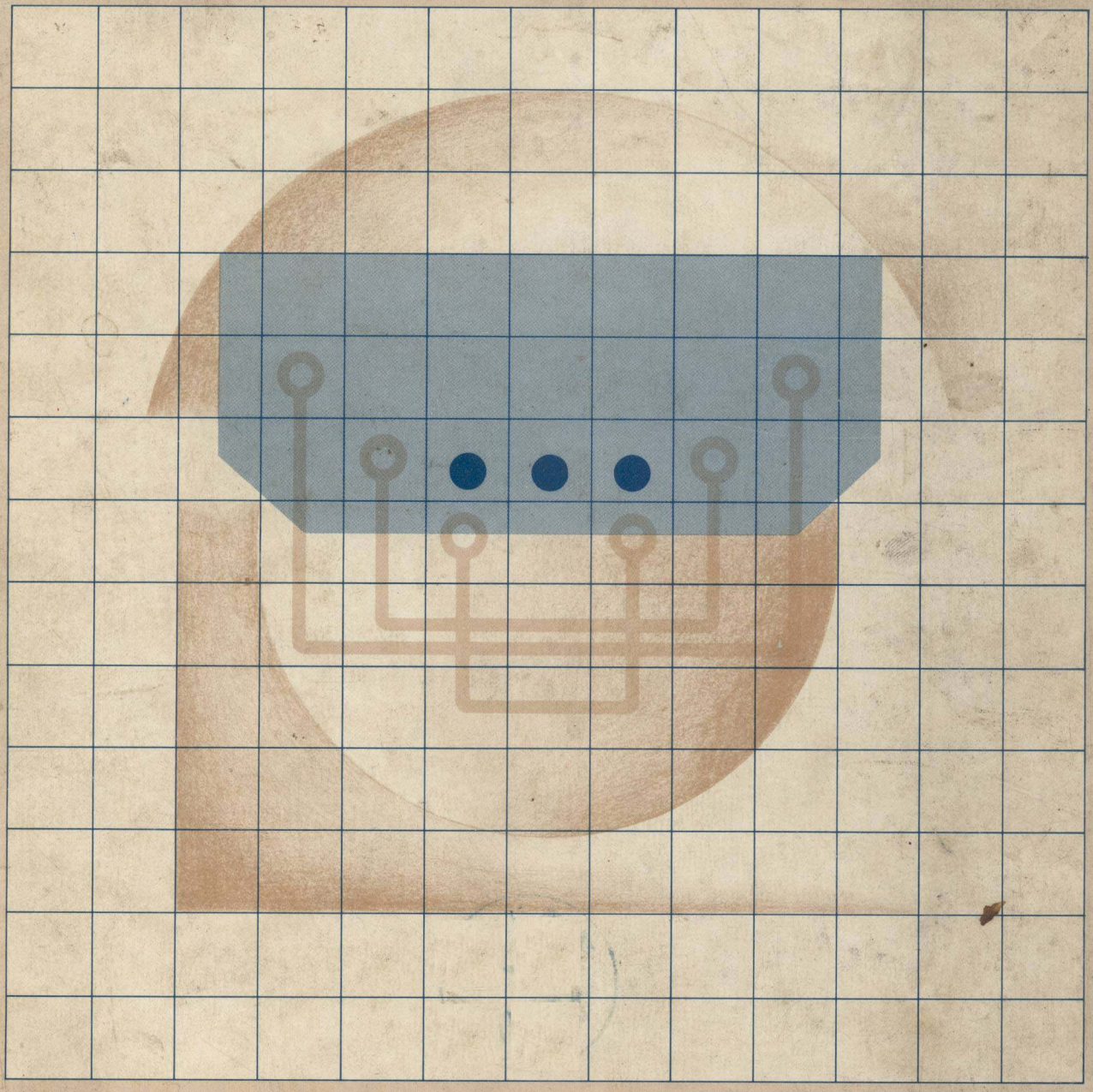
Herbert W. Richter

Electrical and Electronic Drafting



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To my wife
Madelin
and my children
John and Anne

Preface

This book was written expressly to interpret industrial drafting practices for the beginner. It introduces the various drafting techniques and types of drawings used in the design and construction of electronic and electrical equipment. Community college students, draftsmen, engineering technicians, and others planning a career in the electronics industry will find it a practical working text of great value. This book was also planned to coordinate with the recent emphasis on career education in high schools. The material and order of its presentation are largely based on the very successful electronics drafting course taught at the Kalamazoo Valley Community College in Kalamazoo, Michigan since 1968.

Since electronics drafting is likely to be offered early in a community college electronics program, circuit theory (Chapter 5) is limited to developing the students' knowledge of basic circuit recognition. References are included at the end of each chapter for those students who wish further information on a particular subject. The symbols of common electronic and electrical components are pictorially illustrated in Chapters 4, 6, 11, and 12 so that the beginner may quickly associate the symbol with the component. All electronic symbols conform to American Standard Y32.2-1970, which has been incorporated by the Institute of Electrical and Electronic Engineers as IEEE Std. 315-1971. Graphic symbols for electrical wiring and layout diagrams used in architecture and building construction conform to the American National Standards Institute (ANSI) Y32.9-1972, also adopted by the IEEE.

This material presented here can be taught in a single-semester course, although the instructor may wish to place more emphasis on the electronic chapters and less on the architectural construction and industrial wiring chapters, depending on the employment opportunities in the area. The problems and self-evaluation questions presented in each chapter are directed toward self-study. Each problem includes working data, specific instructions, and is illustrated when necessary; how-

ever, I recommend that the instructor supplement the problems with actual *bread-boarded* circuits, manufactured assemblies, or subassemblies, since such problems will more closely relate to actual job experience. It is not necessary for the components and assemblies to be in operating condition.

Production and assembly drawing are emphasized since electronics drafting is almost entirely devoted to this area. Chapters 7 to 10 are therefore concerned with isometric and perspective pictorial drawings, which are necessary in electronic manufacturing plants for use by possibly untrained assemblers and sales and purchasing personnel.

I gratefully acknowledge the support and help of the Wiley staff, particularly Alan B. Lesure and Dr. Irving L. Kosow. Special thanks must go to manufacturers who generously contributed photographs, circuits, and other useful data, and gave permission for their use.

Kalamazoo, Michigan

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Contents

Chapter 1 Instruments and Drawing Techniques

Instructional Objectives

To learn:

1. The desirable characteristics and properties of a drawing board and T-square.
2. The purposes and uses of a T-square and triangles.
3. To draw parallel horizontal lines and lines at any angle.
4. The correct techniques of using the instruments.
5. The desirable characteristics and properties of drawing instruments and papers.
6. The application of templates and other drafting aids.
7. The proper care of drawing equipment.
8. Desirable work habits.

Self-Evaluation Questions

Test your prior knowledge of the information in this chapter by answering the following questions. Watch for the answers as you read the chapter. Your final evaluation of whether you understand the material is measured by your ability to answer these questions. When you have completed the chapter, return to this section and answer the questions again.

1. Give the name of the type of drawing in which all lines lie at right angles to the plane of projection.
2. Give the advantages in fastening drawing paper to a drawing board using adhesive tape rather than thumbtacks.
3. How should the drafting pencil be held and inclined when drawing a line using a straight edge?
4. What is the minimum drafting equipment needed to produce an orthographic drawing?
5. Describe the proper method of drawing a perpendicular to a given nonhorizontal line.
6. What are the important characteristics of vellum drawing paper?
7. What method would you use to draw a line accurately connecting two points?
8. What effect does conversion to the metric system have on drawing techniques?

9. How could an angle of 75° be drawn using two drafting triangles and a T-square?
10. Describe your method to draw an angle of 22.5° using T-square, triangles, and compass.

1-1 Drawing Boards and Tables

The *drawing board* must be large enough to accommodate the largest drawing that may be contemplated. Its surface must be smooth flat, and constructed of a warp-free material. If a *T-square* rather than a drafting machine is used, one edge of the board must be a *straight* or reference edge for perfect alignment with the *head* of the T-square. Often to protect the board surface, a sheet of paper slightly smaller in size than the board dimensions is fastened to the surface with adhesive tape. This provides a clean, nonslip, and only slightly resilient surface that protects the board from nicks, cuts, or dents.

Figure 1-1 Pedestal-type shadowless tracing table. (Courtesy Bruning Div. AM.)

Many different board materials may meet these specifications: smooth pine, plywood, particle board, linoleum, or sheet metal. Boards 97 × 122 cm (38 × 48 in.) and larger may be provided with either permanent or folding legs. Such *drafting tables* are also provided with an adjustment so that the drawing surface may be made to slope at a convenient angle as shown in Figure 1-1. The overall height of most pedestal-type tables may be adjusted at the legs for a less tiring posture; desk-type drafting tables may not have this advantage but often contain storage space. The table shown in Figure 1-1 is actually a specialized drafting table in that it has a *translucent* glass or plastic working surface illuminated from below the tabletop; this construction is extremely useful for tracing work.

1-2 T-Squares and Triangles

The purpose of a *T-square* is to draw *horizontal* and *parallel* lines. The T-square, in conjunction with drafting *triangles,* is used to draw *vertical* lines in a fundamental drafting procedure called *orthographic* or multiview projections (Fig. 1-11). A clear plastic straight edge may be bonded to the blade providing a convenient "see through" edge.

The T-square is possibly the most easily damaged drafting tool. If it is dropped, the head may no longer be rigidly attached at right angles to the blade. Lines drawn when the head is loose are no longer parallel to each other. Obviously a nicked straight edge results in drawing a discontinuous line.

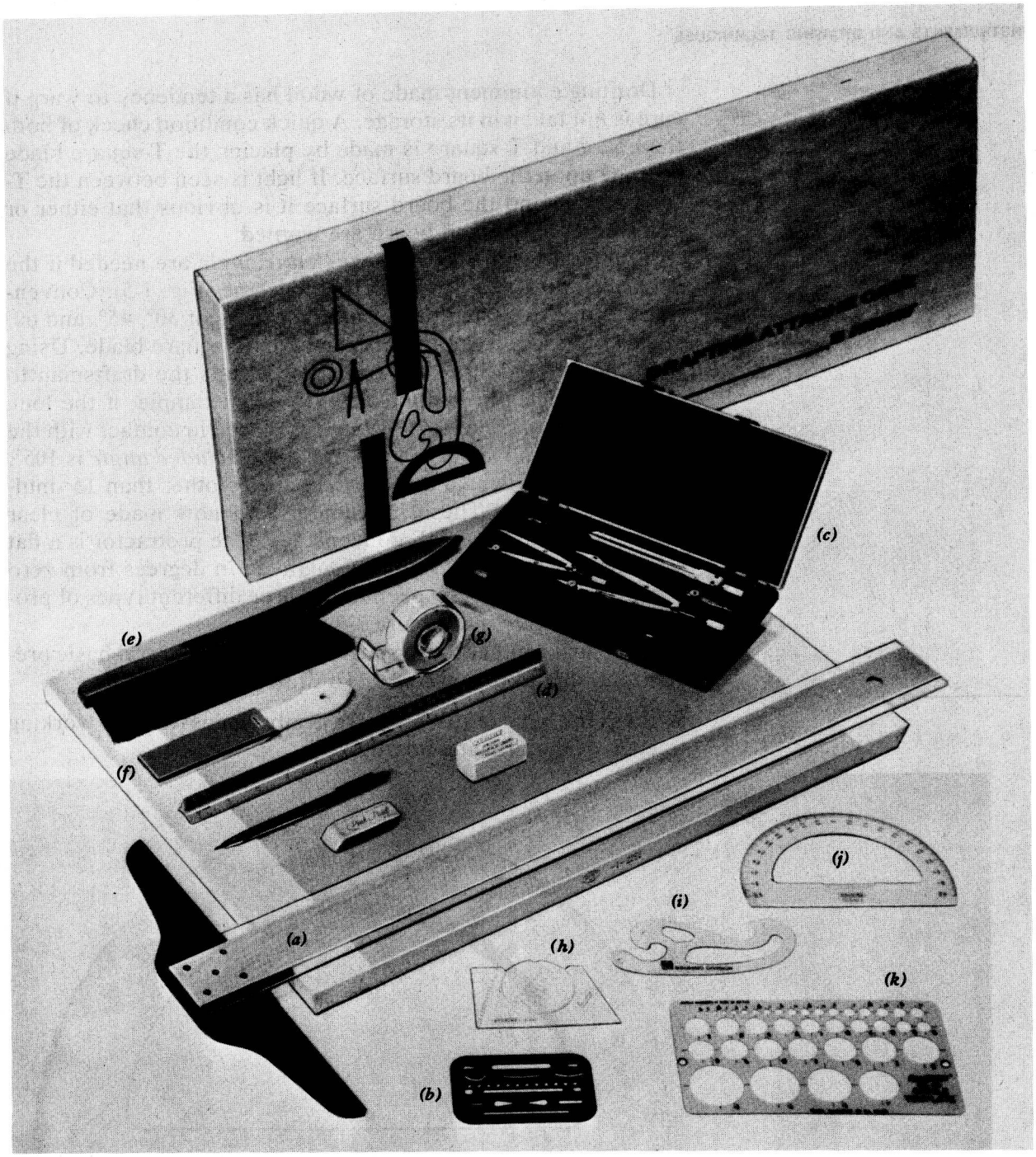


Figure 1-2 Drafting attache case. (Courtesy Bruning Div. AM.) (*a*) T-square; (*b*) erasing shield; (*c*) instruments case; (*d*) triangular scale; (*e*) dust brush; (*f*) sandpaper block; (*g*) cellophane tape; (*h*) lettering guideline template; (*i*) French curve; (*j*) protractor; (*k*) circle template.

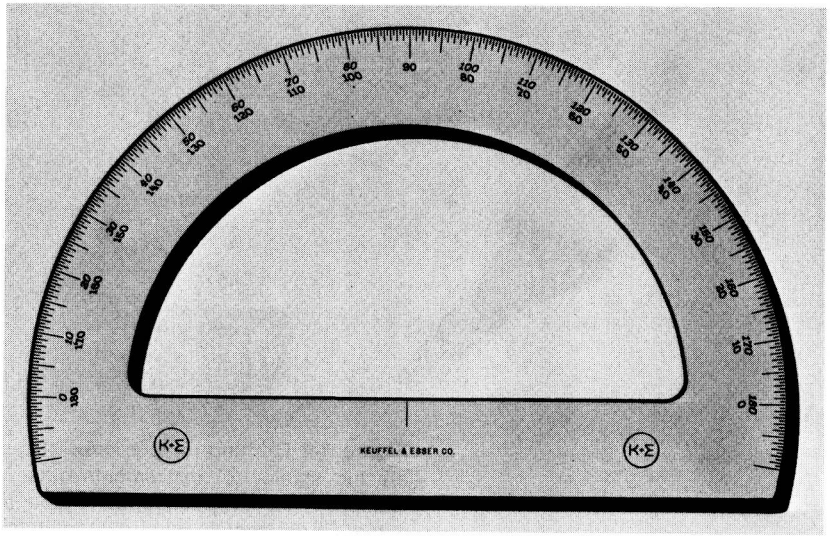
Drafting equipment made of wood has a tendency to warp if care is not taken in its storage. A quick condition check of both the board and T-square is made by placing the T-square blade on edge upon the board surface. If light is seen between the T-square edge and the board surface it is obvious that either or both the T-square and board are warped.

A 30 to 60° and a 45° *right-angled triangle* are needed if the draftsman does not use a drafting machine (Fig. 1-5). Conventional triangles permit the accurate drafting of 30°, 45°, and 60° angles with respect to the horizontal or T-square blade. Using both the 45° and 30 to 60° triangles permits the draftsman to construct angles in multiples of 15°. For example, if the long side or *hypotenuse* of a 45° triangle is placed in contact with the short side of a 30 to 60° triangle, the total *included angle* is 105°.

A *protractor* is also useful when angles other than 15° multiples are drawn. These instruments are now made of clear plastic for "see through" convenience. The protractor is a flat semicircular or circular device engraved in degrees from zero through 180° or 360°, respectively. Three different types of protractors are shown in Figure 1-3.

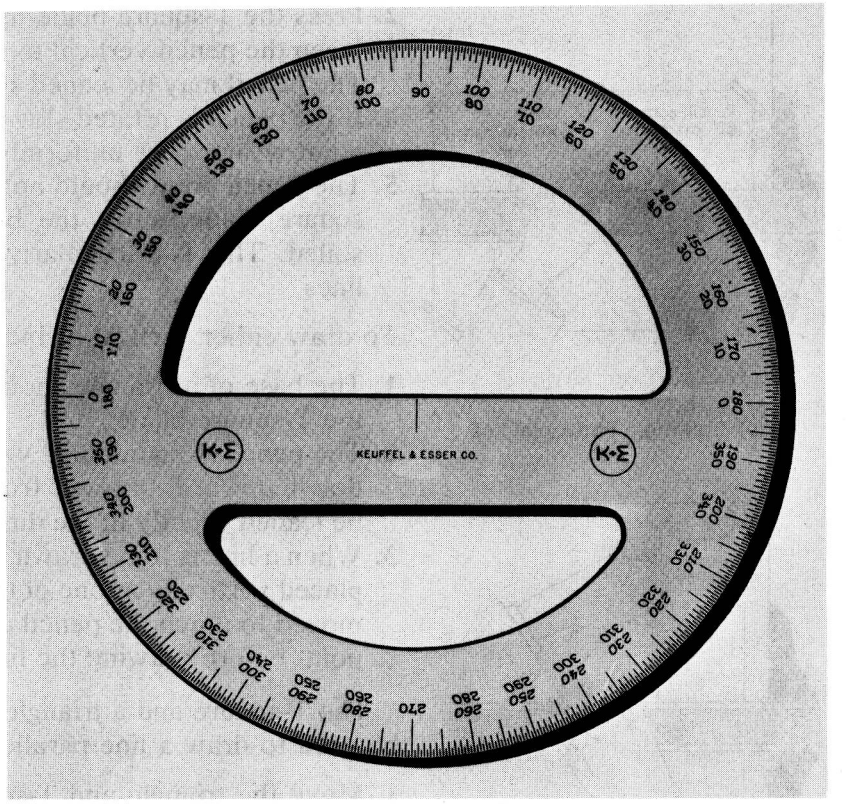
When using either the T-square or triangles several basic precautions should be observed. To draw a horizontal line:

1. Press the head of the T-square firmly against the left working edge of the drawing board.

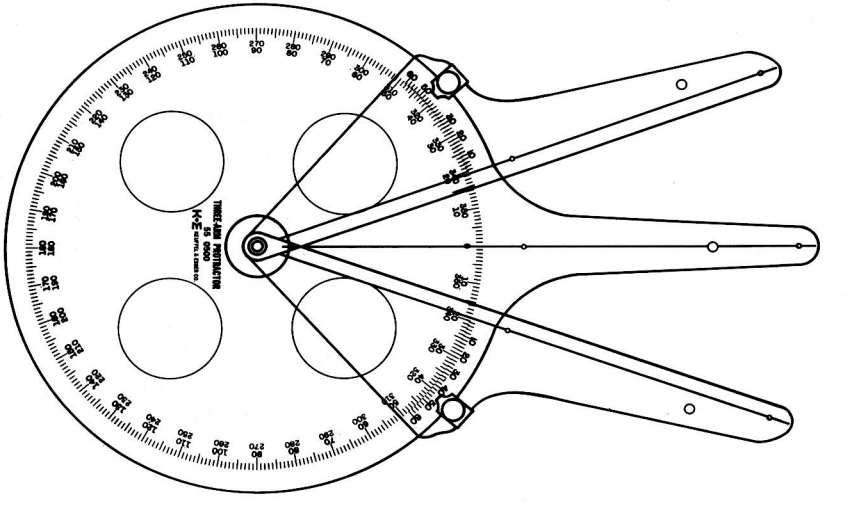


(*a*) 180° protractor

Figure 1-3 Protractors. (Courtesy of Keuffel & Esser Co.)

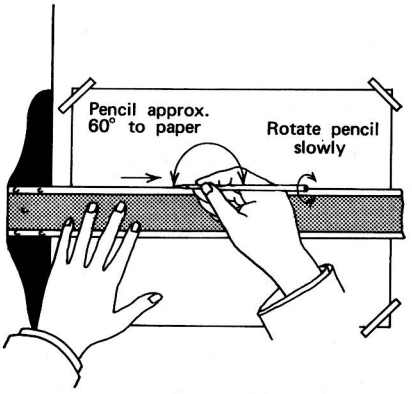


(*b*) 360° protractor

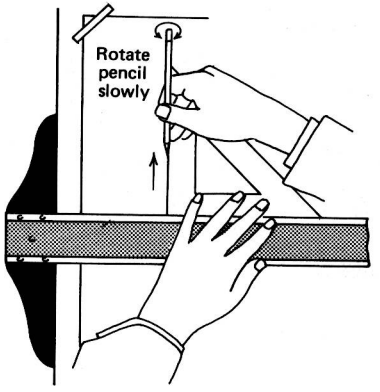


(*c*) three-arm protractor

Figure 1-3 (*continued*)



(*a*) Drawing a horizontal line



(*b*) Drawing a vertical line

Figure 1-4 Pencil techniques.

2. Press the T-square blade tightly against the paper.
3. Keep the pencil vertical to the board while drawing the line. The pencil may be leaned slightly in the direction of motion.
4. If the pencil is rotated slowly as the line is drawn, the pencil point wears more uniformly.
5. The pencil point should not touch the bottom edge of the T-square blade, since the blade and drawing may become soiled. This is particularly important when drawing inked lines.

To draw either vertical or inclined lines:

1. The base of a triangle should rest evenly and firmly against the T-square blade.
2. The pencil is maintained vertical to the board but the line is drawn *upward,* or away from the draftsman; the pencil may be leaned slightly in the direction of motion. See Figure 1-4.
3. When a line is to be drawn between two points, the pencil is placed vertically at one of the points. A straight edge is then moved to touch the pencil point and aligned with the second point before drawing the line.

The T-square and a triangle, or a pair of triangles, may also be used to draw a line parallel to a given non-horizontal line:

1. Move the triangle and T-square as a unit until the hypotenuse of the triangle lines up with the given line.
2. Hold the T-square firmly in position.
3. Slide the triangle away from the given line.
4. Draw the required line along the hypotenuse.

1-3 Drafting Machines

Drafting machines may be purchased apart from or with a drawing board. The *parallel-rule mechanism,* known as a drafting machine, is shown in Figure 1-5. An L-shaped straightedge replaces the T-square and its position is maintained parallel to the top edge of the board by an arrangement of cords, pulleys, gears, or levers. Triangles and protractor are not needed since the left end of the straightedge may be pivoted and locked at any angle as measured by the protractor on the machine. This function is of special value when making pictorial drawings.

The drawing machine is a precision instrument; the pro-

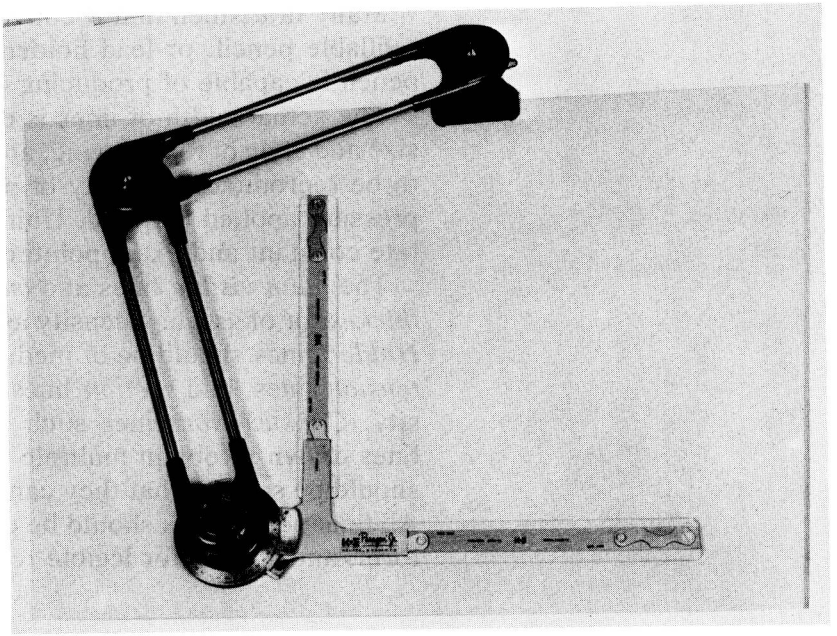


Figure 1-5 Drafting machine. (Courtesy of Keuffel & Esser Co.)

tractor degree dial at the lower left may be adjusted to a fraction of a degree. The vertical straightedge is maintained at 90° to the horizontal straightedge.

1-4 Pencils and Line Widths

Pencil leads are made of *graphite*. A special clay is added in different amounts to make 18 *grades of hardness* from 7B to 9H. The *soft* grades, 2B through 7B, are used for preliminary sketches since the lines produced are easier to erase. The *medium* grades, B through 3H, are used for general purpose work and lettering. The *hard* grades, 4H through 9H, are only used when extreme accuracy is required because the lines produced are apt to be too light. The final choice of pencil hardness also depends on the brand of pencil and the texture of the drawing paper.

The drafting pencil is usually sharpened to about 4 cm (1.5 in.) from the end, with about 10 mm (⅜ in.) of uncut lead exposed. The lead may be shaped to a sharp, conical point on a sandpaper block, or by a special hand sharpener for leads, and wiped clean. Special cutters or pencil sharpeners that remove only the wood to expose a given cylindrical length of lead are also obtainable.