COMPUTER-AIDED GRAPHICS AND DESIGN

Second Edition, Revised and Expanded

Mechanical Engineering 38

Daniel L. Ryan

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Preface

This second edition reflects the many changes that have been requested. These requests have come from the thousands of readers who are presently using the first edition of this classic approach to computer-automated graphics and design instruction. The theory of presentation has remained the same—that is, the beginning level has not changed—but the applications and illustrations have all been updated to reflect the current state of the art in hardware and software. The premise of this book is that beginning readers will want to read and understand the material presented. Therefore, a common sense approach has been used throughout. For example, the use of advanced mathematical transformations has been kept to a minimum, with emphasis on the *use* of programs containing these concepts and *not* the reinvention of these.

Computer-Aided Graphics and Design, then, is a text for engineering and technology students because the computerized approach to engineering graphics is an indispensable supplement to the manual/analytical methods taught in traditional graphics courses. Producing graphics by computer for many types of applications, especially those involving massive amounts of data or repetition, is much more efficient than by traditional manual methods. Portions of the first edition now appear in traditional textbooks published since 1979 and, as an author, it is always gratifying to see one's ideas accepted by colleagues. There remain, however, many CAD graphical problems that can be easily analyzed and automated. These now appear in this second edition. No attempt has been made to replace all engineering graphics subject matter with computer/automated methods. Only those graphical procedures which are felt to make a definite contribution to the effective graphical communications area are presented.

The selection of material for this second edition is based on the premise that the readers and users of this text are the best judge of what is needed. Nearly 50 percent of some chapters have been rewritten, edited, expanded, or deleted so that basic situations are explained in the clearest terms. Thanks to the many letters, telephone conversations, and meetings detailing these changes for the second edition, the emphasis remains on computer graphics usage in engineering problem solving. The expanded methods of using software procedures are stressed, as is the procedure for writing new procedures. The emphasis here, as in the first edition, is on use rather than on how to create software. It is the author's belief, supported by the users of the first edition, that this delimitation is necessary in a first course in computer graphics, because CAD requires more ingenuity, inventiveness, imagination, and patience. Anyone who has ever tried to teach computer graphics to freshmen knows this.

The unique features of the second edition are:

1. It is a complete study of engineering graphics, not a computer or mathematics textbook.
2. Types of modern CAD equipment are demonstrated and explained in lay terms.
3. The book has a substantial amount of illustrative examples with computer solutions explained in step-by-step fashion.
4. Common computer languages (BASIC and FORTRAN) are used side-by-side.

The author makes no claim to the originality of the illustrations presented; most were completed by students at Clemson University during the last five years. Most illustrations reflect the presentation technique taught throughout the book, and represent a pioneer effort in the computerization of heretofore manual methods. The references consulted during the editing of the second edition are listed in the bibliography and in various foonotes. The unique character of this second edition lies in its industrial orientation, its use by leading colleges, and the user-oriented manner in which topics are presented.

To present this industrial orientation, a number of industrial organizations and manufacturers have generously assisted the author by supplying appropriate materials and information needed in developing certain topics. The author deeply appreciates the kindness and generosity of these companies and the personnel who found the time to consult and allow the author to visit their various manufacturing plants. Special appreciation must be expressed to the other members of the engineering graphics staff at Clemson University for their continuing support and patience during the creation of this second edition. Not to be forgotten are the many students and users of the first edition who made valuable contributions to this edition. The author's indebtedness to excellent, intelligent students is hereby reaffirmed.

Daniel L. Ryan

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1

Introduction to Automated Graphics

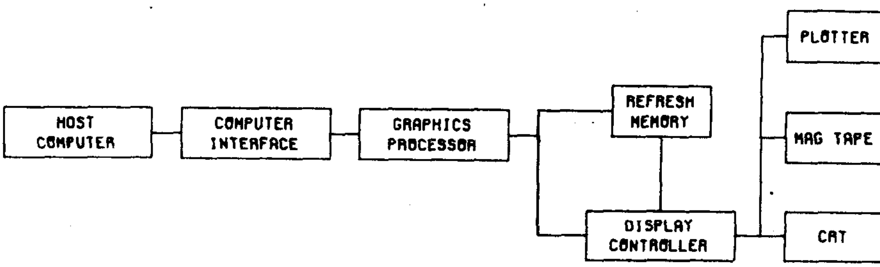
A complete study of engineering graphics must include something about the age of computerization and how it affects work done by a designer or engineer. The human is smart, creative, and slow, while the computer is stupid, uncreative, and very fast. The problem then is to allow human and machine to work well together as a team. Certainly their characteristics complement each other, but their languages are very different. We think in symbols and pictures, while the computer understands only simple electrical impulses. Computers and automated graphics are playing an increasingly large part in our lives. Over the past decade, automated graphics applications, particularly for computer-aided design, have been justified because they can save money and time and can improve the quality of the drawings. Dollar savings of from 3:1 to 6:1, and time savings of from 20:1 to 50:1, are typical of those quoted in applications explained later in this text.

Automated graphics or computer graphics is a way of converting the computer's impulses into engineering documents and, conversely, to translate the operator's instructions into electronic data. In many of the more sophisticated systems, we need know little about computer programming in order to control the human-machine effort. In general, computer graphics includes any device that converts computer language to people language, or any device that converts people language to computer language, with the intent of solving problems by creating graphical images.

QUALITY OF COMPUTER-GENERATED DRAWINGS

Most automated graphics devices are easy-to-operate, self-contained, automated systems for the direct translation of rough sketches into high-quality finished ink on vellum drawings. The system is designed for simple, real-time operation by drafters or designers and is particularly useful for producing drawings containing repetitive symbology and text. It can be used in a drafting room since it does not depend totally on an outside processing source. Applications include logic diagrams, illustrations, technical schematics, detailed drawings, technical layouts and many other drawings where speed and accuracy are a must.

An example of an automated system and how it works can be studied by examining a typical block diagram as shown in Figure 1.1. The quality of a computer-




```
C *****************************************************************
C *  IT SHOULD BE NOTED IN THE TYPICAL AUTOMATED GRAPHICS SYS-     *
C *  TEM BLOCK DIAGRAM THAT DATA CAN ALSO BE ROUTED FROM THE       *
C *  DISPLAY CONTROLLER TO THE HOST COMPUTER.  IN MANY CASES       *
C *  THE HOST COMPUTER EMPLOYS A LINE PRINTER THAT WILL PRO-       *
C *  VIDE A HARD COPY OF THE DISPLAY PROGRAM UPON COMMAND FROM     *
C *  THE USER.  IN ADDITION, A JOY STICK WHICH CONTROLS A DVST     *
C *  SCREEN CURSOR IS USED TO ALLOW THE USER TO ENTER DATA AT      *
C *  SPECIFIC LOCATIONS.  THE HOST COMPUTER MUST BE ABLE TO        *
C *  OBTAIN THE DISPLAY CODE AT ANY GIVEN TIME FROM THE DISPLAY    *
C *  CONTROLLER AND MUST ALSO BE ABLE TO OBTAIN JOY STICK OR       *
C *  OTHER POINTER LOCATION INFORMATION FOR DATA ENTRY.  THE       *
C *  DISPLAY CONTROLLER, UPON REQUEST FROM THE HOST COMPUTER,      *
C *  ROUTES DATA TO THE COMPUTER FROM THE DISPLAY MEMORY VIA       *
C *  THE COMPUTER INTERFACE.                                       *
C *****************************************************************
```

Figure 1.1 Typical automated graphics system.

generated drawing can also be noted since the diagram produced for Figure 1.1 was produced by a digital computer (IBM 370/3081) and plotter (online CalComp). The typical offline plotter is brought online as shown in Figure 1.1 by the addition of the controller shown in Figure 1.2. This controller is a microprocessor-based data control system which functions as an online interconnecting device between a CalComp plotter and host computer. Both a pen plotter, shown in Figure 1.3, and an electrostatic plotter, shown in Figure 1.4, may be simultaneously attached to the controller. The controller has a simple-to-use operator control panel for using the same display coding technique for pen plotting and raster vector plot data via an RS-232-C or a bisynchronous serial interface from the host computer as shown in Figure 1.1.

Every illustration, diagram, and drawing using in this textbook was produced by a computer with the help and instructions of a human operator.

An automated method, then, would be the combination of these two elements to produce synergy, or united action. The logical basis for this concept lies in the fact that the human mind tends to solve problems heuristically (trial and error), while a mechanical system solves by the use of algorithms (error-

Figure 1.2 Online CalComp controller. (Courtesy CalComp Corp.)

Figure 1.3 Model 960 pen plotter. (Courtesy CalComp Corp.)

free sequences of logic). By letting each (mind/machine) work to its best capacity, a new and better method can be automated. How this human-machine process is automated is rather simple. Strictly speaking, the automation of any process means the improvement or elimination of certain or all parts of the manual labor involved in doing a job. This does not mean the elimination of humans from the scene, for we have to start and stop the process, either directly by pushing a button or indirectly by programming another machine device such as a host computer. Modern automated graphics terminals, for in-

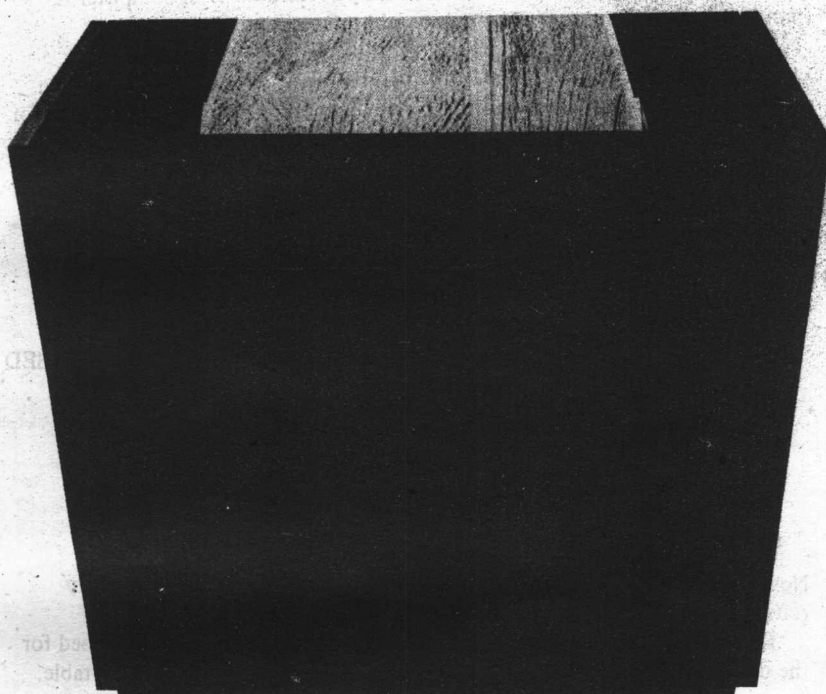


Figure 1.4 Model 5105 electrostatic plotter. (Courtesy CalComp Corp.)

stance, can be programmed so that all the data in a computer file can be displayed by pushing a single key on a typewriter keyboard. The signal of the depressed key releases a set of data points that can describe an entire engineering drawing or something as simple as a circle.

To demonstrate this, suppose the host computer used in Figure 1.1 was contacted from the keyboard of the graphics terminal through the computer interface as:

LOGON
—enter userid—

where the drafter entered the instruction LOGON and the host computer responded with –enter userid. The user would then enter:

USERID/PASSWORD

and the host would respond with the current date, time, and messages useful for the drafter. The user would then enter the instructions for the preprogrammed output, for example

CE .PFK1

which stands for CREATE a PROGRAMMED FUNCTION KEY called one. Next the drafter enters the list of instructions for that function as:

```
INPUT
00010  C  THIS IS A LIST OF OUTPUT COMMANDS TO BE PROCESSED
00020  //USERID1 JOB (0923-1-003-TB-I,:01,1)
00030  //S1 EXEC FORTCLG, PLOTTER = VERSATEC
00040  //C.SYSIN DD *
00050
00060  EDIT
SAVE
```

Now when the 1 key is depressed, the list of instructions are automatically routed to the VERSATEC plotter.

The first drafting machine to come onto the market eliminated the need for the drafter to push and pull a triangle and T-square around the drafting table. The first step in automating the drafting procedure, then, would be the elimination of the pencil or pen from the drafter's hand. A good example of these types of automated drafting machines is shown in Figure 1.5. These are commonly called precision plotters for they are very accurate, usually with a resolution of 0.0002 inch. The model shown in Figure 1.5 is capable of speeds up to 42 inches per second with liquid ink. A full range of line widths can be used. The four-pen pressure inking system provides consistent line quality. In addition to liquid inks, dry ink (ballpoint) pens can be used. The system goes beyond pen and ink plotting, however. Various papers and synthetic drafting materials can be used on the large flatbed plotter surface as well as scribe-coated and the strippable films. Vacuum holddown is standard. A scribing and cutting head attachment is provided.

Using the controller shown in Figure 1.2 adds flexibility in online modes of operation. In the offline mode, it includes a magnetic tape unit that reads plot data from the host computer shown in Figure 1.1. Software is loaded from a magnetic tape cartridge or a disk as demonstrated in Figure 1.6. This software processes the plot data, generates plotter commands, and gives the user complete control over plotter acceleration, maximum speed and pen delays, as well as

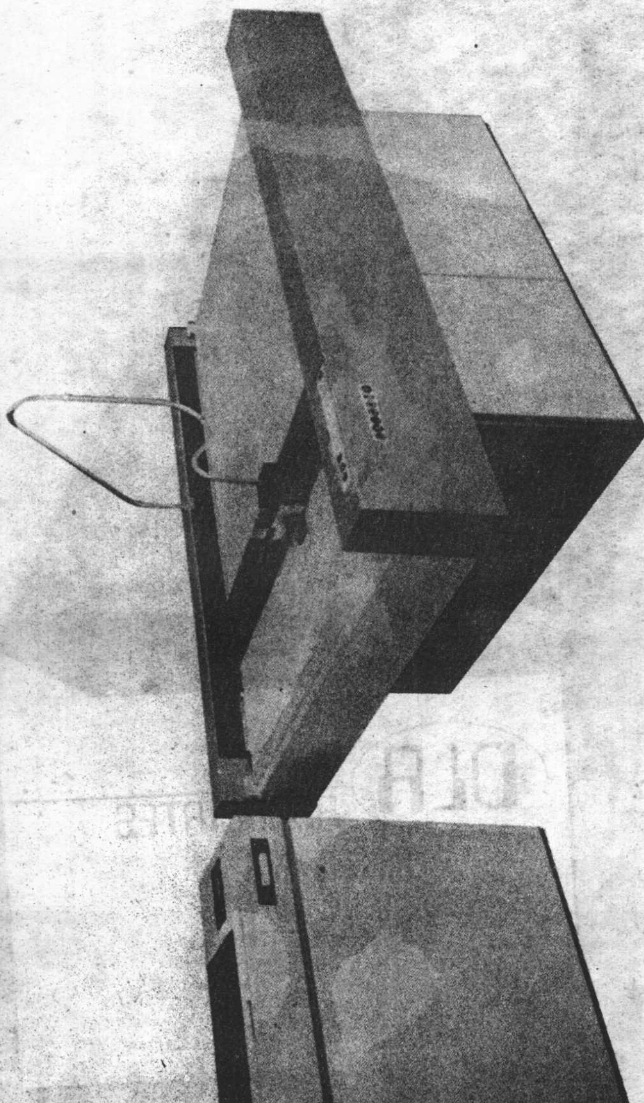


Figure 1.5 Model 7000 high-performance drafting system. (Courtesy CalComp Corp.)