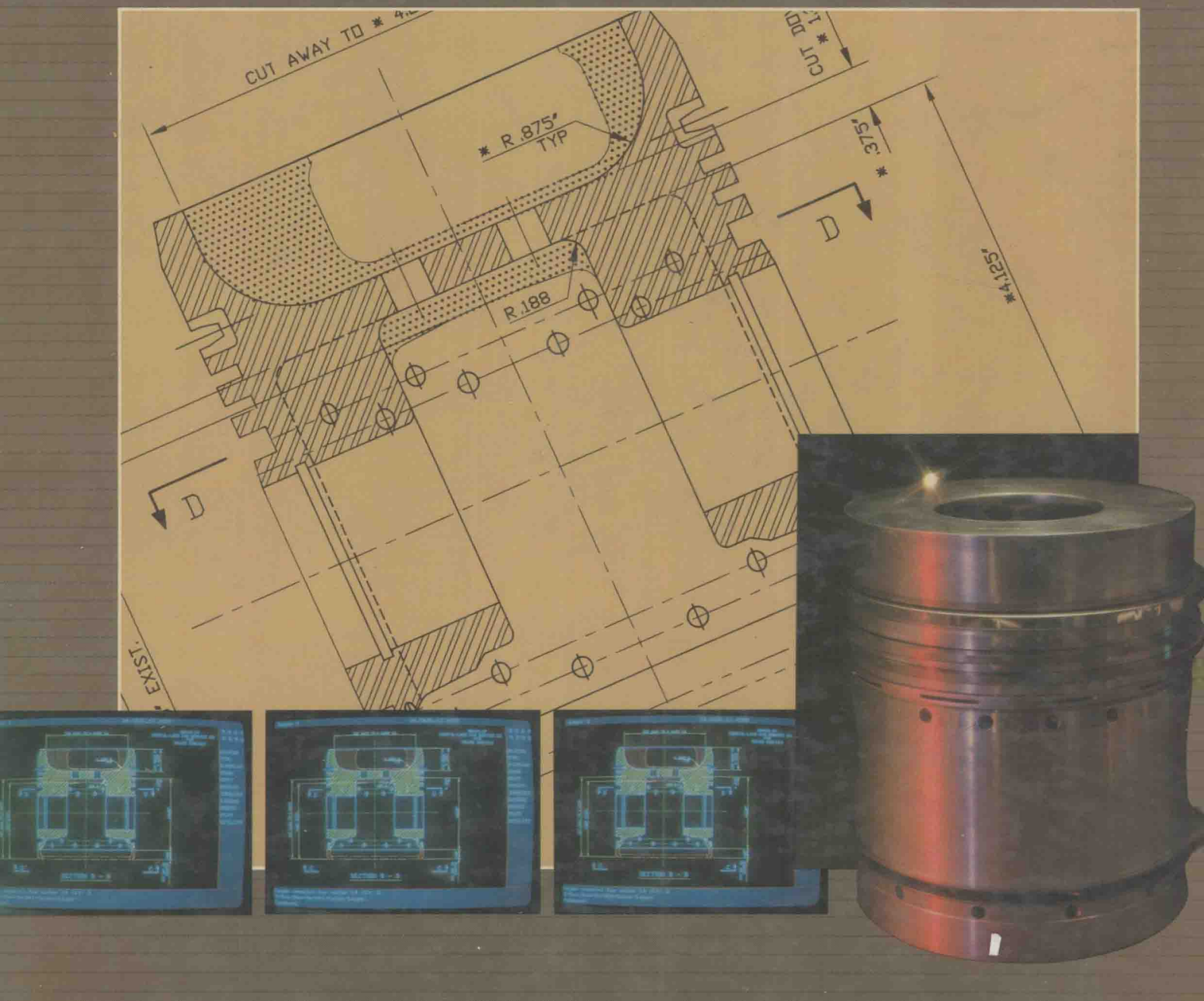
MECHANICAL DRAFTING

David A. Madsen • Terence M. Shumaker • Susan A. Stewart



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Preface

MECHANICAL Drafting is a practical, in-depth textbook that is easy to use and understand. The mechanical drafting concepts provide the core for further learning in other fields of drafting. The content may be used as presented, following a logical sequence of learning activities, or the chapters may be rearranged to accommodate alternate formats for traditional or individualized instruction. Students will need no other reference.

PREREQUISITES

An interest in drafting plus basic arithmetic, written communication, and reading skills are the only prerequisites for this in-depth study of mechanical drafting.

MAJOR FEATURES

Mechanical Drafting provides a practical approach to drafting as related to the *American National Standards Institute (ANSI)* standards with some comparison to *Military (MIL)* standards and common alternates that may be found in traditional industrial standards. One excellent and necessary foundation to drafting training and the implementation of a common approach to drafting nationwide is the emphasis of standardization at all levels of drafting instruction. When students become professional drafters, this text will go along as a valuable desk reference.

Each chapter provides *realistic examples, illustrations, drafting problems, and related tests.* The examples will illustrate recommended drafting presentation based on ANSI standards with actual industrial drawings used for reinforcement. The correlated text will explain *drafting techniques* and provide *helpful hints* for skill development. *Step-by-step layout methods* will provide a logical approach to setting up and completing the drawings.

INDUSTRIAL APPROACH TO PROBLEM SOLVING

The drafter's responsibility is to convert the engineering sketch or instructions to formal drawings. This book explains how to prepare drawings from engineering sketches by providing the learner with the basic guides for drafting layout and arrangement in a knowledge-building format; one concept is learned thoroughly before the next is introduced. Problem assignments are presented in order of difficulty within each chapter and throughout the text. *The concepts and skills learned in one chapter will be used in subsequent chapters* so that by the end of the text the student will have the ability to solve drafting problems using a multitude of skills learned from previous activities. *The problems are presented as engineering sketches* in a manner consistent with industrial methods. There are no copy draw problems, though early problems provide suggested layout sketches. It is not enough for students to duplicate drawings from given assignments; they must be able to think through the process of drawing development. The goals and objectives of each problem assignment are consistent with recommended evaluation criteria based on the progression of learning activities. *The drafting problems and tests recommend that work be done using drafting skills on actual drafting materials with proper manual or computer drafting equipment.* A correct problem solution or test answer should be accurate and demonstrate proper drafting technique.

COMPUTER GRAPHICS

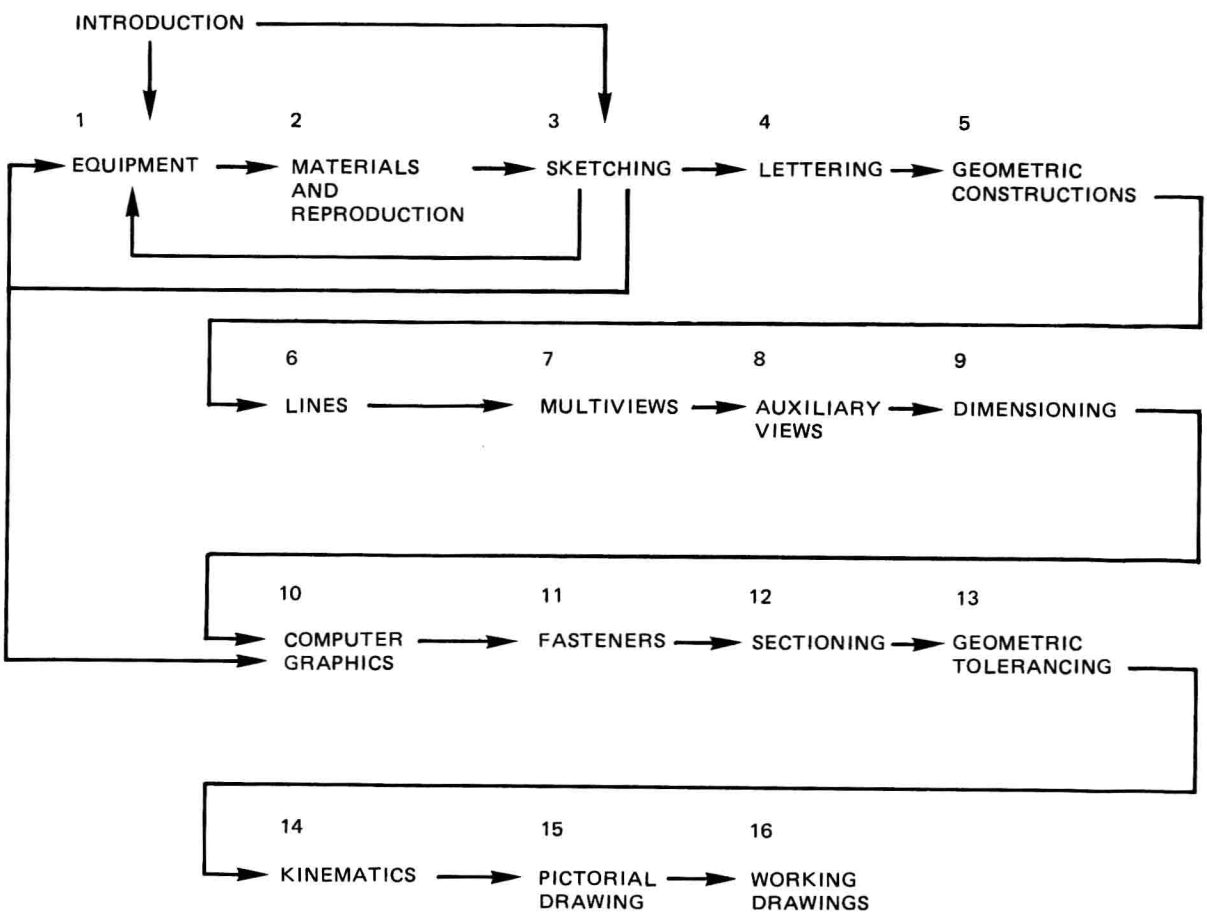
Computer graphics is here to stay and is therefore presented as a drafting tool throughout the text, both in general discussions and related to specific topics. Topics are presented where appropriate from the introduction through the last chapter, and with an in-depth study that is in sequence with recommended learning procedures. Computer drafting may be used as a drafting tool after manual skills are developed, in which case the main emphasis is presented after substantial drafting concepts are learned. An alternative is to study computer graphics early and use the computer as a tool to perform drafting tasks throughout the text.

COURSE PLAN

Mechanical drafting is often considered the core of drafting; it is the primary emphasis of many drafting curriculums and often the preliminary drafting instruction prior to expansion into other drafting fields. While the content of this text reflects the common elements in a drafting curriculum, there are several professional opinions on how the actual organization of chapters should be presented. Some chapters build on each other, while others may be used in alternate arrangements.

The diagram below indicates the interdependence of chapters in this text. The introduction to this text provides a detailed look at drafting as a profession, discussing drafting occupations, professional organizations, occupational levels, opportunities, and computers in drafting. Chapter 1, Equipment, covers manual and computer graphics equipment with actual instructions on equipment use. Chapters 2 through 5 may be presented as appropriate with individual curriculum guidelines. Chapters 6 through 9 are designed in a concept-building approach. Lines (Chapter 6) are the core of the graphic language. Learning development continues as students are introduced to multiviews and auxiliary views (Chapters 7 and 8). After a foundation of view layout has been built, students will begin placing dimensions on multiview drawings. Chapter 9, Dimensioning, provides a comprehensive coverage of general dimensioning practice as related to ANSI Y14.5M—1982. Dimensioning is presented in metric with a discussion of dual dimensioning concepts used in industry. This chapter also covers manufacturing processes and surface finishes.

Chapter 10, Computer Graphics, builds on the concepts discussed in Chapter 1, Equipment. It provides a detailed look at how computer graphics is used in industry today and what the trends are for tomorrow.



The learning objectives of previous chapters provide a basis for implementation of computer graphics as a tool that may be used on all drafting projects. The fundamentals of lines, multiviews, auxiliary views, and dimensioning are the same whether manual or computer drafting is used. The computer is presented as a tool; the drafting concepts are the same.

Chapters 11 (Fasteners), 12 (Sectioning), and 13 (Geometric Tolerancing) are presented in this order so that the learning concepts build in each chapter and from previous chapters. Chapter 14, Introduction to Kinematics, is an in-depth discussion of gears, cams, and linkages. Chapter 15, Pictorial Drawing, is a complete presentation of pictorial drawing, including isometric, oblique, perspective, and technical illustration. Curriculum guidelines may indicate an earlier use of this chapter. Chapter 16, Working Drawings, is a culmination of all previous chapters. The student will combine everything previously learned in the preparation of a complete set of working drawings. This chapter also includes the most complete explanation of engineering change documentation procedures found in any drafting text.

SECTION LENGTH

Chapters are presented in individual learning segments that begin with elementary concepts and build until each chapter provides complete coverage of each topic. Instructors may choose to present lectures in short fifteen minute discussions or divide each chapter into forty- to fifty-minute lectures.

APPLICATIONS

Special emphasis has been placed on providing realistic drafting problems. Drafting problems are presented as engineering sketches in a manner consistent with industry practices. Many of the problems have been supplied by industry. Each problem solution is based on the step-by-step layout procedures provided in the chapter discussions. Problems are given in order of complexity so that students may be exposed to a variety of drafting experiences. Early problems in each chapter often recommend the layout to help students save time. Advanced problems require the students to go through the same thinking process that a professional drafter is faced with daily, including scale and paper size selection, view layout, dimension placement, sectioning placement, and many other activities. Problems may be solved using manual or computer drafting as determined by the individual course guidelines. Chapter tests provide a complete coverage of each chapter and may be used for student evaluation or as study questions.

DRAFTING EQUIPMENT AND MATERIALS

Identification and use of manual and computer drafting equipment is given in Chapter 1. Students will need to have an inventory of equipment available for use as listed in this chapter. Professional drafting materials are explained in Chapter 2. It is recommended that students prepare problem solutions using actual drafting materials.

INSTRUCTOR'S GUIDE

The instructor's guide contains learning objectives, recommended course outlines, and problem and test solutions.

ACKNOWLEDGMENTS

I would like to express my deepest appreciation to my wife, Judy, and my family for their support during the long and seemingly endless development of this text. Also, a special thanks to my colleagues and coauthors: Terence M. Shumaker for his outstanding implementation of the computer graphics and pictorial drawing chapters and Susan L. Stewart for development of an excellent chapter on kinematics.

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TO THE STUDENT

This mechanical drafting text is designed for you, the student. The development and format presentation have been tested in actual conventional and individualized classroom instruction. The information presented is based on industrial standards, drafting room practice, and trends in the drafting industry. This text is the only drafting reference that you will need for mechanical drafting. Use it as a learning tool while in school and take it along as a desk reference when you enter the profession. The amount of written text is complete, but kept to a minimum. Examples and illustrations are used extensively. Drafting is a graphic language, and most drafting students learn best by observation of examples. Here are a few helpful hints:

1. *Read the text.* The text content is intentionally designed to make easy reading. It probably won't read the same as an exciting short story, but it does give the facts in as few, easy-to-understand words as possible. Don't pass up the reading, because the content will help you clearly understand the drawings.
2. *Look carefully at the examples.* The figure examples are presented in a manner consistent with drafting standards. In many situations common errors are shown next to accepted practice. Look at the examples carefully in an attempt to understand the intent of specific applications. If you can understand why something is done a certain way, it will be easier to implement the concepts on drawing problems and later in industry. Drafting is a precise technology based on rules and guidelines. The goal of a drafter is to prepare drawings that are easy to interpret. There will always be cases in which rules must be altered to handle a unique situation. This is when you will have to rely on judgment based on accepted standards. Drafting is often like a puzzle; there may be more than one way to solve a problem.
3. *Use the text as a reference.* Few drafters know everything about drafting standards, techniques, and concepts; so always be ready to use the reference if you need to verify how specific applications are handled. Become familiar with the use and definitions of technical terms. It will be difficult to memorize everything in this text, but after considerable use of the concepts mechanical drafting applications should become second nature.
4. *Learn each concept and skill before you continue to the next.* The text is presented in a logical learning sequence. Each chapter is designed for learning development, and chapters are sequenced so that drafting knowledge grows from one chapter to the next. Problem assignments are presented in the same learning sequence as the chapter content and also reflect progressive levels of difficulty.

5. *Practice.* Development of good manual and computer drafting skills depends to a large extent on practice. Some individuals have an inherent talent for manual drafting and some people are readily compatible with computers. If you fit into either group, great! If you don't, then practice may be all you need. Practice manual drafting skills to help improve the quality of the drafting presentation, and practice communicating and working with a computer. A good knowledge of drafting practice is not enough if the manual skills are not satisfactory. When the computer is used, however, most manual skills are not used.
6. *Use sketches.* When drawing manually or with a computer, the proper use of a sketch can save a lot of time in the long run. Prepare a layout sketch for each problem. This will give you a chance to organize thoughts about drawing scale, view selection, dimension and note placement, and paper size. After you become a drafting veteran you may be able to design sheet layout in your head, but until then you will be sorry if you don't use sketches.
7. *Use professional equipment and materials.* For the best possible learning results and skill development, use the professional drafting equipment, supplies, and materials that are recommended.

David A. Madsen

ABOUT THE AUTHOR

The principal author, David A. Madsen, is an experienced drafting educator and author. He holds baccalaureate and masters degrees from Oregon State University and has taught drafting for 15 years, first in high school and more recently in a community college. He also worked for Stanley Tools as a draftsman and designer. Other texts by David Madsen include *Basic Drafting, Geometric Dimensioning and Tolerancing, Civil Drafting Technology,* and *Architectural Drafting and Design,* which is being published simultaneously with *Mechanical Drafting.*

Contents

Introduction

DRAFTING TECHNOLOGY

According to the *Dictionary of Occupational Titles,* published by the U.S. Department of Labor, drafting is grouped with professional, technical, and managerial occupations. This category includes occupations concerned with the theoretical and practical aspects of such fields of human endeavor as architecture; engineering; mathematics; physical sciences; social sciences; medicine and health; education; museum, library, and archival sciences; law; theology; the arts; recreation; administrative specialties; and management. Also included are occupations in support of scientists and engineers and other specialized activities such as piloting aircraft, operating radios, and directing the course of ships. Most of these occupations require substantial educational preparation, usually at the college, junior college, or technical institute level.

Men and women employed in the drafting profession are often referred to as drafters. A general definition of drafter, as prepared by the Career Information System at the University of Oregon, is as follows:

> Drafters translate ideas and sketches of engineers, architects, and scientists into detailed drawings which are used in manufacturing and construction. Their duties may include interpreting directions given to them, making sketches, preparing drawings to scale, and specifying details. Drafters may also calculate the strength, quality, quantity, and cost of materials. They utilize various drafting tools, engineering practices, and math to complete drawings.

DRAFTING OCCUPATIONS

There are several types of drafting technology occupations. While drafting in general has one basic description, specific drafting areas have unique conceptual and skill characteristics. The types of drafting occupations fall into three general professional areas; architecture, engineering, and surveying. The following are specific drafting areas as defined by the *Dictionary of Occupational Titles.*

Architectural Drafter

Draws artistic architectural and structural features of any class of buildings and like structures. Delineates designs and details, using drawing instruments. Confirms compliance with building codes. May specialize in planning architectural details according to structural materials used. (See Figures I–1A and I–1B.)

Landscape Drafter

Prepares detailed scale drawings and tracings from rough sketches or other data provided by Landscape Architect. May prepare separate detailed site plan, grading and drainage plan, lighting plan, paving plan, irrigation plan, planting plan, and drawings and detail of garden structures. May build models of proposed landscape construction and prepare colored drawings for presentation to client. (See Figure I–2.)

Electrical Drafter

Prepares electrical-equipment working drawings and wiring diagrams used by construction crews and repairmen who erect, install, and repair electrical equipment and wiring in communications centers, power plants, industrial establishments, commercial or domestic buildings, or electrical distribution systems, performing duties described under Drafter. (See Figure I–3.)

Aeronautical Drafter

Specializes in preparing engineering drawings of developmental or production airplanes and missiles and ancillary equipment, including launch mechanisms and scale models of prototype aircraft, as planned by Aeronautical Engineer.

Electronic Drafter

Drafts wiring diagrams, schematics, and layout drawings used in manufacture, assembly, installation, and repair of electronic equipment, such as television cameras, radio transmitters and receivers, audioamplifiers, computers, and radiation detectors, performing duties as described under Drafter. Drafts layout and detail drawings of racks, panels, and enclosures. May conduct service and interference studies and prepare maps and charts related to radio and television surveys. May be designated according to equipment drafted. (See Figure I–4.)

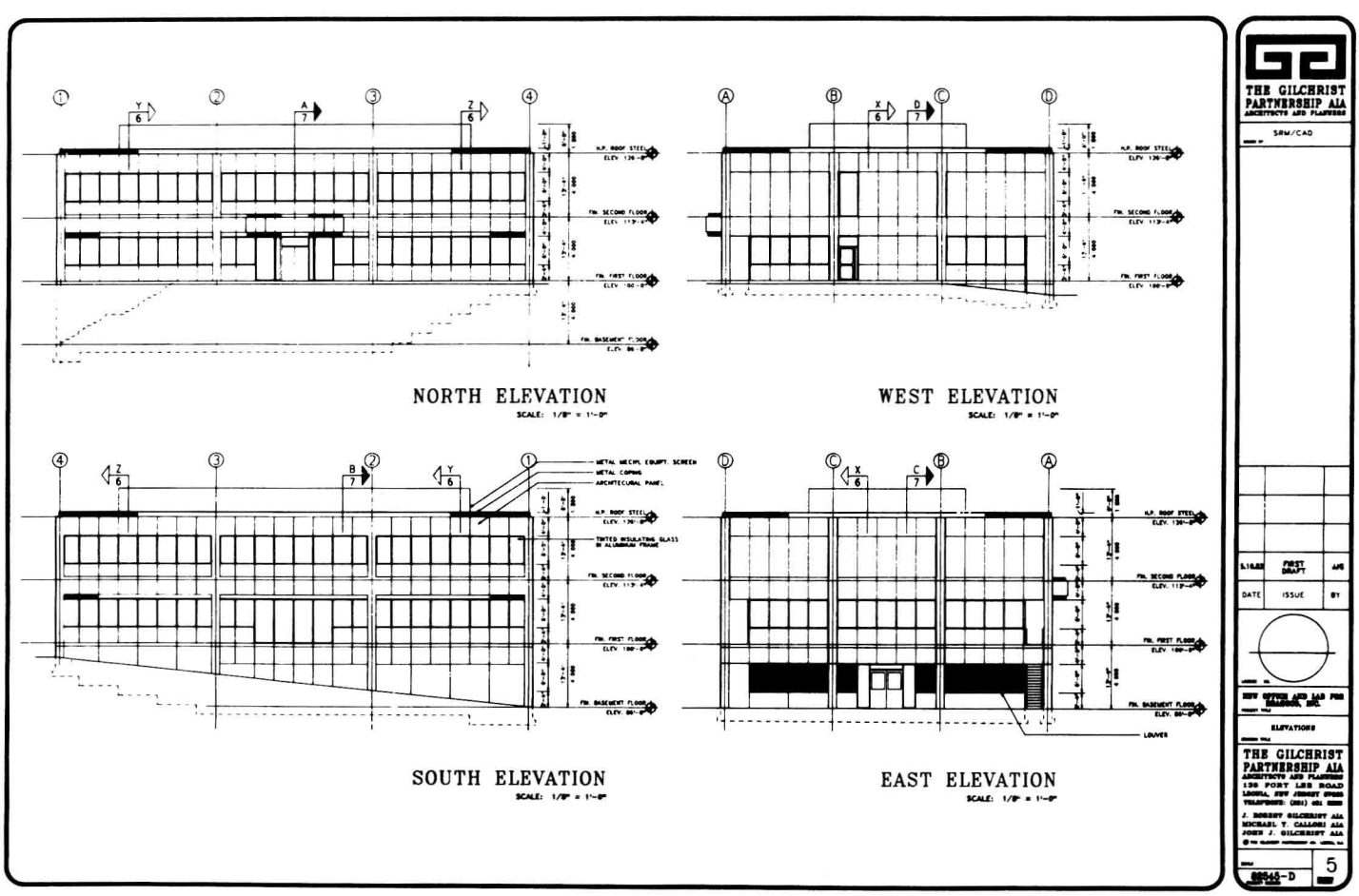

Figure I–1A Computer generated architectural elevations. *Courtesy Summagraphics Corporation.*

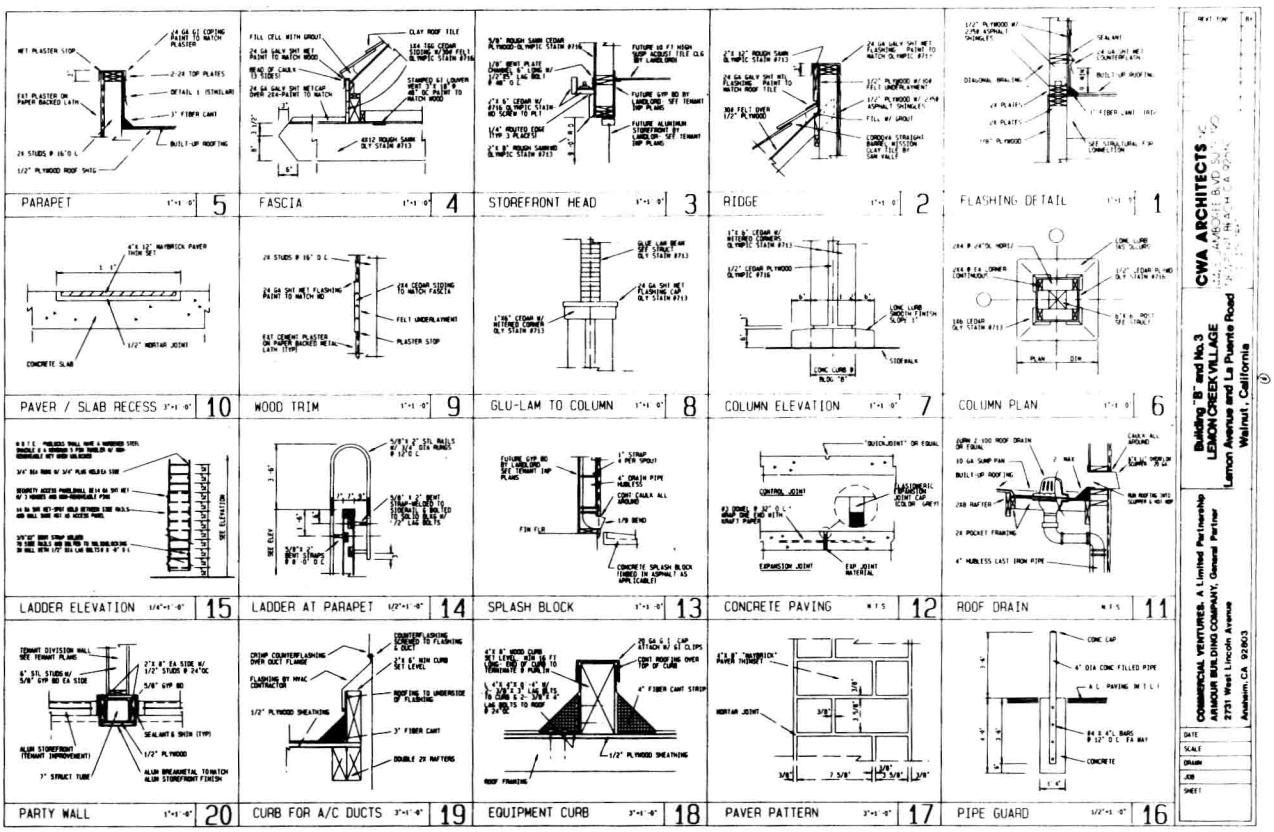

Figure I–1B Computer generated architectural details. *Courtesy T & W Systems, Inc., Huntington Beach, California*

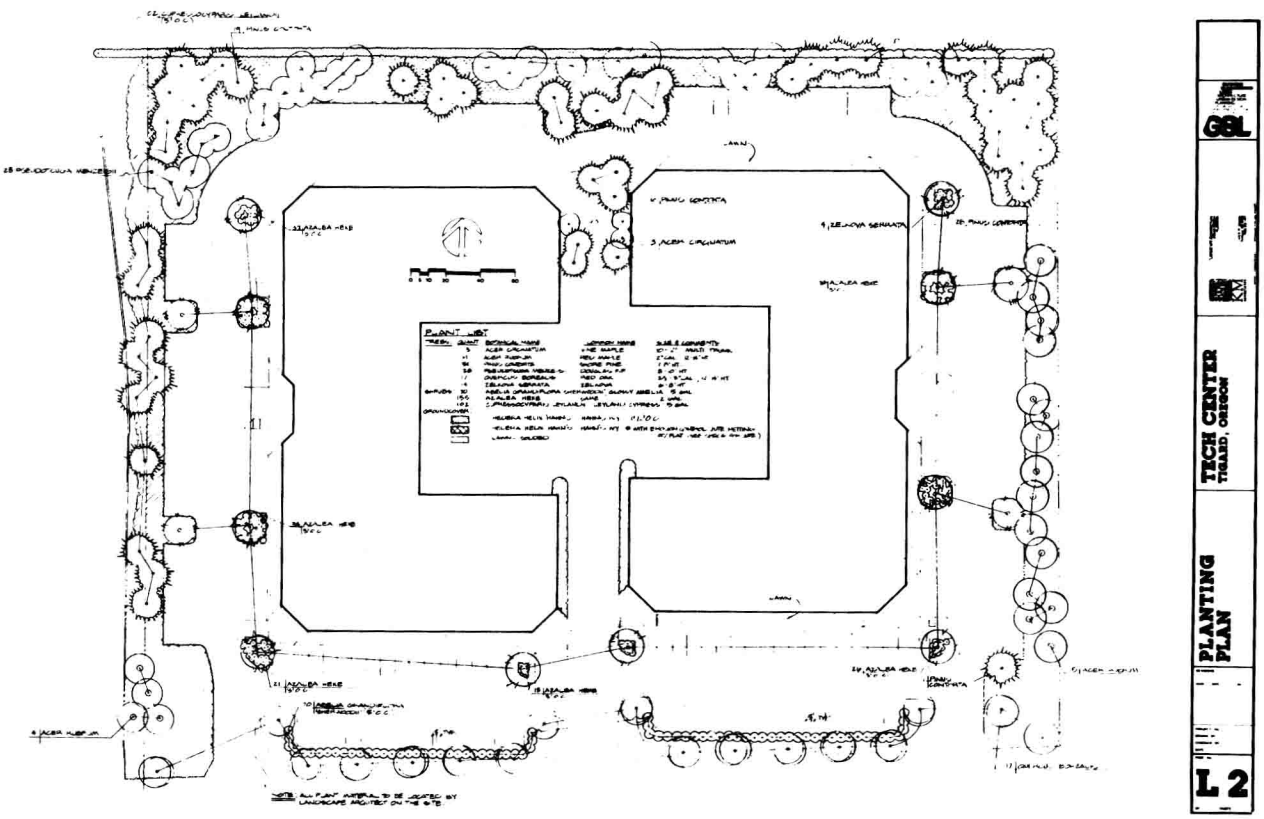

Figure I–2 Landscape plan. *Courtesy Guthrie, Slusarenko, Leeb Architecture Urban Design Planning; KM Associates Landscape Architecture.*

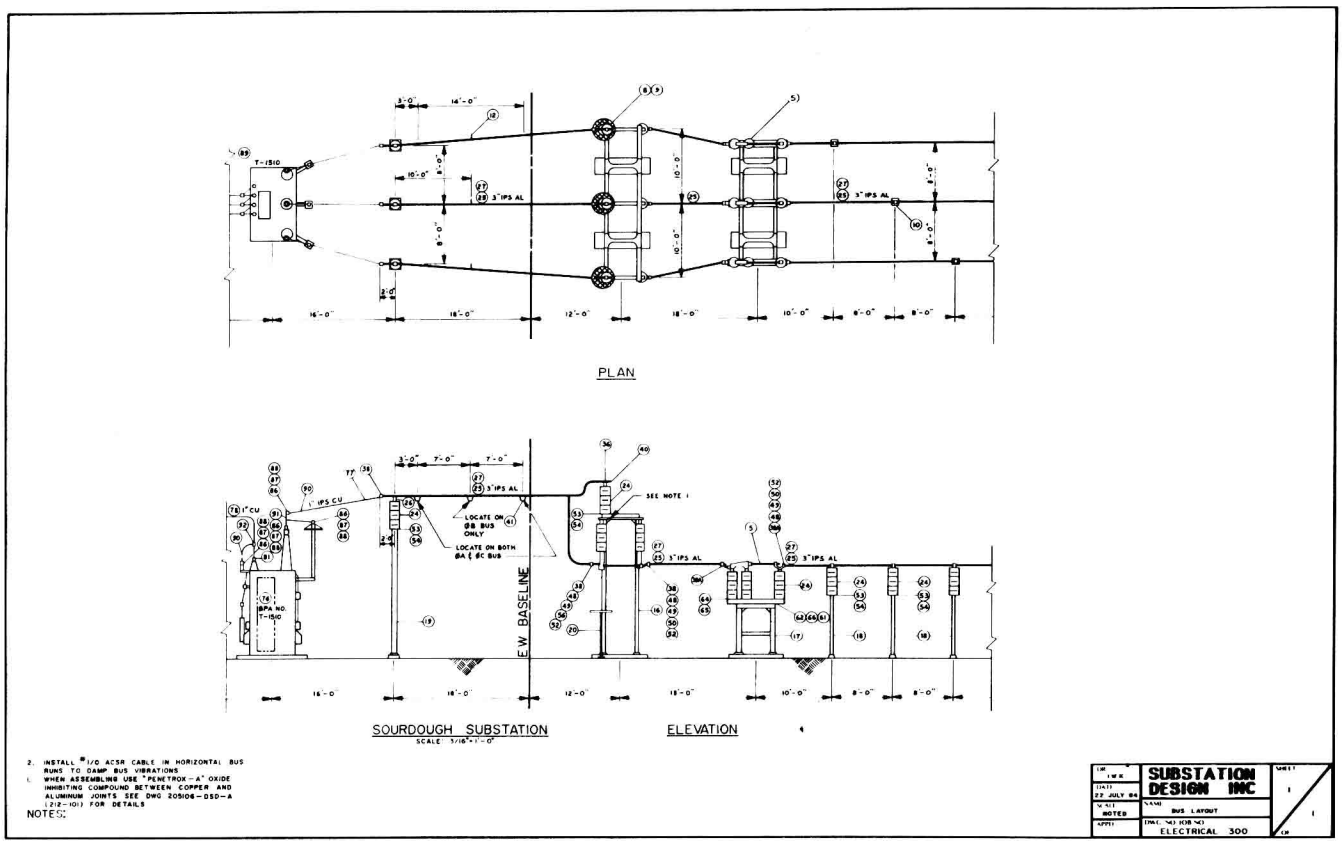

Figure I–3 Electrical drafting plan and elevation.

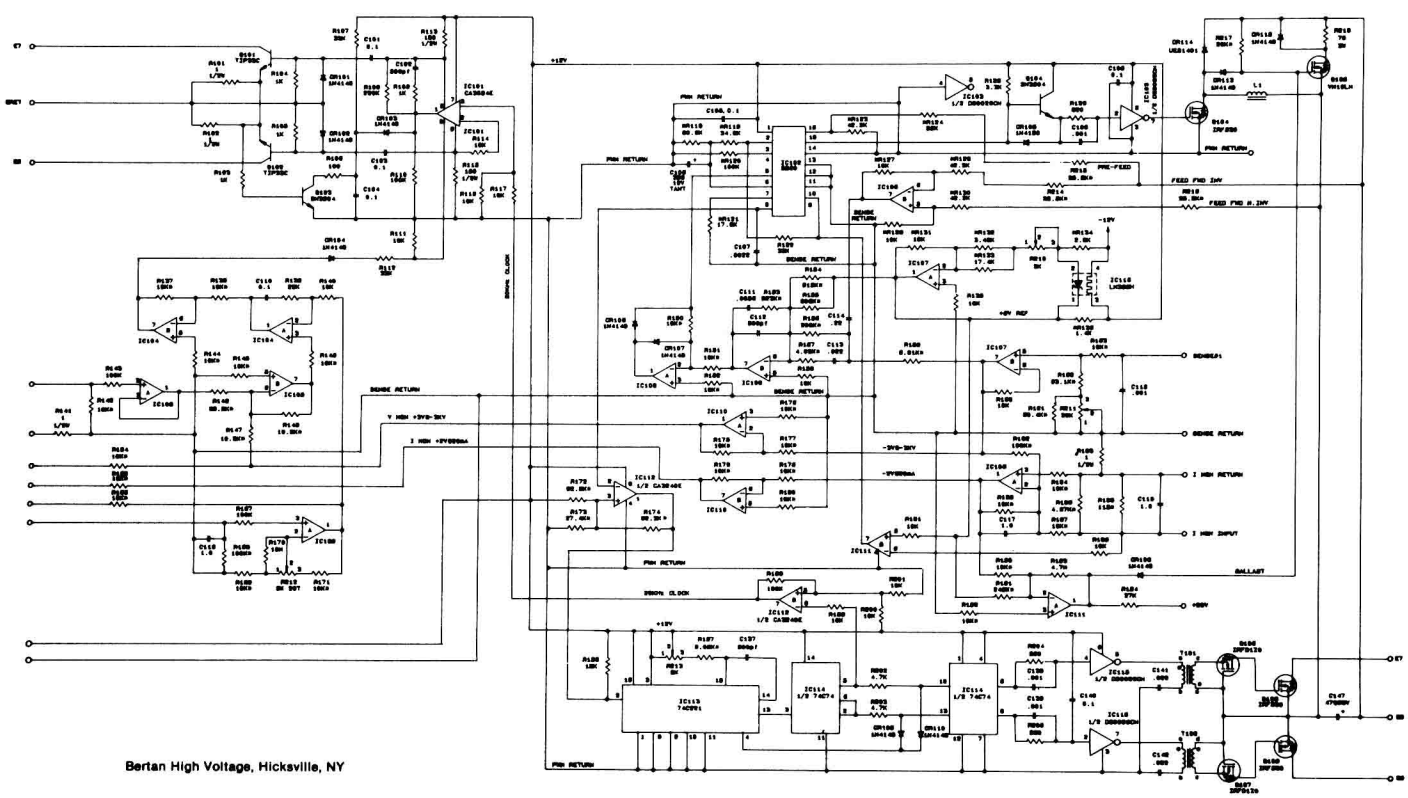

Figure I–4 Computer generated electronics schematic. *Courtesy T & W Systems, Inc., Huntington Beach, California*

Civil Drafter

This category is also known by the following titles: Drafter, Civil Engineering; Drafter, Construction; and Drafter, Engineering. Prepares detailed construction drawings, topographic profiles, and related maps and specification sheets used in planning and construction of highways, river and harbor improvements, flood control, drainage, and other civil engineering projects, performing duties as described under Drafter. Plots maps and charts showing profiles and cross-sections indicating relation of topographical contours and elevations to buildings, retaining walls, tunnels, overhead power lines and other structures. Drafts detailed drawings of structures and installations such as roads, culverts, fresh water supply and sewage disposal systems, dikes, wharfs, and breakwaters. Computes volume of excavations and fills and prepares graphs and hauling diagrams used in earthmoving operations. May accompany survey crew in field to locate grading markers or to collect data required for revision of construction drawings. May be designated according to type of construction. (See Figures I-5A and I-5B.)

Structural Drafter

Performs duties of Drafter by drawing plans and details for structures employing structural reinforcing steel, concrete masonry, wood, and other structural materials. Produces plans and details of foundations, building frame, floor and roof framing and other structural elements. (See Figures I-6A and I-6B.)

Castings Drafter

Drafts detailed drawings for castings which require special knowledge and attention to shrinkage allowances and such factors as minimum radii of fillets and rounds.

Patent Drafter

Drafts clear and accurate drawings of varied sorts of mechanical devices for use of Patent Lawyer in obtaining patent rights.

Tool Design Drafter

Drafts detailed drawing plans for manufacture of tools, usually following designs and specifications indicated by Tool Designer.

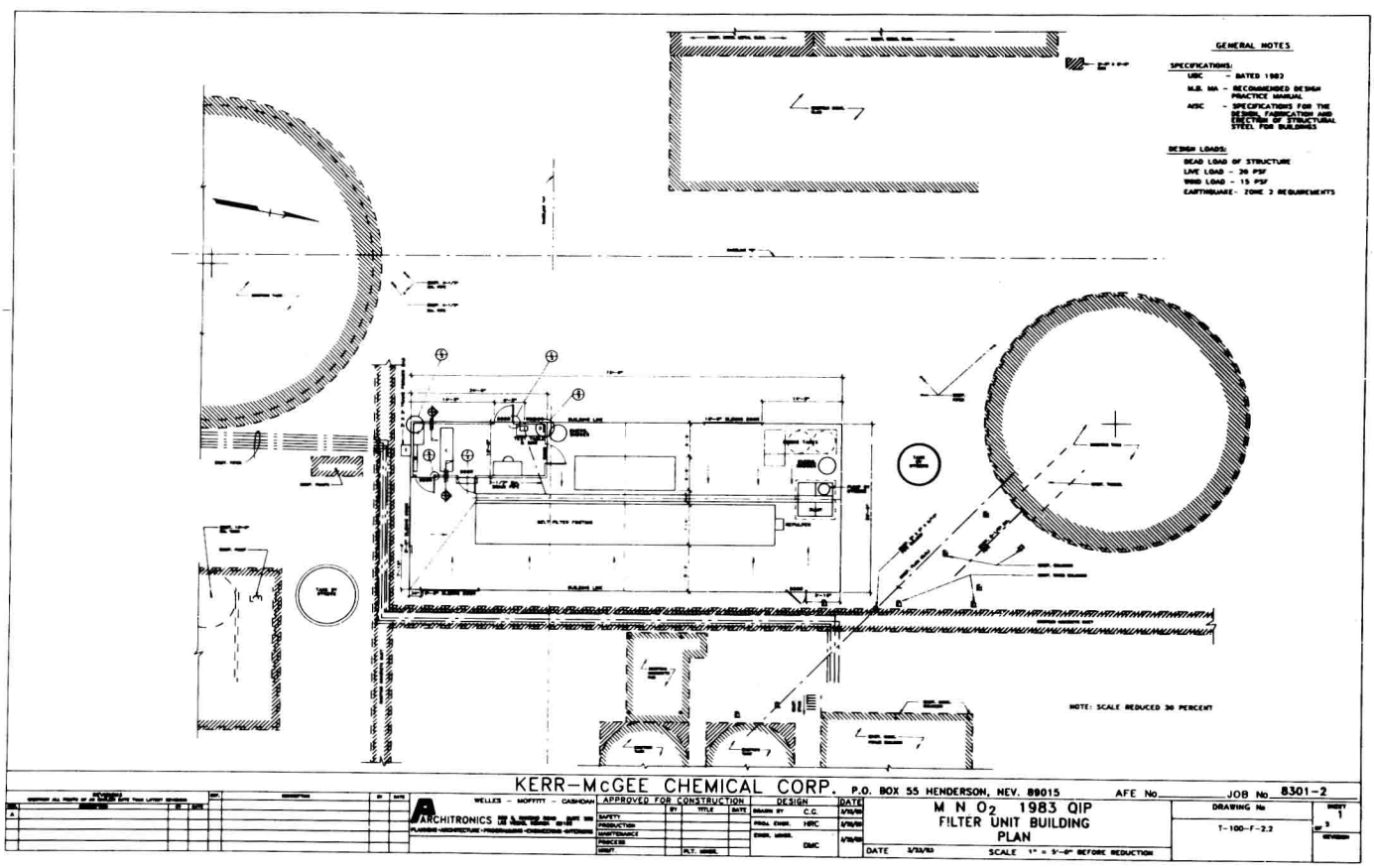

Figure I-5A Civil drafting, a computer generated construction plan. *Courtesy Summagraphics Corporation.*

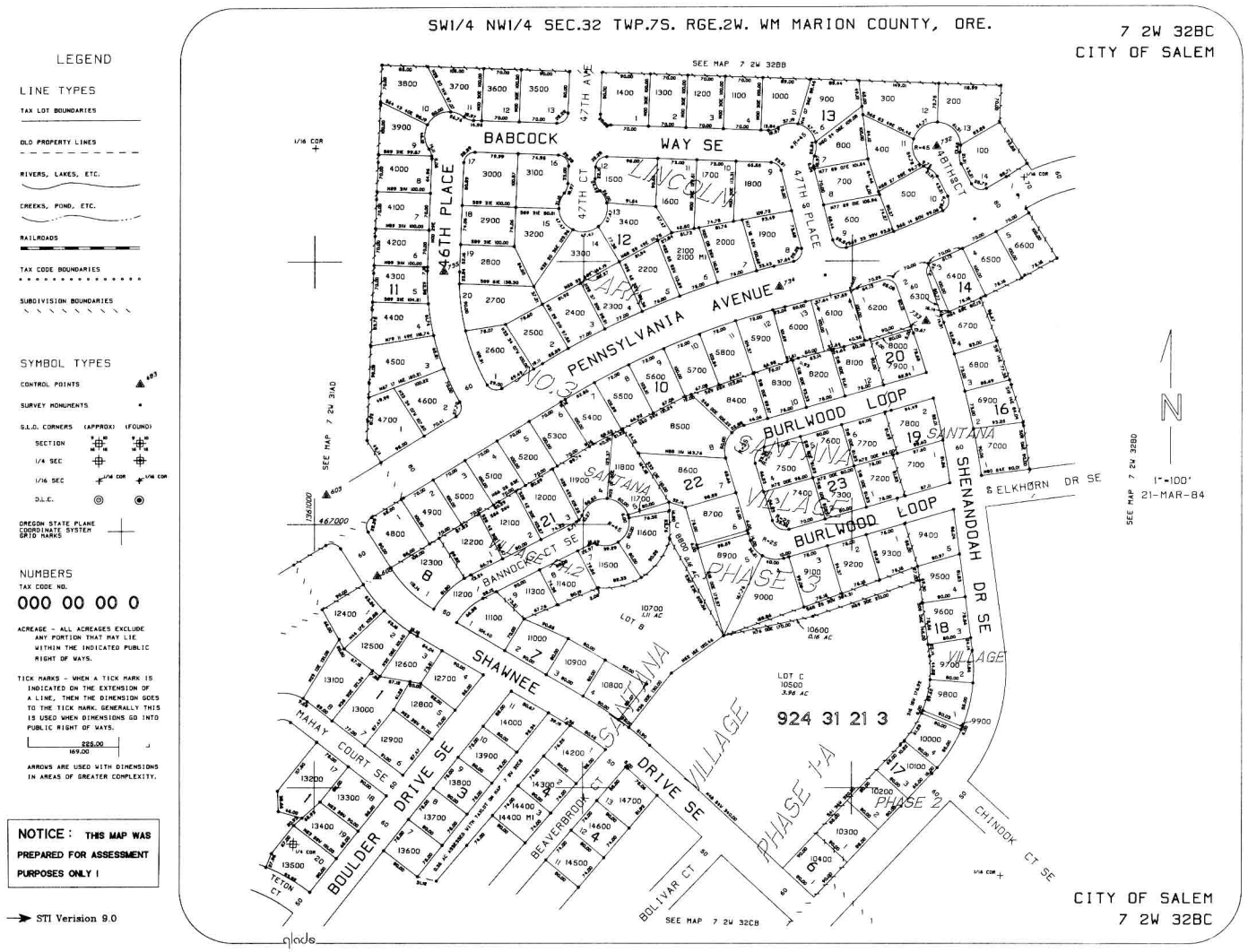

Figure I–5B Civil drafting, a computer generated subdivision plat. *Courtesy Glads Program.*

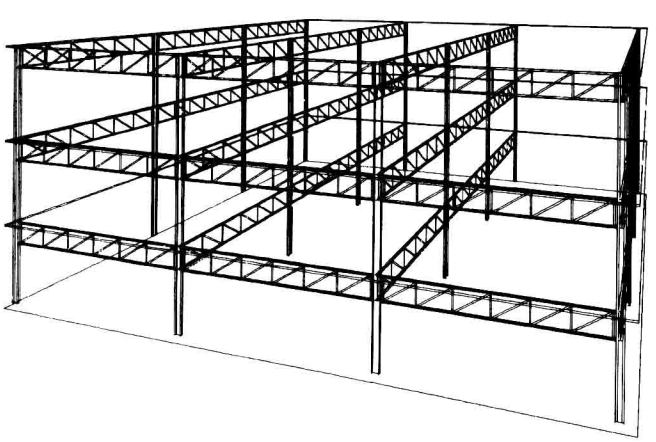

Figure I–6A Structural drafting, a computer generated isometric.

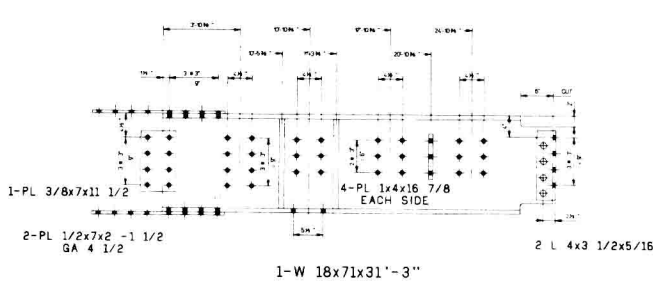

Figure I–6B Structural drafting, steel detailing. *Courtesy Computervision Corporation.*

Mechanical Drafter

Drafts detailed working drawings of machinery and mechanical devices indicating dimensions and tolerances, fasteners and joining requirements, and other engineering data. Drafts multiple-view assembly and subassembly drawings as required for manufacture and repair of mechanisms. Performs other duties as described under Drafter. Mechanical drafting, in general, is the core of the engineering drafting industry. (See Figure I–7.) This drawing sample illustrates Military (MIL) standards. Most of the content of this text will show examples of drawings prepared in accordance with American National Standards Institute (ANSI) standards.

Directional Survey Drafter

Plots oil- or gas-well boreholes from photographic subsurface survey recordings and other data. Computes and represents diameter, depth degree, and direction of inclination, location of equipment, and other dimensions and characteristics of borehole.

Geological Drafter

Draws maps, diagrams, profiles, cross sections, directional surveys and subsurface formations to represent geological or geophysical stratigraphy and locations of gas and oil deposits. Performs duties described under Drafter. Correlates and interprets data obtained from topographical surveys, well logs, or geophysical prospecting reports, utilizing special symbols to denote geological and geophysical formations or oilfield installations. May finish drawings in mediums and according to specifications required for reproduction by blueprinting, photographing, or other duplication methods.

Geophysical Drafter

Draws subsurface contours in rock formations from data obtained by geophysical prospecting party. Plots maps and diagrams from computations based on recordings of seismograph gravity meter, magnetometer and other petroleum prospecting instruments and from prospecting and surveying field notes.

Heating and Ventilating Drafter

Also known as Heating Ventilating and Air Conditioning (HVAC) Drafter. Specializes in drawing plans for installation of heating, air-conditioning, and ventilating equipment. May calculate heat loss and heat gain for buildings for use in determining equipment specifications, following standardized procedures. May specialize in drawing plans for installation of refrigeration equipment. (See Figure I–8.)

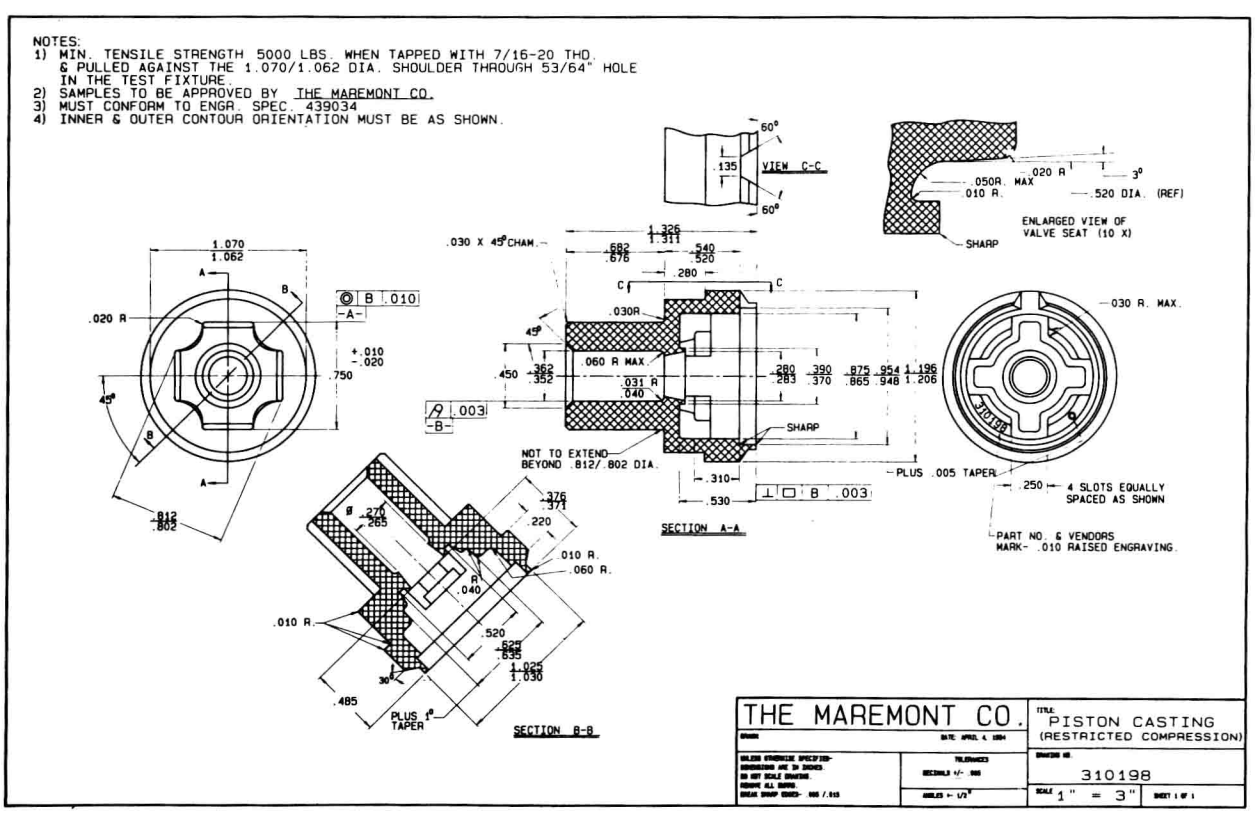

Figure I–7 Computer generated mechanical drafting. *Courtesy T & W Systems, Inc., Huntington Beach, California*

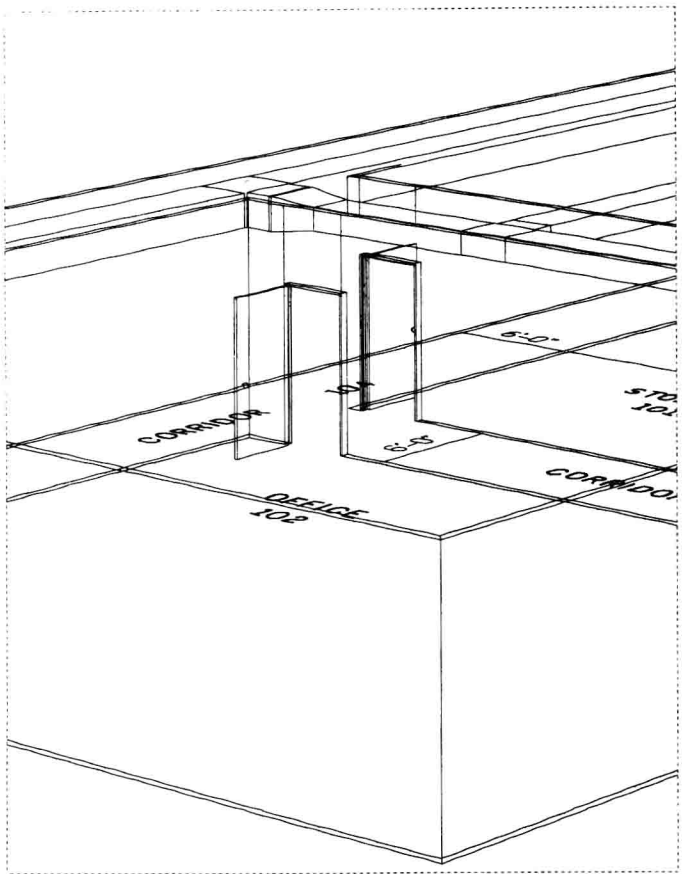

Figure I–8 Computer generated HVAC pictorial. *Courtesy Computervision Corporation.*

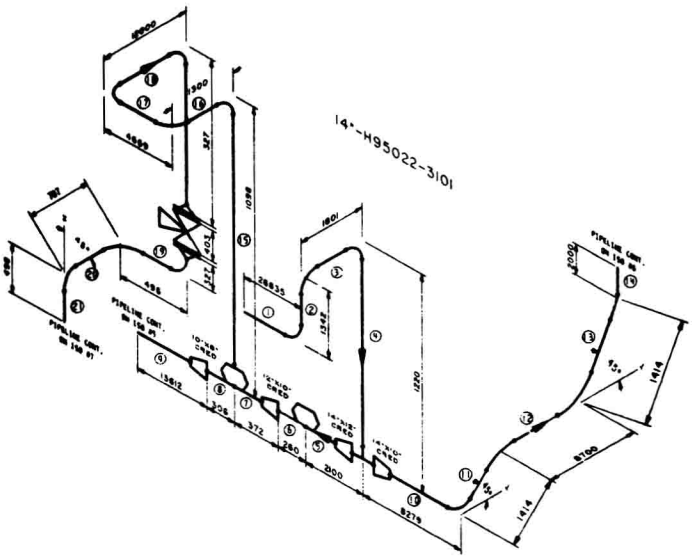

Figure I–9 Piping drafting, isometric layout. *Courtesy Computervision Corporation.*

Plumbing Drafter

Also known as Piping Drafter. Specializes in drafting plans for installation of plumbing and piping equipment for residential, commercial, and industrial installations. (See Figure I–9.)

Automotive Design Drafter

Designs and drafts working layouts and master drawings of automotive vehicle components, assemblies, and systems from specifications, sketches, models, prototype and/or verbal instructions, applying knowledge of automotive vehicle design, engineering principles, manufacturing processes and limitations, and drafting techniques and procedures, using drafting instruments and work aids. Analyzes specifications, sketches, engineering drawings, ideas and related design data to determine critical factors affecting design of components based on knowledge of previous designs and manufacturing processes and limitations. Draws rough sketches and performs mathematical computations to develop design and work out detailed specifications of components. Applies knowledge of mathematical formulas and physical laws and uses slide rule or digital calculator to make calculations. Performs preliminary and advanced work in development of working layouts and final master drawings adequate for detailing parts and units of design. Makes revisions to size, shape and arrangement of parts to create practical design. Confers with Automotive Engineer and others on staff to resolve design problems. Specializes in design of specific type of body or chassis components, assemblies or systems such as door panels, chassis frame and supports, or braking system.

Oil and Gas Drafter

Drafts plans and drawings for layout, construction, and operation of oil fields, refineries, and pipeline systems from field notes, rough or detailed sketches, and specifications. Develops detail drawings for construction of equipment and structures, such as drilling derricks, compressor stations, gasoline plants, frame, steel, and masonry buildings, piping manifolds and pipeline systems, and for manufacture, fabrication, and assembly of machines and machine parts. (See Figure I–10.)

Technical Illustrator

Lays out and draws illustrations for reproduction in reference works, brochures, and technical manuals dealing with assembly, installation, operation, maintenance, and repair of machines, tools, and equipment. Prepares drawings from blueprints, designs, mockups, and photographs by methods and techniques suited to specified reproduction process or final use, such as diazo, photo-offset, and projection transparencies, using draft-