined to a straight line, do not forget that it is not simply a line. Take for example a church; in drawing the plan, the axis of this plan will be a straight line separating it into two parts, but this line itself will be only the projection of the central vertical plane which is the axis of the whole building; and the keystones of the vault, the lights which drop from them, the center of the rose window, etc., are *in the axis* of the church. Notice besides this that the straight line which is the axis of the plan, and the line which is the axis of the front and rear facade, the line which is the axis of the transverse section—these lines are only the traces, all belonging to some axis plane, as it may be called, and this plane is the principal axis.

But there are other minor axes. Parallel to the main axis are the axes of the side arms and between these are the axes of the columns. Running transversely are the axes of the transept, those of each bay, the radiating axes of the chapels, etc.

In laying out the drawings of a church, for example, first place all of these different axes with the utmost accuracy. This method of laying out the drawings of a building by starting with the axes may 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.

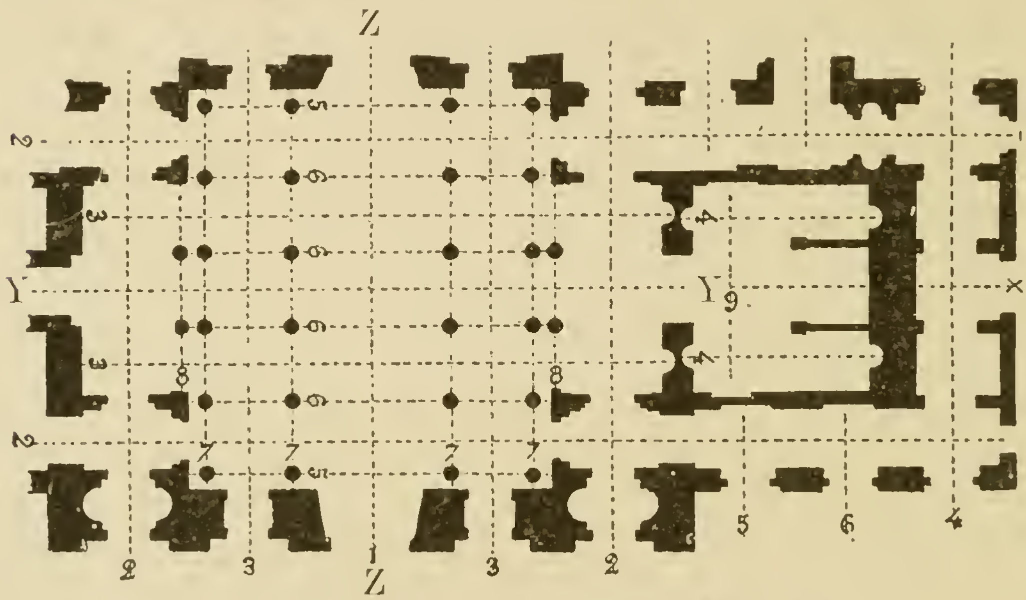


Fig. 6. Plan of Vestibule of Hotel des Monnaies.

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

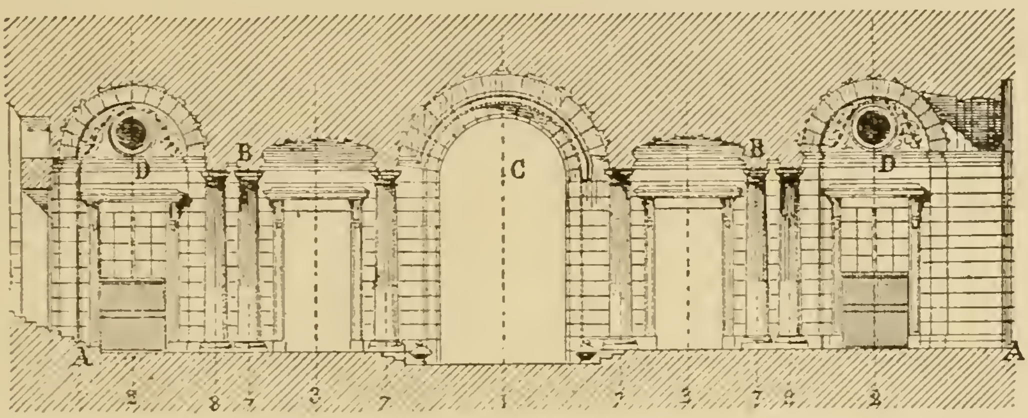


Fig. 7. Hotel des Monnaies. Transverse Section of Vestibule. Section on YY.

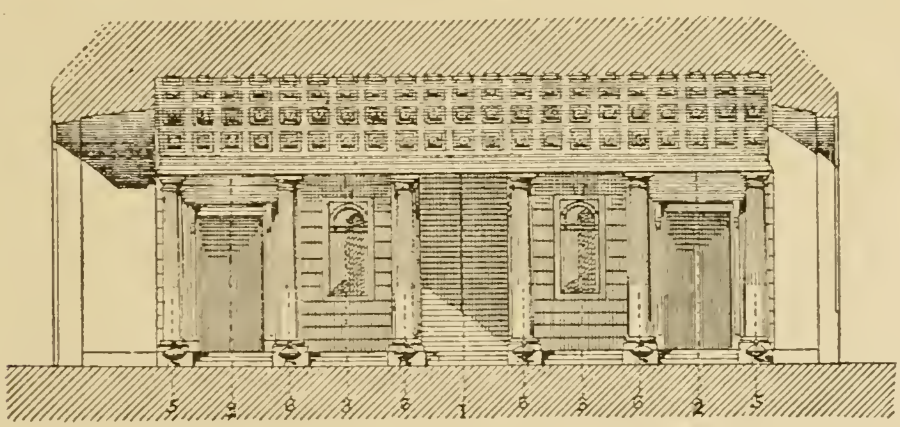


Fig. 8. Hotel des Monnaies. Longitudinal Section of Vestibule. Section on ZZ.

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 the capital, the total height of the architrave, the complete frieze, the complete cornice; then draw in each detail in height within these first divisions.

The channels of the triglyphs, the guttae, etc., are all drawn in on their own axes. As for the channels of the column, these can only be drawn by projecting them. Do not copy them from the drawing, but draw out a plan, dividing the circumference into twenty parts or whatever number the design calls for, and project these divisions up to the elevation.

Study the model carefully before copying it; thus, in this example a close examination will show that the architrave is slightly sloping while the frieze is not. If the student has the opportunity to see mouldings similar to those which he is drawing, he should study them carefully. It cannot be too often repeated that architectural drawing should not confine itself to exercise for the hand; there should be the opportunity for real study of whatever is drawn.

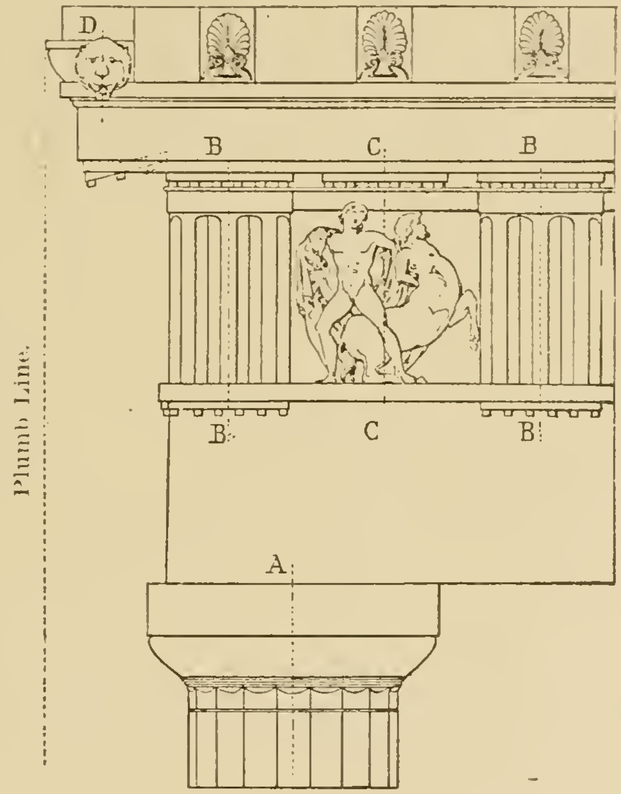


Fig. 9. Capital and Entablature from the Parthenon.

Limiting Lines. In geometry, we have learned what the *abscissa* and the *ordinate* are; *i.e.*, the elements of reference by which a point is referred to a system of fixed rectilinear co-ordinate axes. For every part of a design of which the elements are not geometrical lines, such as a right line or circle, the method of abscissa and ordinate is used, as in laying out profiles of mouldings or curved ornaments such as eggs in the egg and dart motive. Take for example a baluster, Fig. 10; it is evident that it should be drawn in relation to its axis. The student will mark the general divisions, A B the die, B C the base, C D the shaft, D E the capital, after which the secondary lines 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.

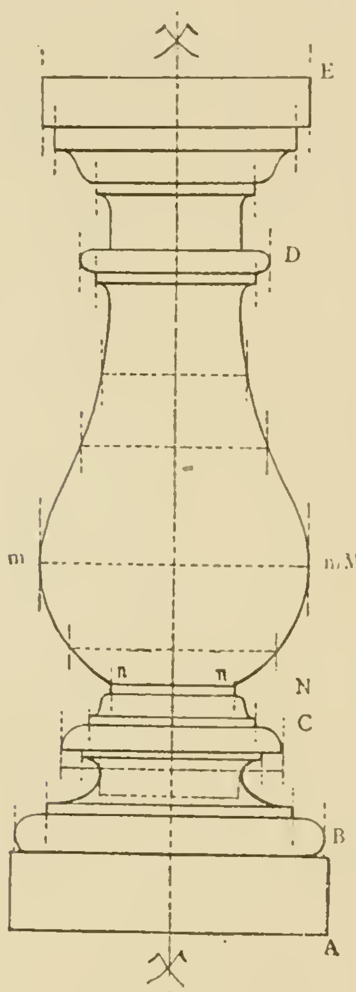


Fig. 10. Baluster.

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.

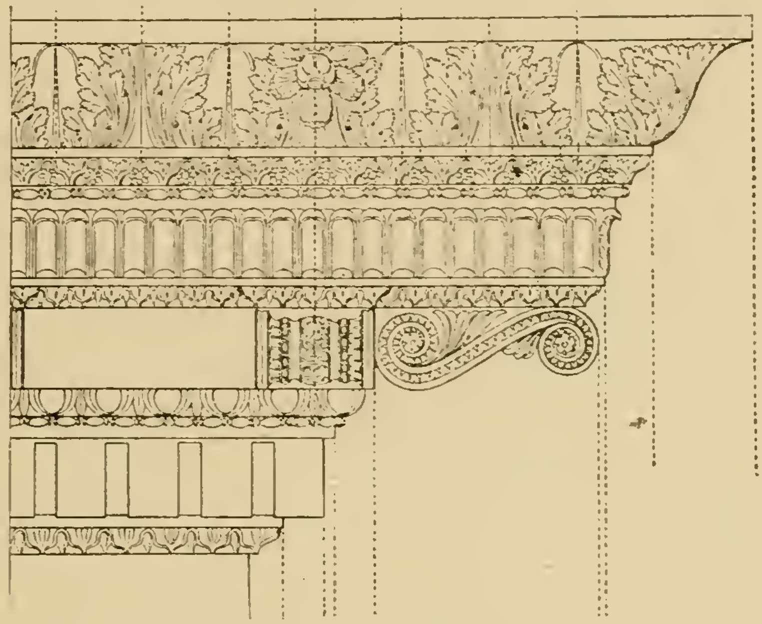


Fig. 11. Entablature from the Temple of Concord, Rome.

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.

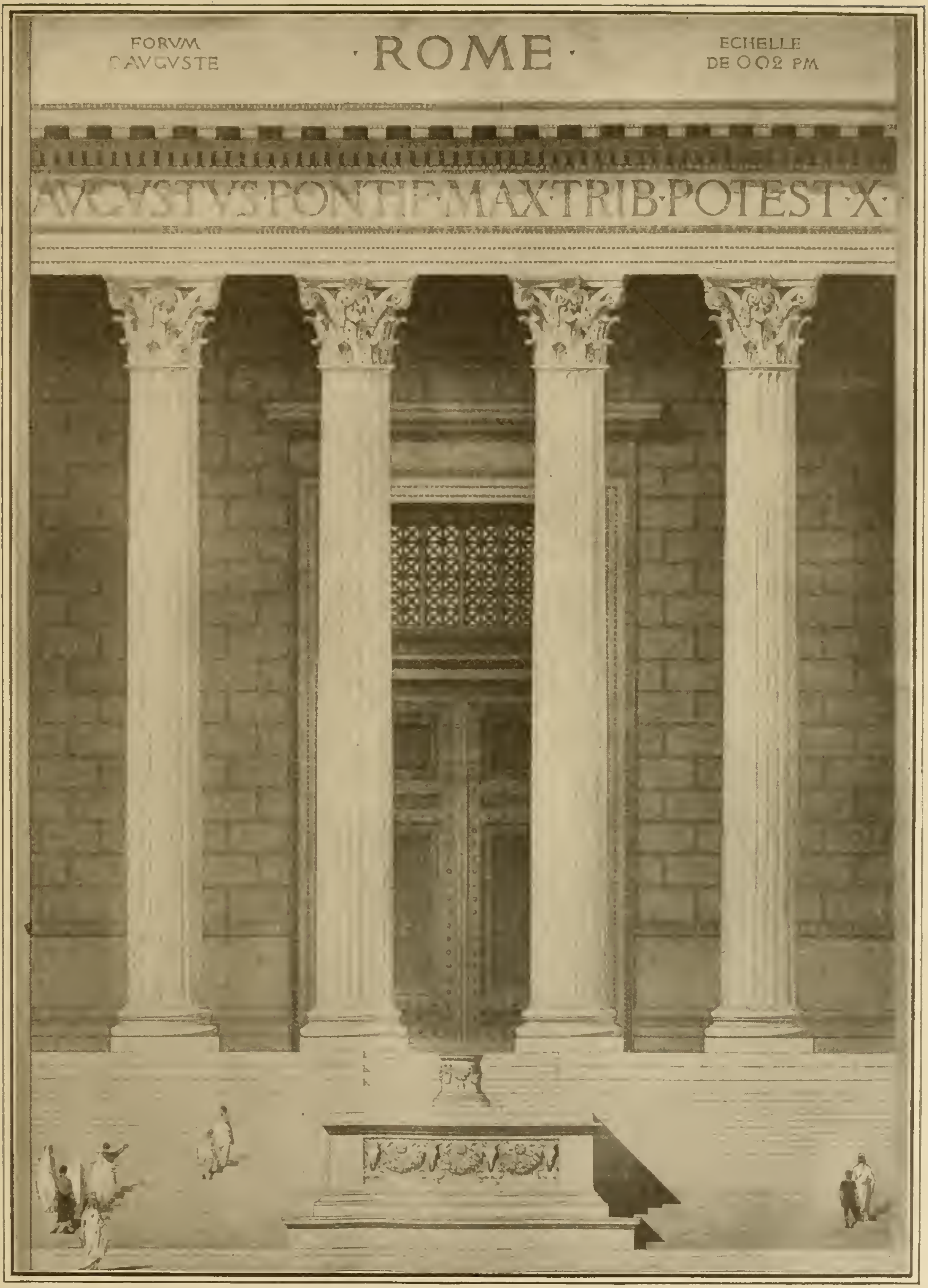
Consider, for example, two windows, one in direct elevation and the other projected at an angle. It is evident that the direct elevation permits the study of proportions and it is evident also that the oblique projection shows more than the direct elevation of the different parts of the window. In the 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.



DETAIL FROM TEMPLE OF MARS VENGEUR.

An example of classic lettering, conventional shadows and rendering.

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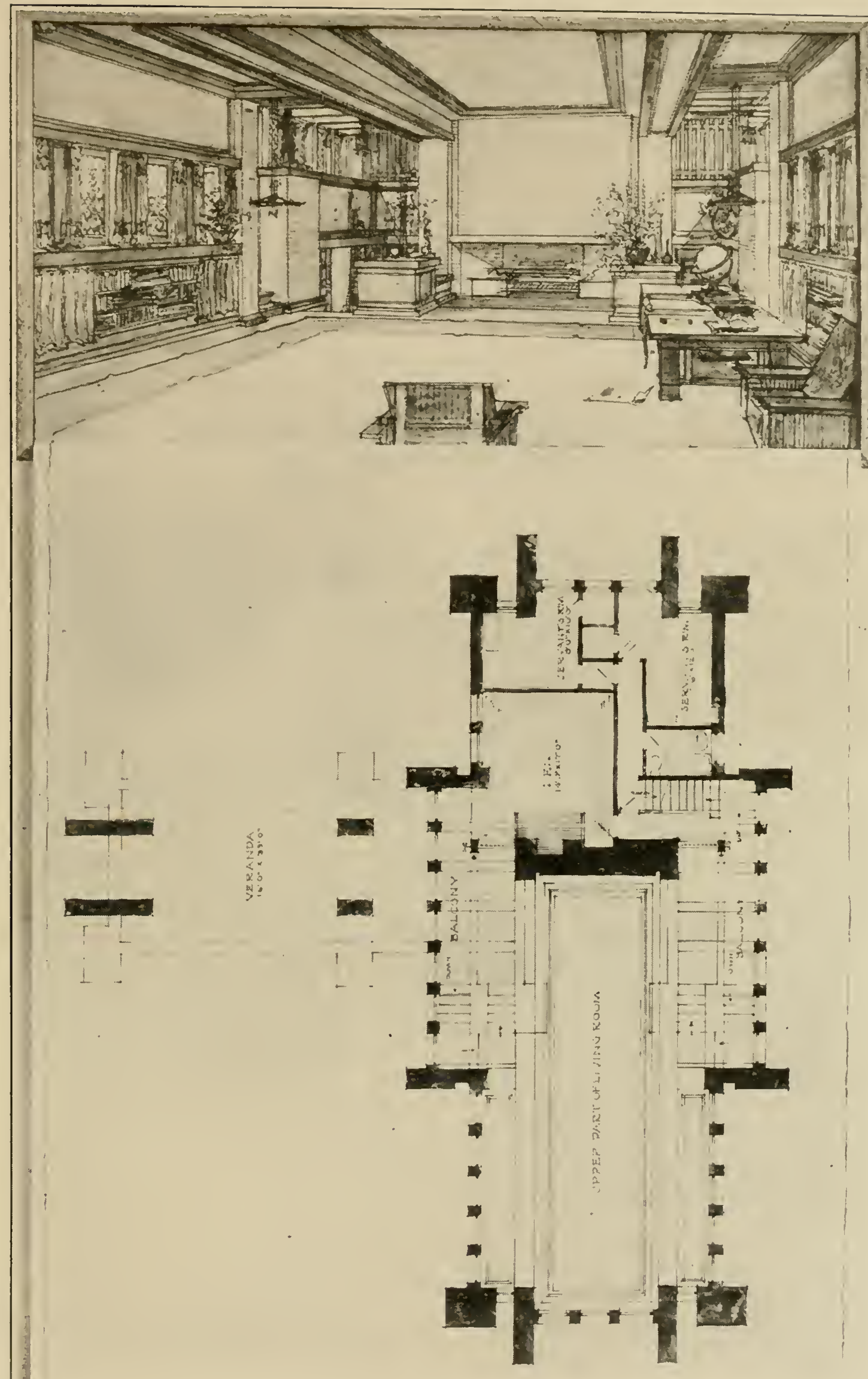

DESIGN FOR LIVING ROOM IN RESIDENCE OF MR. H. J. ULLMAN, OAK PARK, ILL.
Frank Lloyd Wright, Architect, Oak Park, Ill.

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.

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 be cast on a body unless this body is in the light and some other body is casting the shadow; (2) The value of the intensity, *i.e.*, the degree of darkness, of the cast shadow at any point is in direct ratio to the strength of light on that point.

The application of these rules can be illustrated on a geometric body, for example, the capital of a Doric column and its architrave.

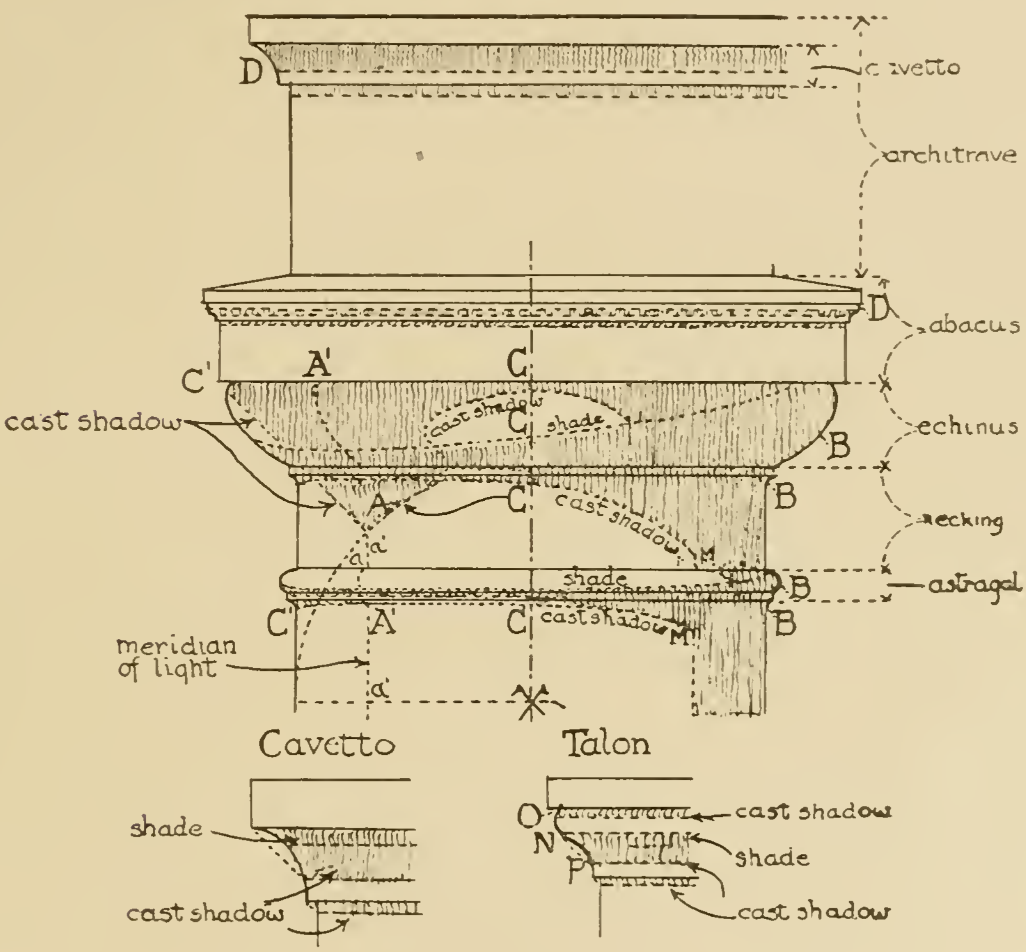

Fig. 12. Shadows on Capital of Doric Column.

Fig. 12. The shadows should be drawn out and a light shadow tint laid over them. Now let us consider where the most intense shadows will be. Evidently at A, where the shadow is determined by a ray normal to the cylindrical surface of a column, and the parts A′ A′, of the cast shadows which meet the surface of revolution following its meridian of light. The clearest reflected shadows cannot be seen in the drawing as they will be found at the back of the projection on the meridian opposite the point A. But among the parts seen on the drawing the most reflected light will be at the point B B, doubly lighted by its position on plan and by the form of the moulding.

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.

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of good wash drawings; for example, a large number of "Envois de Rome", or drawings made by students in Rome, have been photographed and published. These are models which cannot mislead one.

RENDERING IN WASH.

All studies and completed exhibition drawings in the architectural schools are tinted in India ink or water-color. This is done to show the shadows, and to indicate the relative position of the different planes, and is the method of representation in common use in architects' offices, especially in the presentation of competition drawings.

MATERIALS.

Chinese, Japanese or India inks are used for rendering, on account of their clear quality and rich neutral tone. The ink comes in sticks, Fig. 13, and it is ground in a slate slab provided with a piece of glass for a cover. See Fig. 14.

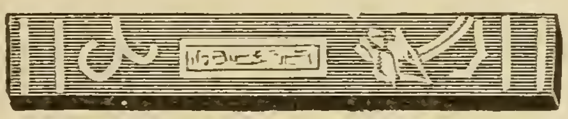


Fig. 13. India Ink.

There are various kinds of brushes. Camel's hair brushes are the cheapest and are useful for rough work. Sable brushes, Fig. 15, are two to three times as expensive as the camel's hair ones on

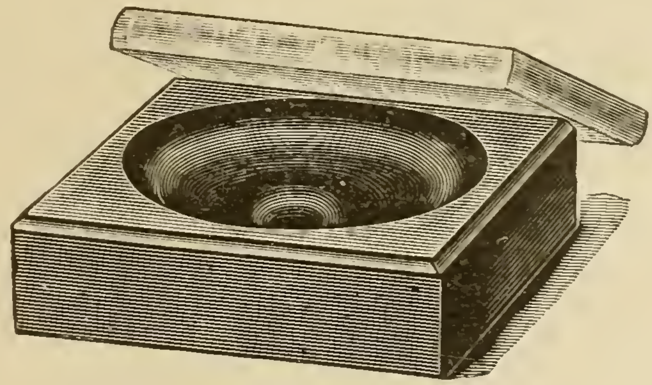


Fig. 14. Ink Slab.

account of the material, but are also very much better. The sable brushes have a spring to them not to be found in the camel's hair brush, and they come to a finer, firmer point. Chinese and

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.

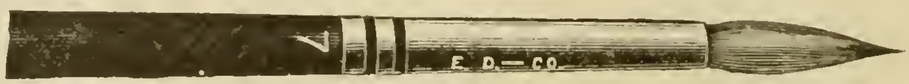


Fig. 15. Sable Brush.

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.

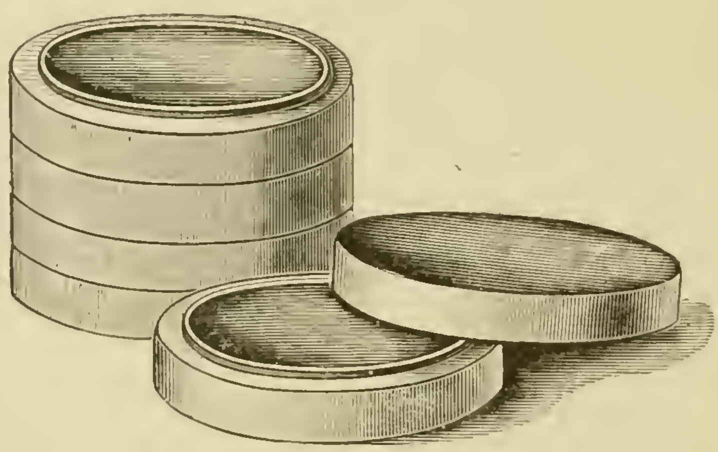
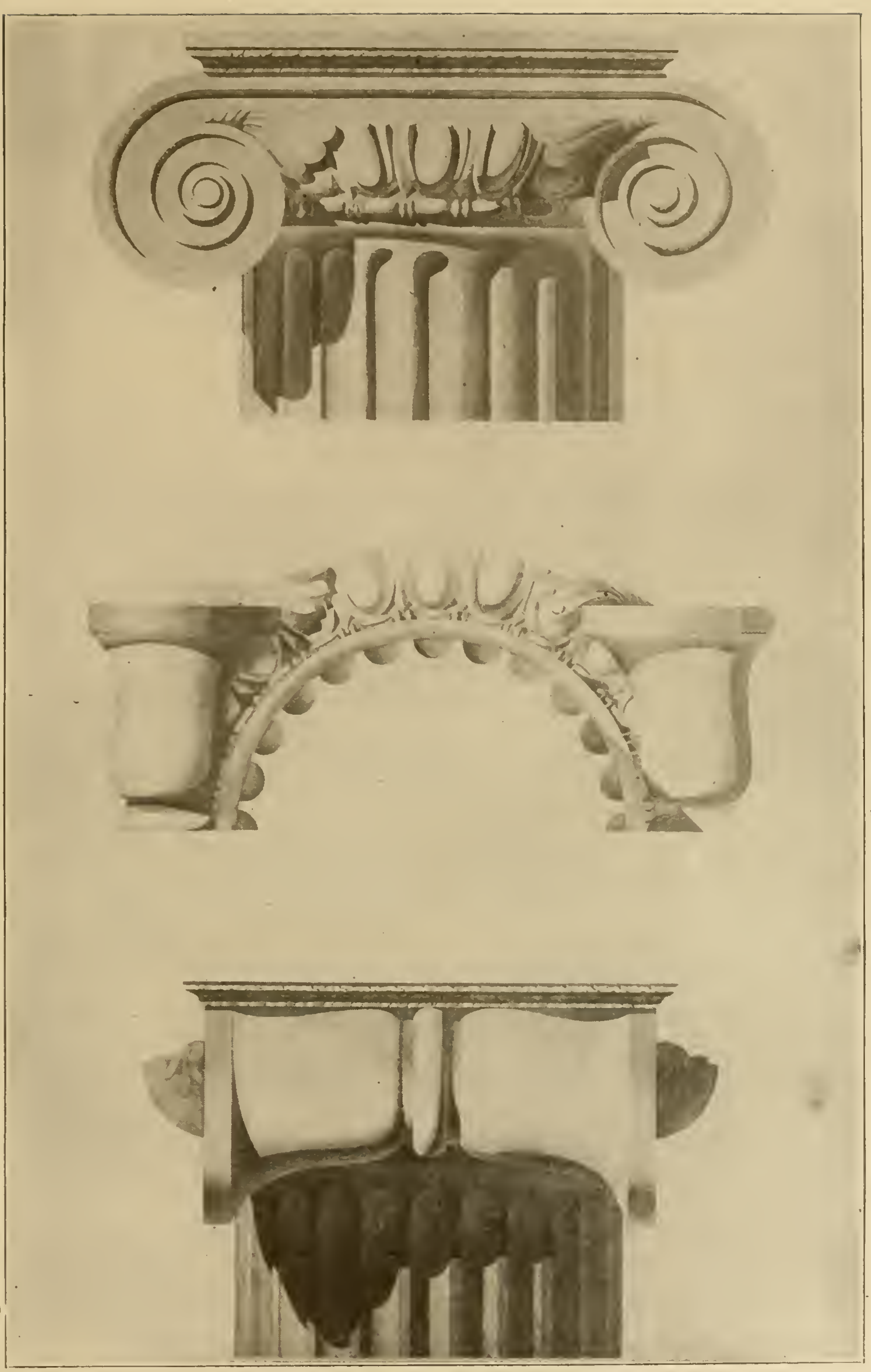


Fig. 16. Nest of Saucers.

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.

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should vary with the scale of the drawing, the larger and bolder the drawing the wider the line.

India ink evaporates very rapidly. It should be kept covered and changed several times a day, especially in summer. After the drawing is inked it should be washed to remove the surplus ink, otherwise when the tint is applied the ink will spread. This is best done by placing it under a faucet and rubbing it *very* lightly with a soft sponge. If the inking has been properly done the lines will now have the appearance of a firm pencil line of a soft neutral color forming a harmonious background for the tint. The shadows should then be cast and drawn in with a hard pencil in *faint* lines.

Preparing the Tint. For large washes India ink should be freshly ground in a clean saucer each time it is required. In no case use the prepared India ink which comes in bottles, as this is full of sediment which settles out in streaks on the drawing. Always use the stick ink.

Rub the ink in the saucer until it is *very* black; then let it stand, keeping the saucer covered. This allows the sediment, which is so fatal to a clear wash, to settle. After it has settled take the ink from the top with a brush without disturbing the bottom. Put this ink into another saucer and dilute it with the necessary amount of water. Never use the ink in the saucer in which it was originally ground. In dipping the brush into the second saucer it is well to take this ink also from the surface and thus avoid stirring any sediment which may still remain in the ink. In other words, the sediment which is found in even the most carefully ground ink should never be used for washes, otherwise streaks and spots may show in the washes.

Where only a small surface is to be rendered the tint can be mixed on a piece of paper in the same manner in which it is mixed in the saucer. Thus various shades can be obtained more quickly and experiments made more easily. Skill in laying washes is only acquired by practice. However, some instruction is necessary. If, after all possible care has been taken during the drawing, such as placing paper under the hand to keep the paper from getting greasy and keeping the drawing covered to protect it from the dust, the paper has nevertheless become soiled, it should be 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.

Reproduced by permission of Massachusetts Institute of Technology.

The edge of the wash should always be kept wet, for if it begins to dry a streak will surely follow. The tint should be carried down evenly across the board, moving the brush rapidly from side to side so that one side does not advance faster than the other. Carry the tint down about an inch at a time, the amount depending upon the size of the brush and of the surface rendered. Always go over the previous half inch at every new advance, taking care not to touch any part that has already dried. In this way the tint will dry gradually, parallel to the work. Carry the sides of the tint forward a little more slowly than the center. This will make the tint run towards the center and help to avoid the lines or streaks due to uneven drying.

The tint should be carried forward in such a way that the paper will be thoroughly and evenly wet. In fact, it is a very good plan to dampen the entire drawing with a soft sponge before beginning to lay a wash. This dampening should be carried well beyond the edges of the drawing so as to prevent the color from spreading to the drier and more absorbent parts of the paper. Always remove the pool of tint which remains at the bottom of a wash in the manner described under "Handling the Brush." If allowed to remain it will dry more slowly than the rest of the drawing and a streak will show.

The drawing board should be left inclined until the wash is dry. Never lay one wash over another before the previous one is absolutely dry.

In laying washes which grade gradually, either from dark to light or light to dark, grade the tint by the addition of water or color each time that an advance is made, and be careful that these additions are such that the change in color is made evenly.

It is very difficult to lay an evenly graded dark tint with one wash only. It is usually better to lay a light flat wash or a light graded wash to serve for a background on which to lay the dark graded wash. By a flat wash is meant a wash which is the same tone or color throughout; that is, a wash that is not graded. See opening in Doric Doorway, Roman Temple, Cori, opposite page.

Water has to be added constantly in grading. Where there is a series of graded washes, as in successive window openings, it is better to have two or three saucers containing tints of different 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.

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.

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

Rendering Elevations. The object of rendering a drawing is to explain the building. Those parts of the building nearest to the spectator should show the greatest contrast in light and dark, for in nature, as an object recedes from the eye, the contrast becomes feebler and feebler and finally vanishes in a monotone. Every elevation shows the horizontal and vertical dimensions of a building, or details of a building, but in a line drawing the projections of the different parts when in direct front elevation are not shown ; and it is to indicate these projections that the shadows are cast and the drawing is rendered. The appearance of a building or any details of a building will be clearly shown by the shadows in their different values of light and dark. (See plates, pages 18 and 23.) The windows and other openings of a building should be colored dark, but not black—although this is sometimes required in competition drawings—and varying lighter tints should be used to indicate the color of the material in the roof and walls, the difference in the color intensity indicating the varying distances from the spectator. Note in plate on page 5, the comparative values of rendering in roof and shadows on roof ; also portions of order in light, portions in shadow, and background of column. This method of drawing is frequently carried to an elaborate extent by showing high lights, reflected shadows, etc., and an elevation can thus be made to show almost as much of the character of the proposed building as would be shown by a perspective view or by a photograph of the completed structure. See frontispiece, "Fragments from Roman Temple at Cori." Study the different tone values of the various objects in the foreground and in the background, and note the perspective effect of the background.

It is a good plan, before starting to render a drawing, to make a small pencil sketch to determine the tone values which the various surfaces should have, so that they will assume their proper relative positions in the picture.

Drawings of this kind are much superior to any others as a means of studying the probable effect of the building to be constructed, as they show the character of the building and, at the same time, dimensions can be figured directly on the drawing. It is difficult and unusual to give measurements on a perspective drawing.

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.

the true mass of the openings. Many good designs are greatly injured in the rendering by the violent contrast in the grading of the openings from dark to light.

In the shadow itself it will be found that detail is accented or

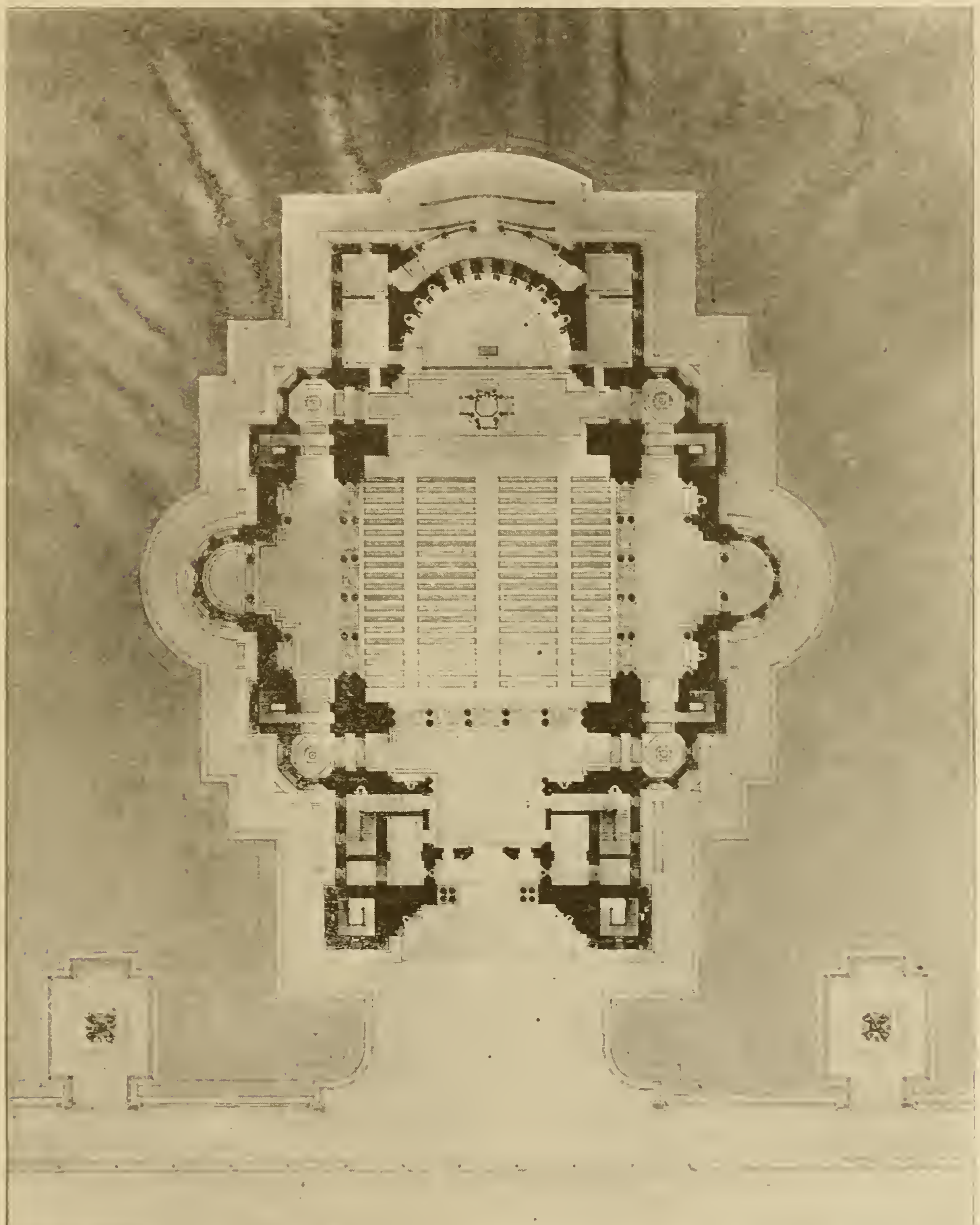


Fig. 17. Conventional Method of Rendering Plan.

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.

colors in the tubes can be squeezed out on the palette as needed, and if this is done fresh bright effects are obtained. For the be-

Fig. 18. Box for Pan Colors.

ginner, however, pan colors are recommeded, as they are more easy to handle. Fig. 18 shows a japanned tin box for pan colors. Fig. 19 shows a pan color, and Fig. 20 a tube color.

List of Colors: The following list of colors will make a very good palette:

Cadmium	Orange Vermilion	Cobalt Blue	Emerald Green
Indian Yellow	*Carmine*	New Blue	*Hooker's Green*
Lemon Yellow	Light Red	*Prussian Blue*	
Gallstone	Burnt Sienna	*Paine's Gray*	Chinese White
Yellow Ochre	*Warm Sepia*		

The colors printed in italics are clear colors which will give clear even washes. The others will settle out, the color settling

Fig. 19. Pan Color.

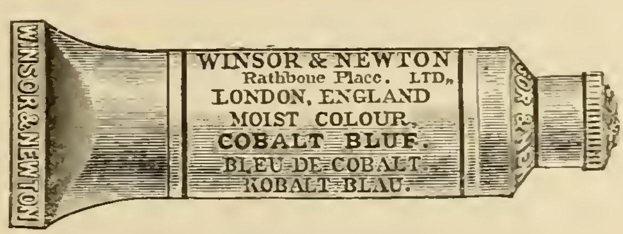


Fig. 20. Tube Color.

into the pores of the paper producing many small spots. This effect is often desirable, giving a texture which cannot be obtained with the clear colors

For use in the offices, India ink, Chinese white, galistone, 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.

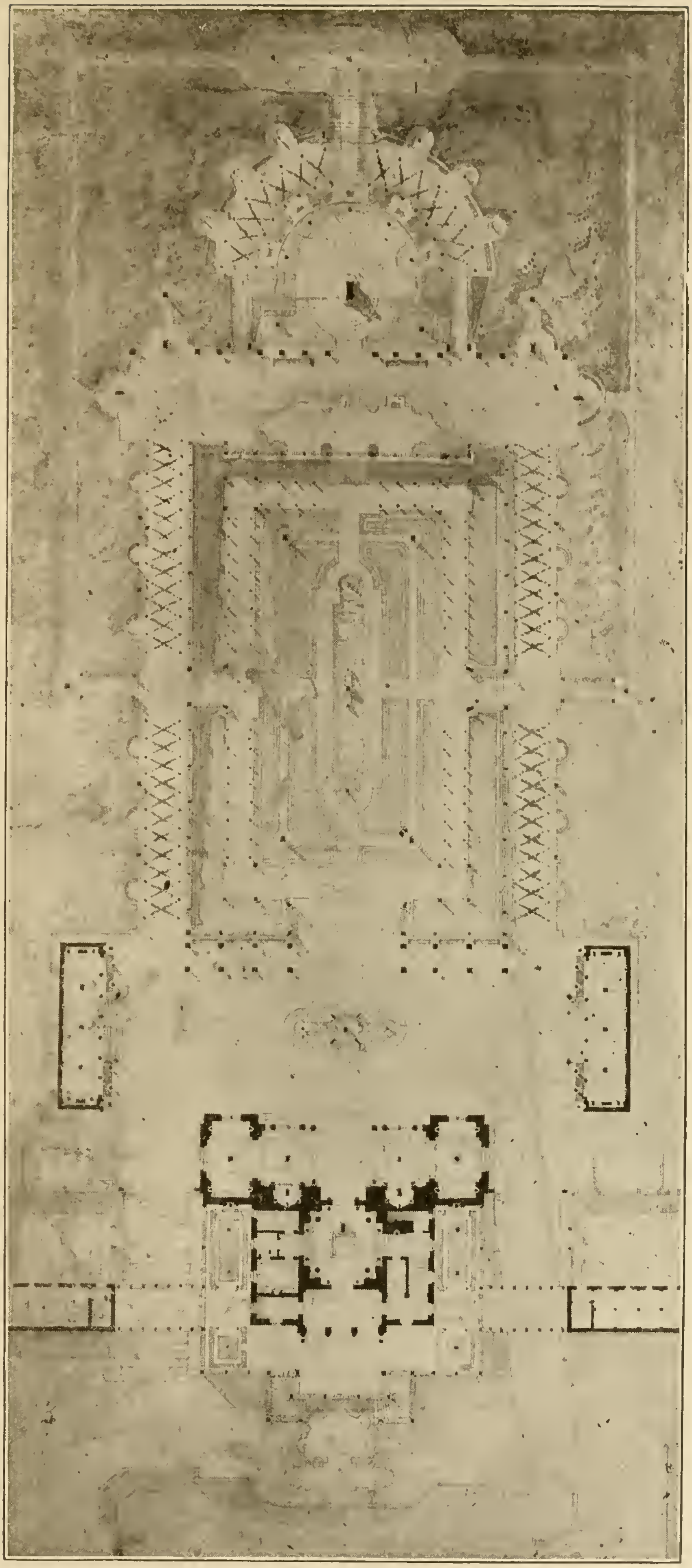
Brushes and Paper. A small brush with a good point is necessary for "drawing in" and for detail. A bristle brush is very useful to remove color and to soften hard lines. Chinese brushes are very good, as they hold a great deal of color and at the same time have a good point.

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



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.

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

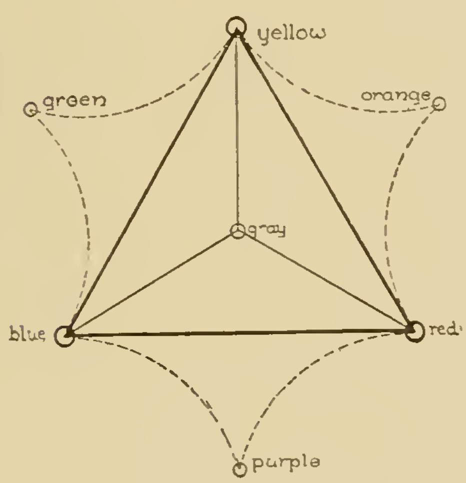


Fig. 21. Diagram of Colors.

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.

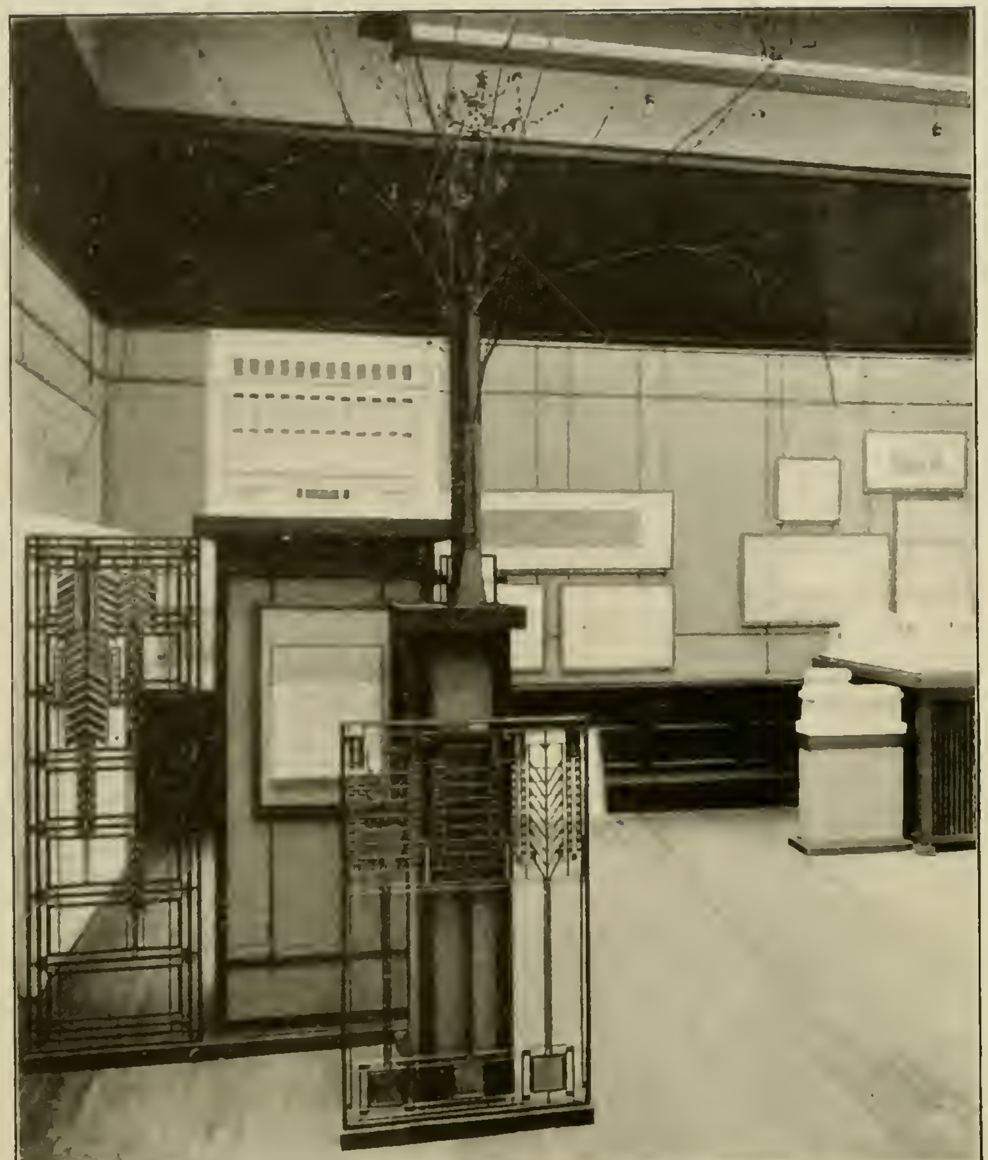
Sketch elevations in pencil may be inked in or may be rendered directly in water color, the shadows being cast and various colored tints laid on to show the different materials, shadows, window openings, etc.

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



CHICAGO ARCHITECTURAL CLUB EXHIBITION, SPRING OF 1907.

Exhibit of Frank Lloyd Wright, Architect, Oak Park, Ill.

this; in other words, the aim should be to make as harmonious a composition as taste, talent and thought can produce.

Water Color Sketching. Nothing is more useful to an architectural draftsman than out-of-door sketching in colors. A water color block should be his constant companion on his Saturday half holidays, and, if possible, he should join some sketching class.

The sketches in water color may be taken from natural scenery, but the student should also make studies and color sketches from color decorations of exterior and interior of buildings.

Do not indicate too much in water color sketching, search for the big masses in shape and color values and put them in direct and simple.

A draftsman who gives his leisure time to water color sketching in summer, and to evening classes in drawing from the antique and from life in winter, will have as good a training as could be wished for in this part of his architectural career.

PRELIMINARY STUDIES IN ARCHITECTURAL DESIGN.

Methods of Study. Different designers work up their drawings in individual ways. Good results are, as a rule, accomplished by getting ideas on paper, comparing and working up the best, and combining different features from the different sketches. Some men of the highest ability prefer to work in this way. Others work up the ideas in their minds before drawing them on paper, often not changing a line once it is put on paper. The latter proceeding is dangerous, as it tends to make the designer satisfied with the first idea that comes to his mind, and makes him unwilling to search for other ideas; he is liable to become narrow and careless.

Putting Ideas on Paper. The problem which the architect has to work out is to make the building of a form and of dimensions best suited to the demands of the client, so that all the parts are in good proportion and in harmony with each other. Much detail in former times was studied on the building in course of construction, but now everything has to be prepared beforehand, and the smallest details foreseen before the building is commenced. The preliminary sketches are generally made on a small scale, one-eighth inch, one-sixteenth inch, or one-thirty-second inch to the foot, worked up from rough thumb-nail sketches often not drawn to scale. Some designers 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 having been accepted, it is his duty to carry them out with as little change as possible, excepting to perfect the proportions and details.

Sketch Plans. The plans, even in the studies, should have the walls colored in with any appropriate color, such as dark gray, as otherwise it is very difficult to see on paper the proportion of the spaces, the ease of circulation, and the general character of the whole in mass and in detail.

Sketch Elevations. After the plans have been thoroughly studied the elevations may be worked up, studying the architectural style and general character of the exterior in relation to the plan. These drawings should be studied over and over again on tracing paper, casting the shadows so that the projection of cornices and sizes of window openings may be seen; at this time also details of a larger scale may be studied in sketch form.

On the elevations or in perspective, the jointing of the stone, brick or terra cotta, may be drawn and this will give a surface texture that may save further rendering.

Perspective Studies. For all smaller buildings, such as cottages, farm buildings and small public buildings, requiring a picturesque treatment, such as a broken roof line, it is better, instead of spending much time on elevations with the shadows cast, to draw almost at the start, a perspective from the most important point of view, and make rapid sketch perspectives from several different points of view.

Perspective Drawing. A perspective should be made of every building designed, primarily in order that the designer may see how planes at right angles—for instance, the side and front elevations—come together, and also how roof lines will look from the customary point of sight. This is especially necessary in buildings of a picturesque character. A perspective is also generally demanded for exhibition purposes, so that clients may gain a better idea of the appearance of the proposed building.

Perspective sketches to explain certain points in the drawings are of great value. Very difficult detail drawings may have sketched on them the details in perspective from different points of view. These sketches will explain more clearly than many careful drawings how certain parts come together. Such drawings are very welcome in the workshop and on the building in course of construction.

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,

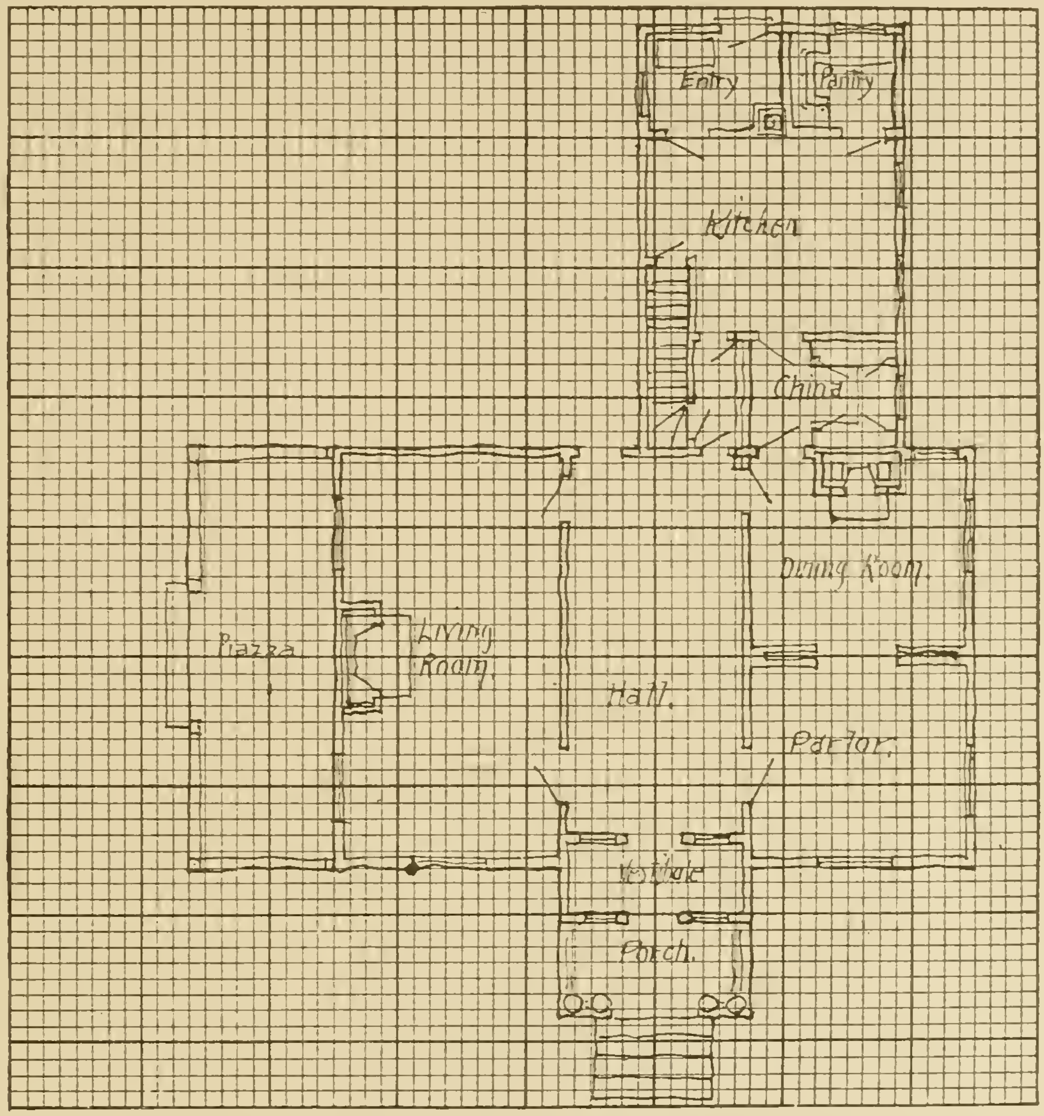


Fig. 22. Cross-Section Paper.

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 the latter he can learn besides how in olden times natural objects were conventionalized for use in decoration.

Memory sketches are excellent practice. Go to see a model, study it as carefully as possible; then go home and make a sketch of it. The student may be sure that his memory will betray him, and he should go back to the subject and study it again and again—twice or three times if necessary—after which he will finally arrive at a reasonably accurate sketch.

MEASURED WORK.

There are two occasions for making measurements of old buildings; one, when it is proposed to make alterations; the other, for the sake of study, making drawings of portions either for immediate study or future reference.

Materials. It is a good plan if possible to take a small drawing board, T-square, and triangles to the building. Cross-section paper ruled one-eighth inch between light lines and one inch between heavy lines is very convenient. See illustration, Fig. 22, showing use of cross-section paper. Drawings may be laid out directly to scale on this paper, at one-eighth, one-quarter, or one-sixteenth inch to the foot, or details drawn at three-quarters inch to the foot, or full size.

Measuring Tapes. The dimensions should be taken with a tape, and for architectural work a "metallic" tape or cloth reinforced with fine wires and having clear figures, is very satisfactory, though it will be advisable to use a steel tape for very accurate work.

Datum Lines. As a general rule, it is best in frame buildings to take the horizontal measurements on the sill line, making a small section to show the relation of the sill to the walls. In brick and stone buildings they should be taken on the outside wall face or ashlar line. For heights, the finished floor levels should be taken as starting points, the main first floor of the building being the general datum. If there are many projections in plan it will be well to draw a straight base line and measure it from this line. If old buildings are out of level it will be necessary to use a straight edge or draw a level line on the wall and measure up and down from this level.

Hand Level. The hand level will be found very convenient for obtaining approximately the grades about the building. This 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,

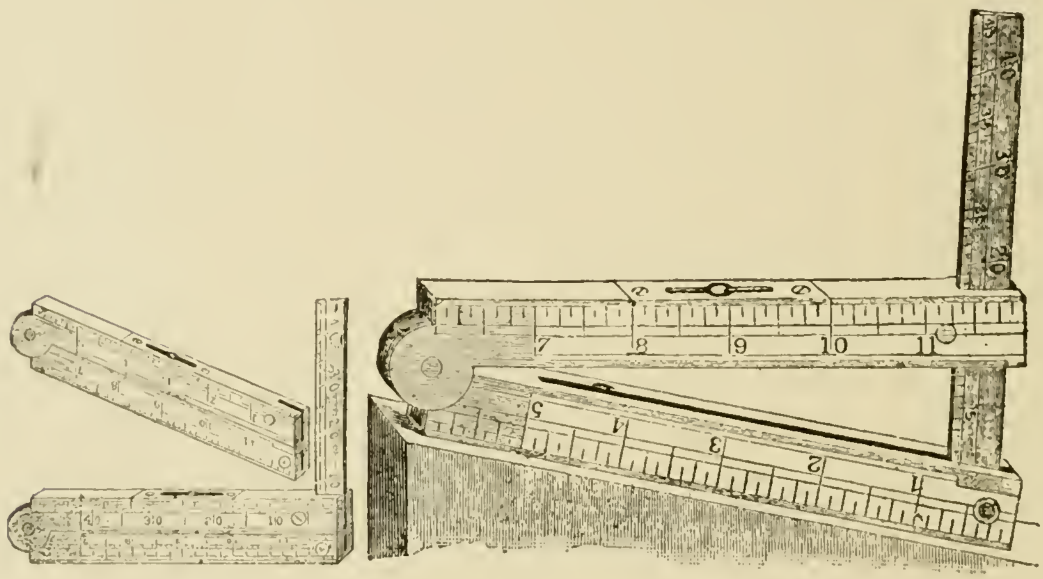


Fig. 23. Twelve-inch Single Jointed Rule and Level.

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.

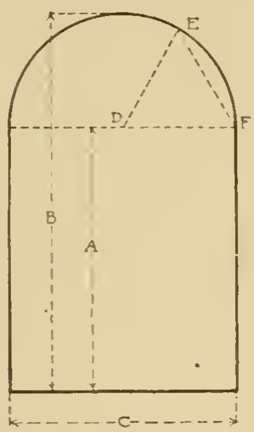


Fig. 24. Measurement of Arches.

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.

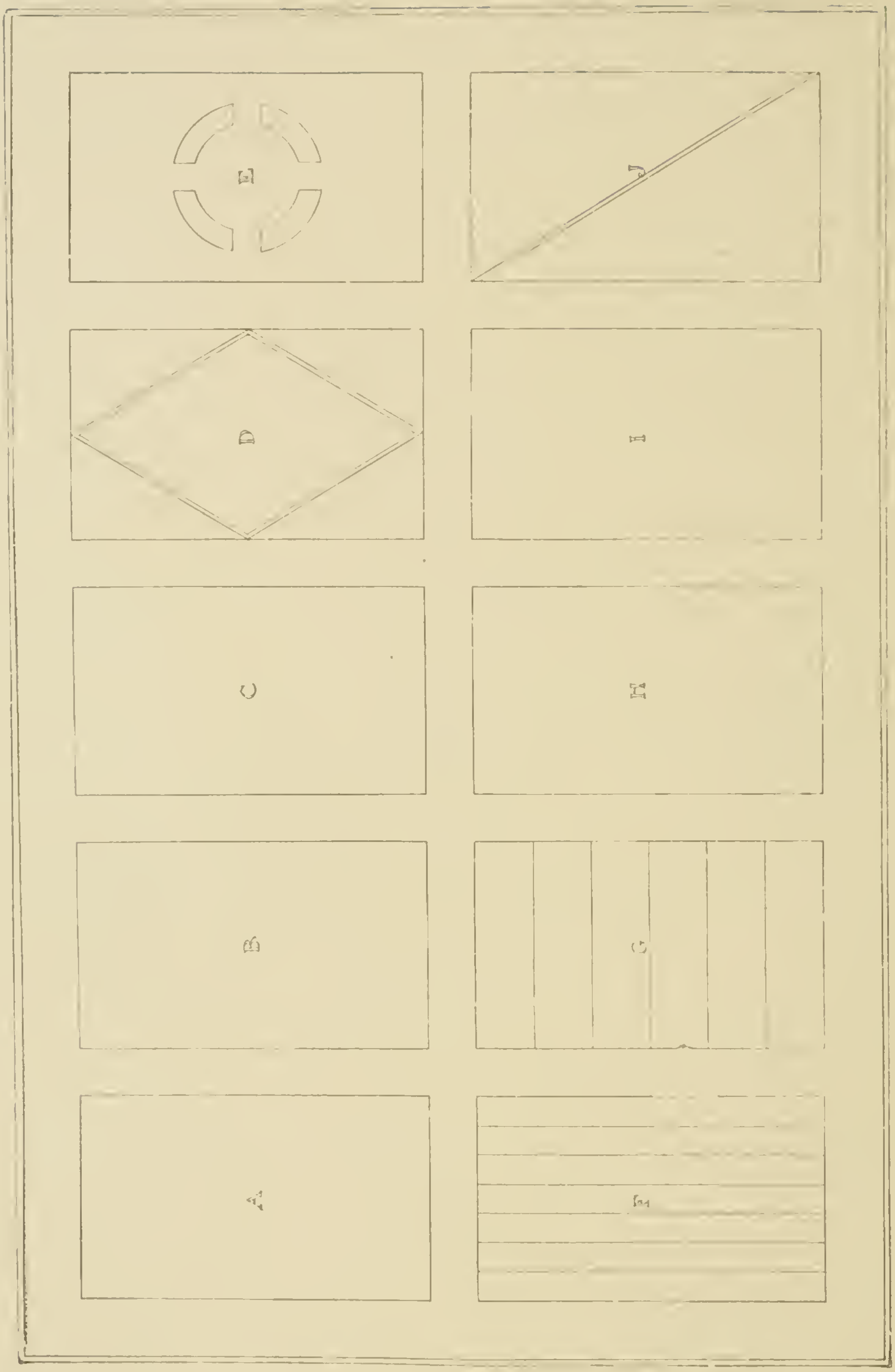


PLATE A

REVIEW QUESTIONS

ON THE SUBJECT OF

ARCHITECTURAL DRAWING.

PART I.

Materials required: H H, F, and B B pencils.

Erasers: A large soft rubber, and a firm one; also an ink eraser and erasing shield.

Set of instruments, including compasses, bow instruments, dividers, ruling pen.

Architect's scale. 2 drawing boards, 28 × 42 and 23 × 32 inches. T-square, and one 45° and one 30°-60° triangle. Nest of tinting saucers, sponge, blotters, India ink, half-cake of carmine, half-tube of Prussian blue, Whatman's hot-pressed paper, Imperial size. Manila paper. Cross-section paper. Tracing paper.

1. Give the dimensions of "Double Elephant" paper; of "Imperial" paper.

2. What simple method is adopted by architects to correct a T-square which does not fit a drawing exactly?

3. What expedient is adopted by architects to identify the T-square with which a drawing is made and why is this necessary?

4. Describe the difference between "hot pressed" and "cold pressed" paper and the purposes for which each is best adapted.

5. Describe "tinted papers, and scratch papers" and their use.

6. How is the flow of ink on tracing cloth improved? Which side of the cloth is used? Why?

7. What is the advantage of tracing paper? of tracing cloth?

8. What is the customary scale for drawings in American offices? in English offices?

9. Explain fully the special advantages of the 3-inch, 1-inch and $\frac{3}{4}$-inch scales.

10. What is a plan; an elevation; a section?

11. Lay out the plan and section of a staircase on a scale of $\frac{1}{4}$-inch equals 1 foot, to the following dimensions: Width 5 feet,

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":

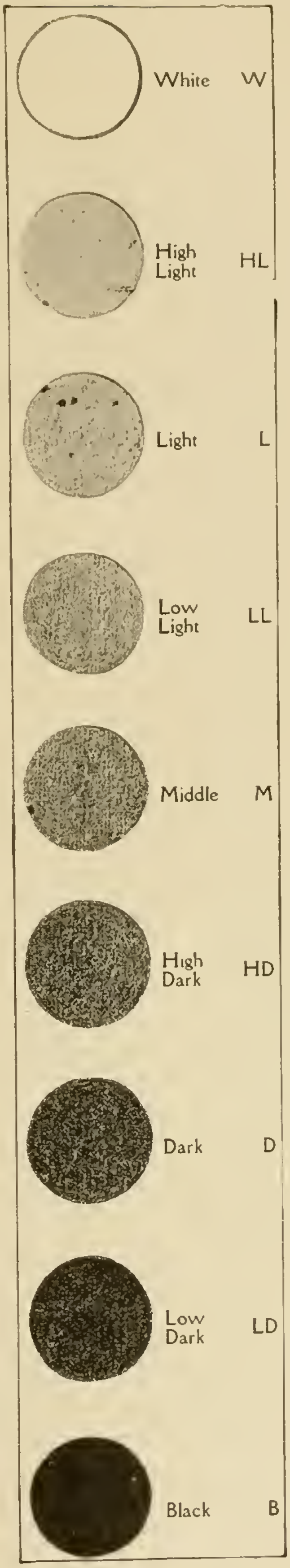
Rectangle F, with alternating dark and medium stripes, the first, third, fifth and seventh stripe to be dark, similar to "High Dark", the others light similar to "Low Light":

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.

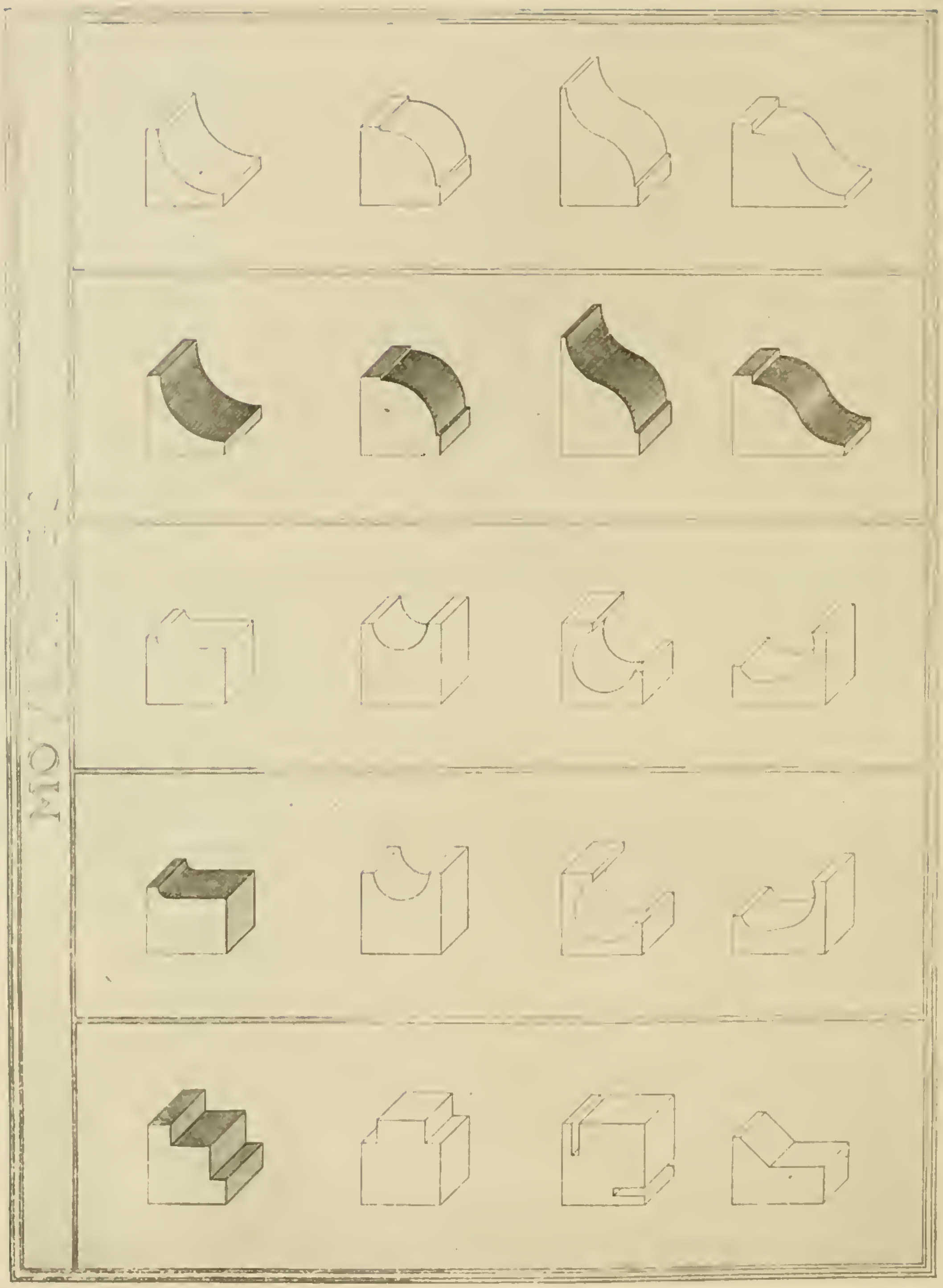


PLATE B

The Value Scale is given merely to show the relative degrees of darkness, not to show the actual appearance of the wash. The wash itself must be perfectly clear and transparent.

Note. The various values should not be made in one wash. Better effects are obtained by superimposing several light washes and thus obtaining a dark wash, than by putting on a dark wash in one operation.

PLATE II.

This plate is to be drawn three times the size of plate B. The section of the mouldings is to be drawn first, then lines drawn at an angle of 45° from the different corners of the mouldings. The vertical surfaces are to be rendered darker than the horizontal ones as shown in the top moulding in the first column. The mouldings in the second and fourth columns are to be rendered by the French method, drawing *fine light* parallel pencil lines and rendering by successive washes, as shown in the rendered illustrations. The mouldings in the third and fifth columns are to be rendered by grading directly, by the addition of water if the tone changes from dark to light or by the addition of tint if the tone changes from light to dark. The letters and the border lines are to be rendered as indicated. A margin of half an inch of white paper is to be left outside of the border lines.

PLATE III.

Rendering of Doric Order. This plate is to be three times the size of plate C. The order is the same size as the order on plate VII, in the Roman Orders. For rendering the order, the plate on page 5, "Detail of Greek Doric Order", will serve as a guide. The background A should be graded from dark at the top to light at the bottom similar to the wash between the column and pilaster in the plate mentioned above. The mouldings may be put in by the French method as shown on page 28. The background B should be a light evenly graded wash similar to the upper part of the background in the frontispiece, "Fragments from Roman Temple", having the wash somewhat darker at the top and grading it out to very light at the bottom. No trees, etc., are to be shown in the background. The steps will have a very light wash, that on step C being hardly noticeable, the step D a slightly more pronounced wash, and the step E a little darker still, but very light in tone. Study the value scale to determine these gradations. The tablet with letters may be rendered similar to the tablet at the bottom of

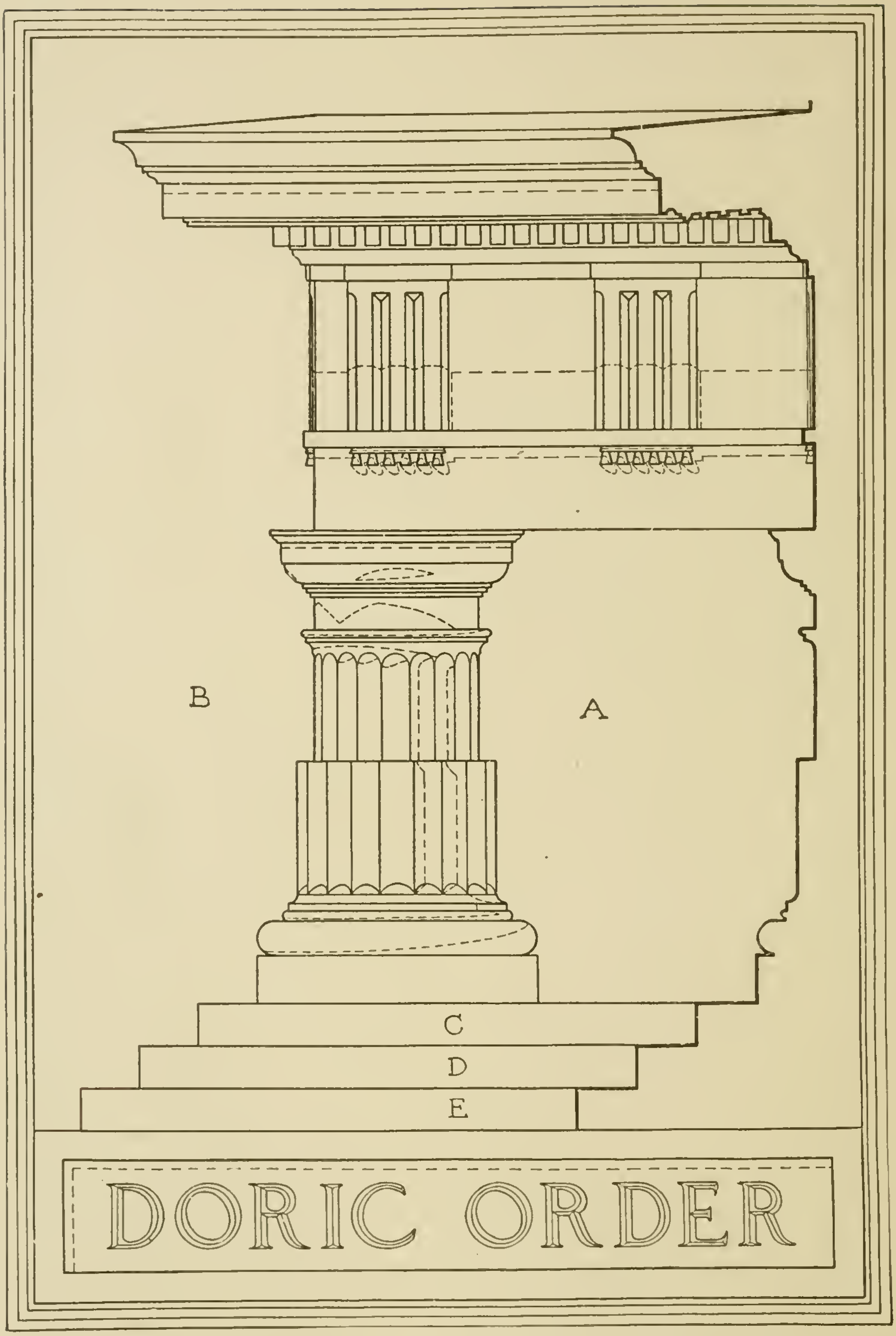


PLATE C

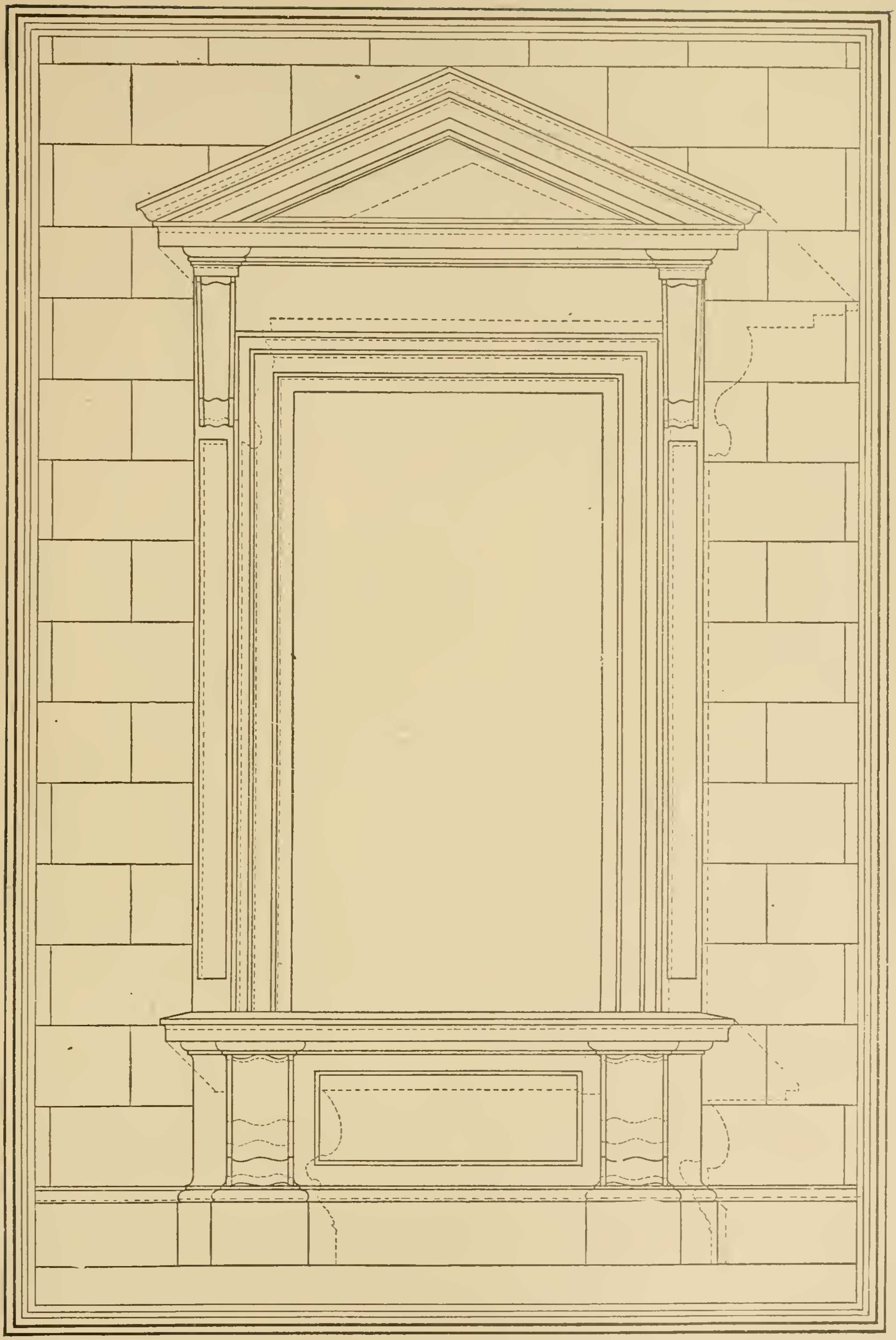


PLATE D

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.

PLATE E

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.

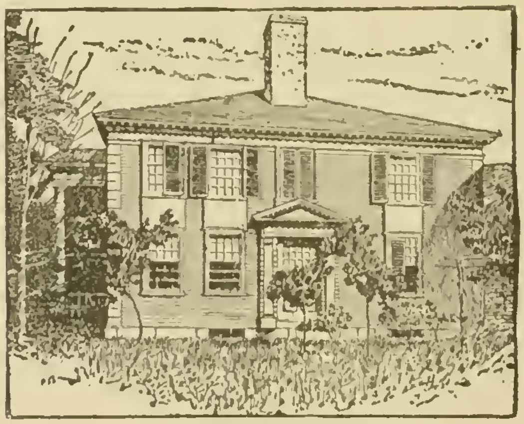
16. Draw the balluster shown in Fig. 10 at double the size by the method of "limiting lines."

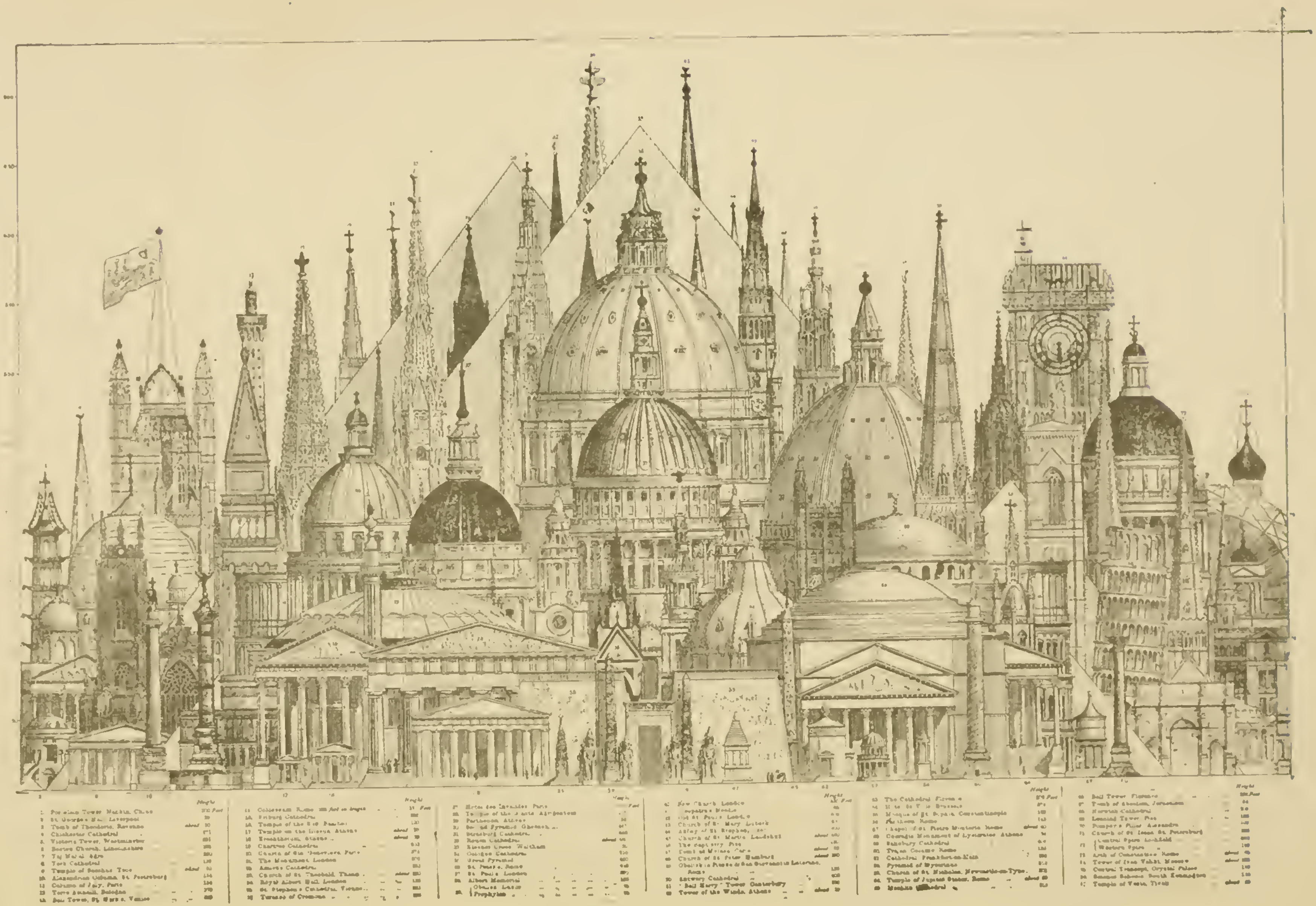
17. What is meant by modelling a drawing; by values?

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 in 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.

Note:—Authorities Differ with Regard to the Height of Many of These Buildings.

ARCHITECTURAL DRAWING

PART II

PRACTICAL PROBLEMS IN DESIGN

NOTES ON THEORY OF DESIGN

Composition. It is impossible to formulate laws of composition which, even if faithfully observed, will absolutely insure satisfactory results. That is to say, any work of art—such as a picture, a statue, or a building—may comply with all the general laws of composition and still not be really artistic.

A great deal depends on the feeling of the designer. A carpenter may make a cornice for the exterior of a house, or a mantel-piece for the interior, without having been taught any of the formal laws of composition; and nevertheless, by careful study and through the desire to build something pleasing, may produce something much more artistic than the most carefully wrought effort of a designer who knows all these so-called laws but lacks all artistic feeling.

Workmen in the various trades can assist the architect materially in producing an artistic result. One of the most desirable characteristics in a workman is that he shall execute the wishes of the owner as expressed in the architect's drawings, and carry them out as artistically as possible in every detail. There is a certain character in every piece of work which every workman should try to understand and carry out in a simple, frank, decisive, and straightforward way. Every workman feels the value of truthfulness in work, and objects to sham in doing good work.

Turner, the great English painter, was a man who did everything that he had to do, no matter how trivial, well. John Ruskin says of him, in his lectures on architecture and painting:

> "He took a poor price that he might live; but he made noble drawings that he might learn. He never let a drawing leave his hands without having made a step in advance and having done better in it than he had ever done before."

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.

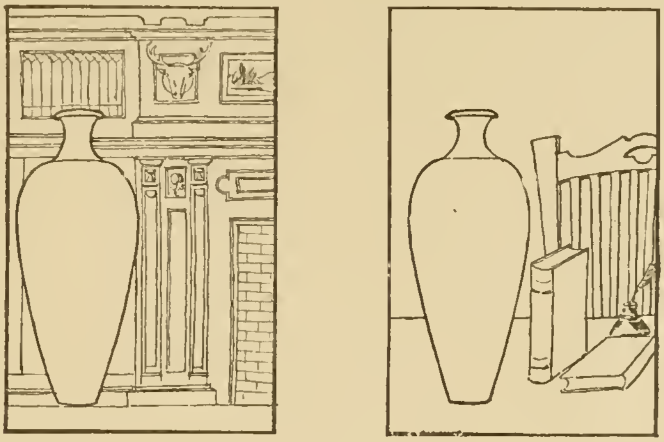


Fig. 25.

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.

DESIGN OF THE DWELLING

The plan of the modern residence began to be worked out in the 18th century. There is a treatise on architecture published at that time by Blondel, who says that a complete reformation had been made in the architecture of large and small dwellings from the point of view principally of the arrangement of rooms; great efforts had been made to substitute for the long, rambling succession of single rooms, an arrangement of rooms double in depth, with separate communications so indispensable for conveniences in a building.

It became clear that in a dwelling the ease of circulation was very important, and that the approaches to and exits from the various parts had to be well worked out, for the living rooms as well as for the service rooms. The aim of architects in the 18th century was for *independence* in the house, and it is to this that we owe their very remarkable plans.

The treatise on architecture by Blondel contains many interesting plans, well worthy of careful study. On the subject of Room, in particular, Blondel gives some interesting data:

> "It seems", he says, "that within about fifty years French architects have, in this respect, invented a new art. Before this, our edifices in France, in imitation of those of Italy, had an exterior decoration which made a very beautiful architecture; but the interiors were hardly livable. The architects seem to have tried to keep out the light; one could hardly find a place for a bed and for the principal articles of furniture. The fireplace occupied the largest part of the rooms, and the smallness of the doors gave an inadequate idea of the places to which they gave entrance . . . . The arrangement should be the first object of the architect; decoration depends absolutely on a well-studied plan. It is the arrangement which establishes the length or width and the height of a building."

Number of Rooms. The great objection to many small houses is that the people want the same number of rooms for a small amount of money that others have where more money has been spent. A desire to have six rooms and a bath often results in making all the rooms tiny and uncomfortable—more like boxes than living, habitable spaces. These houses are not necessarily cozy just because they are small; a cozy corner in a big room has much more of the cozy feeling than is found in the small rooms of an apartment. There should be one good-sized room in every house or apartment, even though one room has to be sacrificed.

Hallway. The hallway should be neither a cramped, narrow 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, may 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.

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 can be clearly expressed, since workmen generally are not inclined or able to gather information from several different drawings.

The working drawings are laid out at quarter-inch scale,* *i.e.* one-quarter inch equals one foot, with details at a scale of three-quarter inch to the foot, accompanied with full-size details. This is the customary scale in America. In England and also in some American offices, the rule is to make the working drawings at a scale of one-eighth inch to the foot, with details at a scale of one-half inch to the foot.

Plans of every floor, including basement and roof, all the elevations, and such sections as may be necessary to explain the construction, are required. In the sections, the vertical dimensions should be figured from finished floors.

Besides these drawings, a block or ground plan is frequently given, generally at $\frac{1}{16}$ or $\frac{1}{32}$ inch to the foot, to show adjacent walls, gardens, etc., and layout of grounds, location of drains, dry wells, cesspool, and water supply.

Separate plans may be given in procuring estimates for heating, ventilating, plumbing, and gas and electric lighting. These should be made subject to changes that may be proposed by the successful bidder, and, with these changes, should be presented by him to the architect for approval before finally going ahead with the work. This method is followed, because a guarantee is expected from the contractor for the successful operation of his work; and each contractor in the trades mentioned is likely to have good methods of his own, which he should be allowed to use. Sometimes all of these drawings may be incorporated in the general drawings.

Full-Size Details. Mouldings, and special parts of exterior and interior fiinish, such as base-courses, water-table, belts, cornices, capitals, special arrangement of brickwork, panels, carving, window-casings, mantels, stair-newels, balusters, etc., are drawn full size; carefully drawn sections are made full size. "Key drawings" at small scale, isometrics, and freehand perspectives are invaluable aids if drawn on the full size drawings. For cast iron and terra-cotta, allowance is sometimes made for shrinkage. This should preferably be left to the pattern-maker.

*Note:—There is a great difference between "quarter-inch scale" (*i.e.*, ¼ inch = 1 foot) and "quarter scale," or one-quarter of full size (*i.e.*, 3 inches = 1 foot).

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.

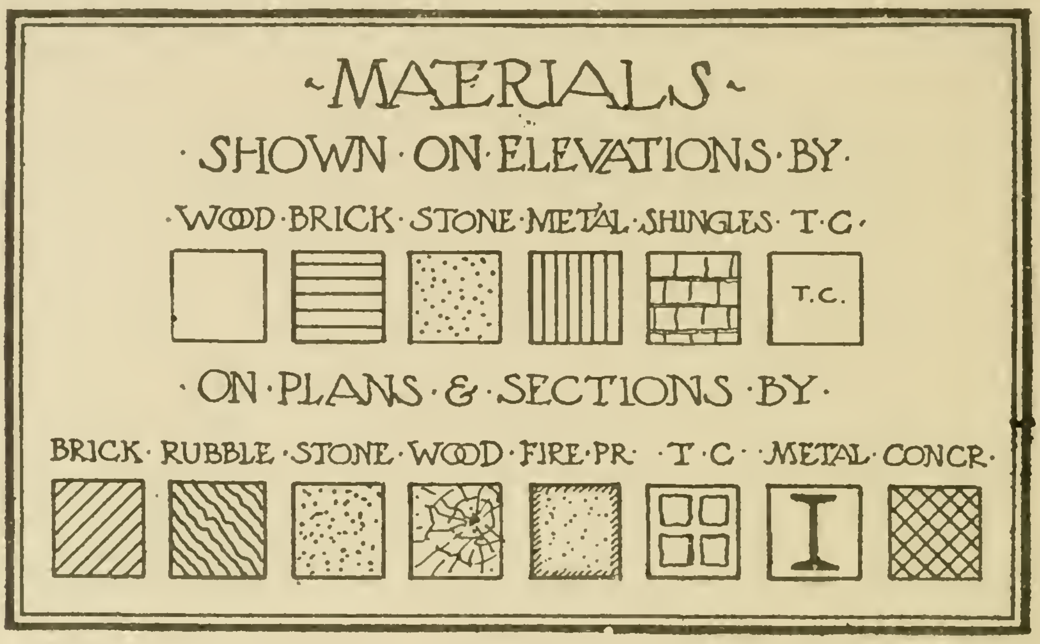


Fig. 26.

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 sub-bids 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.

Staircases are rarely used in an office building. A width of 3 feet 3 inches is generally sufficient; and sometimes staircases are as small as 2 feet 9 inches.

If there is a light court, it should be of such shape and location as to receive as much sun as possible.

There should be toilet rooms on every floor; generally lavatories are placed in the separate offices. Radiators are put in front of each window, transoms over every door; the lighting is done by electricity with drop-lights and receptacles for desk-lights.

Write the specifications so that the building may be economically constructed and will be a paying investment, and yet not so cheaply built that it will be unattractive or constantly needing repairs.

PRACTICAL EXAMPLE: A COLONIAL HOUSE

Conditions. A business man, having purchased a lot sufficiently large to give him space on all sides, wishes to build a colonial house containing nine rooms.

On the first floor, a hall is to be in the center, with vestibule and porch in front and doorway at the rear, so that the air may circulate freely in the summer time. The hall is to be about 15 feet wide. At the front, on the left, opening off this hall, the owner wishes to have a large room about 14 feet by 25 feet. The parlor and dining room are to be about 14 feet by 12 feet each. On the right of the hall, next to the dining room, is to be a china closet, with shelves and drawers, connecting with the kitchen. Beyond the kitchen is to be a pantry, with shelves, cupboards, and cases of drawers. The back entry is to have a place for a refrigerator. The rear door of the front hall is to open on an ample porch, where the family may sit.

The second floor is to have four bedrooms and an alcove in the main part of the house, a convenient bathroom and bedroom in the rear, and suitable linen closets. There are to be a front stairway and a compact back stairway. The attic is to be arranged for sleeping rooms.

Sketches. The drawings first to be made are sketches at a scale of one-eighth inch to the foot, drawn on Whatman's paper, with the plans inked in and the walls shown black. The elevations may be sketched in pencil, merely the front and left-side elevations being shown.

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

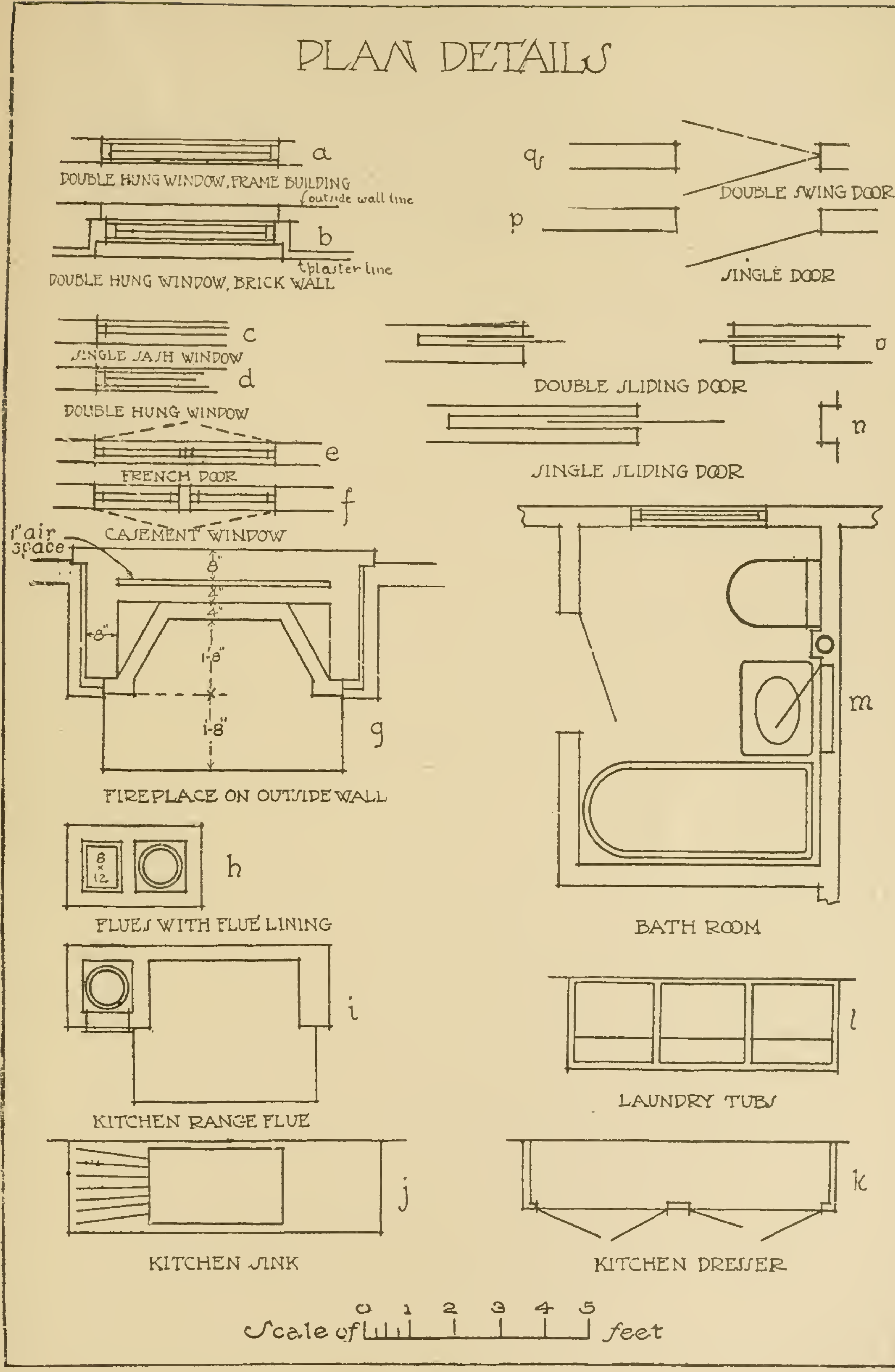
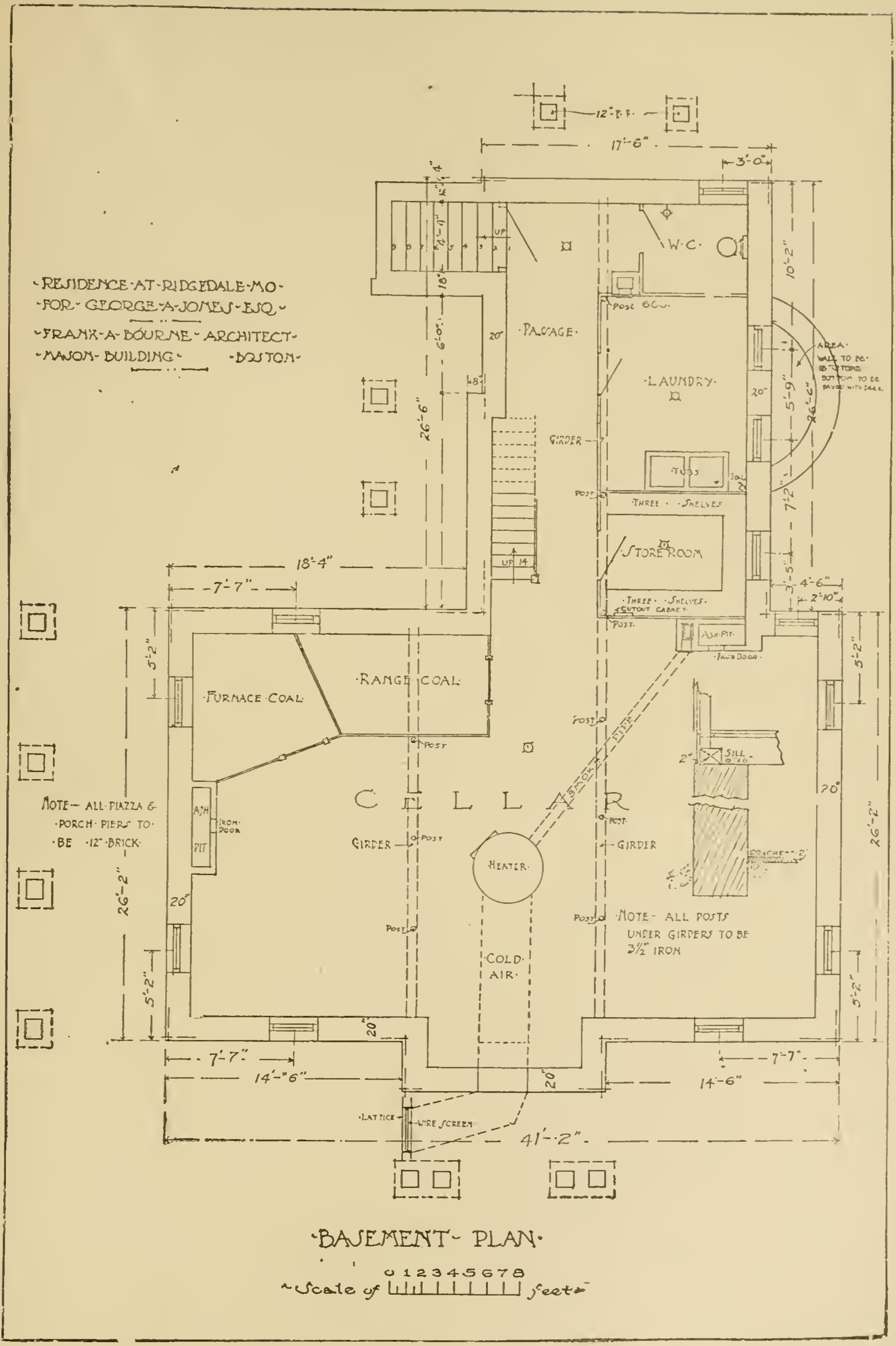

PLAN DETAILS
a
DOUBLE HUNG WINDOW, FRAME BUILDING
outside wall line
b
plaster line
DOUBLE HUNG WINDOW, BRICK WALL
c
SINGLE SASH WINDOW
d
DOUBLE HUNG WINDOW
e
FRENCH DOOR
f
CASEMENT WINDOW
1" air space
8"
4"
4"
8"
1'-8"
1'-8"
g
FIREPLACE ON OUTSIDE WALL
8 x 12
h
FLUES WITH FLUE LINING
i
KITCHEN RANGE FLUE
j
KITCHEN SINK
q
DOUBLE SWING DOOR
p
SINGLE DOOR
o
DOUBLE SLIDING DOOR
n
SINGLE SLIDING DOOR
m
BATH ROOM
l
LAUNDRY TUBS
k
KITCHEN DRESSER
0 1 2 3 4 5
Scale of 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 flues. 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.



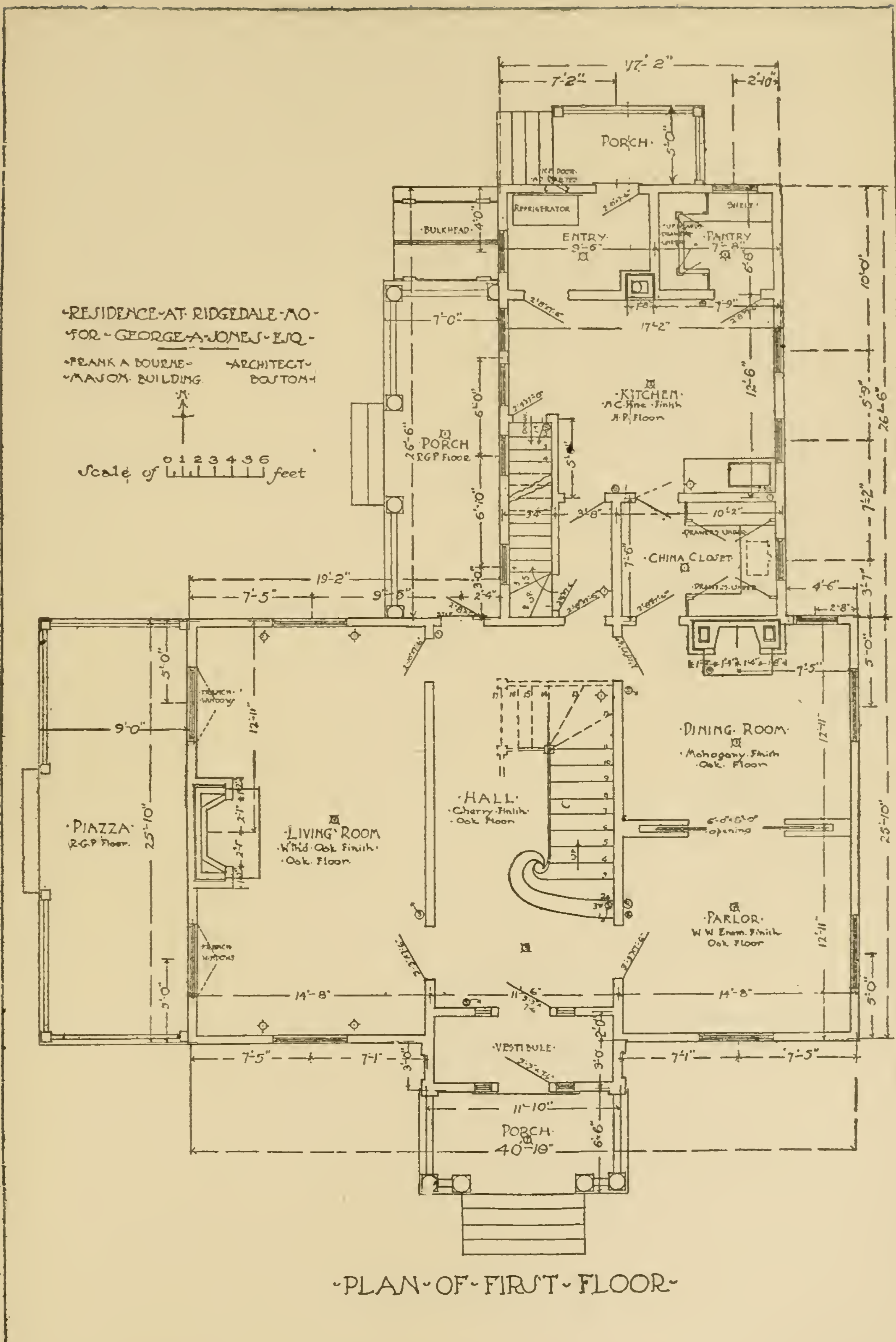
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A BOURNE ARCHITECT
MASON BUILDING BOSTON
NOTE— ALL PIAZZA & PORCH PIERS TO BE 12" BRICK
PASSAGE
W.C.
LAUNDRY
TUBS
STORE ROOM
THREE SHELVES
FURNACE COAL
RANGE COAL
CELLAR
HEATER
COLD AIR
GIRDER
POST
ASH PIT
IRON DOOR
NOTE— ALL POSTS UNDER GIRDERS TO BE 3½" IRON
LATTICE
WIRE SCREEN
17'-6"
18'-4"
7'-7"
26'-6"
26'-2"
14'-6"
41'-2"
BASEMENT PLAN
0 1 2 3 4 5 6 7 8
Scale of feet

Fig. 28.

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
ENTRY
PANTRY
BULKHEAD
REFRIGERATOR
KITCHEN
PORCH
R.G.P Floor
CHINA CLOSET
PIAZZA
R.G.P Floor
LIVING ROOM
HALL
Cherry Finish
Oak Floor
DINING ROOM
Mahogany Finish
Oak Floor
PARLOR
W.W. Enam. Finish
Oak Floor
VESTIBULE
PORCH
-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.

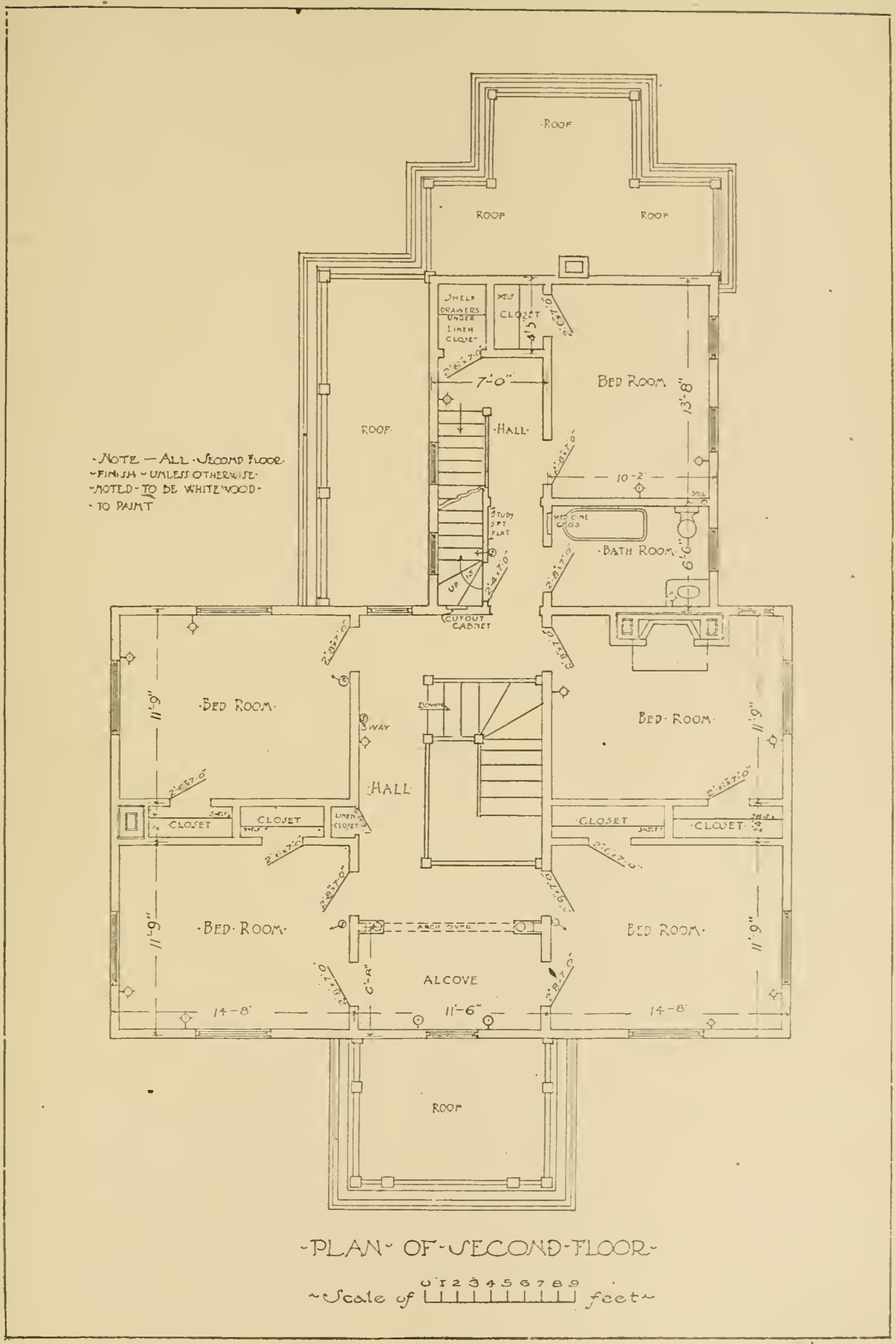
From the rear of the hall a door opens on the rear porch, and another door leads to the passage connecting with the kitchen and the back stairs. Between the dining room and the kitchen is a large china closet, having glazed shelving and also a counter shelf on which is dotted the location for a china-closet 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.

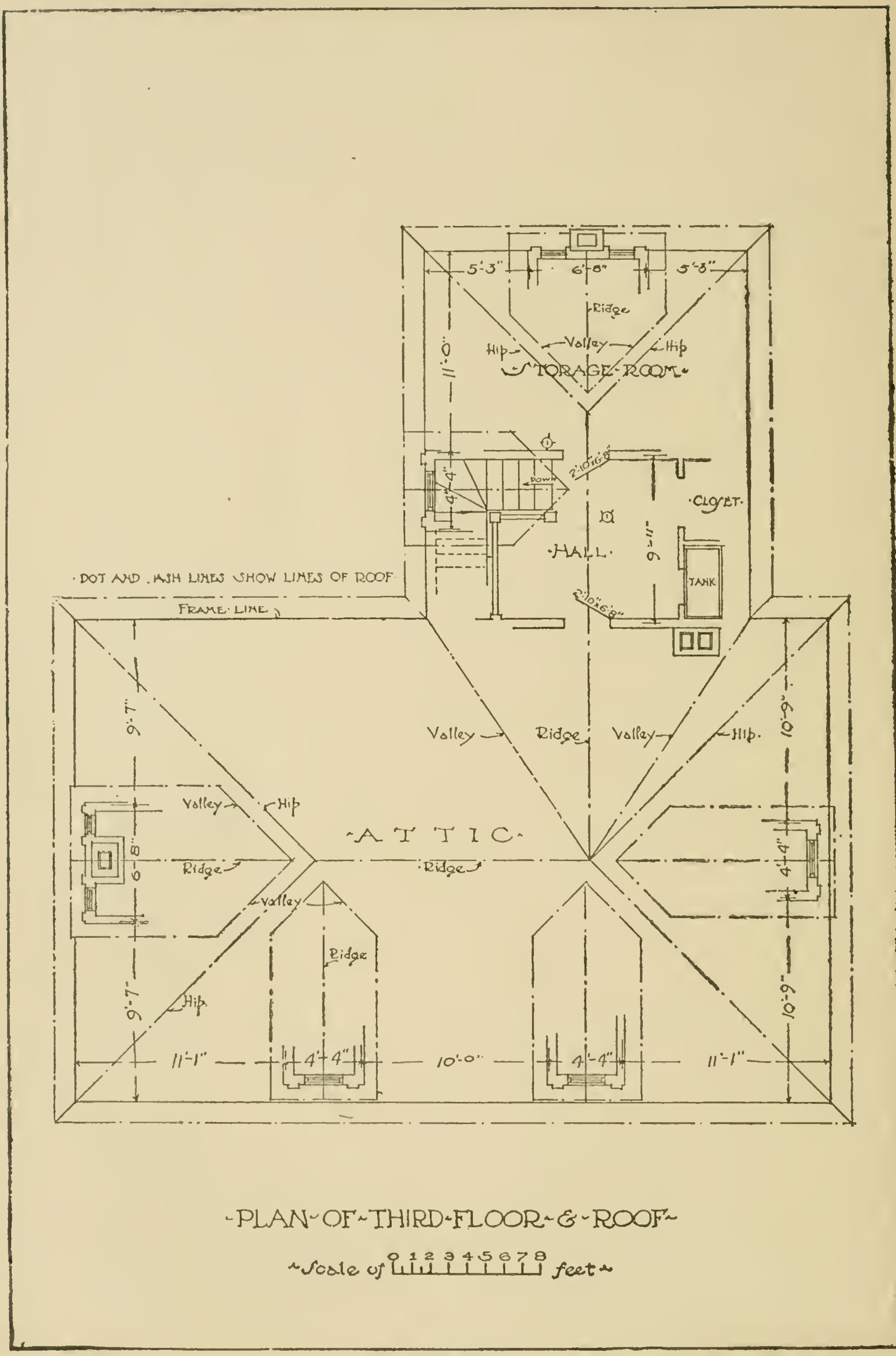
The sill line is $\frac{7}{8}$ inch inside the outside line of the walls shown, while the inner line representing the plaster surface is $4\frac{3}{4}$ or $4\frac{7}{8}$ inches inside the sill line. The dimensions being given in this way, it is a simple matter for the carpenter on the building to run 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



ROOF
ROOF
ROOF
ROOF
BED ROOM
HALL
BATH ROOM
CLOSET
LINEN CLOSET
CUTOUT CABINET
BED ROOM
BED ROOM
BED ROOM
BED ROOM
HALL
CLOSET
CLOSET
CLOSET
CLOSET
ALCOVE
ROOF
NOTE — ALL SECOND FLOOR FINISH UNLESS OTHERWISE NOTED TO BE WHITEWOOD TO PAINT
PLAN OF SECOND FLOOR
Scale of feet

Fig. 30.



5'-3"
6'-8"
5'-8"
Ridge
Hip
Valley
Hip
STORAGE-ROOM
11'-0"
2'-10"x6'-8"
DOWN
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
4'-4"
Valley
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. 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
SHINGLES
SHINGLES
CLAPBOARDS
CLAPBOARDS
CLAPBOARDS
Attic 8'-0" in the clear
ATTIC FLOOR
8'-6"
SECOND FLOOR
9'-0"
FIRST FLOOR
CELLAR TO BE 8'-0" IN THE CLEAR
12 x 14
12 x 14
12 x 14
12 x 15
12 x 15
10 x 14
10 x 14
BRICK
FRONT·ELEVATION
0 1 2 3 4 5 6 7 8
Scale of feet

Fig. 32.

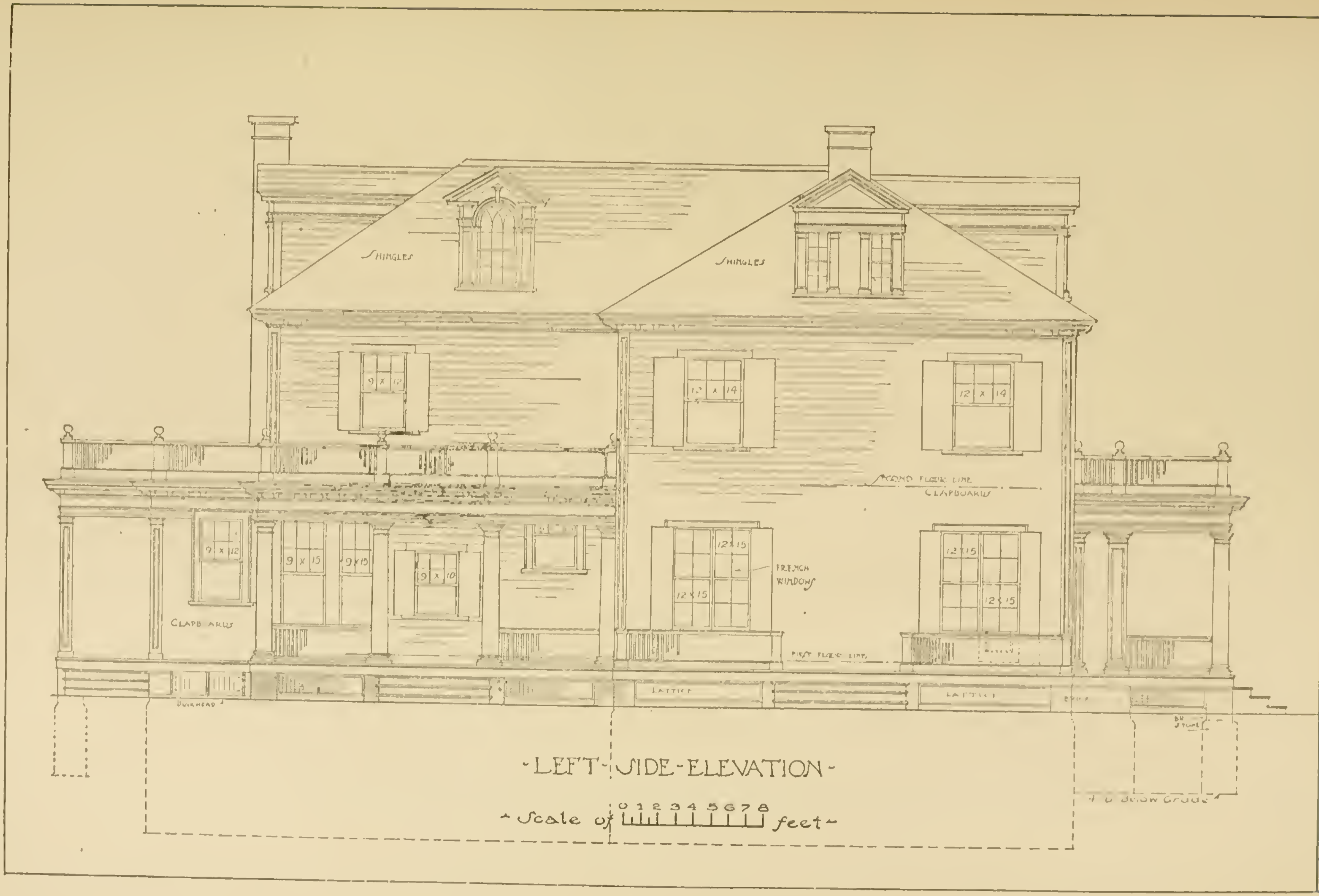
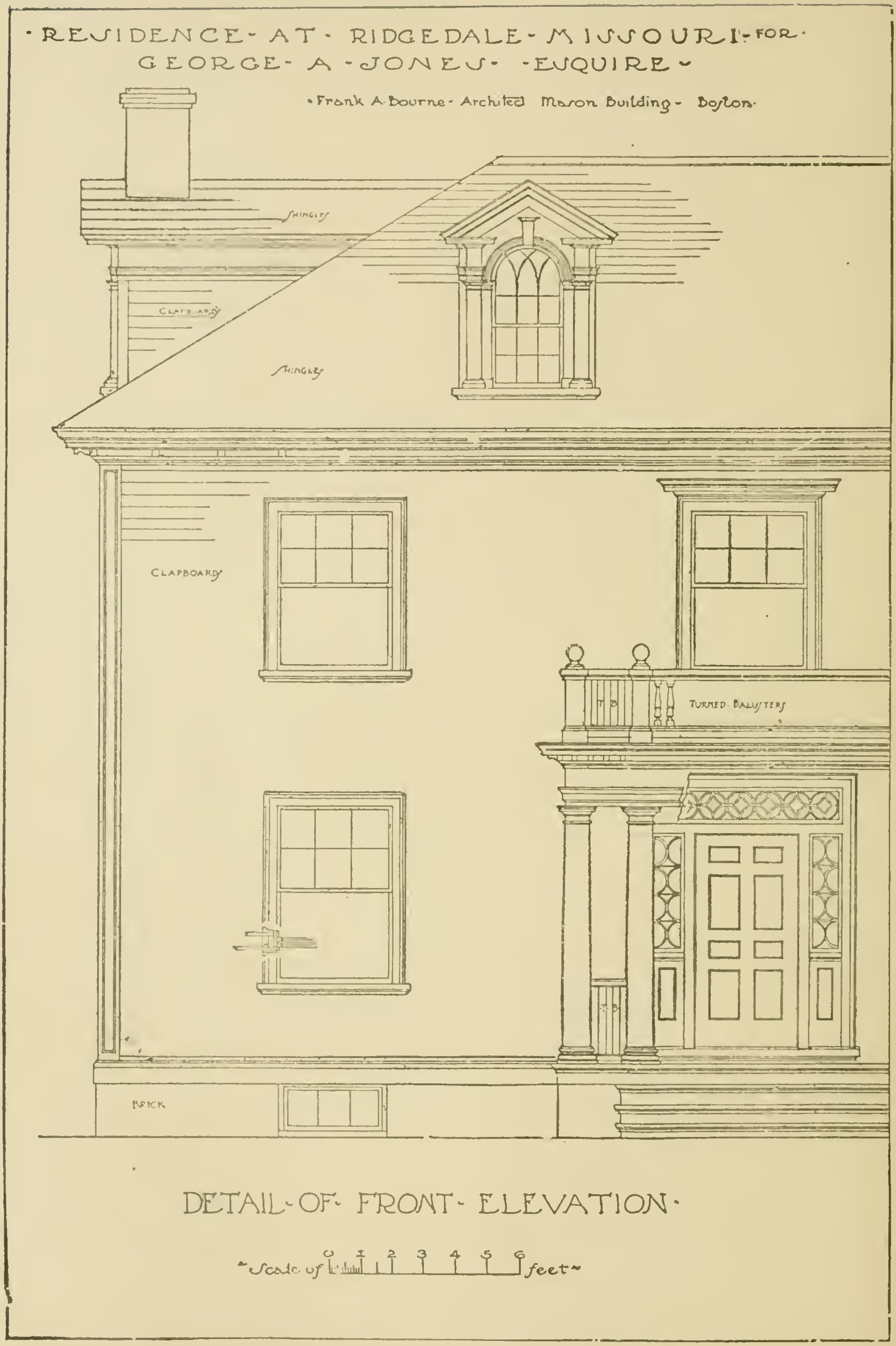

SHINGLES
SHINGLES
9 x 12
12 x 14
12 x 14
SECOND FLOOR LINE
CLAPBOARDS
9 x 12
9 x 15
9 x 15
9 x 10
12 x 15
12 x 15
FRENCH
WINDOWS
12 x 15
12 x 15
CLAPBOARDS
FIRST FLOOR LINE
BULKHEAD
LATTICE
LATTICE
-LEFT-SIDE-ELEVATION-
-Scale of 0 1 2 3 4 5 6 7 8 feet-

Fig. 33.



·RESIDENCE·AT·RIDGEDALE·MISSOURI·FOR·
GEORGE·A·JONES· ·ESQUIRE·
·Frank A. Bourne· Architect Mason Building· Boston·
SHINGLES
CLAPBOARDS
SHINGLES
CLAPBOARDS
TURNED·BALUSTERS
T.B.
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-

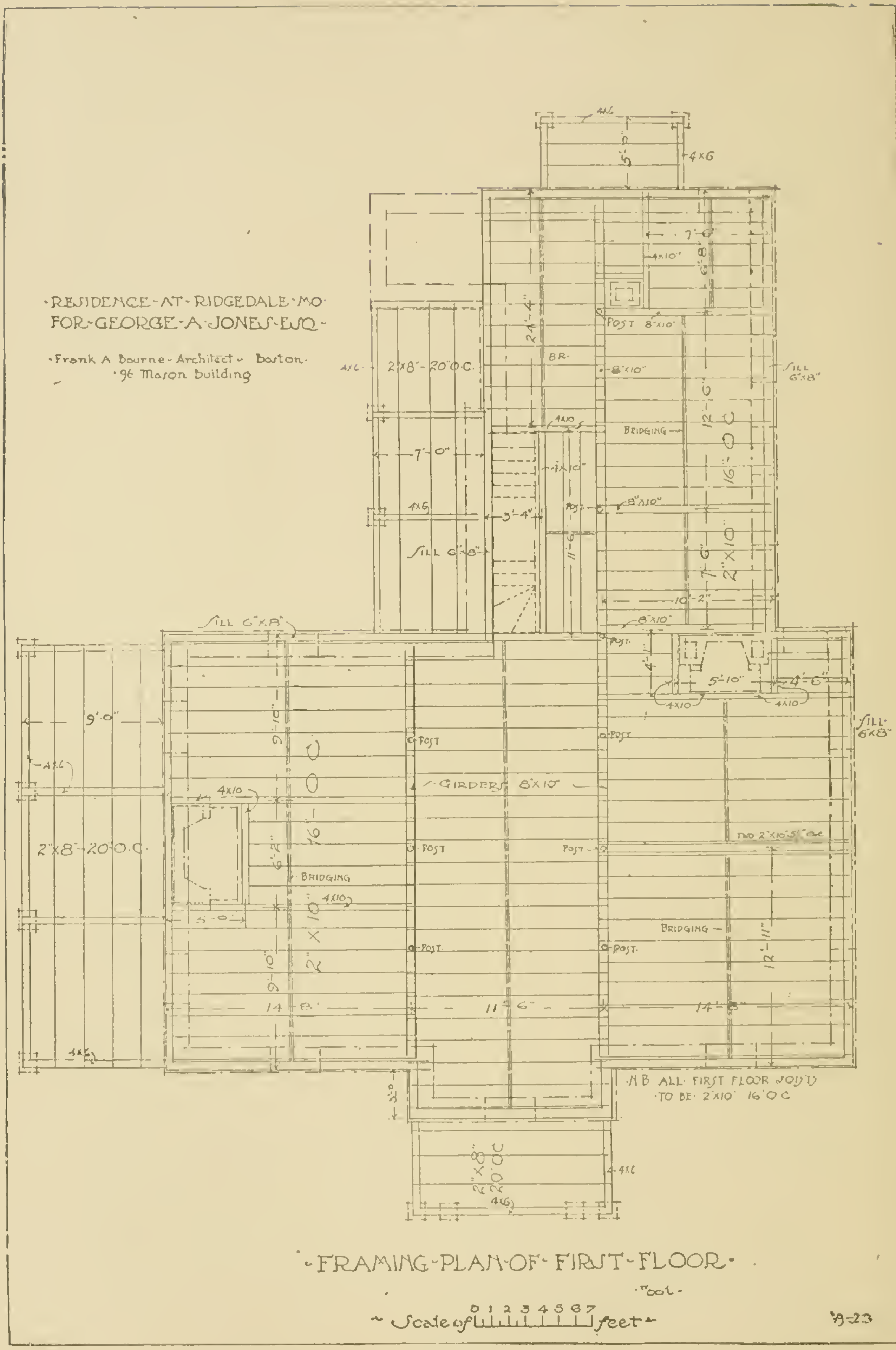

·RESIDENCE·AT·RIDGEDALE·MO·
FOR·GEORGE·A·JONES·ESQ·
·Frank A Bourne·Architect· Boston·
·96 Mason Building
·FRAMING·PLAN·OF·FIRST·FLOOR·
Scale of feet
N.B. ALL FIRST FLOOR JOISTS
TO BE 2"X10" 16"O.C.
GIRDERS 8X10
BRIDGING
POST
SILL 6"X8"
2"X8"-20"O.C.

Fig. 35.

tablature is used. The dormer shows a peculiar Colonial treatment, using a small Doric Order on each side of the arched window. The muntins of the sash are generally worked out in wood. At the side of the roof is shown a side elevation of the dormer.

First-Floor Framing Plan. (Fig. 35.) The supports shown with a dot-and-dash line would usually be shown in red ink in the working drawings. The sill, 6 by 8 inches, laid flat, is shown with a full line running all around the building. The girders and the posts on which they rest are shown in a full line, the girders being 8 inches by 10 inches, and the posts not over 10 feet apart. The piazza girders are 4 by 6, and the piazza sills are 4 by 6. The piazza floor joists are 2 by 8 inches, 20 inches on center. The dimensions are given to the outside of the sill, and to the centers of the partitions. Where the partitions come over each other and are parallel to the joists, a joist is set 1 inch each side of the studs of the partition, so that the rough floor boards may run directly through and leave room for nailing for the finished floor each side of the partitions. Trimmers and headers are double the size of their respective floor joists, being 4 by 10 inches in this case. All joists are set 2 inches clear of the fireplace openings. The distances are given to the centers of the trimmers, but sometimes dimensions are given for the clear opening. All the first-floor joists are to be 2 by 10, placed 16 inches on centers. The bridging is shown dotted. This is made of 1 by $2\frac{1}{2}$-inch stock set diagonally between the joists.

It will be noticed that all the 2-inch joists except those in special locations—for example, under a partition, as above mentioned—are shown with only a single line, all other timbers being shown with a double line.

Second-Floor Framing Plan. The second-floor framing plan (Fig. 36) is similar to the first-floor, the girts, 4 by 6 inches, being shown instead of the sill. The framing of the roofs of the porches is shown, and notes are made where the girts are flush or where they are sunk. In certain cases it will be noticed that the joists are carried through, continuous. It often happens that shorter stock might have been used at no disadvantage to the building. The joists across the building should be nailed together wherever possible, so as to make a complete tie across the building.

Attic Framing Plan. On this drawing (Fig. 37), the roof plate is shown, and also the location of the hard pine ledger-board. The

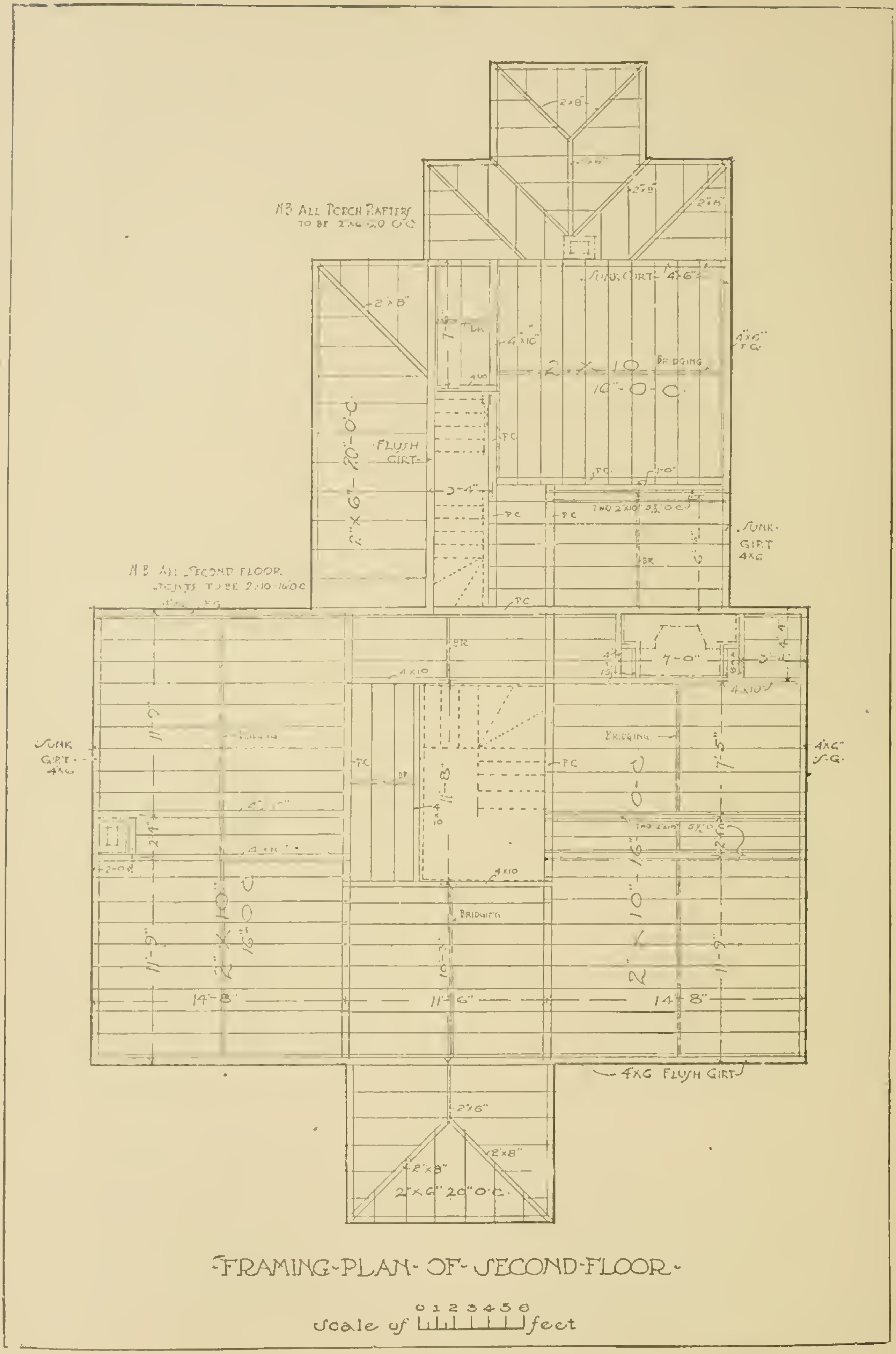
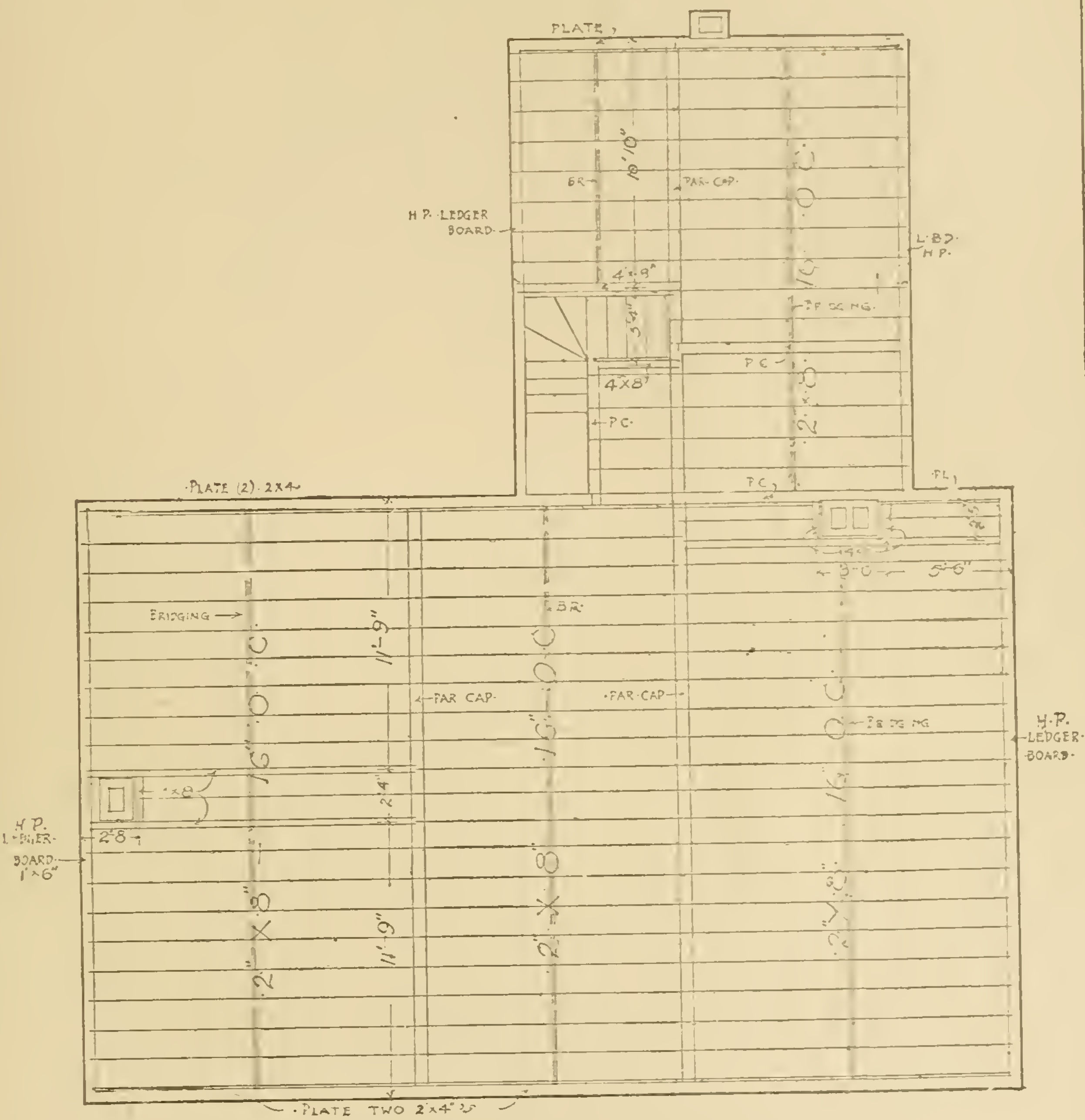

N.B. ALL PORCH RAFTERS TO BE 2"x6" 20" O.C.
N.B. ALL SECOND FLOOR JOISTS TO BE 2"x10" 16" O.C.
SUNK GIRT 4"x6"
4"x6" F.G.
2"x10" 16" O.C.
BRIDGING
FLUSH GIRT
SUNK GIRT 4x6
4"x6" S.G.
4x6 FLUSH GIRT
14'-8"
11'-6"
14'-8"
2"x6" 20" O.C.
FRAMING-PLAN-OF-SECOND-FLOOR-
0 1 2 3 4 5 6
Scale of feet

Fig. 36.



·FRAMING·PLAN·OF·THIRD·FLOOR·

Scale of feet

Fig. 37.

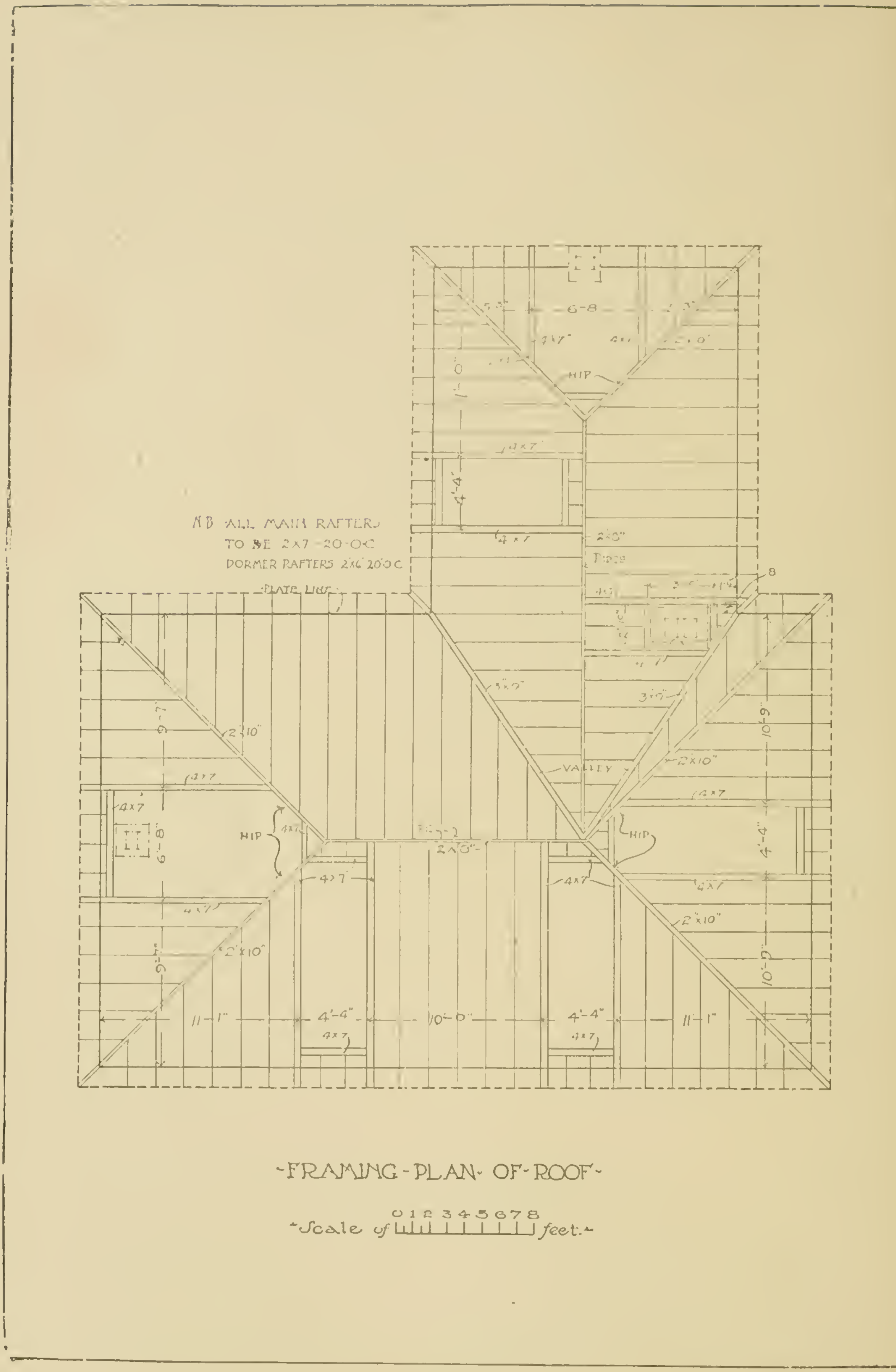
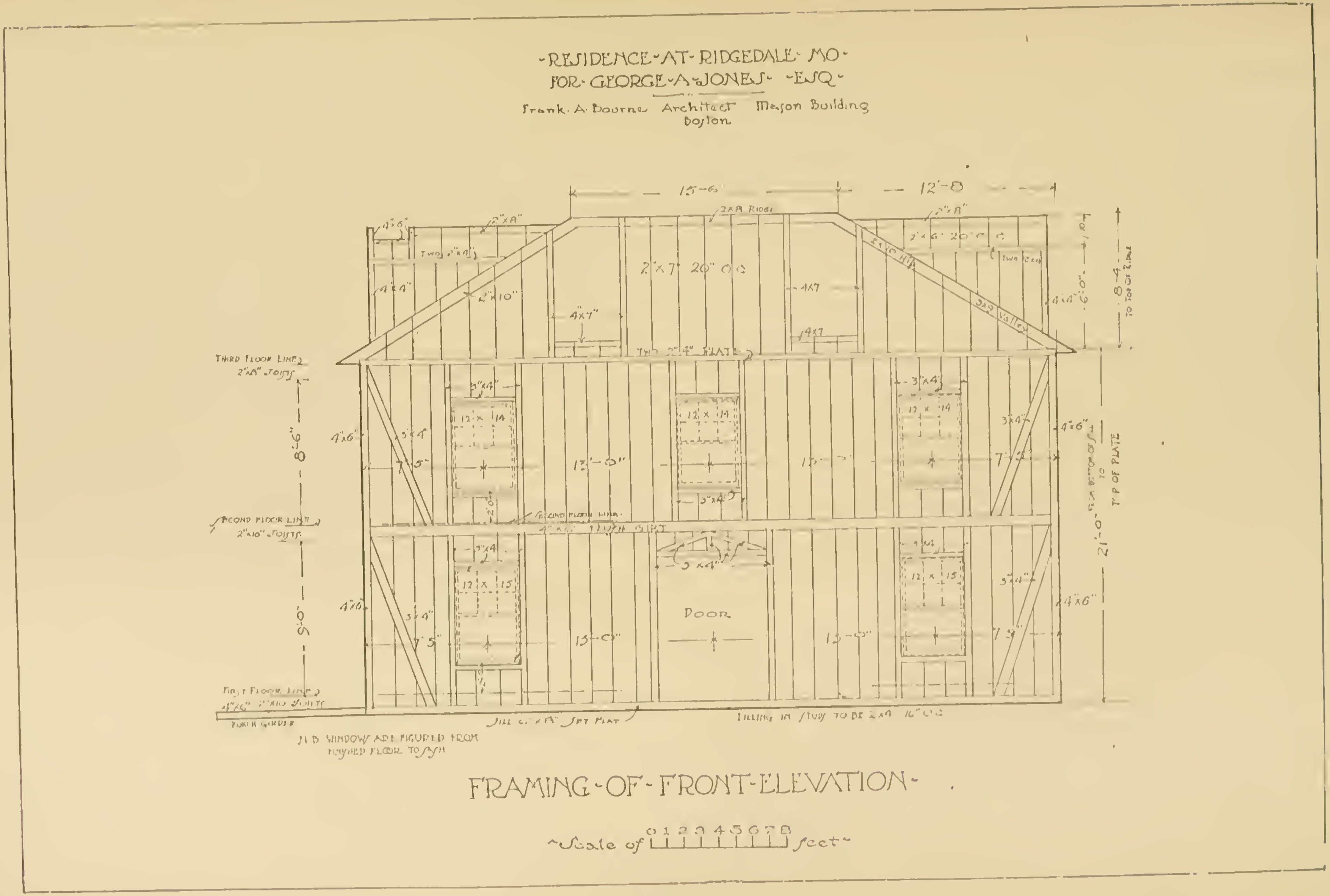
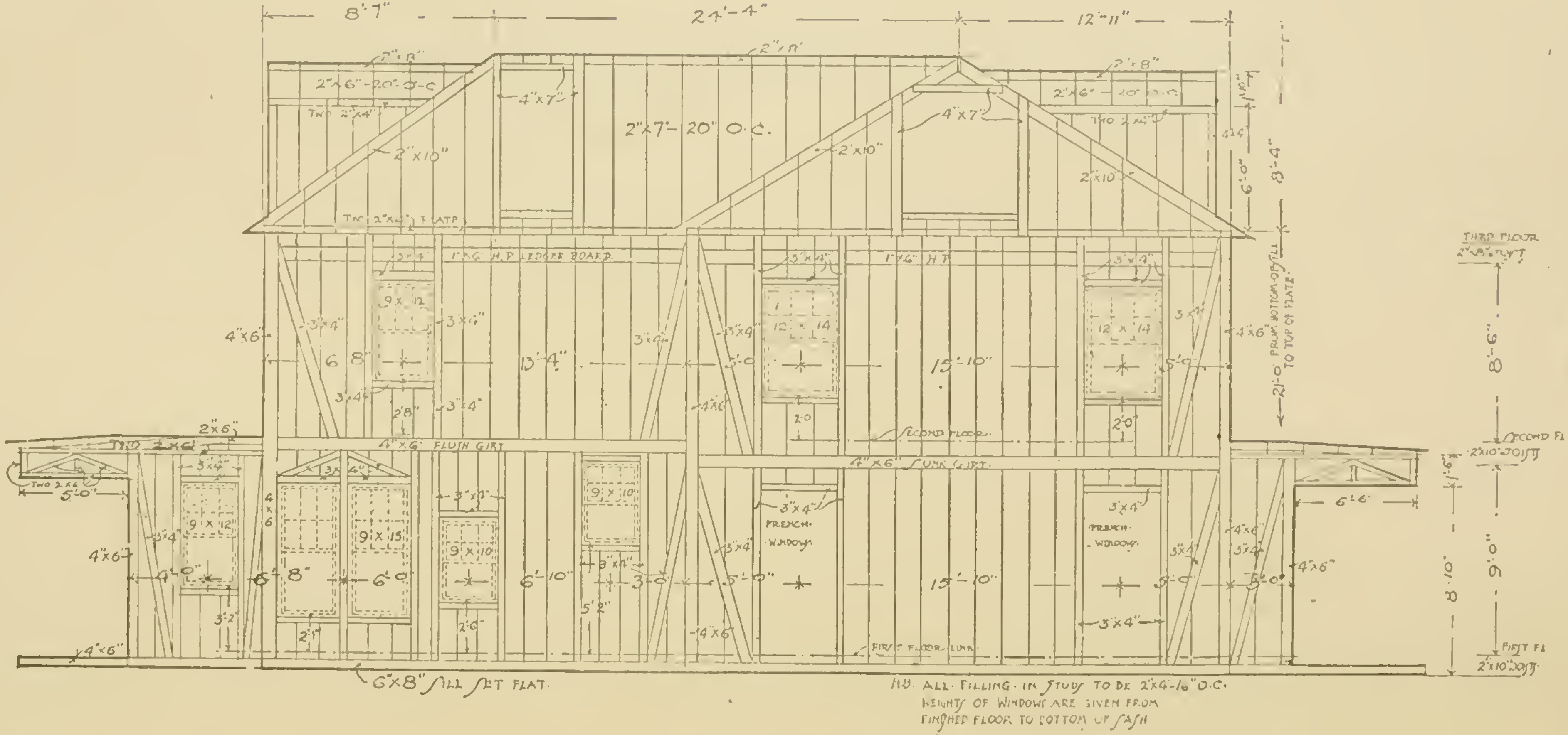

NB ALL MAIN RAFTERS
TO BE 2x7 20-OC
DORMER RAFTERS 2x6 20 OC
PLATE LINE
HIP
VALLEY
6-8
4'-4"
2x10"
4x7
6'-8"
9'-7"
11'-1"
10'-0"
10'-9"
2x8"
8
-FRAMING-PLAN-OF-ROOF-
Scale of 0 1 2 3 4 5 6 7 8 feet.

Fig. 38



-RESIDENCE-AT-RIDGEDALE-MO-
FOR-GEORGE-A-JONES-ESQ-
Frank. A. Bourne Architect Mason Building
Boston
15'-6"
12'-8"
2'x7" 20" O.C.
Door
THIRD FLOOR LINE
SECOND FLOOR LINE
FIRST FLOOR LINE
PORCH GIRDER
FRAMING-OF-FRONT-ELEVATION-
~Scale of 0 1 2 3 4 5 6 7 8 feet~

Fig. 35.



·FRAMING·OF·LEFT·SIDE·ELEVATION·

~Scale of 0 1 2 3 4 5 6 7 8 9 feet~

Fig. 40.

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

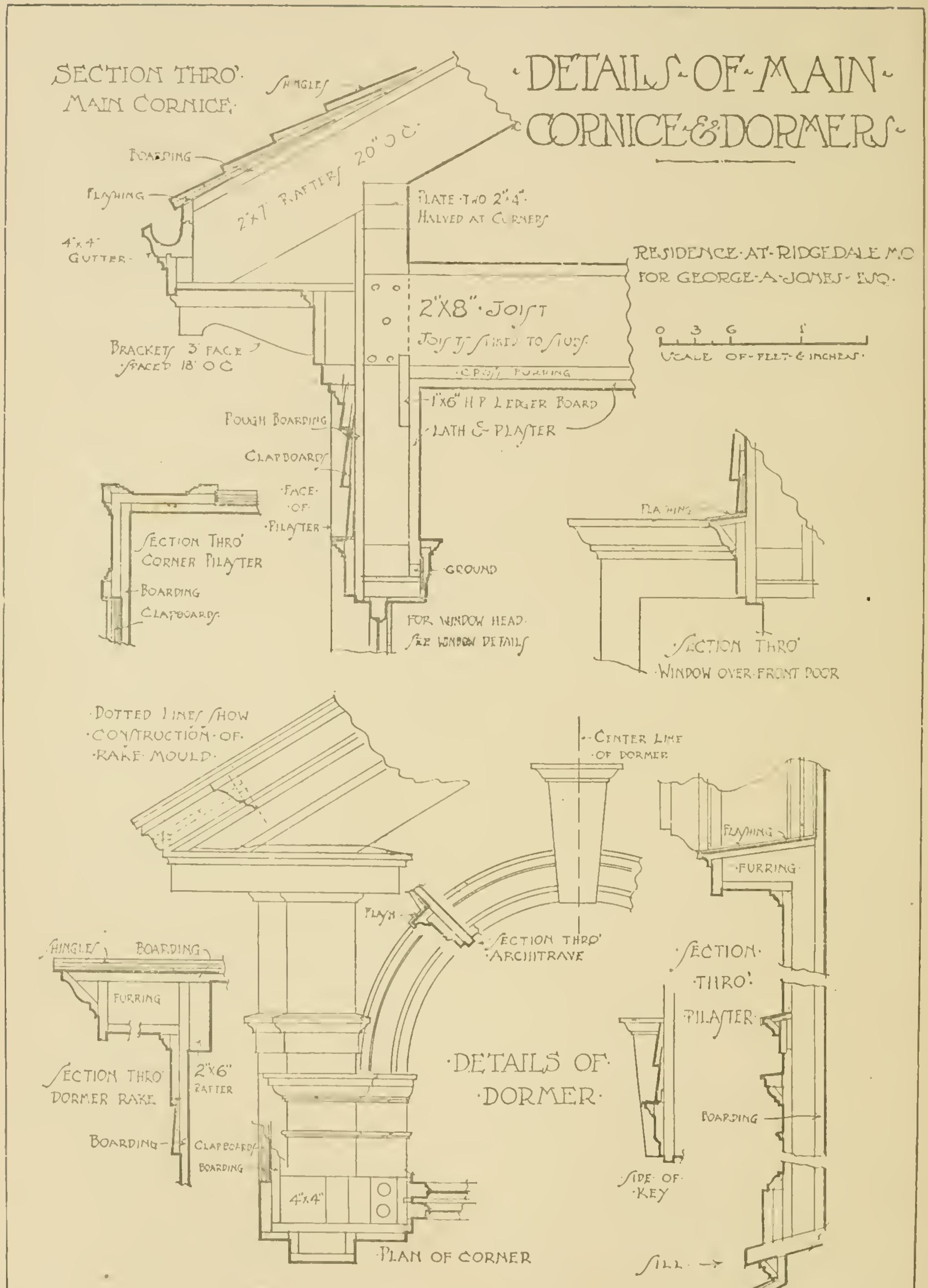
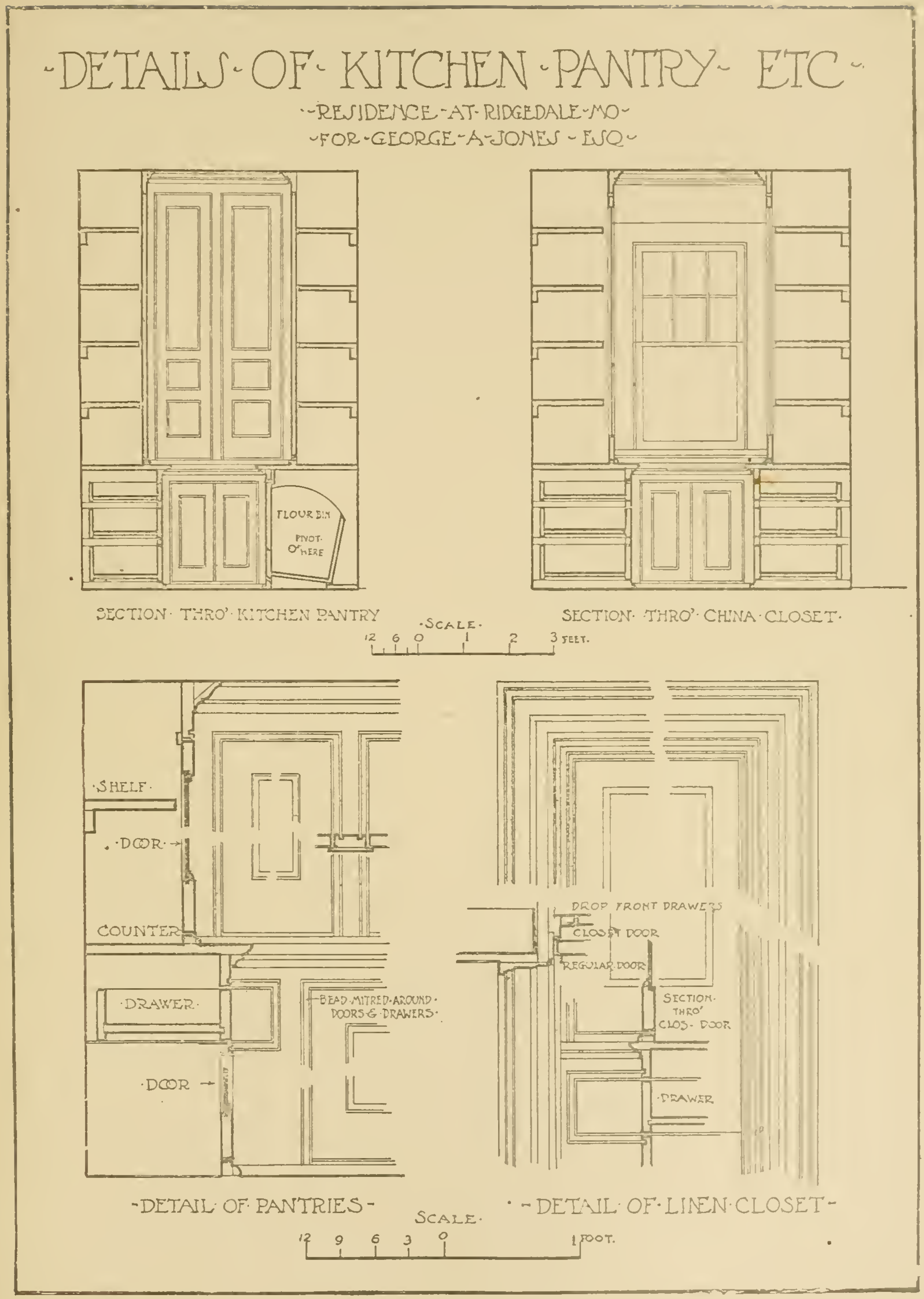

DETAILS OF MAIN CORNICE & DORMERS
SECTION THRO' MAIN CORNICE
SHINGLES
BOARDING
FLASHING
4"x4" GUTTER
2"x7" RAFTERS 20" O.C.
PLATE TWO 2"x4" HALVED AT CORNERS
RESIDENCE AT RIDGEDALE MO FOR GEORGE A. JONES ESQ.
2"X8" JOIST
JOISTS SPIKED TO STUDS
0 3 6 1'
SCALE OF FEET & INCHES
BRACKETS 3" FACE SPACED 18" O.C.
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"
DETAILS OF DORMER
SECTION THRO' PILASTER
BOARDING
SIDE OF KEY
PLAN OF CORNER
SILL

Fig. 41.



DETAILS OF KITCHEN PANTRY ETC
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FLOUR BIN
PIVOT HERE
SECTION THRO' KITCHEN PANTRY
SECTION THRO' CHINA CLOSET
SCALE
12 6 0 1 2 3 FEET.
SHELF
DOOR
COUNTER
DRAWER
DOOR
BEAD MITRED AROUND DOORS & DRAWERS
DROP FRONT DRAWERS
CLOSET DOOR
REGULAR DOOR
SECTION THRO' CLOS. DOOR
DRAWER
DETAIL OF PANTRIES
DETAIL OF LINEN CLOSET
SCALE
12 9 6 3 0 1 FOOT.

Fig. 42

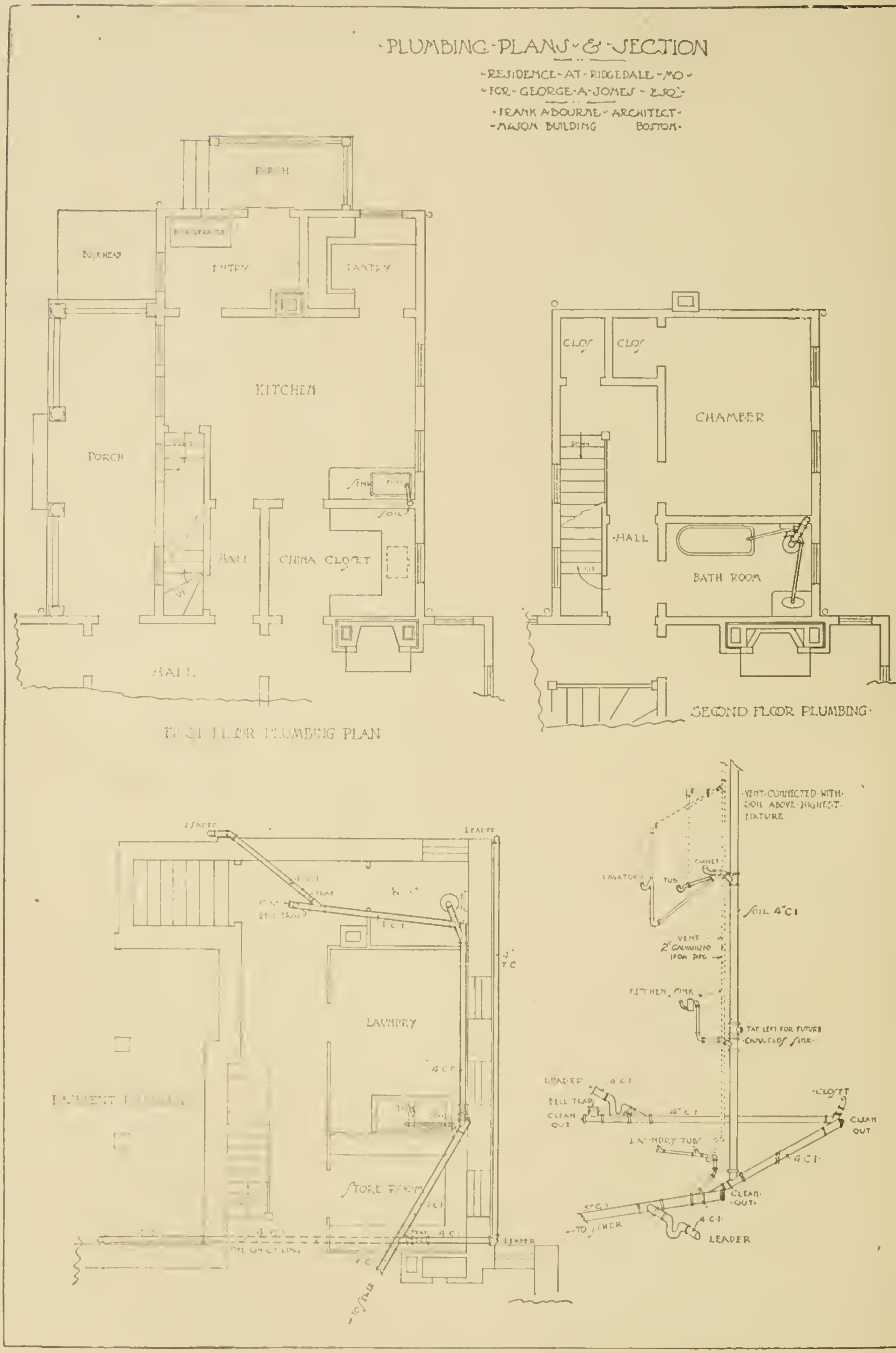

PLUMBING PLANS & SECTION
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A JONES ESQ
FRANK A BOURNE ARCHITECT
MASON BUILDING BOSTON
KITCHEN
PORCH
ENTRY
PANTRY
CHINA CLOSET
HALL
FIRST FLOOR PLUMBING PLAN
CLOS
CLOS
CHAMBER
HALL
BATH ROOM
SECOND FLOOR PLUMBING
LAUNDRY
STORE ROOM
VENT CONNECTED WITH SOIL ABOVE HIGHEST FIXTURE
LAVATORY
TUB
CLOSET
SOIL 4" C I
VENT 2" GALVANIZED IRON PIPE
KITCHEN SINK
TAP LEFT FOR FUTURE CHINA CLOS SINK
LEADER
BELL TRAP
CLEAN OUT
LAUNDRY TUBS
CLOSET
CLEAN OUT
4 C I
CLEAN OUT
TO SEWER
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.

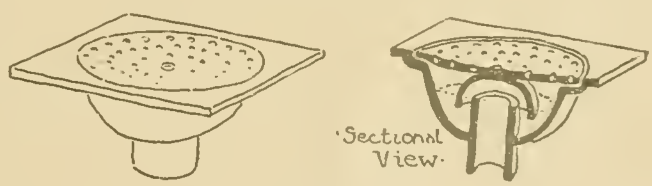


Fig. 44.

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

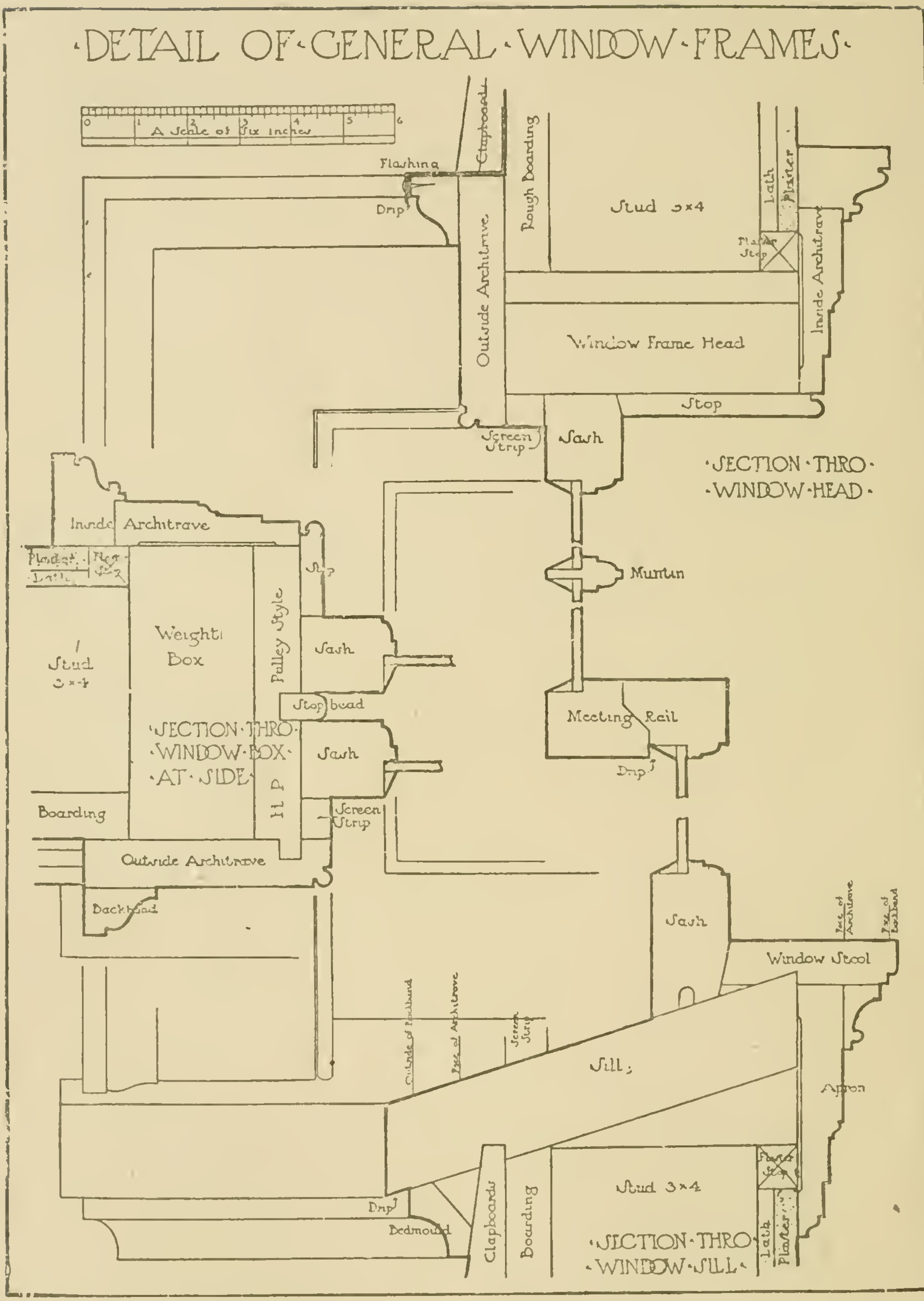

·DETAIL OF·GENERAL·WINDOW·FRAMES·
A Scale of Six inches
0
1
2
3
4
5
6
Flashing
Clapboards
Rough Boarding
Drip
Stud 3×4
Lath
Plaster
Plaster Stop
Outside Architrave
Inside Architrave
Window Frame Head
Stop
Screen Strip
Sash
·SECTION·THRO·
·WINDOW·HEAD·
Inside Architrave
Plaster
Lath
Stop
Muntin
Weight 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
Window Stool
Face of Architrave
Face of Backband
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. 15.

carried back into the soil pipe or through the roof. Branches are taken off for the laundry tubs, china closet, sink, lavatory, tub, and closet, as shown in the section and on the first and second-floor plumbing plans. Sometimes these pipes are shown in blue on the regular working drawings; but there is an advantage in having them on a separate sheet, as has been done in this detail. The vent pipes from the traps may be of 2-inch cast iron or of 2-inch galvanized wrought iron. This practice varies with the building laws in different localities.

Detail of General Window Frames. Fig. 45 shows the method of laying out a full-size detail of a window box. Such a drawing is one of the first things usually given to a draftsman on entering an architect's office, and one of the most important details of house building to become acquainted with. The drawing shows an elevation of the lower left-hand corner and upper left-hand corner of the window-frames seen from the outside. The lower part of the drawing shows a section through the window sill. Taking the scale of 6 inches shown at the top of the drawing, it would be found that the window sill can be made from 2-inch stock finished about one and three-quarters inches thick. On the outside, next to the clapboards, is a bed-moulding, and the slope of the sill forms a good drip to throw off water. The clapboards are housed into the under side of the sill. The sill rests on a 3 by 4 or 4 by 4 horizontal stud under the window opening. The inner side of the sill is cut to come on a line with the finished plaster. The plaster stop or ground, which is either three-quarters or seven-eighths inch thick, according to the proposed thickness of the plaster, is nailed on to the 3 by 4 stud. The space between the stud and the sill is frequently filled with mortar. At the left of the drawing is shown a section through the side of the window box.

The outside architrave is arranged on the outside of the boarding; and a back band, or moulded strip, forms a finish around the outside edge. The layers of paper are generally run on the boarding under this outside architrave; and sometimes zinc flashing is used in very exposed positions, being turned up against the outside architrave. The small three-quarter round bead shown in the drawing may be omitted. The 3 by 4 stud is set so as to leave space for the weights. It is a good rule to remember that the distance from the stud to the glass opening is 5 inches, and the distance from the sill stud the same. The distance from stud at window head to glass opening is 4 inches.

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

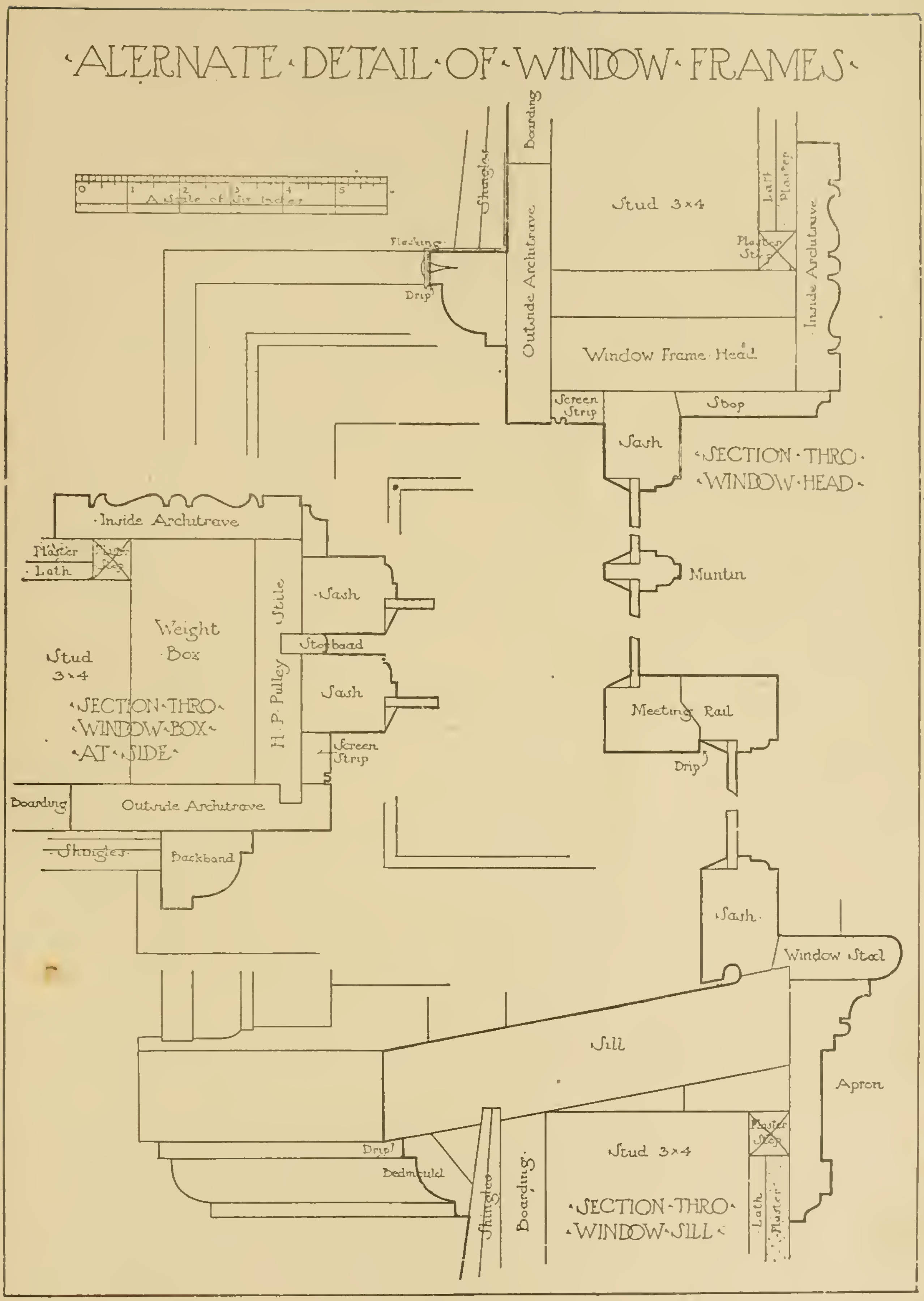

·ALTERNATE·DETAIL·OF·WINDOW·FRAMES·
Boarding
Shingles
Flashing
Drip
Outside Architrave
Stud 3×4
Lath
Plaster
Plaster Strip
Inside Architrave
Window Frame Head
Screen Strip
Stop
Sash
·SECTION·THRO·
·WINDOW·HEAD·
Muntin
Meeting Rail
Drip
·Inside Architrave
Plaster
·Lath
Weight Box
Stile
·Sash
Stopbead
Stud 3×4
·SECTION·THRO·
·WINDOW·BOX·
·AT·SIDE·
H. P. Pulley
Sash
Screen Strip
Boarding
Outside Architrave
Shingles
Backband
Sash
Window Stool
Sill
Apron
Plaster Strip
Drip
Bedmould
Shingles
Boarding
Stud 3×4
·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.

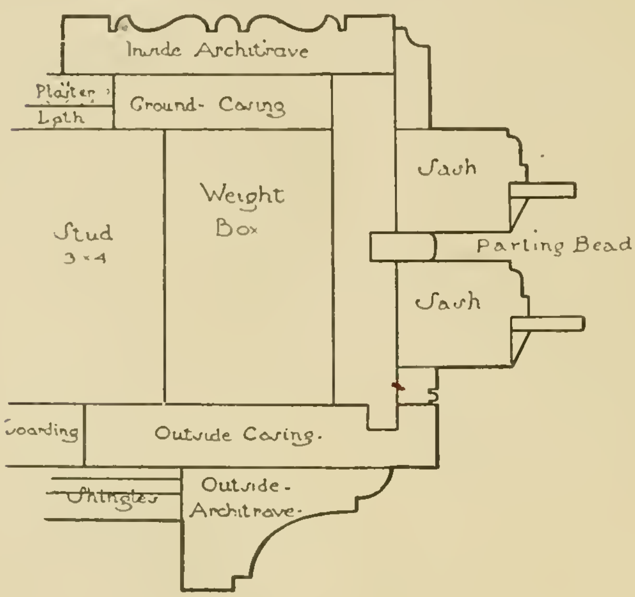


Fig. 47.

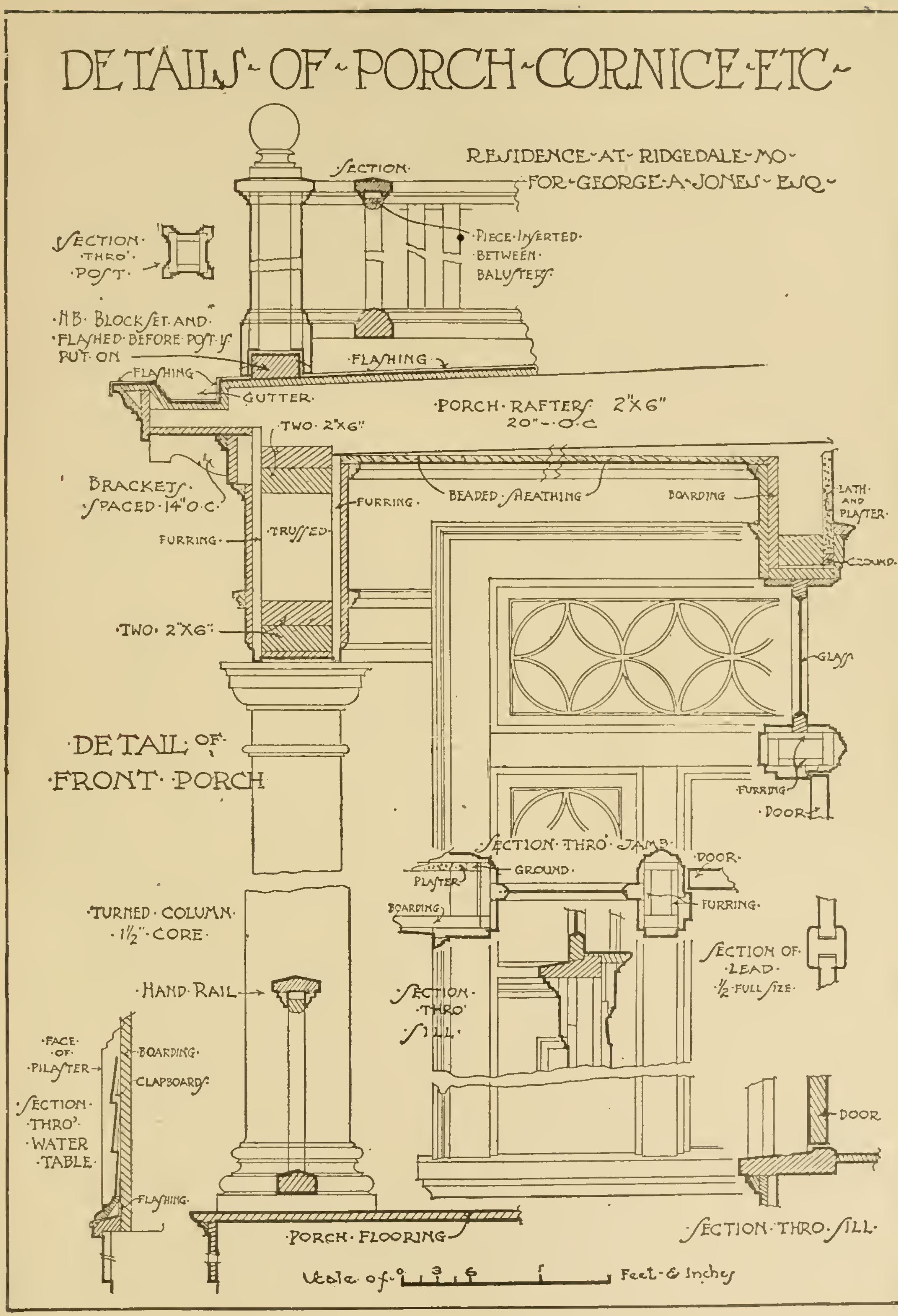
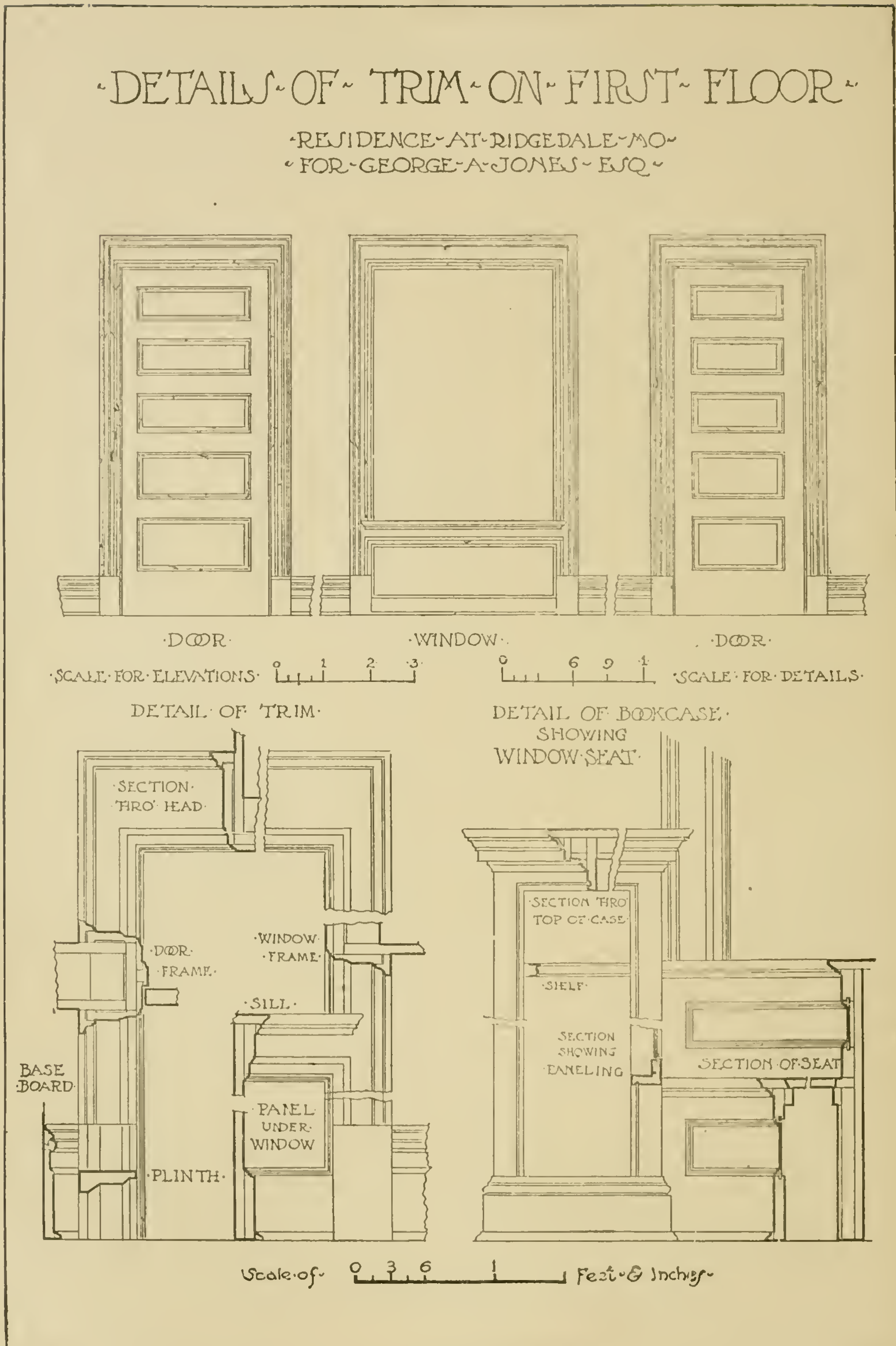

DETAILS OF PORCH CORNICE ETC
RESIDENCE AT RIDGEDALE MO
FOR GEORGE A. JONES ESQ
SECTION
SECTION THRO' POST
PIECE INSERTED BETWEEN BALUSTERS
H.B. BLOCK SET AND FLASHED BEFORE POST IS PUT ON
FLASHING
FLASHING
GUTTER
PORCH RAFTERS 2"X6" 20" O.C.
TWO 2"X6"
BRACKETS SPACED 14" O.C.
FURRING
BEADED SHEATHING
BOARDING
LATH AND PLASTER
GROUND
FURRING
TRUSSED
TWO 2"X6"
GLASS
DETAIL OF FRONT PORCH
FURRING
DOOR
SECTION THRO' JAMB
DOOR
GROUND
PLASTER
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
DOOR
FLASHING
SECTION THRO SILL
PORCH FLOORING
Scale of Feet & Inches

Fig. 48.



·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

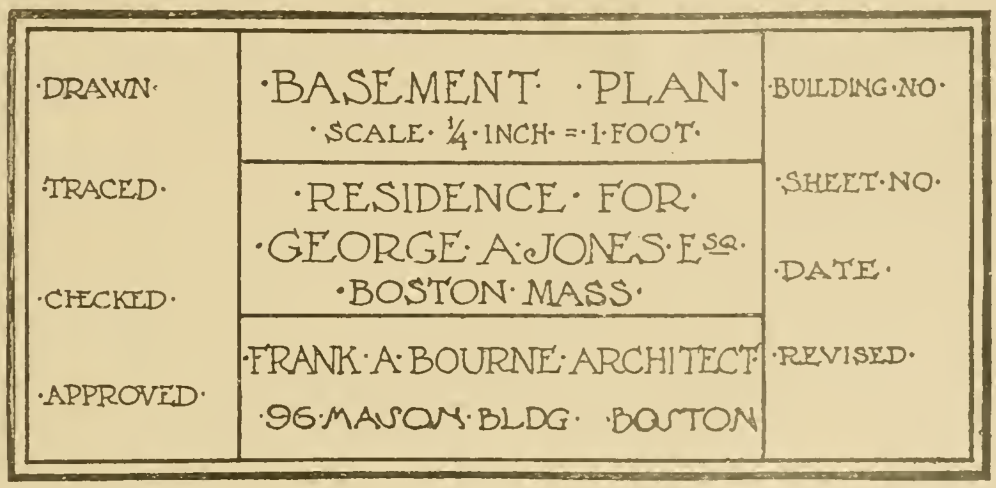


Fig. 50.

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-

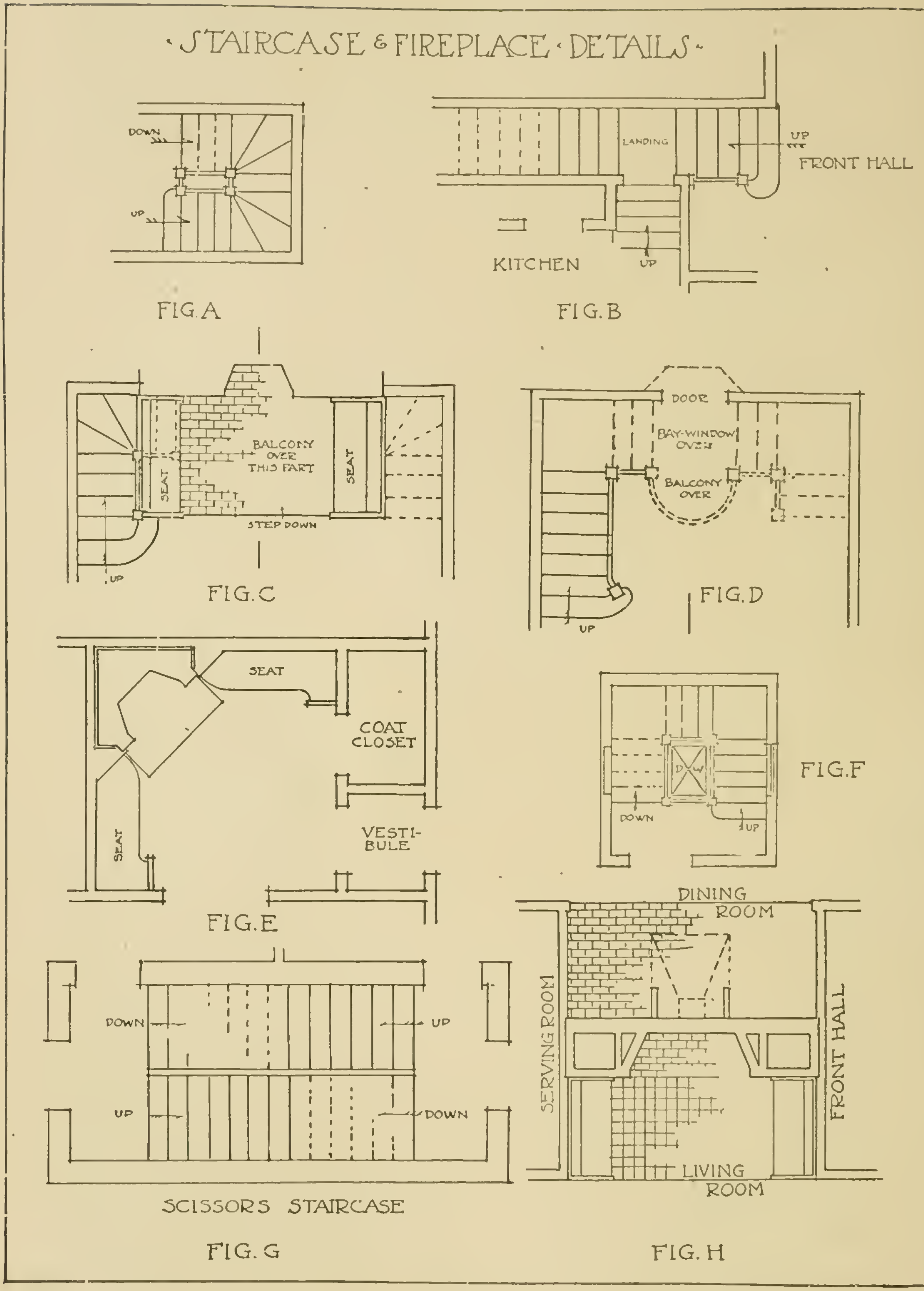

STAIRCASE & FIREPLACE DETAILS
DOWN
UP
FIG. A
LANDING
UP
FRONT HALL
KITCHEN
UP
FIG. B
BALCONY OVER THIS PART
SEAT
SEAT
STEP DOWN
UP
FIG. C
DOOR
BAY-WINDOW OVER
BALCONY OVER
UP
FIG. D
SEAT
COAT CLOSET
VESTI-BULE
SEAT
FIG. E
DOWN
UP
FIG. F
DOWN
UP
UP
DOWN
SCISSORS STAIRCASE
FIG. G
DINING ROOM
SERVING ROOM
FRONT HALL
LIVING ROOM
FIG. H

Fig. 51.

tractor on receiving the drawing, or for any other memoranda in regard to drawings.

Staircase and Fireplace Details. One of the best ways to prepare for the designing of buildings is to study and make memoranda of interesting plans and details. This is especially true in relation to house building, as well as to the planning of large buildings. Some of the most interesting sketch books are those filled with small-plan details which can be referred to and used in the same manner as window or door details could be used in designing elevations. Fig. 51 shows several such small drawings on one sheet.

Fig. A shows the usual way of working out a back staircase entirely enclosed between partitions, one staircase going down under the other. This is very compact, and may be worked out in wood or iron and between plaster or brick walls. The space may be larger or smaller than that shown. The width of stairs from the finished wall to center of rail shoultl never be less than 2 feet 2 inches for the smallest staircase, and usually 2 feet 8 inches is employed for a back staircase. Sometimes the newel posts are brought together as one, making what is practically a circular staircase.

Fig. B shows a combination staircase; that is to say, the front staircase goes up to a landing, and then continues in any direction to the second floor. From this landing a door opens, leading down to the service part of the house, giving many of the advantages of a back staircase, with loss of only a small amount of space.

Fig. C gives an interesting combination of staircase and fireplace. The fireplace is one step below the general floor level; and the ceiling is kept lower than the general ceiling of the room, with a small staircase leading up to a mezzanine story, above the fireplace, which may be arranged to look down on the main floor of the room or may form a sort of gallery.

Fig. D shows a staircase going up to a landing which is carried out into a room as a balcony indicated by dotted lines. At this level a little bay window is carried out over an outside doorway below. As there are only eleven risers shown, it would be necessary in this case to have the landing made of plank laid flat, to get head room for the seat.

Fig. E shows a compact arrangement of hall, coat closet, and out-

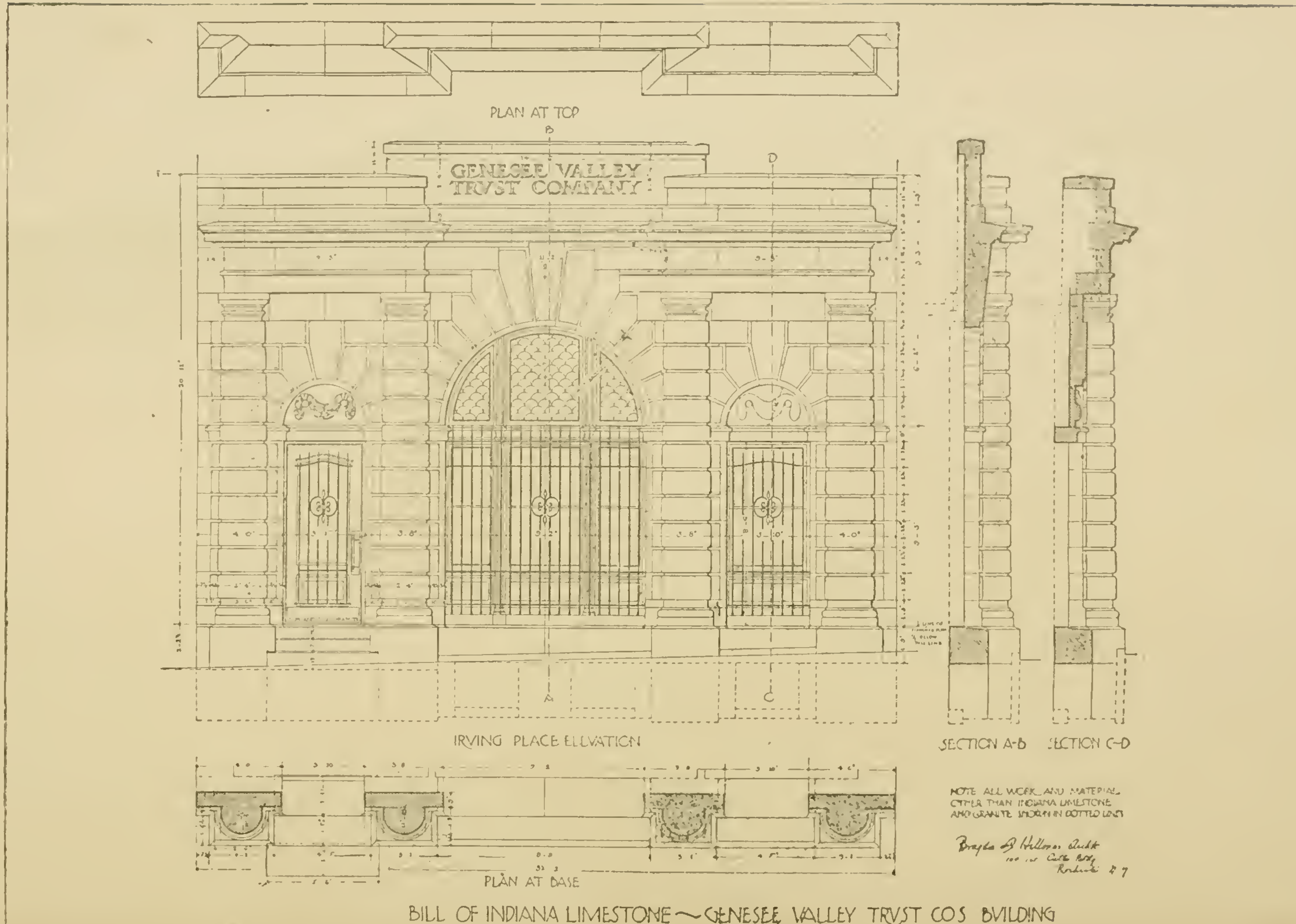

PLAN AT TOP
GENESEE VALLEY
TRUST COMPANY
IRVING PLACE ELEVATION
SECTION A-B
SECTION C-D
PLAN AT BASE
NOTE ALL WORK AND MATERIAL OTHER THAN INDIANA LIMESTONE AND GRANITE SHOWN IN DOTTED LINES
BILL OF INDIANA LIMESTONE ~ GENESEE VALLEY TRUST COS BUILDING

Fig. 52.

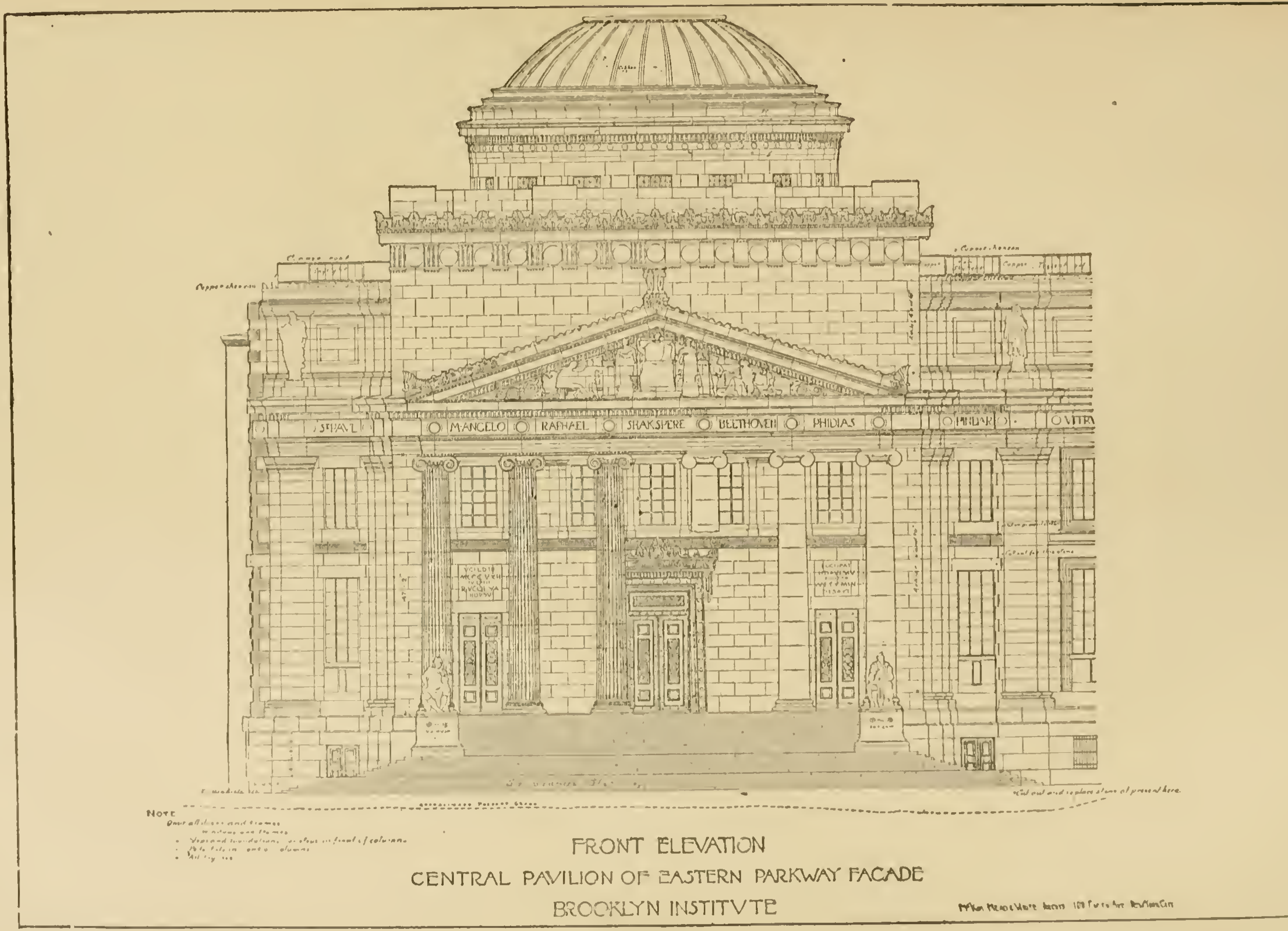

ST PAUL
M·ANGELO
RAFAEL
SHAKSPERE
BEETHOVEN
PHIDIAS
PINDAR
FRONT ELEVATION
CENTRAL PAVILION OF EASTERN PARKWAY FACADE
BROOKLYN INSTITVTE

Fig. 53.

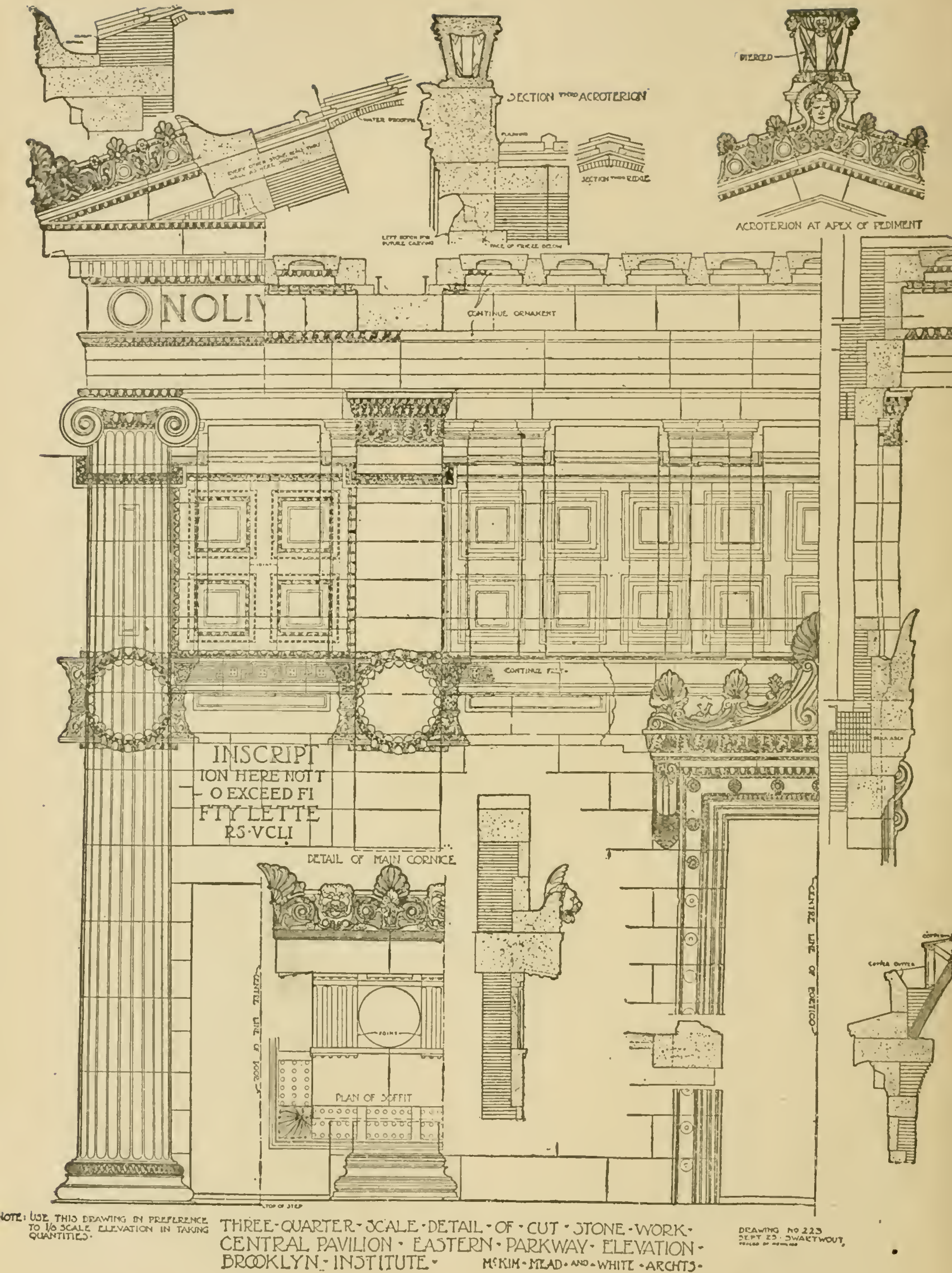

SECTION THRO ACROTERION
SECTION THRO RIDGE
PIERCED
ACROTERION AT APEX OF PEDIMENT
NOLI
CONTINUE ORNAMENT
CONTINUE FRET
INSCRIPT
ION HERE NOT T
O EXCEED FI
FTY LETTE
RS·VCLI
DETAIL OF MAIN CORNICE
PLAN OF SOFFIT
CENTRE LINE OF PORTICO
NOTE: USE THIS DRAWING IN PREFERENCE TO 1/8 SCALE ELEVATION IN TAKING 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.

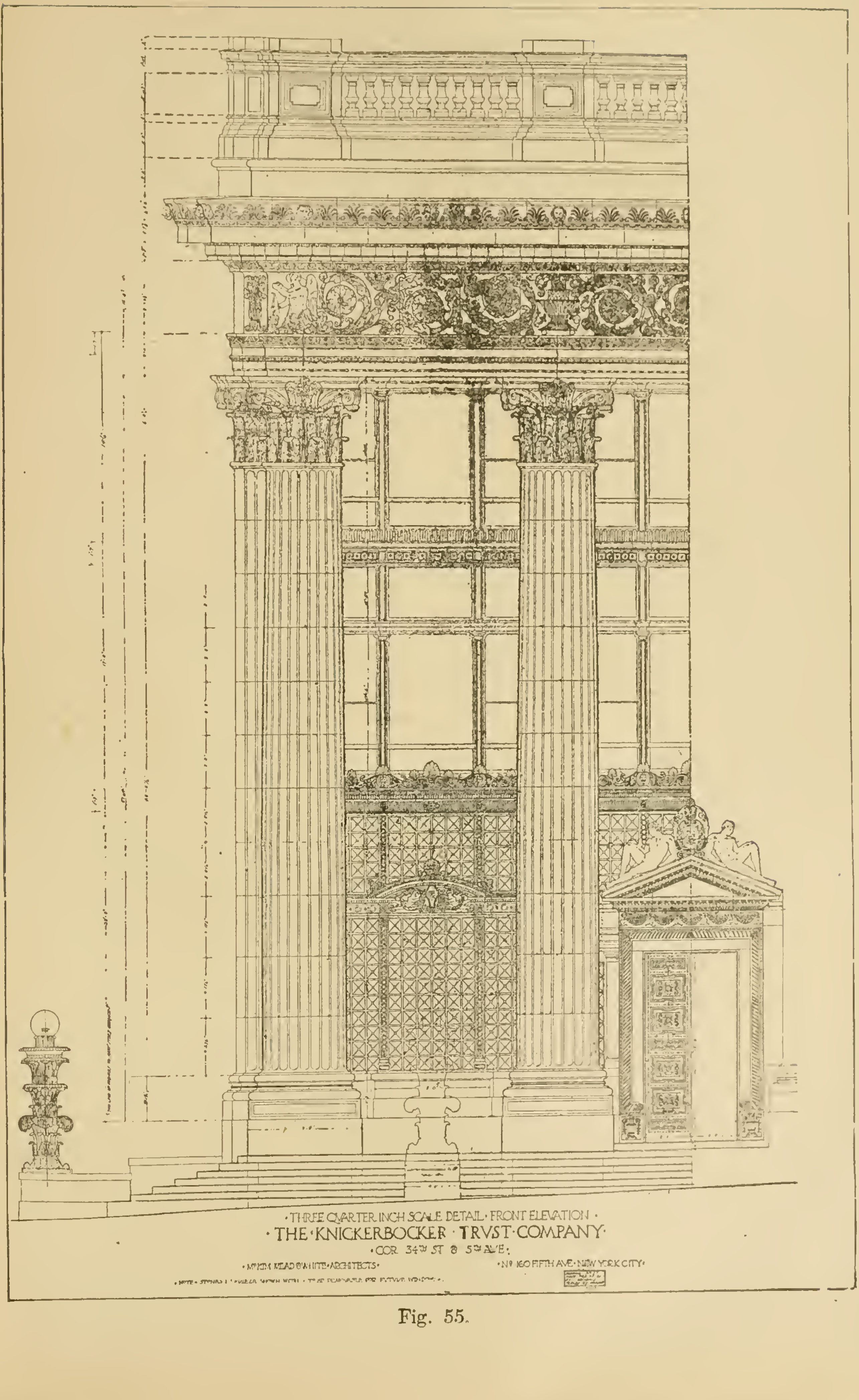

·THREE QUARTER INCH SCALE DETAIL·FRONT ELEVATION·
·THE·KNICKERBOCKER·TRVST·COMPANY·
·COR 34TH ST & 5TH AVE·
·McKIM MEAD & WHITE·ARCHITECTS·
·Nº 160 FIFTH AVE·NEW YORK CITY·

Fig. 55.

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.

REVIEW QUESTIONS

ON THE SUBJECT OF

ARCHITECTURAL DRAWING.

PART II.

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1. What is the meaning of composition in architectural design? What are some of the first principles of good composition?

2. Why should a draftsman study to cultivate his artistic taste?

3. What two meanings has the term "scale"? When is a drawing large in scale? What affects the scale of a building? How can a drawing be tested for scale? Why should ornament at the top of a building be of a different size than at the bottom?

4. What should we do to the small scale drawings when any change is made in the ornament? What is likely to be the result of overlooking this precaution?

5. In planning a dwelling, what is a good principle for number and size of rooms?

6. What should we avoid in the hall of houses for cold climates?

7. Give a rule for proportioning stair riser to tread.

8. Suggest a good way to avoid draughts in the sitting room.

9. Toward what point of the compass should be the exposure of the dining room, and why?

10. Describe some of the features of a butler's pantry.

11. What should be the exposure of the kitchen?

12. Where should the refrigerator be placed?

13. Describe several other rooms that must be considered in house-planning.

14. Make a set of one-eighth inch scale sketches of the house shown in Figs. 29, 30, 32 and 33, as described on page 61, plans to be in ink, elevations to be in pencil.

15. What is meant by the term "working drawings"?

16. What are the customary scales used in America?

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.