

PART I

DRAWING INSTRUMENTS AND THEIR USES

NEXT in importance to the intelligence necessary to learn any new branch of trade, science or art, are the tools and appliances with which to perform the work. While an expert may possibly do good work with inferior tools, such a method involves a loss of time, energy and patience which need not be sustained where proper tools are at hand. The advantage therefore to be gained by the use of perfect tools more than repays their cost. Furthermore fine tools and materials are an incentive to work, which the beginner, who will no doubt meet with difficulties enough during the progress of his work, should not hesitate to avail himself of, even at a sacrifice.

The term instrumental drawing often heard, refers to the method of making drawings by the use of instruments, in contradistinction to another kind of drawing called free-hand drawing. In all engineering and constructive

work accurate drawings become a necessity. Instruments are therefore designed to accomplish with speed and accuracy that which the hand unaided, could not do. This part will therefore be devoted to describing and explaining the uses of the various tools and appliances necessary to the work of the pattern draftsman, as well as the results to be accomplished by their use.

Drawing Materials

Drawing-Boards.—The purpose of the drawing board is not only to hold the paper in place while a drawing is being made but also to render certain assistance to the draftsman while at work, as will be explained. In size it should be suited to the purpose for which it is intended. If for use in drafting rooms where working drawings are made, a table such as described below will be required, but

if intended for the use of the student in pattern drafting, it should be as large as can be conveniently handled upon a table or desk in the available space, which is often very limited. It may be 18 x 24 inches, or even less, and should be as light in weight and thickness of material as possible. Since its sides are used as guides to the T-square, as will be hereafter explained, it should be rectangular in shape and have if possible two of its adjacent sides perfectly straight and the angle between them a perfect right angle. It would be an ideal board if the same could be said of all of its sides and angles, but if constructed thus perfectly at first, it could not be relied on to remain so long, owing to the unequal shrinkage of the wood and to wear while in use. On account of this difficulty, draftsmen usually use only one edge of the board (that at the left) during the execution of any one drawing. It is

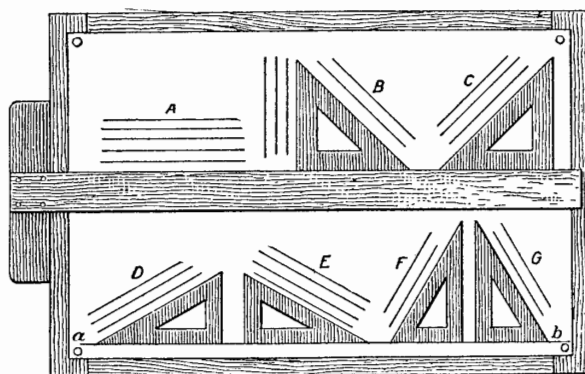


Fig. 1.—Method of Using T-Square and Triangles on the Drawing Board

necessary therefore that at least one of its edges be kept perfectly straight against which the head of the T-square may slide. But as either a side or an end of the paper used may become the top of the drawing it is desirable if possible to have one side and one end of the board perfectly straight. Owing to the liability to error in the angles of the board, lines to be drawn at right angles to those made along the edge of the T-square are usually done by means of the triangles as will be explained. The board should also have a smooth surface and be made of soft wood so as to be easily pierced by the thumb tack used to hold the drawing paper upon its surface. It is better to buy the board than to make it, as some do, since great accuracy in its construction is necessary; and the same is true of all the instruments required.

Fig. 1 shows a drawing board suitable for small

work. It is preferably of white pine from one-half to seven-eighths of an inch thick, in one piece if the size permits, or of two or more pieces glued edge to edge. Cleats made of either hard or soft wood should be tongued and grooved or dovetailed across the ends as shown in the engraving. These, if the cleats are dovetailed, should not be glued. This will permit the wood in the body of the board to shrink without splitting, thus eventually leaving the ends of the cleats to project beyond the sides of the board, when they may, if desired, be sawed off flush or a little short to allow for further shrinkage. Boards of this style can be bought in sizes varying from 12 x 17 inches up to 23 x 31 inches.

The accuracy of the edges and angles of the drawing board can best be tested by the application of an ordinary steel square such as is used by carpenters. The blade of a T-square or other straight-edge may, if known to be perfectly straight, be used for testing the sides of the board in the absence of the steel square. The angle of the drawing board, as that at A in Fig. 2, between any two of its sides may also be tested in the following manner: First place the head of the T-square against one of the sides about the angle to be tested, as shown at B, and draw a fine line *a b*

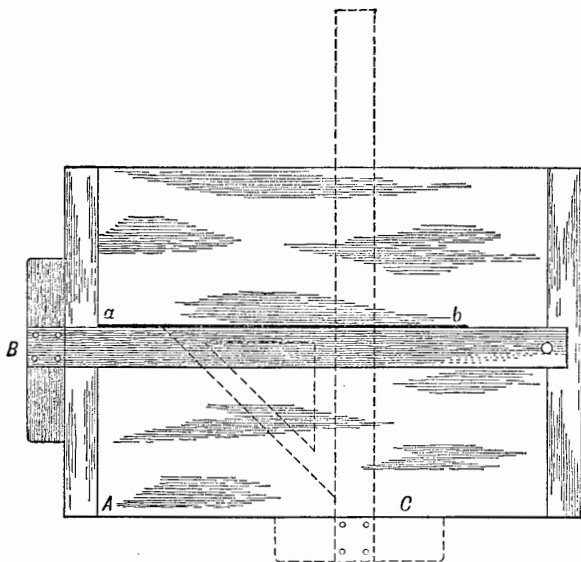


Fig. 2.—Testing the Angle of the Drawing Board

along the edge of the blade, then, shifting the T-square, place it against the other side to be tested as at C, and place one side of a triangle against the blade, and slide the triangle along till its perpendicular side comes to the line *a b*, previously drawn, as shown. The sides of the triangle to be

used in this test are of course those having a right angle. If the two sides of the board against which the T-square has been used are at right angles to each other, the side of the triangle in the above test will exactly coincide with the line drawn. If they do not coincide, it follows that the side being tested should be planed or otherwise cut away toward one end or the other in order to make the angle exact.

Drafting Tables.—For all purposes of study a small drawing board will be quite sufficient for the pupil's work, but for actual work in a well equipped



Fig. 3.—Adjustable Drafting Table for Shop Use

shop, a drafting table will be required of sufficient proportions to be used in laying out full size details of the work to be constructed.

While drawing boards can be obtained from all dealers in drafting materials of any size up to 30 x 42 inches, drafting tables of suitable size, for use in shops where cornice, skylight and sheet metal work is being done have usually to be built to order by competent workmen. For such purposes a table can be from five to eight feet or more in length and four or five feet in width. A drafting table of moderate size is shown in Fig. 3. It is practically a large drawing board supported on trestles or horses. It should be from one and one-half to two inches in thickness and should be built up from pieces or strips of wood which are as even and straight grained as possible so as to insure uniformity of shrinkage as the wood dries. The best results are obtained by making it of narrow strips from one to two inches wide glued together, after which it may be dressed down to a smooth surface. It should be reenforced by means of dovetailed battens near the ends. If made of very narrow

strips in the manner above described, it is advisable to run long bolts through it edgewise, the heads and nuts with washers being sunk into the edges of the board as shown in the cut. The nuts can be tightened by means of a socket wrench to hold the strips together while the glue is drying and further tightened as shrinkage occurs. The height of the trestles should be such that the draftsman, as he stands at the table will not have to stoop to his work. One or more drawers may be suspended from cleats on the lower side of the table as shown to contain the drawing instruments.

T-Squares.—One of the most important, and without doubt the most used instrument in the draftsman outfit is the T-square. T-squares can be purchased in a variety of sizes and qualities. Since the greatest of care and accuracy is required in their manufacture, a suitable one should be purchased, as a "home made" article is seldom a success. Its blade should be as long, or nearly so, as the long side of the board upon which it is to be used. The pear wood T-square with single head shown in Figs. 1 and 2, is probably the cheapest instrument of its kind, is used extensively in the schools and will serve the beginner very well. A better instrument is made of rose wood or mahogany, and has so called ebony edges on its blade. Still better and more expensive is a blade having celluloid edges. Either of the above kinds may have an extra or swivel head, two styles of which are shown in Fig. 4, by means of which the blade may be caused to assume any angle at which it is desired to draw lines, which renders it especially adaptable to making developments. Care should be taken to see that the device by which the loose head is clamped to the fixed head is perfect as otherwise there is great liability to error.

For the actual work of pattern drafting the blade should be not less than 42 inches and it is

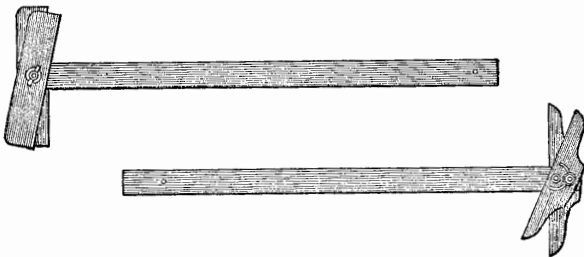


Fig. 4.—Swivel Head T Squares

sometimes desirable to have one as long as 54 inches. In the longer blades extreme thinness and lightness are necessary so that they may lie close to the paper without dragging. The great essential

in the blade of a T-square is that it shall be perfectly straight, rigid and free from spring. When not in use, T-squares and straight edges made of wood should be hung up by the hole always to be found near the end of the blade.

Straight-Edges.—The straight edge, shown in Fig. 5, is a very desirable tool for use in drawing



Fig. 5.—Maple or Nickel Plated Steel Straight Edge

long lines when large work is being done. In construction it is similar to the blade of the T-square but is usually a little thicker thus adding to its rigidity, while one edge is sometimes beveled to bring it close to the paper as shown. To be especially serviceable it should be longer than the blade of the longest T-square. One of nickel-plated steel or brass is very useful in testing and tracing up the edges of large drafting tables and drawing boards.

Triangles, sometimes termed set-squares, are used for the purpose of drawing lines at right angles or at certain required angles to the blade of the T-square. These in general use at the present time are made of either hard rubber and black in color or of celluloid and of a light amber color.

Two triangles will be necessary. In one of these the oblique side is placed at an angle of 45 degrees with the other two sides, as shown above the blade of the T-square in Fig. 1, while in the other it is so placed as to form an angle of 30 degrees with one of the remaining sides and 60 degrees with the other, as shown near the bottom of the board; these three angles together with the right angle, found on both triangles, being the angles most frequently required in mechanical drawing. A triangle having angles of $22\frac{1}{2}$ and $67\frac{1}{2}$ degrees is convenient in the construction of octagonal work. It is advisable to get those made of celluloid, as that material retains its shape well and has the further advantage of being transparent.

The combined use of the T-square and triangles is illustrated in Fig. 1. The T-square is operated by the left hand along the edge of the board as shown. For this reason it will be advisable to select for use that edge or end of the board which is found most perfect and to so turn the board as to bring this edge to the left. Any inequalities in the edge of a board can usually be taken down by the careful use of sand paper. No attempt to plane it down by means of a plane should ever be made. By placing the board and T-square

in the positions shown, the T-square can be manipulated by the left hand while holding the pencil in the right. All horizontal lines, as those shown at A, can thus be drawn along the upper edge of the blade of the square, sliding it along the edge of the board to the required position. Vertical lines should be drawn by placing one of the triangles against the blade of the square so that one of its sides shall be at right angles to the blade, turning it so as to draw the pencil along its left side, as shown at B or C. To this end the light in the room should be so arranged as to be to the left and slightly in front of the draftsman, except in the case of a left-handed person, when, of course, the reverse of the directions stated above will be followed. By keeping the head of the T-square always against one side of the board (the left) and using one of the triangles for lines at right angles thereto, the greatest accuracy will be obtained. It is only safe to use the T-square on another side of the board when the angles of the board are known to be perfect right angles.

Lines at an angle of 45 degrees slanting in either direction can be drawn along the oblique side of the 45 degree triangle, as shown at B and C, while lines at angles of 30 or 60 degrees to the horizontal and slanting in either direction can be drawn along the oblique side of the 30 x 60 degrees triangle, by placing it against the blade of the T-square in the positions shown at D E F and G, where the line *a b* represents the edge of the T-square blade. When it is necessary to draw a number of parallel lines at angles other than those given by the triangles, in the absence of a T-square having a swivel head, the blade of the T-square or any straight edge may be held by the hand or by weights, at such an angle that one of the triangles, when slid along its edge to any desired position, will give the required angle.

Drawing Instruments

In regard to drawing instruments it is advisable to get those of good quality, since durability and accuracy of adjustment are of the first importance. The usual full set or case of instruments contains really more than the pattern draftsman requires. In almost every field of drafting it is necessary that the lines of the drawing should be inked, it being necessary to preserve the drawings for future reference. Since in sheet metal work, however, this is seldom necessary, instruments for the use of ink, as the ruling pen and the small bow pen, can, if economy is an object, be dispensed with, except where it is desired to make a nicely finished drawing

for exhibition purposes. The real essentials are then a pair of *compasses* about 5½ inches in length with lengthening bar and movable or changeable feet shown in Fig. 6, a pair of *plain dividers* somewhat less in size, Fig. 7, and a small *bow pencil*, Fig. 8, and a pair of *spacing dividers*, Fig. 9. The latter is a very essential instrument and will be convenient for dividing profiles into equal spaces, especially in practical work, as a greater degree of accuracy can be obtained by means of the screw adjustment A than by the use of the plain dividers.

It should be noted here that it will be found very

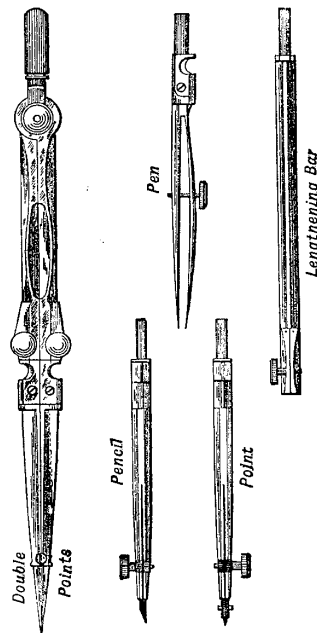


Fig. 6.—Compasses with Various Parts



Fig. 7.—Plain Dividers

convenient in some of the operations of pattern development, principally those known as "triangulation," to have three pairs of dividers in use at the same time, one of which can be the spacers. It will therefore not be wise to economize in the matter of dividers.

If inking is to be done, a *bow pen*, Fig. 10, will then be required as well as a *ruling pen*, such as is shown in Fig. 11.

Fig. 12 shows a case of instruments such as is sold for the use of pupils in mechanical drawing. It is usually composed of instruments of good quality which are also suitable for general use in practical work.

A *scale rule* will also be needed for some purposes as will be hereinafter explained. The kind most used is known as the triangular scale shown in Fig. 13, which, beside having the ordinary 12-inch rule,

has also a number of smaller scales for use when it is necessary to make drawings less than full size.

An *irregular* or "*french*" curve, shown in Fig. 14 is found by some to be a great convenience in drawing those curved lines of a pattern obtained by the processes of intersection. With a little prac-

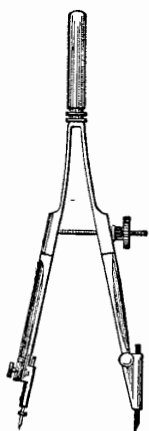


Fig. 8.—Bow Pencil

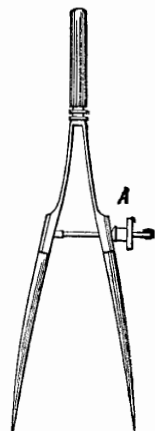


Fig. 9.—Spacing Dividers

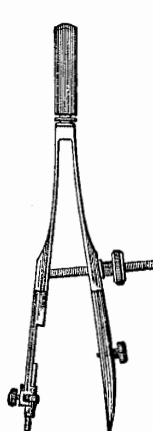
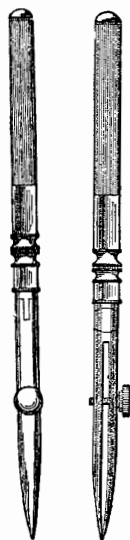


Fig. 10.—Bow Pen

tise, however, the patterns can usually be drawn free hand with sufficient accuracy.

Trammels.—A trammel, or beam compass as it is sometimes termed, is a very useful instrument to the sheet metal draftsman when it is required to describe circles having very long radii. As will be seen in Fig. 15 it consists primarily of two steel points which are adjustable upon a bar, usually of wood or steel, of any desired length consistent with rigidity. The points are so constructed that they can be removed and a pencil substituted in its place. The instrument is therefore adaptable for use upon paper or upon the metal. In the better instruments, this point is fitted with a screw adjustment at A so that it can be adjusted with extreme accuracy to the radius required.



Front Side
Fig. 11.—Ruling Pen

Protractors.—A protractor, an illustration of which is shown in Fig. 16 is usually included in a set of instruments; its use is often required by the sheet metal draftsman, for laying out the rise of the miter lines in elbow work. It is usually made of brass,

though sometimes of horn or celluloid, and consists essentially of a half circle divided into degrees, so that by its use an angle of any number of degrees from 0 to 180 can be obtained. The principal angles required in ordinary

work however are those given on the triangles as above explained, to which may be added those obtained by combinations of the triangles, as 75 (30 +

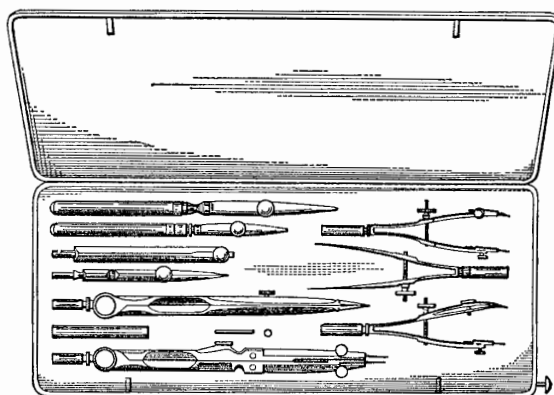


Fig. 12.—Case of Drawing Instruments

45) and 15 (90—75), which angles may be measured from the horizontal or the perpendicular according to the way the triangles are placed upon one another on the drawing board.

Paper.—Next in the order of material required by the student is paper suitable for his purposes.

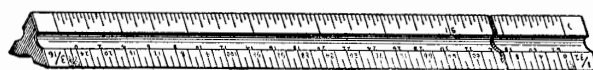


Fig. 13.—Architects' Scale Rule

Reference to the catalogues of dealers in drawing materials will show that there are many kinds, quality and grades of papers manufactured for the vari-

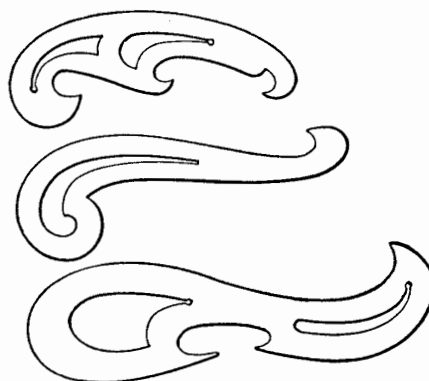


Fig. 14.—Three Styles of Irregular Curves

ous classes of artistic, semiartistic and mechanical drawing. The kinds in which the sheet metal worker is most concerned however, are those which have a smooth but not too highly glazed surface upon which fine lines can be drawn.

For the use of the student probably the most

suitable paper is either that called "Linen Ledger" which is white, or an imported drawing paper of buff tint. They can be purchased in sizes to suit a small drawing board. Paper for this purpose should have a calendered surface like writing paper, with a very fine "tooth" and should be heavy enough to permit handling without becoming wrinkled. Papers in-

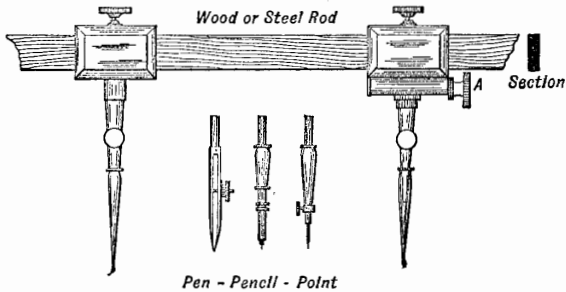


Fig. 15.—Trammels or Beam Compass with Parts

tended for the use of artists, as Whatmans or any papers possessing a rough and soft surface, are wholly unfit for the uses of the pattern draftsman.

A heavy white drawing paper known as "Egg-shell" is much in favor with architectural draftsmen for use in making elevations and perspective drawings because it is adapted to the use of ink

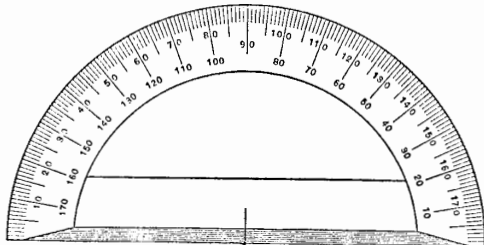


Fig. 16.—Protractor

in the ruling pen and to india ink or water colors when used as "washes." This can also be obtained in sheets or in rolls.

When elaborate pen and ink drawings are to be made with the view of being photo-engraved or if it is desired to preserve them with great care they should be done on bristol board. This is a card board with a highly calendered surface and is of various thicknesses which are designated by the terms three, four, six or eight ply, according to the number of thickness of paper which are used to make up its body. Bristol board cannot, generally speaking, be bent or rolled without damaging its surface, although for use in making drawings for the patent office, a two or three ply board is made which can be rolled to facilitate transportation by mail and through which a blue print can be made if necessary.

In the practical work of pattern drafting in the shop the kind of paper used is known as "Manila" drafting paper or detail paper. It is buff in color and comes in rolls varying in width from 36 to 48 inches, and is of a great variety of thicknesses and qualities of surface. Extra widths are made 54 and 60 inches. It can be purchased in small rolls of 10 yards each, or by the pound in full rolls of 50 to 125 pounds each. That best adapted to shop use should be of medium weight or rather heavy and of smooth surface. The quality of its surface can best be tested by the use of an eraser. It should be able to withstand several erasures in one spot without materially damaging the surface. The student will do well to provide himself with a small quantity of this kind of paper for practice and preliminary work as it is much cheaper than white drawing paper.

Tracing Paper is a thin and very transparent paper used for tracing or making duplicates of drawings previously made on heavier paper. In use it is placed over a drawing already made, when the lines of the first drawing, being visible are drawn upon its surface. It is to be had both in sheets and in rolls, the finer qualities being sold in sheets. Those in which oil is used to produce the transparency have a rather rough surface and take pencil marks readily and are therefore suitable for use when it is necessary to trace and transfer some part of a drawing to another part of the sheet. This kind of paper is ill smelling and deteriorates in time so that it can scarcely be handled without tearing. A kind prepared with parafin is stronger, smoother, more transparent and more durable, and is better when ink is to be used.

Tracing Cloth, is a kind of linen rendered even more transparent than some kinds of tracing paper, and has the advantage over either tracing or drawing paper of greater durability. It is made usually with one dull side though it can be obtained with both sides smooth.

It is used to make duplicate drawings that will require much handling. The principal use of tracings now however, is for the purpose of obtaining therefrom duplicates known as "blue prints." It is sold only in rolls varying from 30 to 54 inches in width.

Thumb Tacks are used to fasten the paper on the drawing board or table on which a drawing is to be made. They are made in several forms some of which are shown in Fig. 17. The style shown at A can, on account of its beveled edge, be more easily withdrawn from the board by means of the thumb and finger nails, but for the same reason is more

liable to damage the edges of the T-square and triangles than the style shown at B whose outer edges come close to the surface of the paper and thereby allow those instruments to pass over them without damage. A very important qualification in a thumb tack is that its point shall be so fastened to the head

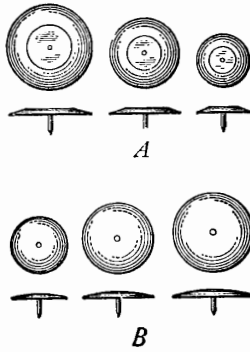


Fig. 17.—Two Styles of Thumb Tacks

that it will not, after some use, push up through the head when being pressed down into the board by the thumb. It is better to use tacks which require the use of a thumb tack lifter or the point of a knife blade to remove them than to run the risk of denting the edges of the T-square and triangles.

Pencils.—The best pencils for the draftsman's use are of the kind known as artist's or polygrade pencils. They are hexagonal in shape usually yellowish in color and somewhat higher priced than pencils for ordinary use. If economy is desired the red hexagon or the round, which are cheaper grades, may be kept at hand for the preliminary work or sketching. The polygrade pencils, as their name indicates, are made in very many degrees of softness and hardness. The softest grade is marked 3B or BBB, and the hardest 8H. The several grades are designated as follows: 3B, 2B, B, HB, F, H, 2H, 3H, etc., to 8H; the grades marked B, HB, F, 2H and 4H corresponding respectively with Nos. 1, 2, 3, 4 and 5 of the cheaper grades. The best makes of pencils are probably those known as the Koh-i-noor, or the Faber pencils. These can be

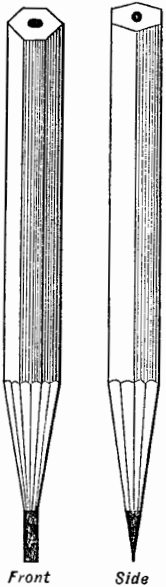


Fig. 18. Pencil Sharpened to a Chisel Point.

bought most economically by the dozen of any grade desired or of assorted grades to suit.

The grade of pencil required will of course depend

upon the work to be done and the kind of paper used. The more "tooth" the paper has the harder will be the pencil required. For lining on Manila paper having a very smooth surface any grade from H to 3H will be found best, but if the surface is rougher as is the case in "ledger" paper, a 4H or even a 6H will be required. For lettering, softer grades should be used, as F or H. If the pupil prefers it, the graded leads can be bought for use in a holder. In that case a double holder carrying leads of two different grades will be found very convenient.

In making drawings on white paper to be inked, many lines will of course be made in the construction of the drawing which are not intended to be inked. With this in view a pencil should be used of such grade that the lines can be perfectly erased. Where extremely fine lines are required, as in intricate miter work when projected points sometimes fall very close together, a very hard pencil as 4H or 6H should be used. The greatest degree of accuracy can be obtained by sharpening the pencil to a chisel point, as shown in Fig. 18 where two views are shown and the pencil will retain its point if thus sharpened much longer than if sharpened in the ordinary manner. For this purpose fine sand or emery paper or a fine file will be found very convenient.

Erasers. Rubber erasers suitable for use on detail paper are red or green in color and should be soft enough to take hold of the paper and not glide over it, thus spreading the pencil marks. These erasers are made with a wedge shaped point at the ends so that they are very convenient in enabling the draftsman to remove just what is wanted and no more.

Sponge Rubbers which are made of black rubber and are very soft and porous, are very useful in cleaning the pencil marks from drawings that have been inked.

Ink.—India ink in sticks can still be purchased if desired, but most draftsmen now prefer to purchase it already prepared in liquid form. Two principal kinds are now in the market known as Higgins' Ink and the French Ink. The latter is imported and perhaps preferable as it is capable of producing a somewhat finer line. That prepared by Higgins is of two kinds, one of which is termed waterproof. Both the soluble and the waterproof are sold in several different colors for use when technical distinctions are required. The soluble ink is designed to be reduced with water to be used when "washes" are required. For the usual work requiring only lines, the waterproof ink should be used.