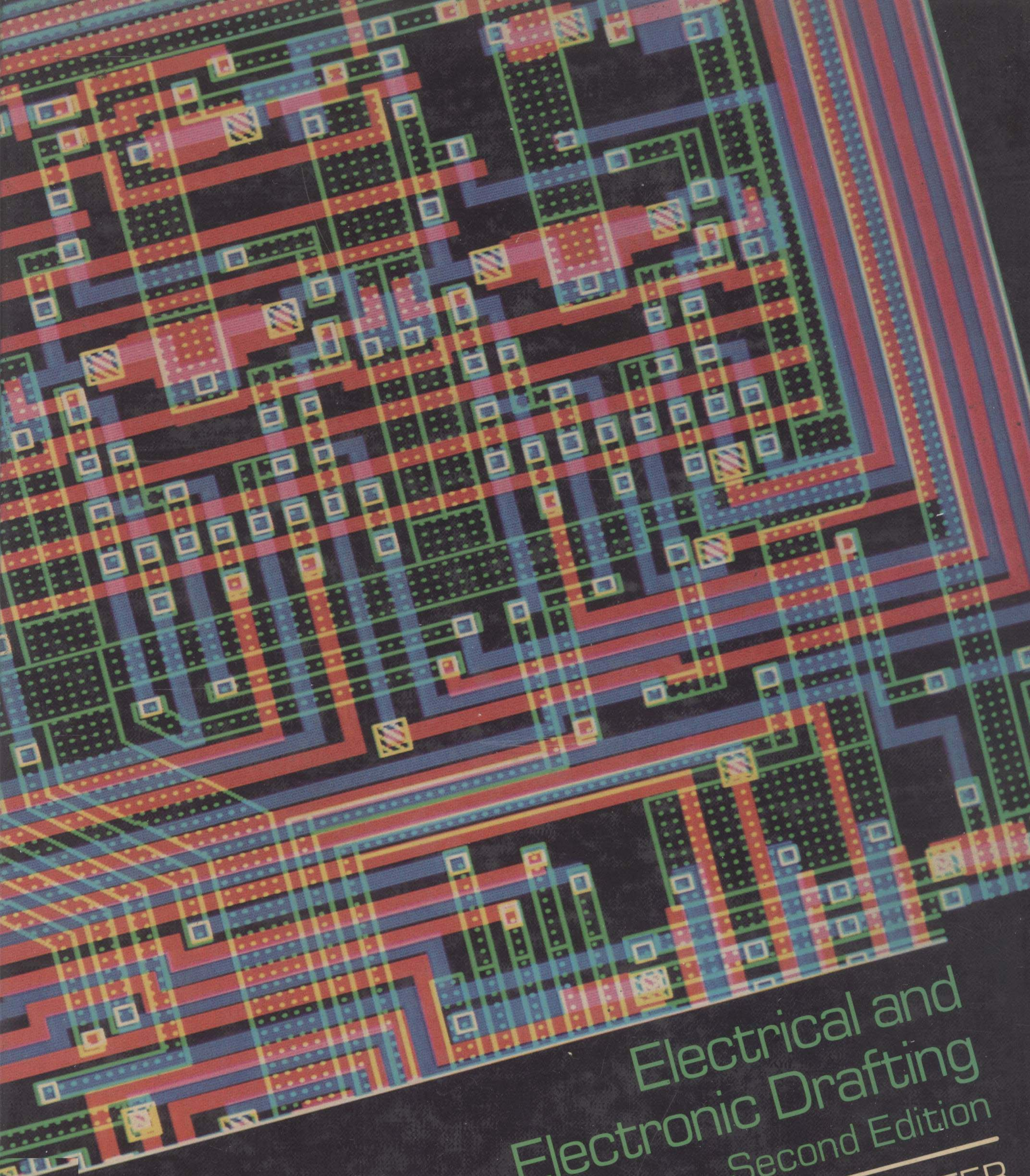

Electrical and Electronic Drafting

Second Edition

RICHTER
RUBENSTEIN

Electrical and Electronic Drafting

Second Edition

Herbert W. Richter

Charles F. Rubenstein, B.E.E., M.E.E., P.E.

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Electrical and Electronic Drafting

To my wife, Susan,
and to Fran, Glenda, Larry,
and my grandson Brian

Preface

This book was written expressly to introduce students to the various drafting techniques and types of drawings used in the design and construction of electronic and electrical equipment. It is appropriate for use in drafting technology programs at the associate degree level, as well as for courses offered in Bachelor of Engineering and Bachelor of Engineering Technology programs at colleges and universities.

It is assumed that the student who takes an Electrical and Electronic Drafting course has already completed a basic Technical Drawing or Engineering Drawing course and a first course in Electronic Devices.

The sequence of chapters presented in this edition of *Electrical and Electronic Drafting* is based on the successful course given at Cuyahoga Community College. Chapters 1, 2, and 3 provide a general overview of instruments, drawing techniques, lettering techniques, and standard approaches to preparing graphs and charts. Once students have learned this material, the instructor may wish to select subsequent chapters in an order tailored to the specific course requirements.

The use of the computer in the areas of engineering, drafting, and manufacturing has developed into a special application, CAD/CAM, for these areas. Chapter 14 reviews this new technology and describes a number of commercially available CAD/CAM systems.

The electrical and electronic components referred to in this edition are based on the MIL-STD requirements. Instructors may wish to obtain parts catalogues from local distributors for comparison with the MIL-STD components. If the class schedule permits, a tour of a local facility is suggested to enhance the students appreciation of subject matter by relating classroom assignments to industrial realities.

All electrical and electronic symbols conform to the current American National Standards Institute (ANSI) Y 32.2 series (as incorporated by the Institute of Electrical and Electronic Engineers (IEEE) standard 315. Graphical symbols for electrical wiring and layout diagrams used in architecture and building construction conform to the ANSI Y 32.9 series. Graphical symbols used in industrial motor control circuits conform to the latest Joint Industrial Council (JIC).

I gratefully acknowledge the assistance and support of the Wiley staff, in particular the guidance of Ms. Judith Joseph and Ms. Cindy Zigmund. Special thanks go to Mr. Bruce W. Owen, P.E., Vice President of Problem Solvers, Inc., for his detailed review of the preliminary manuscript. I also wish to express my appreciation to those organizations which provided data sheets, samples, photographs, and other related items. Helpful reviews of this text were provided by Dean Chowenhill (College of San Mateo), Jerry T. Baxter (Sabine Valley Vocational-Technical School), Thomas J. Bingham (St. Louis Community College), Steve Huycke (Lake Michigan College), Ron Ebben (North Central Technical Institute), Mark Kocher (Columbus Technical Institute), Thomas A. Singletary (Georgia Southern College), Lou Gross (Columbus Technical Institute), Larry D. Goss (Indiana State University at Evansville), Roman J. Ozarka (College of DuPage), and Robert S. McFarland (Columbus Technical Institute). I would also like to acknowledge the work of Herbert W. Richter, the author of the first edition of this text. It is my hope that the second edition will capture the concern for students and for new technology reflected in the first edition.

Charles F. Rubenstein

Contents

Chapter 1 Instruments and Drawing Techniques

Instructional Objectives

1. To learn the desirable characteristics and properties of a drawing board and T-square.
2. To understand the purposes and uses of a T-square and triangles.
3. To learn to draw parallel horizontal lines and lines at any angle.
4. To develop the correct techniques of using the instruments.
5. To become aware of the desirable characteristics and properties of drawing instruments and papers.
6. To become familiar with the applications of templates and other drafting aids.
7. To become aware of the proper care of drawing equipment.
8. To develop 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 straightedge?
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 (45° and 30°/60°) 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 tape. This provides a clean, nonslip, and only slightly resilient surface that protects the board from nicks, cuts, or dents.

Many different board materials may meet these specifications: smooth pine, plywood, particle board, linoleum, or sheet metal. Boards 38 × 48 in. (97 × 122 cm) 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 and printed circuit board layout.

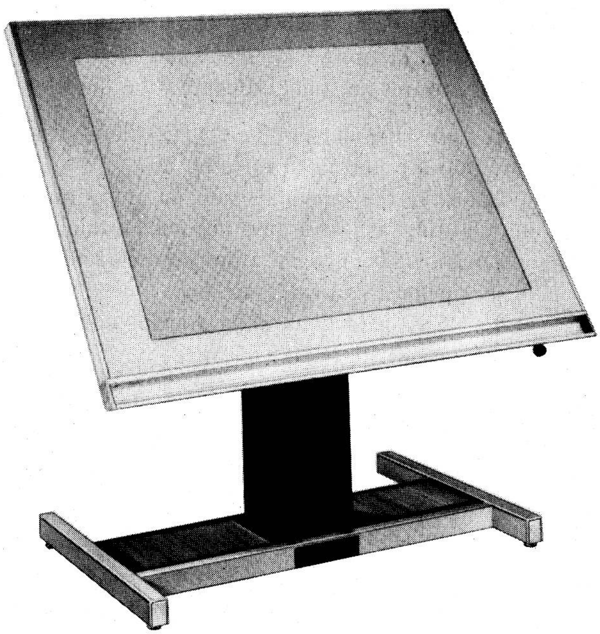


Figure 1-1 Light table. (Courtesy of Hamilton Industries.)

Figure 1-2 Drafting attache Case. (Courtesy of The Uteley Co., Inc.) (*a*) T-square; (*b*) erasing shield; (*c*) instrument case; (*d*) triangular scale; (*e*) dust brush; (*f*) sandpaper block; (*g*) drafting tape; (*h*) Ames Lettering Guide; (*i*) French curve; (*j*) protractor; (*k*) circle template.

1-2 T-Squares and Triangles

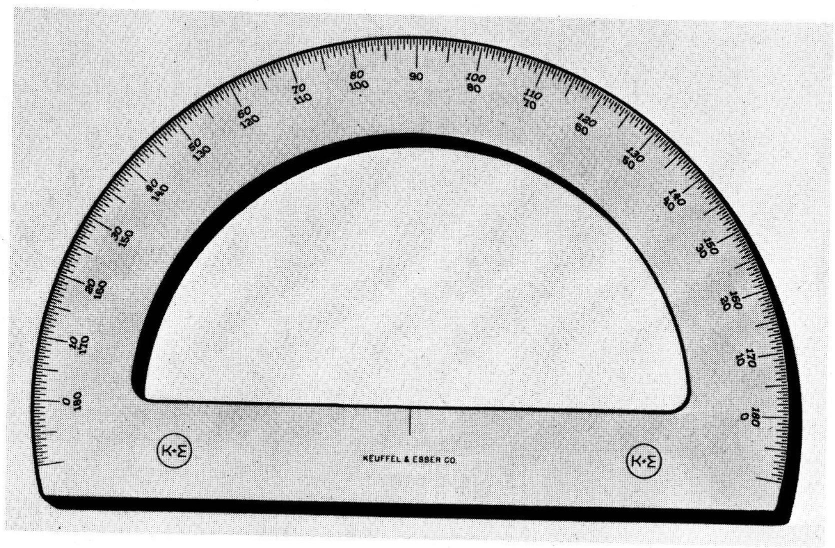
The purpose of a *T-square* is to draw *horizontal* and *parallel* lines. The T-square, in conjunction with drafting *triangles,* is used to draw *vertical* lines in a fundamental drafting procedure called *orthographic* or multiview projections (Fig. 1-11). A clear plastic straightedge may be bonded to the blade providing a convenient "see-through" edge (Fig. 1-2).

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 straightedge results in drawing a discontinuous line.

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.

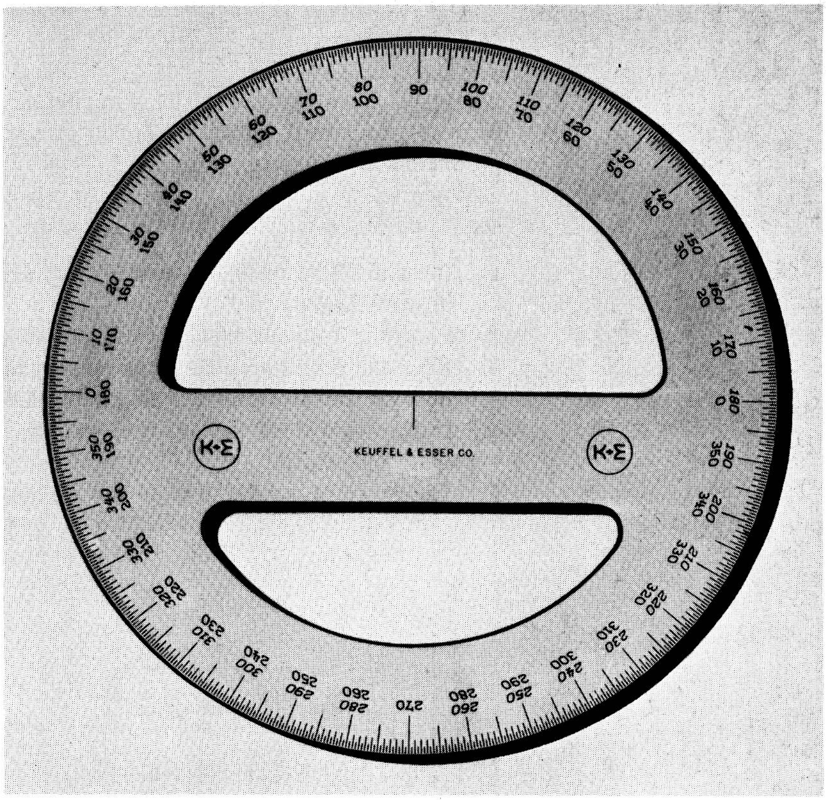
A 30 to 60° and a 45° *right-angled triangle* are needed if the drafter does not use a drafting machine (Fig. 1-5). Conventional triangles permit the accurate drafting of 30°, 45°, and 60° angles with respect to the horizontal or T-square blade. Using both the 45° and 30 to 60° triangles permits the drafter 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" conve-

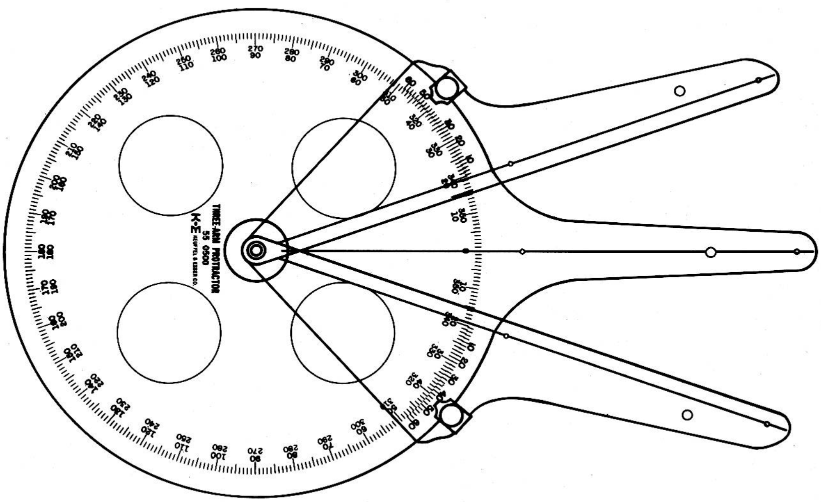


(*a*) 180° protractor

Figure 1-3 Protractors. [Courtesy of Keuffel & Esser (a KRATOS Company), Morristown, New Jersey.]



(*b*) 360° protractor



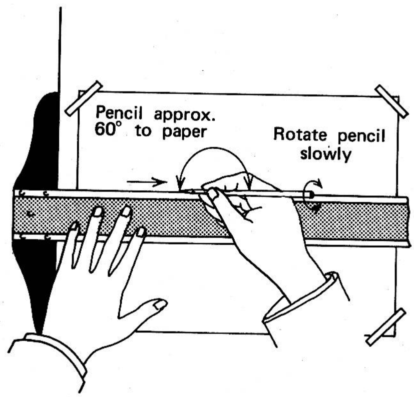
(*c*) three-arm protractor

Figure 1-3 (*continued*)

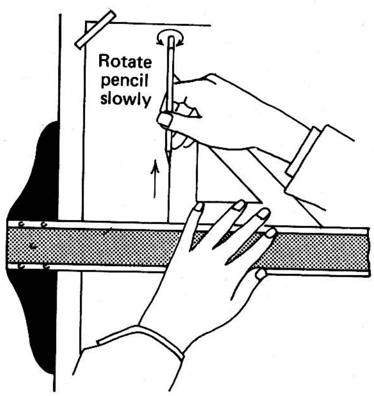
nience. The protractor is a flat semicircular or circular device engraved in degrees from zero through 180° or 360°, respectively. Three different types of protractors are shown in Figure 1-3.

When using either the T-square or triangles, several basic precautions should be observed. To draw a horizontal line (Fig. 1-4*a*):

1. Press the head of the T-square firmly against the referenced edge of the drawing board.
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,



(*a*) Drawing a horizontal line



(*b*) Drawing a vertical line

Figure 1-4 Pencil techniques.

since the blade and drawing may become soiled. This is particularly important when drawing inked lines.

To draw either vertical or inclined lines (Fig. 1-4*b*):

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 drafter; the pencil may be leaned slightly in the direction of motion.
3. When a line is to be drawn between two points, the pencil is placed vertically at one of the points. A straightedge 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 nonhorizontal 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 protractor degree dial at the lower left may be adjusted to a fraction of a degree. The vertical straight edge 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 1.5 in. (4cm) from the end, with about $\frac{3}{8}$ in. (10 mm) of uncut lead exposed. The lead may be shaped