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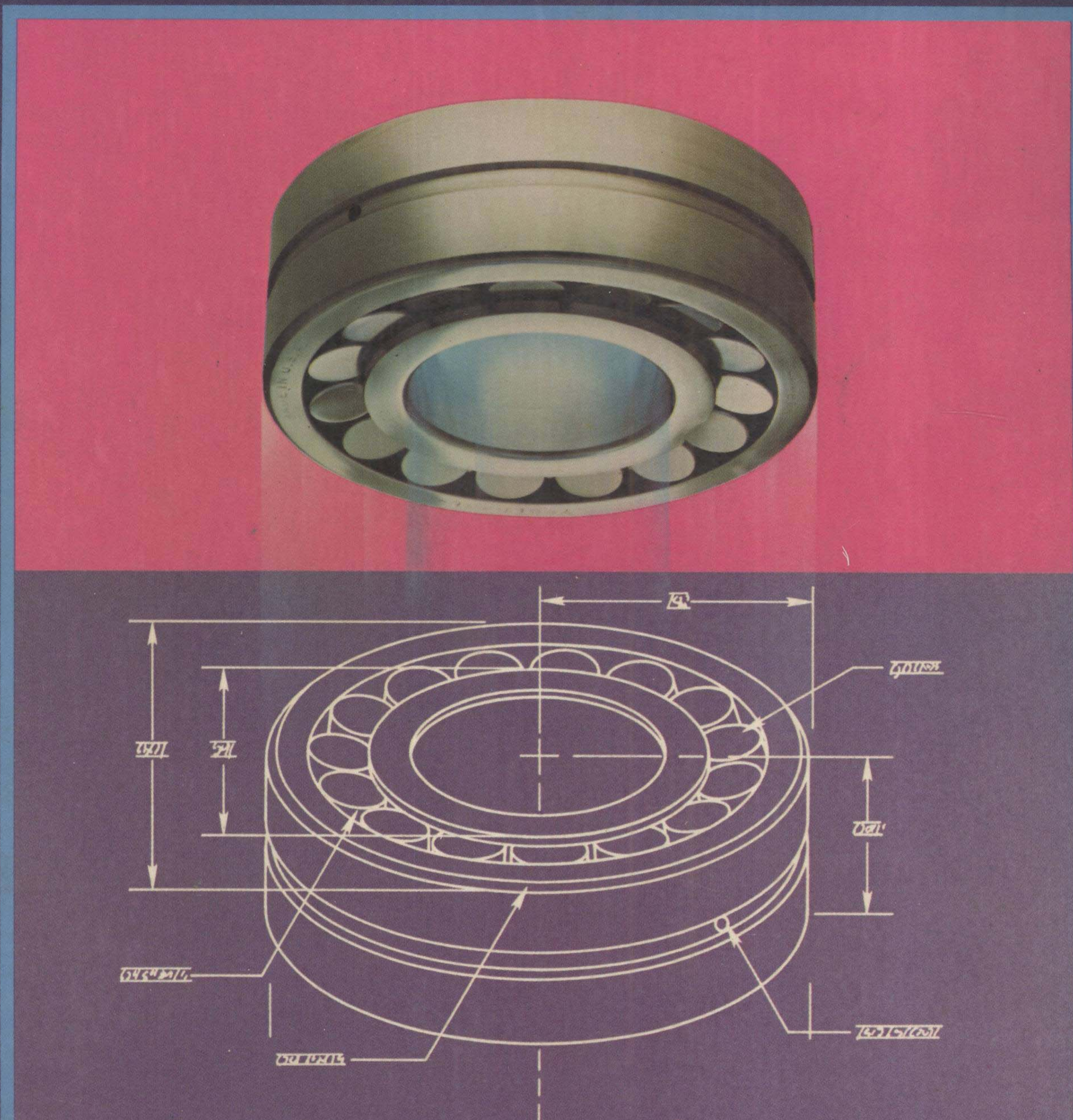
The CAD/CAM Primer

Daniel J. Bowman



The CAD/CAM Primer

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by

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Preface

CAD/CAM— The Engineer's Right Brain

Recently, there has been much talk about your right brain and your left brain. Your brain resembles the halves of a walnut, with your left half controlling the right side of your body and the right half controlling the left side of your body. This fact people have known for years.

Until recently, that has been the main emphasis on brain studies. However, it now seems that your creative, or visual, side is controlled by your right brain, and the verbal or written by your left brain. The gist of all these recent studies is that we do not know or use the right half of our brain as much as we should. In a nutshell (no pun intended) we use only half the brain power given to us.

Using the right/left brain relationship as an analogy, the computer functions as the left half of our brain. For years we have been pumping out reams of paper, not necessarily because it was needed, but since the computer put it out, we might as well print it. And for years, tons of paper have been routinely passed from accountant to accountant, from engineer to engineer, and from manager to manager, because this was the thing to do.

CAD/CAM and in particular the computer graphics era has entered our way of life to increase productivity. Computer graphics allows us to condense the tons of printouts into neat little pictures that can be easily understood—and then acted upon. The decision maker can get the picture, and then decide what to do. In essence, graphics and CAD/CAM offer the engineer a chance to use the results of the right side of his or her brain.

As simple as that may seem to be, it isn't. When anything simplifies manufacturing, political struggles come into play. Instead of investing in the future, we now find that certain individuals will want extensive financial studies and analysis made to justify these systems. And then they will want another analysis. Or they will buy half a system, or just part of the concept.

That is the basic reason for this book—"THE CAD/CAM PRIMER." One simple little book is not going to teach you how to be proficient in

CAD/ CAM. However, it will present to you the basics of CAD/CAM, so that you will know what it is all about. And it should give you enough information so you can go to the decision maker and give him or her the PICTURE. In truth, to really understand CAD/CAM, you need to jump in, get your feet wet and go to it. The savings are there. They may not pop out at you in a financial analysis, and they may not be there when you first get your system in place. But, believe me, they are there.

As rhetorical as this statement may seem, the most you can risk if you buy a CAD/CAM system are some investment dollars. But if you don't buy CAD/CAM, you may be risking your business.

So let's use our right brain. Let's use the new creative, visionary tool, CAD/CAM.

DANIEL J. BOWMAN

To Annette

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1

CAD/CAM Overview

From Fortune Magazine to OMNI, the articles pouring fourth the accolades of CAD/CAM are almost endless. Acronyms are sprouting equally fast with CIM, CAE, CNC, FMS, etc., being tossed around like jelly beans. The net result is that most people are confused, awed, and somewhat fearful of this new technology. Workers in outmoded plants are trying to compete in a world market that is offering lower prices and better quality.

Prior to the twentieth century, most attempts at automation were unsuccessful. Many of the attempts met with heavy worker resistance, such as the Luddites group in England during the early 1800s. This particular group smashed labor-saving textile machinery as a protest against reduced wages and unemployment. However, at the turn of the century, mass-production became the American way of life, and is now becoming a universal way of life.

Today, we are seeing the beginnings of some modern-day Luddites, and not only in labor's ranks. Many manufacturing and engineering managers are becoming hopelessly lost in computerization, not knowing where to begin, or where it will end. Therefore, some building blocks are necessary for an easier understanding of what it is all about.

JUST WHAT IS CAD/CAM?

Although many people ascribe the name CAD/CAM to a graphics workstation, the name itself is an acronym meaning Computer-Aided Design and Computer-Aided Manufacturing, with each one being a separate discipline.

In reality, CAD/CAM is a marriage of many engineering and manufacturing disciplines. In its simplest form, it is a computerized communication and design function within and between design engineering and manufacturing engineering. If we take it to the extreme, we can include almost any phase of the business and manufacturing cycle. This would include marketing, office automation, accounting, quality control, and almost anything else that could attach itself to a central data base. In general, we can look at the CA in any of the acronyms as being Computer Aided and being synonymous with automation.

Some of the more common meanings for the various CAD/CAM acronyms are as follows:

CAD/CAM[1]

CAD	CAM
Geometric modeling	Numerical control
Analysis	Robotics
Testing	Process planning
Drafting	Factory management
Documentation	

These two disciplines are tied together by a common data base.

CAE/CAM

CAE stands for Computer-Aided Engineering and incorporates the NC tape programming in with the CAD. As a result, a CAE/CAM system is broken down as follows:

CAE	CAM
Automated design	Tool production
Simulation analysis	Parts production
Process and tool design	Assembly automation
NC tape programming	Inspection and testing

As with a CAD/CAM system, the disciplines are tied together with a common communications system and use a common data base.

HISTORY

CAD/CAM is a concept that has many roots and is primarily hardware oriented. However, software is the photosynthesis that gives CAD/CAM life. And although many segments of the CAD/CAM concept have been with us for some time, there are several key developments that gave substance to the concept.

The first development is naturally the computer. Rather than be repetitious and trace the history of the computer, the graphics workstation is really the key that ties the concept together. And it is this graphics workstation that will be the focus of this book.

However, we cannot overlook the importance of the microelectronics industry in the development of the CAD/CAM concept. The first operational computer, the ENIAC, contained some 18,000 vacuum tubes and had 400°F temperatures inside the electronic equipment. With its continuous breakdowns, it became apparent that the vacuum tube would be a serious bottleneck for future electronic development.

Bell Telephone Laboratories, which had sponsored semiconductor research ever since 1936, was finally rewarded when three of its scientists discovered the transistor in 1947. From that time on, the microelectronics business took off like "gangbusters." And today it would be virtually impossible to imagine what our world would be like without that fateful discovery in 1947.

During the 1950s, the first computer driven display on a crt was produced by MIT's Whirlwind I computer. In the mid 1950s the SAGE air defense system was the first to use command and control crt consoles, whereby operators identified targets by pointing at them with light pens.

Graphic displays were available as early as 1951 and plotters were in general use by 1953. Light pens existed in 1958 with data tablets available in 1964. In fact, most of the hardware technologies in use today were around in 1965, but the actual number of installed refresh displays was less than 200 at that time. Available software and cost were major deterrents to more widespread usage.

During 1962, Ivan Sutherland at MIT stated in his doctoral thesis[2] that interactive computer graphics was a viable system. A result of Sutherland's work was a film he made about computer graphics that, through wide distribution, created much interest in the concept. Sutherland introduced and developed many of the fundamental ideas and techniques that are still in use today.

During this same period, the General Motors Corporation and Lincoln Laboratories independently demonstrated the feasibility of coupling crt's to a graphics display. By 1965 large scale computer graphics research was being carried on at GM, MIT, Bell Laboratories, Lockheed Aircraft, and McDonnell Douglas.

On the CAM side of the picture, during the past 30 years virtually all of the new technology has been aimed at moving the tool past the work piece more quickly. Probably the most mature of CAM technologies is numerical control. This is the method whereby programmed instructions stored on punched paper tapes control automatic machine tools. Computer Numerical Control (CNC) is a more advanced system that incorporates a dedicated minicomputer or microcomputer to control the machine tool. The NC instructions are stored in its memory. In a Direct Numerical Control (DNC) system, individual machine tools are connected to a central computer that supplies the instructions. Basically, the history of NC follows the history of controls and in particular integrated circuits.

Two of the first CAM programs were developed in the late 1950s. The two programs, APT and PRONTO, provided languages that eliminated the need for the programmer to directly communicate with a machine tool through hole punched codes. They are both still in use today, with APT being the most widely used for language-driven numerically controlled machine tape generation. However, one of the major problems with many CAM systems is compatibility of languages.

As an example, the development of DAC (Design Augmented by Computers) at General Motors in the early 1960s was definitely a CAD/CAM milestone.[3] This was a significant development because DAC did not require users to be programmers. And for the first time, designers and manufacturing personnel could communicate with a computer graphically.

Unfortunately, DAC was developed for IBM 7090 computers. No sooner was DAC a successful operation, than IBM introduced its 360 mainframe, which was incompatible with the DAC program. However, DAC did enable GM to produce important die models when its car models were charged at the last moment in 1964 and 1965.

Probably the biggest boost for CAD/CAM came in 1973 when GM's VSAP (vehicle structural analysis program) helped the company resize new model cars in nine months less than the original time table provided. Of course, much of the time saving came from design prototypes by simulation. The manufacturing aspect was much slower to take hold because it required the replacement of production machinery.

However, there have been many computerized manufacturing operations that approach CAD/CAM. In 1977, Minister Machine Company hooked up a computerized flame-cutting machine to a CAD graphic system, resulting in a 30 percent increase in flame-cutting productivity.

And we have a host of other computerized manufacturing operations that we could talk about, such as computerized testing, computerized welders, etc., but probably the device that most people associate with CAD/CAM is the robot.

Being programmable, the industrial robot is often described as having human characteristics. Unfortunately, the robot has been pictured as an evil device and detrimental to mankind. The word robot was derived from the Czech word "robotit," which means "to drudge." It came into use in 1921 after a play written by Czech dramatist Karel Cepak entitled "R.U.R." The initials stood for "Rossum's Universal Robot," and he wrote the play as a protest against regimentation.

Actually, the first industrial robot wasn't developed until the 1950s, when George Devol began patenting his concepts of an industrial robot. In 1958, Devol entered into a license agreement with Consolidated Control Corp., a subsidiary of Condec Corp.

By 1960 a laboratory model of the first machine was in operation and in 1962 prototypes were ready. During that year, Condec and Pulman Inc., merged and formed Unimation. Thus, the robotics industry was born.

If we want to carry the automated factory concept to a conclusion, everything in the production cycle would be computerized, from marketing to shipping the product out the door. Although each manufacturing plant may use variations of the CAD/CAM concept, there are some common facets that we can use as a basis for the CAD/CAM Primer:

1. Computer Graphics Workstation
2. Common Data Base
3. Software
4. Numerical Control of the machine
5. Automated materials handling and in particular—Robotics

COMPUTER GRAPHICS WORKSTATION

Graphic displays are a significant element in the CAD/CAM evolution. And both hardware and software are still evolving. Basically, a computer graphics workstation is a hardware/software combination that gives a user what he or she needs to interact and create graphics information, including graphics input, graphics display, and graphics processing. Although many engineering graphics workstations have significant local power, most are intended for use with a supermini computer or mainframe host computer.

Workstations support a wide assortment of graphics input and output peripherals, with a keyboard being the most popular input peripheral. On the output side there exists a variety of peripherals for producing hard copy for the user.

The terminal itself can be raster-scan (similar to a tv set), direct-view storage tube (similar to an oscilloscope), or a random-scan vector display. Likewise, the screens can be monochromatic (black and white) or color.

Since more and more work can be performed on the terminal through simulation, the computer and the graphics workstation are the key hardware elements of the CAD/CAM concept.

COMMON DATA BASE

If we look at a new product entering the manufacturing cycle for the first time, we see that it requires a data base. There are certain facts about this upcoming product that can be filed in a computer system for future use by those in the manufacturing process. And these facts have either been dictated by the customer, or the marketing department has made an analysis as to the type of product the company should be making.

Because these facts have been fed into the computer for storage they can be drawn upon by those who need this information. In most plants, certain aspects of this data base are used by almost every department in the company. Unfortunately, in most manufacturing plants many do not have access to much of this information.

Therefore, along with a data base we need a means of communicating this data to those who need it—the computer is ideal. Not only can we store this information in the system, but with the networking capabilities of the modern computer system we can use telephone, coax cables, microwave, and fiber-optics transmission of this data, Fig. 1-1.

Thus, we have the basic needs for the CAD/CAM system—a common data base, and method for communicating this data. However, with this invasion of the computer into nearly every facet of engineering management and factory operation, a process standard is a virtual necessity. One concept or philosophy that is coming back into play is group technology (GT). GT can be defined as the bringing together of and organizing (grouping) of common parts, principles, problems, and tasks (technology) to improve productivity.[4]

Group technology originated in Russia and was used during World War II.

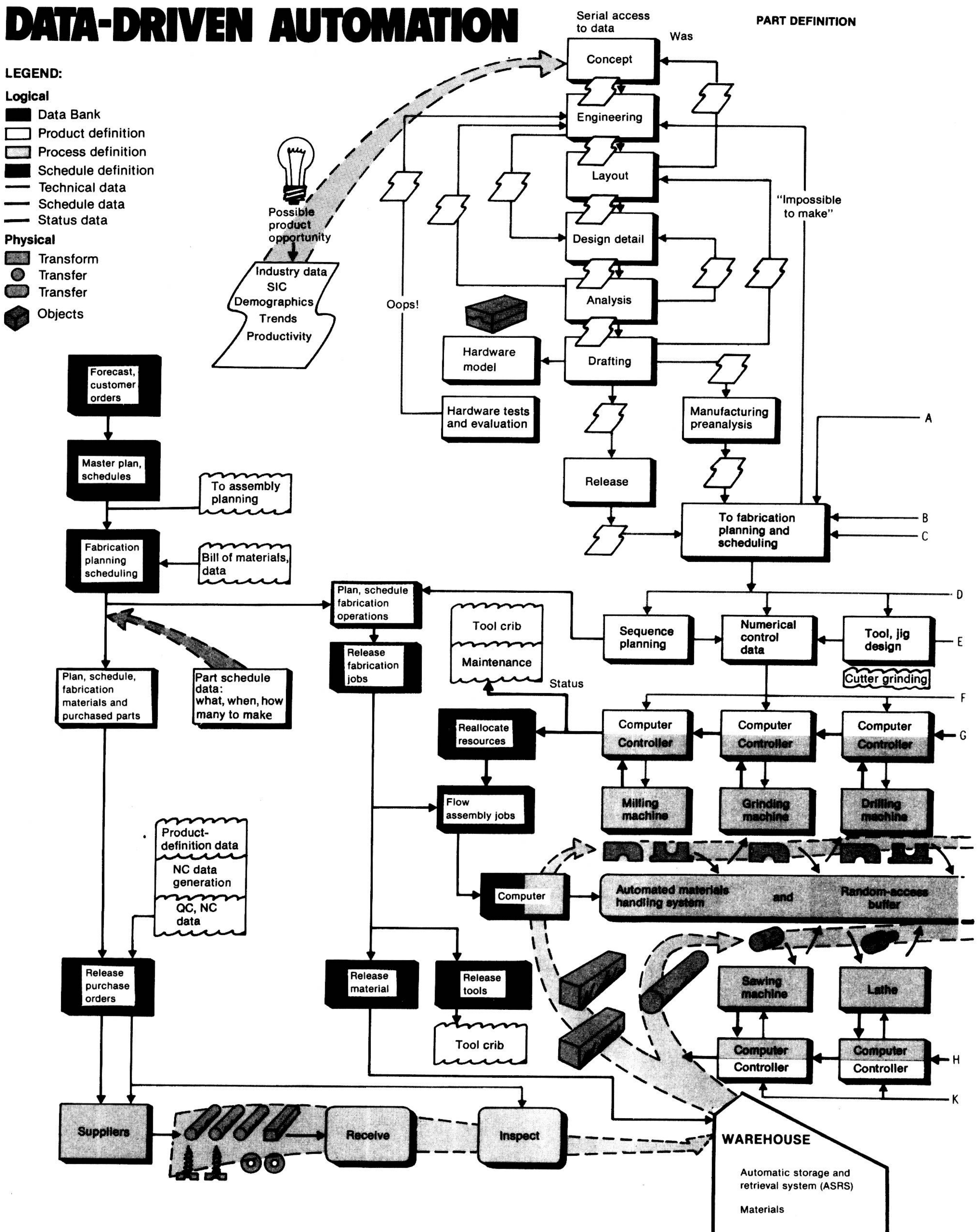

Fig. 1-1. Chart from IEEE Spectrum magazine illustrates how a common manufacturing of a product in an automated factory.