普通高等教育“十一五”国家级规划教材

双语教学版

Fundamentals of Engineering Drawing

工程制图基础

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夏 红 王建宏 副主编

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内 容 提 要

本教材是为配合大专院校工科基础课程——工程制图的双语教学而编写的。在不改变我国工程制图现有课程体系并遵照我国技术制图国家标准的前提下，参考国外同类教材，采用双语编写而成。其内容包括：制图的基础知识；点、直线和平面的投影；基本立体及表面交线；组合体；物体的表达；螺纹及螺纹连接件；零件图及装配图简介等，共10章。本书可供本科工科各专业教学用，也可供成人高校及网络远程教育教学使用。

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序

1. 课程的性质、任务和学习方法

图样和文字、数字一样，也是人类用以表达、构思、分析和交流思想的工具。在工程技术中，为了准确地表示出物体的形状、大小、材料等内容，通常将物体按一定的投影方法和技术规定表达在图纸上，称之为工程图样，简称工程图。工程图在工程技术上的应用非常广泛。无论是制造产品还是建造房屋，都必须先画出工程图，然后根据图纸加工或修建，才能得到预想的结果。因此，工程图被喻为工程语言。

本课程研究绘制和阅读工程图的原理和方法，培养学生的形象思维能力和空间思维能力，是一门既有系统理论又有较强实践性的技术基础课。近年来，计算机绘图突飞猛进，大大提高了绘图速度和质量，但是在应用计算机绘图之前，还必须掌握绘制工程图样的基本原理和方法。所以绘制和阅读工程图样的能力是工程技术人员必须具备的最基本的能力。

本课程的任务是：

1）学习正投影法的基本原理和应用。

2）培养对三维形状与相关位置的空间逻辑思维能力和形象思维能力。

3）熟悉技术制图国家标准的有关规定，并学会查阅有关手册和相关的国家标准。

4）培养绘制和阅读机械图样的能力。培养耐心细致的工作作风和严肃认真的工作态度。

在学习本课程时应注意以下几点：

1）学习掌握正投影的基本原理及其应用时，应该坚持理论联系实际的学风，要认真学习投影原理。在理解基本概念、掌握正确作图方法的基础上，由浅入深地通过一系列的绘图和读图实践，不断地由物绘图，由图想物，分析和想象空间物体和图纸上图形之间的对应关系。以养成自觉地应用作图手段来构思、分析和表达工程问题的习惯。

2）绘图时，必须遵守技术制图国家标准。在不断地绘图实践中养成自觉遵守国家标准的习惯。因为只有符合“国家标准”的图样才能相互交流。

3）正确使用绘图工具和绘图仪器。所绘图样应该做到：投影正确、图线分明、尺寸齐全、字体工整、图面整洁。

要注意培养自学能力，要循序渐进地认真阅读课本，逐渐养成英文思考的习惯。

2. 对教材的几点说明

本教材及配套习题集是为配合大专院校工科基础课程——工程制图课程的双语教学，在不改变我国工程制图现有课程体系并遵照我国技术制图国家标准的前提下，参考美国俄亥俄州立大学工程制图教授 THOMAS E. FRENCH 主编的教材《Engineering Drawing and Graphic Technology》和华盛顿大学机械工程教授 E. G. PARE 主编的教材《Descriptive Geometry》，用双语（主要用英文，个别不常见单词采用汉语注释）编写的工程制图教材。书中采用的几乎都是常见词汇，在写法上也尽量做到浅显易懂。内容包括：制图的基础知识；点、直

线和平面的投影;基本立体及表面交线;组合体;物体的表达;螺纹及螺纹连接件、键、销、垫圈及齿轮;零件图及装配图简介等,共10章,可供本科工科各专业学生使用,也可供成人高校学生及网络远程教育学生使用。编写这套双语教材的目的是让学生在学习工程制图基础知识的同时,获得英语实践的机会,使学生把多年所学的英文作为工具来学习其他知识;同时,提高学习英文的兴趣,为今后进一步的学习和研究打下基础。

本书及习题集中的工程制图知识符合教育部2000年批准的《画法几何及工程制图课程教学基本要求》及《工程制图基础课程教学基本要求》。本教材和习题集所采用的技术制图国家标准符合国家质量技术监督局最新颁布的中华人民共和国国家标准。

本书第1章、4章、10章及附录由张庆伟编写;第2章由夏红编写;第3、5、7章由王建宏编写;第6章由朱小飞编写;第8章由薛寒松编写;第9章由易于编写;全书由张庆伟统稿和修改。重庆大学机械学院宋主民教授担任本教材的主审。重庆邮电大学外国语学院龚银玲老师担任英文指导并参与修改。

本书及配套习题集已入选了普通高等教育"十一五"国家级规划教材。在本书的编写过程中,得到重庆大学机械工程学院刘昌明教授、何玉林教授、丁一教授的指导和支持,同时还得到重庆大学国家工科机械基础课程教学基地杨学元、王喜庆老师的支持,在此一并表示感谢。

在本书的出版过程中得到了重庆大学出版社编辑刘秀娟、刘丽萍的大力支持,在此深表感谢。

本书获重庆大学教材建设基金资助。

最后,竭诚欢迎广大读者对本书提出宝贵的意见和建议。

编　者

2007年8月

Contents

Chapter 1 Basic Skills of Engineering Drawing

A new machine, or product must exist in the mind of the engineer or designer before it becomes a reality. This original concept or idea is usually placed on paper called drawing paper to form engineering drawing. The engineers or designers can communicate each other with the engineering drawing. So, the engineering drawing is often compared to a working language.

Since drawing instruments are indispensable tools in making engineering drawings, this chapter will introduce some basic instruments used by engineers and drafters, and discuss the way to use them. Again, the Chinese National Standards of Technical Drawing are briefly introduced in the chapter. Lastly, some of geometric constructions are also brought in.

1.1 Drawing Instruments

1.1.1 Drawing pencils

A good drawing begins with a proper drawing pencil and its correct use. Pencil grade ranges from the hardest, 9H, to the softest, 7B. Grade H, HB and B are most frequently used because of their medium hardness. The choice of the proper drawing pencils depends on personal preference and the drawing paper used. Recently, mechanical pencils (自动铅笔) become popular. Leads in a mechanical pencil do not need sharpening but provide a uniform line.

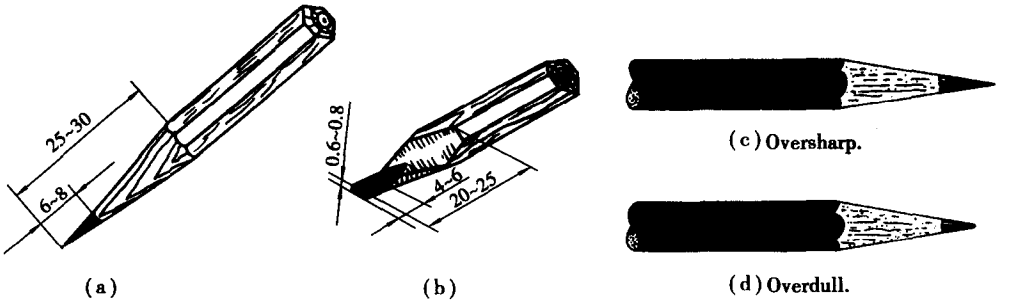

Fig. 1.1 Sharpen drawing pencils correctly.

If a wooden pencil is chosen, the procedure of sharpening it is as follows. First sharpen about 25 to 30 mm of the wood with a knife. Meanwhile, expose the lead about 6 to 8 mm. Note that the mark grade H or HB at the end of the pencil can not be sharpened. Second, a sandpaper is used to achieve the desired pencil point (笔尖) as shown in Fig. 1.1(a). You must exercise carefully in sharpening pencil point. Oversharp point may be broken or cut into the drawing paper easily (Fig. 1.1(c)). Conversely, overdull point, as shown in Fig. 1.1 (d), will create fuzzy (模糊的) and inconsistent lines (不连续的线). The drawing pencil sharpened as shown in Figs.

1.1 (a) is used to draw thin line while the drawing pencil sharpened as shown in Fig. 1.1 (b) is used to brighten (加粗) thin line to form thick line.

1.1.2 Pencil eraser

A good eraser is necessary for removing the marks on paper quickly without smudging (污渍).

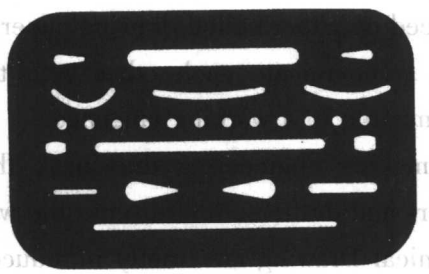

Fig. 1.2 Erasing shield.

1.1.3 Erasing shield (擦图片)

It is helpful to have an erasing shield similar to the type as shown in Fig. 1.2. The erasing shield will allow selective erasing without removing the drawings nearby. This can save time and enhance the quality of appearance of finished drawing.

1.1.4 Triangles (三角板)

Most inclined lines in engineering drawing are drawn with the 45° triangle and the 30° ~ 60° triangle (Fig. 1.3). The triangles are made of transparent plastic (透明的塑料) so that lines of the drawing can be seen through them. With the help of a pair of triangles it is easy to generate lines parallel or perpendicular to a given line (Figs. 1.4 and 1.5).

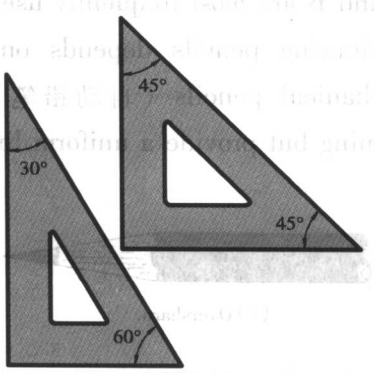

Fig. 1.3 Triangle.

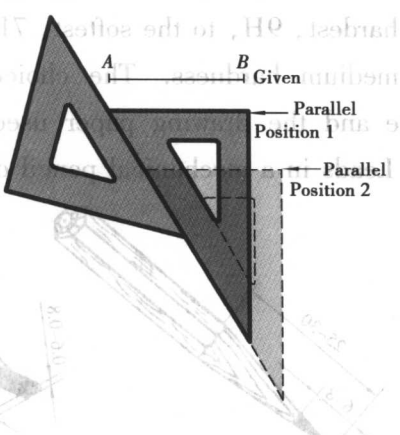

Fig. 1.4 Parallel line construction

Fig. 1.4 illustrates how to draw a line parallel to the given line *AB*. One side of a triangle is placed along the given line *AB* first and then the supporting triangle is fixed against another side of the first triangle. Slide the first triangle along the supporting triangle to any position desired, and draw the parallel line.

Perpendicular lines may also be produced by the sliding triangle method. As shown in Fig. 1.5, one perpendicular side of a triangle is placed along the given line *AB*, the supporting triangle is then fixed against the hypotenuse (斜边) of the first triangle. Slide the first triangle across line *AB* along the supporting triangle to any perpendicular position desired, and draw the perpendicular line.

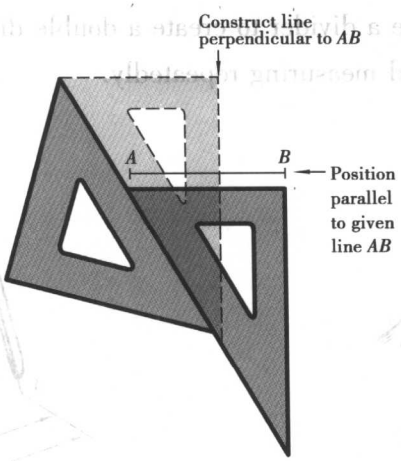

Fig. 1.5 Perpendicular line Construction.

1.1.5 Compass（圆规）

A compass is applied to draw circles and circular arcs（弧）(Fig. 1.6).

In order to obtain a high quality circle or circular arc, the lead of the compass must be properly sharpened and positioned correctly. A sharpening device such as a metal file（金属锉刀）or a sandpaper may be used to create the beveled side（斜面）of the lead as shown in Fig. 1.6 (a). The lead with beveled side is called compass lead（圆规芯）.

To draw a circle, (1) set off（截取）the required radius on one of the center lines, (2) place the needle point at the exact intersection of the center lines, (3) adjust the compass to the required radius, and (4) lean（倾斜）the compass forward and draw the circle clockwise while rotating the handle between the thumb and forefinger（食指）. To obtain a thick circle, it may be necessary to repeat the movement several times as shown in Fig. 1.6 (b).

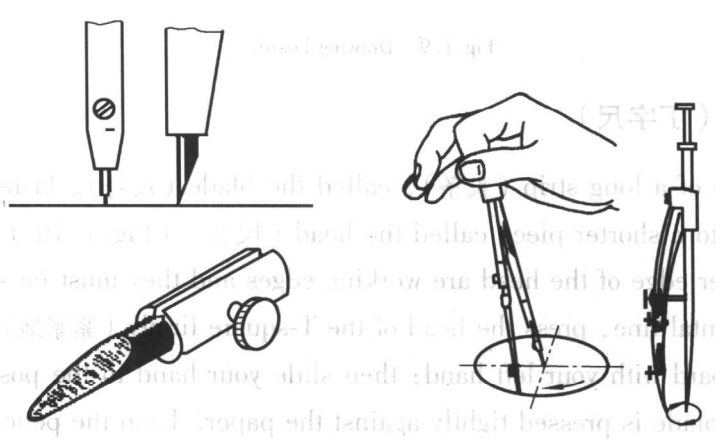

Fig. 1.6 Compass.

1.1.6 Divider（分规）

A divider is similar to a compass in construction. It is used for measuring distances from a ruler. It is also used for transferring distances or for setting off a series of equal distance (Fig. 1.7).

Fig. 1.8 illustrates how to use a divider to create a double distance simply by transferring the dimension measured, thus to avoid measuring repeatedly.

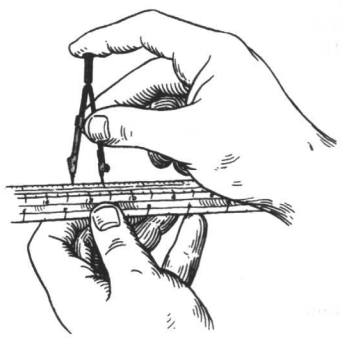

Fig. 1.7 Divider.

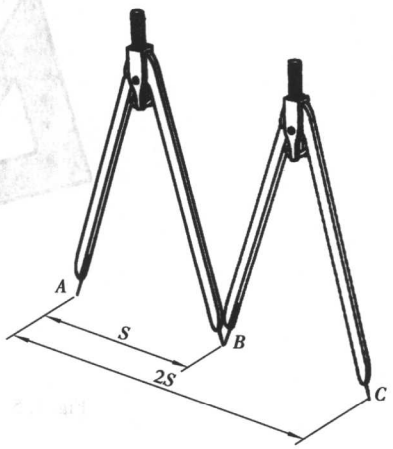

Fig. 1.8 Using divider.

1.1.7 Drawing board（图板）

A drawing board is made of wood on which the drawing paper is stuck（粘贴）. The drawing board for student is shown in Fig. 1.9. The left side edge of the drawing board is working edge and it must be straight and smooth.

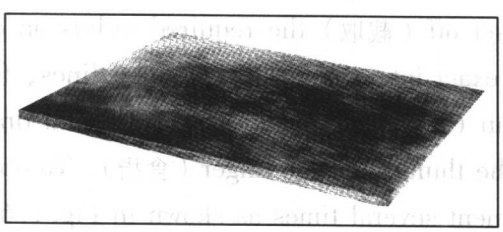

Fig. 1.9 Drawing board.

1.1.8 T-square（丁字尺）

T-square is made of a long strip（长条）, called the blade（尺身）, fastened rigidly（牢牢地固连）at right angles to a shorter piece called the head（尺头）（Fig. 1.10）. The upper edge of the blade and the inner edge of the head are working edges and they must be straight and smooth.

To draw a horizontal line, press the head of the T-square firmly（紧紧地）against the working edge of the drawing board with your left hand; then slide your hand to the position shown in Fig. 1.11（a）so that the blade is pressed tightly against the paper. Lean the pencil in the direction of the line at an angle of approximately 60° with the paper, and draw the line from left to right. Rotate the pencil about its axis while drawing so that its point will wear evenly（Fig. 1.11（b））.

To draw a vertical line, press the triangle on the T-square with the vertical edge on the left, as shown in Fig. 1.12. With the left hand, press the head of the T-square against the drawing board; then slide the hand to the position shown in Fig. 1.12 where the hand must holds both the T-square and the triangle firmly in position. Draw the line upward, rotating the pencil slowly

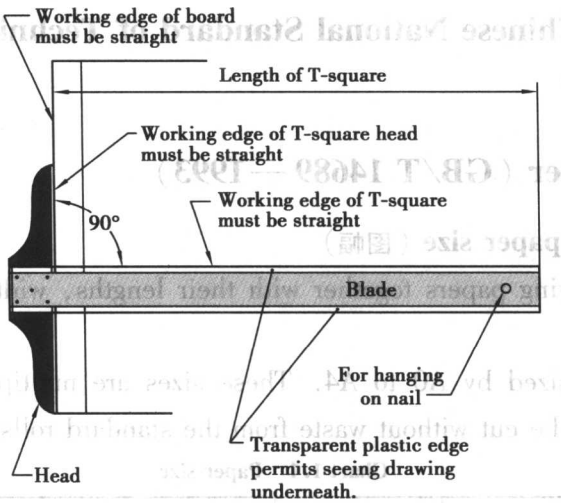

Fig. 1.10 T-square.

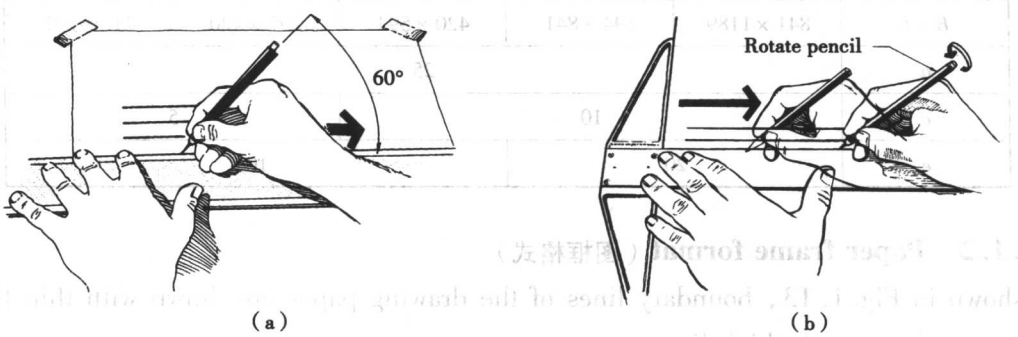

Fig. 1.11 Drawing a horizontal line.

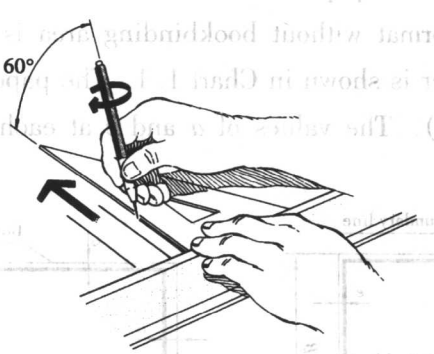

Fig. 1.12 Drawing a vertical line.

between the thumb and forefinger. Lean the pencil in the direction of the line at an angle of approximately 60° with the paper.

1.2 Provisions of Chinese National Standard of Technical Drawing (机械制图国家标准的规定)

1.2.1 Drawing paper (GB/T 14689—1993)

1.2.1.1 Drawing paper size (图幅)

The sizes of the drawing papers together with their lengths, widths and letter designations, are listed in Chart 1.1.

Drawing papers are sized by A0 to A4. These sizes are multiples of the standard size of 1188 ×841 and they can be cut without waste from the standard rolls of paper.

Chart 1.1 Paper size Unit (mm)

Format Code (幅面代号)	A0	A1	A2	A3	A4
$B \times L$	841 ×1189	594 ×841	420 ×594	297 ×420	210 ×297
a	25				
c	10			5	
e	20		10		

1.2.1.2 Paper frame format (图框格式)

As shown in Fig. 1.13, boundary lines of the drawing paper are drawn with thin line while frame lines are drawn with thick line.

Usually, there are two types of paper frames in use, i.e. without or with bookbinding (装订边) areas. The paper frame format without bookbinding area is shown in Fig. 1.13 (a). The value of e at each drawing paper is shown in Chart 1.1. The paper frame format with bookbinding area is shown in Fig. 1.13 (b). The values of a and c at each drawing paper are indicated in Chart 1.1.

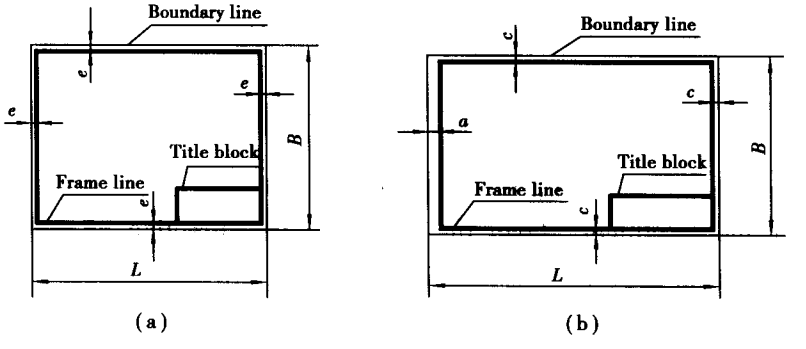

Fig. 1.13 Format of paper frame.

1.2.2 Title block (标题栏)

A title block is designed to show some information such as the name of the part, drawing scale, part material, part number, name of the drafter, name of the checker, name of the

company, date of drawing and so on.

The title block is usually placed at the right bottom corner of the drawing paper (Fig. 1.13). However, sometimes drawing paper may be rotated 90° counterclockwise to make the title block be located at the right top corner of the drawing paper (Fig. 1.14).

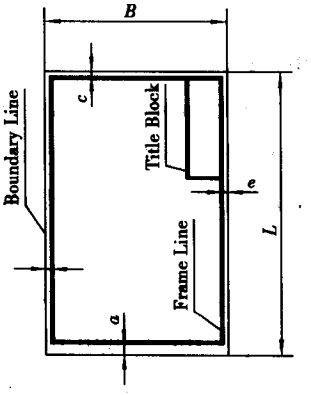

Fig. 1.14 Papers located vertically.

A typical title block is shown in Fig. 1.15 where all the words and digits should be written horizontally.

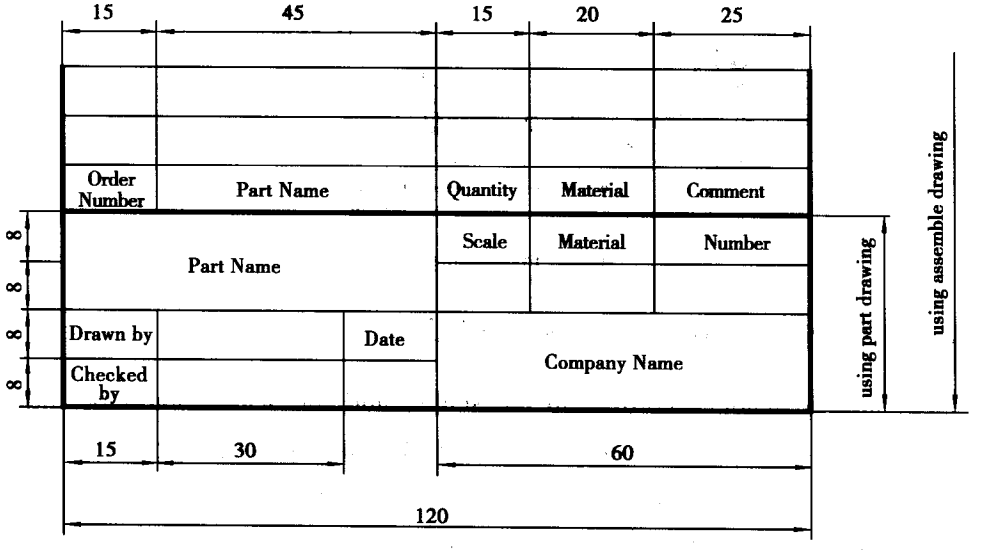

Fig. 1.15 Title block

1.2.3 Measurement units for engineering (工程计量单位)

1.2.3.1 Metric system (SI) of units

The International Standard Organization (国际标准化组织, ISO) recommends to adopt the metric system for length in engineering, and the international system of units is abbreviated (缩写) to SI.

In the SI units, the meter is defined as a length equal to the distance traveled by light of a certain wavelength in a

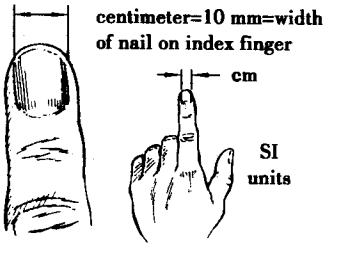

Fig. 1.16 The centimeter.

vacuum during a time interval of 1/299,792,458 second. In life, the nail width of your index finger (食指) is approximately equal to 1 centimeter, or 10 millimeters.

Besides, in engineering drawing, the units of all the dimensions are in millimeter (mm) which is one-thousandth of a meter, and its unit "mm" is generally omitted. For example, "25" means "25 mm".

1.2.3.2 English system of units

The English (Imperial 英帝国的) system of units is based on arbitrary units of inch, foot, cubit (腕尺), yard, and mile. England has set up a more accurate determination of the yard, which was legally defined in 1842 by act (法令) of Parliament (国会). A foot is 1/3 yard, and an inch is 1/36 yard.

In old England, an inch was defined as the width of a thumb or three barley corns (三棵麦粒), round and dry, and a foot was simply the length of a man's foot and so on (Fig. 1.17).

Conversion of two units is as follows: 1 meter = 39.37 inch, 1 inch = 25.4 mm

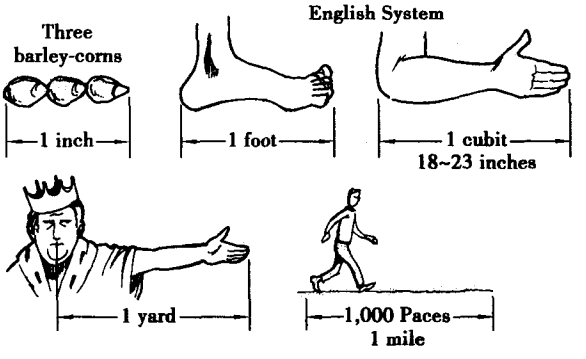

Fig. 1.17 English units.

1.2.4 Scales (比例) (GB/T 14690—1993)

Drawings should be made according to the scale, and the scale should be indicated in the title block. Large objects may be drawn smaller than life size (真实尺寸) while small objects may be drawn larger than life size. The ratio of drawn size to life size is the scale. Scales may be classified into original value scale (原值比例), enlarged scale (放大比例) and reduction scale (缩小比例) as shown in Chart 1.2. The scales in ( ) are second series and they are spare (备用) scales.

Chart 1.2 Scales

Kinds	Scale
original value scale	1:1
enlarged scale	2:1(2.5:1)(4:1) 5:1 1×10^n:1 2×10^n:1 5×10^n:1
reduction scale	(1:1.5)1:2(1:2.5)(1:3) (1:4) 1:5 $1:2\times10^n$ $1:5\times10^n$

1.2.5 Characters (字体) (GB/T 14691—1993)

1.2.5.1 Height and number of a character (字高和字号)

Chinese National Standard of Technical Drawing stipulates that the height of a character may be 1.8, 2.5, 3.5, 5, 7, 10, 14 and 20 (unit: mm). Small letter (小写字母) *h* is used to assign the height of a character. The height of a character is defined as the number of the character. For example, the character of No. 3.5 means 3.5 mm in height.

1.2.5.2 Chinese characters (汉字)

In general, Chinese characters are square written symbols. In engineering drawing, Chinese characters are written in font of "长仿宋体" (Fig. 1.18). If small letter h stands for the height of a Chinese character, its width is 0.7 h. As mentioned above, the Chinese character of No. 10 also means 10 mm in height.

No.10 字体工整笔画清楚间隔均匀排列整齐

No.7 横平竖直注意起落结构均匀填满方格

No.5 技术制图机械电子汽车航空船舶土木建筑矿山井坑满口纺织服装

No.3.5 螺纹齿轮端子接线飞行指导驾驶舱位挖填施工引水通风闸阀拥麻化纤

Fig. 1.18 Chinese characters in font of "长仿宋体".

Basic stroke in Chinese characters are point (点), horizontal stroke (横), vertical stroke (竖), left-falling (撇), right-falling (捺), rising stroke (挑), turning stroke (折) and hook stroke (钩). The witten orders are shown in Chart 1.3.

Chart 1.3 Basic stroke in Chinese characters and the witten orders

名字	点	横	竖	撇	捺	挑	折	钩
基本笔划及运笔法	尖点 垂点 撇点 上挑点	平横 斜横	竖	平撇 斜撇 直撇	斜捺 平捺	平挑 斜挑	竖折 横折 撇点 横折折撇	竖钩 弯钩 右曲钩 平钩 竖弯钩 横折钩 横折弯钩 竖折折钩
举例	方光 心活	左七 下代	十 上	千月 八床	术分 建超	均公 技线	凹 周 安 及	牙 子 代 买 孔 力 气 码

1.2.5.3 Letters and numbers (字母和数字)

Letters and numbers may be written in italic (斜体) or vertical (直体). Italics are frequently applied in engineering drawing. Italic numbers are shown in Fig. 1.19; italic capitals in Fig. 1.20; italic small letters in Fig. 1.21; italic Grecian (希腊的) letters in Fig. 1.22 and Roman numerals in Fig. 1.23.

Fig. 1.19 Italic numbers.

Fig. 1.20 Italic capitals.

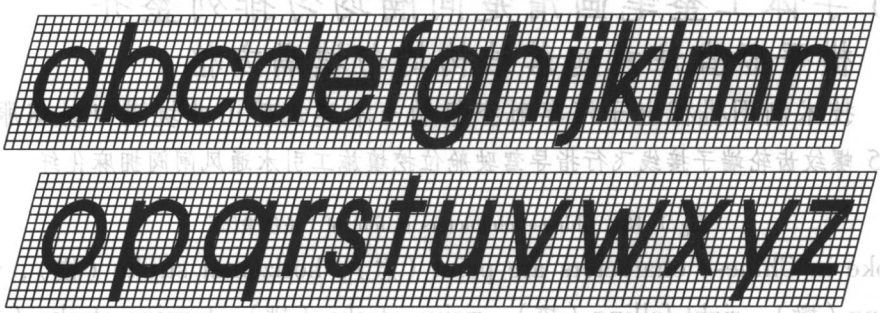

Fig. 1.21 Italic small letters.

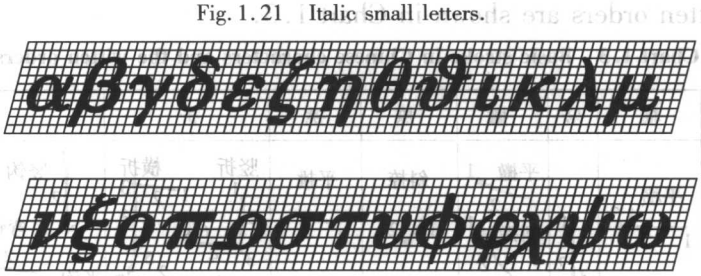

Fig. 1.22 Italic Grecian letters.

Fig. 1.23 Italic Roman numerals.

1.2.6 Drawing lines (图线) (GB/T1 7450—1998)

Each line on an engineering drawing has a definite meaning and is drawn in a certain way. Chart 1.4 shows various lines required in the engineering drawing.