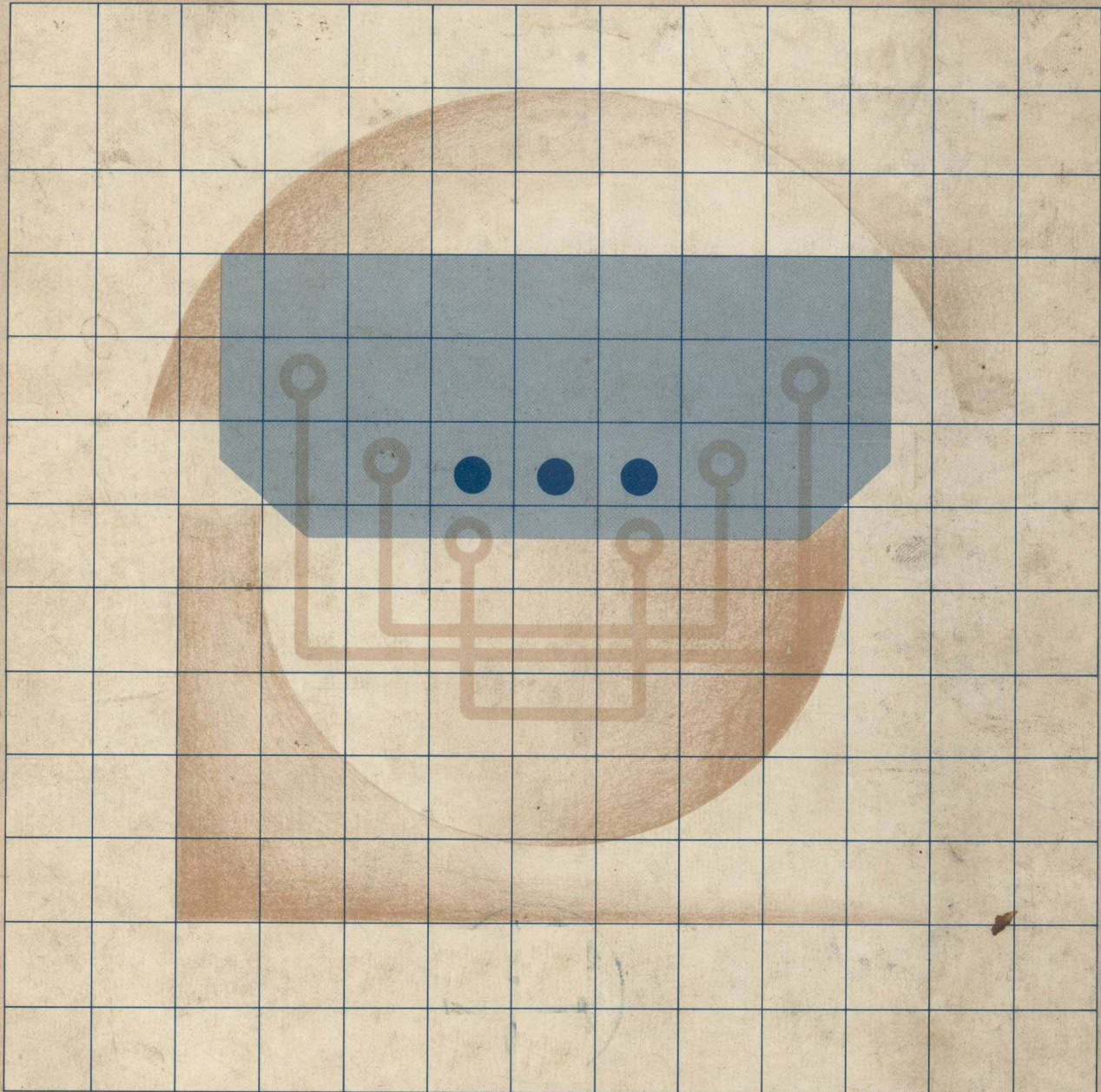


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**Herbert W.
Richter**

**Electrical
and
Electronic
Drafting**



Herbert W. Richter

Kalamazoo Valley Community College

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

Herbert W. Richter

Electrical and Electronic Drafting

Contents

1		3	
Instruments and Drawing Techniques	1	Block and Logic Diagrams	31
INSTRUCTIONAL OBJECTIVES	1	INSTRUCTIONAL OBJECTIVES	31
SELF-EVALUATION QUESTIONS	1	SELF-EVALUATION QUESTIONS	31
1-1 Drawing boards and tables	2	3-1 Flow diagrams	32
1-2 T-squares and triangles	2	3-2 Electronic system diagrams	33
1-3 Drafting machines	6	3-3 Digital logic diagrams	37
1-4 Pencils and line widths	7	Summary	39
1-5 Erasers and erasing shields	8	Problems	39
1-6 Inks and inking pens	8		
1-7 Instrument kit	12	4	
1-8 Drawing papers and materials	13	Electronic Component Symbols	42
1-9 Templates	14	INSTRUCTIONAL OBJECTIVES	42
1-10 Drafting aids	14	SELF-EVALUATION QUESTIONS	42
1-11 Basics of orthographic drawing	15	4-1 The development of electronic	
1-12 Work habits	16	symbols	43
Summary	17	4-2 Inductors	43
Problems	17	4-3 Capacitors	45
		4-4 Resistors	47
		4-5 Batteries and cells	49
		4-6 Switches	50
		4-7 Electron tubes	50
		4-8 Two-terminal semiconductors	54
		4-9 Multiple-terminal semiconductors	56
		4-10 Accessory devices	59
		4-11 Size of symbols	61
		Summary	65
		Problems	66
2		5	
Lettering	19	Basic Circuits	70
INSTRUCTIONAL OBJECTIVES	19	INSTRUCTIONAL OBJECTIVES	70
SELF-EVALUATION QUESTIONS	19	SELF-EVALUATION QUESTIONS	70
2-1 The importance of lettering	20	5-1 Power supply circuits	71
2-2 Letter styles	20	5-2 Amplifier circuits	71
2-3 Guidelines and guideline devices	23		
2-4 Spacing of letters	24		
2-5 Lettering templates	25		
2-6 Parts lists and tables	26		
2-7 Mechanical lettering machines and			
appliqués	28		
Summary	29		
Problems	29		

X
CONTENTS

5-3	Inter-stage coupling	74	8-5	Circuit board layout	128
5-4	Oscillator circuits	76		Summary	132
5-5	Demodulator circuits	78		Problems	134
5-6	Filter circuits	81			
5-7	Integrated circuits	83			
	Summary	85	9		
	Problems	85	Integrated Circuit (IC) Drawings		136
6			INSTRUCTIONAL OBJECTIVES		136
Drawing Schematic Diagrams		89	SELF-EVALUATION QUESTIONS		136
	INSTRUCTIONAL OBJECTIVES	89	9-1	Microelectronics	137
	SELF-EVALUATION QUESTIONS	89	9-2	The planar process	138
6-1	Cables, junctions, and crossovers	90	9-3	Integrated circuit resistors	140
6-2	Grounds, chassis, and circuit returns	91	9-4	Integrated circuit capacitors	141
6-3	Layout of schematic diagrams	91	9-5	Integrated circuit layout	143
6-4	Rotary switch layout	93	9-6	Packaging	145
6-5	Identification of components	96	9-7	Drawing ICs in linear and digital circuits	145
	Summary	96		Summary	149
	Problems	97		Problems	149
7			10		
Wiring Assembly Diagrams		103	Pictorial Assembly Drawings		151
	INSTRUCTIONAL OBJECTIVES	103	INSTRUCTIONAL OBJECTIVES		151
	SELF-EVALUATION QUESTIONS	103	SELF-EVALUATION QUESTIONS		151
7-1	Wires and cables	104	10-1	Purpose of pictorial drawings	152
7-2	Cable drawings	105	10-2	Isometric drawing	152
7-3	Point-to-point connection diagrams	107	10-3	Oblique drawing	156
7-4	Baseline connection diagrams	109	10-4	Dimetric projection	157
7-5	Highway connection diagrams	111	10-5	Perspective drawing	157
7-6	Cable harness construction drawings	112	10-6	Photographic pictorials	159
	Summary	112	10-7	Pictorial assembly design factors	159
	Problems	113		Summary	164
				Problems	165
8			11		
Printed Circuit (PC) Drawings		117	Electrical Building Construction Wiring Diagrams		167
	INSTRUCTIONAL OBJECTIVES	117	INSTRUCTIONAL OBJECTIVES		167
	SELF-EVALUATION QUESTIONS	117	SELF-EVALUATION QUESTIONS		167
8-1	Discrete versus printed circuit wiring	118	11-1	Symbols	168
8-2	Materials and processes	118	11-2	Single line diagrams	172
8-3	Silk-screen printing	124			
8-4	Design factors	126			

11-3	Floor plan layouts	175	13-7	Polar graphs	223
11-4	Convenience outlet details	176	13-8	The Smith chart	225
11-5	Switching circuit details	176		Summary	227
11-6	Service entrance details	178		Problems	227
11-7	Branch circuit load calculations	180			
11-8	Service load calculations	180	Appendix		230
	Summary	180	A	Acronyms and abbreviations for electrical terms	230
	Problems	182	B	Metric equivalents table	234
12			C	Resistor color code and standard stock resistor values	236
Industrial Control Wiring Diagrams		185	D	Wiring color code	238
INSTRUCTIONAL OBJECTIVES		185	D-1 Chassis wiring		238
SELF-EVALUATION QUESTIONS		185	D-2 Power transformer leads		238
12-1	Components and symbols	186	D-3 Audio transformer leads		239
12-2	Schematic layout conventions	194	D-4 Intermediate frequency transformer leads		239
12-3	AC motor control circuits	195	D-5 Industrial control circuits		239
12-4	DC motor control circuits	197	E	Typical mechanical data of semiconductors	240
12-5	Power distribution systems	203	F	Engineering standards and specifications	246
	Summary	206	F-1 Military		246
	Problems	208	F-2 Institute of printed circuits		246
13			G	Relay operation codes	248
Graphs and Charts		210	H	Circuit board eyelets	249
INSTRUCTIONAL OBJECTIVES		210	I	Circuit board connectors	250
SELF-EVALUATION QUESTIONS		210	J	Standard drafting paper and film sizes	252
13-1	Pie and bar graphs	211	Glossary		253
13-2	Rectilinear graphs	211	Index		267
13-3	Graph construction standards	215			
13-4	Logarithmic graphs	216			
13-5	Conversion scales	217			
13-6	Nomographs	219			

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.

Drawing Boards and Tables 1-1 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.

T-Squares and Triangles 1-2 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.

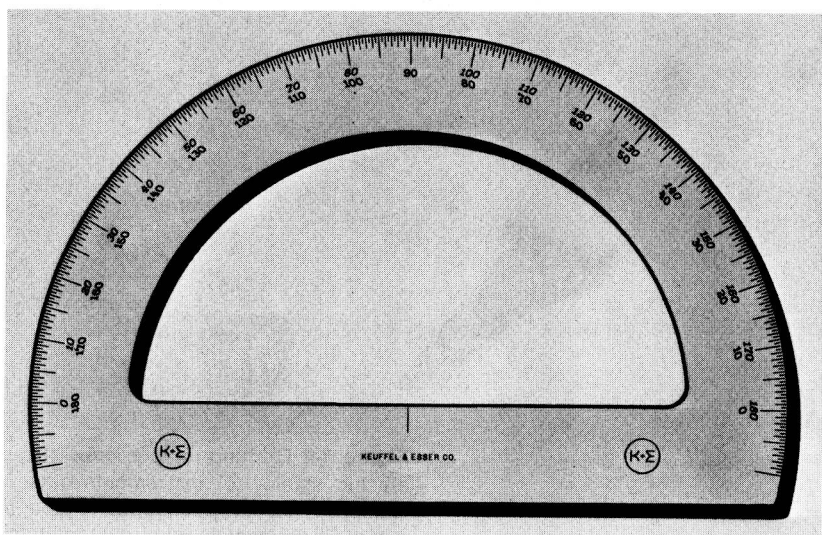
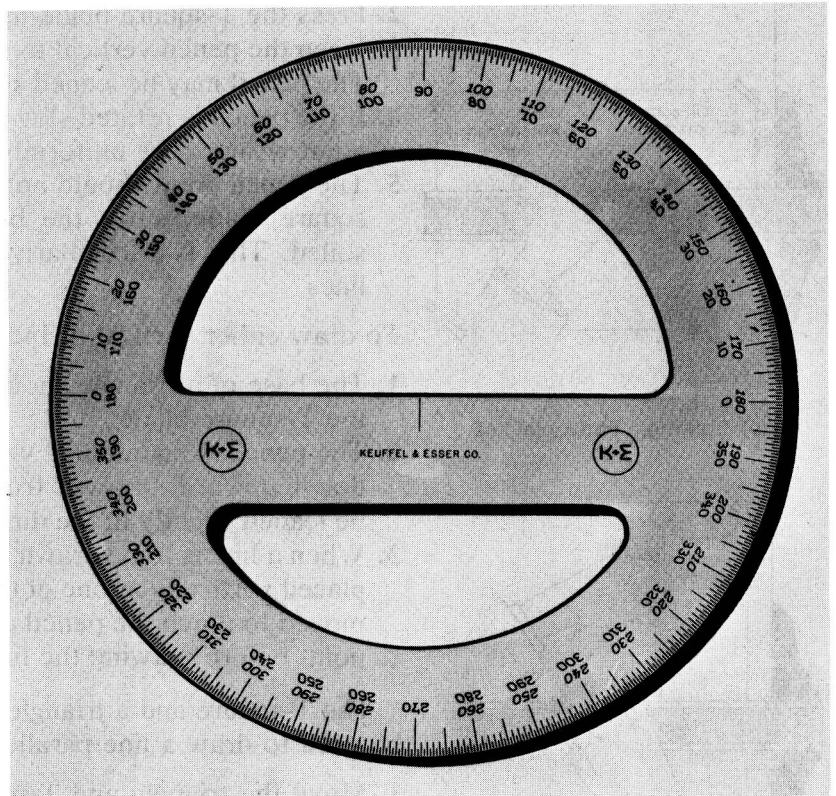
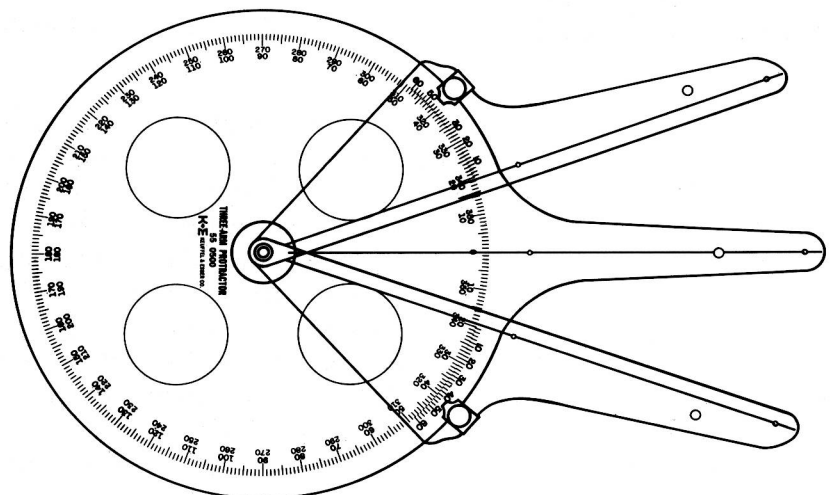


Figure 1-3 Protractors. (Courtesy of Keuffel & Esser Co.)

(a) 180° protractor

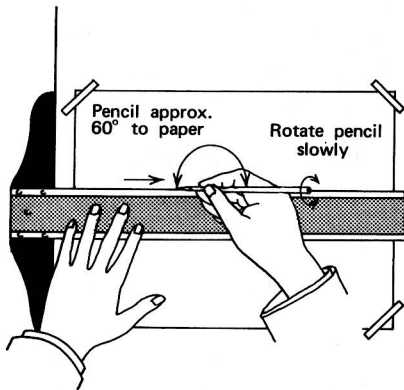


(b) 360° protractor

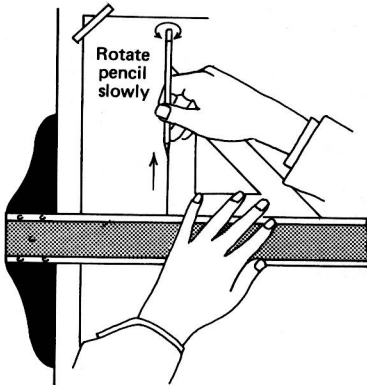


(c) three-arm protractor

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.

Drafting Machines 1-3 *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-

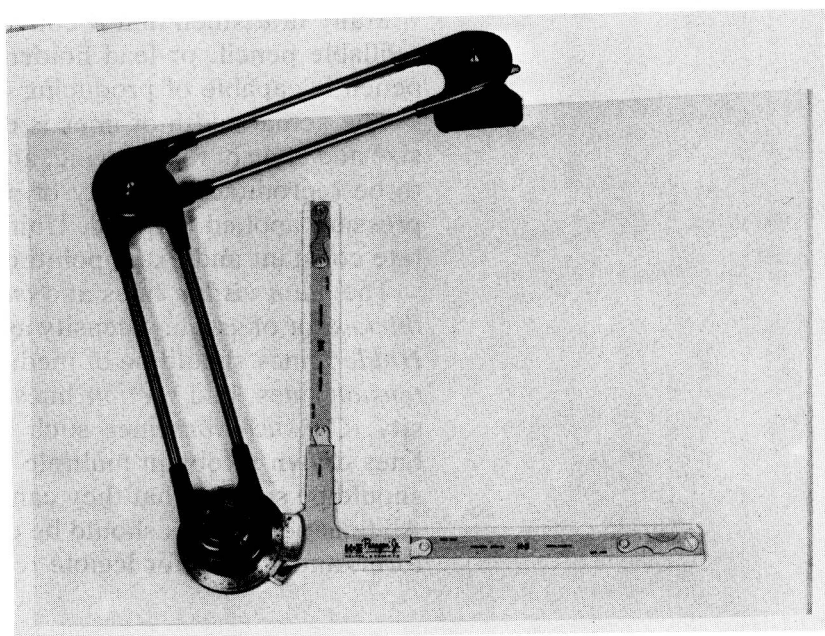


Figure 1-5 Drafting machine. (Courtesy of Keuffel & Esser Co.)

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.

Pencils and Line Widths 1-4 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 ($\frac{3}{8}$ 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.