3 January 1972 Earl M Vraa

COMPUI'ER-AIDED DESIGN– WHAT IS REALLY WORTHWHILE?

Computer-Aided Design, Automated Design, Design Automation are terms which are freely interchanged by people in the computer industry or in industries utilizing computers. What is Computer-Aided Design? What is really worthwhile in Computer-Aided Design? This paper will briefly review the Computer-Aided Design (CAD) activities in Univac CAD (specifically in the Univac-Defense System Division), and provide some insight concerning CAD cost effectiveness, philosophy of operation, and problems.

CAD activity at Univac was initiated in 1954 with two people who started with automated documentation on a Flexowriter. This initial effort was very crude by today's standards, but it was a start toward CAD as it now is known. Now, nearly two decades later, this original activity has grown to include five identifiable CAD organizations within three operations:

- Roseville Development Center (RDC)
- Philadelphia Development Center (PDC)
- Defense Systems Division (DSD)

The two development centers are subdivided into Research and Advanced Techniques, and Engineering; DSD combines the two functions within one organization. Although multi-organizations may appear to be redundant and inefficient, each location has a different charter: i.e., RDC [at St. Paul, Minnesota] designs large-scale computers; PDC designs small-to-medium scale computers and peripherals. DSD [also at St. Paul] is military oriented. Moreover, the technology varies at each location and is best supported by separate CAD organizations. This separation does not, however, preclude competition, information interchange, cross-pollination, etc. Univac corporate management monitors the activities of each CAD organization and provides general direction for research projects as well as application development. Periodic CAD seminars at both the Univac and Sperry Rand level also tend to provide insight for the activities, planned development, and problem areas in other organizations. Although the CAD activities are necessarily varied in a corporation as large as Sperry Rand, the interchange of information at these seminars is invaluable. Algorithmic investigation, hardware benchmarks, technique evaluation, system development, etc. are presented and the respective merits are all discussed for potential use by the other organizations.

Hardware wise, facilities operate with the same basic computer systems. These are UNIVAC 1108's with the standard peripherals including magnetic tape units, fast and mass drum storage, high speed printers, and communication interface operating under EXEC-8. Also, using the same design date base format at all locations facilitates program interchange.

DEFENSE SYSTEMS CAD

DSD CAD operates in a remote environment for all CAD development and processing with the 1108 computer at another location. This environment dictates the availability of a facility to access the computer [Figure 1]. This facility includes a UNIVAC 9300 computer system for remote batch processing, printing terminal initiated listings, and producing Computer Output

Microfilm (COM) and XYNETICS plotter driver tapes. The Design-Drafting Department also used these remote terminals for data base management. The COM, built in 1964 by Univac, produces quick-look, working type documentation, and the XYNETICS plotter generates the Form 2 documentation.

Now, with the background and facility description completed, what is Computer-Aided Design to Univac-DSD? It is neither total automation nor the ultimate in design automation. And, it is not a penny--ante game! CAD is as implied, "an aid to design using the power of a computer to extend the capability of man". With women's lib in the fore-front these days, I should include "the capability of women". Where does DSD obtain its greatest cost effectiveness? Reference Figure 2 for a block diagram overview of the CAD system. For this discussion, categorize this overview into

- Logic design
- Drafting
- Manufacturing
- Test

LOGIC DESIGN

First, a discussion of logic design aids with their associated accomplishments and problems is in order. Univac-DSD operates on the premise that the Design-Drafting department is responsible for maintaining the design data base. This approach solves a basic problem. Engineers, in general, often delay maintenance design documentation until absolutely necessary -- sometimes until delivery to the customer. Engineers, however, do face the burden of manual documentation which can be very tedious and some times very repetitious. But when Design-Drafting has the proper automated documentation aids, they ease the preliminary documentation effort and assure that final design is properly documented from the original concept through manufacturing.

The implementation of MSI/LSI designs can cause havoc with most CAD systems if they are oriented toward the node or gate concept. In theory, xSI packages ease the design function. Unfortunately for CAD, the designs or amount of logic in a design increase at a rate which eliminates the possibility of processing xSI designs in a nodal environment. Univac has eliminated this problem by developing ark xSI Library of Modules. The library contains the design characteristics of each "building block" used in a design. These characteristics include the logic representation of the package, truth-table, geometric description with pin numbering, logic diagram information, etc. Furthermore, this technique eliminates the need for updating the software whenever new packages are introduced into the design repertoire.

A recent example of the application of the xSI concept in CAD is the logic simulation and timing analysis which was used for the Minuteman Computer design. Initially it was thought that a truth table for each package type would provide the solution to process this design, but consider generating a truth table for a 4-bit adder! The final solution was a hybrid simulation which uses either an algorithm or a truth table solution for each package type, dependent on software and computer storage efficiency. The result was a program that will process an equivalent 25,000 gates at a rate of a 1-microsecond instruction with 15 seconds of 1108 CPU time. Another advantage is that core storage decreases by approximately an order of magnitude.

To date, DSD has virtually bypassed the automatic circuit assignment and placement because of the printed circuit card types used in design. Optimization of logic on a complex card does not adapt well to design automation.

Automated Drafting Aids

Another area of' cost effectiveness in CAD is automated drafting aids. Specifically, these are automated P.C. card routing, Form 2 logic diagrams, and Form 2 P.C. card schematics. Basically two card types are used in DSD design -- the single-layer, two-sided maze-routed card (very simple) and the multi-layer maze-routed card with high density packaging. With the design restraints now in effect, neither of these cards can usually be completely automatically routed. But, the use of CAD augmented with human intervention, substantially reduces the cost of artwork. This technique also provides other pay-offs such as the rapid turn- around time of a design and the manufacturing yield from computer-generated artwork.

Logic diagrams and P.C. schematics (FORM 2) are generated from data in the design master file. Reference Figure 3 - Again, the function is not totally automated. The placement of packages and the routing are totally automatic and are logically correct, but the "hooker" is that the drawings sometimes lack aesthetical appeal. For such drawings, Design-Drafting updates the placement and produces the final print.

Manufacturing

Manufacturing support by CAD is categorized in the area of numerical control. Automatically Programmed Tooling (APT) and Gardner-Denver wire wrap control decks are exceptional cost effective tools. Although most APT processing is point-to- point, complex drilling and milling array control tapes are quickly generated via a remote computer. The XYNETICS plotter offers the parts programmer another design aid. Each part processed by APT is also post-processed for the XYNETICS plotter. This plotter driver tape enables the parts programmer to evaluate machine tool movement and to check for accuracy before the actual machine tooling. The plotter/machine tool ratio is approximately 50:1 which is extremely cost effective for a quick look before tooling.

The Wire-Wrap System for the Gardner-Denver control cards is Univac standard software. It will process a 25,000-wire file and generate the standard engineering, manufacturing, and diagnostic listings. With a Uniscope-300 terminal the system operates in an on-line mode for rapid updates by the user. Here again, the COM and plotter provide quick-look plots. The Wire-Wrap nets are plotted on either device (the plotter provides FORM 2 documentation) to enable the engineer to evaluate wiring in restricted areas and critical nets before the chassis is wrapped,

Test

Univac employs an automatic P.C. card test sequence generation which develops the optimum test sequences for each card and generates fault isolation data for repairing faulty cards. This is a critical and costly effort for most companies and is not eased by the implementation of xSI. It is relatively easy to generate a test for a single chip, but combining chips on a card, adding stimulus and then probing at only I/0 and test points proves to be a monumental project. Within Univac, cards with up to 300 gates are usually processed easily in a completely automated mode. For computer efficiency, test lists for cards larger than that are generated via a man/machine mode.

THE FUTURE OF CAD AT UNIVAC

Where do we go from here with computer-aided design? First, the experience in Univac indicates that very few processes lend themselves to total automation. They can be reduced in both time and cost through the use of CAD, but attempting total automation is prohibitive. (Reference Figure 4). Many processes can be nearly automated at cost effective dollar expenditure. This figure, although theoretical is based on Univac experience. In this case, a process is 95% automated for a 50% dollar ratio. To automate the other 5% of the process would require an equivalent expenditure. At this point the cost effectiveness of CAD decreases. Again, CAD is only an aid to user.

At Univac the outlook in CAD will be toward more interactive devices to provide a greater on-line capability. The interactive devices will include both large-scale graphic systems and alphanumeric CRT terminals. Large-scale graphic systems will be used as an aid for interactive circuit assignment, placement, planar routine, card schematic layout, and logic diagrams. Alphanumeric CRT terminals will augment current interactive capabilities.

Other design aids will be investigated and implemented when feasible. Logic simulation will require a further approach which functions at a module level, i.e., arithmetic, control, etc. This is a systems level simulation using the algorithms derived from complex nodal or gate level simulation. Larger systems can be simulated in total, combining the advantages of both nodal and system simulation. The greatest design aid effort will involve integration of existing software into the large-scale interactive environment.

Exploitation of automated documentation will continue. Higher speed plotters, extremely high quality COM output, and functional text-editing systems are among the tools which tend to make this procedure very cost effective. Besides the reduced cost of documentation, there is the added benefit of reduced turn-around times of documentation which is directly reflected in reduced engineering and manufacturing costs. Experience at Univac indicates that a COM is an exceptional tool for reducing turnaround time.

Improved techniques for factory acceptance test, incoming inspection, and field maintenance will require considerable effort. The increasing complexity of both circuit packages and P.C. cards dictates the need for further investigation and development of algorithms to generate test sequences and fault isolation data. Industry now lacks this capability.

Automated manufacturing techniques are prime candidates for cost effectiveness, not only from reduced labor but most importantly, increased yield. Numerically controlled drilling machines, component testers, and automated etching reduce inherent human mistakes and minimize variables. CAD techniques will provide control information as still another step toward factory automation. This phase of the design-and-build cycle will become increasingly important to the designer as he must ensure compatibility of his design with the automated manufacturing cycle.

In conclusion, Univac DSD is actively pursuing a computer-aided design philosophy of controlled automation. Univac DSD is expanding efforts and funds in those areas which can produce the greatest return on assets employed. Undoubtedly design automation must be considered as "a tool to extend the capability of man and not as a replacement for man".

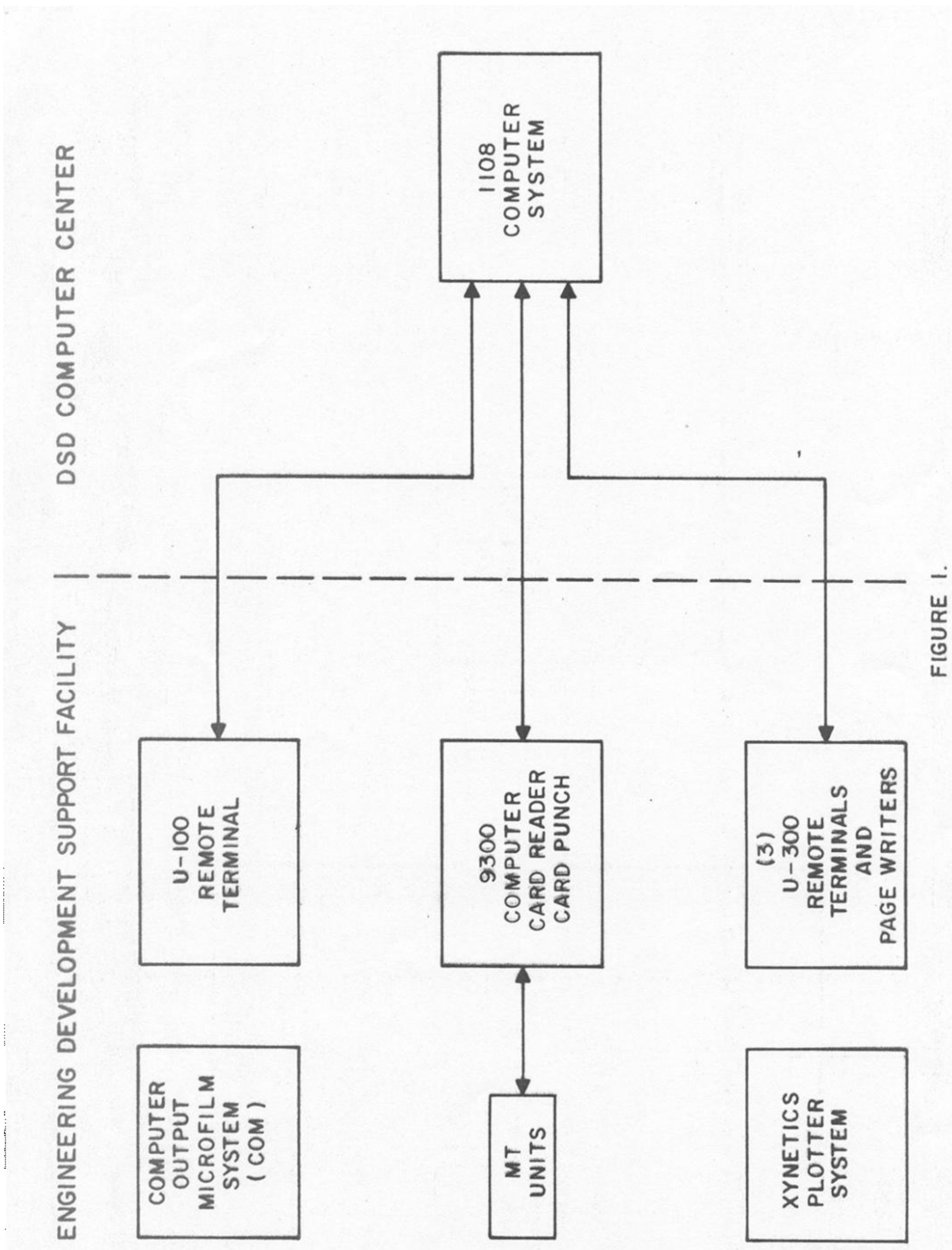

FIGURE 1.

CAD
BLOCK DIAGRAM

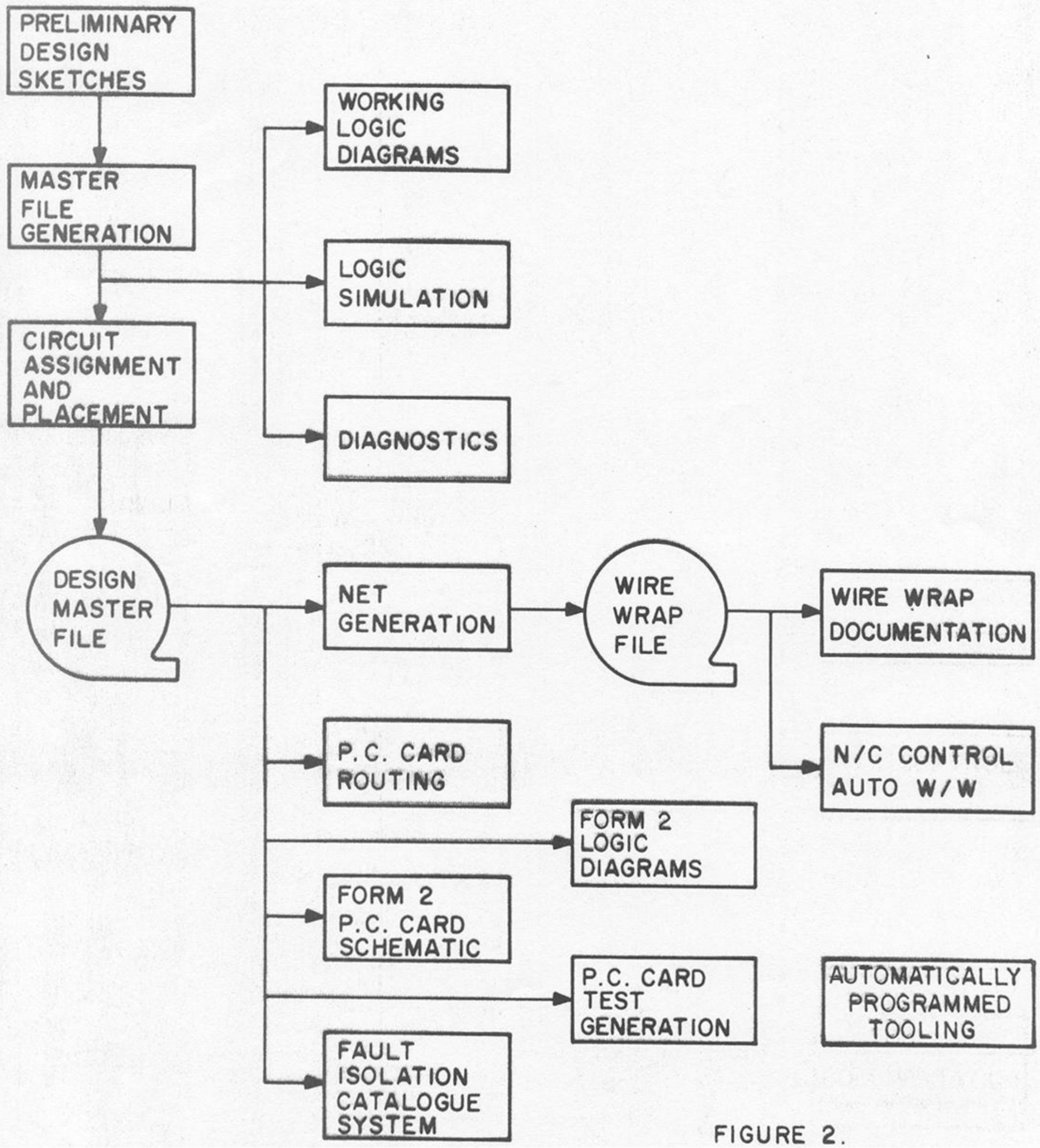

FIGURE 2.

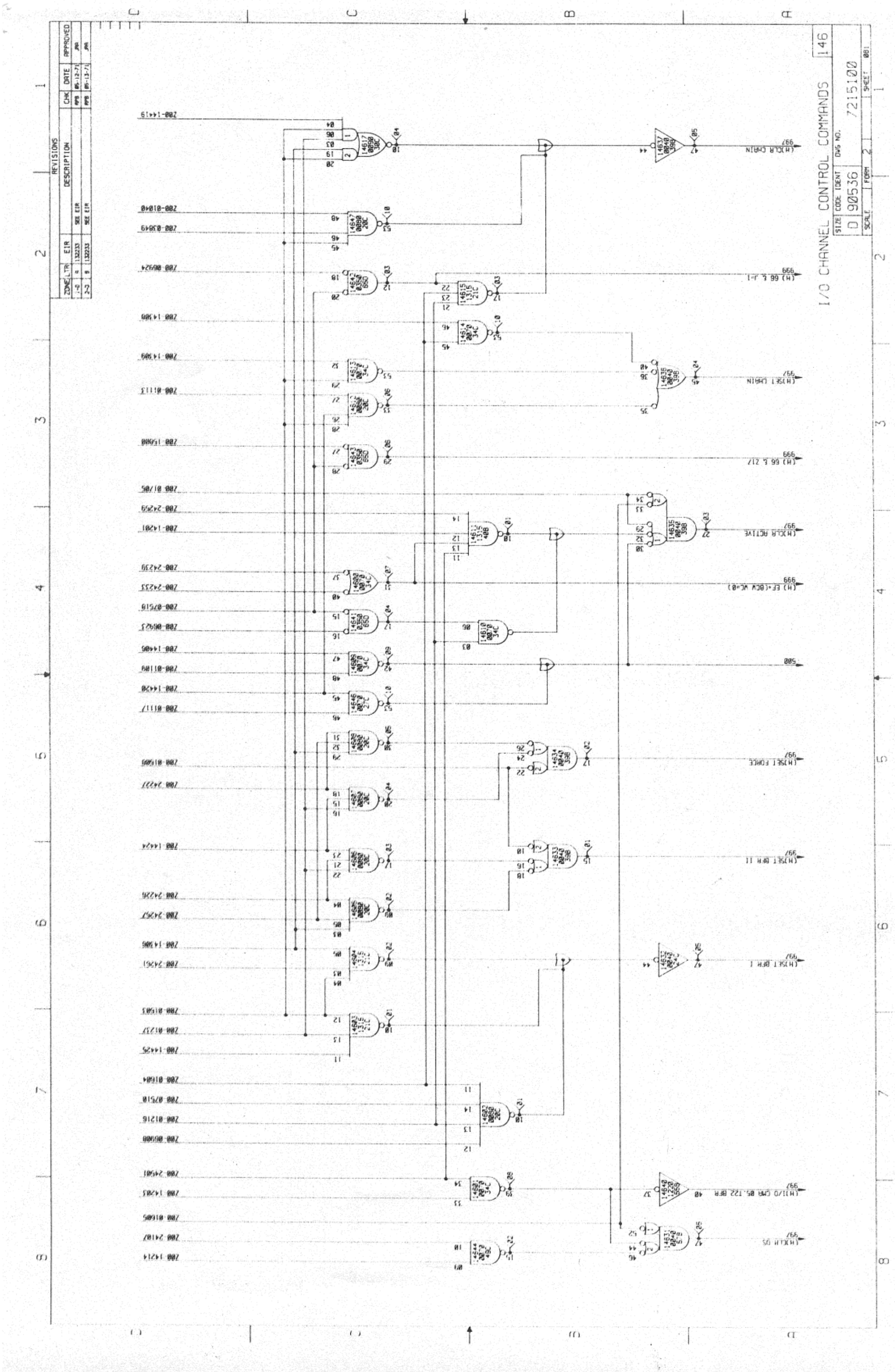

FIGURE 3

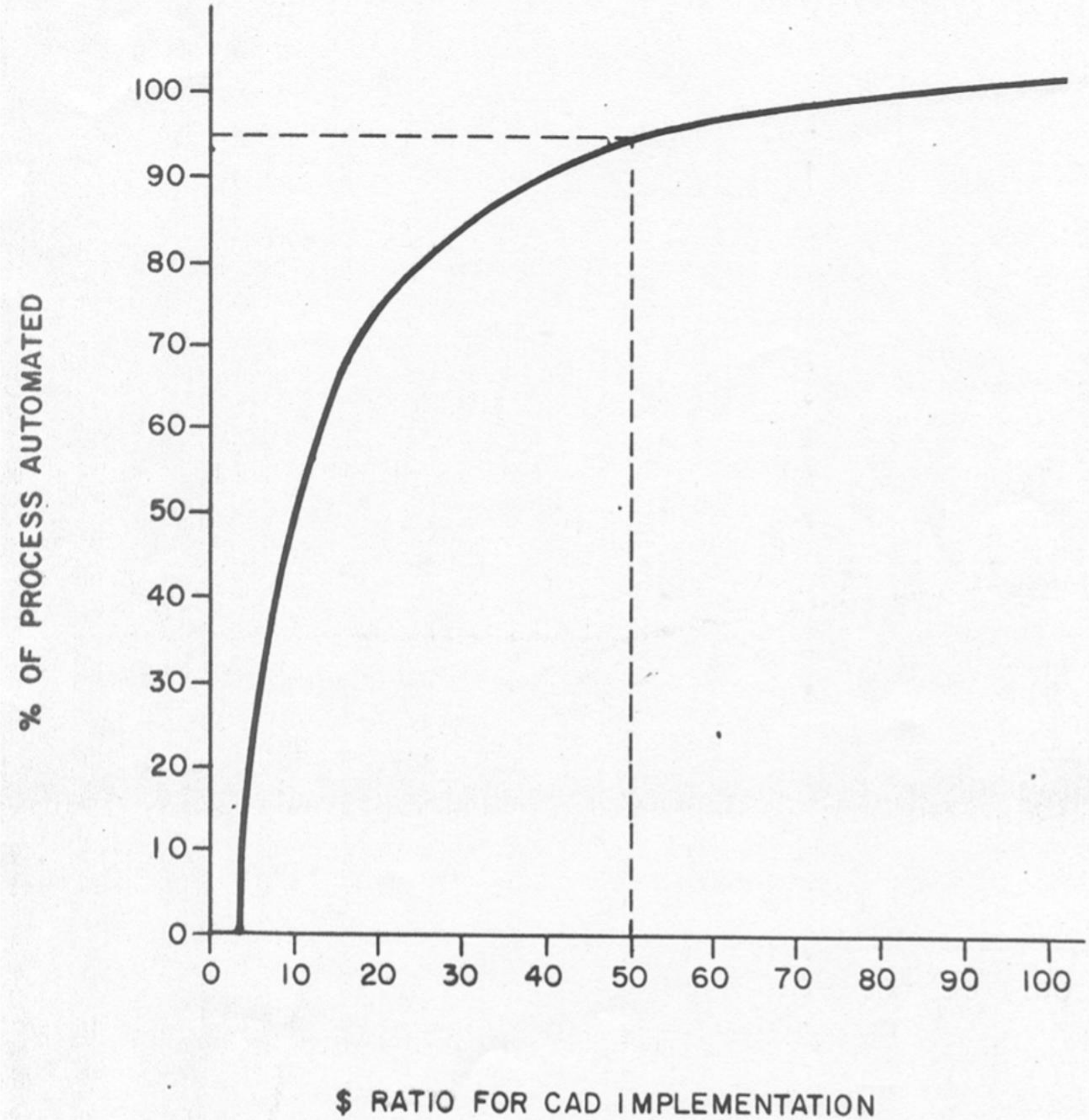
% OF PROCESS AUTOMATED
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100
$ RATIO FOR CAD IMPLEMENTATION

FIGURE 4.