

SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

September 1979
NSRP 0006

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the REAPS Technical Symposium

Paper No. 12: Network Scheduling of Shipyard Production, Engineering, and Material Procurement

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

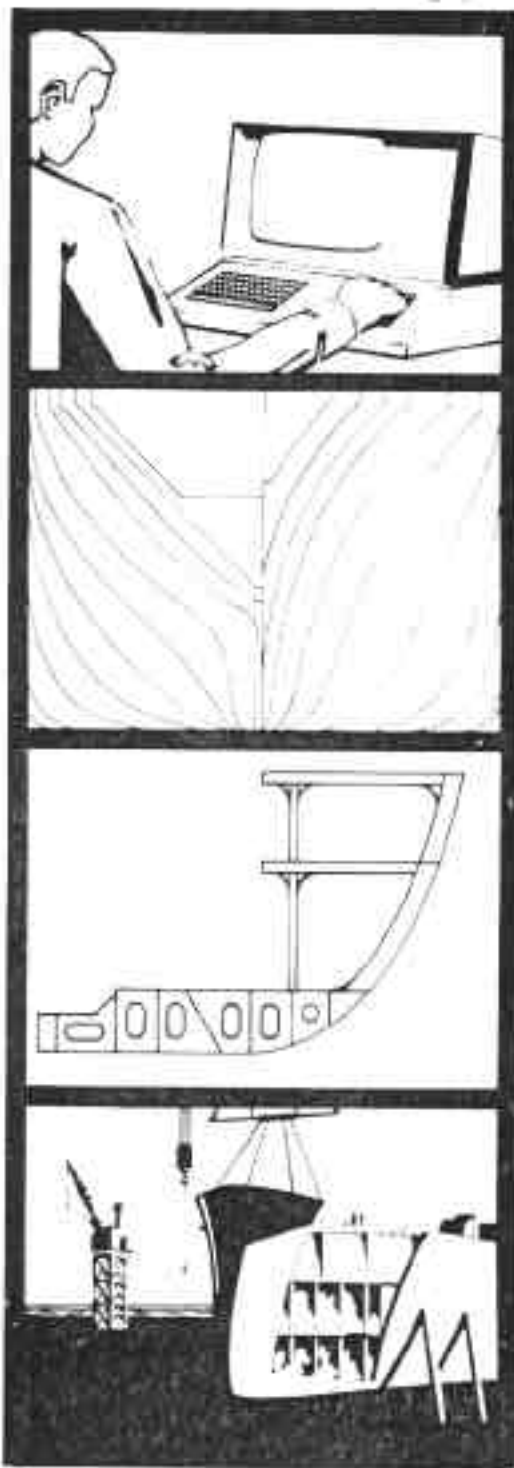
*Form Approved
OMB No. 0704-0188*

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1. REPORT DATE SEP 1979		2. REPORT TYPE		3. DATES COVERED 00-00-1979 to 00-00-1979	
4. TITLE AND SUBTITLE The National Shipbuilding Research Program, Proceedings of the REAPS Technical Symposium: Paper No. 12: Network Scheduling of Shipyard Production, Engineering, and Material Procurement				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center CD, Code 2230 -Design Integration Tower, 9500 MacArthur Blvd Bldg 192 Room 128, Bethesda, MD, 20817-5700				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 15	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

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R ESEARCH
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PRODUCTIVITY
IN
SHIPBUILDING

Proceedings of the
REAPS Technical Symposium
September 11-13, 1979
San Diego, California

COST-EFFECTIVE N/C PROCESSING IN A SMALL SHIPYARD

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As Vice-President of Engineering, Mr. Shipley is in charge of the estimating, design, and production engineering functions to support new vessel construction. He has a degree in civil engineering from Montana State University and has held the positions of Engineering Department Head, Planning and Scheduling Manager, and Project Engineer at Marinette Marine Corporation.

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Since the founding of Cali and Associates Inc, Mr. Cali has directed the continuous development of the SPADES system and expanded the company to provide complete N/C lofting services to the shipbuilding industry, with particular emphasis to the small and medium size shipyards. He has an engineering degree from the Italian Naval Academy.

Mr. Cali has over 30 years experience in all phases of shipbuilding. Prior to founding Cali and Associates, Mr. Cali held the positions of Vice-President for Engineering at Avondale Shipyards, and Director of Engineering at Litton Ship Systems.

PART I - The Shipyard's Viewpoint by W. D. Shipley, Vice President
Engineering, Marinette Marine Corporation

INTRODUCTION

My role here is to present the rationale behind the shipyard's recent decision to upgrade its N/C burning facilities and develop inhouse programming capabilities. Credits for developing and implementing the proposed changes belong to Jim Wilson in the Engineering Department at Marinette Marine Corporation (MMC) and Filippo Cali of Cali and Associates (Cali) who spent many hours researching the alternative ways of generating and transmitting N/C images for shipyard use. In addition, Russel Morgan and Douglas Gifford of the Linde Division of Union Carbide as well as Duane Holloway of Calcomp must be recognized for their active support to provide the necessary software and hardware against a tight schedule once a "GO" decision was made.

BACKGROUND

MMC began N/C burning in 1971 with the acquisition of the first production unit (Serial No. 1) of Linde Model CM100, with gas torches, and paper tape controls. The first tapes were purchased from Cali who has been our N/C source on all programs since, with two exceptions. The original burning machine was later upgraded to cut with plasma-arc as well as gas. In 1978 MMC purchased a second burning center, Linde Model CM150, with plasma and gas torches, and dual mode controls to accept either paper tapes or direct numerical-control commands.

The shipyard has realized greatly improved burning efficiencies with the combination of N/C controls and plasma torches. However, the optimization of the burning process created a new set of problems

which neither the shipyard nor Cali was willing to accept as the price of progress. Two basic problems associated with the process of generating and transmitting paper tapes were recognized:

1. SCHEDULE PROBLEMS

Lead times to produce N/C parts after contract award were often greater than the old manual methods, resulting in schedule slippages for all trades paced by steelwork. In addition, the turn-around time to make tape changes was excessive due mostly to mailing time between Cali & MMC. These changes, usually initiated by the shipyard, disrupted Cali's staff with unscheduled overloads.

2. COST PROBLEMS

The high costs for making unscheduled tape changes were passed on to the shipyard. In addition, the material cost along for high quality paper tapes was excessive. A recent cost study indicates that the shipyard would save roughly \$32,000.00 per year at current production levels by eliminating paper tapes as the N/C control medium.

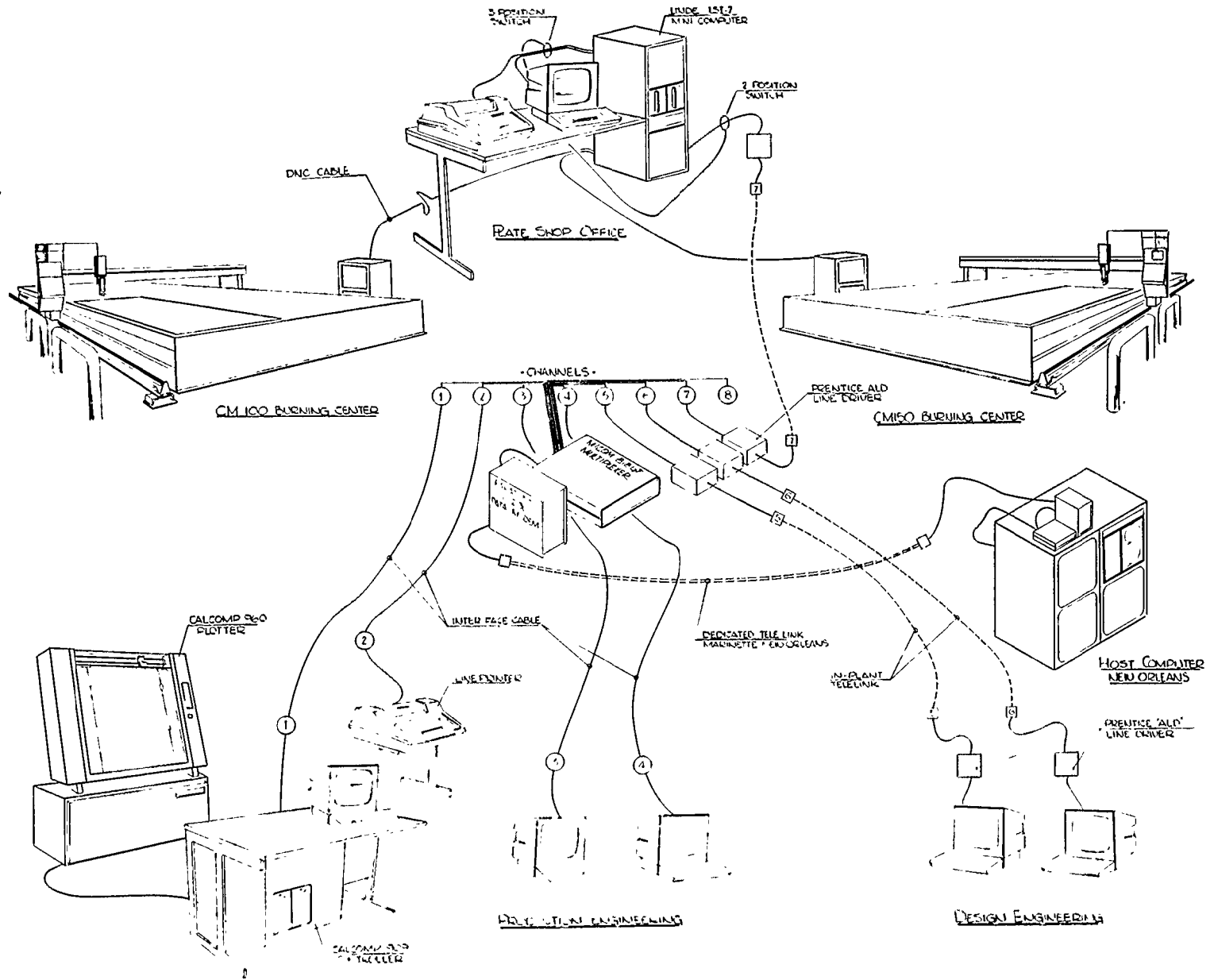
As a result of identifying these problems, it was concluded that the shipyard must develop greater control over the schedules and costs of generating N/C programs. Two goals were proposed and adopted for further study:

1. Convert the burning machine controls from paper tape to DNC mode with direct telecommunication between the burning machine and the host computer to minimize transmission delays between Cali and MMC and to also eliminate paper tape material costs. This change was easily justified as both schedule and cost effective on its own merits.

2. Develop the capability within the shipyard to ultimately perform all N/C programming inhouse. This goal was highly constrained by a tight capital equipment budget and the difficulty of recruiting and training programmers. After considerable "brainstorming" between Cali and MMC **people**, it was concluded that a two-phase approach was the optimum solution. The first phase, now being implemented, would give the shipyard the inhouse capability to plot, verify, and nest parts generated and transmitted by Cali directly to the shipyard over a dedicated telecommunication line. The second phase would add the capability to generate parts inhouse after Cali's new Interactive Graphics System was fully developed and proven.

STATUS

Both proposals (convert to DNC and add partial programming capability) were approved on May 16 this year. The plotter was on line with Cali by June 23 and the first part images were transmitted on July 7. The DNC conversion and checkout is on schedule for completion by september 30, 1979. The shipyard's Management is impressed and pleased with the rapid progress made to implement-the adopted changes. Details of the system will be covered in the second part of this paper. Finally, MMC intends to further utilize the new hardware in the near future with the addition of ship design software modules..



PART II - Technical Development and Hardware by Filippo Cali, President,
Cali and Associates, Inc.

Background History of the Development

In order to present the technical side of Marinette Marine's Installation I think it is proper to review the past events that led to it. It was in 1976 that Cali & Associates developed, jointly with Avondale Shipyards, the interactive graphics version of the Spades System. A paper on the subject was presented and a movie shown at the 1976 Reaps Symposium. While this software has been used successfully by Avondale, the requirement of a large IBM/370 Main Frame and expensive IBM 2250 CRT's has prevented us to use it in the course of our N/C service work or to make it available to any other Spades user.

During the fall of 1978 we started looking for alternatives that would allow us to continue Interactive Graphics Development and not require a large capital investment in hardware. The present I/G version of Spades includes:

- Part generation
- Nesting
- Shell Development
- Data Base access and display

It is our intention to further improve the nesting by combing with it an automatic nesting capability utilizing the Bill of Material, Modules Break-down and N/C information collected by the "SPAC" (Shipbuilding Production and Control) module of Spades.

The other area that needs development is the generation of 2 dimensional drawings for engineering and 3-D (isometric) drawings for production using graphic CRT's.

In December we selected the host computer we wanted to use and we placed an order with Prime Computers for the following hardware:

P	400 CPU with 1 Megabyte Core	
2	300 Megabytes Disk Drives (Removable packs)	
1	Mag Tape Drive (800/1600 BPI)	
1	600 LPM printer	
1	300 CPM Card Reader	
2	Bisynchronous Ports	
16	Asynchronous Ports	
4	80 Character Alphanumeric CRT's	
1	132 Character Alphanumeric CRT (VT 100)	ADDED
1	150 Characters Per Second Teleprinter (T.I. Omni 800)	LATER

A tentative selection was also made for the graphic CRT's, but the order for two 3205 IMLAC's was not placed until July this year since we would not have had the resources for the conversion and further development of the graphic software until completion of the equivalent task with the standard batch version of Spades.

The "Prime" computer was installed on February 1, and by April 1, the conversion and checkout of "Spades" and Data Base Conversion Program was complete.

Even though many changes were necessary, they were made in such a way to maintain total compatibility with the "IBM" version used by all other "Spades" users. This was essential in view of our commitment to release yearly the current version of "Spades" with all latest improvements to all users at no cost. It goes without saying it that we make sure the implementation of each release is totally transparent to the user, i.e. "Spades '80'" is totally compatible with Data Bases and input data generated with "Spades '70'".

The program to convert the binary Data Base works both ways from "IBM" to "Prime" and vice versa. That is we generate, using the "Prime" computer, an "IBM" compatible mag-tape to be read directly into a "Spades" "IBM" Data Base.

Since April, when we switched to "Prime", we have concentrated our effort to improve our operation efficiency in that environment, with two broad goals in mind:

- Easy access and use of the system through the various alphanumeric "CRT's"
- On line access and display of the Data Base for all data suitable for alphanumeric display.

During this period the possibility of remote entry and "DNC" (Direct Numerical Control) became more real than in the past. This subject had been discussed many times with Marinette but always postponed because of the capital cost of the hardware and cumbersome software (RJE, HASP, etc.)

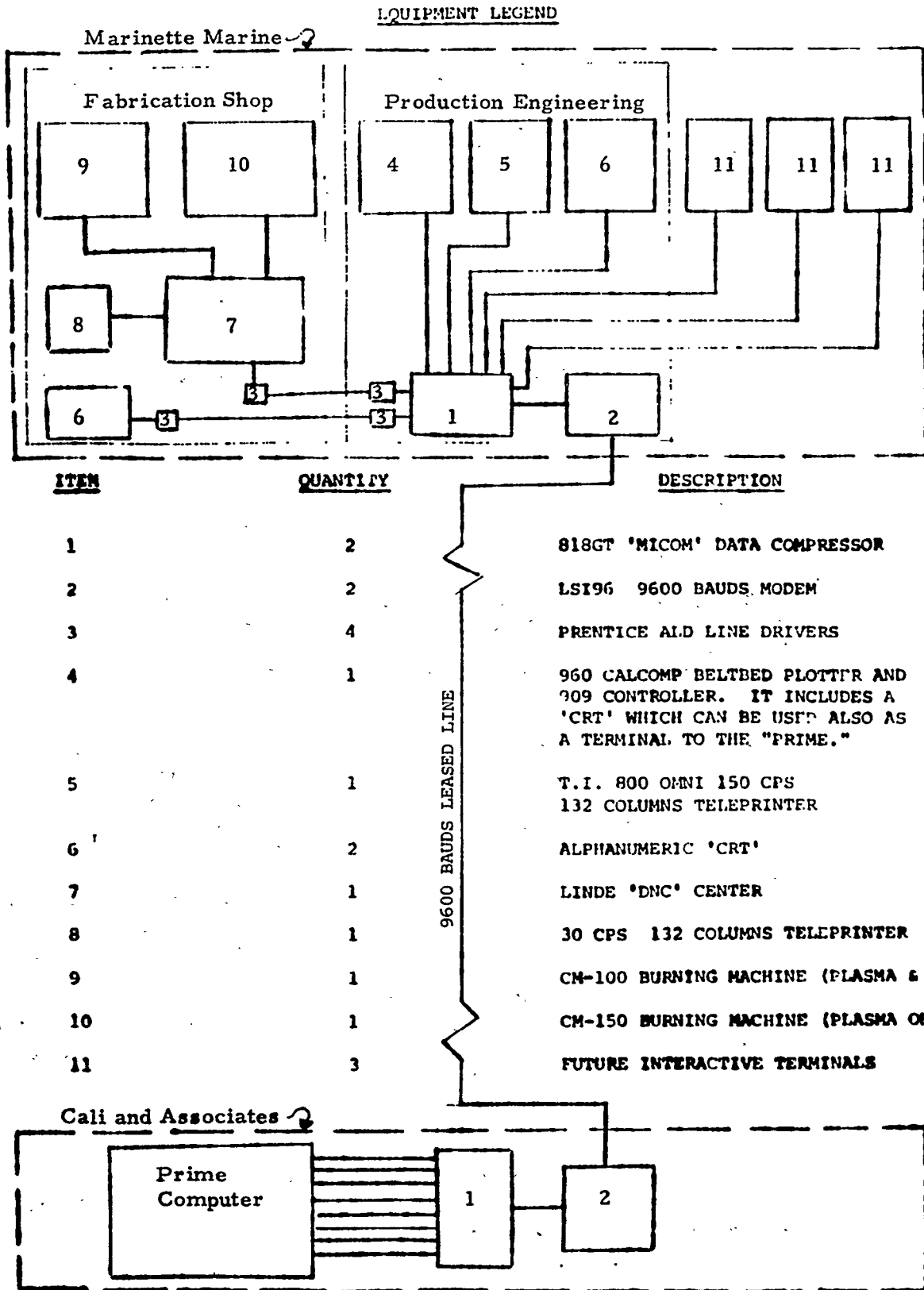
Even with the "Prime", which can host a 2780 terminal, our first approach was again the conventional remote entry with enough hardware at the remote site to handle the numerous communications with the host needed in a shipyard using numerical control in a "DNC" mode. Of course, this alternative precluded totally in line access to the Data Base for both alphanumeric and graphic CRT'S. While looking for communication equipment, we became aware that both cost and availability of hardware had improved to the point where a totally different alternative was possible. Additional software would be needed in the "Prime" to handle the plotter and the burning machine, but the increased flexibility and reduced cost at the shipyard made it worthwhile.

This alternative was discussed with Marinette Marine and at the end of May their management decided to go ahead with it. By the end of June, communication was established to access the "Prime" and drive the Calcomp plotter. Following is a detailed description of the entire installation.

Detailed Description

Fig. (A) shows all components. All devices at the shipyard, in so far as the user is concerned, are at all times in direct and independent communication with the host. Each one is "TTY" compatible and uses an Asynchronous Line.

Figure A



All lines go through the Micom 818GT Data Compressor which packs all data for synchronous transmission through the Paradyne Modem at 9600 Bauds across a four wires dedicated line from the shipyard to our offices in New Orleans. A matching set of Modem and Micom reverses the packing and distributes all data to the corresponding eight Asynchronous Lines going to the "AMLC."

The advantages of this approach can easily be appreciated when we consider the following sample list of communications with the "Prime" being handled simultaneously:

1. In the burning machine shop the LINDE 'DNC' Center is receiving and storing in floppy disks N/C tape images to be routed to either of the two burning machines.
2. Still in the shop the 'CRT' is being used to request additional tape images from the "Spades" Data Base or perhaps request a tape image for a single piece, part of a previously cut nested plate, that has been misplaced, damaged, or affected by design changes.
3. In the Production Engineering Department the Calcomp plotter is receiving plotting data to either plot directly or store on floppy's for later plotting.
4. In the Production Engineering Department another 'CRT' is being used to enter input data for execution by "Spades." This function not only replaces the traditional keypunch, but stores the data at the same time in the "Prime."
5. In the Production Engineering Department another 'CRT' is being used for any other miscellaneous task such as:
 - . Execution of any "Spades" module
 - . Requesting additional plotting files for the Calcomp plotter
 - . Accessing the "Spades" Data Base in real time to display and check data or to enter data such as recording the validation of a part or putting under hold a burning machine tape image affected by drawing changes.
6. In the Production Engineering Department the printer is receiving hard copy of title blocks and processing time associated with nested tape images to be released.
7. In production control, a 'CRT' is being used to access "SPAC" to check the status of lofting for a construction module or perhaps to extract the corresponding Bill of Material.
8. In the Design Engineering Department a 'CRT' is in use to enter data and generate hydrostatic curves, damaged stability tank capacity and sounding tables, etc.

The advantages of the above capability over that of a conventional remote batch entry are obvious enough to not require any further elaboration.

The baud rate presently assigned to each of the channels is 1200 with the exception of the calcomp plotter which uses 4800 baud's. This distribution is more than adequate when we consider the human speed at each terminal and the buffering and "No Dead Air" capability of the 818GT Micom. Marinette's plans for the near future call for the use of the interactive graphic version of "Spades." I would assume at this time that a four channels installation similar to one above will be required with each channel rated at 4800 bauds. In order to better support both our own and remote graphic terminals we have already scheduled the upgrading in the first quarter of next year, of our CPU from the "400" to a "750."

Supporting Software

To make the Marinette installation a practical reality, a considerable amount of supporting software had to be conceived, developed, and implemented :

- . Spooling programs to handle communication and transmit data to the burning machines and to the plotter with the appropriate protocol each required.
- . The generalized "Spades" post-processor had to be modified to include the Calcomp. This is one of the instances when the modular structure of the "Spades" system has paid off handsomely. By changing the post-processor all "Spades" modules with graphic output acquired the Calcomp option, whether to plot a set of curves of form or a nested tape image.
- . All procedures for execution of Spades both batch type or interactive had to be modified to recognize each user and check the right of the user to access any of the ships in the Data Base. That is, Marinette can only access Marinette jobs.
The "Spades" output also had to be screened to insure compatibility with the receiving device, i. e.
 - . The burning machine should only receive data in the format required by the LCNC-6 and UCNC controllers.
 - . The Calcomp Should receive only Calcomp plotting data.
 - . Form control for the printer has to be the appropriate for that type vs. the conventional 600 LPM printer at our office.

The development of this software required in some cases a considerable amount of adaption on our part. For instance the "909" controller of the plotter does not allow at the present storing **more** than one plot file in any one disk. To accept this limitation, it would have **meant** a continuous changing and storing of floppies. Instead, the spooler was designed to keep the plot file open and accumulate all the separate drawings in one single plot file, that would be closed only at user's request. This, of course, imposed the necessity of creating Calcomp search addresses (pointers within the plot file), associating them with the user's drawings' names and recording them for future reference to the user when plotting in a random sequence from the plot file.

As a further aid to the operator of the plotter, changes were made to "Spades" System that cause a stop at the beginning of each logical drawing and display a message on the 'CRT' stating X & Y dimensions in inches required by the drawing. If the "Spades" system finds the area required by the drawing to be larger than the maximum for the plotter the scale is automatically reduced and a message displayed to the operator.

This last feature is now part of the system for all installations whether or not operating in a "DNC" mode. The only difference being that the message is written on the drafting machine through the paper tape itself.

Closing Remarks

The entire development described above would have not materialized without Marinette Marine's tradition to commit to new technology without waiting to be proven first somewhere else.

I would like also to take this opportunity to point out that, as in the past for all "Spades" developments, this also was accomplished with financing from the private industry without any government grant and associated red tape. The April to July time span from conception to implementation of this project offers in itself the best proof of the cost effectiveness of the free enterprise approach vs. government financing.

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