

NSRp-0139

MANUFACTURING TECHNOLOGY
FOR
SHIPBUILDING

SHIPBUILDING TECHNOLOGY TRANSFER

U.S. DEPARTMENT OF TRANSPORTATION
MARITIME ADMINISTRATION

in cooperation with
Avondale Shipyards, Inc.
New Orleans, Louisiana

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MOLDLOFT, PRODUCTION CONTROL ACCURACY CONTROL
AVONDALE SHIPYARDS INC.

First Day - November 3, 1982,

~~07:30~~	08:00	Coffee
~~08:00~~	08:30	Overview and Background
		O. Gatlin
~~08:30~~	09:00	Introduction
		E. Blanchard
~~09:00~~	10:00	Production Engineering
		B. Oehmichen
~~10:00~~	10:15	Coffee
~~10:15~~	11:45	Moldloft
		B.-Pourciau
~~11:45~~	13:00	Lunch
~~13:00~~	14:30	Material Control
		F. Logue
~~14:30~~	14:45	Coffee
~~14:45~~	16:15	Accuracy Control
		J. Taylor and W. Weidman
~~16:15~~	16:45	Questions & Answers

Second Day - November 4, 1982

08:00	- 08:30	Coffee
08:30	- 09:00	Production planning Interface
		C. Starkenburg
09:00	- 09:30	Engineering Department Interface
		T. Doussan
09:30	- 10:00	Steel Department Interface
		R. - Marks
10:00	- 10:15	Coffee
10:15	- 11:00	Production Operations Interface.
		J. Taylor.
11:00	- 11:45	Questions/Discussion,
11:45	- 13:00	Lunch.
13:00		ASI Tour

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Research Institute**

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MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

OVERVIEW AND BACKGROUND

Prepared by: O.H. GATLIN

Graph 14 PE, 13, 12 EE

These graphs are for aggregate costs. They are not traceable through the system. I.E. delays in one area cannot be traced into the future to predict impact on schedule. Luckily for ASI — lean times mean can put extra people to work — if it is really packed I & others most notably (Exxon) have doubts about how this will work

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL OVERVIEW AND BACKGROUND

1. INTRODUCTION

MarAd, over the past several years, sponsored a series of studies on the level of technology. In fiscal year 1980, MarAd and Avondale cooperated on a "Technical Evaluation of Avondale's Production Operations and Organization, the Development of a Long Range Facilities Plan, and the Integration of Both," under Contract No. MA-80-DOC-01017. The technical evaluation of Avondale's Production Operations and Organization was performed by Ishikawajima-Harima Heavy Industries (IHI). In this study, Avondale concluded that they could significantly improve their productivity by using the IHI technology. But, there are so many areas that could be affected - many of which are outside the shipyard control - that Avondale could not implement all of the recommended changes at one time.

In order to improve productivity the most with the least amount of disruption, Avondale proposed to implement four of the IHI systems recommended in the Technical Evaluation. They are:

- Accuracy Control
- Production Planning
- Computer Application

Design Engineering for Zone Outfitting with Procurement Specifications.

This effort was to be a demonstration intended not only for the benefit of Avondale, but of all U.S. shipyards. Avondale was required to work closely with MarAd and the U.S. shipbuilding community to insure adequate dissemination of all information.

II. OBJECTIVES

The objectives were to decrease the time between the contract date and ship delivery and to increase productivity and reduce cost.

The following specific objectives arose out of the Technology Evaluation:

- implement the IHI system of accuracy control at Avondale
- implement the IHI system of production planning at Avondale
- implement the IHI system of computer application at Avondale
- implement the IHI system of design engineering with procurement specifications at Avondale.

Each of the four systems were broad and extensive. In order to implement the systems, the following action was taken:

- A) We selected the specific elements within each of the four systems which realize the most significant improvement in productivity with the least amount of disruption during integration period.
- B) We determined to what extent the selected elements must be tailored for adoption for Avondale and for use as an Americanized version of Japanese technology.
- C) We determined what elements of the four systems are measurable and that a comparison can be made between the method previously being used and the method finally adopted.

We will tell you the organization adjustment problems encountered and how they were overcome.

The subject of this seminar is Moldloft, Production Control Accuracy Control. An agenda of the seminar is included in the hand-book. For future planning purposes, all the seminars we plan to hold are scheduled as follows:

- Production Planning & Scheduling - May 18-19, 1982
(Complete)
- Design Engineering for Zone Outfitting July 21-22, 1982
(Complete)
- Production Control Lofting, Accuracy Control & Line Heating - November 3-4, 1982

Each seminar is organized to cover in-depth the primary subject. Additionally, we will present the influence or interface and effects of Design Engineering for Outfitting to the other departments or subject areas.

This may not be the best approach; however, we feel it is able to demonstrate that implementing this technology requires that all departments of a company must work as a team and re-align their thinking in order to succeed.

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

INTRODUCTION

Prepared by: E. E. BLANCHARD

Gene

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL INTRODUCTION

I. INTRODUCTION

This will be the third seminar presented by Avondale Shipyards on the transfer of IHI technology. We will address three areas of production upon which IHI technology has had a great effect, i.e. Moldloft, Production Control (production Engineering/Material Control) and Accuracy Control.

Today's seminar basically covers those activities that take place from the "Moldloft Meeting" (month nine of construction period) through delivery of the vessel. (VIEW GRAPH NO. I-1)

The "Process Lanes" approach to hull construction has been implemented at Avondale and, as a result, many changes as well as additional job functions have occurred within these three departments. In the case of Accuracy Control, a completely new department was established.

I would now like to point out the major areas of change and/or additions to these departments. I will try to be brief since the presentations of today will be very detailed.

A. MOLDLOFT

In the Moldloft the existing personnel were restructured to suit the many new functions that were adopted. A list of the new functions are as follows:

- the establishment of a Moldloft Planners and Scheduling Group;
- the production of steel tapes used for layout;
- the production of line heating templates;
- the preparation of key line marking information;
- the formulation of a new piece marking system.

Another new Moldloft function and perhaps the most significant was the establishment of the unit control manual group. This new group has undertaken the task to produce simplified working drawings and cutting information for the

production worker. These drawings are produced with an integrated "Spades/Cadam" system.

The drawings produced tell the worker "what he needs to know" to accomplish his work with the utmost of efficiency. This new U.C.M. Group required additional workers which were drawn primarily from other departments that had previously produced the same information in a different and much more complicated format.

This new system of Moldloft information and working drawings has been successfully implemented on a current contract, the construction of three product carriers for Exxon.

The results have been very satisfactory. We feel the new system reduces the error rate in production because of built-in validation during the production of Unit Control Manuals on the Cadam tubes. We have also consolidated the information center, which reduces the possibility of transformation errors.

The production workers have been instrumental in the development of the format in which Moldloft information is now being furnished to them to perform their duties. Therefore the information answers their needs and, as a result, the system has shown to be very accepted, cost efficient and resulting in increased productivity.

B) PRODUCTION ENGINEERING

"Process Lanes" has resulted in changes to our Production Engineering policies and techniques.

The most important document, the "Production Estimate," is used as a guide by the production engineers to issue the budget to the work centers. This document has undergone a major change in format due to "Process Lanes."

One "Process Lane" concept is to categorize hull structure into "like" or "similar" kinds of work and then set aside specific work centers to accomplish each work category. This now allows the production engineer the flexibility to establish a cost code system which will be compatible with the specific work center and the specific category of work that the center will accomplish.

The new cost code will make each "work center" a "cost center" thereby allowing management to observe work center efficiency as well as monitor job cost. The concept of

scheduling the same category of work to a specific work/cost center opens up a new spectrum of cost collection and analysis.

Organizational changes have also occurred to insure continuity between all departments. The Production engineers on the Exxon contract have been divided into two groups. One group will manage hull and the other will manage outfitting. Other contracts, work started prior to "Process Lanes," are still being managed by our method of a craft-by-craft approach. Eventually, the entire department will be structured into hull and outfitting categories.

The new cost code system of work centers will allow for grouping many items of work and, as a result, will greatly reduce the paperwork. The reduction of work orders (approximately 60%) will affect savings in the Data Processing Department, as well as reduce the burden of field supervisors who are required to manage and report progress on these work orders. With less time devoted to this paperwork, the supervisor can spend more time with his workers and work toward increased productivity.

C. MATERIAL CONTROL

The basic concept of good material control is effective material flow. The main objective has been to minimize the number and length of material movements, reduce bottlenecks, meet production schedules, and reduce the ratio of material handling time to production time.

Prior to "Process Lanes," approximately 61% of all hull steel was received from the Plate Shop, sorted, palletized, stowed, and finally issued to the field by the Material Control Department. This became a burdensome task, requiring a large number of employees. Today, with "Process Lanes," steel cutting is scheduled and work stages level-loaded to the point that 92% of cut steel flows directly to the fabrication platens.

As a result, the number of workers previously handling hull steel has been greatly reduced. In addition, the cost of transporting that material has been reduced by 85%.

An average of 82 trips per week to and from the fabricated steel area has been reduced to 12 trips per week, as a result of "Process Lanes."

Another benefit of this reduction of hull steel storage is the vast area of valuable real estate which became available for other use. Presently, that area at Avondale is utilized as an assembly area for main deck pipe packages.

Another cost savings which cannot be measured is the reduction of lost and/or misplaced material due to the additional handling at the storage area. The lost/misplaced parts are very disruptive to schedules and have a negative effect on cost..

Although there are other changes to the Hull Steel Material Control Section, this is by far the most cost effective area of change.

The pre-outfitting material is now being marshalled by the Material Control Group and palletized from pallet code listing furnished by the Production Planning Department. This pre-outfitting material such as ladders, handrails, foundations, etc. are received from fabrication shops, palletized per pallet list, and shipped to the pre-outfit work stage as scheduled.

The outfitting items, like the hull steel parts, were previously received at the material control storage area by shipsets, then stowed and issued as required. Prior to "Process Lanes" methods, outfitting items suffered costly damage and deterioration from the elements.

The last area I would like to comment on is the control of pipe spools by the Material Control Department. Upon completion of Avondale's semi-automated pipe facility and the development of pre-outfit planning and scheduling, we now have a smooth flow of pipe spools scheduled pallet-by-pallet. This allows for better control and reduced cost. On previous contracts, pipe spools were fabricated system-by-system and required long term storage which subjected the material to damage and deterioration.

The Material Control Department, as a result of "Process Lanes," has become more productive and efficient with reduced effort and cost.

In conclusion, cost savings has been realized as a result of reductions in manpower, equipment, real estate and energy usage in the Material Control Department. As a result of "Process Lanes," material handling will be reduced by as much as 30%.

D. ACCURACY CONTROL

The Accuracy Control Department is a newly formed group consisting of four qualified engineers. The efforts of this group are aimed at development of accuracy standards and assembly sequences to be used by each production stage for proper accuracy control.

Studying and implementing tools and jigs which will assist in maintaining accuracy is another function of the group.

Development of "forms" has also been beneficial. These forms contain pertinent feed-back information required from each work stage to assist in monitoring accuracy of each work center.

These efforts have already resulted in the ability of Avondale to produce true, accurate hull unit assemblies (Category 1) in a neat condition at the assembly stage of construction. The erection of units without stock will result in a considerable savings of time and cost at the erection stage.

The Accuracy Group interfaces with all departments of the shipyard. For example, they have been instrumental in updating expansion factors used in the Moldloft for parts generation. They have, through a feed-back system to the Design Engineering Department, caused design changes which have resulted in cost savings. While monitoring the work at various stages, they have determined certain items of work which should be routed through other "Process Lanes" for improved cost. This information is then fed back to the Production Planning Group for revision in work breakdown structure.

These are only a few of the many functions of the group. Some extend beyond the scope of Accuracy Control. These are fall-out benefits which also contribute to cost reductions.

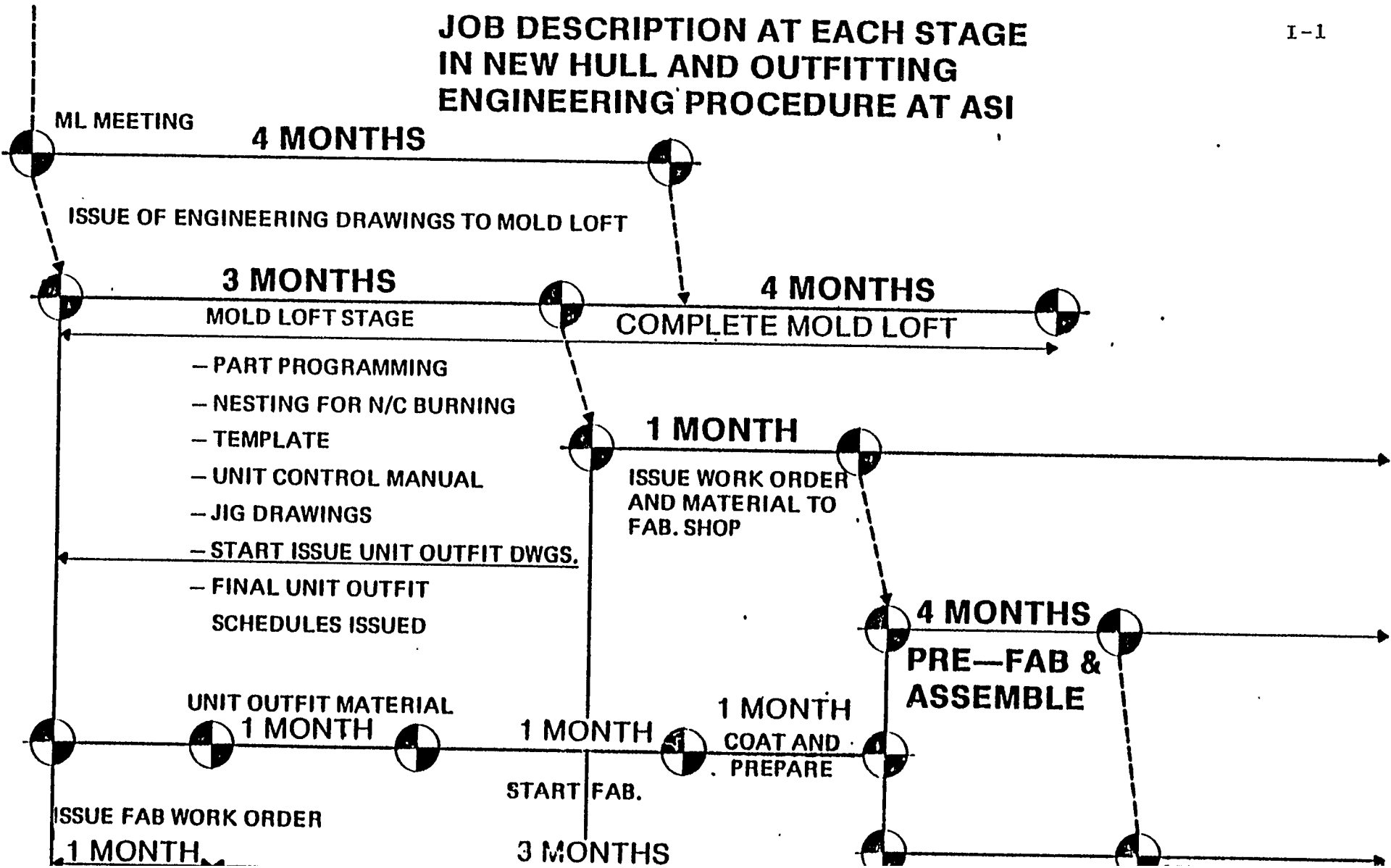
To date, the results of this group have shown to be very successful in improving dimensional and accuracy control of work being performed at Avondale Shipyards.

II. CONCLUSION

The presentations of today will reflect in detail many of the changes adopted from the transfer of IHI technology at Avondale. Some of these systems existed previously, but changes to them were influenced by IHI. The systems that will be Presented are currently being used at Avondale Shipyards. They have resulted in improved planning and scheduling, increased productivity, and reduction in costs.

**JOB DESCRIPTION AT EACH STAGE
IN NEW HULL AND OUTFITTING
ENGINEERING PROCEDURE AT ASI**

I-1



MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

PRODUCTION ENGINEERING

Prepared by: R. OEHMICHEN

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
PRODUCTION ENGINEERING

I. WORK ORDER ESTIMATING AND PREPARATION

A. THE WORK ORDER SYSTEM AT AVONDALE SHIPYARDS, INC.

The Work Order is management's primary means to initiate all production work, monitor cost, progress against schedule, and efficiency.

The document is prepared by the Production Engineering Department and appears in two different forms which are:

1. Shop Order - (VIEW GRAPH NO. 01PE) - used primarily for packages of work to be accomplished at a specific machine within a work center, such as a lathe in the machine shop, or at a numerical control burning machine.
2. Work Order - (VIEW GRAPH NO. 02PE) - used primarily when the work effort has progressed beyond the pre-fabrication stage and usually describes fabrication, assembly, erection or installation work.

For the purposes of this presentation; we will address the system as it applies to estimate preparation and cost monitoring, primarily of hull work. This is the area most affected by that aspect of the IHI technology transfer known as Process Lanes.

B. PREREQUISITE PRODUCTION EFFORT

Before the work order can be prepared and used as a cost collection "tool," certain other production functions must, in order of priority, take place. So that a better understanding of the Production Engineering effort required in the preparation of the work order, its contents, and usage of cost collection, a brief summary of those requirements will be addressed.

1. Master Plan - developed from a meeting, or series of meetings, attended by those in Production and Engineering management outlining the specific major contractual requirements of the job, such as key event dates leading up to and including delivery, where delivery is to take place, and any special criteria for review regarding the formation and development of schedules and proposed methods of construction.

2. Hull Unit Arrangement - a breakdown of the hull configuration into smaller blocks called modules or units - prepared by the Production Planning Section.
(VIEW GMPHNO. 03PE)
3. Hull Unit Summary - prepared by the Production Planning Section - describes in detail how, and at which work center, the hull unit construction will take place.
(VIEW GRAPH NO. 04PE)
4. Long Term Schedules - prepared by the Production Planning Section to reflect the best overall construction schedule consistent with criteria set forth by the Hull Unit Summary and at the same time providing for work center level loading for steady flow of product and a constant level of manning.
5. Short Term Schedule - a hull work schedule produced mainly for final level loading of the work center, and published by the shop or work center planner under the direction of the area manufacturing superintendent to insure a steady day-by-day flow of material and manufactured product.
6. Unit Weight Calculation - prepared by the Hull and Structural Section of the Design Engineering Department. Effort includes LCG, VC.G and TCG.
7. Contract Specifications and Developed Engineering Drawings - prepared and furnished to the Production Department by Contract Administration and the various Design Engineering groups.
8. Unit Control Manual (UCM) - a set of construction drawings prepared by the Numerical Control and Moldloft Section to reflect the required construction information in booklet form for each stage of hull unit construction for each of the hull units as described in the Hull Unit Summary.
9. Production Plan (VIEW GRAPH NO. 05PE) and Summary Estimate (VIEW GRAPH NO. 06PE) - a detailed breakdown of direct labor in manhours prepared by the Production Engineering Section. The Production Plan allocates the overall manhour budget for each vessel of a contract divided into trade or craft cost groups, sub-groups, and items in accordance with work/cost center schedules, outfitting schedules, and the Cost Code Manual produced and maintained by the Comptroller. The Summary Estimate is prepared as the "top sheet" of the Production Plan and summarizes the craft budget totals.

C. THE PRODUCTION ENGINEER

Within the Avondale Production Engineering Department is the individual Production Engineer. The responsibility of each individual engineer varies between craft or discipline and is basically subdivided between three (3) distinct sections the three sections being Hull, Outfitting, and Mechanical. Each section works from standards which have been developed from past history and are experienced with problem solving relative to their work. Although the standards and problems vary between the sections, there are those responsibilities which are common to all three. Those are:

- working drawing take-offs and preparation of direct labor cost estimates;

- the preparation of work orders to the various manufacturing facilities in accordance with the production Plan and the various hull, outfitting, machinery, and testing schedules;

- to assist the planning engineers with required direct labor manhour estimates or manning requirements that may be required in the preparation of schedules and information regarding the most economical and practical manufacturing areas in which to place construction;

- to monitor the production progress of the program and take necessary steps to insure its scheduled completion in a timely and economical manner;

- to work closely with the Design Engineering Department, especially in the early stages of design, to insure the incorporation into the design of established economical production techniques and practices;

- to study the various prepared cost reports to stay abreast of the direct labor expenditures relevant to the program to which he or she is assigned;

- to prepare cost projections as may be required by management;

- work sampling as required in the analysis of work order cost returns to determine production efficiency and verification of work standards;

- to make and/or propose changes in the production effort, where cost overruns are projected;

- last, and perhaps the most important, is to assume the initiative, that as a production engineer, ALL DEPARTMENTS WORK FOR HIM, to the extent that if he or she is, in fact, actively striving for the highest production efficiency, best possible cost, and to make a profit, all departments will give him their cooperation; and that he or she should provide the leaders toward a profitable contract, and in this sense, set the example and strive to extract from all departments their best effort.

II. HULL WORK COST COLLECTION AND MONITORING

The work order (VIEW GRAPH NO. 07PE) is prepared by the Production Engineer for a specified portion of hull construction and reflects the following criteria:

- job number;
cost group, sub-group, item number and vessel number (obtained from production plan);
weight (in tons) obtained from the Ship Production & Control Report (SPAC);
manhour estimate, prepared by the Production Engineer through detailed drawing take-off and "weighted" with the production plan manhour-per-ton estimates for the stage of construction and work/cost center. This individual work order estimate has the net effect of issuing the manhours (reflected to the cost "item" level in the production plan) to the manufacturing superintendent in small, measured increments which can be more closely monitored.
indicates the work/cost center and authorizes the manufacturing superintendent to accomplish the work;
- describes the work to be accomplished based on instructions contained in the Hull Unit Summary and the UCM construction details;
indicates the starting date and completion date obtained from the short or long term schedules;
serial number - gives the work order identity for data processing tracking and control;

vehicle for accumulating the daily direct labor cost expended toward the work effort. When the Production Engineer releases the work order to the work center, a copy goes to the Data Processing Department where D/P cards are key punched with the cost codes, estimate, weight, serial number, etc., which is returned to the Production Engineering Department affixed to the superintendent's copy. Data Processing also enters the work order into the computer data base. As the work prescribed in the text of the work order progresses, the direct labor manhours are "entered" directly into the computer data base by the work/cost center superintendent at a local terminal. The computer accumulates the man-hour charges and D/P printouts are run on a daily basis and forwarded to the Production Engineer for continuous monitoring of progress regarding percent completion and cost (actual spending versus estimate). D/P printouts can be sorted in various ways to facilitate overall job monitoring such as the listing of all "active" work orders on one report and all "closed" work orders on another (VIEW GRAPH NO. 08PE). The daily reports are used to monitor individual work order efficiency and progress, whereas the "closed" and "active" reports are used for determining overall Percent completion and a projection on work remaining to be accomplished.

III. PROCESS LANES

A. ESTABLISHMENT OF WORK/COST CENTER

Details of the establishment of that portion of the IHI technology transfer called Process Lanes were presented at a previous seminar. However, in order to clearly present Avondale's work/cost center ideas, a brief review of the Process Lanes concept and implementation is necessary.

One of the most important functions of the Planning Section is to prepare "unit" or "module" arrangement drawings for the purpose of further detailed planning, engineering, weight calculations, and categorization. (VIEW GRAPH NO. 09PE)

Categorization of these "units" or "modules" in accordance with the Process Lanes concept then becomes an "early on" effort for purposes of sequencing or "level loading" the various work centers.

By definition, categorization (as it applies to hull construction) is the separation of, and placing into, specified groups, like or similar kinds of work. Reviewing briefly

what you have seen and heard in the previous seminars, the six basic unit categories are: (VIEW GRAPH NO. 10PE)

- Category #1 - typical flat panel units such as cofferdam bulkheads, mid-body double bottoms, mid-body longitudinal bulkhead side shell units.
- Category #2 - curved side shell or wing tank sections.
- Category #3 - machinery space flats with side shell and/or bulkheads below and all superstructure units.
- Category #4 - fore and afterpeaks.
- Category #5 - engine room and machinery space double bottoms.
- Category #6 - miscellaneous bulwarks, bilge keels, skegs, etc.

It is this grouping of similar kinds of work, and the assigning of a specific work center to accommodate each group of work, that has enabled Avondale to now consider each work center a cost center. In the past at Avondale, a given work center could not be a specific cost center because the types of construction at each work center varied too widely. For example, a given work center might do fabrication work as well as sub-assembly work. Another work center might do all main assembly work but be saddled with everything from 200-ton afterpeaks to 50-ton cofferdam bulkheads or 5-ton margin plates. The cost per ton varied too widely to be trackable from the standpoint of monitoring work center efficiency, and because the work varied so widely, the anticipated learning curve multi-hull savings were not experienced.

The flow of varied kinds of material, both prefabricated steel and purchased outfitting, was inefficient and costly.

Process Lanes now has provided a specific work/cost center for fabrication, sub-assembly, pre-outfitting, and main assembly for each of the six (6) major categories of work as shown on VIEW GRAPH NO. 11PE.

Each of these work centers has been assigned a unique cost code which is carried by the individual work order when issued to the work center for construction of a specific block of work.

Each work/cost center is assigned a "target" direct labor manhour budget which is based on the targeted construction tonnage planned for that work center through the efforts of

shop or platen loading. As shown in VIEW GRAPH NO. 12PE, charts are prepared for each work center indicating the projected budget and tonnage.

As work progresses throughout the contract, cost returns are monitored in terms of manhour-per-ton efficiency on a weekly basis. The "actuals" are recorded on data sheets shown on VIEW GRAPH NO. 13PE.

Actual accumulated completed tonnage and cost from CLOSED work orders are recorded, as well as the estimated manhours from the same orders. In addition, the shop planners at each work center turn in reports recording the physical effort of work (tonnage) completed at that specific work center through the close of business the previous week. The total accumulated actual manhours, as well as "period actual" manhours, are recorded to develop the efficiency for the period.

From the data sheets, the curves as shown in VIEW GRAPH NO. 14PE are plotted to reflect actual accumulated manhour spending, along with accumulated tonnage produced.

Management is now in a position to observe not only the progress of the job in terms of projected cost, but to determine the overall efficiency of the work center and its supervision.

It is important to note that hull construction cost is no longer collected by piece or item. In the past, the policy was to issue work orders for the fabrication of, and collect cost for, individual ship parts or items such as floors, or girders, or web frames. This effort created literal mountains of paperwork for more departments than Production Engineering. That policy has been discarded for the Process Lanes category concept whereby we now only want to know:

- what does fabrication cost for category one (1) construction? (one work/cost center)
- what does sub-assembly cost for category one (1) construction? (one work/cost center)
- what does main assembly cost for category one (1) construction? (one work/cost center)
- what does erection cost for category one (1) construction?

and so on for the other categories of construction.

What are the benefits:

- less work orders to prepare, issue and monitor;
- less paperwork for field supervision and Data Processing to manage;

cost returns that are meaningful and usable for those who must use cost history to prepare estimates for future bid documents;

the manhour per ton efficiency ratio thus established for category four (4) construction of afterpeaks or forepeaks, for example, is usable for all construction of similar types of ships;

the manhour per ton ratio established for category (1) construction is again a very usable standard for future bid estimates for like kinds of ships.

IV. LINE HEATING

The IHI technology of line heating has become a cost effective procedure since Avondale's transition from the conventional Blacksmith Shop furnacing and jig forming methods.

After the decision was made to study the line heating technology, Avondale committed the Blacksmith Shop supervisor and four (4) of his workers to the program. With the very capable assistance of the IHI representatives, they progressed in only four (4) months to the point of being "self starters" and could successfully apply the technology on their own. It should be noted here that the people thus trained were already experienced in conventional furnace type plate and structural forming.

Since adapting the program, the group manning the line heating station has grown to seven (7) which includes two in training and is steadily gaining in efficiency.

For comparison, the cost of plate forming using the conventional furnace methods was 16.61 manhours per plate average. On the first contract where the line heating technology was implemented, Avondale formed 451 plates at an average cost of 16.56 manhours per plate. This was only slightly less than the conventional furnacing cost when considering direct labor; however, it should be noted that there was an appreciable savings in construction of plate forming jigs. Previous cost history reflected a direct labor savings of 60 manhours per jig, not including material dollars. This was considered to be savings enough to warrant continuation and refinement of the program.

On the present contract now making full use of the technology, Avondale's direct labor cost has dropped to an average of 11.6 manhours per plate on the first vessel and 10.0 manhours per plate on the second vessel. This represents a 39% decrease in Avondale's direct labor plate forming cost (excluding jigs) which is substantial.

In closing, it should be noted that Avondale's line heating group has succeeded in developing its own program technology to line heat form the twist in all shipbuilding structural.

Job No.	Group No.	Sub-Group	Item No.	Ver. No.	Title
SHOP ORDER					
			Drawing No.		Alt. No.
			Sheet No.		Serial No. 5101
TO	Superintendent			FROM	Originator
	Foreman				Date
	Work Center				Transfer No.
Machine or Equipment			Total Est. Hours	To Be Started	To Be Completed
YOU ARE INSTRUCTED TO PERFORM THE FOLLOWING WORK:					
OPERATION	NO. AND KIND OF PIECES	SIZE, LENGTH, ETC.		UNIT HOURS ALLOWED	HOURS ALLOWED FOR OPER.
TOTAL HOURS ALLOWED, Including Supervision →					
GENERAL INSTRUCTIONS:					
GRAPH NO. 01PE					
NOTE: Foreman to report actual date started, inspected and completed. Return to Production Dept. office when completed.					
DATE STARTED		DATE INSPECTED AND COMPLETED		Signs	

Job No.	Group No.	Sub. Group	Item No.	Ves. No.	Unit	Zone	Weight (tons)	Serial
WORK ORDER						Title		
TO	Superintendent					FROM	Originator	
	Foreman						Date	
	Work Center						Transfer No.	
Drawing No.			Alt. No.	Sheet No.	Total Est. Hours	To Be Started		To Be Completed
YOU ARE INSTRUCTED TO PERFORM THE FOLLOWING WORK								
GRAPH NO. 02PE								
NOTE: Foreman to report actual date started, inspected and completed. Return to Production Dept. office when completed.								
Date Started			Date Inspected And Completed				Signed	

HULL UNIT SUMMARY

UNIT #98. (CATEGORY #1) WGT.(TONS) DATE: 03/08/82 REV.#1

MAIN DECK CENTER FROM 8" FWD. OF FR. 77 TO 8" FWD. OF FR. 81.
(DWG. 00-098-000)

- A. PARTIAL SUB UNIT #098-001-001
WORK CENTER - PANEL LINE "A PANEL"
FABRICATE THE MAIN DECK PLATES WITH STRUCTURAL DET. 5A. WHEN COMPLETE SEND TO PLATEN #20 SUB ASSEMBLY STAGE.
- B. PARTIAL SUB UNIT #098-001-002
WORK CENTER - PLATEN #24
FABRICATE AND PARTIAL SUB ASSEMBLE THE TRANSV. MAIN DECK WEB AT FR. 81 WITH BKTS. WHEN COMPLETE SEND TO PLATEN #20 SUB ASSEMBLY STAGE.
 - (1) 098-001-003 - WEB FR. 81 DET. 6A
 - (2) 098-001-004 - BKT. ON CL. DET. 7A
 - (3) 098-001-005 - BKT. AT LONG'L #3 PORT DET. 7A
 - (4) 098-001-006 - BKT. AT LONG'L #3 STBD DET. 7A
- C. SUB UNIT #098-001
WORK CENTER - PLATEN #20 - SUB ASSEMBLY STAGE
SUB ASSEMBLE TO THE MAIN DECK (P.S.U. #098-001-001) THE TRANSV. WEB FR. 81 (P.S.U. #098-001-002) WHEN COMPLETE MOVE TO PRE-OUTFIT STAGE ON PLATEN #20 IF REQ'D.
- D. UNIT #098
WORK CENTER - PLATEN #20 - PRE-OUTFIT STAGE
PRE-OUTFIT IF REQ'D, THEN MOVE IT TO FINAL ASSEMBLY STAGE ON PLATEN #20.
- E. UNIT #098
WORK CENTER - PLATEN #20 - FINAL ASSEMBLY STAGE
CALL OUT FOR A.S.I. AND OWNER STRUCTURAL INSPECTION, COMPLETE PICK WORK THEN TURN UNIT OVER TO COMPLETE OUTFITTING, THEN SEND TO BLAST AND PAINT.

GRAPH NO. 04PE

PRODUCTION PLAN

GRAPH NO. 05PE

ASI 3217

JOB

PRODUCT CARRIERS				SHIP "B"	
GROUP	OPERATION	QUANTITY	MH/UNIT	M. H.	REMARKS
	Main Assembly Fit				
-51-00	Platen #20				
-51-01	Shipfitting	7510T	1.756	13,188	
-51-02	Dry Search	7510T	0.125	945	
	SUB TOTAL	7510T		14,133	
-52-00	Platen #17				
-52-01	Shipfitting	1434T	4.548	6,522	
-52-02	Dry Search	1434T	0.325	467	
	SUB TOTAL	1434T	*	6,989	* CAT. #2 CAT. #3
-53-00	Platen #10				
-53-01	Shipfitting	594T	4.558	2,708	
-53-02	Dry Search	594T	0.372	221	
	SUB TOTAL	594T		2,929	
-54-00	Platen #307				
-54-01	Shipfitting	1548T	5.311	8,222	
-54-02	Dry Search	1548T	0.371	575	
	SUB TOTAL	1548T	*	8,797	* CAT. #3 CAT. #4 Cat. #5
55-00	Platen #14				
55-01	Shipfitting	141T	10.29	1,451	
55-02	Dry Search	141T	0.312	44	
	SUB TOTAL	141T		1,495	
	2-51				

GRAPH NO. 06PE

COST ESTIMATE SUMMARY
PRODUCTION

CUSTOMER: _____ DATE _____

JOB: _____ PRODUCT CARRIERS (VESSELS) _____ ESTIMATE _____

Group			Hull 1	Hull 2	Hull 3
1	ENGINEERING	Ves. 2 Ves. 3	203,127	203,127	203,127
2	HULL	96.4 94.4	634,608	611,762	599,070
3	SUPERSTRUCTURE	96.9 95.1	69,776	67,613	66,357
4	JOINER		-	-	-
6	PIPING	92.3 88.1	210,828	194,594	185,739
7	MACHINERY	98.2 97.2	65,627	64,446	63,789
8	ELECTRICAL	92.0 89.0	150,713	140,012	134,135
9	SHEETMETAL	97.0 95.3	102,200	99,134	97,397
10	CARPENTRY		428	428	428
11	INSULATION	96.9 95.1	32,226	31,227	30,647
12	CLEAN & PAINT	96.9 95.1	243,608	236,056	231,671
13	CONSTRUCTION SERVICES	97.0 95.3	67,266	65,248	64,104
16	FITTINGS	96.0 93.8	119,673	114,886	112,253
17	OUTFITTING	97.0 95.3	31,292	30,353	29,821
18	DECK COVERING	97.0 95.3	1,454	1,410	1,386
19	JIGS & DIES		45,036	45,036	45,036
20	FOUNDATIONS	89.1 83.3	57,903	51,592	48,233
21	CRANES		100,619	100,619	100,619
23	TESTS & TRIALS	96.9 92.4	61,041	59,149	56,402
25	MOLDLOFT		38,262	38,262	38,262
26	LAUNCHING	93.0 89.1	36,593	34,031	32,604
27	PRODUCTION DEPT.		41,433	41,433	41,433
28	QUALITY CONTROL		23,513	23,513	23,513
31	WAREHOUSING		53,535	53,535	53,535
32	CLEAN DURING CONST.	97.0 95.3	56,336	54,646	53,688
33	DRYDOCKING & SHIFTING		9,000	9,000	9,000
34	INSURANCE		-	-	-
43	WELD RODS, STEEL FREIGHT		-	-	-
46	PACKAGE UNITS	94.77 91.9	22,833	21,639	20,984
81	PROGRAM MANAGEMENT & EXPRESS ENGR.		14,007	14,007	14,007
82	ESTIMATING		1,224	1,224	1,224
95	REWORK	97.0 95.3	14,189	13,763	13,522
99	DELIVERY		-	-	-

JOB No. ①	Group No. ②	Sub. Group	Item No.	Ver. No.	Section	ZONE []	Weight (tons)	Serial No. ③ K 1851
WORK ORDER						Title ④		
TO	Superintendent ⑤					FROM	Originator ⑨	
	Foreman ⑥						Date ⑩	
	Work Center ⑦						Transfer No. ⑪	
Drawing No. ⑧			AIL No.	Sheet No.	Total Est. Hours ⑫	To Be Started ⑬	To Be Completed	

⑭ YOU ARE INSTRUCTED TO PERFORM THE FOLLOWING WORK

- ① JOB NUMBER (CONTRACT)
- ② COST CODE PER PRODUCTION PLAN
- ③ WORK ORDER NUMBER (UNIQUE IDENTIFICATION)
- ④ DESCRIPTIVE TITLE OF WORK
- ⑤ SUPERINTENDENT RESPONSIBLE
- ⑥ FOREMAN RESPONSIBLE
- ⑦ WHERE WORK IS TO BE PERFORMED
- ⑧ WORKING DRAWING REFERENCE
- ⑨ PRODUCTION ENGINEER
- ⑩ DATE THE ORDER IS WRITTEN
- ⑪ MATERIAL DOCUMENT REFERENCE
- ⑫ ESTIMATED HOURS BASED ON UNITS OF WORK
- ⑬ SCHEDULE
- ⑭ DETAILED LISTING OF WORK & BASIS FOR ESTIMATED MANHOURS

GRAPH NO. 07PE

NOTE: Foremen to report actual date started, inspected and completed. Return to Production Dept. office when completed.

Date Started

Date Inspected And Completed

Signed

GRAPH NO. 08PE

21.0.30 AVIMBULL

BY JIM, GROUP, S. GMP, IIRH CLOSED WITH UNLERS 10-11-82

PAGE 32

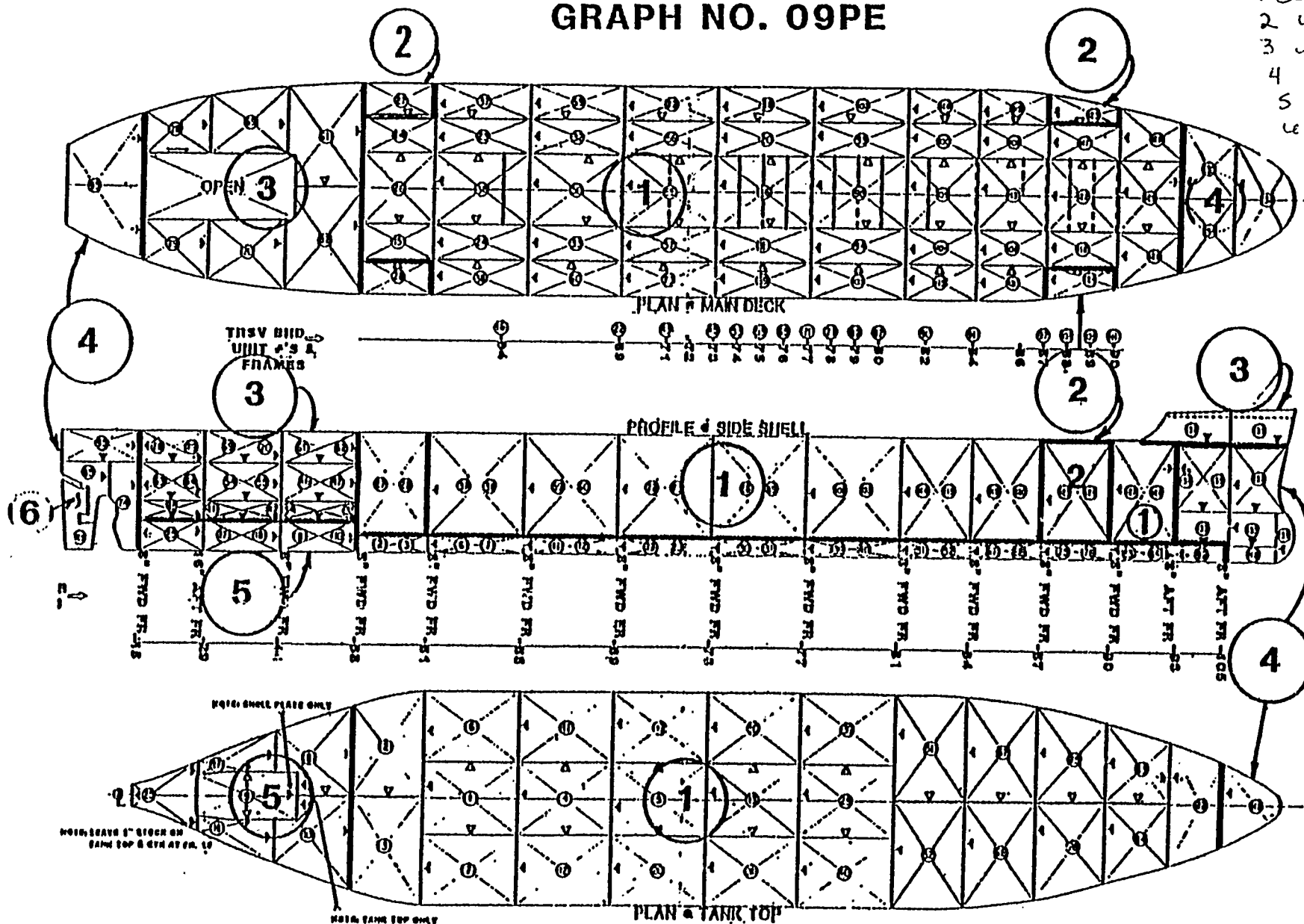
SO	P	JOB	CR	LD	IL	VLS	NRK	U	WT	EST.	LDI-DAY	HOURS	TODATE	UNEXP	%	%	EXP	DATE	FSY-DAY	FOREHA
PI	E	NUMBER	IR	EM			ORDER	N			ACTIVE	ACTUAL	PREMIUM	TOTAL	BAL.	USED	COMP	FINAL	ISSUED	STARTED
02	Z	C10015	02	03	01	011	J0117	055				4-17-2	.0					8-23-2	8-26-2	H W197
02	5	C10015	02	03	01	011	J7311	011				8-23-2	.0					8-04-2	8-06-2	N W215
02	5	C10015	02	03	01	011	J7323	000				8-17-2	.0					8-04-2	8-09-2	W201
02	5	C10015	02	03	01	011	J7324	000				8-17-2	.0					8-04-2	8-09-2	W201
02	5	C10015	02	03	01	011	J7390	050				9-10-2	.0					8-10-2	8-14-2	H W197
02	5	C10015	02	03	01	011	J7392	050				9-10-2	.0					8-10-2	8-17-2	H W215
02	5	C10015	02	03	01	011	J8014	020				8-12-2	.0					7-13-2	7-21-2	H W197
02	5	C10015	02	03	01	011	J8018	020				8-12-2	.0					7-14-2	8-09-2	H W197
02	5	C10015	02	03	01	011	J8064	070				9-11-2	.0					7-27-2	8-04-2	H W197
02	Z	C10015	02	03	01	011	J8205	024				8-06-2	.0					7-12-2	7-27-2	H W197
02	Z	C10015	02	03	01	011	J8206	024				8-17-2	.0					7-13-2	7-27-2	H W197
02	Z	C10015	02	03	01	011	J8220	013				7-22-2	.0					7-13-2	7-22-2	H W197
02	Z	C10015	02	03	01	011	J8221	063				7-19-2	.0					7-13-2	7-19-2	H W197
02	Z	C10015	02	03	01	011	J8233	075				7-27-2	.0					7-19-2	8-04-2	N W215
02	Z	C10015	02	03	01	011	J8241	044				7-22-2	.0					7-23-2	8-04-2	N W215
02	Z	C10015	02	03	01	011	J8247	052				8-13-2	.0					7-23-2	8-12-2	H W197
02	Z	C10015	02	03	01	011	J8255	057				8-19-2	.0					8-11-2	8-12-2	B W690
02	5	C10015	02	03	01	011	J8413	050				8-10-2	.0					8-13-2	8-14-2	H W197
05	G	C10015	02	06	01	011	C8529	051				6-21-2	.0					6-02-2	6-08-2	B S139
05	H	C10015	02	06	01	011	F1614	029				9-22-2	.0					9-03-2	9-10-2	N S139
05	Z	C10015	02	06	01	011	I2709	058				5-21-2	.0					9-09-2	9-16-2	N S139
05	Z	C10015	02	06	01	011	J2205	055				7-20-2	.0					6-18-2	6-30-2	B S139
05	Z	C10015	02	06	01	011	J2217	054				6-07-2	.0					6-24-2	7-12-2	B S139
05	Z	C10015	02	06	01	011	J2240	025				7-21-2	.0					7-08-2	7-19-2	B W385
05	Z	C10015	02	06	01	011	J2243	026				8-04-2	.0					7-08-2	8-02-2	B S139
05	Z	C10015	02	06	01	011	J2375	060				6-23-2	.0					6-09-2	6-15-2	B S139
05	Z	C10015	02	06	01	011	J2303	026				6-28-2	.0					6-11-2	6-16-2	B S139
05	Z	C10015	02	06	01	011	J2367	051				7-12-2	.0					6-14-2	6-22-2	B S139
05	Z	C10015	02	06	01	011	J2359	116				7-29-2	.0					6-18-2	6-25-2	B S139
05	G	C10015	02	06	01	011	J3707	649				7-26-2	.1					6-17-2	6-23-2	B S139
05	G	C10015	02	06	01	011	J3719	614				7-01-2	.0					6-23-2	7-01-2	B W385
05	G	C10015	02	06	01	011	J3719	041				7-26-2	.0					6-24-2	7-02-2	B S139
05	G	C10015	02	06	01	011	J3723	641				7-28-2	.0					6-29-2	7-19-2	B S139
05	G	C10015	02	06	01	011	J3725	039				7-29-2	.0					6-29-2	7-07-2	B S139
05	G	C10015	02	06	01	011	J3734	024				7-28-2	.0					7-02-2	7-14-2	B S139
05	G	C10015	02	06	01	011	J3738	045				8-02-2	.0					7-07-2	7-22-2	B S139
05	G	C10015	02	06	01	011	J3738	028				8-11-2	.0					7-07-2	7-16-2	B S139
05	G	C10015	02	06	01	011	J3741	025				7-30-2	.0					7-07-2	7-21-2	B S139
05	G	C10015	02	06	01	011	J3743	625				7-30-2	.0					7-07-2	7-21-2	B S139
05	G	C10015	02	06	01	011	J3755	001				7-20-2	.0					7-13-2	7-20-2	B S139
05	5	C10015	02	06	01	011	J4447	042				7-20-2	.0					6-30-2	7-13-2	B S139
05	5	C10015	02	06	01	011	J4448	614				7-00-2	.0					6-30-2	7-08-2	B W385
05	5	C10015	02	06	01	011	J4448	016				8-05-2	.0					7-08-2	7-23-2	B S139
05	5	C10015	02	06	01	011	J4448	012				7-21-2	.0					7-08-2	7-20-2	B W385
05	5	C10015	02	06	01	011	J4449	055				8-11-2	.0					7-08-2	7-25-2	B S139
05	5	C10015	02	06	01	011	J4449	055				8-11-2	.0					7-08-2	8-02-2	N S139
05	H	C10015	02	06	01	011	J4450	655				8-10-2	.0					7-14-2	7-29-2	B S139

SORP PE

UESSE

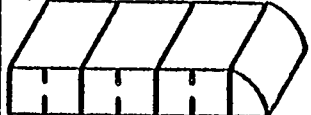
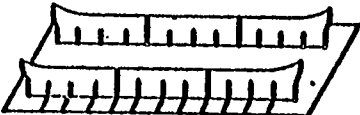
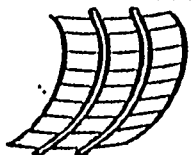
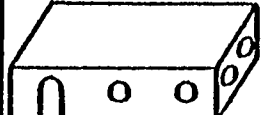
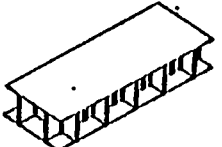
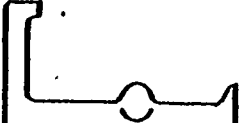
GRAPH NO. 09PE

- 1 red
- 2 white
- 3 yellow
- 4 blue
- 5 green
- 6 white



MAIN ASSY CATEGORIES

GRAPH NO. 10PE

CATEGORY	UNIT NAME	PLATEN SUPPLYING FABRICATED PARTS	SHAPE	ASSEMBLY PLATEN
(No. 1) FLAT PANEL UNIT	MID PART DOUBLE BOTTOM SIDE SHELL LONG BHDS.	(23)		(20) 50-60%
		(24)		
(No. 2) CURVED SHELL UNITS	AFT & FORE PART SIDE SHELLS	(16)		(17)
(No. 3) SUPERSTRUCTURE UNITS	DECKS FLATS BULKHEADS HOUSES ETC.	(18)	 	(8) (9) (11)
(No. 4) FORE PEAK AFT PEAK	LARGE AND VERY HEAVY 3 DIMENSION UNITS	(18)		(10) (13) (307)
(No. 5) ENGINE ROOM INNER BOTTOMS	LARGE AND HEAVY INTRICATE UNITS	(18)		(14) stays longer in (307) main assy
(No. 6) SPECIAL UNITS SKESGS RINDERS	BULBOUS SHAPES STERN CASTINGS	(18)	 	(18)

GRAPH NO. 11PE

CATEGORY #1

Process Lanes

	Main Assy	Sub Assy	Partial Sub Assy	Pre-Fabrication
Platen	20	20	23/24	various
Platen	20	20	Panel Line	various
Platen*	20	17	16	various
Platen*	20	17	Panel Line	various

CATEGORY #2

Process Lanes

	Main Assy	Sub Assy	Partial Sub Assy	Pre-Fabrication
Platen	17	17	16	various
Platen	17	17	Panel Line	various

CATEGORY #3

Process Lanes

	Main Assy	Sub Assy	Partial Sub Assy	Pre-Fabrication
Platen	8,9, or 11	8,9,or 11	16	various
Platen	Westwego Yard	-----	-----	-----
Platen	*8,9,or 11	17	16	various

CATEGORY #4

Process Lanes

	Main Assy	Sub Assy	Partial Sub Assy	Pre-Fabrication
Platen	10,13,307	10,13,307	16	various
Platen	*10,13,307	17	16	various

CATEGORY #5

Process Lanes

	Main Assy	Sub Assy	Partial Sub Assy	Pre-Fabrication
Platen	14	14	16	various
Platen	*14	17	16	various

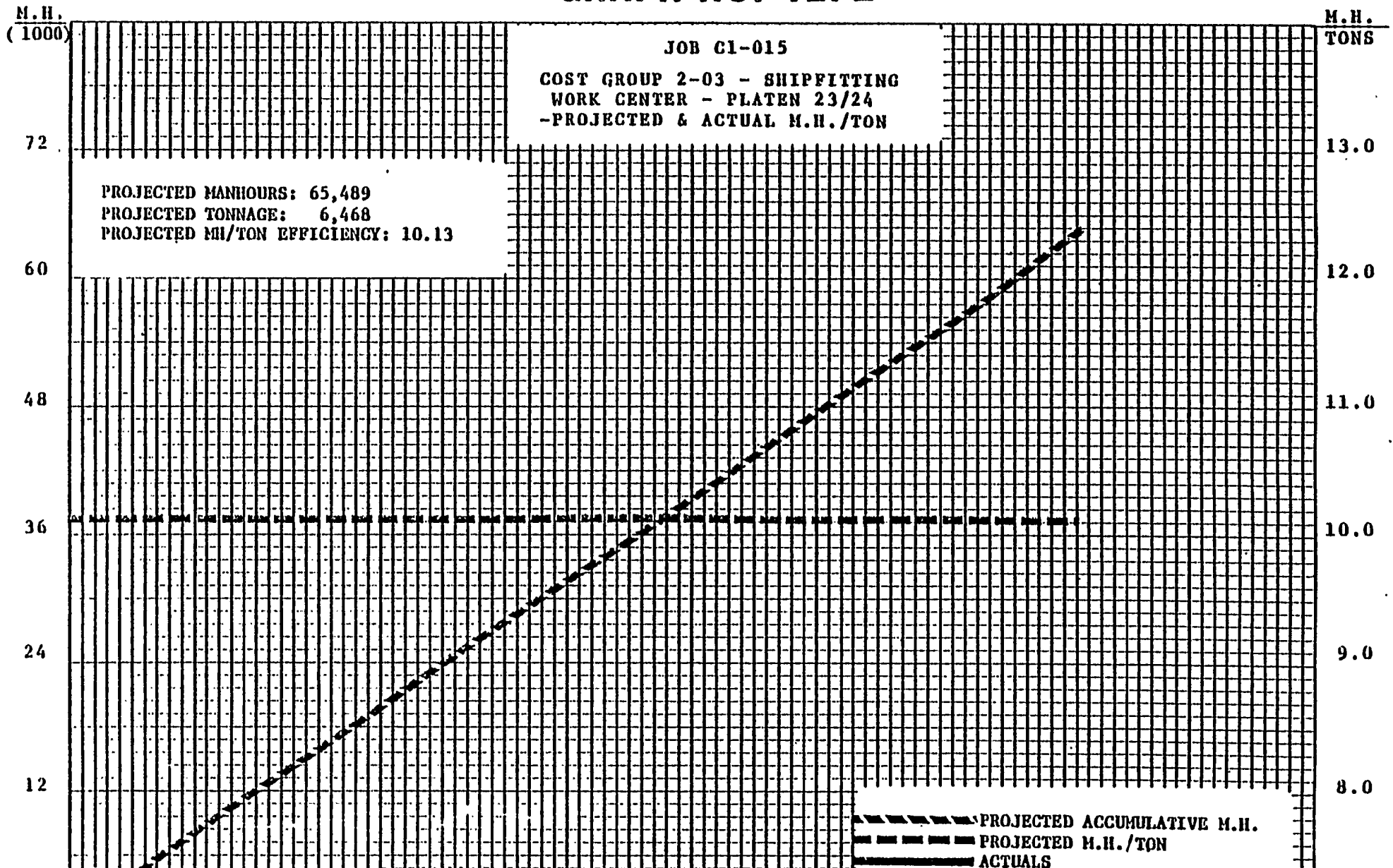
CATEGORY #6

Process Lanes

	Main Assy	Sub Assy	Partial Sub Assy	Pre-Fabrication
Platen	19	19	16	various

* Sub Assy on this stage might occur on rare occasions

GRAPH NO. 12PE



COST GROUP 2-03
PLATEN 23/24 FABRICATION FIT

PROJECTED MANHOURS: 65489
PROJECTED TONNAGE: 6468
PROJECTED EFFICIENCY (MI/TON): 10.13

[illegible]

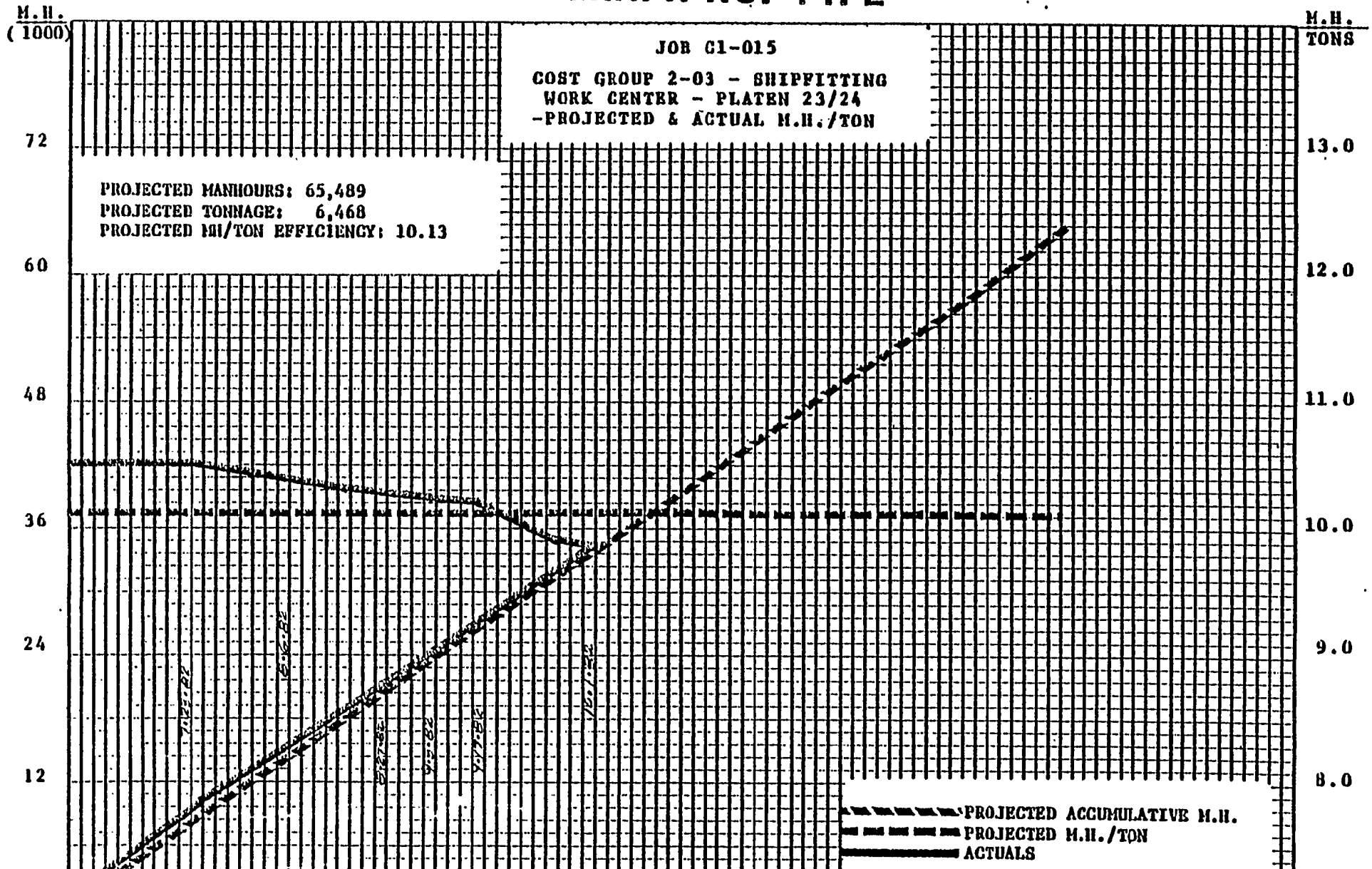
~~GRAPH NO. 13PE~~

1 week's work

#₅ for presentation only

aggregate costs only

GRAPH NO. 14PE



MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

MOLDLOFT

prepared by: B. POURCIAU

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL MOLDLOFT

I. INTRODUCTION

Moldloft management worked with IHI technicians for a period of two years during which time there was an interface of Japanese and American shipbuilding concepts and methodology. Those two years of work resulted in many innovations in the Moldloft.

Many of these innovations were easily merged into, or replaced, existing systems in the Moldloft. Those procedures that were totally unusable because of the vast differences in our two computer systems were dissected and modified to suit ASI needs while trying to retain the original IHI concepts. Change was implemented only in an effort to either improve the existing ASI system or to replace an existing system with a more efficient one. Those procedures, that we felt were efficient, accurate, and cost effective to the company, were retained. Therefore, the system that ultimately evolved for the present Exxon contract was not solely IHI but IHI or a combination of ASI and IHI, and sometimes totally Avondale procedures. In general, the close scrutiny we gave the entire Moldloft operation prodded us to become more efficient.

Additional manning was required for some procedures such as steel tape production; some areas were a trade-off in man-
Manhours utilized for line heat templates were partially absorbed by the elimination of steel plate forming jigs. Key line data resulted in an increase in manhours spent but, again, the implementation of pin jig data reduced the N/C coding and nesting effort necessary for the conventional fabrication jigs used in the past.

The greatest additional cost incurred by the Moldloft was the formation of the Unit Control Manual group. This group provides the yard with the fabrication drawings for all stages of ship construction, plus all of the data necessary to cut structural and plates for the vessels. The UCM concept, although not directly a result of IHI technology, was developed in conjunction with the various IHI systems. The UCM concept was also compatible with the Japanese idea of "stage plans" which are drawings relating to each stage of ship construction and following the "need to know" philosophy.

A. NEW TECHNOLOGY IN MOLDLOFT AS A RESULT OF IHI'S INFLUENCE
VIEW GRAPH NO. ML-1):

steel tape system,
key lines,
line heating method,
scheduling by stages,
Moldloft planning,
pin jig utilization,
shrinkage factor,
piece numbering system.

B. IHI IMPACT ON MOLDLOFT SECTIONS: (VIEW GMFH NO. ML-2)

1. Numerical Control Group

- pin jigs,
- key line data,
expansion factor,
steel tape date.

2. Unit Control Manual Group

stage plans.

3. Conventional Moldloft

- steel tape production,
- line heat templates,
 - key line tapes.

Impact to N/C programming work was minimal. Differences in the computer systems at IHI and Avondale prohibited any merger or adoption of Japanese N/C methods. What we did discover is that in most areas we were comparable in N/C capabilities. Specialized programs were formulated by members of our N/C programming group to create the data required for production of steel tapes and key line. In the future, we hope to automate these areas which will be most cost effective for the lofting operation.

Impact to the Nesting Department by implementation of IHI was minimal. Some recommendations for preliminarily ordering steel and sequence of nesting were studied with the results being beneficial to the process lanes concept on future contracts. Accuracy control dimensions and accuracy check points for N/C burning-tapes were incorporated into the system as a result of the Accuracy Control Section.

IHI's greatest influence on the conventional Moldloft resulted in the additional responsibility of producing line heating templates and the production of steel tapes.

II. ENGINEERING STANDARDS

The object of implementing engineering standards was to reduce the amount of different configurations found on engineering drawings and to give the draftsmen and loftsmen guides to improve efficiency and consistency in their work output. Through constant use, these standards also ultimately become recognizable to the workers in the yard.

Many areas of the engineering drawing were standardized. A committee of Loft and Engineering representatives spent many manhours and countless discussions reviewing past practices regarding standards. Were these practices consistent? Were they easy to use? Were they practical in application for field use? What new areas could be standardized that may have been overlooked? These meetings pointed the direction that we anticipated we would follow in defining a new set of ASI engineering standards.

Previous contracts were reviewed and all of those structural cutouts for side shell longitudinal, etc., that were used in the past, were scrutinized. Data used in the SPADES program was also involved. One of our objectives was to have a correspondence between the symbolism used in the SPADES data base and the notation used on the engineering drawings. This concept would give the N/C coder instant reference to the applicable cutout if for some reason the data base could not be used. Collars and clips for the cutouts were defined such that there would be a relationship to the cutout that indicated material thickness, welding process, and piece codes. (VIEW GRAPH NO. ML-3)

Air holes and drain holes, along with snipe sizes, were compressed into as few different entities as possible. Special notations for identification were also provided as to the designation of holes. HO-3 (VIEW GRAPH NO. ML-4) and HO-23 (VIEW GRAPH NO. ML-5), for example, indicate a specific size hole, distance from the edge of the member where hole appears, and in some cases references to the nearest frame.

Brackets were categorized into hard nose, soft nose, and chocks. This type of standard indicates reinforcement, if required, in the form of a flat bar. If this type bracket is required, all dimensions for the bracket, piece code, welding to the parent member, and size and piece code of the reinforcing flat bar are indicated. These brackets are coded once by the Loft and recalled as often as necessary for each unit the ship.

Past experience proved that the number of configurations for stiffener end cuts was too great. This area of standardization was attacked vigorously by Engineering and the Loft until a viable system with a reasonable amount of end cuts existed (VIEW GRAPH NO. ML-6). This system is now being used on the Exxon contract with good returns for cost and an almost negligible percentage of errors. Manhours used for producing sketches to cut structural have also been drastically reduced with more consistency evident in their output.

III. MOLDLOFT STANDARDS

A set of moldloft standards for working procedures was developed by the Loft for each group within the Loft structure

- N/C Programmers,
- Nesting,
- UCM Group,
- Conventional Moldloft.

As these standards were developed, each one was carefully reviewed by those departments influenced by the standard. The standards system in the Moldloft served as a "how to guide" for all Loft personnel (VIEW GRAPH NOS. ML-7, 8, 9). Periodically, new standards are added to our archives, reviewed and implemented. We find that the standards have reduced the supervisors' time spent answering routine, procedural type questions. More consistency is evident in our work, with a good reduction in errors.

IV SCHEDULING

Development of process lanes, level loading at stages, and shop planning forced the Loft to do detailed planning for the Exxon contract very early. We examined scantling drawings and any other pertinent data available to us. Based on this data, we made preliminary schedules for:

- N/C Parts Generation (by unit),
- N/C Nesting (number of burning tapes),
- UCM Group (number of documents),
- Shell Plates.

These schedules were level loaded and manned. CRT hardware was also considered at this time.

As more detailed drawings were received, we enhanced our preliminary planning effort to include such items as number of shell plates that had to be line heated, rolled or formed, stock requirements were also considered and a list of raw material sizes provided to Engineering.

As GRAPH NO. ML-10 illustrates, we categorized the curved shell plates according to the area of the vessel on which they appeared:

- Afterbody,
- Engine Room,
- Cargo Area,
- Forebody.

Once this was accomplished, we isolated each type bending, rolling, or heating process (VIEW GRAPH NO. ML-11). This data provided us with a chart that indicated percentages and quantities for each process. Applying manhours required for each operation against these figures enabled us to produce a level loaded schedule (VIEW GRAPH NO. ML-12) that reflected the Blacksmith Shop and Plate Shop capabilities.

Other detail schedules were produced for each stage that utilizes information produced by the Moldloft. Schedules were provided for:

- Completion of N/C Parts,
- Completion of Burning Tapes,
- Completion of Templates,
- Completion of Key Line Tapes,
- Jig Scheduling.

The seven UCM documents that had to be produced were separately scheduled based on level loaded shop and production schedule. On past contracts, the Loft had only to provide pre-fab information to the yard. On the Exxon job, we scheduled each stage of the UCM according to its function:

- Pre-fabrication Cutting List,
- Partial Sub Unit Drawings,
- Sub Assembly Drawings,
- Main Assembly Drawings,
- Erection Drawings,
- Panel Line Drawings,
- Lifting Lug Arrangements.

To date, the Loft has adequately met its schedule requirements to the yard. In those areas requiring extensive changes to units, etc., we now have the visibility, based on detailed scheduling, to foresee problem areas. As this occurs, we can inform the shop planners so that production schedules can be modified with as little disruption as possible.

v. PIECE NUMBER SYSTEM

The piece marking system adopted by Avondale serves two basic purposes:

it identifies material by use of a unique piece number;
and

it identifies the routing of a part or an assembly through the various stages of fabrication and erection.

There are four basic components used in the piece numbering:

unit number,
sub-unit number,
partial sub-unit number,
piece number.

Individual pieces are fabricated together to form sub-units. The combination of partial sub-units with other partial sub-units and/or individual pieces, depending on the fabrication site, create a uniquely numbered, larger partial sub-unit. The fabrication of a sub-assembly to another sub-assembly, partial sub-units, and/or individual pieces, if done in the sub-assembly area, will create another unique sub-unit. If the work is done at the main assembly site, the result is the main assembly of the unit.

In all cases, the location of the fabrication work done on pieces or assemblies determines the type of assembly produced. If the work is done on an initial fabrication platen, then the result is a partial sub-unit (PSU). If fabrication is done on a sub/main assembly platen, the result is sub-assembly and likewise to main assembly.

An individual piece (before fabrication) will always have the following numbering configuration (VIEW GRAPH NO. ML-14).

Unit No. - Sub-Unit No. - Partial Sub-Unit No. - Piece No.

Ex. #003 - 001 - 017 - 143

A partial sub-unit will always have this configuration:

Unit No. - Sub-Unit No. - Partial Sub-Unit No.

Ex. #003 - 001 - 017

(NOTE : After initial fabrication, the resulting assembly loses its individual piece number identities.)

A sub-unit will have the following configuration:

Unit No. - Sub-Unit No.

Ex. #003 - 001

(NOTE : P.S.U. identities no longer needed after fabricated to crest sub-unit.)

A main assembly or erection numbering configuration is:

Unit No.

Ex. #003

A special notation is used for any fabrication of loose items or partial sub-units done at the erection site during the erection of the unit.

If a loose item is to be added to the unit at the time of erection, the piece number will fall between 900 and 999 (Ex. #0000 - 0000 - 915). This piece, without prior fabrication to another piece, is sent directly to the erection site where it will be fabricated to the unit.

If a partial sub-unit is welded to the unit at the time of erection, the partial sub-unit portion of the piece number will be between 900 and 999 (Ex. #003 - 000 - 902). This partial sub-unit was fabricated on one of the initial fabrication platens, then shipped to the erection site.

Examples of the various piece number configurations can be seen on the following pages.

As we have seen in the previous examples, the information given by the piece numbers explicitly indicates not only the unique identity of a part or assembly, but also its next designation in terms of fabrication. Therefore, it is extremely important that all of the piece marks be considered when referring to a part or assembly. Remember, zeros cannot be omitted - they are an integral part of the piece number.

Due to our new piece numbering system, quantity of labeling on the steel has been greatly reduced. The following is an example of the old and new labeling concepts:

Old Labeling Concept:

1 - 2 - 330 (Unit 1, Sub-Unit 2, Pc 330)
Det. 17A Dwg. 11-03-06
AH-32 1/2" plate
C1-15 Hull 1

Total - 47 characters

New Labeling Concept:

1 - 2 - 3 - 330 (Unit 1, Sub-Unit 2, P.S.U. 3, Pc 330)
AH-32 1/2" plate
Exxon Hull 1

Total - 29 characters

The Hull Engineering Section uses the following symbolic references on the yard plans and the unit parts lists in order to help clarify piece numbering at the various stages of construction:

<u>Symbolic Logic</u>	<u>Stage Name</u>	<u>Function</u>
none	hull	erection
	sub-unit	sub-assembly
	(large or combined) partial sub-unit	fabrication
	partial sub-unit	fabrication
	piece	pre-fabrication

These symbol notations have been utilized in the following example of our piece marking system - broken down from the individual piece level through the erection stage.

This chart (VIEW GRAPH NO. ML-14) gives accurate examples for Unit No. 1 on the Exxon contract. However, all types of routing are not shown here because the omitted situations do not apply to Unit No. 1. They are as follows:

- An individual piece being routed directly to the erection site - to be installed at the time of erection of the unit.

(Ex. Piece Number **#001-000-000-953**

The nine-hundred part number identifies this piece to be installed at the erection stage.)

- A partial sub-unit being routed to the erection site - to be installed at the time of the unit's erection.

(Ex. P.S.U. Number **#001-000-905**

Again, the nine-hundred number of the partial sub-unit identifies this assembly to be installed at the erection stage.)

- Two or more sub-assemblies that are combined to form one large sub-assembly. This entire effort would be accomplished at the sub-assembly site.

(Ex. Sub-Assembly Numbers **#001-003** and **#001-004**, combining to make sub-assembly **#001-002**.)

- A series of "loose" items that are to be fabricated together at the sub-assembly, main assembly or erection site prior to the actual sub, main assembly or erection work that is to be done. A notation in the "remarks" column in the Unit Parts List will identify these items as those to be treated in a special manner. The notation will read as follows:

"SPECIAL FAB PANEL," "SPECIAL FAB WEB," etc. , depend on the type of material being fabricated.

VI. MOLDLOFT PLANNING GROUP

The establishment of the Moldloft Planning Group was an IHI innovation that was necessitated by the huge amount of data flowing through the Moldloft from other departments.

This data was previously processed by supervision and parts programmers. Often, in screening the various documents, a lack of continuity was evident in the Loft's output. With the establishment of the Planning Group and the use of standards, we now find more consistency in our work with a reduction in errors. Functions of the Planning Group are to:

- review and screen all documents utilized by the Loft;
- indicate processing data for each part of the vessel;
- determine the shrinkage factor to be used by programmers and loftsmen at each stage;
- indicate and research where steel tapes are to be applied and assign steel tape numbers;
- review revisions;
- review and keep records of drawing discrepancies, "red lining" these areas for caution by the drawing user;
- verify stock requirements for each stage of construction
- monitor problem areas and point out these tendencies to help avoid problems in the future;
- feed back to the various departments discrepancies found on their documents.

(VIEW GRAPH NO. ML-13) In conclusion, the planning effort has increased overall efficiency in the Loft's work while providing consistency of format.

VII. STEEL TAPE SYSTEM

To maintain continuity across units during the construction stages and to assure the accuracy of panels, etc., Avondale has adopted the use of "Steel Tapes" as a measuring medium. These

steel bands are provided for all stages of ship construction. They relieve the steel worker of conventional measures and eliminate costly errors in mis-read dimensions. Since the same information is used over a number of units, more consistency in construction becomes possible.

Steel tapes are normally provided at: (VIEW GMPHNO. ML-15)

- transverse butts,
- erection seams,
- transverse bulkheads,
- decks,
- longitudinal bulkheads,
- longitudinal girders,
- diagonals for checking accuracy in jigs.

Each steel tape is uniquely numbered with one side of the tape providing finished dimensions and the other side of the tape providing "expanded" dimensions before welding occurs. UCM documents guide the workers by indicating where and what steel tapes are to be used. Steel tapes are marked with a scratch awl and show locations of: (VIEW GRAPH NO. ML-16)

- frames,
- seams,
- girders,
- longitudinal,
- decks,
- stringers,
- special structure.

Steel tapes are produced in the conventional loft utilizing "special computer programs. These programs provide the loftsmen with a "printout" that he uses on a specially constructed table. Average time to produce and validate a steel tape is approximately three hours. Duplicate tapes are provided for those areas where more than one platen requires the same tape. Number of steel tapes produced to date on the Exxon contract is 242. Manhours saved by the field are immeasurable by the utilization of the steel tape method. Time normally consumed

by workers having to measure and read precise dimensions is saved. More continuity within and across units is assured by utilizing steel tapes. Less interpretations of dimensions on drawings is required, and a high degree of accuracy is assured.

VIII. PIN JIGS

An item that has reduced some of the cost of N/C coding and nesting has been the implementation of pin jigs at ASI. Prior to the Exxon contract, all fabrication jigs were cut from plate and assembled in an assigned area. This operation was costly to the yard because of manhours and material involved with the actual fabrication, storage, and cutting of steel for the jig. Moldloft costs were also involved because all jigs were N/C burned.

The pin jig concept has reduced these costs by approximately 50% (VIEW GRAPH NO. ML-17). Computer output for the pin jig grid and heights is provided for the yard via the SPADES pin jig program (VIEW GRAPH NOS. ML-18 THROUGH ML-22). Line heating technology used to produce accurately formed shell plates assures that the shell plates will conform to the contour established by the pin jig. The key line method of checking layouts assures that the N/C layout on the plating is accurate. The configuration of the Exxon vessel is such that 42 "solid jigs" would have been normally required. Pin jig implementation reduced this number by 50%.

The Moldloft has monitored the accuracy of finished units fabricated in pin jigs. We find the units to be satisfactory in shape and dimensionally accurate. Some of these units are presently being erected unto the Exxon vessel with good results.

IX. SHRINKAGE FACTOR FOR WELDING

One of the prime objectives in our studies with IHI was to produce more accurate output pertaining to welding shrinkage factors. Over the past fifteen years, based on feedback from the field, we have modified these factors many times, sometimes adding extra material, sometimes reducing material as conditions warranted. This data was assembled and examined by a committee of Avondale supervisors and IHI experts. Many meetings were held to examine past performance at Avondale against present practices at IHI. In general, our conclusion were that basically our expansion factors were adequate but could be refined. At this point, we examined closely what was being done in Japan and found these differences in our method:

- Japanese shipbuilders did not introduce any factor into structural components (i.e. angles, tee beams, etc.).
- Expansion factor was added according to stage (i.e. factor required at PSU stage was utilized but some excess remained for sub-assembly, if required).
- A factor was introduced for line heating.
- Different factors were used for manual and automatic welding.

As a result of this input, we developed a table that is a compromise between ASI methods and IHI methods. This table is based on number of stiffeners, amount of welding (VIEW GRAPH NOS. ML-23 & ML-24), thickness of plate, and length of plate to be welded. We feel this system is far superior to what we have done in the past. As our experience increases on Exxon and as we receive feedback from the yard, these tables will expand to encompass such items as type of welding and beveling. We impressed on the field that it is vitally important that no other factors, such as opening butts, etc., be introduced so that accuracy control can be maintained and feedback to the Moldloft will be meaningful.

X. LINE HEATING

Line heating is very effective and works on sound scientific principals. It can be used to move and mold steel into many shapes. Proper application of line heating can produce rolled, twisted and compound shaped plates or any combination of these (VIEW GRAPH NO. ML-25); but, it is a procedure that takes workers time to become efficient.

The Moldloft provides roll templates with sight edges shown (VIEW GRAPH NO. ML-26) (usually made at frame lines), with a plane established approximately normal to the roll axis, with a sight line and the declevity angle the template will be held to the plate. The roll set portion gives the desired transverse shape. The plane gives the amount of twist. The sight line, or thread line, gives the amount of compound shape. A plate has the correct shape only when the roll sets fit the plate completely at the prescribed declevity, the plane is sighted to be a good flat plane, and the thread or sight line is straight.

A similar method is used to twist formed longitudinal. This will be used on members that require excessive force to twist them in the field.

Due to the introduction of line heating technology, the Moldloft had experienced a substantial reduction in the number of costly steel jigs required for forming shell plates. We have also monitored those units requiring line heated shell plates on the present Exxon contract and find that the shell plating fit significantly more accurately than on previous contracts. Naturally, we will realize a considerable savings in manhours at the assembly stage of construction.

XI. UNIT CONTROL MANUAL

The Unit Control manual is a group of seven individual documents produced by the Moldloft and designed to be used by the yard workers in every stage of hull construction from pre-fabrication to erection. The UCM is an instructional plan for each unit of the vessel that isolates each stage of construction. The objective of the UCM is to "break down" the engineering "yard plan" into basic components so that the average worker in the shipyard can understand and follow simple instructions.

Two years of development went into the final format of the UCM documents. Upon the arrival of IHI's team of technicians in the Moldloft, the UCM was being utilized on the Zapata dredge and was in its infancy. IHI recommended as part of its technology transfer that Avondale Shipyards adopt the "stage plan" concept of drawings. The UCM was then introduced to IHI and found by IHI to be the media that would be further developed by the Loft. Many significant recommendations were suggested by IHI and introduced into the UCM. Items such as vital dimensions for accuracy control, steel tape marking, dimensioning, etc. were incorporated into the basic UCM concept. These refinements helped improve the UCM and provided to the yard more information than on previous contracts.

The different booklets produced can be categorized by stage:
(VIEW GRAPH NO. 27)

- pre-fabrication (steel cutting),
- partial sub assembly stage (fabrication),
- sub assembly stage,
- main assembly stage,
- erection stage.

Since each of these functions is unique., the format of the UCM is arranged so that each stage can be addressed independently.

UCM production is accomplished by the use of the SPADES Numerical Control System and the CADAM interactive graphics system. Special programs were written by ASI to develop interfaces that allow the merger of these two systems. Loft personnel were trained to utilize the CADAM drawing system and some areas of SPADES to produce the required documents.

A. GENERAL PROCEDURES FOR PRODUCING UCM'S

The data used for production of UCM booklets is stored in the CADAM data base. The Numerical Control parts generation group provides structural and plate components which are stored in the computer and used as a base for the UCM shop drawings. UCM production is interfaced with the SPADES data base, so that the UCM draftsman can utilize as much data as possible from the computer. Various components, as required for the drawing, can be retrieved from the SPADES data base and displayed simultaneously on the CRT screen. The merger of these components and the addition of necessary details creates the desired drawing. Each drawing is then filed by module and sub-group into the CADAM files. The CADAM standards file is constantly utilized. CADAM operators have easy access to such details as welding symbols and bevels, standard end cut configurations, labeling and stiffener details. These details are "hung" directly on the drawing without having to re-draw the various details each time. As new standards are created, they are added to these files. Final output is a hard copy of the drawing by means of a Versatec electrostatic plotter. Turn around can be within minutes when necessary. The books are then assembled, copied and distributed by the Loft.

B. INFORMATION FOUND IN UCM DRAWINGS

Information that can be found in UCM drawings varies, depending on stage.

1. Cutting Lists

Prior to the Exxon contract, Cutting Lists or "Unit Books," as they were called, were prepared by the Steel Department, sent to the Loft, completed and returned to the Steel Department. With the UCM concept, cutting lists are prepared by utilizing the UPL from Engineering with the Moldloft adding additional data as necessary to complete the cutting lists. A total cutting package includes UCM cutting lists, N/C burning tapes, structural sketches, frame bending data, templates and pin jigs data. Each unit is scheduled with its own "start pre-fabrication" date as established by the shop planners in

accordance with the process lanes directive and level loaded plate shop schedules. Continuity in checking methods, associated with other stages at the part generation level, has helped us reduce the error rate of cutting steel. Once pre-fabrication commences and steel is being cut according to the schedule, the parts are palletized according to need date and sent to the various platens where they will be used. Storage of parts in a specified storage area has been virtually eliminated in lieu of a smooth flow of material to the fabrication platens (VIEW GRAPH NO. ML-28).

The Cutting List includes:

- material size and grade,
- quantity to be cut,
 - applicable hull number,
 - method of cutting,
 - thickness of material,
 - weight,
- special processing (VIEW GRAPH NO. ML-29),
 - line heat,
 - form,
 - punch,
 - structural sketches,
- length or size of piece,
 - stage (by piece number),
- location,
 - stock amount and location.

C. FABRICATION DRAWINGS

The engineering yard plan communicates to the Loft the detailed hull structural work that must be accomplished. The yard plan format is by unit or module of the ship. Utilizing the yard plan and UPL (Unit Parts List), the CADAM draftsman in the UCM group will extract those details required from the yard plan to produce a "shop drawing." Only that information, presented in its simplest form, is

given to the worker in the yard who will be doing the fabrication. This limited amount of information, presented in its simplest form, is given to the worker in the yard who will be doing the fabrication. This limited amount of information, without any frills, is contingent with the IHI philosophy of "need to know." Many hours of drawing research are eliminated with the end result being that the supervisor in the yard spends more hours, directly overseeing the fabrication work. A less skilled worker can also be used, since blueprint reading requirements are diminished from the work platens.

The lowest level of fabrication in the system is identified as the "Partial Sub Unit" or PSU level. A PSU can be as simple as fabricating a flat bar to a bracket or as complex as fabricating shaped floors to a girder. Each PSU has its own UCM drawing, and unique identity in the system (VIEW GRAPH NO. ML-3%).

UCM, PSU fabrication drawings include the following data:

- flat plate assembly instructions,
accuracy control dimensions,
welding and bevel details,
special instructions,
stock locations and amount,
- declivity information,
- fitting details,
- location and orientation of stiffener on the part,
- list of material,
- material grade,
- identification number of steel tape (VIEW GRAPH NO. ML-31).

c. SUB ASSEMBLY DRAWING

Sub-assembly is the assembling of previously fabricated partial sub-units to other partial sub-units and includes "loose" parts that must be installed at that stage.

UCM booklets are produced depicting this fabrication proc and sent to the appropriate platens. These drawings incl the following information: (VIEW GRAPH NO. ML-32)

- welding instructions,
- parts list,
- fitting instructions,
accuracy control dimensions,
steel tapes,
- beveling requirements,
stock requirements,
special instructions,
- datum lines.

D. MAIN ASSEMBLY

Main assembly booklets include:

- isometric drawing of the unit (VIEW GRAPH NOS. ML-33 & ML-34),
- datum lines,
- parts list,
steel tape requirements,
welding and fitting details,
special fitting instructions,
accuracy control dimensions.

E. ERECTION DRAWINGS (VIEW GRAPH NOS. ML-35 & ML-36)

Erection drawings include the following:

- isometric of unit,
special instructions for assembling to companion units
- loose piece table,

welding and beveling,
steel tapes,
accuracy control requirements.

XII. KEY LINE MARKING METHOD FOR CURVED SHELL UNITS

In order to completely achieve the Shell Jig *System* in the shipyard, we have adopted the IHI curve shell marking method by means of steel marking tapes.

It is our experience that in producing curve shell assemblies, the following errors can occur:

- errors caused by plate development,
- errors caused by heat deformation,
- marking errors caused by the N/C punching device,
- deformation caused by shrinkage and expansion through the plate bending procedures.

Even if these errors are minute for one plate, the accumulated errors will affect the entire assembly.

The use of the girth table is not enough to obtain accurate curved shell, because the girth table indicates distances of structures from centerline of the ship. Therefore, it is impossible to determine what seam position should be the starting point.

In order to obtain accurate curved units, the most significant way is to establish two (2) key lines which are perpendicular to each other on the curved shell.

SEE FIGURE 1 (VIEW GWPHNO. ML-37).

This marking method has the following advantages:

- accurate cutting on curved shell erection joints,
- higher accuracy in the layout of curved units.

SEE FIGURE 2 (VIEW GRAPH NO. ML-38).

All calculations for this marking system are generated through the SPADES programming system.

SEE FIGURES 3, 4 & 5 (VIEW GRAPH NOS. ML-39, ML-40, & ML-41)

This information is sent to the Moldloft where the finished marking tape and degree templates are prepared.

A. MARKING METHOD

1. Step No. 1 - Marking Procedure of Key Line

- a. Using the highest tape at the aft and forward butts check the material size of each plate and the size of the assembly.
- b. Mark the key line points on the shell at the aft and forward butts and at a frame nearest the center of unit. This frame is called the Key Frame.

SEE FIGURE 6.

- c. Place the length tape along the three (3) points (A, B, and C).
- d. Connect points A and B with a thread line. Place the key line-template along the key frame at the key line. This procedure will check the longitudinal curvature of the assembly.

SEE FIGURE 7 (VIEW GRAPH NO. ML:42).

2. Step No. 2 - Marking Procedure of the Vertical Lines

- a. In order to establish an accurate key frame, the vertical curvature of the assembly must be checked first.

SEE FIGURE 8 (VIEW GRAPH NO. ML-43).

- b. With the use of a beam compass and a set of three dimensional lengths obtained through the N/C program (FIGURE 3), mark points A and B from points C and D.
- c. If the cross marks fall off the seam, this will indicate either a bad cut or incorrect curvature.
- d. If differences do exist, check the following items:
 - clearance between the shell plate and the jig,
 - distance between corners of the starting plate and the jig,

- heights of the pins,
 - loose hanging edge of the shell plate,
- recheck the assembly marking tape.

3. Step No. 3 - Marking Procedure of the Key Frame Line

SEE FIGURE 9 (VIEW GRAPH NO. ML-44)

- a. Join points G and F with a thread and put the backset template on the key line to check backset length and the declivity of the frame.
- b. The backset template at this point establishes point H. Point H represents the intersection of the key line and key frame.
- c. With another thread, join points F, H and G. By seeing through the threads, visualize a plane through the three points to confirm the key frame. Mark several points on the shell and, by using a wooden batten, create the key frame.

SEE FIGURE 10 (VIEW GRAPH NO. ML-45).

4. Step No. 4 - Marking Procedure of Frame Lines and Internal Structure Lines

SEE FIGURE 11 (VIEW GRAPH NO. ML-46).

- a. Taking the height tape, meet the key line mark on the tape to the key line at each frame position. Mark all height points of the internal structures, water lines, and erection seam lines at every frame.
- b. Taking the length tape, meet the key frame mark on the tape to the key frame line. Mark all length points of the internal lines, buttock lines, and erection butts.
- c. Using a wooden batten, join all cross mark points to get the frame lines, buttock lines, water lines, internal structure and erection seam lines.

B. CONCLUSION

This concludes the Assembly Marking Method for Curved Shell. At this point, all lines have been re-marked, even if the line had been already marked by the N/C burning machine. Good results from this marking system are being realized as the Exxon ship is being erected. We are already experiencing better alignment of internals across units with less stock required on the units.

XIII. CONCLUSION

In conclusion, what has been presented to you today are the results of two years of hard work by many individuals. We are excited about the many innovations implemented and what they are doing for the shipyard. Our overall costs have been reduced, accuracy has improved, and the time frame for fabrication and erection shortened. We anxiously look forward to applying our new technology to future contracts with continued growth.

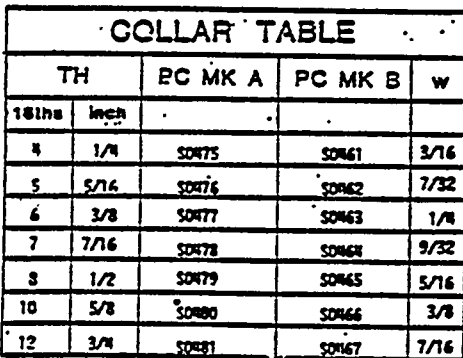
I H I
TECHNOLOGY IN MOLD LOFT

- * MOLD LOFT PLANNING
- * MOLD LOFT SCHEDULING BY STAGE
- * DEVELOPMENT OF UNIT CONTROL MANUALS
- * STEEL TAPE SYSTEM
- * KEY LINE
- * PIECE NUMBER SYSTEM
- * LINE HEATING
- * PIN JIGS
- * SHRINKAGE FACTOR REFINEMENT

ML 1

IMPACT OF IHI TO MOLD LOFT SECTIONS

- 1) N.C. PART GENERATION GROUP
 - A) PIN JIG DATA
 - B) KEY LINE DATA
 - C) EXPANSION FACTOR
 - D) STEEL TAPE DATA
- 2) CONVENTIONAL MOLD LOFT
 - A) PRODUCTION OF STEEL TAPES
 - B) LINE HEAT TEMPLATES
 - C) KEY LINE TAPES
 - D) KEY LINE TEMPLATES
- 3) UNIT CONTROL MANUAL
 - A) INTEGRATION OF IHI RECOMMENDATIONS
TO IMPROVE DRAWINGS



**AVONDALE
SHOPYARDS INC**
P O BOX 38286
NEW ORLEANS, LA
70180

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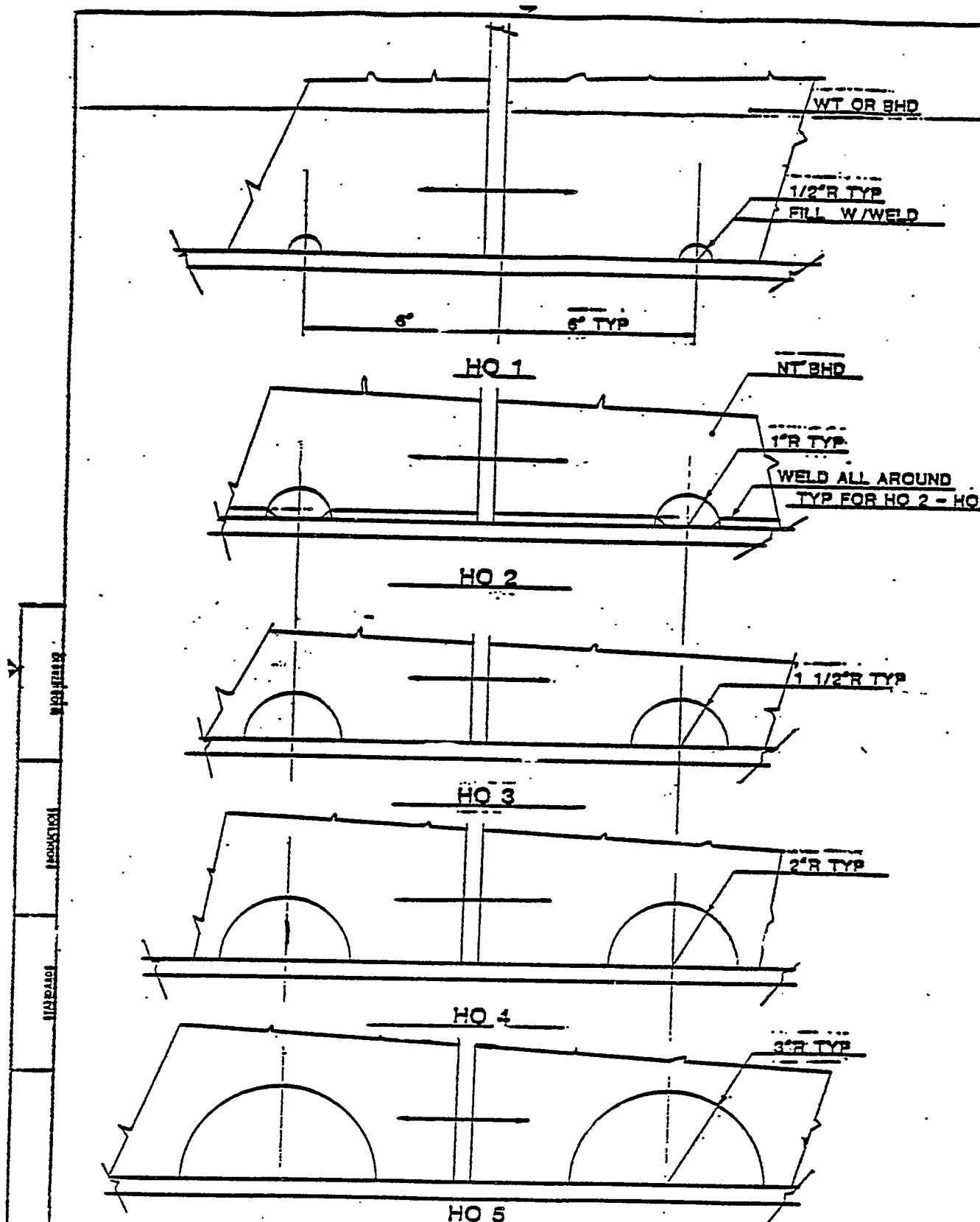
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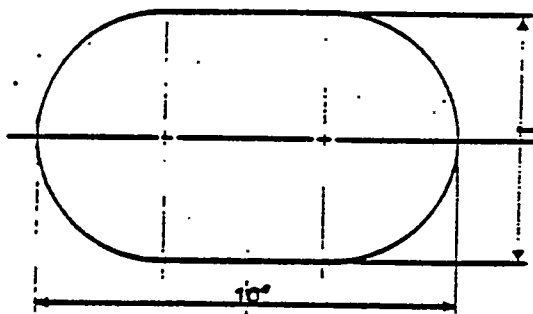
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ML 3

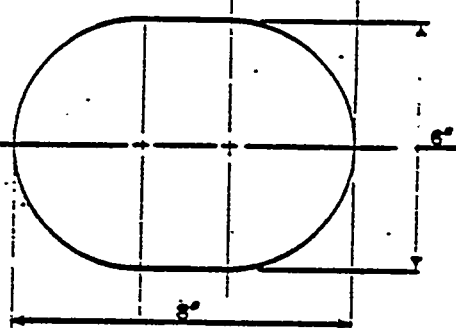


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	AS	SD			

ML 4



HO 21

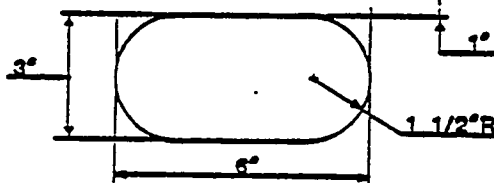
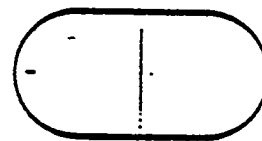


HO 22

BHD



1" TYP



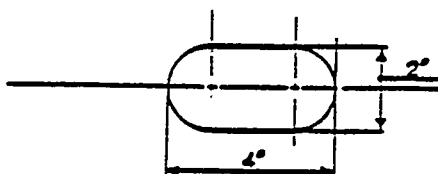
1" TYP

GIRDER
OR FLAT

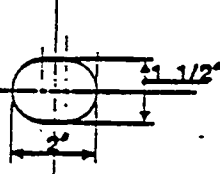
1 1/2" R

HO 23

BHD



HO 24



HO 25

AVONDALE
SHIPYARDS INC
P O BOX 30288
NEW ORLEANS, LA
70130

STANDARD

AS SD

DRAIN AND
AIR HOLES

DWG NO

HO 21 - 25

BY
0

SCALE

SH NO OF
316

Form C-AS-30 (1/84)

ML 5

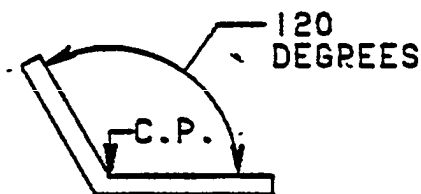
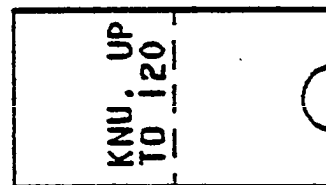
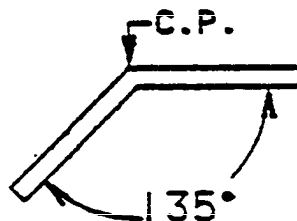
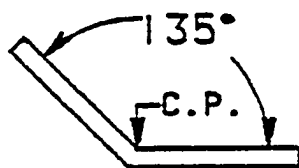
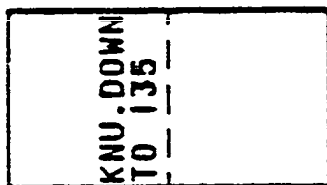
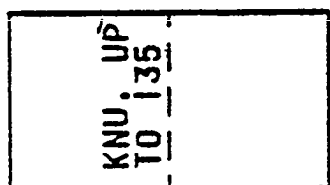
STRUCTURAL CLASSIFICATION	NUMBER OF CONFIGURATIONS	TEMPLATE DESIGNATION	CONFIGURATIO TEMPLATE
1. Flatbars (Fig.6)	21	"E"+No. (E1, E9)	Web Temp.
2. Angles (Fig.7)	19	AE+No. (AE9, AE3)	Web Temp. Flg. Temp.
3. Tee's (Fig.8)	16	TE+No. (TE6, TE3)	Web Temp. Flg. Temp.

"STANDARD END CUT CONCEPT"

LABELING:
 WHEN LABELING A PART OR TEMPLATE, IF THE PLATE IS TO BE KNUCKLED IN THE DIRECTION OF THE SIDE OF THE PLATE THAT IS CENTERPUNCHED, THE CORRECT LABEL IS "KNU. UP TO-(DEGREES)". IF THE PLATE IS TO KNUCKLE AWAY FROM THE CENTERPUNCHED SIDE, THE CORRECT LABEL IS "KNU. DOWN TO-(DEGREES)". THE LABEL "TRANSFER CENTERPUNCH AND KNU. UP", IS INCORRECT. SEE EXAMPLES BELOW.

THE RESULTING ANGLE (IN NUMBER OF DEGREES) IS TO BE LABELED ON THE PART OR TEMPLATE. ONLY SPECIAL CONDITIONS WILL ALLOW THE USE OF THE LABEL, "KNU. TO SET". SEE SUPERVISOR IF IT IS NOT POSSIBLE TO LABEL THE KNUCKLE IN DEGREES.

THE DEGREE SYMBOL (°) WILL NOT BE USED IN LABELING THE KNUCKLE ANGLE. ONLY THE NUMBER OF DEGREES, ROUNDED OFF TO THE NEAREST 1/2 DEGREE, WILL BE INDICATED. A TYPICAL LABEL WOULD BE "KNU. UP TO 120" MEANING THAT THE RESULTING ANGLE CREATED ON THE PLATE IS 120 DEGREES. SEE EXAMPLE BELOW.



SOURCE OF INFORMATION: PRODUCTION MEETING WITH GENERAL FOREMEN BUTCH LIVACCARI, BOOGIE GALATAS, K. HONDA ON 7-14-81.

APPLICABLE TO

JOB: ALL

REVISIONS:

DATE

REV.

TITLE: KNUCKLES-LABELING AND HOW TO INDICATE.

DRAWN BY
L.LASSALLE

DATE
7-16-81

ORIGINATOR
G.HARMYER

DATE
7-16-81

APPROVED

DATE

S.P.512

SHT 5.4

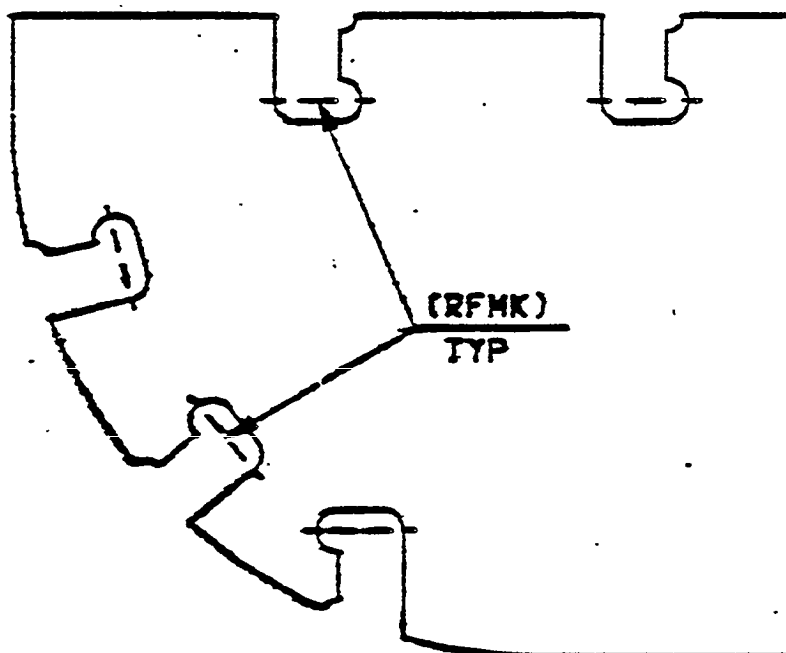
ML 7

REFERENCE MARKS (RFMK) FOR THE INNER TRACE OF A MEMBER, MUST BE PUNCHED ACROSS THE CUTOUT IT PENETRATES. THIS ESTABLISHES CORRECT ALIGNMENT OF STIFFENERS.

THIS IS DONE BY USING COMMAND (DBCT) WITH (RFMK). THE RESULT IS AN AUTOMATIC PUNCH.

FOR CUTS NOT LOADED TO THE DATA BASE, AN INNER TRACE POINT MUST BE SAVED AND A MANUAL PUNCH GENERATED WITH THE PUNCH NORMAL TO THE MEMBER.

EXAMPLE:



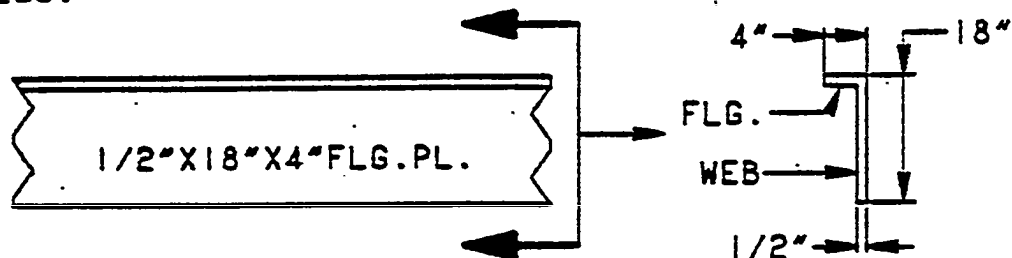
SOURCE OF INFORMATION: NUMERICAL CONTROL STANDARD PRACTICE			APPLICABLE JOB <u>ALL</u>
REVISIONS:			DATE
TITLE: INNER TRACE REFERENCE MARKS FOR ALIGNMENT OF STIFFENERS			S.P. 5 SHT 5.6
DRAWN BY C. BURGANY	DATE 8-4-81		
ORIGINATOR J. B. PODOLIAH	DATE 8-4-81		
APPROVED	DATE		

•STANDARD PROCEDURE

ML 8

EXAMPLE:

1) IF DRAWING CALLS FOR 18"X4" FLANGE PLATE 1/2" THICKNESS.



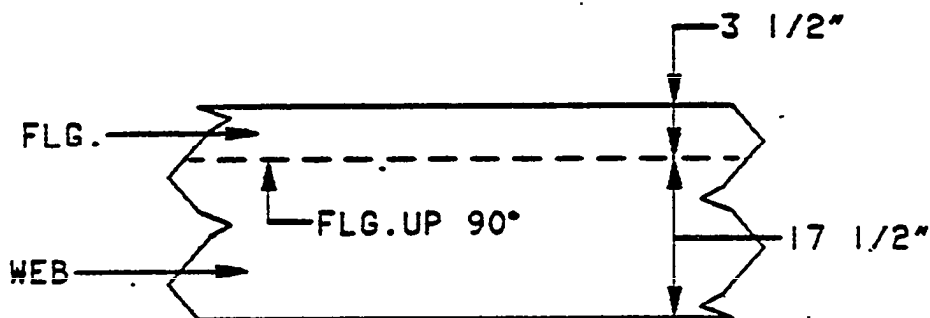
2) TO DEVELOPE A FLANGED PLATE:

A) SUBTRACT ONE PLATE THICKNESS FROM DEPTH OF WEB.

$$18'' - 1/2'' = 17 \frac{1}{2}''$$

B) SUBTRACT ONE PLATE THICKNESS FROM WIDTH OF FLANGE.

$$4'' - 1/2'' = 3 \frac{1}{2}''$$



SOURCE OF INFORMATION: MOLD LOFT STANDARD PRACTICE.

APPLICABLE TO

JOB: ALL

REVISIONS:

DATE

REV.

TITLE: PROCEDURE FOR FLANGE PLATES
(BENT FLANGE).

DRAWN BY

L. LASSALLE

DATE

8-20-81

ORIGINATOR

B. POURCIAU

DATE

8-20-81

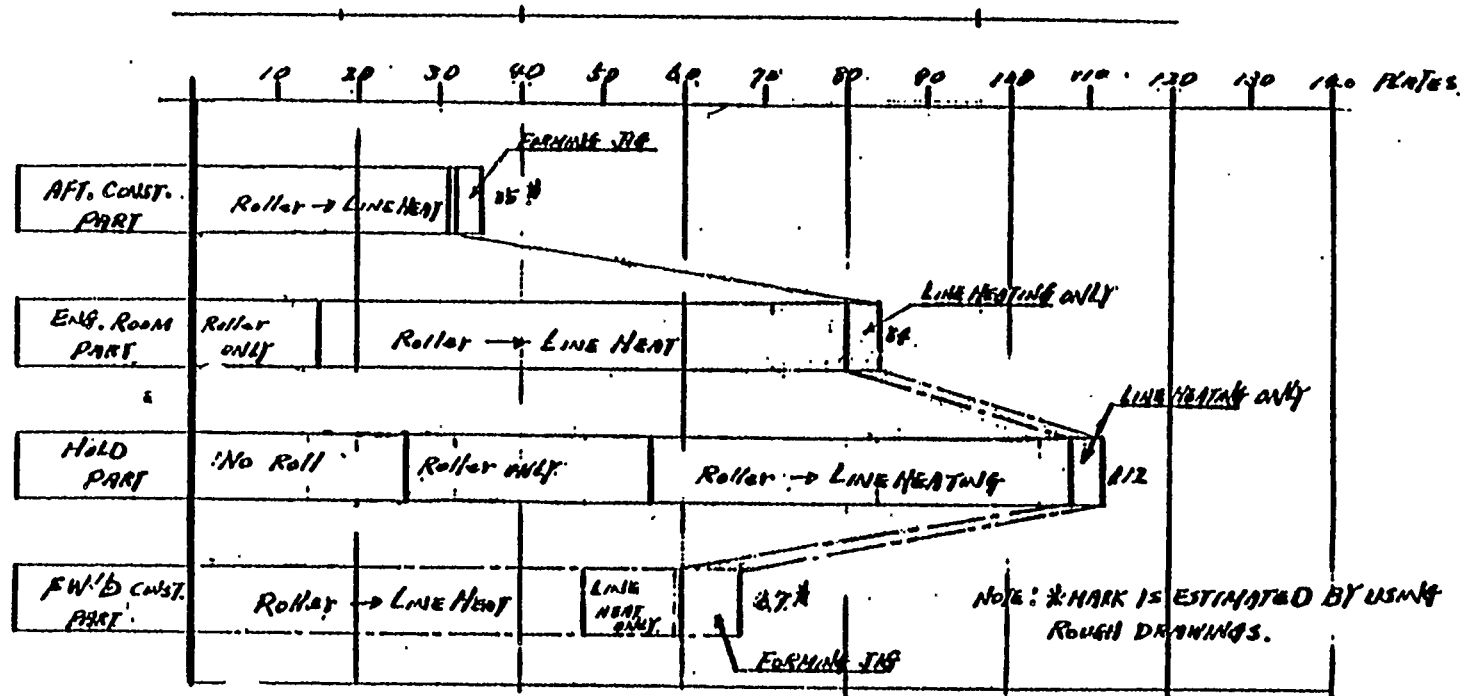
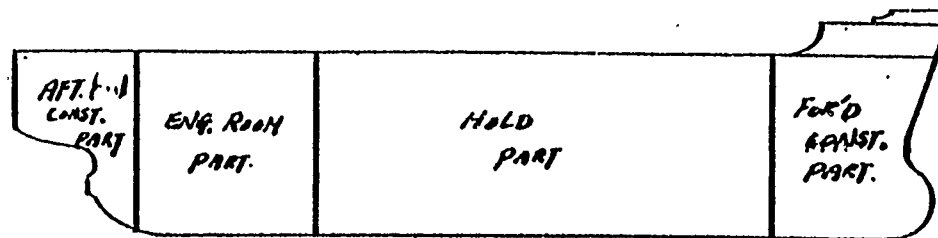
APPROVED

DATE

S.P. 303

SHT 3.4

ML 9



EXXON
ENGINE ROOM PART (1/2)

TABLE OF CURVED PLATES

2/11

PIECE CODE		APPROXIMATE PLATE SIZE			DEPTH			TWIST (DEGREE)	BENDING PROCESS	KIND OF TEMPLATE	REMARKS
UNIT	P. NO	THICKNESS	BREADTH	LENGTH	ACT. BUTT	END BUTT	CONCAVITY				
⑨	FK1 (14)	.63"		28'	-	-	-	0°	FLAT R.		
	FK2 (14)	.63"		27'	1/4"	0	-	0°	R		TANG LINE
	A1	.63"	9'	28'	1/4"	0	0"	0°	R		TANG LINE
	A2	.63"	10'	27'	1"	1"	1"	15°	R.L.		TANG LINE
⑩	K1	.63"	7'	19'6"					R.L.		TANG LINE
	K2	.63"	8'	22'	1"	4"		10°	R.L.		
	E	.63"	7'	20'	4 1/4"	5"	0"	0°	R.L.		
	Q1	.63"	5'6"	13'6"	3"	2 1/2"	1"	8°	R.L.		
	H1	.63"	5'	42'	1 1/2"	0"	1"	17°	R.L.		off. curve
	H2	.63"	5'	42'	1 1/2"	0"	2"	20°	R.L.		off. curve
⑪	J1	.63"	5'	42'	2 1/2"	1/2"	5 1/2"	10°	R.L.		off. curve
	J2	.63"	5'	42'6"	2"	0"	11"	9°	R.L.		off. curve
⑫	K2	.63"	8'6"	42'	0"	1 1/2"	11 1/2"	17°	R.L.		
	L1	.63"	10'	41'	3"	3"	1'0"	18°	R.L.		
	L3	.63"	8'6"	41'	3"	2"	9"	16°	R.L.		
⑬	M	.63"	7'	41'	1"	0	9"	11°	R.L.		
	N	.63"	7'0"	41'	2"	0	9 1/2"	5°	R.L.		

11 + 2 1/2" (11 1/2")

(11 1/2")

R roll
L blue heat

ML 11

Estimation of Curved Shell Plates on EXXON

1. Amount of curved shell plates (per one ship)

Aft. Construction Part	* 35 Plates
Engine Room Part	84 Plates
Cargo Hold Part	112 Plates
Fwd. Construction Part	* 67 Plates

TOTAL	298 Plates
-------	------------

NOTE: * MARK WAS ESTIMATED BY ROUGH DRAWINGS

2. Classification of curved plates bending works.

BENDING PROCESS	QUANTITY OF PLATES	RATIO
a) No roll	26	8.7%
b) Roller(or press) only	45	15.1%
c) Roller → Line Heating	196	65.8%
d) Line Heating Only	20	6.7%
e) Roller → Forming jig	11	3.7%
TOTAL	298	100.0%

Roller work = $\frac{(b)}{45} + \frac{(c)}{196} + \frac{(e)}{11} = 252 \text{ plates/one ship}$

Line Heating Work = $\frac{(c)}{196} + \frac{(d)}{20} = 216 \text{ plates/one ship}$

NOTE : The above classification of bending work was estimated by using drawings and small scaled body plans.

3. Capability of Line Heating Work Loading

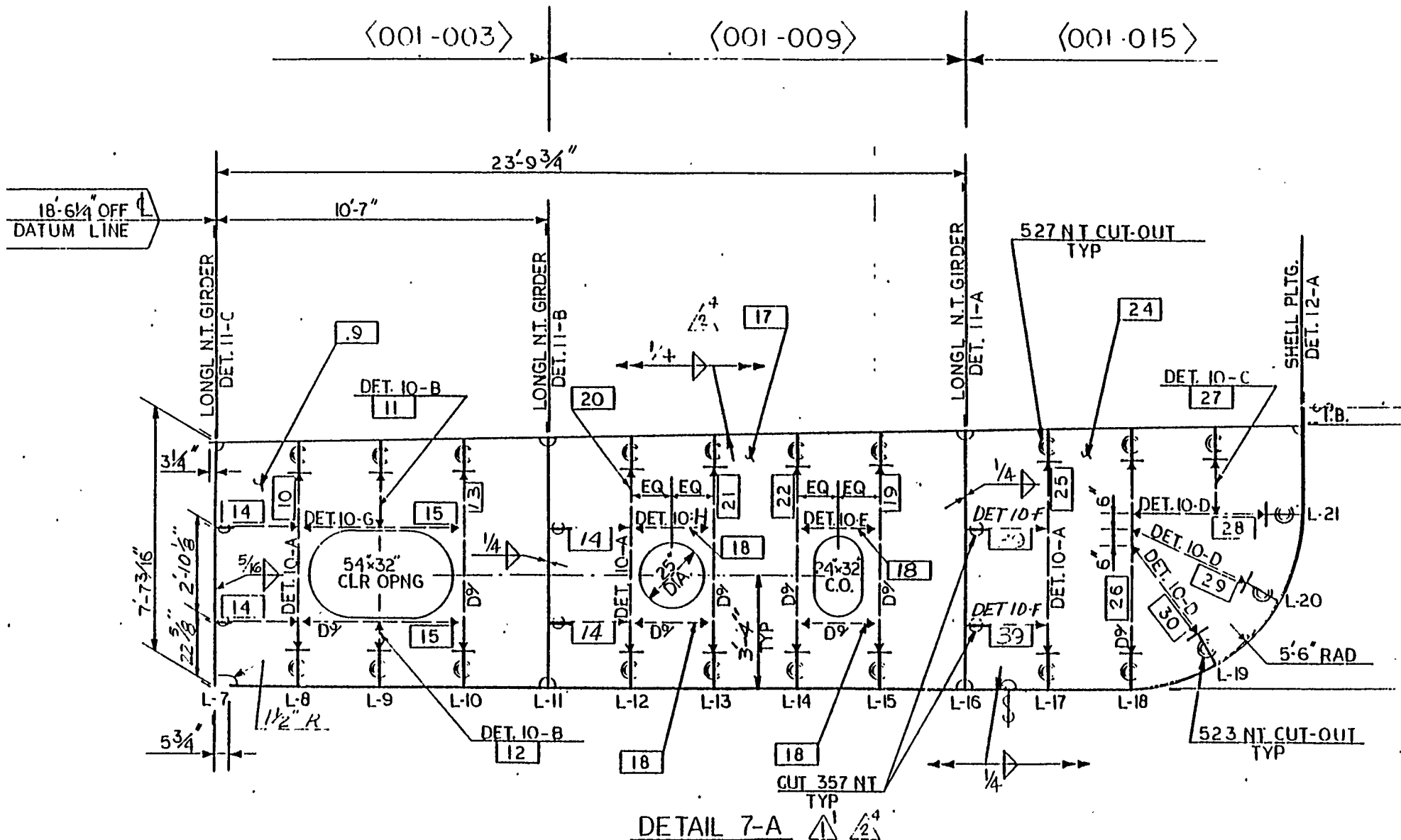
This capability is confirmed by two ways as follows:

(a) Necessary manhours for Line Heating work

Estimatable average (excluded idle time); 11 mh/one plate

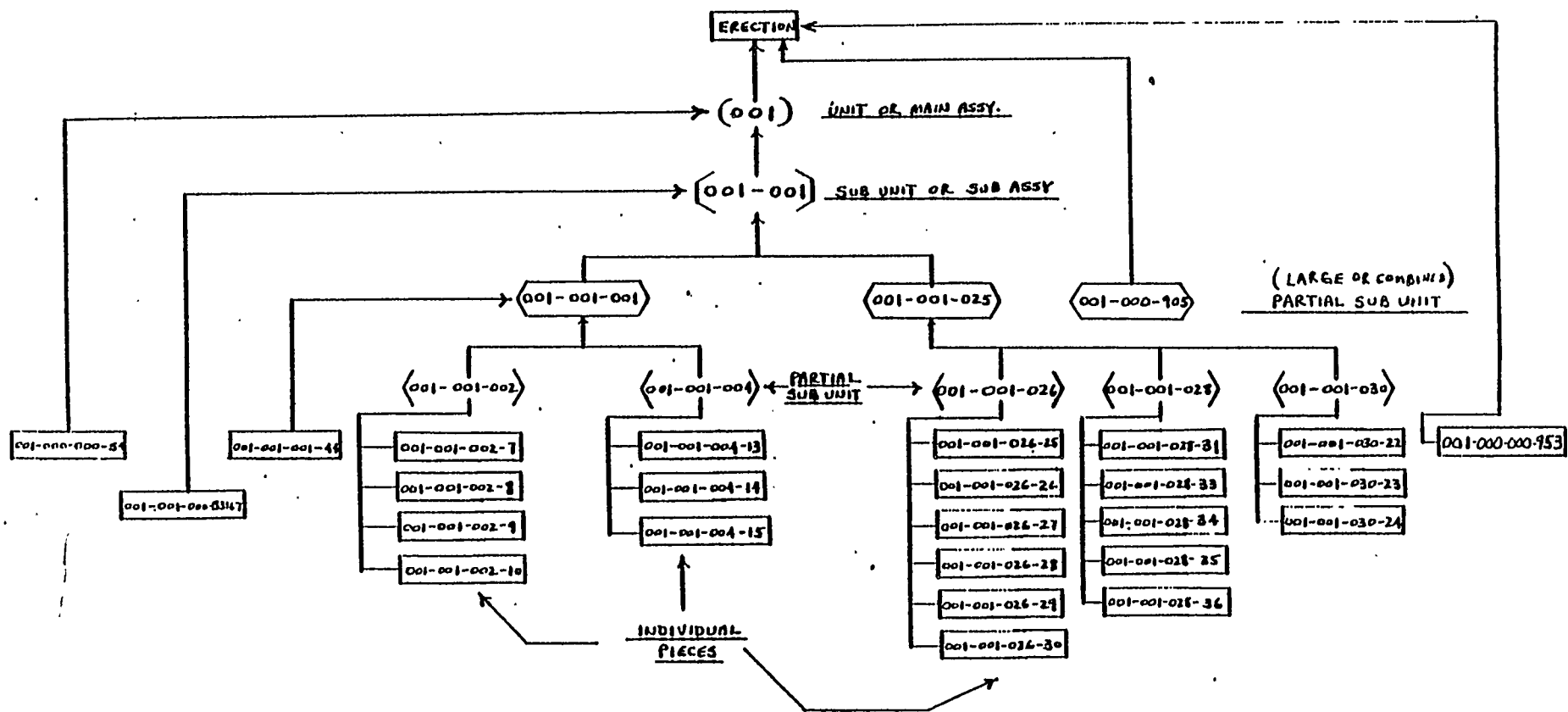
(IHI's average (Included idle time); 6 mh/one plate

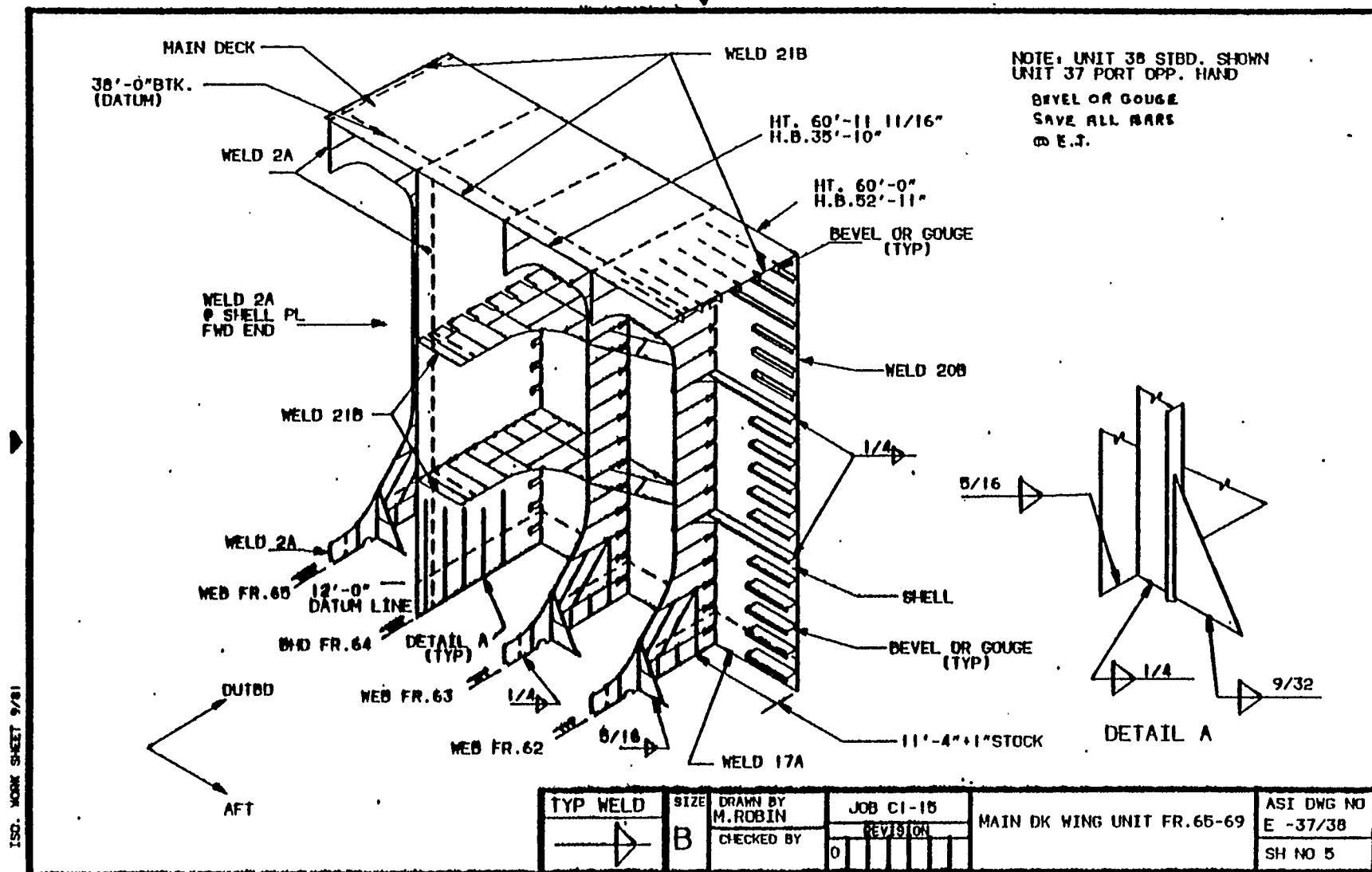
ML



N.T. FLOOR FR. NO. 67

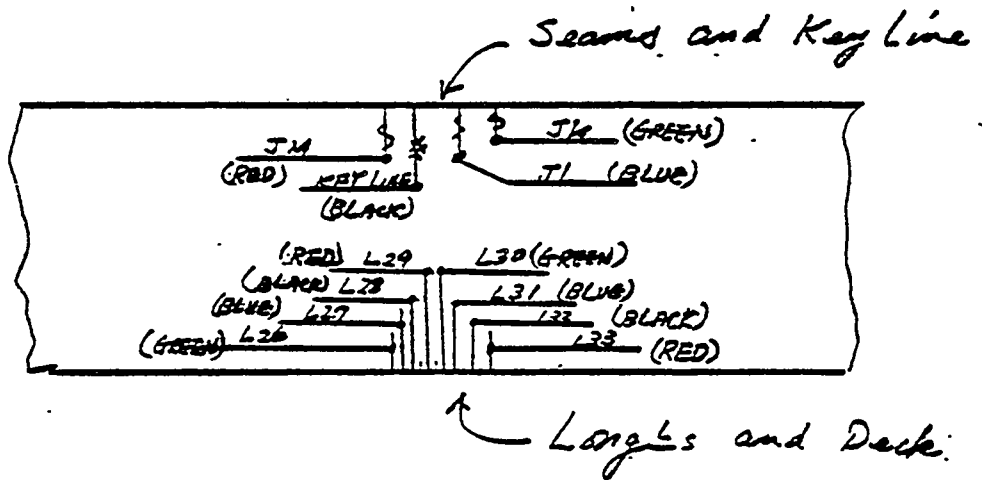
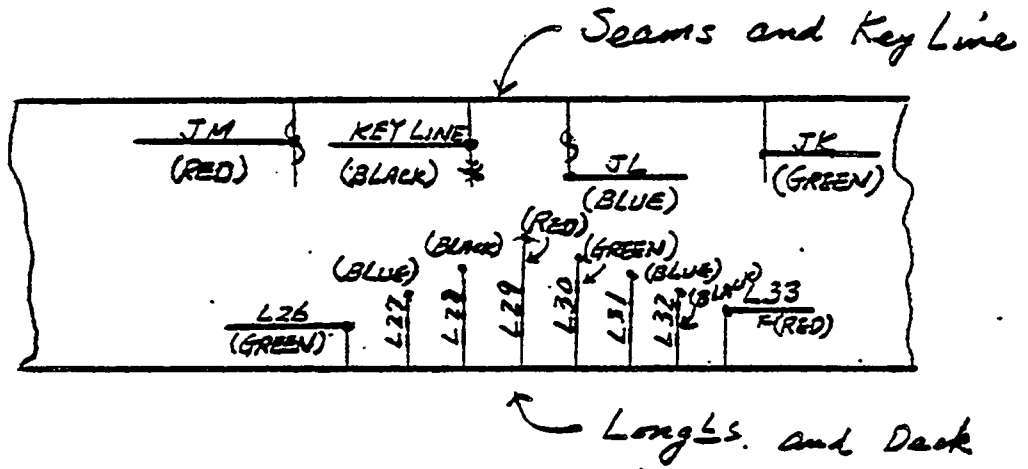
DI TC 1542 CD AL-32





15 ML

mark side on the steel tapes



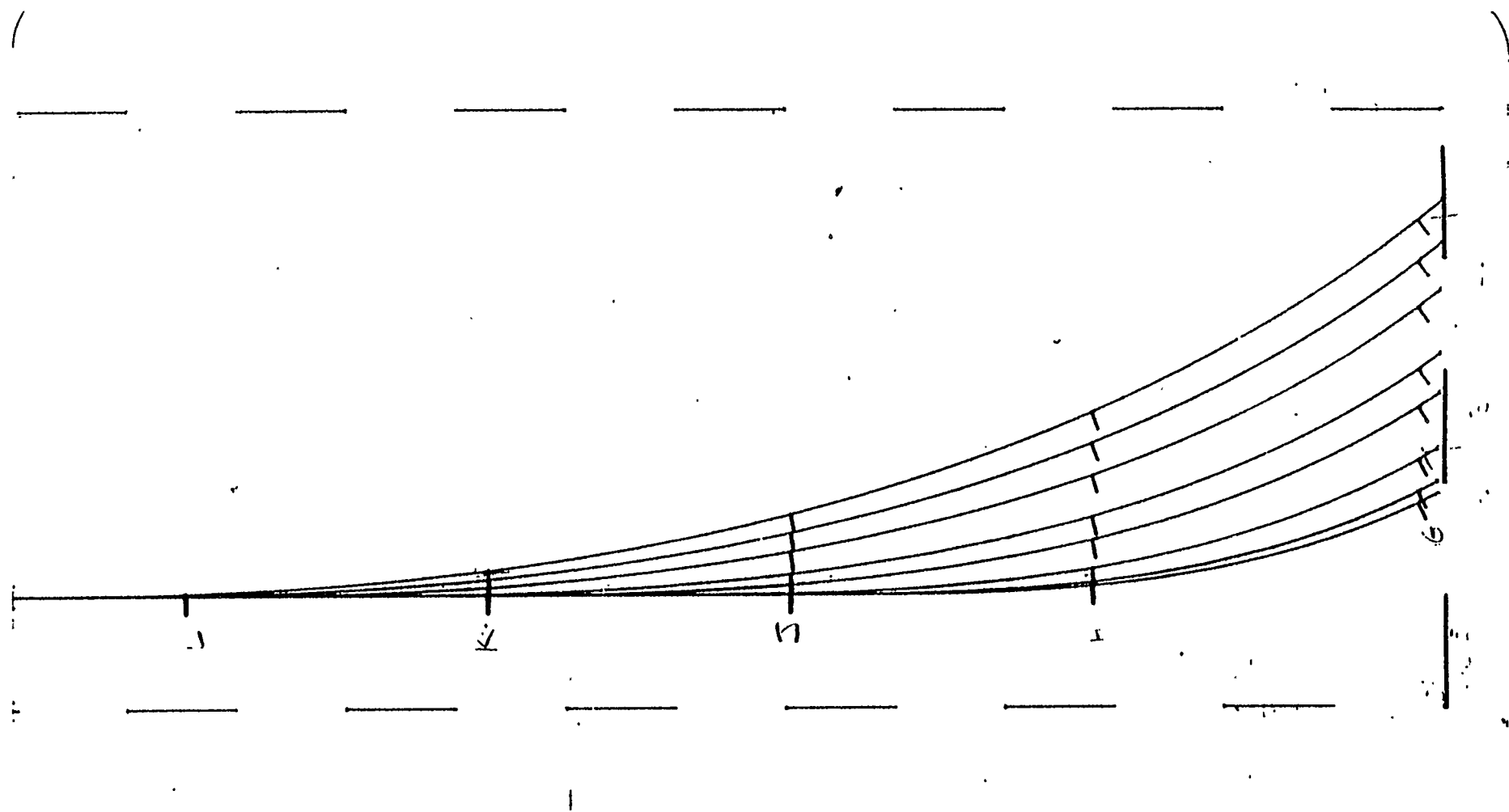
Subject: Exxon Assembly Jig's

After discussions it has been decided to build the following units on pin jigs:

UNITS #	DESCRIPTION
8/10	T.T. to stringer shell panel only
27/28	O.B. tank sect on shell
41/42	Shell Panel only
61/62	Shell Panel only
69/70	Shell Panel only
78/79	Shell Panel only
95	Shell Panel only
119/120	O.B. Tank Sect - on Shell
123/124	O.B. Tank Sect - on Shell
127/128	Wing Tank Sect Shell Panel only
138	Shell Panel only
139	Shell Panel only

Because of excessive curvature, twist or narrow width - the following Units will be built on Fixed Plate Jigs.

UNITS #	DESCRIPTION
17/18	T.T. to stringer - Shell panel only
25	T.T. to stringer - Shell panel only
34/35	Shell Panel only
37/38	Built on Flat platten with small aft-lower corner plate jig
46/47	Shell Panel only
48/49	Shell Panel only
54/55	Shell Panel only
63/64	Shell Panel only
132	Shell Panel only
133	Shell Panel only
134/135	Shell Panel only
 137	Shell Panel only (to bow wrapper)
 74	Shell Panel only (upper two strskes)



DATE: 03/15/92
JOB NO.: C1-15

SHELL JIG PIN HEIGHTS

PAGE NO. 1

ASSEMBLY: 4

PROJECT CARTER

UNIT 27-P/28-S

ALL DIMENSIONS GIVEN IN FEET, INCHES & 16TH

DISPLAY OF SHELL ASSEMBLY CORNER POINTS

CORNER NO. 1 ON SIGHT EDGE 0 700/00 FEET END OF FRAME 81900

CORNER NO. 2 ON SIGHT EDGE HOR 700/00 FEET END OF FRAME 81900

CORNER NO. 3 ON SIGHT EDGE HOR 700/00 FEET END OF FRAME 58900

CORNER NO. 4 ON SIGHT EDGE 0 700/00 FEET END OF FRAME 58900

ANGLE OF WERFRAME AGAINST BASE IS 86 DEGREES

JIG CONFIGURATION: HOR SPACING 4.0 FEET HARBIN 7000 FEET

PIN SPACING 4.0 FEET PIN OFFSET 0.0 FEET

CORNER LOCATIONS ON THE JIG

CORNER NO. 1 IS DISPLACED 33/00/00 IN Y 24/06/00 IN 1 FROM PIN 1 IN ROW 14

CORNER NO. 2 IS DISPLACED 701/06 IN Y -3/05/10 IN 2 FROM PIN 2 IN ROW 14

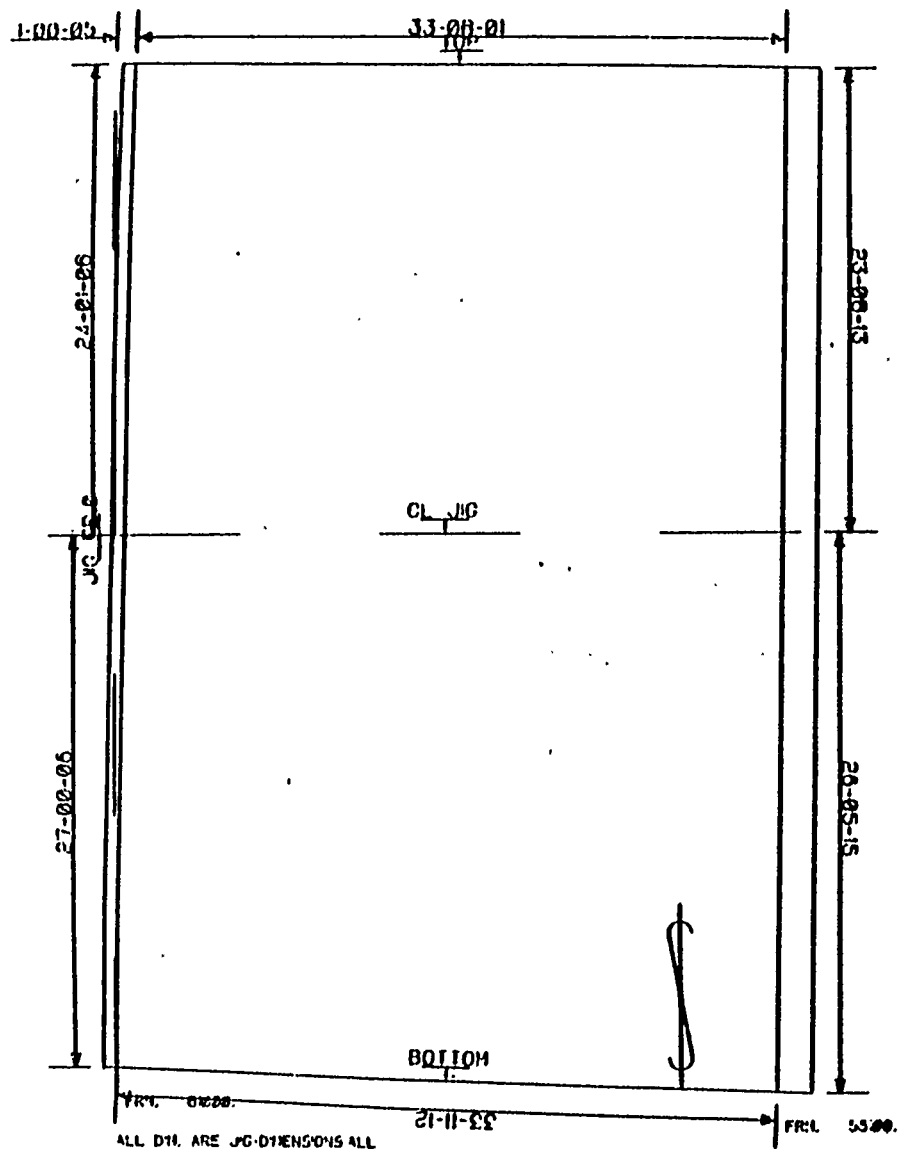
CORNER NO. 3 IS DISPLACED 3706/13 IN Y 705/05 IN 1 FROM PIN 10 IN ROW 13

CORNER NO. 4 IS DISPLACED 3706/00 IN Y 3/10/14 IN 2 FROM PIN 9 IN ROW 11

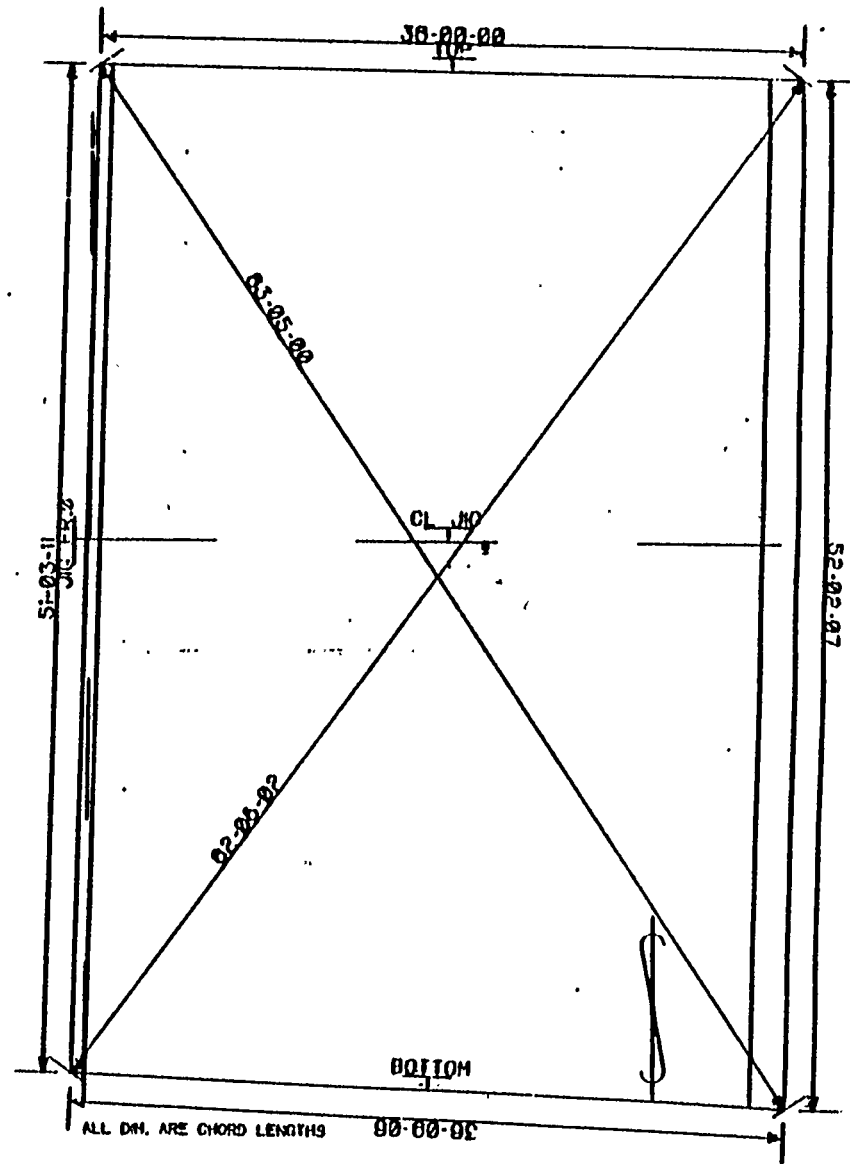
Y DENOTES DIRECTION ACROSS ROWS
Z DENOTES DIRECTION WITHIN ROWS

ML 19

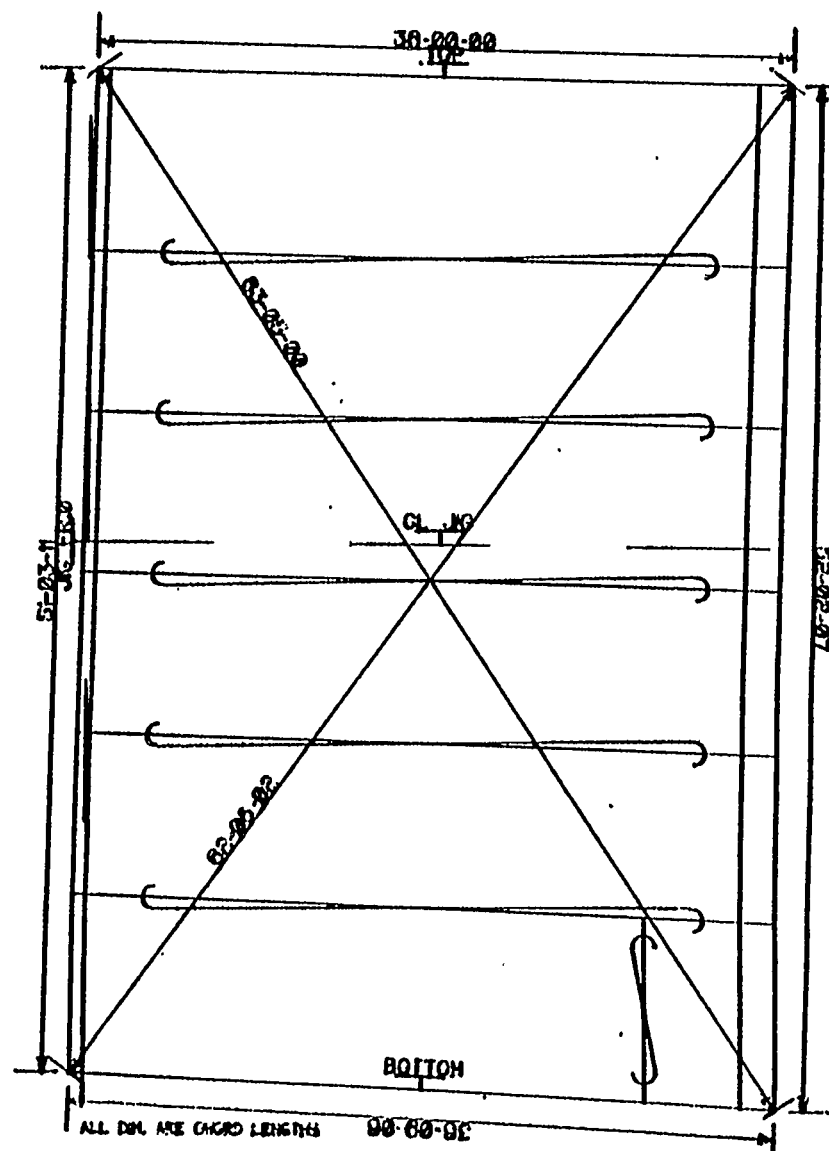
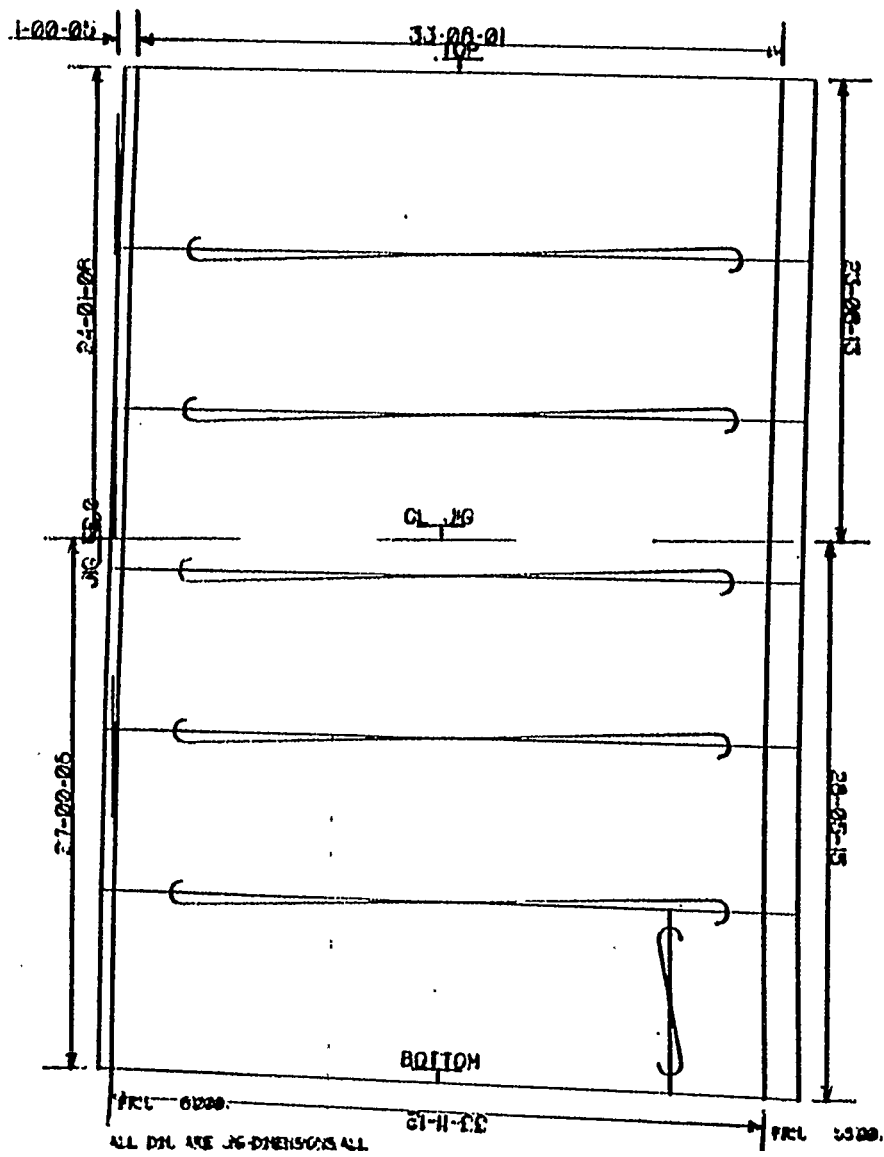
7 12 x 71



EXN1 - 167002-481



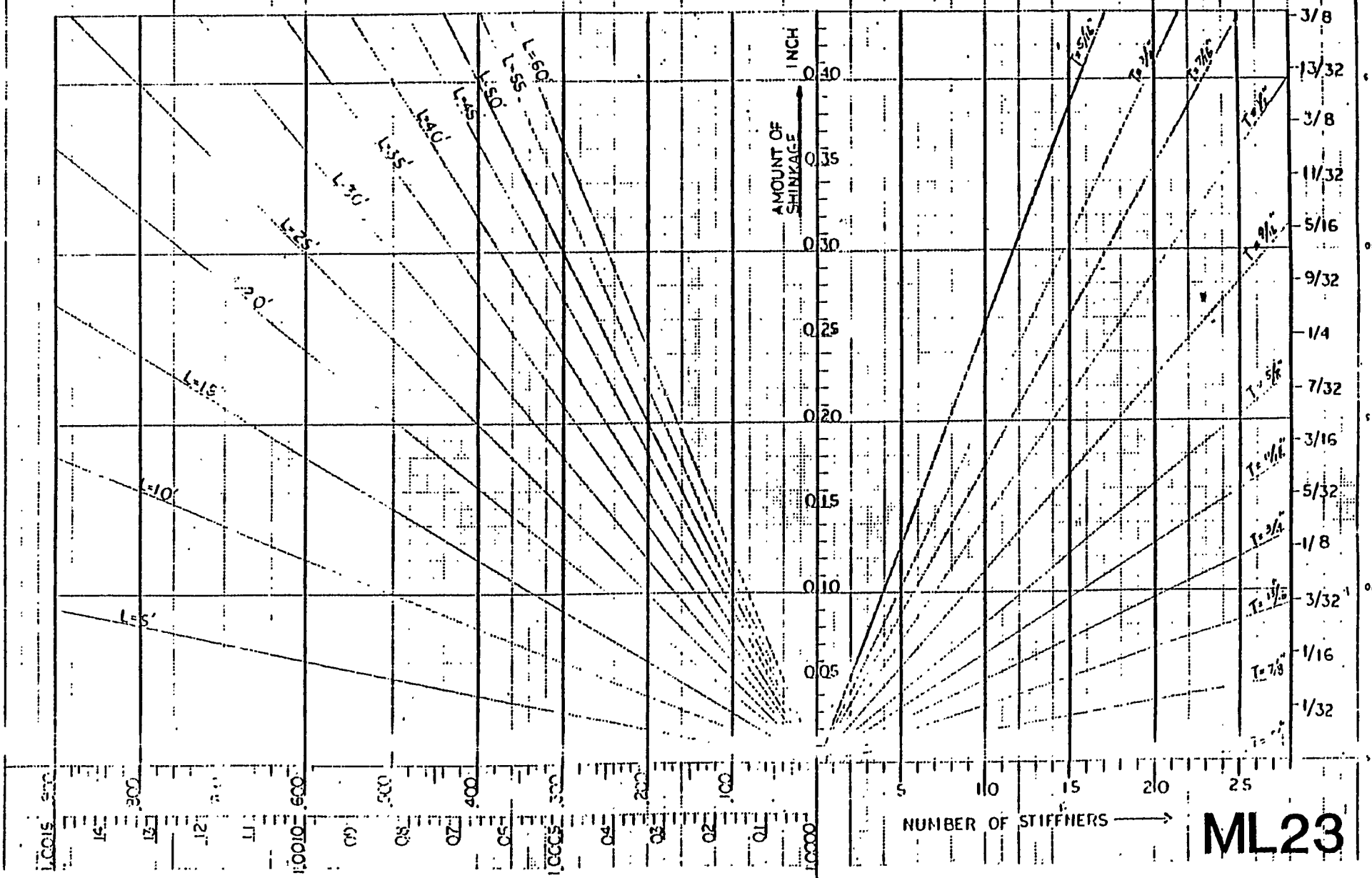
ML 21



SHRINKAGE BY STIFFENERS

CHART - 2

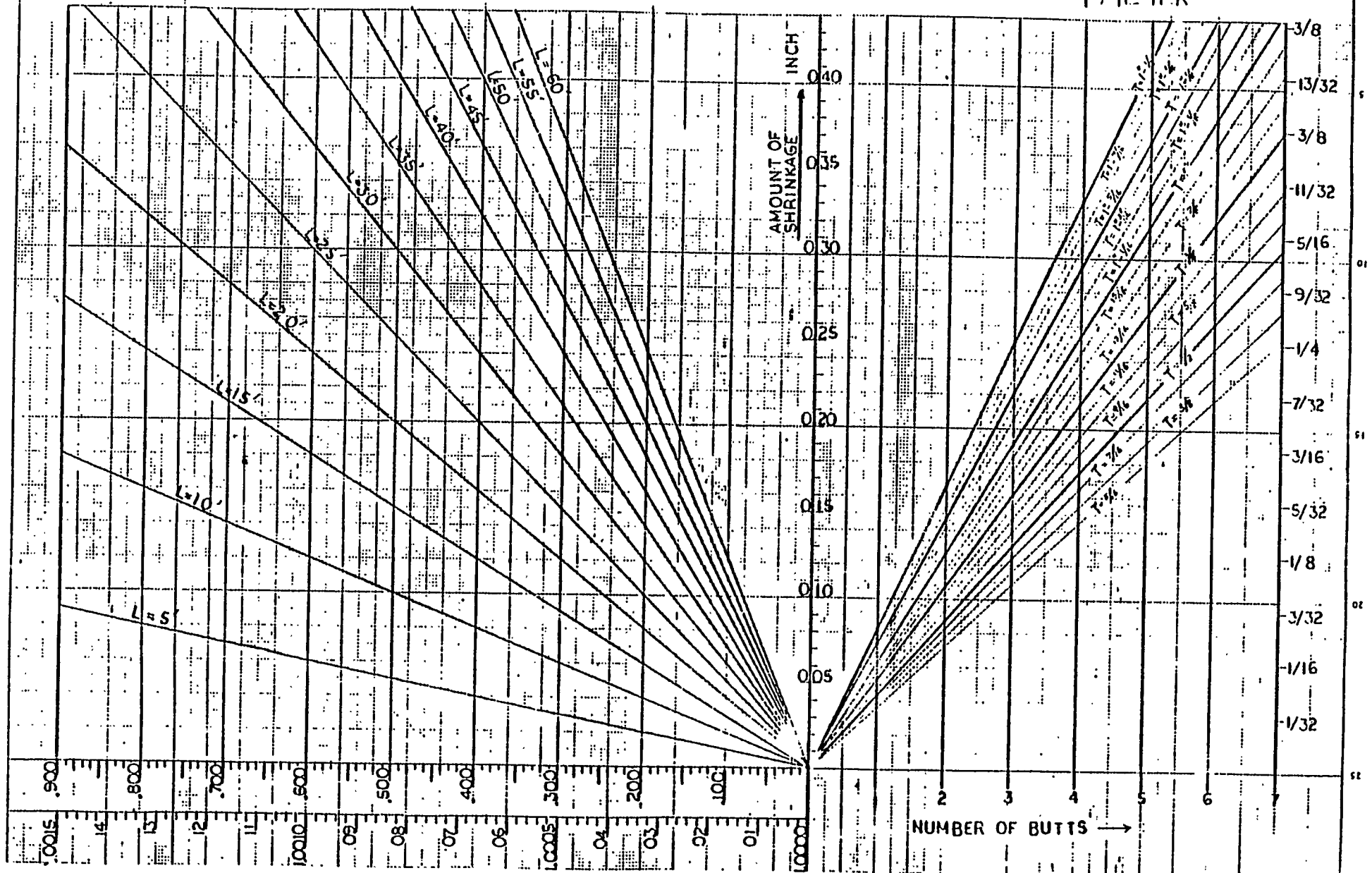
T; R TIK



ML23

SHRINKAGE BY BUTT WELDING (PLATE) CHART - I

T: PL THK



1.0°	0.0°
0.9°	
0.8°	2.5°
0.7°	
0.6°	3°
0.5°	1.5°
0.4°	
0.3°	1°
0.2°	
0.1°	0.5°

[illegible]

Handwritten:

20658	2-25-79
20659	2-25-79

Handwritten: 20658 2-25-79

~~7. 2. 5. 11 2. 5. 11~~

The figure consists of two schematic diagrams. The top diagram, labeled 'A. PLE', shows a cross-section of a rectangular block with a central vertical channel. The bottom diagram, labeled 'T. BEAN', shows a top-down view of the same block, with a central vertical channel and two side channels. The diagrams illustrate the geometry of the experimental setup.

Twist	Twist
Dead	Dead
Twist	Twist
Dead	Dead

25

10/2/2011

11/11/11

WILLIAM

200

SECRET

1990

$$T_{\text{RCE}} = 82 \text{ K} \cdot \text{cm}^2$$

FACE = 250 POWERS

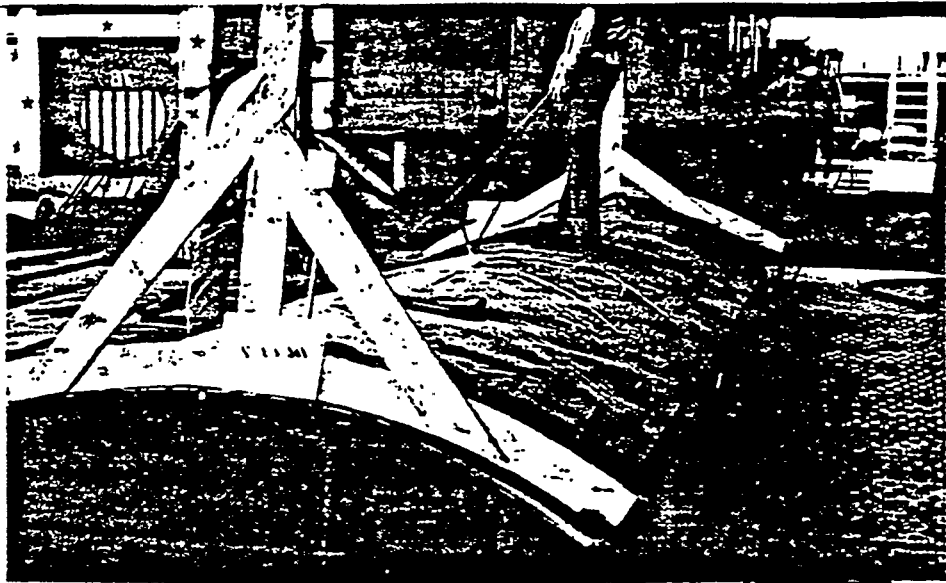


PHOTO 18

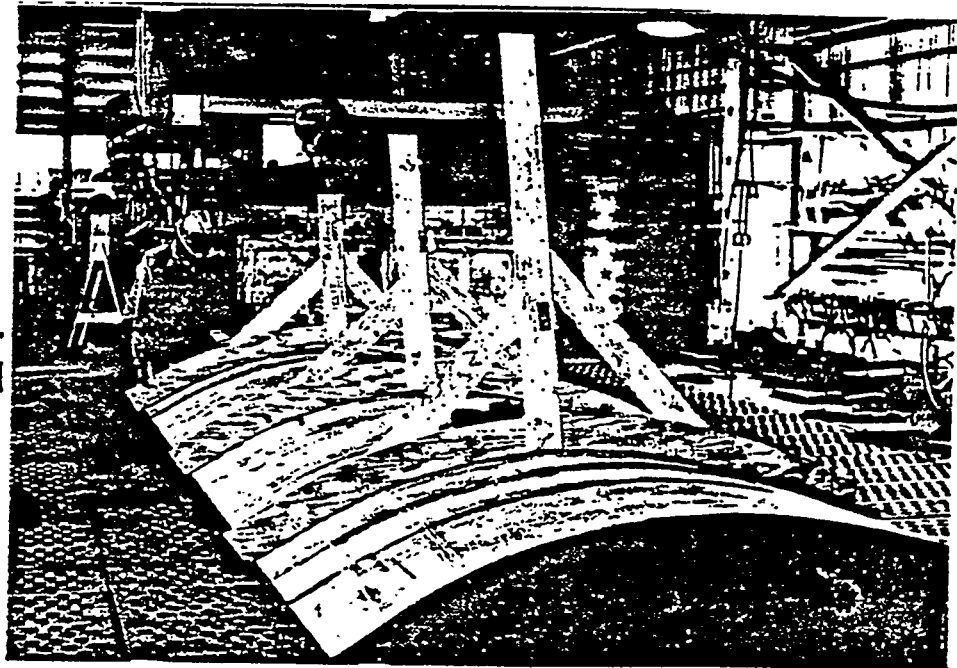


PHOTO 19

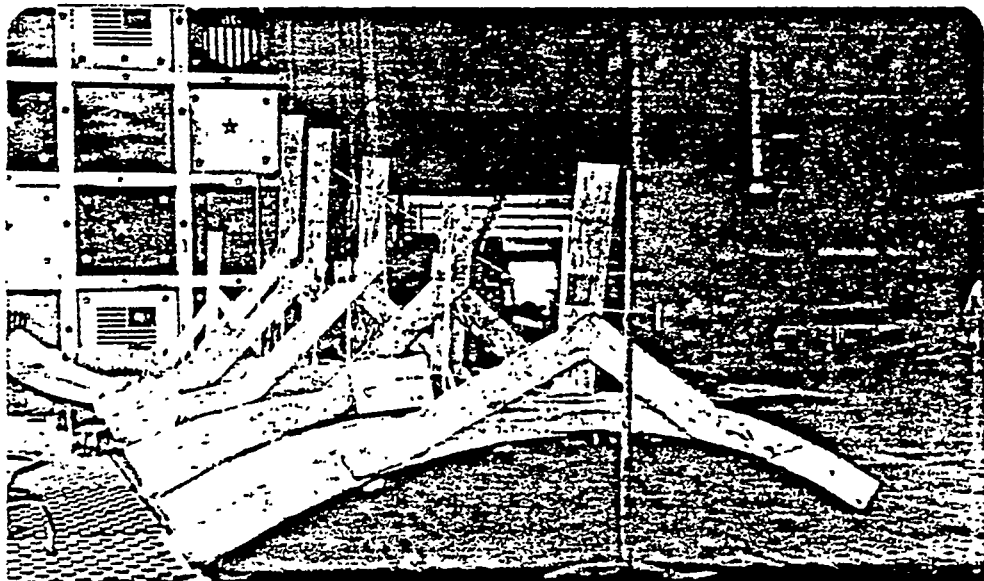


PHOTO 20

UNIT CONTROL MANUAL

2335 (B)		
2336 (H)		
2337 (G)		
ASI HULL NO	NAME OF VESSEL	
AVONDALE SHIPYARDS INC  P O BOX 50280 NEW ORLEANS, LA 70150	ASI JOB NO C1-15	
	EXXON	
DRAWN BY DATE	42,000 DWT MULTI-PRODUCTS CARRIERS UNIT -	
CHECKED BY DATE		
APVD		
ISSUED		
SIZE B	CUTTING LIST	REV

SIZE B	PANEL LINE	REV
------------------	------------	-----

SIZE B	PARTIAL SUB-UNITS	REV
------------------	-------------------	-----

SIZE B	SUB ASSEMBLY	REV
------------------	--------------	-----

SIZE B	MAIN ASSEMBLY	REV
------------------	---------------	-----

SIZE B	ERECTION	REV
------------------	----------	-----

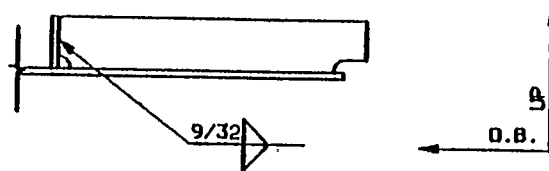
"PRE-FABRICATION INFORMATION IN U.C.M."

PRE-FAB INFO. IN U.C.M.	TYPE OF INFO. PLATE SHOP WILL RECEIVE	LABELING MEDIUM
N/C Burning Tape No.'s 16-----	1 1" scale drawing represent- ing steel plate to be burned. 2. Burning data stored on IBM system 7.	1" scale burning tape drawing
Servo (Servograph)	Full size optical tracing template (film)	Full size serve graph template
Temp. (Template)	Full size wooden or paper template	Full size woode or paper teizpla
N.T. (No Template)	cut to size given in "Di- mensions" column of U. C.M. cutting List	U.C.M. Cutting List
Exacto No . (Exactograph)	Exactograph Sketch	Exactograph Ske
FRBD (Frame Bending)	1. Framebending computer printout of inverse curve. 2. Paper end cut templates.	Frame Bending computer print- out
MLCSK No. (Mold Loft Cutting Sketch)	1. Sketch of structural show- ing dimensions & process- ing instructions. 2. Standard end cut template (if applicable)	Mold Loft Cutting Sketch
PLCSK (Panel Line - Cutting Sketch)	Sketch of panel (butt station) indicating lengths, widths & bevels of plates to be cut on exacto machine.	Butt Station Drawing (found panel line boo let)

"SPECIAL INSTRUCTIONS IN U.C.M. FOR PROCESSING"

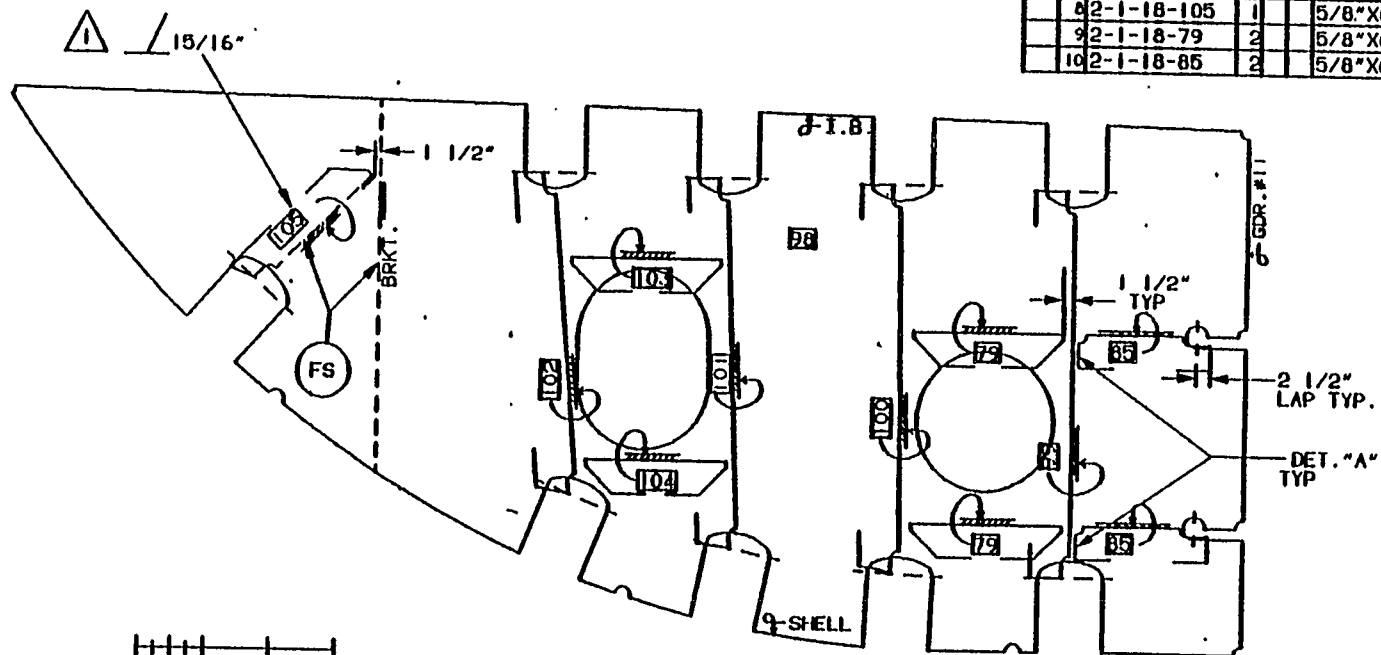
SPECIAL INSTRUCTIONS IN U.C.M.	TYPE OF INFORMATION GIVEN TO YARD	USE
Roll	Wooden Roll set or standard roll radius sets	Rolling plates in Plate Shop
Form	FRBD info. or wooden tem- plate	To establish shape of framebender items, pieces shaped by line- heating.
Punch	Standard wooden templates used as guide for punching HO-1 etc.	Indicates struct- ural member must have vent, drain, or waterstops punched.
Line Heat	Wooden templates	Forming steel plates or struct- urals.
Knuckle	Wooden knuckle set or in some cases angles and degrees (see Mold Loft standard books)	Used to bend plates or struct- urals
Stock	Items identified in U.C.M. cutting list as N.T. some- times require stock dimen- sion include stock	Excess material

DET. "A"

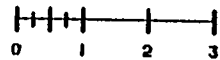


PARTS LIST

LN	PIECE NO.	QTY	MATERIAL	GRADE
1	2-1-18-98	1	16/32" PLATE	AN-32
2	2-1-18-99	1	5/8"X6"FB	A
3	2-1-18-100	1	5/8"X6"FB	A
4	2-1-18-101	1	5/8"X6"FB	A
5	2-1-18-102	1	5/8"X6"FB	A
6	2-1-18-103	1	5/8"X6"FB	A
7	2-1-18-104	1	5/8"X6"FB	A
8	2-1-18-105	1	5/8"X6"FB	A
9	2-1-18-79	2	5/8"X6"FB	A
10	2-1-18-85	2	5/8"X6"FB	A

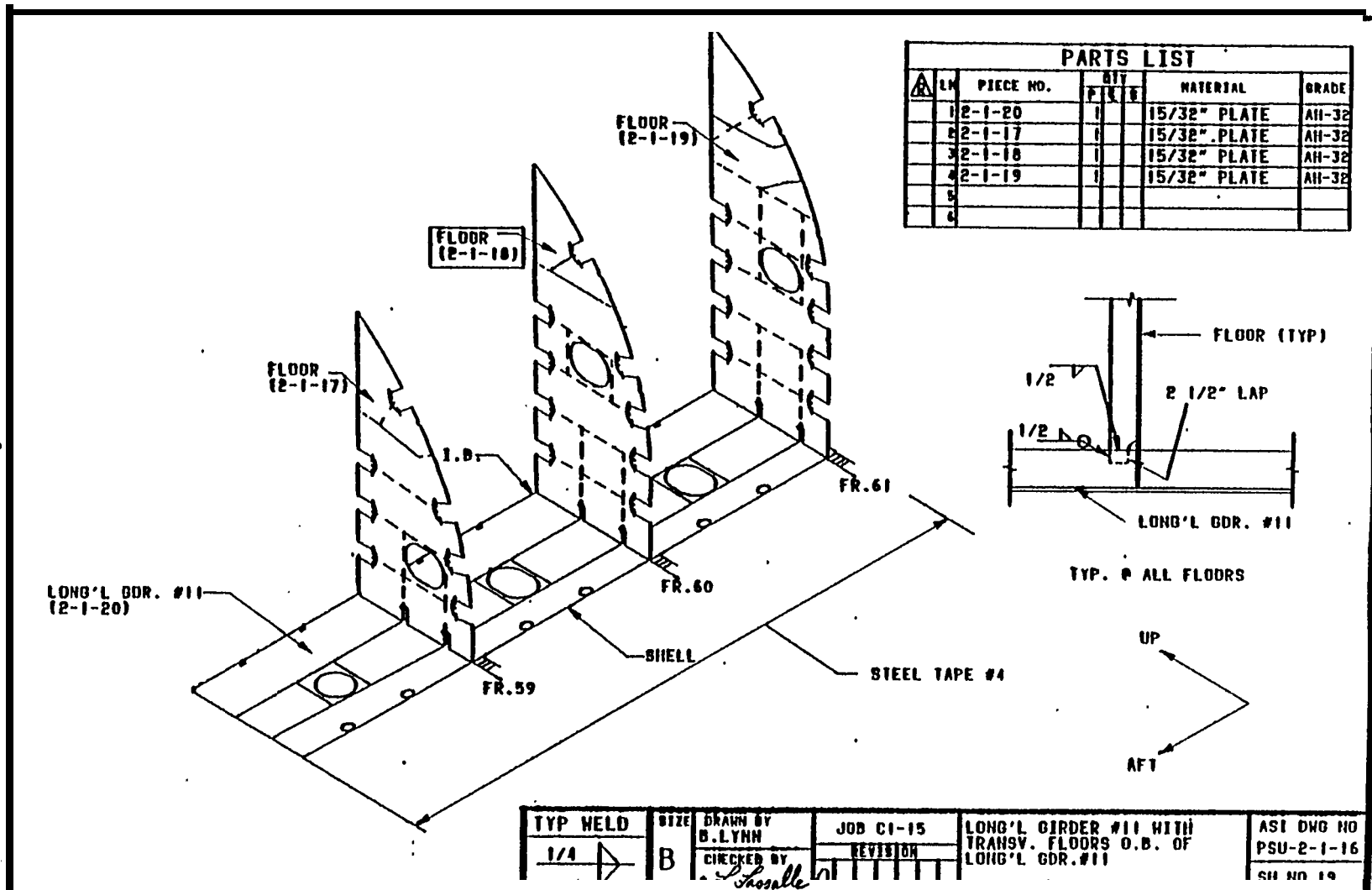


WORK SHEET 9/81



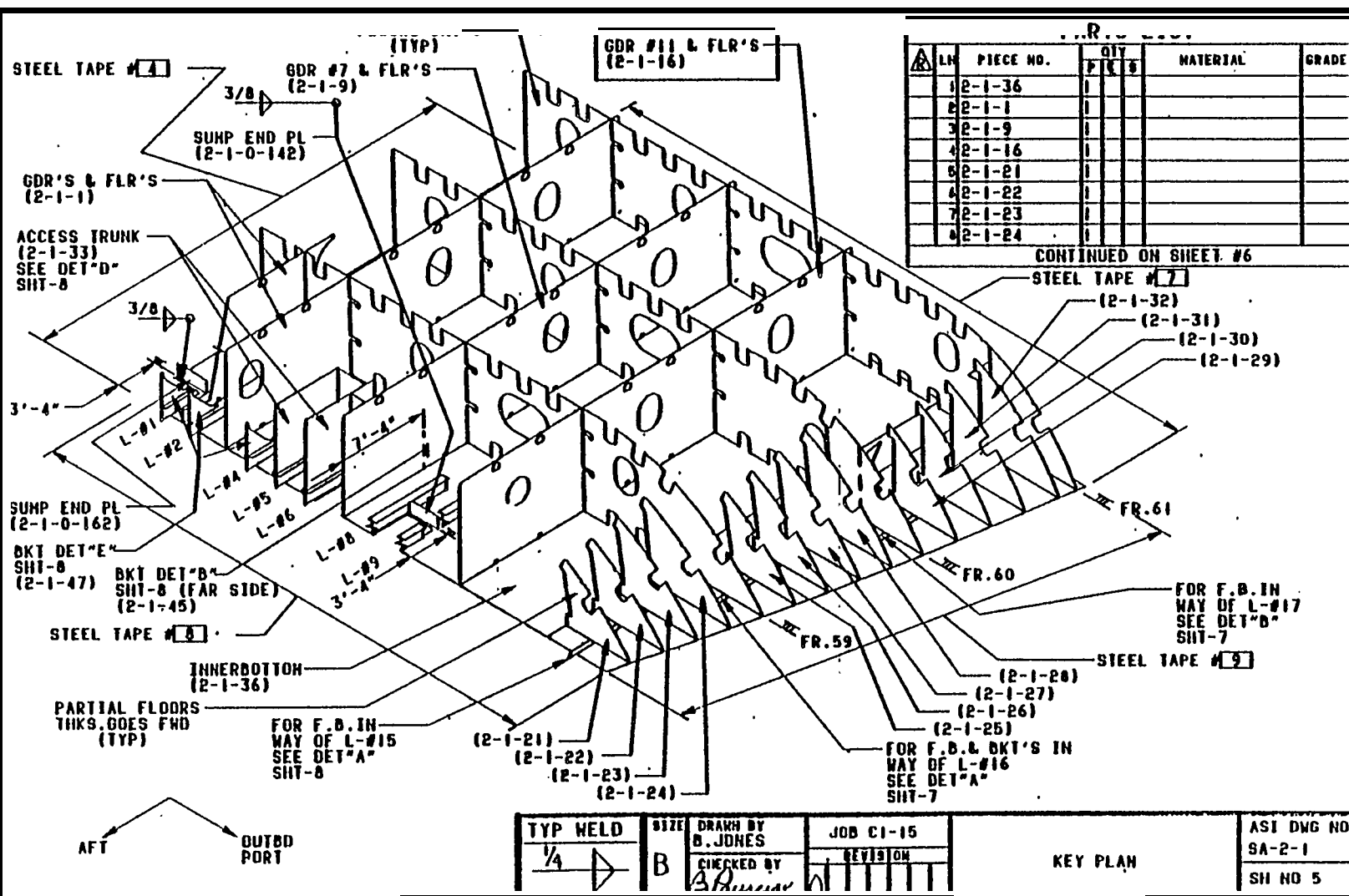
TYP WELD	SIZE	DRAWN BY	JOB	TRANSV. FLOOR FR. 60 PORT	ASI DWG NO
3/16	B	B. LYNN	CI-15		PSU-2-1-18
		CHECKED BY	REVISION		SH NO 16
		<i>W. Halland</i>	0 1		

ISO. WORK SHEET 8/81

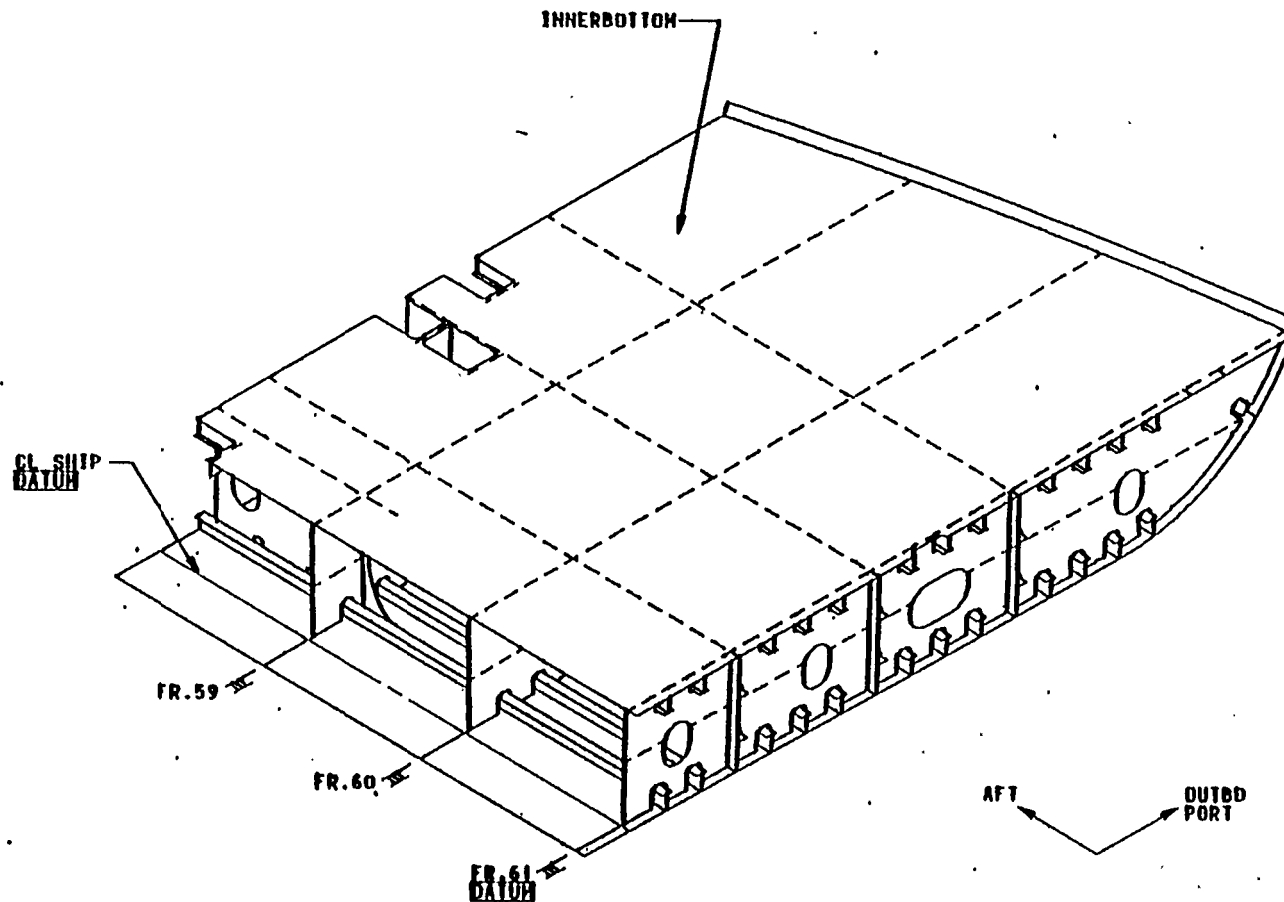


ML 31

ISO. WORK SHEET 9/81



ISO. WORK SHEET 9/81

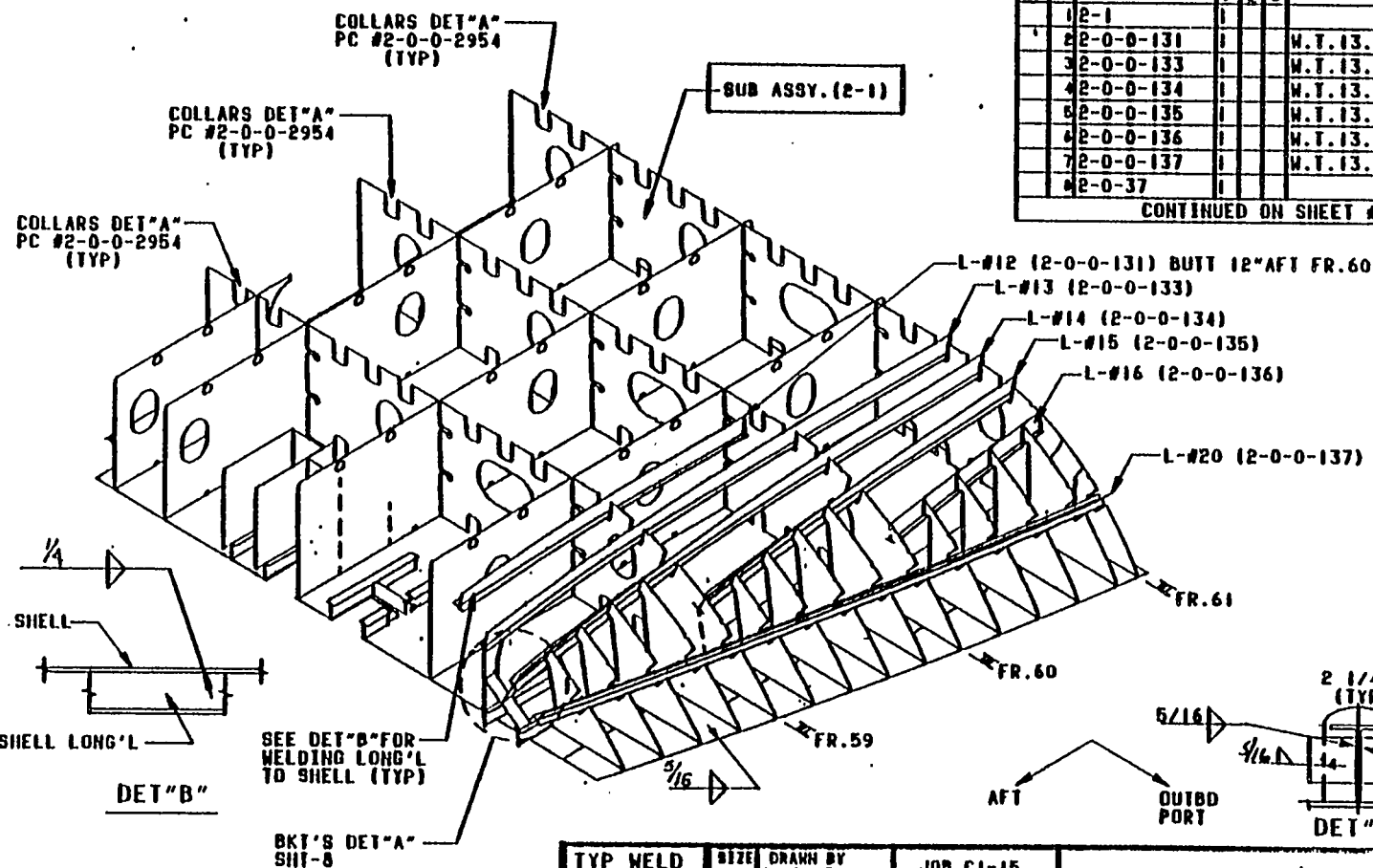


TYP WELD	SIZE	DRAWN BY	JOB C1-15	ASI DWG NO
—▷—	B	B. JONES	REVISION	NA-2
		CHECKED BY		SH NO 5
		B. JONES		

ISOMETRIC OF
COMPLETED UNIT

ML 33

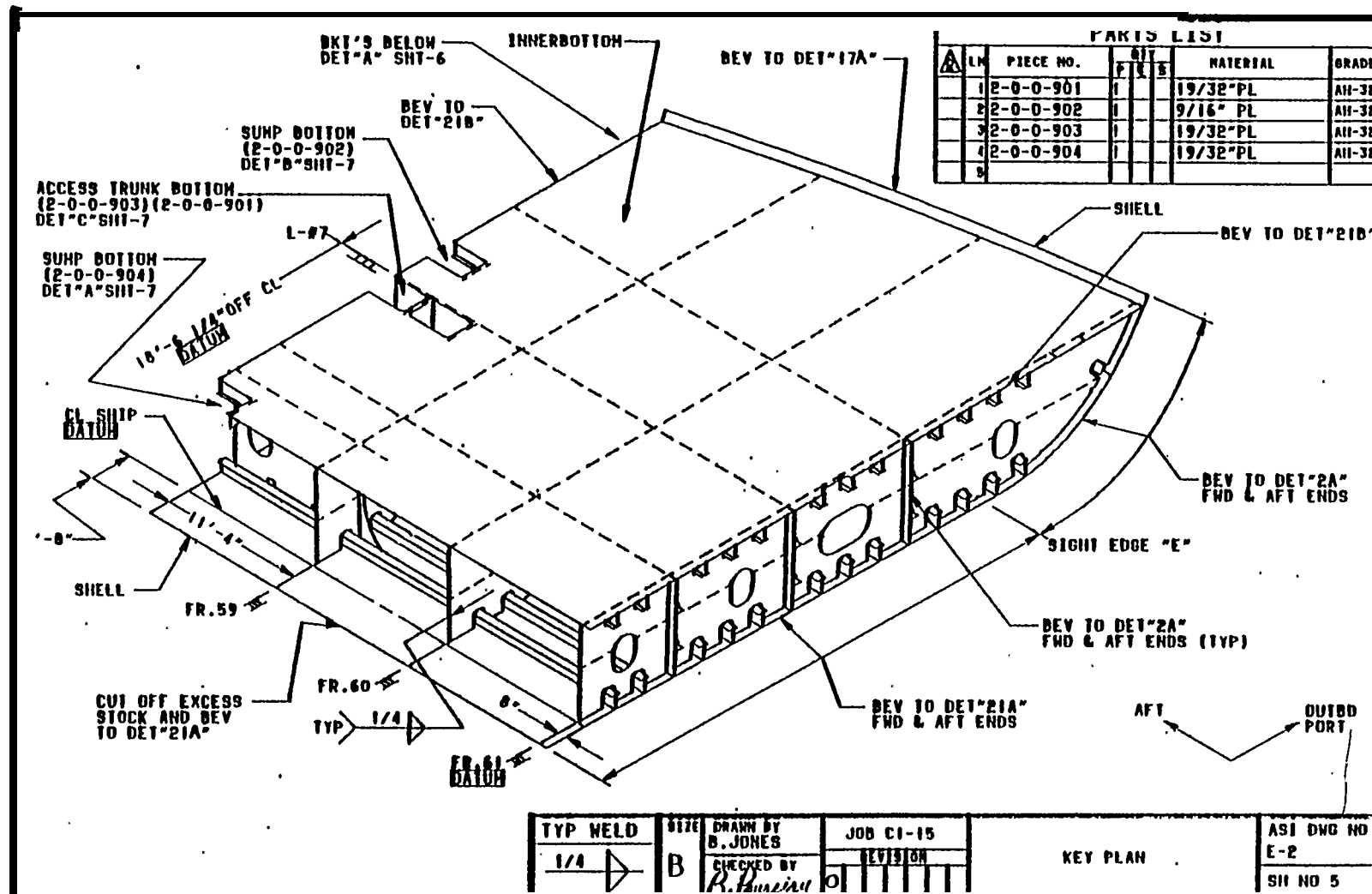
150. WORK SHEET 9/81



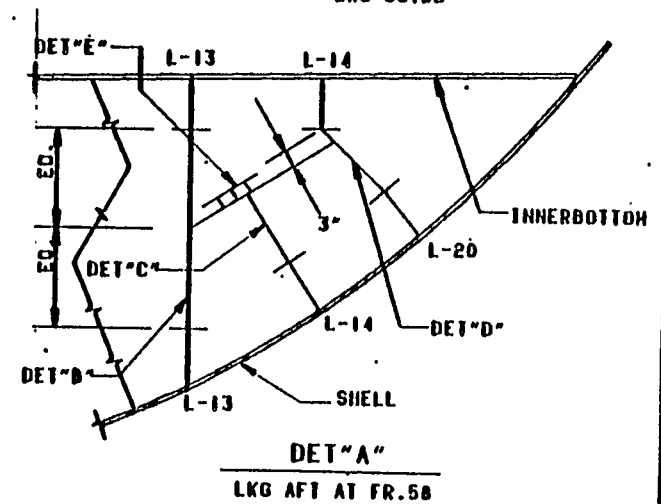
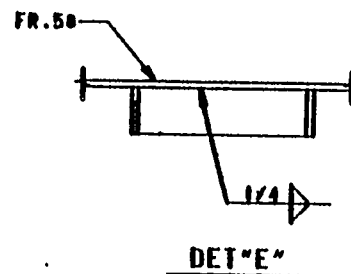
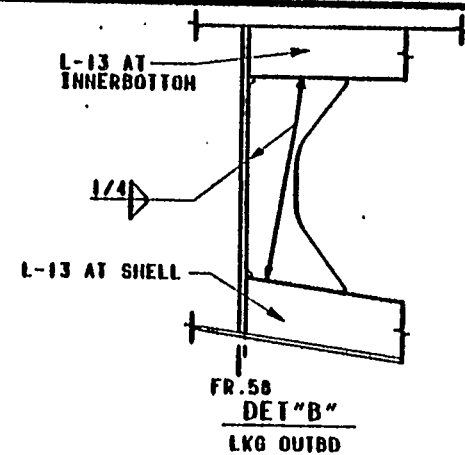
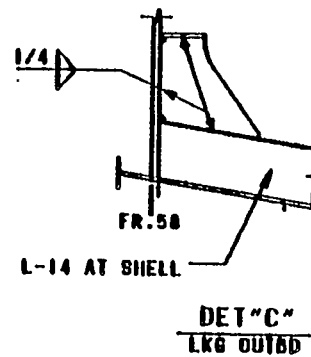
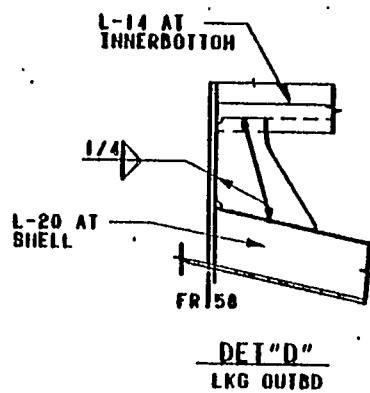
PARTS LIST					
LN	PIECE NO.	QTY	MATERIAL	GRADE	
1	2-1	1			
2	2-0-0-131	1	W.T. 13.5X42#	AH-32	
3	2-0-0-133	1	W.T. 13.5X42#	AH-32	
4	2-0-0-134	1	W.T. 13.5X42#	AH-32	
5	2-0-0-135	1	W.T. 13.5X42#	AH-32	
6	2-0-0-136	1	W.T. 13.5X42#	AH-32	
7	2-0-0-137	1	W.T. 13.5X42#	AH-32	
8	2-0-37	1			

CONTINUED ON SHEET #7

TYP WELD 1/4	SIZE B	DRAWN BY B. JONES	JOB C1-15	KEY PLAN #1	ASI DWG NO HA-2
		CHECKED BY B. JONES/AN	REVISION	(SEE SHIT #6 FOR SHELL PL'S)	SH NO 6



ML 35



TYP WELD —▷	SIZE B	DRAWN BY B. JONES.	JOB CI-15	WELD DETAILS	AST DNG NO E-2
		CHECKED BY <i>B. Jones</i>	REVISION		SH NO 6

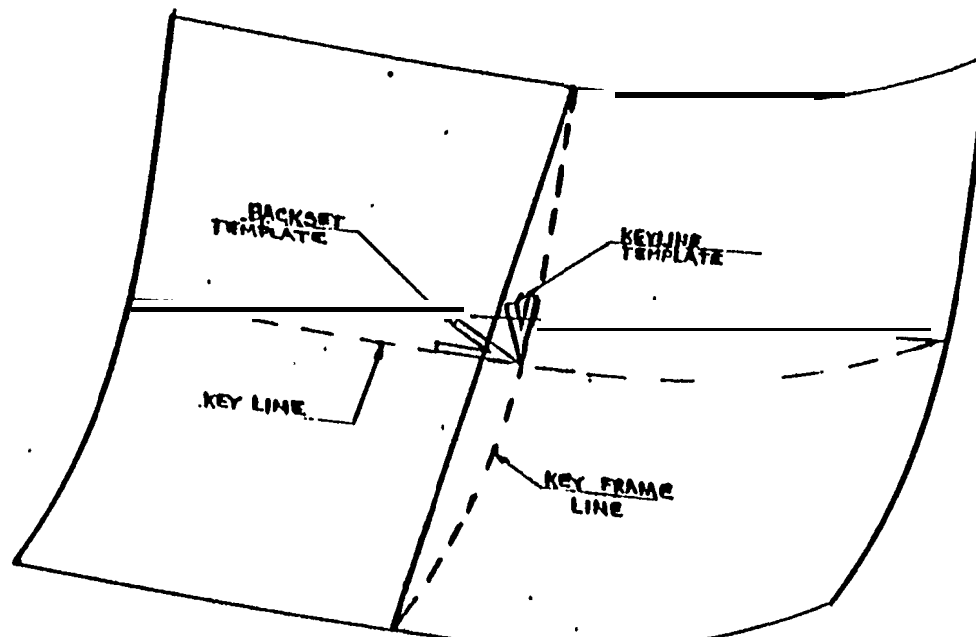
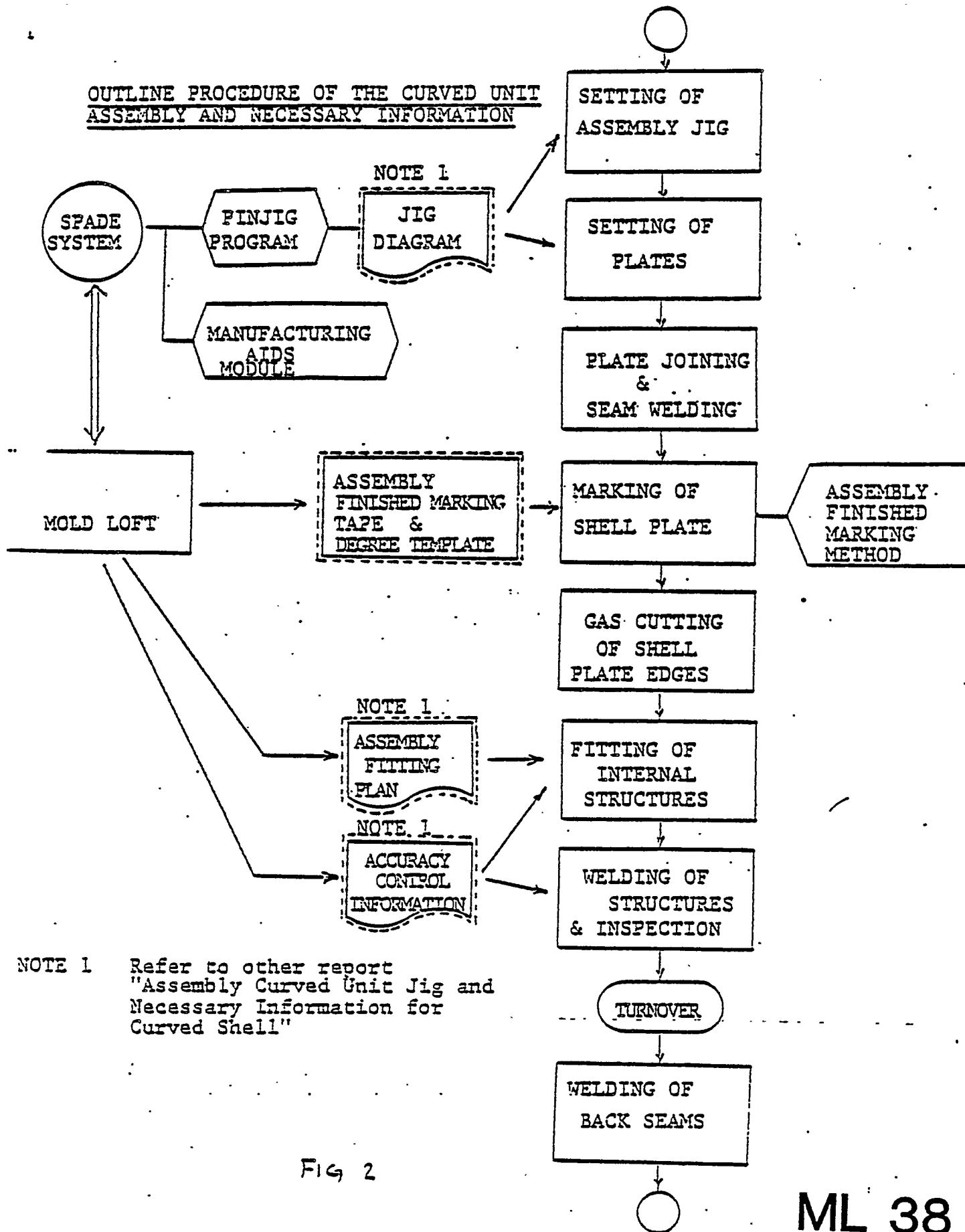
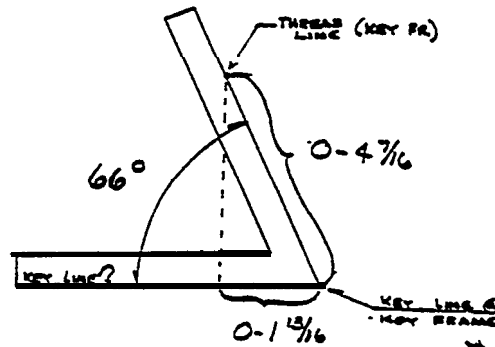


FIG.

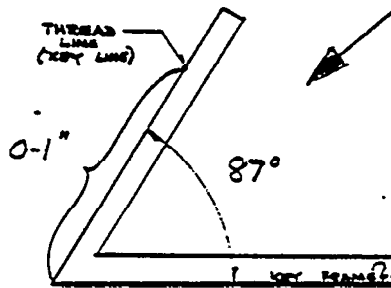


Job C1-15 Unit 48

Back Set Template



Key Line Template



establishes
site
lines

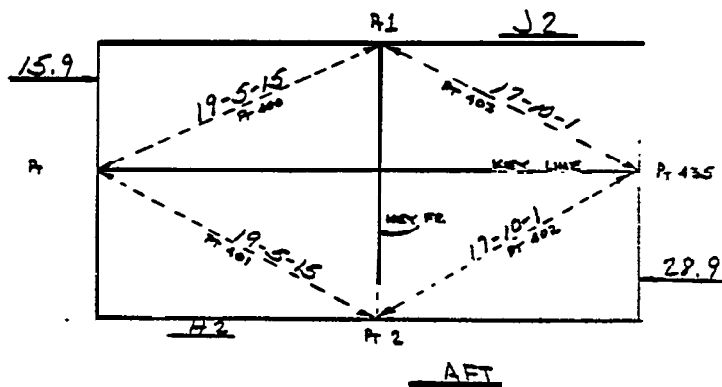


FIG 3

JOB
TAPE
DATE
NAME

31

9-13-82

GIL HERBERT

TABLE LENGTH

UNIT 48

	15.9	16	17	18	19	20	21	KEY 22 FRAME	23	24	25	26	27	28	28.7				
J2	19-5-1	17-3-11	14-5-7	11-6-14	8-8-4	5-9-9	2-10-13	○	2-10-13	5-9-9	8-8-5	11-6-15	14-5-8	17-4-0	18-8-1				
24" 3" FIAT	19-3-13	17-2-13	14-4-9	11-6-4	8-7-13	5-9-4	2-10-11	○	2-10-11	5-9-6	8-8-1	11-6-10	14-5-2	17-3-9	18-7-9				
KEY LINE	18-5-5	16-5-4	13-8-5	10-11-8	8-2-10	5-5-11	2-8-14	○	2-8-13	5-5-10	8-2-6	10-11-2	13-7-13	16-4-8	17-7-12				
J1	18-6-10	16-6-11	13-9-15	11-1-0	8-3-15	5-6-12	2-9-7	○	2-9-8	5-7-2	8-4-12	11-2-9	14-0-6	16-10-4	18-2-1				
H2	17-11-15	16-0-7	13-9-7	10-8-7	8-0-7	5-4-6	2-8-4	○	2-8-5	5-4-12	8-1-4	10-9-14	13-6-10	16-5-6	17-6-11				

$$f_{\text{in}} = \frac{1}{10} \text{ Hz}$$

FIG. 4

MI DO

JOB 1 C1-15
TAPE: 31
DATE 4-13-82
NAME G.L. HEBERT

TABLE HEIGHT

UNIT 48[illegible]

FIG 5

ML 41

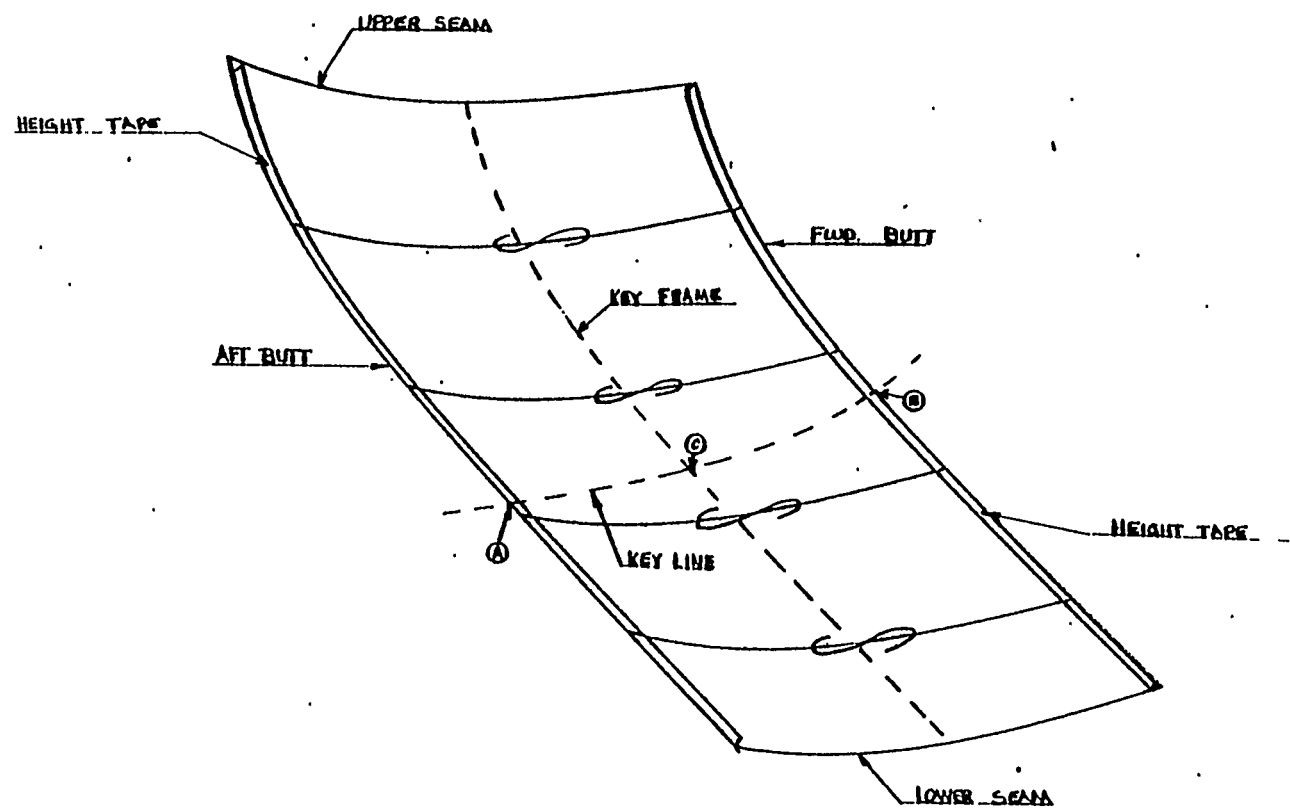


FIG. 7

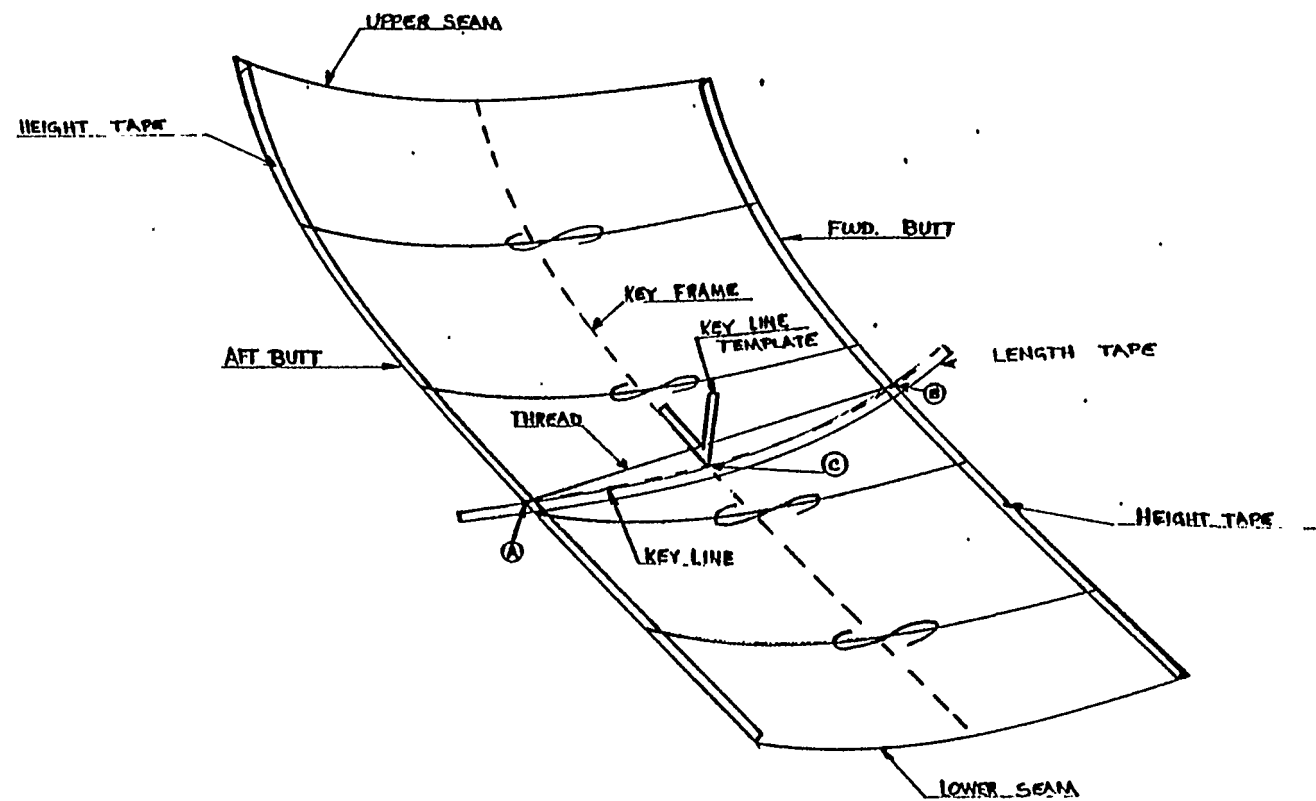
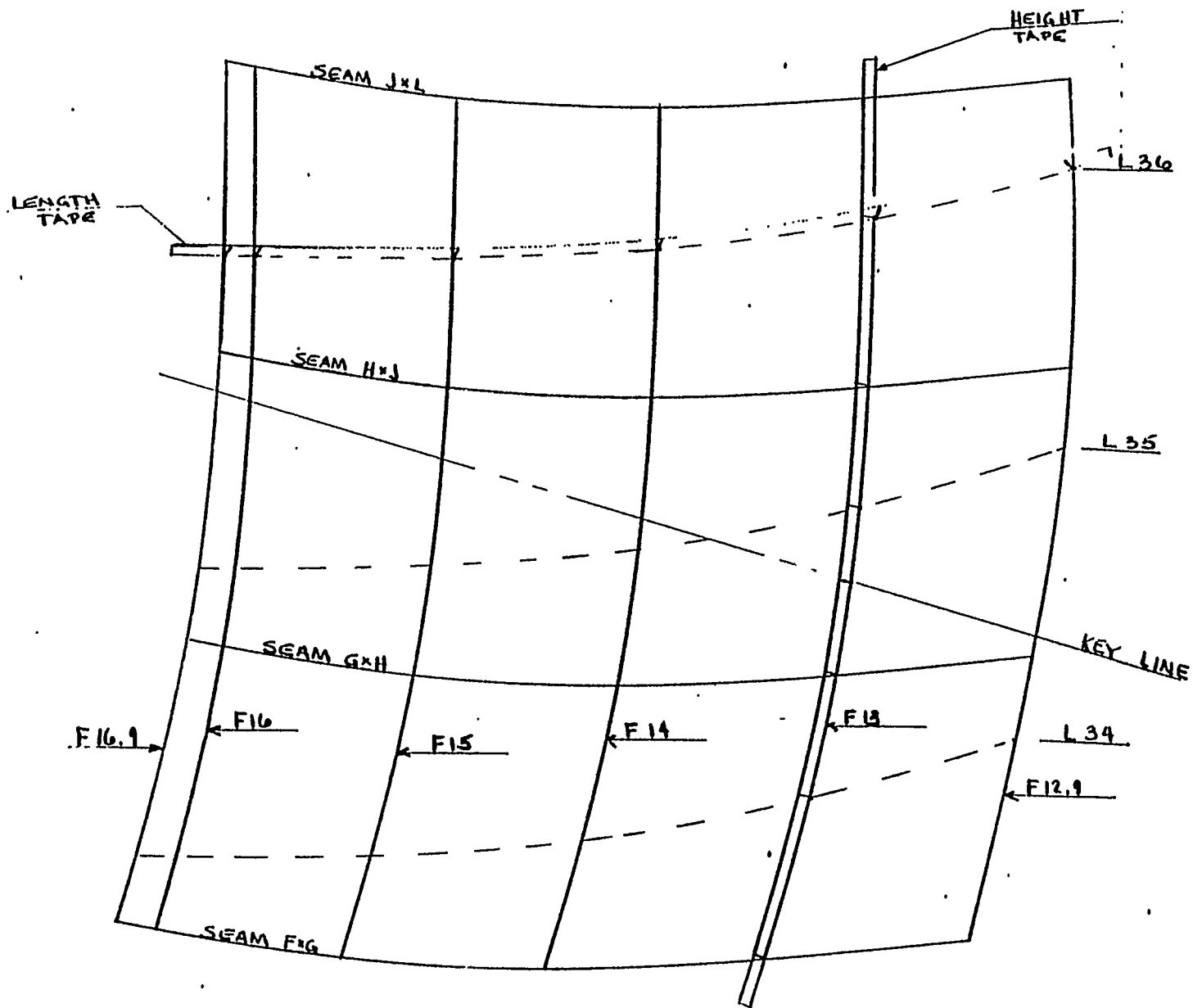


FIG 8



MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

MATERIAL CONTROL (FIRST SESSION)

Prepared by: FRANK LOGUE

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
MATERIAL CONTROL (FIRST SESSION)

1. INTRODUCTION

Material Control is one of the most important functions for shipbuilding. In this heavy industry, material costs account for about 60% to 70% of all the shipbuilding costs. Therefore, the material cost directly affects and may increase interest payable, handling cost, storage area, as well as the disruption of the production schedule and the cost of the material. The fundamental targets for material control are the saving of these undesirable surplus costs.

It is felt that the application of the IHI technology will greatly implement cost savings through material control at ASI. These cost savings are not necessarily to be realized in the Material Control Branch itself, but throughout the various crafts served by the Material Control Branch.

Material Control, Handling, and Delivery to implement the process lanes concept is of extreme importance. As just one example of this, I would like to stress, in statistical detail, the type of savings to be generated from this applied technology in the movement of steel from the plate shop to the process lanes, and its resultant interactions.

The basic concept of good plant layout is effective material flow. The objective is to minimize the number and length of routes and eliminate any unnecessary movements such as back-hauls, crosshauls, transfers, etc. Material flow problems can arise because of changes in the design of a process, or may develop because of gradual changes over time that finally manifest themselves in terms of bottlenecks in production, crowded conditions, poor housekeeping, failure to meet schedules, and a high ratio of material handling time to production time.

The material flow analysis, which was performed at Avondale, concentrates on some quantitative measure of movement between departments or activities. Since the shipyard layout should be designed to facilitate the flow of the product, we are primarily concerned with the flow of materials. Some of the factors that affect material flow are:

- external transportation facilities,
- the number of items to be moved,
- the number of units to be produced,
- material storage locations,
- location of manufacturing service areas.

The development of the information presented in this analysis was generated during a ten-week period in March, April, and May of 1981. The information was extracted from reports derived by the Material Control Branch and mobile crane servicing area. These reports represented actual material movements within the shipyard. The trip and distance information was summarized and is presented here in VIEW GRAPH NO. MC-12. The charts were developed representing a measure of the steel material flow between work areas. These charts provided information concerning the number of material handling trips made between centers of activities, the volume of material moved between centers of activities, and the total material handling distances.

Using information developed by the process lanes committee concerning work locations and working with the previous methods, the material flow method and its associated charts and flow diagrams were developed. The flow method was developed by keeping in mind the process lanes concept of eliminating multi-hull cutting and the concept of work site storage queues. Since the process lanes concept virtually eliminates steel material flow (except outfitting) to the fabrication storage area and directs this material to work site storage queues, charts were developed by shifting related material from the fabrication storage area to the work site storage queues. The end result is a large reduction in material going to fabrication storage, structural bulk storage and an appropriate increase in material going to the work sites from the plate shop and platens.

As we can see from VIEW GRAPH NO. MC-13 under the previous facility layout and storage method, we moved 9,174 pieces of steel material per week of which 61% was moved to or from the fabrication storage area. The process lanes method moves 6,571 pieces per week of which 8% move to or from the fabrication storage area. The reduction of 2,603 pieces per week is due to the large reduction in double handling due to eliminating much of the material movement to the fabrication storage area. Thus, a resultant reduction of 18.4% in the number of pieces handled per week is realized by the process lanes concept.

Previously, we made 170.5 trips per week moving an average of 53.8 pieces per trip, of which 47.5% was moved to or from the fabrication storage area. The process lanes method makes 145.2 trips per week moving an average of 45.3 pieces per trip, of which 6.4% moves to or from the fabrication storage area. Thus, a 14.8% reduction in the number of trips per week is realized while handling 15.8% less material per trip. Theoretically, if we fill the loads to capacity (assume 53.8% pieces/load is capacity), we reduce the trips by an additional 15.8% and arrive at a total reduction of 30.6% on the total number of trips per week.

The previous facility layout had a total steel material movement of 66.6 (in plant) miles per week of which 60% was to and from the fabrication storage area. Under the process lanes method, movement is 43.4 miles per week, of which 13.6% is to and from the fabrication storage area. A reduction of 23.2 miles per week (34.8%) is realized under the process lanes concept.

There were 177 distinct moves from area to area under the previous material flow method. Under the process lanes method, there is a reduction of these moves by 58 for a total of 119, resulting in a 32.8% decrease in the number of distinct moves.

Thus, evaluating the four areas above, it can be stated that a savings of approximately 30% in the handling of steel material is realized due to the implementation of the process lanes concept. The appropriate cost savings is obtained by evaluating the manpower, equipment, and energy reductions which will result from a 30% reduction in the handling of steel material. Thus, it is evident from the analysis, that for effective process lanes implementation there is the need to strive for the evolution of an ideal material handling and flow system.

Always in the past, the basic rationale for the listing, requesting, procuring, receiving, and issuing of material was on a system basis, as compared to the new technique of unit, zone and sub-zone method employed today. The basic physical control of material is enhanced by this new technique in that it presents smaller increments of material to be handled, with much less storage time on-site in the field.

Material is now requested and procured to the unit and zone level, in many instances. Advance purchasing zones are set up early-on in the job, and time structured working toward the fabricated material requirements and purchased material requirements dates.

The basic instrument for outfitting in the IHI concept is the pallet, under whose number the packages of outfitting material are grouped.

The pallet numbers, with the drawing required dates, are issued to Engineering early in all jobs by Production Outfit Planning. At this point in the evolution of a job, these numbers may be thought of as "empty buckets," because it is not known at this time what mix of materials these "buckets" will contain. Production has furnished them and Engineering is to fill them and return them to Production by way of the drawings.

It should be pointed out here that all groups in Engineering strive to place the maximum amount of material on the units in all stages of their construction, so that on-board installation is held to the minimum. This effort obviously involves great attention in the design stage to suit the unit boundaries and its associated conditions.

In discussing unit and zone outfitting we continually refer to material being broken down to pallets by unit or zone. The pallet, as discussed here, requires that you put aside what you usually think of when you hear the word, which is the familiar wooden framework platform used to move material about with a forklift truck. Pallet material, for the pallet as defined here, may be stored or moved using a variety of containers, including the familiar wooden platform.

For purposes of discussion in terms of zone outfitting, the pallet basically defines:

- A work package created at the Engineering level, to be installed in the hull of a ship in a specific place and at an advantageous time.
- The pallet also represents a specified work package, in terms of manhours. Ideally, under the IHI concept, the work package should level load at approximately 100 man-hours. However, in the evolution of this technology at Avondale, this goal has not been attained as yet.
- The pallet number is a unique number which identifies a given package of material.

For those of you who consider the term "outfitting" in the classic shipbuilding sense as items normally installed after launching, it is necessary to revise the definition under the IHI concept to signify all items installed on-unit or on-board during all phases of construction.

In this discussion of Material Control, we do not include the handling of raw steel. This is handled by the Steel Control Section.

An overall Material Marshaling Plan has been implemented to accomplish the total logistics for the recording, expediting, palleting, and delivering the various categories-of material to the process lanes.

Material handled by the Material Control Section is categorized into the following-areas:

- pre-fabricated steel;

- fabricated pre-outfitting items (such as manholes, W.T. doors, deck fittings, foundations, etc.);

- warehoused (purchased) materials;

- raw piping material input to Pipe Shop;

- fabricated pipe details from the Pipe Shop.

I will discuss in some detail the first three categories, and upon completion of these categories my assistant will review the piping categories.

A. PIUS-FABRICATED STEEL

As mentioned earlier, prior to implementing the zone outfitting and process lanes technique, virtually all pre-fabricated steel moved from the plate shop to interim storage at the fabricated steel storage area. It is obvious that the reverse now happens, wherein only a small portion of pre-fabricated steel moves to interim storage, while the overwhelming bulk moves directly to the process lanes.

Under the process lanes concept, this is made possible by detailed process lanes scheduling, emanating from both the long term and short term planning techniques, as demonstrated in previous seminars.

Primarily those items of steel that will continue to flow from the plate shop to interim storage will be nested plates from the numerical control burning machines that must have the tabs cut and then be palletized.

Also, due to certain manufacturing restrictions, curved plates and structural occasionally must be cut and formed in advance of the need dates, and these items of steel will be sent to interim storage.

Additionally, the incorporating of storage queues at the process lanes work site has greatly aided the continual, smooth flow of material. The normal storage time in queue

at the work site is one week. However, there is some built-in flexibility here, and occasionally two weeks storage is tolerated.

The pre-fabricated steel listed on the UCM'S for PSU'S, sub-units, and units is, in general, tracked through the plate shop and the process lanes work platens by the supervision of the shop and platens. It is not tracked by the Material Control Group, and this in itself is a change from former practice. It has been proven that due to the IHI concept of categorization of units and the timely scheduling of events and the constant monitoring by the shop planners that significant cost savings are being affected here.

Adherence to schedules by both the plate shop and the process lanes is of paramount importance in maintaining a smooth, orderly flow of pre-fabricated steel. Occasionally, the process lanes may fall behind schedule due to continuing inclement weather and, in this event, necessary action must be taken to facilitate getting back on schedule at the process lanes.

In the event of any problems arising out of this type of situation, a contingency has been built in to allow marshaling to proceed in an orderly manner.

In an average week, pre-fabricated steel for fourteen (14) sub-units must be delivered to the process lanes. By reviewing the various units to be fabricated, the size of the storage grid, or process marshaling area, can be readily determined. A large typical unit was selected (Unit 67) for this grid sizing study. This unit will require a storage grid 20' x 53'.

The largest determining pieces are the girders, which stack four (4) high in grid storage, and the five (5) items of floors will then stack three (3) high. It is significant to point out that this selective organization of stacking must carry through into the process lanes work storage queue in order to facilitate the minimum crane time and manpower to lay out the pieces on the platen for actual assembly.

Since there is a requirement for fourteen (14) sub-units each week, a three (3) week contingency factor was plotted with the result that forty-two (42) grids were required. In turn, these forty-two (42) grids would require an area approximately 200' x 275', including a burning and sorting area.

A major point to be stressed here is that even if a three (3) week actual storage contingency is needed, the physical space required is greatly lessened compared with our former requirements and, most importantly, our ability to track the material is vastly simplified due to the inherent nature of this system.

The smaller quantity of pre-fabricated steel that flows to interim storage, primarily nested plates, is controlled manually by utilizing the unit cutting manual, which is developed by the Moldloft. This is done by making a simple overlay on the plate cutting list or on the structural cutting list. Each sheet is then reflective of one (1) designated hull.

B. FABRICATED PRE-OUTFITTING MATERIAL

Fabricated pre-outfitting items, such as foundations, ladders, W.T. doors, manholes, etc., were formerly fabricated in entire multi-hull jobsets, thus creating many material handling problems. This method caused:

- the need for a much larger storage facility,
- double and triple handling,
- deterioration due to long-term storage?
- loss of material,
- damaged material,
- greater impact on stored material due to drawing revision (obsolescences).

The process lanes concept, with its thrust for level loading, dictates a new approach in this category of material. With a few exceptions, fabricated pre-outfitting items will not be fabricated in entire shipsets, let alone entire jobsets. Instead, they will be controlled in smaller groupings compatible with short term scheduling needs. This very effectively eliminates most of the handling and storage problems formerly encountered.

In the former method, some fabricated pre-outfitting items moved directly from the fabrication shop to the jobsite, causing the entire shipset, or shipsets, of material to be at the jobsite much too early for installation; whereas, now, all of this material will move to interim storage for palletization by unit, or zone, thus necessitating more line items to be handled by Material Control. The cost of this

small additional volume of pieces to be handled will be greatly compensated for by the reduction of remakes and resultant loss due to remakes such as:

- cost of remake (labor and material),
- = disruption caused to shop production,
- impact on assembly'due to non-availability.

This material is tracked on the Unit Pallet List Material and Zone Pallet List Material, and if a required date is not met, the Material Control Branch is responsible to expedite this material with the different fabrication shops, thus creating a supplier/consumer relationship. This enhances the final result of having the material on the job when needed for installation.

The control of this material will be accomplished on a pallet basis for each hull. Requirements for pallet loading will be obtained from the unit and zone outfitting lists prepared by the Planning and Scheduling Department.

By utilizing this method, Material Control will be in a position to effectively expedite this material through the shops, using the pallet release date minus a two to four week lead time. Formerly, this expediting effort was lacking and, thus, with a much more clearly defined management system, greater cost savings are being accomplished.

C. WAREHOUSED (PURCHASED) MATERIAL

Warehoused, or purchased material, other than piping, is still purchased in group lots, but allocated against unit and zone areas. This material is received and stored by overall material family groupings by job and purchase order number.

Working with the unit and zone pre-outfitting lists,- this material is palletized at the warehouse in accordance with craft type. Material Control is responsible to react to the required pallet release date for a given pallet within two (2) to four (4) weeks of the date.

If any item of material is short, then Material Control notifies the expediting section of Purchasing that there is a deficiency. A copy of this deficiency notice is forwarded to the process lanes with the palletized material if the material has not been received by the time of issue.

From that point forward, Material Control must monitor this shortage and", upon receipt of the item, notify Production and receive instructions as to the proper point of issue (it may have transitioned from unit to zone).

The IHI consultants have remarked, and I think correctly so, that we cannot control people to the ultimate degree; so, therefore, we must control material. By rigidly controlling the flow of material to the work site, we establish a discipline that demands a specified work effort. This discipline must be adhered to in both a plus and minus aspect, meaning we cannot overload the work areas with materials, thus causing a chaotic condition of lost and misplaced material, or fail to deliver the proper quantity of material at the proper time. Either condition causes a profound loss in productivity and resultant loss in cost efficiency and competitiveness.

To date, our experience with the IHI concept of unit and zone outfitting is proving that it is a valuable management tool. From a material management point of view, it affords us the capability to review our material needs in smaller, more controllable packages, and in a much more timely manner.

We are still learning and, on future contracts, intend to further refine our system. One of the points I would like to stress is that in moving from the "System Concept" to the "Package Concept," I find that the overall concept of Material Management is more achievable.

As we all know, piping materials, by volume, account by far for the greatest amount of materials handled in the shipyard. In the recent past, we have implemented a semi-automated pipe shop at Avondale that, coupled with the IHI technology, has had a great impact on our handling of this material. The balance of this portion of the seminar involving Material Control will be devoted to that subject.

HULL STEEL MATERIAL MOVEMENT COMPARISON BY TRIPS AND DISTANCE

	CONVENT.	PROCESS	DIFF
Material Handling Distance/week (Miles)	66.6	43.4	23.2
Material Handling Distance To-From Fab. Storage	39.3	5.9	33.4
Percent M. H. Distance To-From Fab. Storage	60.0	13.6	
Trips / week from Plate Shop	42.3	62.3	(20.0)
Trips/week from Platen 18	5.3	11.4	(6.1)
Trips/week from A-Crane Storage	31.3	7.7	23.6
Distinct Moves	177	119	58

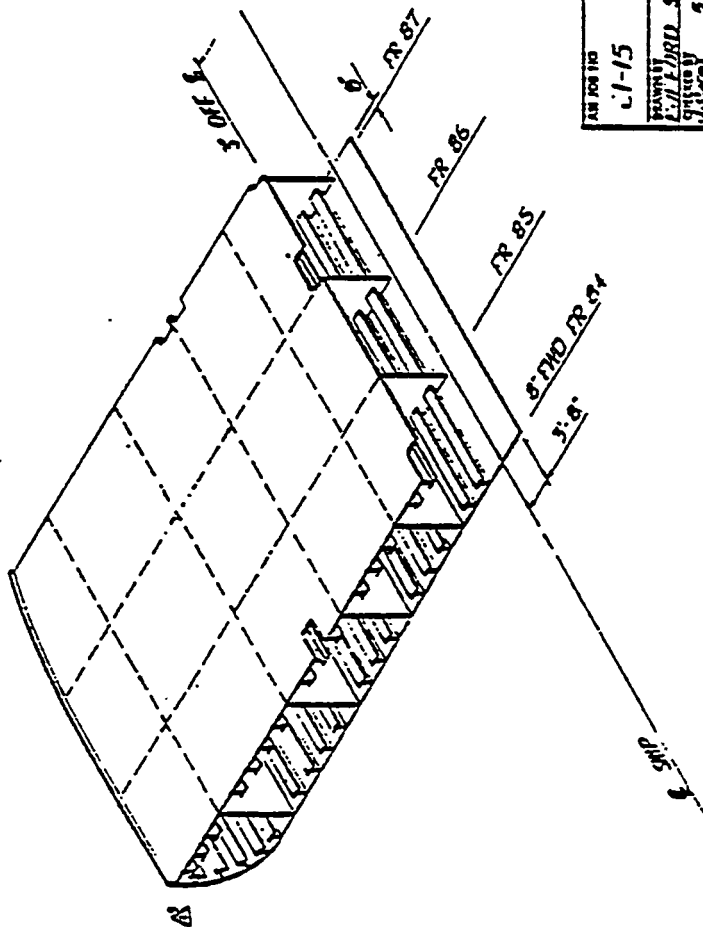
HULL STEEL MATERIAL MOVEMENT COMPARISON BY PIECES

DESCRIPTION	PRESENT METHOD	PROCESS LANES	DIFFERENCE
Pieces/week	9,174	6,571	2,603
Pieces To - From Fabrication Storage	5,564	532	5,032
Percent To - From Fabrication Storage	60.7	8.0	
Trips/week	170.5	145.2	25.3
Pieces/trip	53.8	45.3	8.5
Trips/week To - From Fabrication Storage	81.5	9.3	72.2
Percent To - From Fabrication Storage	47.8	6.4	

STEEL WT. - 99.9 S.F.
LCG - 9.95' - 10.1' F.L.
FCG - 7.45' - 7.5' F.L. 33

OVERALL · DIMS.

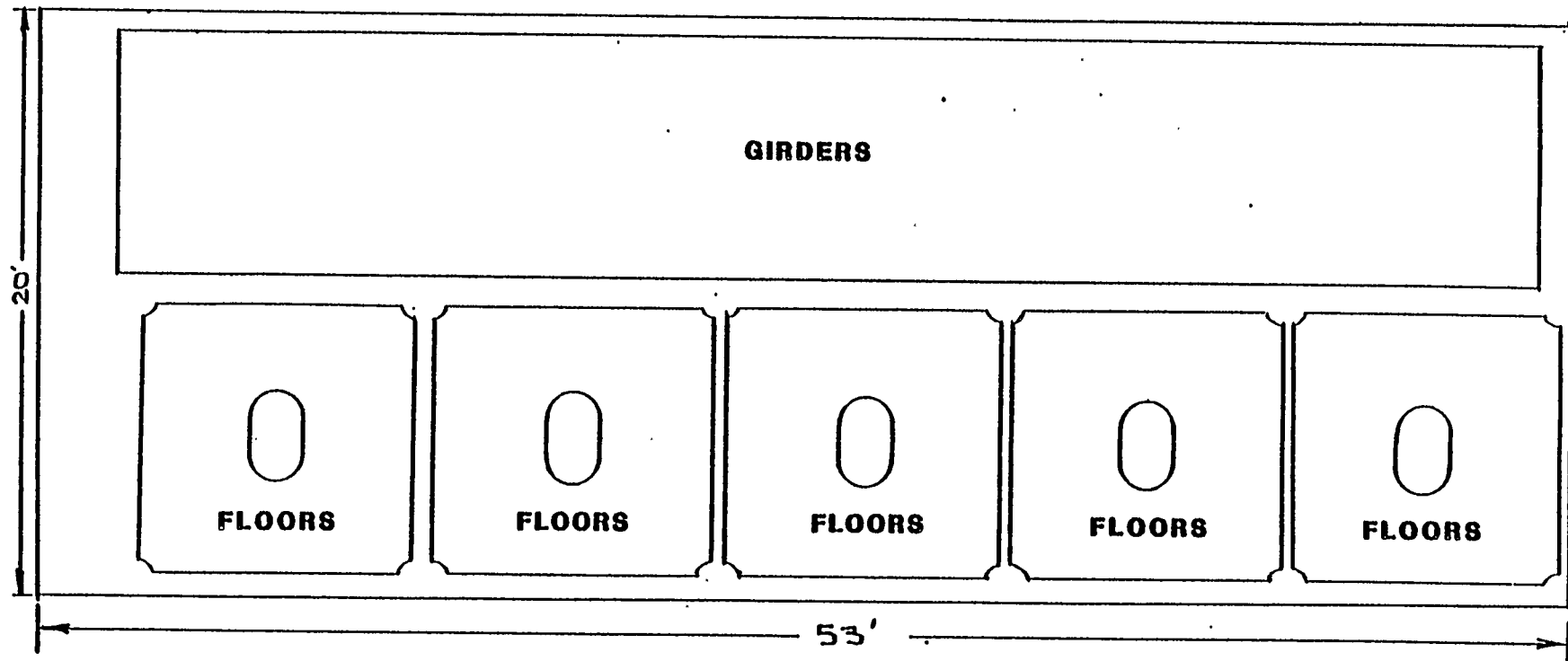
1-36-0-
14-35-7-
1-6-0 7-3 24
14-35-7-
1-6-0 7-3 24



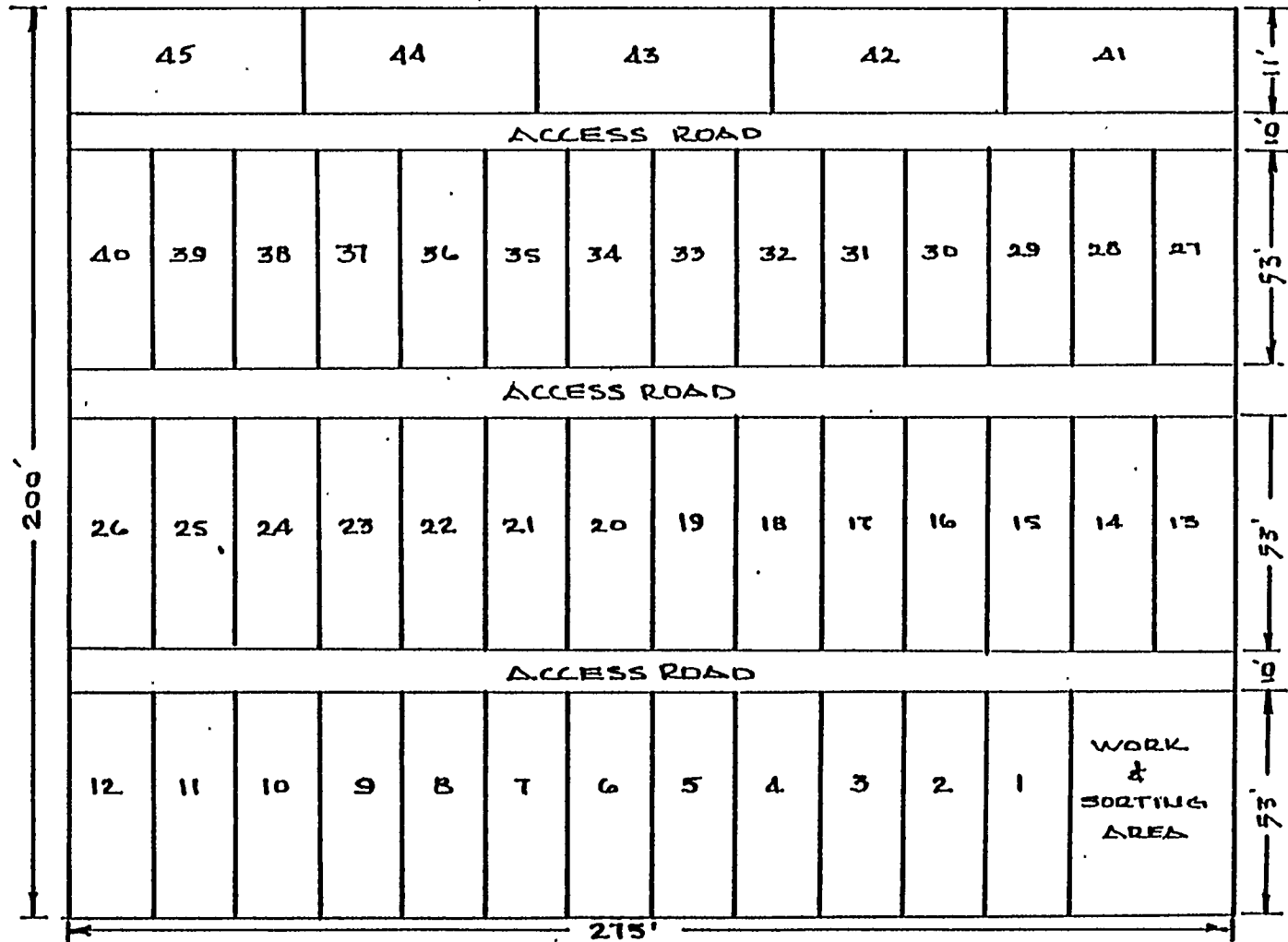
CATEGORY I

[illegible]

**TYPICAL STORAGE GRID
FOR PRE-FABRICATED STEEL
(UNIT 67)**



MARSHALLING AREA FOR PRE-FABRICATED STEEL



HULL 1

PLATE CUTTING LIST

LN	SUHM NO	UNIT-SUB-PSU-PC	QTY	LOCATION	MATERIAL	GRADE	MATERIAL RECEIPTS			MATERIAL ISSUES		
							DATE	TICKET	LOCATION	DATE	TICKET	LOCATION
1		1 - 1 -27 -25	1	FLR.FR.63 STD	15/32" PL	AH-32	4-20-82	876542	17	4-26-82	862348	PLT. #16
2		- - -										
3		- - -										
4		- - -										
5		- - -										
6		- - -										
7		- - -										
8		- - -										

STRUCTURAL CUTTING LIST

LN	SUHM NO	UNIT-SUB-PSU-PC	QTY	LOCATION	MATERIAL	GRADE						
1	30	1 - 1 -27 -26	1	FLR.FR.63 STD	5/8"X6"F.B.	A						
2	31	1 - 1 -27 -27	1	FLR.FR.63 STD	5/8"X6"F.B.	A						
3	32	1 - 1 -27 -28	1	FLR.FR.63 STD	5/8"X6"F.B.	A						
4	36	1 - 1 -27 -29	2	FLR.FR.63 STD	5/8"X6"F.B.	A						
5	30	1 - 1 -27 -30	2	FLR.FR.63 STD	5/8"X6"F.B.	A						
6		- - -										
7		- - -										
8		- - -										
9		- - -										
10		- - -										
11		- - -										
12		- - -										
13		- - -										
14		- - -										
15		- - -										

SIZE

B

DRAWN BY

D.L.YHII

CHECKED BY

JOB C1-15

REVISION

FLOOR FR.63 STD

AS1 DWG NO

CL 1-1-27

(FOR CONTINUATION SEE

SH NO 33

PCL-SEL 1 10/81

MC-

UNIT OUTFITTING PALLET L/M

PRODUCTION. PLANNING

JOB. NO. C1-15 UNIT 25

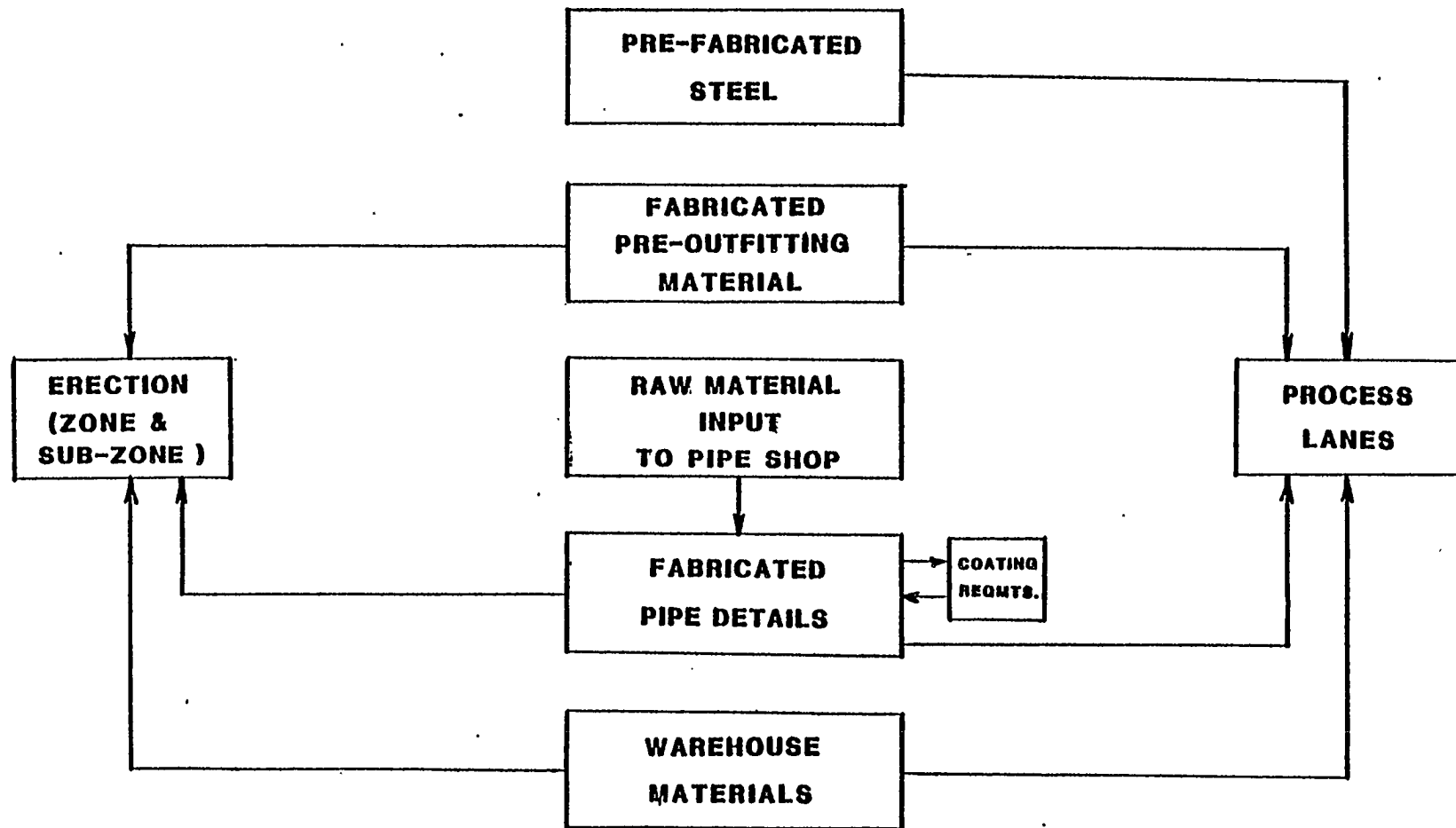
PALLET NO. 025-11

HULL 2335 "B" ZONE M

PALLET REQ'D. AS PER SCHED.

[illegible]

MARSHALLING PLAN MATERIAL FLOW



MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

MATERIAL CONTROL (SECOND SESSION)

Prepared-by: DON DECEDUE

MC-11

PS61201

UNIT PALLET LIST OF MATERIAL
PIPING ARRGT UNIT NO. 13 L/M

PAGE 7

JOB NUMBER: C10015
DRAWING NO.: 06013076
UNIT C13: PALLET 06 C13 IV
QUANTITY 1 SHIP

REV.# 0

03/03/82

	SIZE	PIECemark NUMBER	QUANTITY	COST CODE
ELL 90 THERMOSETTING RESIN RTRP REINF		000093999	1	0601
TEE THERMOSETTING RESIN RTRP REINFORC		000115686	1	0601
REDUCER THERMOSETTING RESIN RTRP REIN		000122771	1	0601
NUT STN STL AISI TYPE 316 HEAVY HEX	9UNC-25	101000484	36	0601
NUT STN STL AISI TYPE 316 HEAVY HEX	8UNC-25	101000586	48	0601
FLAT WASHER STN STL AISI TYPE 316 AN DIA BOLT		101005250	48	0601
FLAT WASHER STN STL AISI TYPE 316 ANS GLT		101005285	96	0601
BOLT STN STL HEX HD AISI TYPE 316 ANS X 5 3/4		101007473	12	0601
BOLT STN STL HEX HD AISI TYPE 316 ANS X 4 3/4		101007474	24	0601
BOLT STN STL HEX HD AISI TYPE 316 ANS X10 1/4		101007476	48	0601

UNIT PIPING PALLET L/M

PRODUCTION PLANNING

CAT V: MN ASSY ERECT SITE.

JOB - CI-015

UNIT

9

PALLET #

06-009-1 F

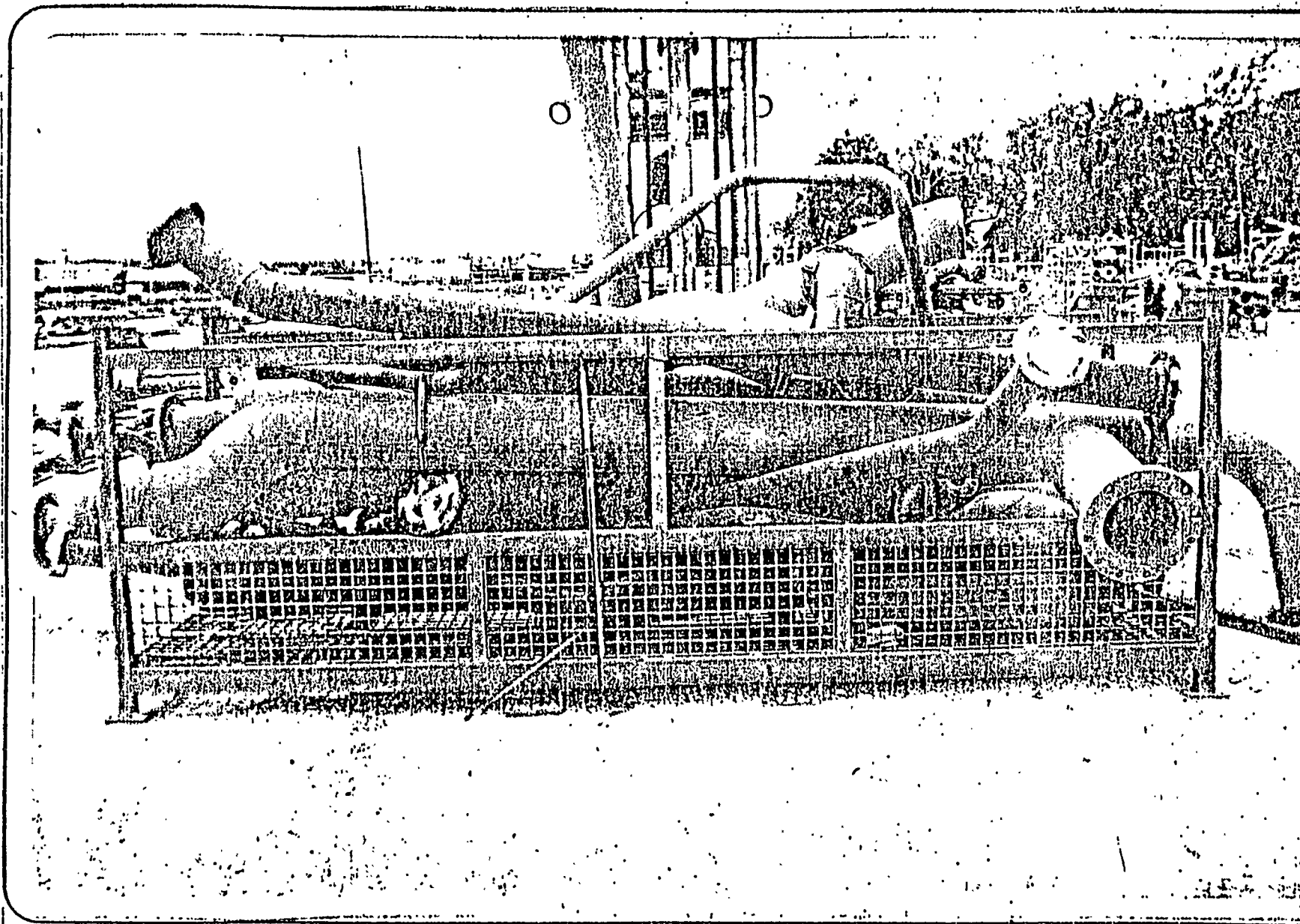
HULL ALL

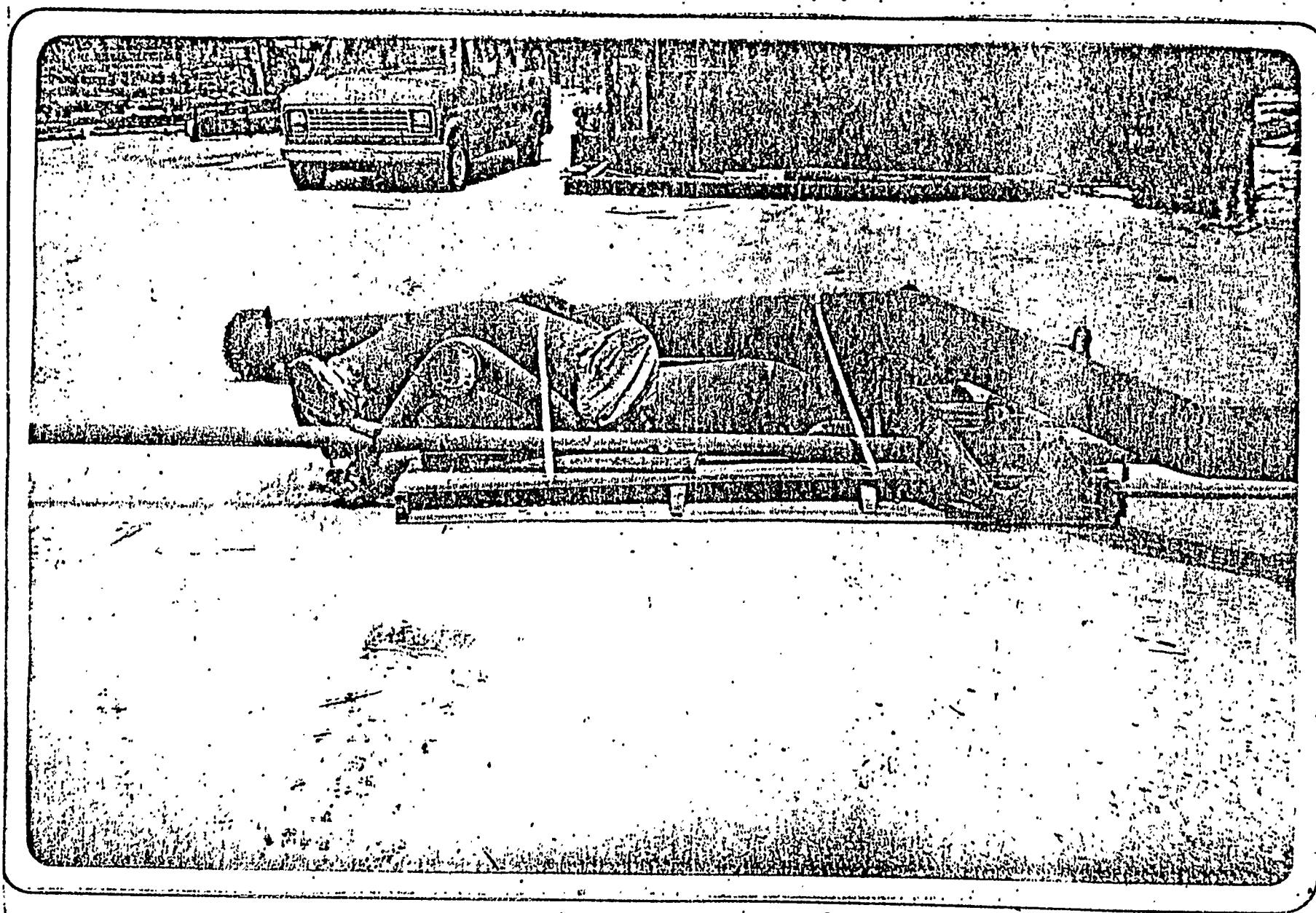
ZONE M.I

PALLET REQ'D. AS PER SCHED.

[illegible]

JOB			HULL		ZONE		DWG.		PALLET								
C1-15			1				06-009-047		06-009-1T								
CL	PD	QTY	RECEIVED		SURFACE PREP				COATED				ISSUED				
			REC.	DATE	LOC.	QTY.	TICKET	DTD	LOC.	QTY.	TICKET	DTD	LOC.	QTY.	TICKET	DTD	REMARKS
PIP	34	1	1	5/18	39563	1	39563	5/18	PIP	1	38585	5/25	R1R60	1	13364	6/1/82	PHD 16
B	35	1	1	5/26	39225	1	39225	5/26	B/A	1	34334	6/8		1			
B	36	1	1	5/18	39564	1	39564	5/18	B/A	1	34306	6/1		1			
B	37	1	1	↓	↓	1	↓	↓	↓	1	↓	↓		1			
PIP	43	1	1	5/26	39224	1	39224	5/26	PIP	1	38590	6/1		1			
B	52	1	1	↓	39225	1	39225	↓	B/A	1	34334	6/8		1			
PIP	60	1	1	5/18	39563	1	39563	5/18	PIP	1	38585	5/25		1			
B	66	1	1	5/26	39225	1	39225	5/26	B/A	1	34346	6/9	↓	1	↓	↓	↓





WEEKLY PIPE DETAIL SHOP LOAD

AVONDALE SHIPYARD, INC.

PAGE 3

MATERIAL LISTING
RELEASE DATE 04/02/62

PD	PD DESCRIPTION		QUANTITY	PIECEMARK	PIECEMARK DESCRIPTION	NO. REQ'D	S/O NUMBER
PD165-6600047-2335	23350600047	6608	1.00000	000070110	FLANGE STL SLIP-ON 150 A	2	0000108420
PD167-6600047-2335	23350600047	0608	2.00000	000070110	FLANGE STL SLIP-ON 150 A	1	0000108370
PD124-6600047-2335	23350600047	0609	1.00000	000070113	FLANGE STL SLIP-ON 150 A	1	0000108270
PD124-6600047-2335	23350600047	0609	1.00000	000070113	FLANGE STL SLIP-ON 150 A	1	0000108530
PD166-6600047-2335	23350600047	6609	1.00000	000070113	FLANGE STL SLIP-ON 150 A	1	0000108310
PD061-6600047-2335	23350600047	6601	1.00000	000070115	FLANGE STL SLIP-ON 150 A	1	0000108390
PD011-6600047-2335	23350600047	6608	1.00000	000070115	FLANGE STL SLIP-ON 150 A	1	0000108240
PD114-6600047-2335	23350600047	0608	1.00000	000070115	FLANGE STL SLIP-ON 150 A	1	0000108650
PD016-6600047-2335	23350600047	6603	2.00000	000070116	FLANGE STL SLIP-ON 150 A	1	0000108300
PD017-6600047-2335	23350600047	6603	1.00000	000070116	FLANGE STL SLIP-ON 150 A	1	0000108600
PD020-6600047-2335	23350600047	6604	1.00000	000070116	FLANGE STL SLIP-ON 150 A	1	0000108210
PD023-6600047-2335	23350600047	6603	2.00000	000070116	FLANGE STL SLIP-ON 150 A	1	0000108430
PD118-6600047-2335	23350600047	6609	1.00000	000070116	FLANGE STL SLIP-ON 150 A	1	0000108230
PD119-6600047-2335	23350600047	0609	1.00000	000070116	FLANGE STL SLIP-ON 150 A	1	0000108640
PD120-6600047-2335	23350600047	0609	1.00000	000070116	FLANGE STL SLIP-ON 150 A	1	0000108360
PD034-6600047-2335	23350600047	0612	1.00000	000070409	FLANGE STL SOCKET WELD 1	2	0000108570
PD030-6600047-2335	23350600047	0612	1.00000	000070409	FLANGE STL SOCKET WELD 1	1	0000108590
PD126-6600047-2335	23350600047	0609	1.00000	000070409	FLANGE STL SOCKET WELD 1	1	0000108480
PD129-6600047-2335	23350600047	0609	1.00000	000070409	FLANGE STL SOCKET WELD 1	1	0000108330
PD130-6600047-2335	23350600047	0608	1.00000	000070409	FLANGE STL SOCKET WELD 1	1	0000108580
PD118-6600047-2335	23350600047	6609	1.00000	000091316	ELL 90 STL BW STD SHLS AS	1	0000108250
PD119-6600047-2335	23350600047	6609	1.00000	000091316	ELL 90 STL BW STD SHLS AS	1	0000108640
PD120-6600047-2335	23350600047	6609	1.00000	000091316	ELL 90 STL BW STD SHLS AS	1	0000108360
PD016-6600047-2335	23350600047	6603	1.00000	000091416	ELL 90 STL BW XS SHLS AS	1	0000108300

MC-5

6/21/82

LIST OF PIECEMARKS IN MLF CONSOLIDATED BY JCB PAGE

61

IN JOB PIECEMARK SEQUENCE

JOB NO	PIECEMARK	DRAWING	QUANTITY
C10015	000093604	48 044C	2
C10015	000093604	48 0450	4
C10015	000093604	48 1010	20
C10015	000093604	48 1020	191
C10015	000093604	55 0130	6
C10015	000093604	55 0140	20
PCM TOTAL			329
C10015	000093605	38 0210	30
C10015	000093605	45 0110	12
C10015	000093605	45 0130	8
C10015	000093605	48 0110	2
C10015	000093605	48 0210	15
C10015	000093605	48 0430	5
C10015	000093605	48 0440	4
C10015	000093605	48 0450	6
C10015	000093605	48 1010	10
C10015	000093605	48 1020	290
C10015	000093605	55 0110	8
C10015	000093605	55 0130	25
C10015	000093605	55 0140	15
PCM TOTAL			430
C10015	000093606	38 0210	13
C10015	000093606	45 0130	15
C10015	000093606	48 0110	4
C10015	000093606	48 0210	16
C10015	000093606	48 0310	10
C10015	000093606	48 0420	8
C10015	000093606	48 0430	2
C10015	000093606	48 0450	4
C10015	000093606	48 1010	8
C10015	000093606	48 1020	170
C10015	000093606	48 1710H	136
C10015	000093606	55 0110	2
C10015	000093606	55 0130	18
C10015	000093606	55 0140	25
PCM TOTAL			431
C10015	000093607	38 0210	16
C10015	000093607	45 0130	40
C10015	000093607	48 0110	3
C10015	000093607	48 0440	2
C10015	000093607	48 1020	72
C10015	000093607	55 0110	1
PCM TOTAL			134
C10015	000093608	38 0210	4
C10015	000093608	45 0110	14
C10015	000093608	45 0120	27
C10015	000093608	45 0130	5

DRG. NO. 48-00-142
ce 758

TITLE OF DRAWING PLBS # INT DR DES ATAS "C" DR # ABOVE

REV. NO. _____

FIG. NO.	TOTAL	QTY.	SKETCH	QTY.	SKETCH	QTY.	SKETCH	QTY.	SKETCH	QTY.	SKETCH	QTY.	SKETCH	QTY.	SKETCH	QTY.	SKETCH	QTY.	SKETCH	QTY.	SKETCH
070111	1	1	PD15																		
090113	8	7	PD25	1	PD26																
090211	1	1	PD15																		
093609	4	2	PD11	1	PD13	1	PD32														
127605	6	1	PD1	1	PD5	1	PD6	1	PD10	1	PD14	1	PD18								
133429	1	1	PD18																		
180876	2	2	PD20																		
180877	6067.11	1	PD1	1	PD3	1	PD4	1	PD5	1	PD6	2	PD7	1	PD8	1	PD9	1	PD10	1	PD12
180877	47	2	PD14	1	PD16	1	PD17	1	PD19	1	PD20										
180879	1	1	PD24																		

PIPE DETAIL SUMMARY - "SHOP LOAD"

MC-3

DATE 2/17/81

P.O.NO.

LIST OF MATERIAL

QUANTITY (1) SHIP

REQ.NO. 6247F

PC. NO.	QTY	DESCRIPTION	UNIT	TOTAL PRICE
000180809	10	BHD & DECK PENETRATIONS. STEEL WT & OF ASB MECH STD NO 11 3 IPS		
000180876	43	SLEEVE STL WELDED SLIP-ON TYPE ASI MECH STD NO 10 1 1/2		
000180877	56	SLEEVE STL WELDED SLIP-ON TYPE ASI MECH STD NO 10 2		
000180879	42	SLEEVE STL WELDED SLIP-ON TYPE ASI MECH STD NO 10 3		
000180881	2	SLEEVE STL WELDED SLIP-ON TYPE ASI MECH STD NO 10 4		
000181159	4	VENT ANTI-SIPHONIC PVC BODY MONEL SCREEN MIN VACUUM TO VENT 1" WATER MIN PRESSURE TO SEAL 1" WATER 3/4 FPT		
000181612	21	DECK DRAIN STL SOCKET WELD TATE 60-160 W/BRASS STRAINER GALV WITHOUT TRAP AND BAFFLE 2		
101000284	4	NUT STEEL GALV HVY HEX MIL-8-857A-5 ASTM A307 ANSI B18.2.2 5/8 11UNC-2B		
101011109	4	BOLT STL GALV HM MIL-8-857A-5 TY 2 GR 2 ASTM A307 GR 8 5/8 11UNC-2A X 3		

DR.	AVONDALE SHIPYARDS, INC.	CUSTOMER	EDGEN MARINE, INC.
CKD.	P.O. BOX 50280 NEW ORLEANS, LA. 70150	JOB NO.	C8-0750
APPD.	TITLE PLUMBING & INT. DK. DRNS. QTRS. "C" DK. & ABOVE - L/M	DWG. NO	46.08 141
		REV.	2

CODE 0619

NO OF VESSELS 2

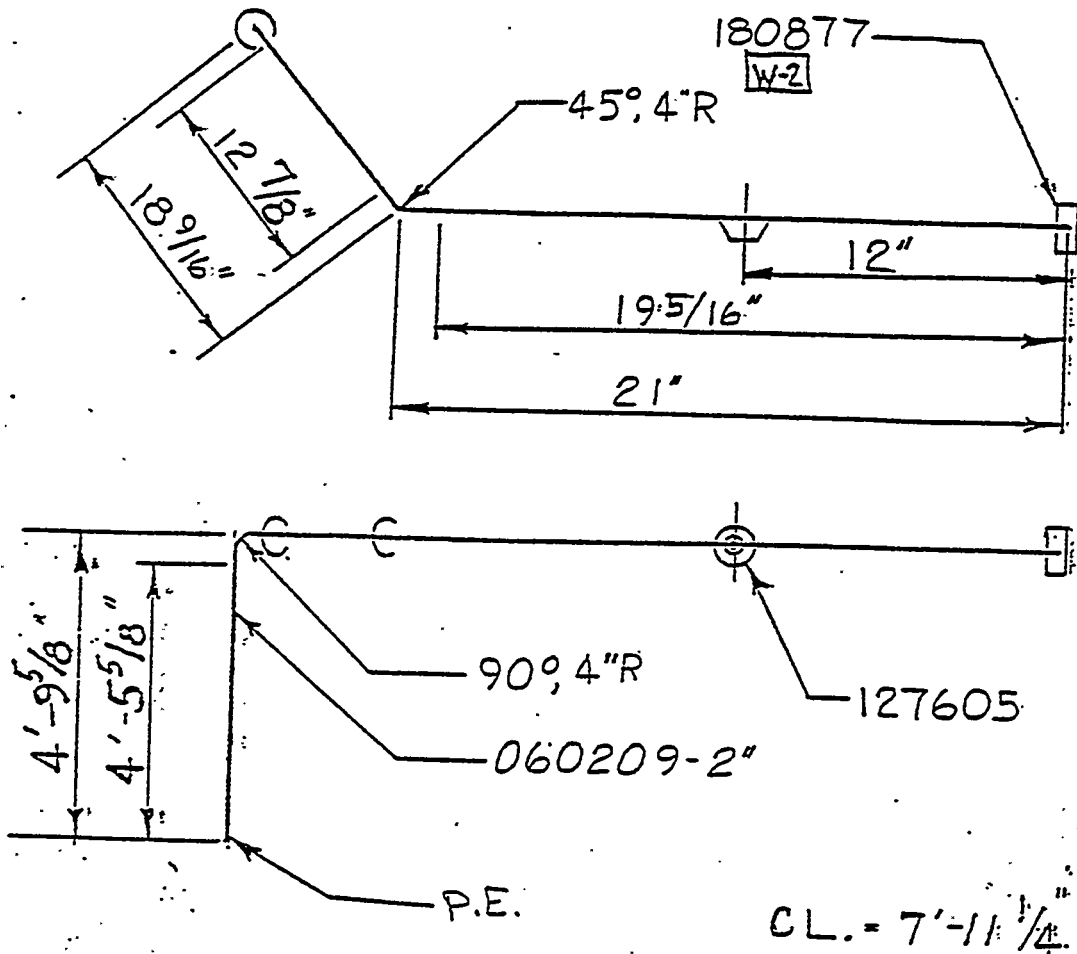
DATE 2/17/81

SHEET 8

PIPE DETAIL SKETCH

P. D. NO. 1-2
 NO. REF. 1
 LOC. 07-71-1

HOT DIP GALV.
 AFTER FABRICATION



127605 COUPLER STL FORGED SW 3000 ASTM A105 VOGT SW-1211 3/4" size
 060209 PIPE STL SW XS ASTM A53
 180877 SLEEVE STL WELDED SLIP-ON TYPE ASI MECH STD NO 10

C7ST	AVONDALE SHIPYARDS, INC.	JOB NO. CA-0750
CODE	P.O. BOX 50750 NEW ORLEANS, LA 70150	DWG NO. 48 CB 142
	TITLE: PLUMBING & INT. DK. DRNS.	DWN. SAW
	OTRS. "C" DK. & ABOVE - P/D	REVISION

SHEET 5

PIPE MAT'L XFER REQ	03-26-82	04-02-82	04-09-82	04-16-82	04-23-82	04-30-82
START FABRICATION	03-29-82	04-05-82	04-12-82	04-19-82	04-26-82	05-03-82
COMPLETE FAB, STAT COAT	04-26-82	05-03-82	05-10-82	05-17-82	05-24-82	05-31-82
INSTALL W/O REQUIRED	05-03-82	05-10-82	05-17-82	05-24-82	05-31-82	06-07-82
COAT COMP-ASSY PALLET	05-10-82	05-17-82	05-24-82	05-31-82	06-07-82	06-14-82
PALLET REQ. IN QUEUE	05-17-82	05-24-82	05-31-82	06-07-82	06-14-82	06-21-82
START INST/ASSY WK OF:	05-24-82	05-31-82	06-07-82	06-14-82	06-21-82	06-28-82

2335 - EXXON #1

UNITS	UNITS	UNITS	UNITS	UNITS	UNITS
8B PIPING	8B PIPING	8SB 8U	17U	18U	9SA
8SA 17S	10SA	(PLAT 307)		18S	(PLAT 16)
(PLAT 16)	(PLAT 16)		1B PIPING	10U	BALL TK
			10SB	(PLAT 307)	PIPING
		MACH PKGS	(PLAT 307)		8SC
		81-10-19V			(PLAT 16)
		06-819-1P			
		81-M11-6X			
		06-806-1P			
		81-10-18V			
		06-818-1P			
		81-10-01V			
		06-801-1P			

2336 - EXXON #2

F. Logue

A PALLET NUMBER CONSISTS OF A COST CODE, A LOCATION CODE, A
SERIAL NUMBER CODE AND A STAGE CODE.

ON UNIT OUTFITTING:

TYPICAL ON UNIT PALLET NUMBERS:

06-001-01U

U upside down

07-001-01T

T turn

08-001-01V

V

09-001-01J

J joining

↑

↑ ↑

Craft

~~*Serial*~~

Serial

stage?

VIII. CONCLUSION

As you can see, the methods that have been developed over the past few years are a giant step forward toward a complete and fully operational zone outfitting material control system. Many obstacles still remain to be overcome; but, given time, these too shall soon be a thing of the past. To date, the progress made toward this goal by the Material Department has been very rewarding and continued advances, especially in the realm of computerization, should find us in a position to respond to future changes and advances with a minimum of disruption. It now appears that the hardest part, the understanding of how the zone outfitting methods function, is behind us and the greatest gains in productivity are yet to be realized.

The requirements for pallet loading are obtained from unit or zone outfitting lists prepared by the Planning and Scheduling Department (VIEW GRAPH NO. MC-11). Individual lists are published for each cost code (craft) within the same pallet code. Using the Master Unit Schedule, the Material engineer reviews pallet requirements approximately two weeks prior to the material being required at the job site, writes the proper material delivery authorization ticket, and at the same time writes a Material Deficiency Report, if required. One week, more or less, prior to the material installation need date, the delivery authorization tickets and a copy of the Material Deficiency Report, the original of which was forwarded to the Expediting Department when written, is sent to the various warehouse storage locations. All of the materials flow from storage to a central marshaling area in the main warehouse for grouping and containerizing by pallet code and craft. Using the outfitting material requirements lists, the warehouseman verifies that all materials required are on hand, or that missing materials are accounted for on the Material Deficiency Report. The material and its accompanying papers are then delivered to the work site two or three days prior to the start of installation.

VII. MACHINERY PACKAGE UNITS

An assembly of machinery, combined with adjacent components such as the foundation, pipe pieces, valves, gratings, ladders, supports, etc. make up a machinery package unit. A good example of this would be a fuel oil pump package unit. These packages are built in a new, modern building with overhead crane service immediately adjacent to the Pipe Shop. Since these packages are designed exclusively by the Mechanical Section of the Engineering Department, a complete L/M is available for each one. This L/M includes all of the material necessary to build a complete package and is treated much as a unit would be by the Material Department with one notable exception. Pipe and fittings sent to the Pipe Shop for fabrication are not turned over to the P/D marshaling area as with other P/D's; rather, they are handled internally going directly from fabrication to coating and returning to the package unit shop for incorporation into the unit.

After completion, the package units are either sent to the warehouse for storage (this only in the event the package unit was built in less than the scheduled time or because the unit into which it is to be installed is not ready to receive it), or sent directly to the unit erection area for installation.

was made to the job site. The same problem of possible damage, loss, or deterioration still existed as before, but the pipe installers were now somewhat freed from material handling.

During the transition period from system orientation to zone outfitting, the record keeping and retrieval of P/D's became infinitely more complex. The storage area soon had to be expanded to accommodate the ever-growing number of P/D's being held pending delivery. Also, more and more manhours were being spent gathering P/D's from many different systems in various locations in an attempt to fill the unit -outfitting requirements.

Today, especially on the third ship of APL contract and beginning with the first ship of the Exxon contract, a smooth, efficient system has replaced the chaos of the past. Since P/D fabrication now is forced to follow the Master Unit Schedule, far fewer P/D's will be held in storage at any given time and they will remain in storage for a much shorter time.

As P/D's are fabricated, they are taken from the Pipe Shop on a daily basis and delivered to the fabricated pipe marshaling yard and then routed for coating, if required, or containerized if no coatings are required. The new metal containers being used replace the old 4' x 8' wooden pallets and each has a capacity of roughly 6 or 7 to 1 over pallets, further reducing the physical storage area required (VIEW GRAPHS NO. MC-7 & MC-8). Record keeping is accomplished by manually posting a P/D control card which is sequenced by pallet number (VIEW GRAPH NO. MC-9). The P/D requirements for each pallet are taken from the piping pallet list of material produced by the Planning and Scheduling Department (VIEW GRAPH NO. MC-10). When all P/D's required to complete a pallet are received, the metal containers are banded and are delivered to the installation site during the week prior to the scheduled start of installation. This method virtually relieves the installers from material concerns and allows them to concentrate on their function.

VI. PURCHASED MATERIALS (WAREHOUSING)

Materials purchased directly for the job are stored in the main warehousing complex or, if permitted, outside in a designated storage area. For purposes of this discussion, materials can be roughly divided into two categories: those items required for fabrication into sub-assemblies, which method was reviewed earlier; and those items requiring installation independently on-unit or on-board.

with the old system, warehouse release authorizations are sent to the warehouse for delivery and material deficiencies are sent to the Pipe Shop for informational purposes and to the Expediting Department for action. The materials delivered to the Pipe Shop are separated into categories such as flanges, elbows, tees, reducers, etc. to facilitate machine station loading. P/D's that were not released when required are listed as "past due." Each week the computer-produced listing of materials will have a separate listing in required date order detailing which P/D's are past due and the materials required for each. These P/D's will be carried as past due until such time as all material requirements are met, at which time the P/D can be released causing it to be dropped from the "past due" listing. Unlike the old system, the Pipe Shop superintendent is not contacted prior to deliveries, nor does he have the option to halt deliveries due to shop overloading. Rather, he must take other corrective steps such as increasing capacity by working extra shifts, rerouting, overtime, or subcontracting. The zone outfitting concept forces this discipline upon everyone because it is more important to the overall success of the shipbuilding process than is shop level loading.

V. FABRICATED OUTFITTING MATERIAL

The handling, storage, and delivery to production of fabricated pipe pieces under the old system concept was originally controlled by the Pipe Shop, itself, in that once a system was fabricated, all the pipe pieces were palletized and stored in racks at the Pipe Shop. When the installing foreman required the first P/D's to begin assembly of a system, he requested the entire system of P/D's from the Pipe Shop. This meant that a search through all P/D's fabricated for that system was required to obtain the P/D's needed for installation at that time. The length of time required to fit an entire system usually resulted in many pipe pieces being lost, damaged, or deteriorating due to long exposure to the weather.

About five years ago, it was decided, due to the ever increasing volume of fabricated pieces, that the Material Department would take over the storage, routing required through coatings, and ultimate delivery to the construction site, as required. This merely shifted the burden of finding the piece needed from the installing foreman to the Material Department. The original idea for recording and storing the P/D's was based on random access with a Kardex file used for recording the various storage locations within each system. As P/D's were needed to fit the system on board, the installing foreman would request only those P/D's needed at that time. These P/D's were located on the Kardex file, each location noted and a picking list made. After gathering together the P/D's requested, delivery

to Material Control is on-line computer capability to search all jobs for any piece mark number. This program allows a Material engineer the flexibility to determine if an item that is needed now, but not received, is available in another pallet L/M, or even in another job, and can perhaps be shifted temporarily to keep the job at hand current. These new aids and approaches, while significant, have not appreciably reduced the work load on the Material Control Group, but have helped the Material engineer to be more effective. It is felt that the real cost savings under the zone outfitting concept will come from material arriving at the job site in the right quantity and at the right time.

The procedures for producing P/D's under zone outfitting has not changed a great deal from the traditional method. The major differences are the addition of the pallet code number, work station routing, and coating information. The P/D drawings are now produced for individual units and contain all the pipe details that are to be fabricated for the unit, regardless of which system they belong to. Each P/D has its own pallet code which is used to eventually marshall all P/D's accordingly. The information contained on each P/D is then input to an EDP program called "Copies" which is used to schedule the pallets, P/D's and the individual pieces that make up each P/D according to its pallet number. From all of this information, a weekly shop load list is produced containing all of the material required for P/D fabrication for each pallet that is scheduled to start fabrication that week (VIEW GRAPH NO. MC-6). Currently, materials are being scheduled through the Pipe Shop on a pallet-by-pallet basis; that is, if a pallet is scheduled to start fabrication on a given day, all of the material for that pallet is released at one time. A new approach to this problem is now being worked on by the Data Processing Department which will attempt to look at only those individual P/D's scheduled to start in any given week. This should reduce the amount of material kept on hand at the Pipe Shop by as much as 75% and require a proportional reduction of material handling by Pipe Shop personnel.

The horizon set in the computer for pallet lists of material is three weeks from the day the information is requested from the computer. This advance listing is required at Material Control in order to have time to review any errors, omissions, or material shortages. After reviewing the material listing from Data Processing, the Material engineer determines those P/D's for which 100% of the required materials are available. These P/D's, to which individual shop orders are computer assigned, are released for fabrication via a CRT terminal located in the Material Control office. Only those P/D's released to the computer can be fabricated by the Pipe Shop and a listing of them, along with their work station routings, are sent to the Pipe Shop superintendent for scheduling through the shop. As

for on-board installation. When a work order was issued to the Pipe Shop to begin fabrication, a copy was forwarded to the Material Control Department for material release. The material engineer would then write the various warehouse release authorizations, and the materials for fabrication of entire systems would be moved from the warehouses to the Pipe Shop. As systems were started and under way and other systems were released, a large quantity of material was usually on hand at the Pipe Shop at any given time, leading to shop overloading and replacement material problems.

In order to alleviate this burden on the Pipe Shop, it was agreed that the shop superintendent would be contacted to determine if the shop load would permit delivery of the material at that time. In effect, the Pipe Shop scheduled its own work based more on shop loading considerations than on schedule requirements. If the shop was in a position to accept the material, the Material engineer released the warehouse removal authorizations required to the warehouse for delivery, and at the same time issued a material deficiency report indicating shortages to the Pipe Shop superintendent for informational purposes and to the Expediting Department for action. Any material that was not available at the time of delivery was designated "deliver on arrival" and sent to the Pipe Shop upon receipt. If, however, the Pipe Shop superintendent decided not to fabricate the system at that time, the warehouse releases were held in suspense by the Material engineer until such time as they were needed by the Pipe Shop.

Materials required for on-board installation were handled somewhat differently from that of the Pipe Shop. A work order did not trigger delivery of all remaining materials to the installing foreman. Instead, as work progress on the system, the material was delivered at the discretion of the field foreman. If all the remaining material was not needed, it became more job surplus or, worse, if material was needed but not shown on the L/M, emergency measures would have to be taken with all the attendant costs and disruptions that usually accompany such measures.

Today, diagrammatic pipe drawings are still used to advance order materials similar to the old system method. These L/M's are also screened against all available materials on hand with the balance being purchased as before. However, in order to screen materials from diagrammatic L/M's more effectively, a computer program was devised to look at each piece mark and indicate upon which diagrammatic L/M each appeared. This information is produced on a weekly computer generated listing by job in piece mark number sequence (VIEW GRAPH NO. MC-5). This allows the entire diagrammatic L/M material to be screened from, eliminating unnecessary purchases, and reducing surplus materials at the close of a job. Also, recently made available

long lead time items or unusual or one of a kind items) were advance ordered. These advance lists of materials were then written as formal requests to the Purchasing Department for buying. These requests were first screened by the Material Control Section against all available materials on hand, such as stock, surplus, job overages, etc., with the remaining material requirements forwarded to the Purchasing Department. These diagrammatic L/M requests were then used to establish material ledgers. Subsequent postings of purchase order, expediting, receipt and issue information completed the record keeping cycle. The material contained in these diagrammatic L/M's was then available for screening against system drawings when they were produced. Once the system drawings were completed, P/D drawing booklets were produced which contained all the pipe pieces that were to be fabricated in the shop (VIEW GRAPH NO. MC-3). This L/M, which included both the materials necessary to build all of the pipe pieces and the materials required for on-board installation, was then screened against its designated diagrammatic L/M and all other available sources with the balance, or unscreened requirements, being forwarded to the Purchasing Department. This information was then used to establish material ledgers for each individual system, detailing each item of material required for the entire system. The record keeping between diagrammatic L/M's and finalized system L/M's amounted to a dual bookkeeping system. For instance, materials contained in diagrammatic L/M's were posted with P.O. numbers, receipt and expediting (anticipated shipping dates) information and, also, with screening information indicating to which system L/M the material was to be transferred when received. In addition, the system L/M ledger was posted with information showing from which diagrammatic L/M the material would be transferred from when received - very complicated. Another hang-up with the advance ordering done with diagrammatic L/M's was the creation of unnecessary surplus material. As systems became more clearly defined, a point in time was reached when it was determined that all remaining materials on diagrammatic L/M's be placed in job overage files and made available for general screening. The problem with this approach was that by the time such determination was made, if ever, most of the material requirements for that job had been satisfied, which resulted in this material being placed in an ever-growing surplus account at the end of the job.

Separation of materials required for P/D fabrication and materials required for on-board installation had to be done manually since system L/M's did not differentiate between the two. To accomplish this, a material take-off was made for each P/D in a system, grouped in piece mark number sequence and totalled in a Material Summary Report (VIEW GRAPH NO. MC-4). This summary, then, represented all of the material requirements necessary for pipe piece fabrication in the shop. The residual materials contained in the system L/M were assumed to be the requirements

"on unit, " "on board, " "machinery package, " and "pipe rack package" pallet. Disciplined use of the Pallet Outfitting Schedule results in the organization and control of materials necessary to control the work effort in the field.

In order for these new methods to be successfully implemented, it became necessary for the Material Department to work much closer with other departments, especially the Planning and Engineering Departments as well as all production crafts. As a result of this increased contact, problems that would ordinarily have gone unnoticed until too late are now being brought to light in time for corrective action to be taken.

III. COMPARISON BETWEEN SYSTEM AND ZONE OUTFITTING METHODS

Comparisons of outfitting methods as they relate to piping and their impact on material functions at ASI can be made in the following major categories:

- pipe and pipe fittings sent to the Pipe Shop for fabrication into sub-assemblies (P/D's);
- sub-assemblies (P/D's) sent to the marshalling area for distribution;
- purchased and stock materials stored in the-warehouse;
- machinery package materials.

Although advances in other crafts have been made as they relate to zone outfitting, piping was chosen for these examples because it is the most complicated and farthest advanced at ASI. The lessons learned from the piping experiments will be the models used for future development of all other crafts by the Material Department;

IV. PIPE SHOP FABRICATION MATERIALS

Pipe and pipe fittings required by the Pipe Shop for assembly into P/D's in the past were handled on a purely system basis. Although this gave the Pipe Shop foreman a large backload of work and permitted him to build P/D's to the limit of the shop capacity, the resulting output from the shop was inconsistent with the system installation demand in the field. This, of course, caused storage and handling problems of large proportion. The old system-by-system method used saw the Mechanical Section of the Engineering Department producing diagrammatic system drawings from which materials (which were thought to be

As time went on and later contracts were better defined and eventually engineered on a unit and zone basis, systems lost their identity and L/M's were concentrated into small packages for "on unit" or "on board" outfitting. These "pallets" of material, enough to do a small segment of work, arriving at the job site only when needed, have greatly reduced the amount of lost, damaged, and deteriorated material, along with the time that had been wasted trying to find it.

II. THE PALLET CODE AND OUTFITTING SCHEDULE

The two most important tools developed to date to group and schedule materials for zone outfitting are the pallet code and the outfitting Pallet schedule. The Pallet code, as used at ASI :

- identifies materials needed to outfit a particular unit or zone;

- identifies where the material is to be installed;

- identifies the material to a pallet serial number, which permits separation into manageable packages;

- identifies the stage or time at which the material is to be installed.

The three applications of pallet numbers to outfit material are:

- grouping unit material at the various stages of construction before erection;

- grouping material for outfitting zones (on board) after unit erection;

- grouping material for installation on machinery and pipe rack packages.

Some typical "on unit" pallet codes are: (VIEW GRAPH NO. MC-1)

- 06-001-OIU

- 07-001-OIT

- 08-001-OIV

- 09-001-OIJ

The Outfitting Pallet Schedule (VIEW GRAPH NO. MC-1A), which is produced by the Outfitting Planning Group, details each stage required to fabricate, coat, palletize, and install every

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
MATERIAL CONTROL (SECOND SESSION)

I. INTRODUCTION

Until recently, all ships built at ASI were outfitted conventionally from drawings that were concerned with whole systems and system functions. The materials required for outfitting were installed mainly after erection and assembly of the hull units and by individual system. Material Control, as a result, looked at material in rather large and cumbersome lots. Issuance of such large lots of material, which could only be installed over a long period of time, invariably led to many replacement purchases due to lost, stolen, or deteriorated components. Control of material, once it left the warehouse, was very casual and inefficient, causing much lost time due to the effort required trying to keep large lots of material accounted for over such a long time period.

Our first attempts at on-unit outfitting were with system designed drawings which were broken up to suit on-unit construction, but not so separated for purchasing or material control purposes. Since all L/M's were generated from system drawings, the attempt to extract parts of each system, such as PD's, valves, pipe, fittings, etc., and fit them into the unit to which they belonged became an arduous task, especially so since all record keeping and material take-offs were accomplished manually. The effort, made by the Material Department's attempts to reconcile the system drawings to the unit outfitting methods, was no more than moderately successful, but many valuable lessons were learned and methods began to develop.

During this transition period, many meetings were held between the IHI Material Control representatives and the ASI Material Control Group, which resulted in a better understanding of the zone outfitting methods developed by IHI. Although all of the IHI methods were not adopted for controlling material at ASI, the basic principles were learned and many are being implemented, such as a computer printout listing the materials required for pallet loading, in piece mark sequence; and at the proper time in the schedule. Some progress has also been made in the conversion of the material control record keeping function from a totally manual system to one that is partially computerized, and it is anticipated that this trend will continue. Eventually, in order to keep pace with the rapid flow of material and information, a fully integrated and computerized material control system must be developed.

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

ACCURACY CONTROL IN THE SHIPFITTING DEPARTMENT

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MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL ACCURACY CONTROL IN THE SHIPFITTING DEPARTMENT

I. INTRODUCTION

The term "Accuracy Control" is a term that has been inherited from Japanese shipyards as a result primarily of the institution of various concepts involved in the IHI technology transfer program. Some minor controversy has developed over the correctness of this term as applicable to American shipyards. Admittedly, what an organization or department is called is of little consequence as compared to the end result that is expected and obtained from that organization or department, but it might be wise nonetheless to delve very briefly into the semantics of the term.

Webster's says that "accuracy" is "freedom from mistakes or errors." If this were applied to ship construction, it would imply that the finished individual parts and ultimately the ship itself would exactly coincide with all design dimensions and details as established by engineering. While obviously no such exactness could be expected to actually exist, one of the functions, perhaps even the primary function, of an Accuracy Control Department is the establishment of realistic goals in the area of "accuracy" within which a shipyard Production Department can operate, with proper consideration being given to the demands of both quality workmanship and sound economics.

The word "control" should be quite literally accepted; the required controls should be implemented to insure the degree of accuracy which is desired. We have now determined the two initial functions of an Accuracy Control Department:

- the establishment of realistic goals in the area of "accuracy;"
- the development of proper procedures or-controls to permit the achievement. of those "accuracy" goals.

The adequate implementation of these two primary functions necessitates the existence of a basic philosophy in management that is committed not to just doing a job the best way possible, utilizing all the facilities that are available, but is rather committed to doing a job the best way possible the very first time it is attempted. Any other philosophy is a positive commitment to the necessity of rework and the elimination of rework should be an inherent part of all activities of an

Accuracy Control Department. The continued operation of an effective accuracy control program, administered under this concept, will virtually assure that the philosophy of doing a job the best way possible the very first time will ultimately pervade all areas of work.

In this discussion we will consider the areas of work where an accuracy control program can be the most cost effective and how that program can best be developed and implemented. An attempt will also be made to determine certain basic priorities to be applied when setting up the activities of an accuracy control program. Such priorities may well vary from shipyard to shipyard, but it is probable that they will generally be applicable.

II. ACTIVITIES OF AN ACCURACY CONTROL DEPARTMENT

A. GENERAL

The activities of an Accuracy Control Department should span all phases of construction from the burning of the plate and structural to the final erection of all material in the completed ship. These activities may be roughly divided into three categories:

- Checks
- Controls
- Statistics

These efforts should have a dual impact: the improvement of immediate work and the improvement of future work (see Fig. 1-1). Although these are distinct and separate activities, they are so thoroughly interrelated that any one cannot be effectual without the involvement of the other two.

1. Checks -

Checks are utilized for three primary purposes:

- a.- The isolation of specific problems that present a demand for controls.
- b. The monitoring of construction to insure that:
 - 1) proper controls are being utilized
 - 2) controls are, in fact, effective

- c. The monitoring of construction to assist in the minimizing of human errors.

2. Controls

Controls are employed for the sole purpose of enhancing existing work practices. Control might be called the magic word in Accuracy Control, but it is, in reality, the magic word in any type of endeavor. The most necessary prerequisite for success in any venture whatsoever is a predictable end result. It is control that makes an end result predictable whether that control be over Personnel, Machinery, Systems, or even Yourself. A lack of control means literally that something is "out of control," resulting in a very poor degree of predictability.

3. Statistics

Statistics may be divided into two categories:

- a. The development of statistics that are applicable to shipfitting work throughout the ship.
- b. The development and maintenance of statistics applicable to a specific unit. In other words, a unit history.

4. Coordination Of Activities

The coordination of these activities is graphically displayed in Figures 1-2 through 1-5. Figure 1-2 indicates that without the utilization of an Accuracy Control Program, a poor product is the predictable end result, both for immediate and future work. Figure 1-3 indicates the implementation of checks. Checks alone cannot improve the end product. Figure 1-4 indicates the development and implementation of controls in addition to checks. This results in an improved product for immediate work but develops slight potential for the improvement of future work. Figure 1-5 indicates the results that may be expected with the implementation of a well coordinated Accuracy Control Department, utilizing checks, controls and statistics.

The results from this are not only a good product in the immediate work nor the potential for a good product in the future work, but the potential has also been developed for improved design concepts, improved engineering concepts and improved production concepts.

* Accuracy control engineers should not be inspectors
Perhaps investigators

The amount of time spent on each of these three distinct but interrelated activities will vary widely, contingent upon many factors such as the stage of development of the Accuracy Control Department or the complexity of the work at hand. In the early stages of the development of an Accuracy Control Department, it is likely that checks will be the single most important activity. Initially, the checks are necessary to develop a cognizance of all the problems that are at hand. As these various problems are recognized and evaluated, controls may then be developed and implemented to alleviate the problems. As the work progresses and the effect of controls becomes pronounced, the need for checks should begin to taper off until ultimately it is used primarily as a monitoring procedure. Similarly, in the early stages of development of an Accuracy Control Program, a very considerable amount of time will be utilized in the development of generally applicable statistics. As these statistics are evaluated and utilized in the development of controls, the need for statistics will also tend to taper off. The maintenance of unit histories must be a continuing effort.

B. OUTLINE OF ACCURACY CONTROL ACTIVITIES

1. Controls

- a. Control Lines, Control Points and Backside Marking
- b. Burning Procedures
- c. Uniform Shrinkage Factors
- d. Construction Procedures
- e. Erection Procedures
- f. Construction Aids

2. Checks

- a. Measuring Procedures
- b. Mathematical Checking "systems"
- c. Forms For Reporting
- d. Establishment Of Unit Profiles

3. Unit Histories

- a. Engineering
- b. Mold Loft and Numerical Control
- c. Plate Shop
 - 1) Burning
 - 2) Panel Line
- d. Structural
- e. Shipfitting
- f. Welding
- g. Handling
- h. Miscellaneous

C. DISCUSSION OF ACCURACY CONTROL ACTIVITIES

1. Controls

a. Control Lines

Control lines, otherwise called master lines or datum lines, are water lines, frame lines, or buttocks that are layed out on various components of units to facilitate the building and erection of the unit. (See Fig. 3-6.) The utilization of these lines will receive further elaboration later in this discussion.

b. Burning Procedures

The accurate burning of all pieces of units, subunits, or partial sub-units is of primary importance because anything else is a commitment to rework. Fig. 2-3 shows several areas where this accuracy is demanded. The fit of floor stiffeners to shell longitudinal requires not only that the stiffener be cut to proper length, but that the shell longitudinal must also be ripped to the proper width. A minimum gap of 1/4" requires that each of these members be cut within 1/8" tolerance. A fit that will always insure no burning at assembly requires even closer burning tolerance.

The fit of floor to girder requires a burning tolerance of $1/32$ " if all of the floors are to be fitted on a unit without reburning. Unit No. 17, the first unit completed on the Exxon contract, with the exception of one shell plate that had stock on it when it should have been neat, was completely assembled without the use of a torch during assembly.

c. Uniform Shrinkage Factors

Few activities are of greater consequence than the development of uniform shrinkage factors. Accurate burning is of little consequence without the utilization of such factors. Floors, as shown in Fig. 2-3 with an excessive shrinkage factor built in, would require occasional reburning to offset a cumulative build-up, even if individual floors were only $1/16$ " oversize. Web frames (see Fig. 2-4) require a different shrinkage factor than the longitudinal bulkhead to which they must be fitted. Specific factors must be developed for all components of a unit.

d. Construction Procedures

Proper construction procedures such as fitting and welding sequences may well offer the most possible and immediate reward for the efforts of an Accuracy Control Department. This area of work will receive greater elaboration later in this discussion.

e. Erection Procedures

The Accuracy Control Department at ASI is primarily involved in work during stages prior to erection. However, erection is a principal beneficiary of the use of control lines. These lines, when layed out with predictable accuracy, are an invaluable aid in setting units at erection. Also, the elimination of stock is virtually impossible without the use of these lines.

f. Construction Aids

Various tools are utilized in the Production Department at ASI to facilitate increased accuracy of construction. These will receive greater elaboration further in this discussion.

2. Checks

a. Measuring Procedures

Accuracy Control engineers spend a great part of their time measuring - slow, methodical, painstaking, tedious measuring. This can at times seem like the most plodding of work, but it is also the most necessary of work. It is this statistical evidence from which proper controls may be developed. A typical example is a web frame. (See Fig. 2-4.) This component must be measured before the butts are welded, after the butts are welded, and after the stiffeners and face plate are welded. This is necessary in order to determine proper shrinkage factors to be utilized in the cutting of component plating. This information is also utilized in the development of assembly procedures that assist in the minimizing of deformation of the component. It may be noted that the dimensions shown on this form provide all the information necessary to make possible these evaluations.

b. Mathematical Checking Systems

Utilizing pertinent X and Y coordinates and rather uncomplicated programs that can be fed into hand-held calculators, it is possible, with only a few measurements to develop the shape of the most common of units. Such procedures of measuring and checking have almost unlimited potential. .

c. Forms for Reporting

The need for and the design of forms for reporting are dictated by the problem at hand. Typical of such forms is Fig. 2-4. A similar form is shown in Fig. 2-5. This is for the reporting of measurements on the longitudinal bulkhead to which web frames must be assembled. When both of these forms provide information that is identical, a first time fit is assured.

d. Establishment of Unit Profiles

This is a procedure that can be very helpful in the determination of the finished shape of complex weldments such as innerbottom units. This procedure will receive greater elaboration further in this discussion.

3. Unit Histories

Unit histories are merely the methodical recording of all problems encountered in the production of a specific unit. This data is used in the development of procedures that will assist in the minimizing of the effect of any particular problem on subsequent units. This is particularly useful on multi-ship contracts.

III. ACTIVITIES DEMANDING SPECIAL EMPHASIS

A. GENERAL

Most of the benefits of a well coordinated Accuracy Control Department are applicable primarily to the Production Department. In the time available today, we will briefly explore some of these activities with an emphasis on the profound effect that they can have on an end product. The Accuracy Control program at ASI was started early in the production of a contract to build three APL Containerships. To date, the activities of the department have been largely restricted to that contract and to a contract for Exxon Product Carriers currently in work. Most of the following information was developed while working on the APL contract. Only a few areas of activity have been selected for discussion at this time, not because they are necessarily of any greater importance than other activities, but rather because they more graphically illustrate the advantages that can be derived from the functions of a well coordinated Accuracy Control program.

Time does not permit a detailed analysis of these procedures. Today, we will only attempt to touch on the highlights of the procedures and the advantages to be secured from them.

B. CONSTRUCTION SEQUENCES

It is probable that the most immediate and most positive improvement that can be achieved in the work process is through the development and implementation of properly conceived fitting and welding sequences. This is quite likely a valid assumption in that the complete lack of such established sequences can virtually negate all other improvements. Dozens of such sequences have been developed for use on contracts underway at ASI. A typical unit has been selected for minimal discussion at this time.

Unit No. 7 is a fairly typical innerbottom unit such as is likely to be found on most contemporary design ships. (See Fig. 3-1.) Three major areas of heat introduction, in the form of welding, present the potential for building in stresses or actually deforming this unit:

- butt welds;
- vertical welds, floors to girders;
- welding of loose shell longitudinal.

Since this unit was built upside down and the tank top was delivered to the platen fully welded with all longitudinal stiffeners fitted and welded, it in no way contributed toward any deformation of the unit. The longitudinal girders were delivered to the platen with the floors immediately outboard already fitted and welded. This, then, necessitated fitting of all girders and attached floors to the tank top, the fitting of all floors to girders immediately inboard of them, the fitting of all loose shell longitudinal, and the fitting of all shell plating to girders, floors, longitudinal, and to the tank top.

Each of these areas of fitting presented a very distinct potential for deforming the unit. No formal construction sequence whatsoever was utilized in the building of Unit No. 7 of Hull No. 1. Figure No. 3-2 is a profile that was developed from that unit, shown to a scale of 1/8"-1' athwartship and full scale vertically, ~~fds~~. A crown in excess of 5/8" developed on this unit. Other similar, but larger, units developed crowns up to 7/8".

Various attempts were made to minimize this deformation, including the building in of a reverse crown, but most of these efforts tended to be ineffective. (See Fig. 3-3.) Ultimately, a detailed construction sequence was developed and implemented. (See Fig. 3-4.)

This procedure isolated and controlled the three basic problem areas: butt welding of all shell plates, welding of all floors to girders, and welding of all loose shell longitudinal. The procedure in no way minimized the heat introduction, but only permitted it to shrink the components in such a manner as to minimize the potential for deformation. The resulting unit on Hull No. 3 was virtually flat. (See Fig. 3-5.)

The deformation of such units as innerbottom, Unit No. 7, resulted primarily from the introduction of heat, in the form of welding, at the shell plate side of the unit while the tank top of the unit was totally restrained by prior fitting and welding. This resulted in horizontal movement

in excess of $\frac{5}{16}$ of an inch on the shell plate side of the unit. Since the tank top side of the unit was restrained and not permitted to move, the crowning of the unit was the unavoidable result. This result is both predictable and calculatable as is shown on accompanying calculations which will be elaborated on in detail in later discussions.

The entire construction sequence was developed to permit a uniform movement of the components of the unit, thereby precluding the possibility of deformation.

C. CONTROL LINES, CONTROL POINTS AND BACKSIDE MARKING

Early in the production phase of the APL contract, it became evident that accurately located control lines on a unit would be advantageous in both the building and erection of the units. Figure No. 3-6 shows the layout of control lines on a typical tank top unit. The buttock is used for setting the unit athwartship and the frame line is used for setting the unit longitudinally. For this procedure to be practical, these lines must be located with unvarying accuracy. To enhance the potential for a high degree of accuracy, future contracts will incorporate these lines into the engineering drawings and panel line sketches that are used for building flats, decks, bulkheads, etc.

D. CONSTRUCTION AIDS

Many tools may be developed to assist the Shipfitting Department in completing accurately built units, but perhaps the one of the greatest practical value is the erection joint tape batten. These battens indicate proper position of all structural at erection joints. When utilized properly and in conjunction with other procedures, it is possible to locate such structural within a tolerance of one quarter inch or less. This procedure has proven itself so effective on the APL contract that on future contracts, battens will be developed at all erection joints. Fig. No. 3-7 shows a backside marker. This piece of equipment permits the accurate transfer of centerpunch marks from the layout side of plating to the opposite side. Such accuracy is required if these lines are to be used in the erection of the ship.

IV. DISTORTIONS OF UNITS

For the simplicity of discussion, we analyzed the unit in the form of a simple beam (see Fig. 4-1 and 4-2). Using a standard W36 x 194 beam, we derived the following comparison: the distortion from welding can be compared to simple beam action when the beam is loaded with a uniformly distributed load.

From the AISC Handbook on simple beams with uniformly distributed loads:

$$\Delta_{\max} = \frac{5wl^4}{384EI}$$

Where: $\Delta_{\max}$ = maximum deflection in the vertical direction

W = load in kips/inch

l = length of the beam in inches

E = modulus of elasticity (30×10^6 PSI)

I = moment of inertia in inches to the fourth.

If $w = .5$ k/in and $l = 480''$ and $I = 12,100$ in⁴ for a standard W36 x 194 shape, then:

$$\Delta_{\max} = \frac{5(.5\text{k/in})(1000 \text{ lb/k})(480 \text{ in})^4}{(384)(30 \times 10^6 \text{ lb/in}^2)(12,100 \text{ in}^4)}$$

$$\Delta_{\max} = 0.9521 \text{ in} = 15/16''$$

We can easily measure the horizontal deflection, but the vertical deflection is more difficult to determine and is very important. To determine the vertical deflection that would occur as a result of the horizontal deflection, we need to derive some more formulas.

Horizontal deflection " Δ_H " caused by a force "P" can be described by the following formula:

$$\text{EQ. I} \quad \Delta_H = \frac{Pl}{AE}$$

Where: Δ_H = horizontal movement of the shell

P = the force in the shell

A = cross sectional area of the plate

l = length (varies with the size and amount of tack welds)

E = modulus of elasticity.

Since stress " σ " = P/A

then EQ.I becomes

$$\text{EQII} \quad \Delta_H = \sigma \frac{l}{E}$$

$$\text{but} \quad \sigma = \frac{Mc}{I}$$

Where: M = moment

C = distance to the neutral axis

$$\text{So: EQIII} \quad \Delta_H = \frac{Mcl}{EI} \quad \text{by substitution}$$

$$\text{Since} \quad M = \frac{wl^2}{8}$$

$$\text{EQIV} \quad \Delta_H = \frac{wl^3c}{8EI} \quad \text{also by substitution}$$

To obtain the vertical deflection " Δ_v " in terms of the horizontal deflection " Δ_H ," multiply both sides of the following equation:

$$\Delta_v = \Delta_{\max} = \frac{5wl^4}{384EI} \Delta_H$$

By equation IV

$$(\Delta_v) \frac{wl^3c}{8EI} = \frac{5wl^4}{384EI} (\Delta_H)$$

$$\underline{\underline{v = \Delta_H \frac{(0.104)l}{c}}}$$

To prove this equation we substituted the values we used in the max equation into our equation IV.

$$\Delta_H = \frac{wl^3c}{8EI}$$

When: $w = .5k/in$

$c = 17.61 \text{ in}$ (steel handbook)

$l = 480''$

$E = 30 \times 10^6 \text{ PSI}$

$I = 12,100 \text{ in}^4$

$$\Delta_H = \frac{(.5k/in)(1000 \text{ lb/k})(480 \text{ in})^3(17.61 \text{ in})}{8(30 \times 10^6 \text{ lb/in}^2)(12,100 \text{ in}^4)}$$

$$\Delta_H = 0.3353 \text{ inches}$$

$$\Delta_v = \Delta_H \frac{(0.104)l}{c}$$

$$\Delta_v = (0.3353 \text{ in}) \frac{0.104(480 \text{ in})}{(17.61 \text{ in})}$$

$$\underline{\underline{\Delta_v = 0.9505 \text{ in} = 15/16''}}$$

This compares with our earlier results of 15/16" in the equation for Δ_{max} .

V. ORGANIZATION OF AN ACCURACY CONTROL DEPARTMENT

A. GENERAL

The most often asked questions concerning accuracy control are "How do you go about setting up an Accuracy Control Department?" and "What problems should receive the greatest initial emphasis?" Obviously, there is no positive answer to either of these questions since there are so many contingency factors involved. However, there are doubtlessly enough common problems prevalent in most U.S. shipyards to warrant an attempt at answering these questions.

B. THE SETTING UP OF AN ACCURACY CONTROL DEPARTMENT

1. Organizational Arrangement

The departmental organization of an Accuracy Control Department is no doubt subject to as many potential variations as are present in the organization of the shipyards themselves. It is probable that some advantages and some disadvantages will become evident regardless of what type of organization is instituted, but it is equally probable that a well-defined and well-instituted department will tend to minimize the disadvantages. Two basic approaches seem to be worth the greatest consideration:

Department consisting of all full-time Accuracy Control engineers.

Department consisting of a coordinating supervisor with representatives of the various departments accepting the accuracy control responsibility for their respective departments. While there may be many other approaches to organizational set-up, it is quite likely that they would be only variations of the ones listed above.

a. Department Consisting Of Full-Time Accuracy Control Engineers.

This type of organizational set-up has many advantages, particularly in the early stages of implementing an accuracy control program. The initial responsibilities of the department consist primarily of the definition of problems at hand and the development of procedures to help in the elimination or minimizing of those problems. Although it might not be immediately realized, it is a rare problem that has a single,

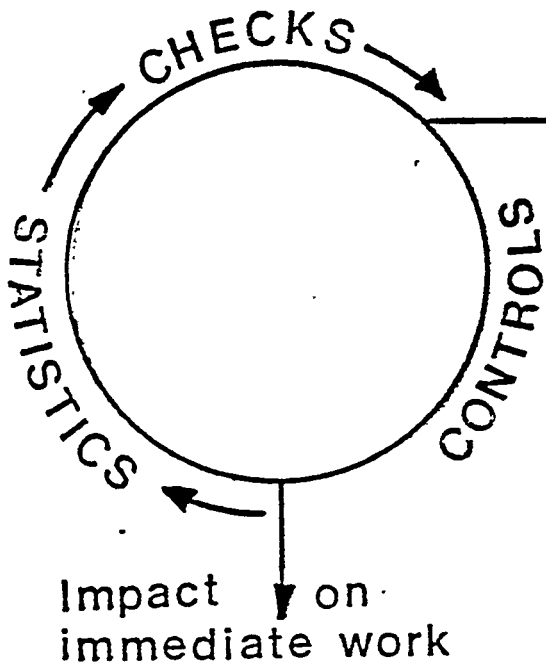
simple solution that can be applied within that one area of work. Most such problems are merely the result of a specific human error and are not of primary importance to accuracy control. It is the interdepartmental problems or "system problems" that Accuracy Control is primarily interested in. An example of such a problem is the lack of well-defined uniform shrinkage factors. Without the development and utilization of such factors, it will be impossible to predict the accuracy of fits between components produced in different areas of the shipyard. This problem can best be solved by the concerted effort of several individuals, analyzing the problem at all levels, arriving at proper conclusions and then disseminating that information to all involved departments such as Moldloft, Numerical Control, Burning Shop, and Fab Shops or Platens. Since a problem of this nature involves so many departments and since the solution of many other related accuracy problems is contingent upon the timely solution of this specific one, it then may be deemed necessary to have the entire department concentrate on this one area of work until a viable solution is achieved. It would probably be more difficult to achieve the required concerted effort with other than full-time Accuracy Control engineers. Many of the problems with which the department will be confronted will demand this type of concerted effort to permit achievement of proper solutions without significant delay.

b. Department Consisting Of Coordinator And Part-Time Accuracy Control Engineers From Various Departments

The primary advantage of this form of organization stems from the familiarity that each of the part-time Accuracy Control engineers has with his own department. This degree of familiarity can result in both incisive conclusions and realistic solutions.

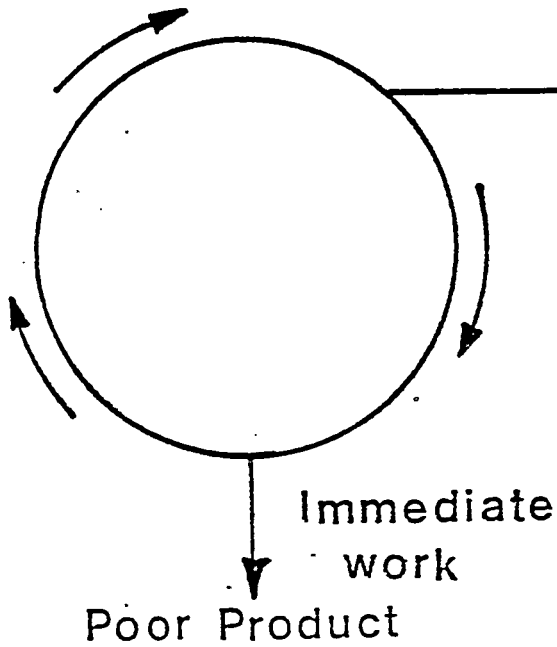
Perhaps the most realistic resolution is the initial development of a department consisting of a full-time supervisor with a group of full-time Accuracy Control engineers, the size of which would be determined by the size of the yard and the scope of the operation. As procedures are gradually and properly implemented, it would then be probable that most solutions would not require the concerted effort of the whole department but could be achieved through the coordinated efforts of two or three full-time Accuracy Control engineers working with part-time Accuracy Control engineers representing all departments.

W. Wiedner



Impact on future work

Fig. 1-1



Future work
Poor Product

Fig. 1-2

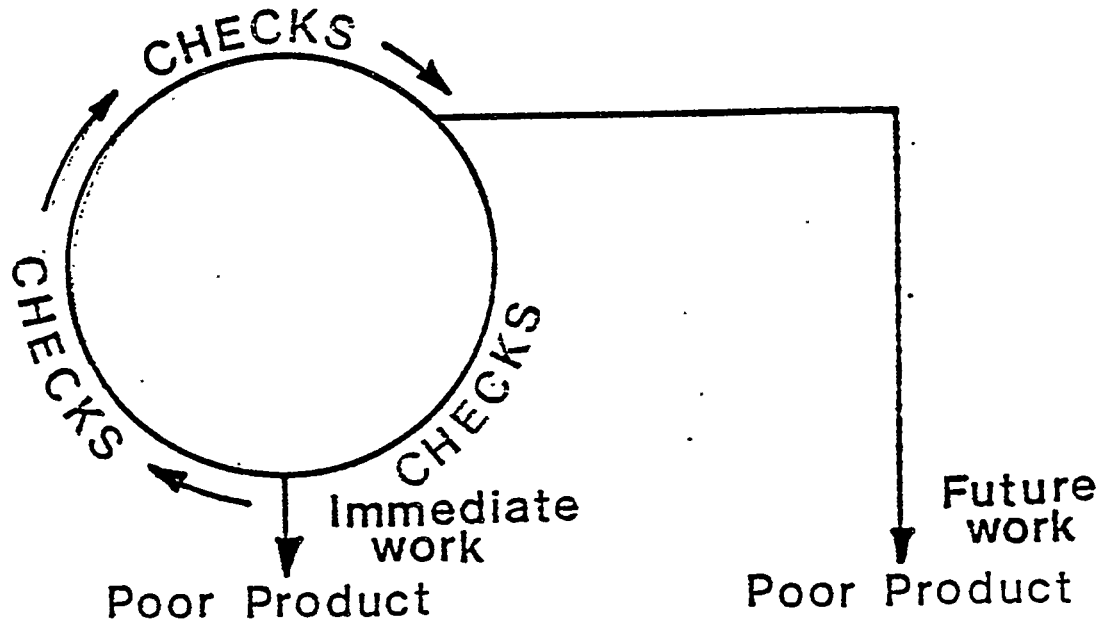


Fig. 1-3

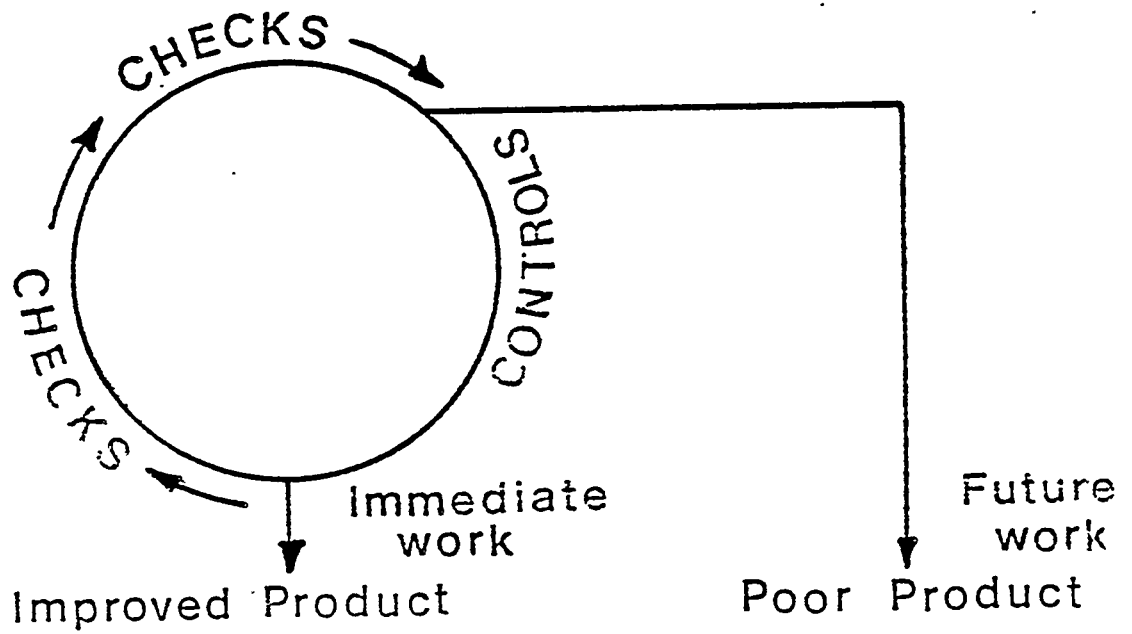


Fig. 1-4

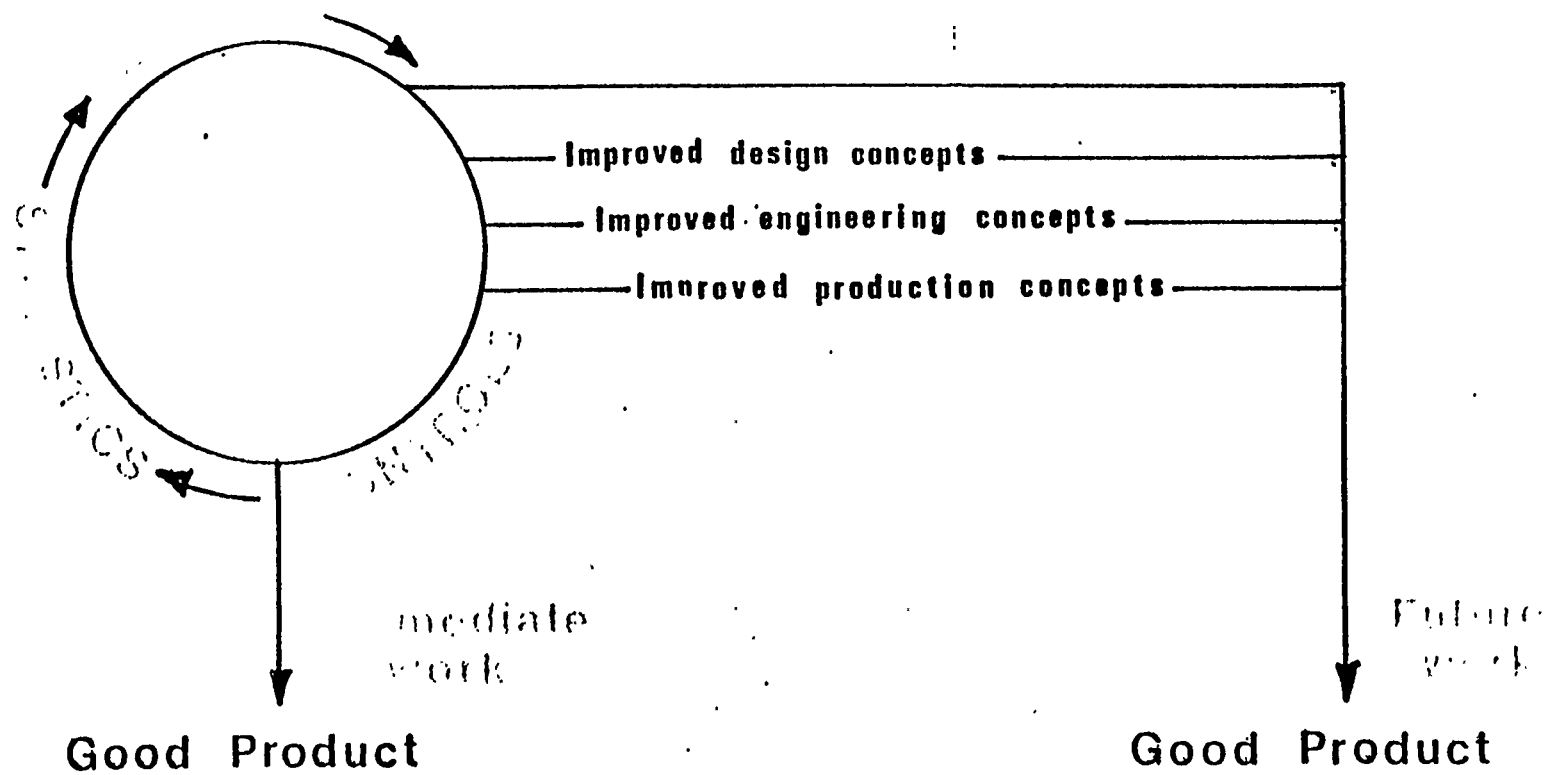


Fig.1-5

2.0 Outline of Accuracy Control Activities

2.1 Controls

- A. Control Lines, Control Points and Backside Marking**
- B. Burning Procedures**
- C. Endform Shrinkage Factors**
- D. Construction Procedures**
- E. Erection Procedures**
- F. Construction Aids**

2.2 Checks

- A. Measuring Procedures**
- B. Mathematical Checking Systems**
- C. Forms for Reporting**
- D. Establishment of Unit Profiles**

2.3 Unit Histories

- A. Engineering**
- B. Mold Loft and Numerical Control**
- C. Plate Shop**
 - 1. Burning**
 - 2. Panel Line**
- D. Structurals**
- E. Shipfitting**
- F. Welding**
- G. Handling**
- H. Miscellaneous**

Fig 2-1

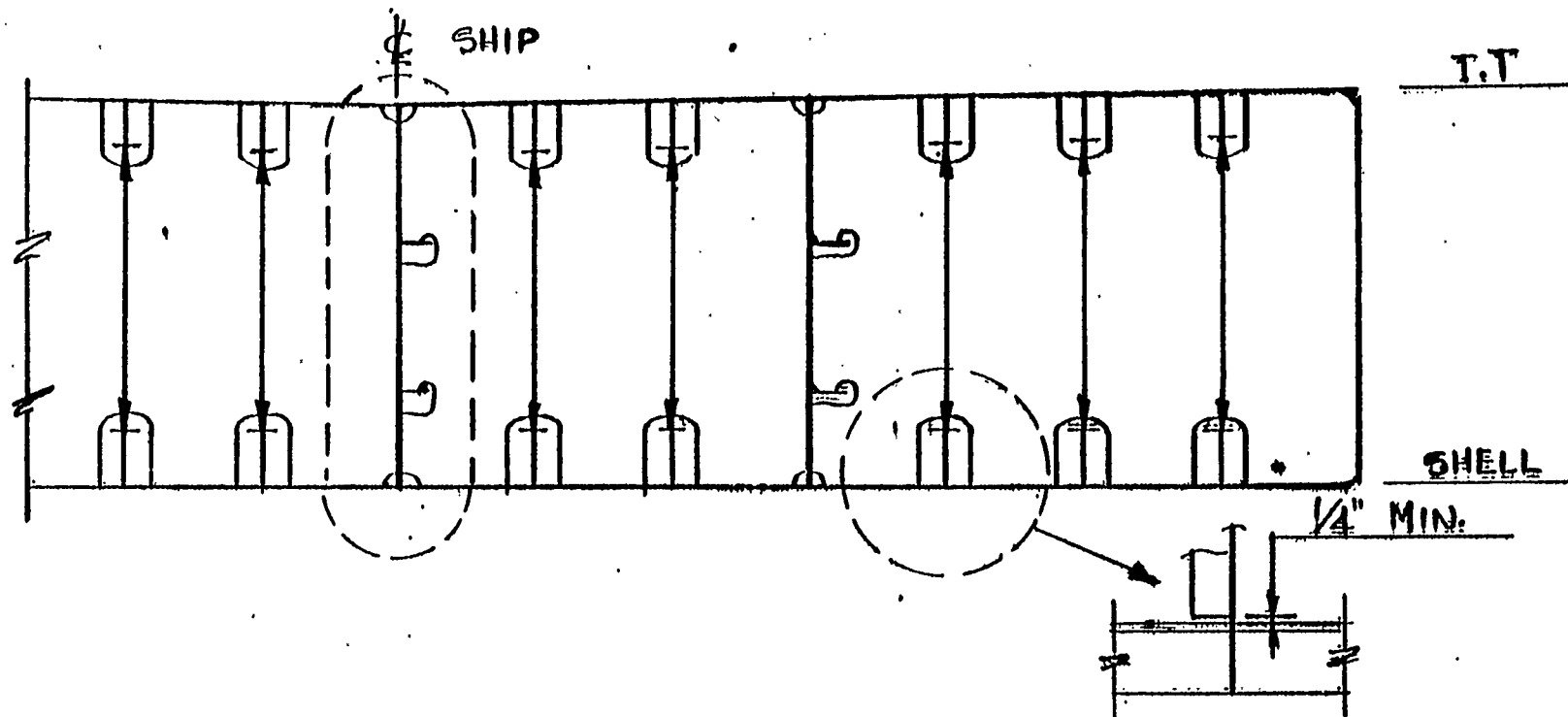


FIG. 2-3

Unit # _____
 Web Fr. _____

Design dim. 44'-0"

Before butt welding _____

After butt welding _____

After stiff. welding _____

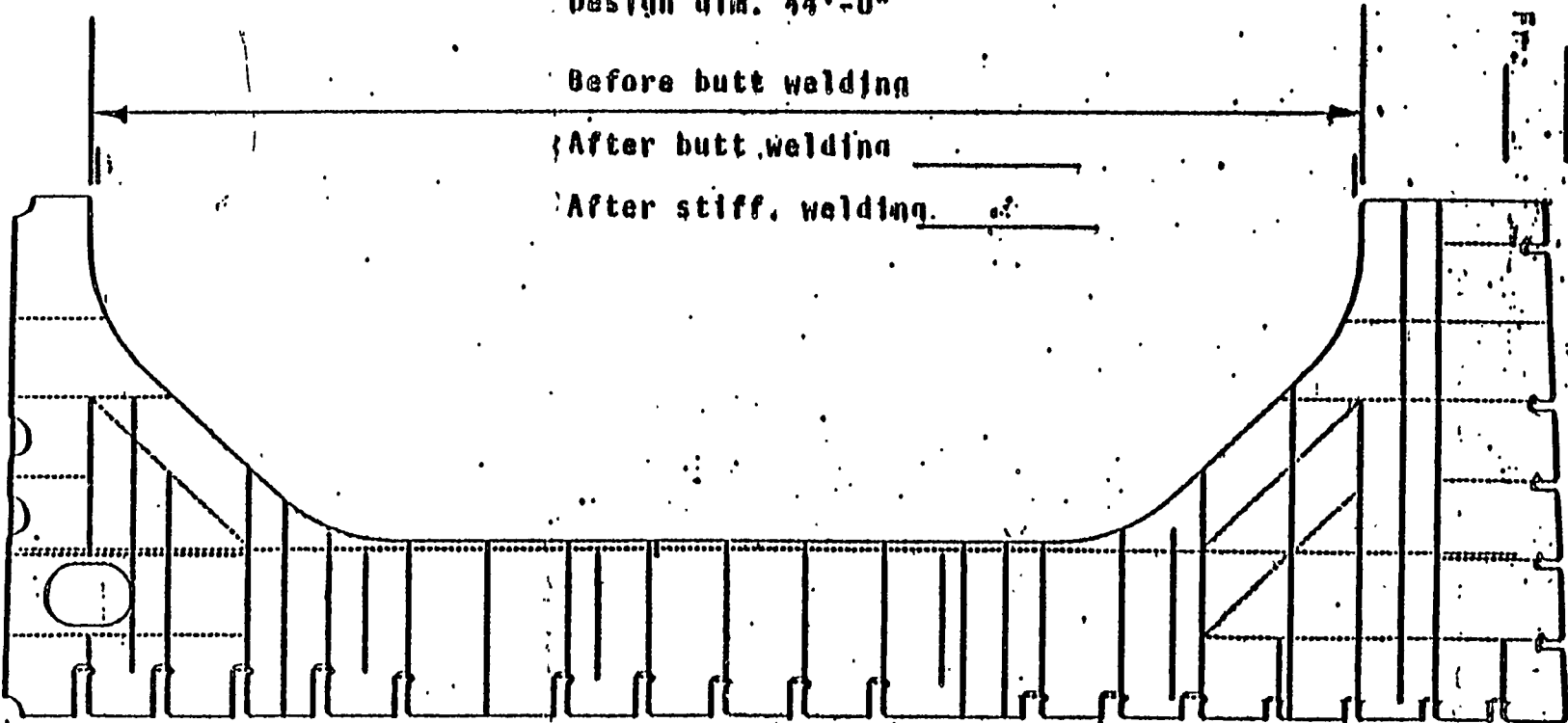


FIG. 2-4

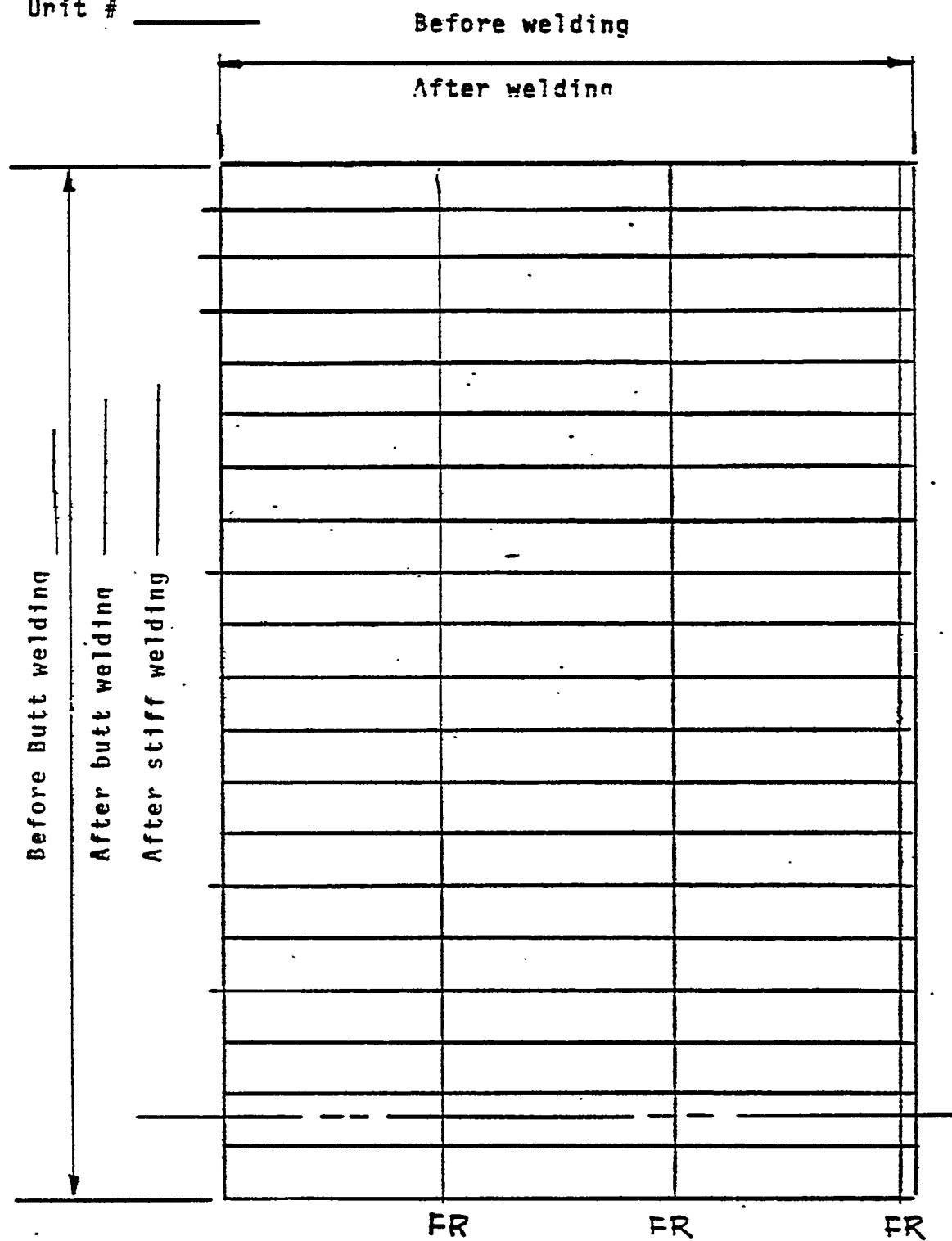
Design dim. 54'-3 3/4"

Before butt welding _____

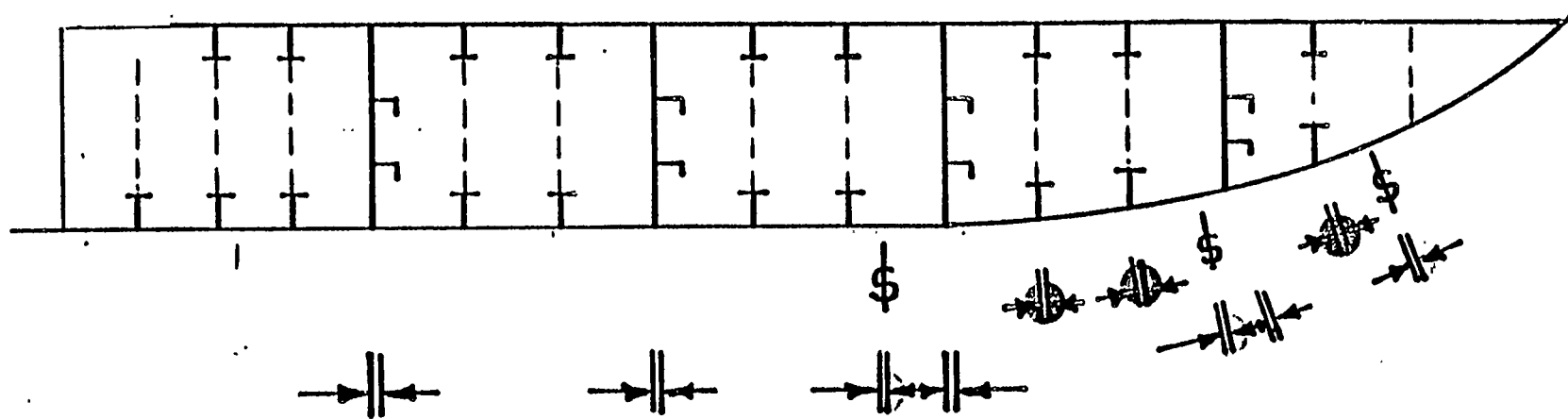
After butt welding _____

After stiff. welding _____

Long. Bhd.
Unit # _____



— FIG 2-5 —



- Butt welds
- Vertical fillet welds
- Welds at longitudinals

Fig. 3-1

Gdr.	Gdr.	Gdr.	Gdr.	End
------	------	------	------	-----

Fig. 3-2
Hull 1

Gdr.	Gdr.	Gdr.	Gdr.	End
------	------	------	------	-----

Fig. 3-3
Hull 2

Gdr.	Gdr.	Gdr.	Gdr.	End
------	------	------	------	-----

Fig. 3-4
Hull 3

Main Assembly Construction Sequence

1. Lay down tank top panels on platen.
2. Hang girders to which floors have been previously fitted and welded.
3. Fit girders to tank top. (2'-0" fwd. and aft. of each frame should left free of tacks)
4. Level unit. (Tack to platen w/clips)
5. Fit floors to girders. (Do not fit floors to tank top)
6. Weld all floors to girders, backstepping four times.
7. Fit floors to tank top.
8. Flat weld all girders and floors to tank top.
9. Fit all stiffeners, collars, brackets, clips, etc. at tank top.
10. Weld stiffeners, collars, etc., at tank top.
Note: No piping to be installed prior to this stage of construction.
11. Hang and fit all loose shell longitudinals.
12. Weld clips or collars at shell longitudinals.
13. Hang and fit shell plate nearest to centerline of ship. (If this is a blanket, fit entire blanket, tacking to floors, girders and longitudinals)
14. Hang adjacent shell plate.
15. Weld shell plate butt.
16. Repeat procedure prescribed in item #14 for each of remaining shell plates up to extreme outboard plate.
17. Hang extreme outboard shell plate. If shell longitudinals fall under this plate, fit as previously described. Otherwise fit shell plate to floors, utilizing welding clips. (Do not fit to floors) Do not fit to tank top at this time!
18. Weld last shell plate butt.
19. Fit shell plate to tank top.
20. Flat weld shell plate to tank top.
21. Turn unit right side up and finish fitting at shell.
22. Flat weld floors, girders and longitudinals and backgouge and weld butts.
23. Check ends of all girders and longitudinals for proper alignment with adjacent units. Fair if necessary.

Fig 3-5

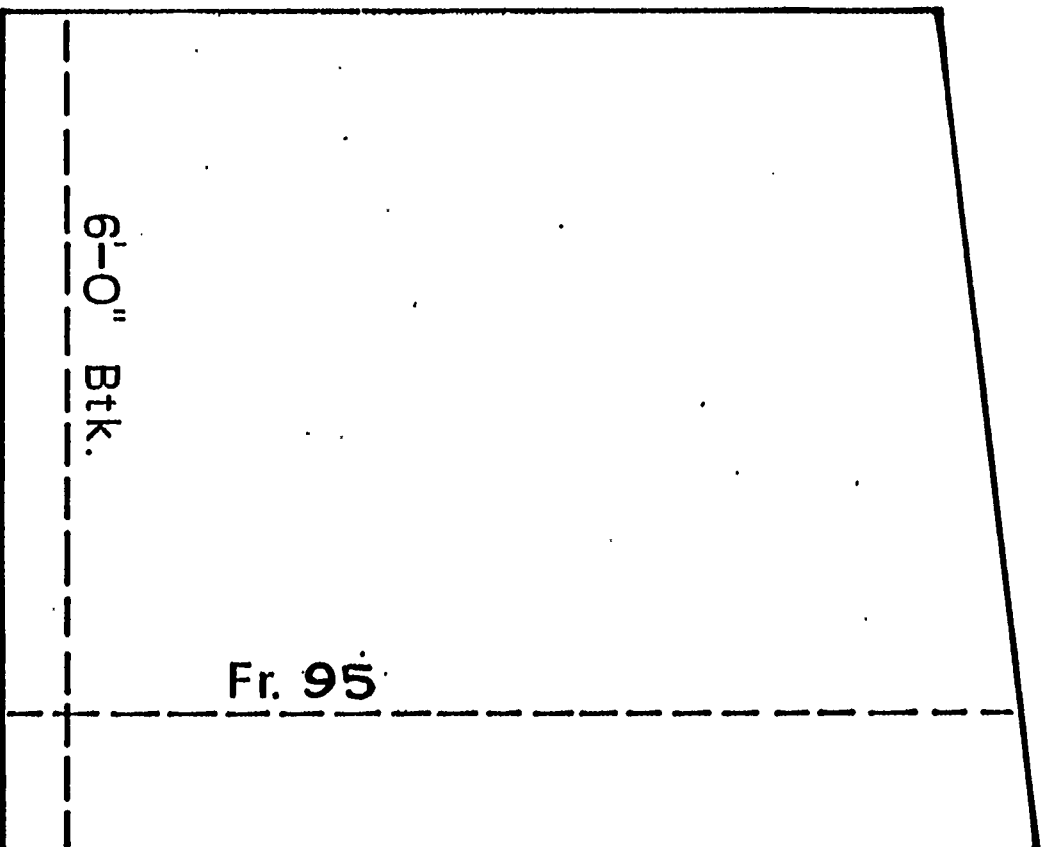


Fig. 3-6
Control lines on typical innerbottom
unit

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

INTEGRATING PRODUCTION PLANNING

Prepared by: C. J. STARKENBURG

Charlie

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
INTEGRATING PRODUCTION PLANNING

I. MOLDLOFT

Production Planning's integration with Moldloft, Material Control, and Accuracy Control very often becomes the leading edge of the effort because of the necessity of establishing, first, the plan and then the schedule.

The plan is based on the most efficient and economical method of building the ship using the IHI taught techniques.

The schedule is based on the resources and facilities available within the corporation and using the parameters generated by the use of the IHI methods. NO. I

Integration with the Moldloft effort is a constant interchange by first producing the planned construction sequences that are illustrated by the preliminary unit arrangement plan and then augmented by the unit scheduling mechanism and network. NO. II

Continued communication exists between the Production planner and the Moldloft personnel for problem definition and resolution.

The Moldloft establishes for planning, for example, those plates that must be furnaced and those that can be line heated or rolled. A plate being line heated is shown here in these illustrations. NOS. III & IV

II. MATERIAL

The interface of Production Planning and Material Control is a highly integrated process.

The Planning Department first established the pallet schedule with pallet number assignments. These are akin to empty buckets with production stage codes and dates being designated for each pallet or work kit and for each stage. NO. V

These empty buckets, with dates, are given to the Engineering Department who then develops a material list for filling them with the proper material for the proper production stages.

These buckets are filled by the Material Control Section and then delivered accordingly to the proper job stage on dates designated by the planning schedule.

All dates are originally designated in a broad scope definition by using a pre-contract document we call "Advance Purchasing Zones." Shown here (NO. VI), for example, is an illustration of what the advance purchasing zones look like for the DDG-51 Class program. Material dates are further refined for composites and working drawings as the engineering progresses by referring to the pallet schedule.

These determinations are shown in their relationships to one another by the illustration shown here. NO. VII

Material purchasing, material planning and scheduling, material control, and material availability are probably the least understood processes in the entire order of integrating the technology. Without tight controls and an exceptional performance in these material areas, many of the benefits of the system are unable to be realized.

III. ACCURACY CONTROL

The integration of Production Planning and Accuracy Control is vital to the development of the entire production process.

The planning effort constantly tries to impose the most productive schedule that can be followed by the production work force.

This means using established parameters of performance.

However, these established parameters are and should always be history, ever changing towards improving the productivity of the engineering and production cycles.

Accuracy Control interfaces with the Planning Department in that it, in itself, creates needs to establish different methods and consequently different planning changes to accomplish these methods.

As an example, we used to leave a great deal of stock on the perimeter edges of our hull modules.

When doing this we had to, out of necessity, plan time and man-hours to allow for the burning and fitting needed to remove this extra stock at the erection site while fitting the module into the ship's structure.

Due to our Accuracy Control program, we are now cutting modules neat according to well defined accuracy control procedures, prior to fitting into the ship's structure.

This causes us to be able to change our plan and reduce some of the time in the erection process. This, of course, affects schedules by decreasing the fitting time needed by erection fitters.

An example is shown in this illustration of burning ratios as it pertains to module erection. NO. VIII

Consequently, the relationship between Accuracy Control and Production Planning is one of constantly planning, executing, and evaluating. This relationship produces a constant tightening-up in most all work processes.

We have also found that a special group of Accuracy Control planners are essential in this area and that statistical information is most important in conducting the business of accuracy control on a continuing basis.

Of utmost importance, to complement these Production and Engineering methods, is the establishment of the quality work circles as shown here in this illustration.

A few examples of the benefits derived at Avondale as a result of this interchange and integration of IHI technology is shown in these illustrations:

1. using Moldloft tapes instead of Lufkin rulers;
2. outside use of the Moldloft tape;
3. using sumitsibo;
4. close up of tape;
5. plates for line heating;
6. setting up templates;
7. setting the line for sight edges;
8. a pallet or bucket full of pipe;
9. some pallets being installed;
10. pre-outfitted bulkheads;
11. main diesel engine foundations pre machined;

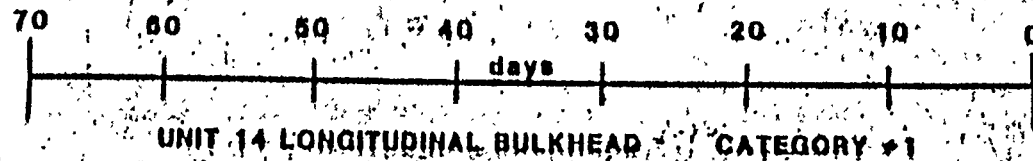
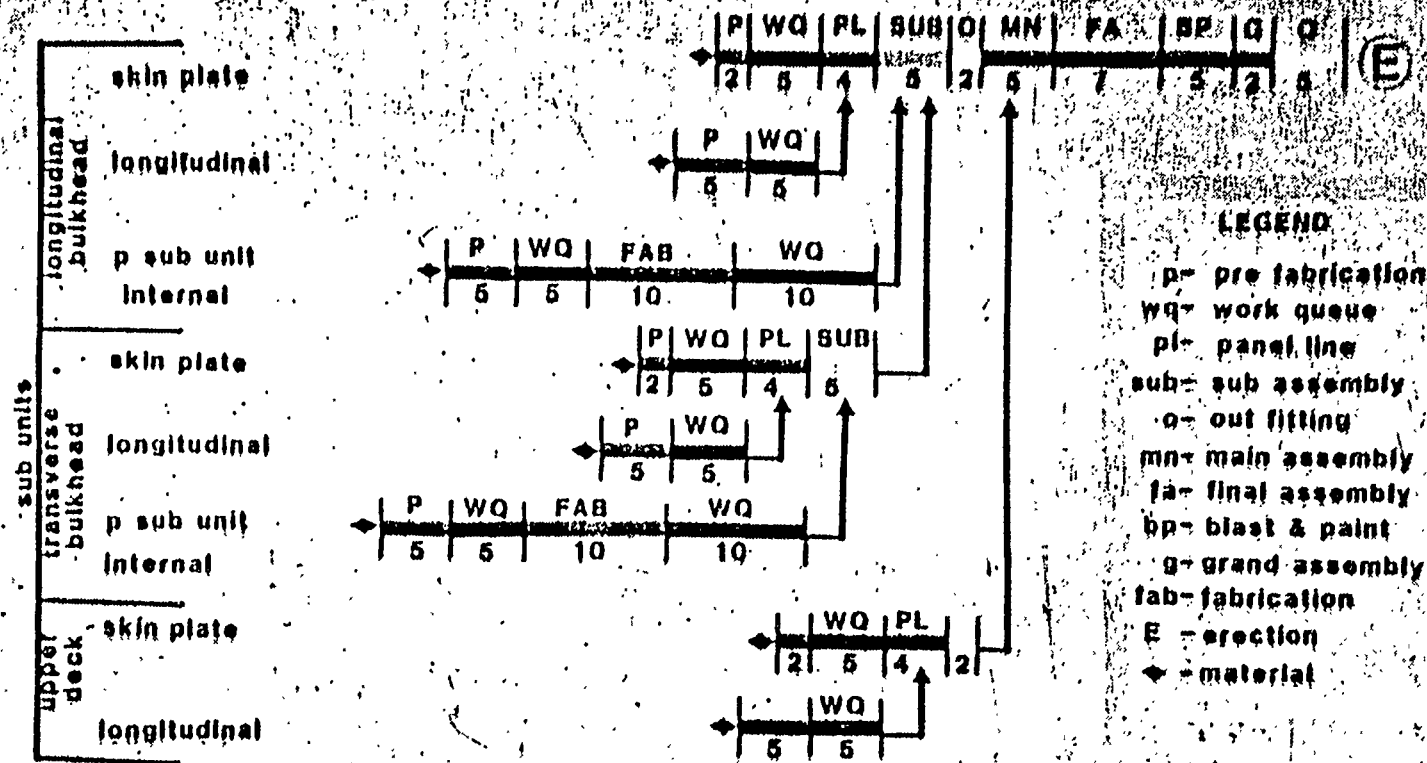
12. a pre-outfitted and accuracy control trimmed unit ready for erection;
13. model of the tanker deck piping for pre-outfitting;
14. the real thing in the production process;
15. another view.

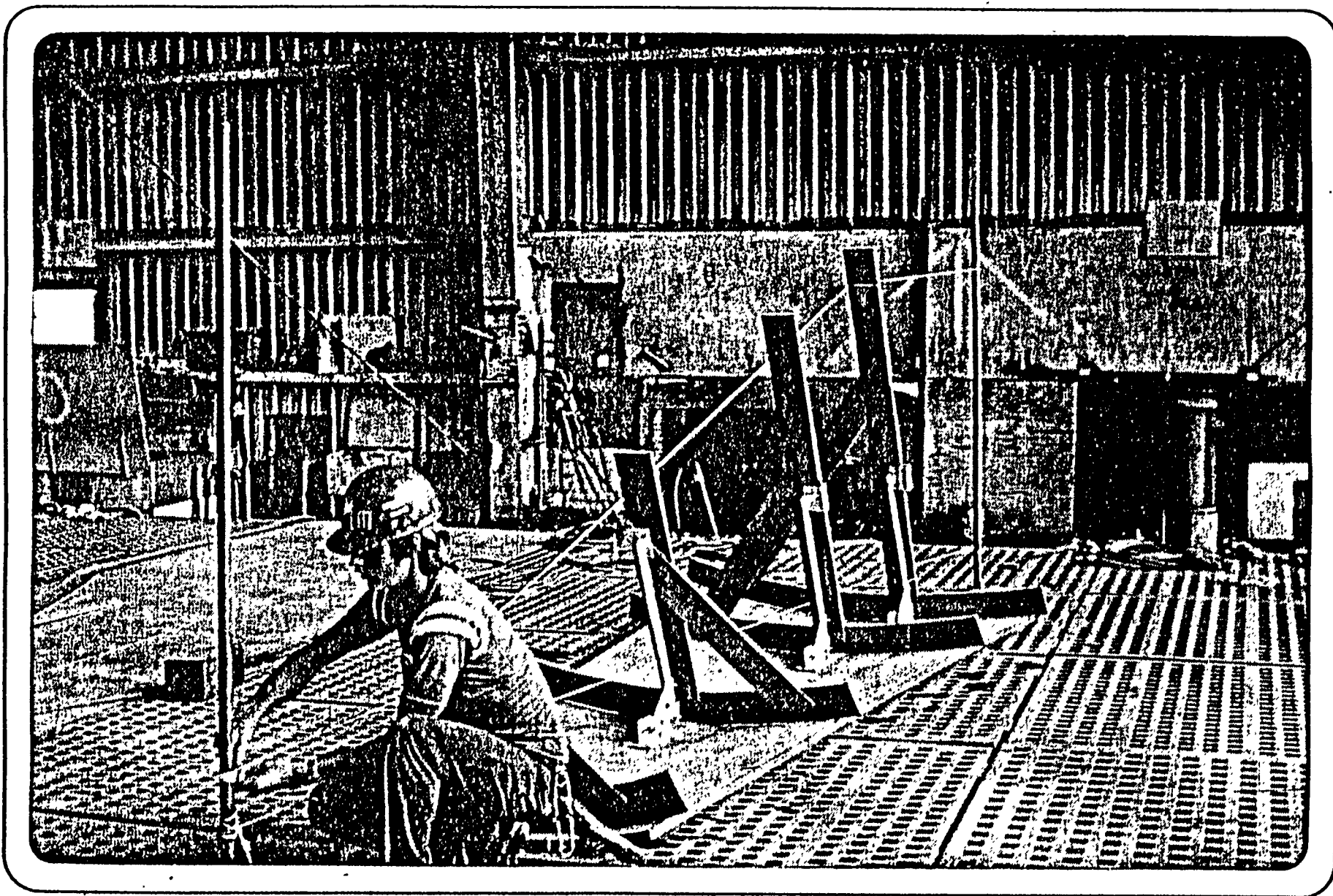
There are many things important to successful production. Most of all, it is a people relationship and everyone attempting to implement not only IHI technology but any technology must recognize the human equation if they are to be successful.

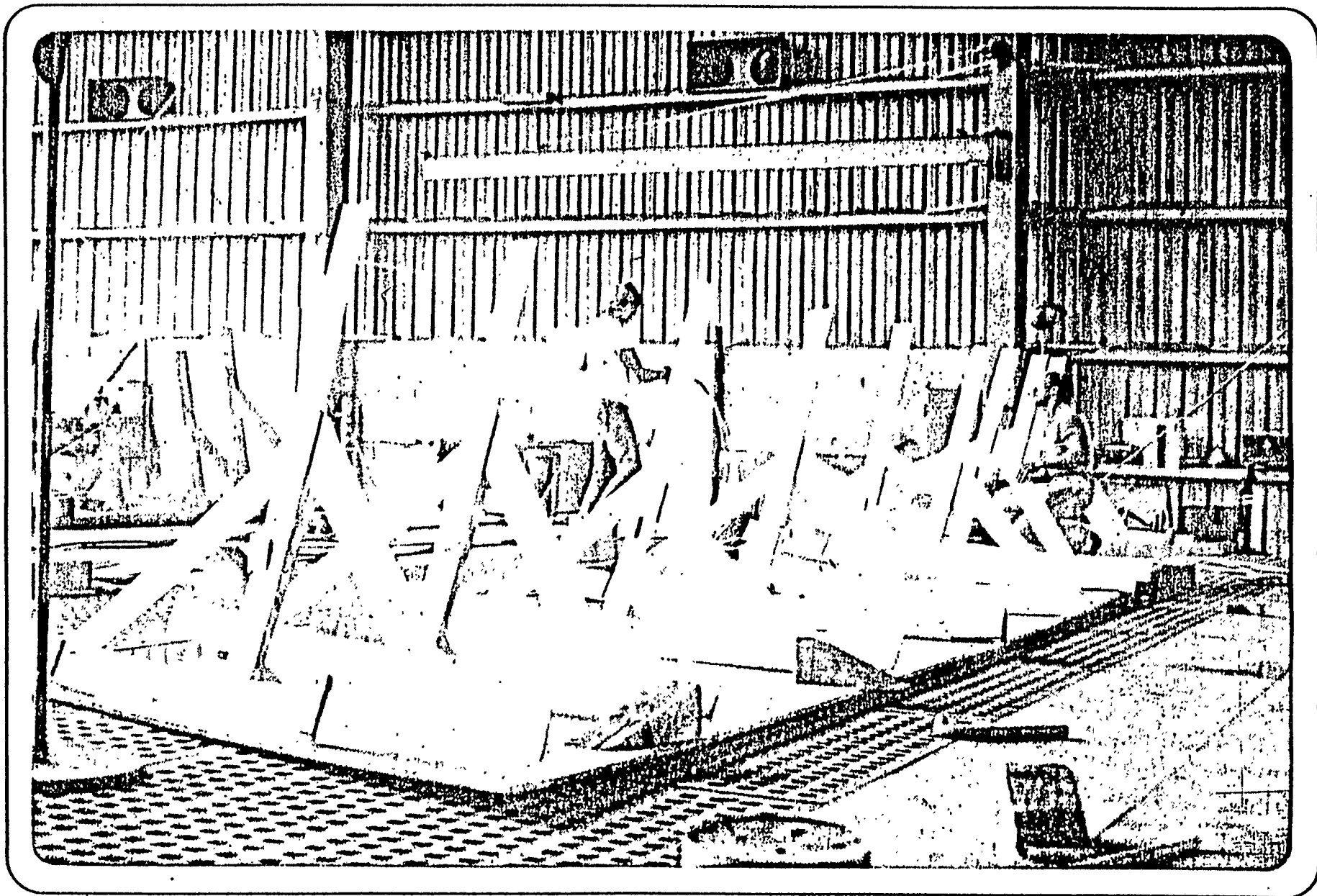
20	22	24	26	28	32	36			
					30	33	38	40	
19	21	23	25	27	29	34	37	39	
					31	35			
93	97	101	105	109	113	117	121	125	129

PRELIMINARY UNIT ARRANGEMENT PLAN

SCHEDULING MECHANISM NETWORK

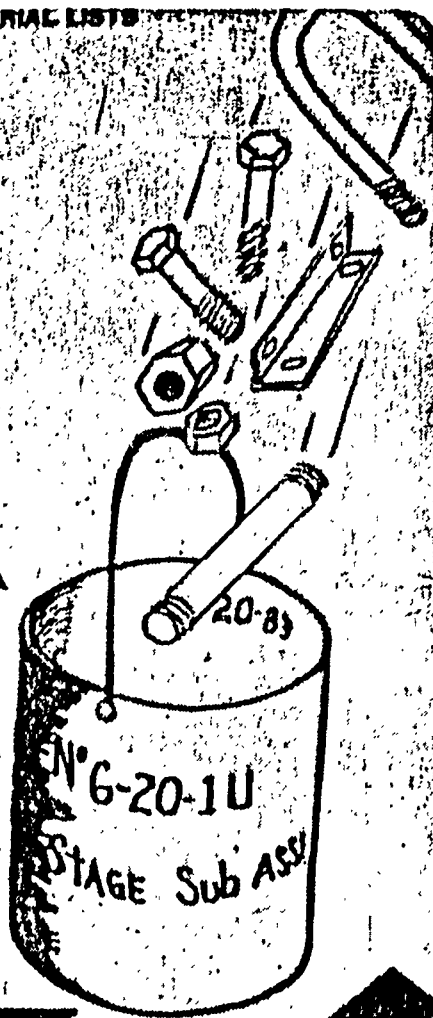
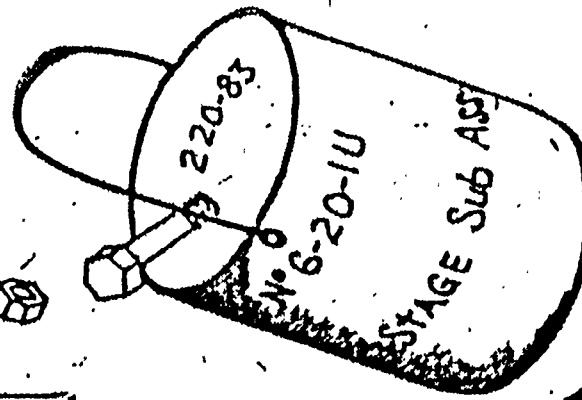
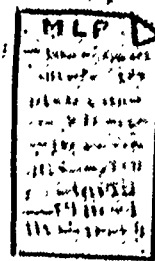
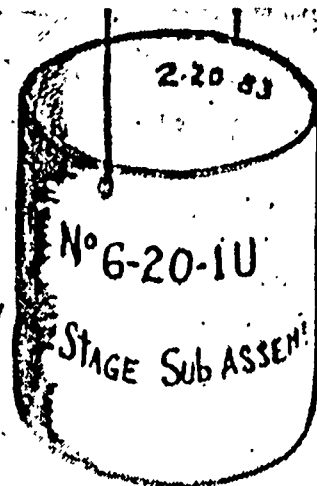
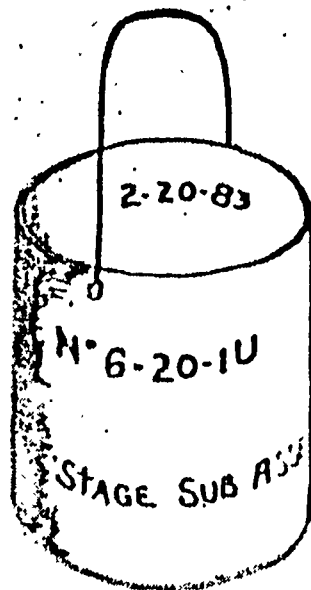






PLANNING DEPT. SUPPLIES
DATES & STAGE CODES

UNIT & ZONE MATERIAL LISTS



BUCKET THEORY
OF DILLETIZING

DELIVERS TO PROPER
PRODUCTION STAGE
AT THE PROPER TIME

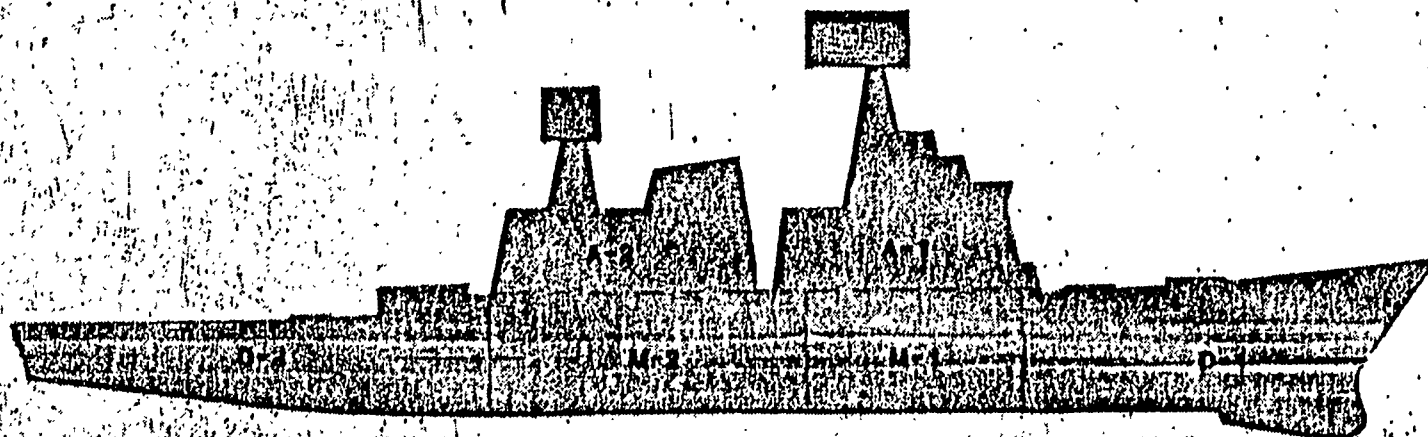
MATERIAL CONTROL
FILLS THE BUCKET AND

LEGEND

ZONE H - MACHINERY SPACES
 ZONE A - ACCOMMODATIONS
 ZONE D - DECK & HOLDS

LENGTH - 408
 BREADTH - 82
 DEPTH - 42

ADVANCED PURCHASING ZONES					
STANDARD TIME			DATE		
ZONE	YEAR	MONTH	DAY	YEAR	MONTH
H					
A					
D					
H					
A					
D					
H					
A					
D					



ESTABLISHED DDG-51 ZONES FOR PURCHASING

CONTRACT

KEEL

LAUNCH

DELIVERY

(MLS)
ADVANCED ORDERED MTL. LIST

(MLF)
PALLET ORDERED MATERIAL LIST

SYSTEM DIAGRAMS

COMPOSITE DRAWINGS

WORKING DRAWINGS

REQUIRED DATE FROM PURCHASING ZONE SCHEDULE

REQUIRED DATES FROM PALLET LIST SCHEDULE

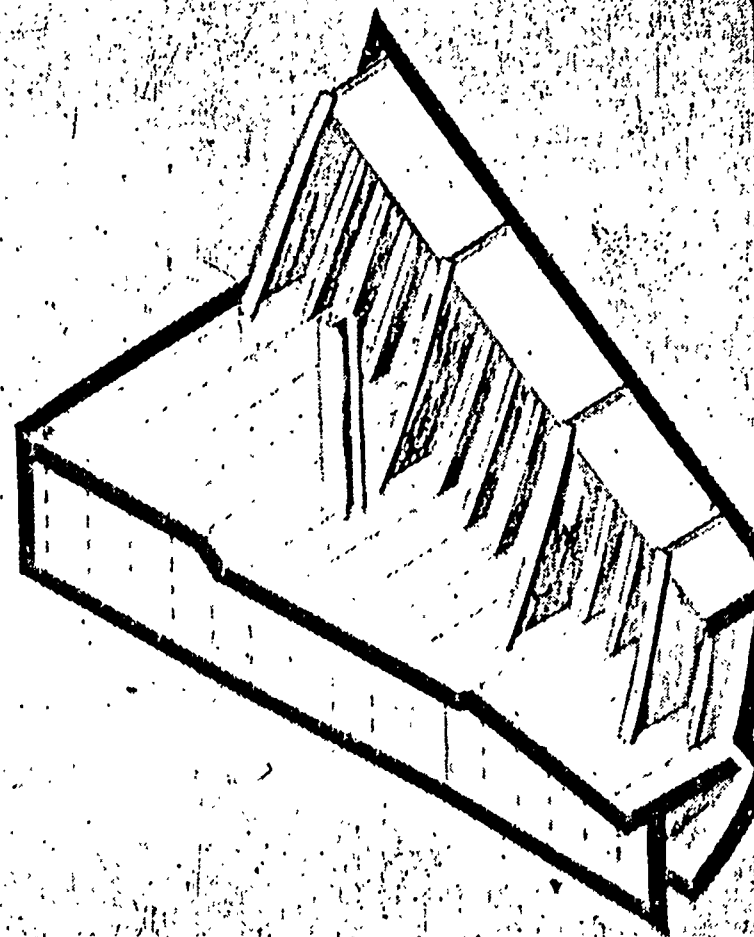
RELATIONSHIP BETWEEN MATERIAL LISTS
AND REQUIRED DATES

	1980	1981	1982	1983
WJ BURNING RATIO	15%	15%	15%	15%
ASI BURNING RATIO	90%	80%	50%	35%

TOTAL SEAM & BUTT LENGTH BURNED
BY BURNERS IN THE ERECTION STAGE

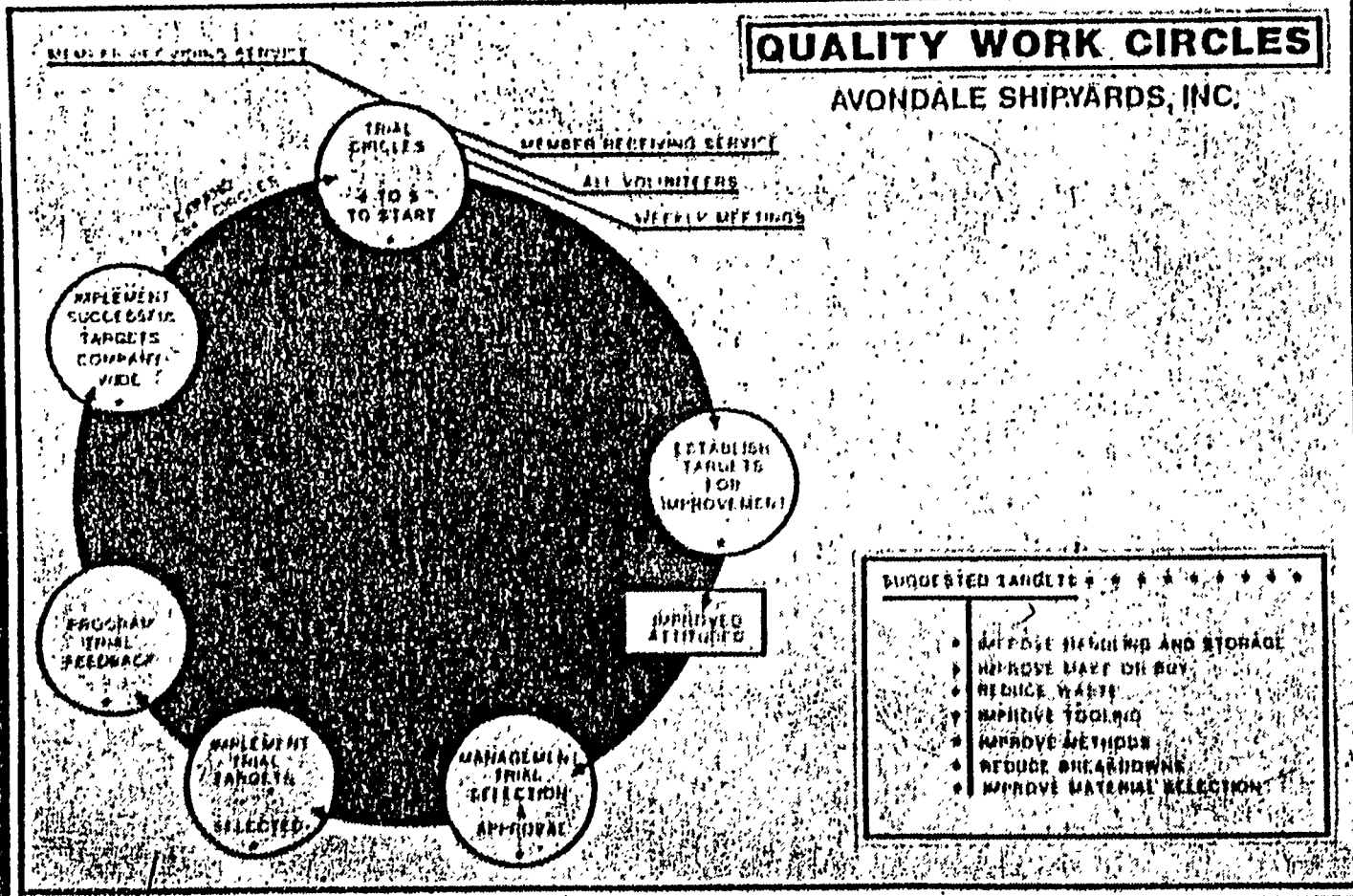
BURNING RATIO =

TOTAL SEAM & BUTT LENGTH OF SHELL &
PLATE EDGES FITTED ON THE MODULE

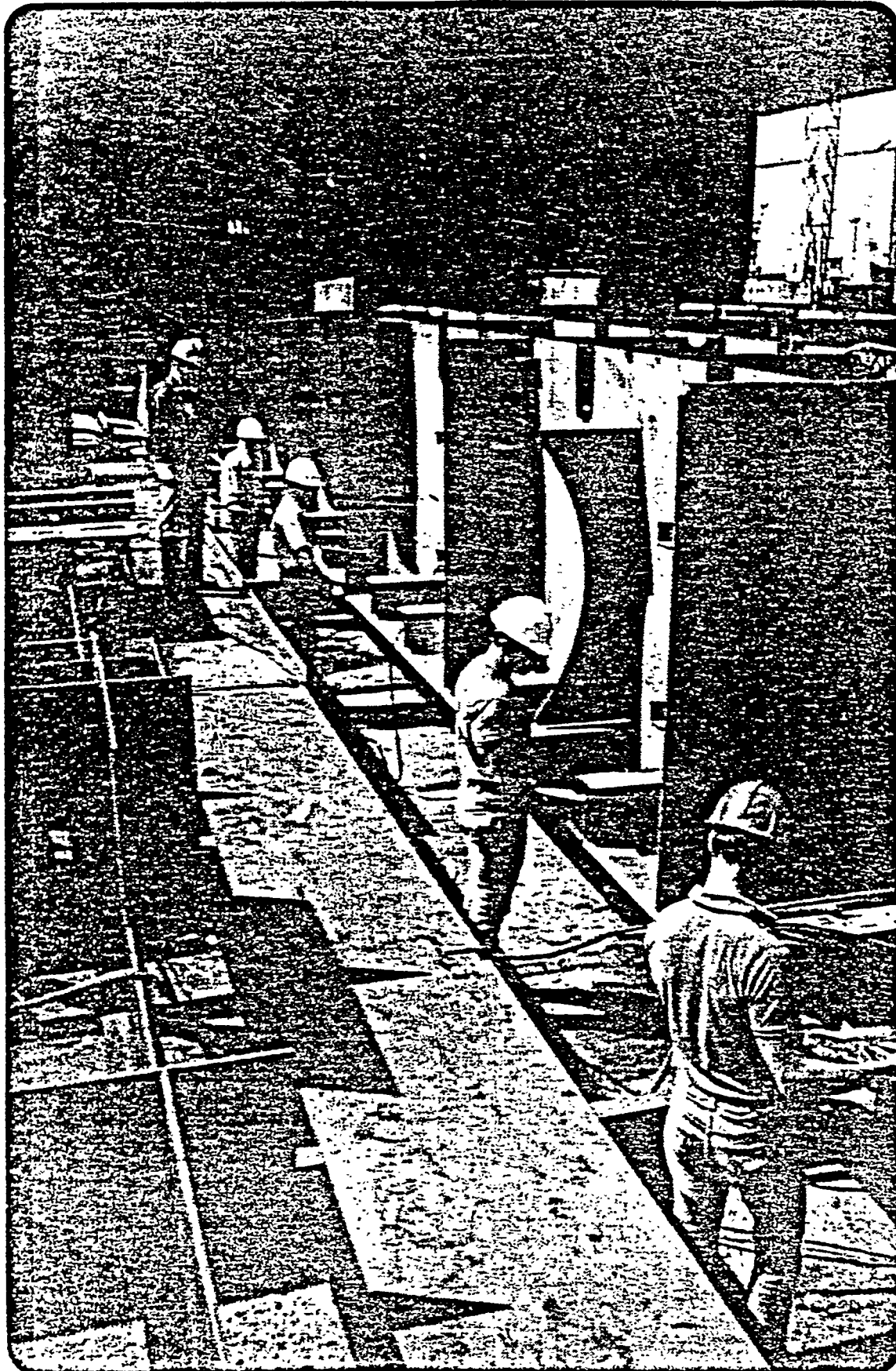


QUALITY WORK CIRCLES

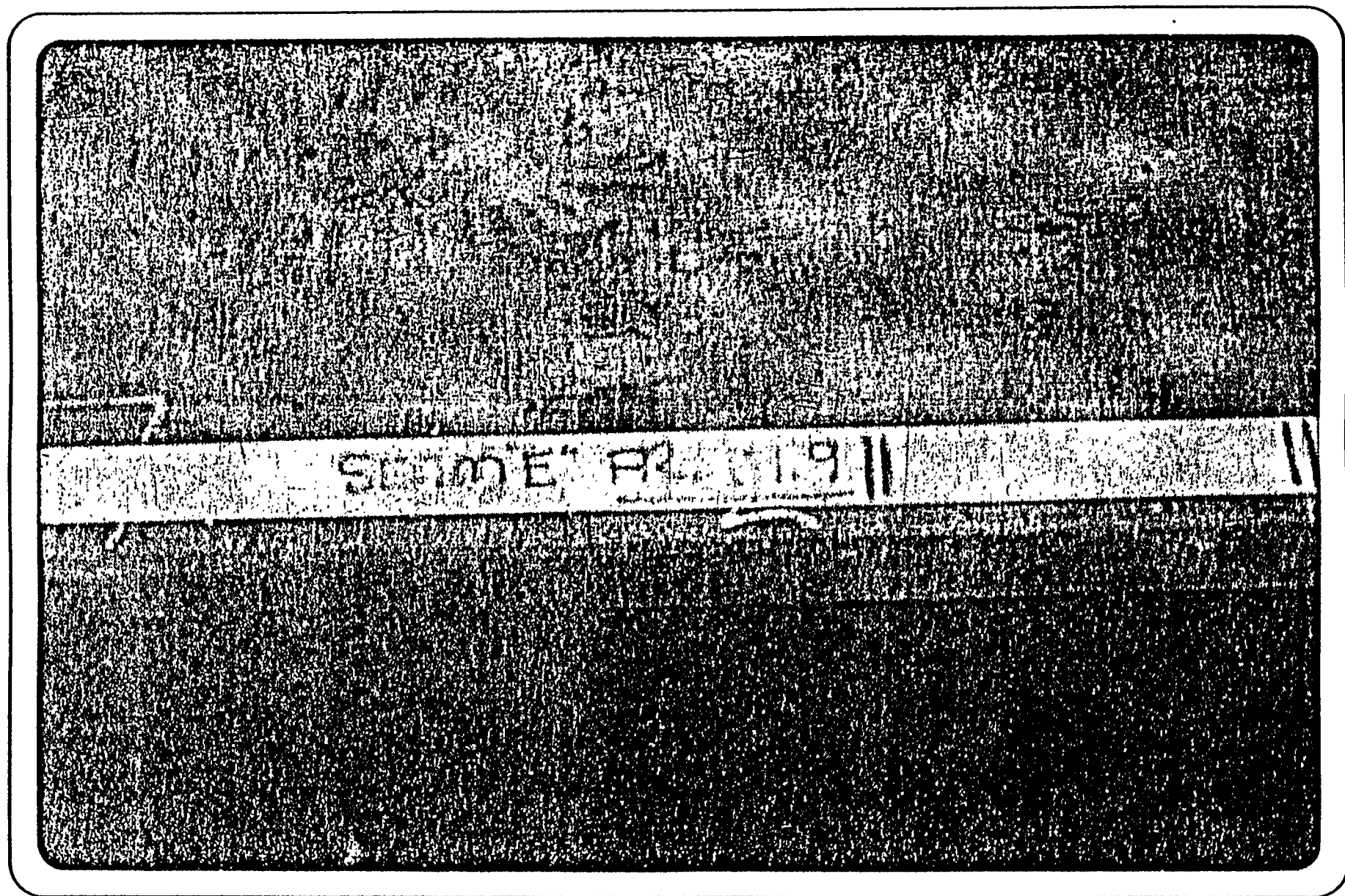
AVONDALE SHIPYARDS, INC.

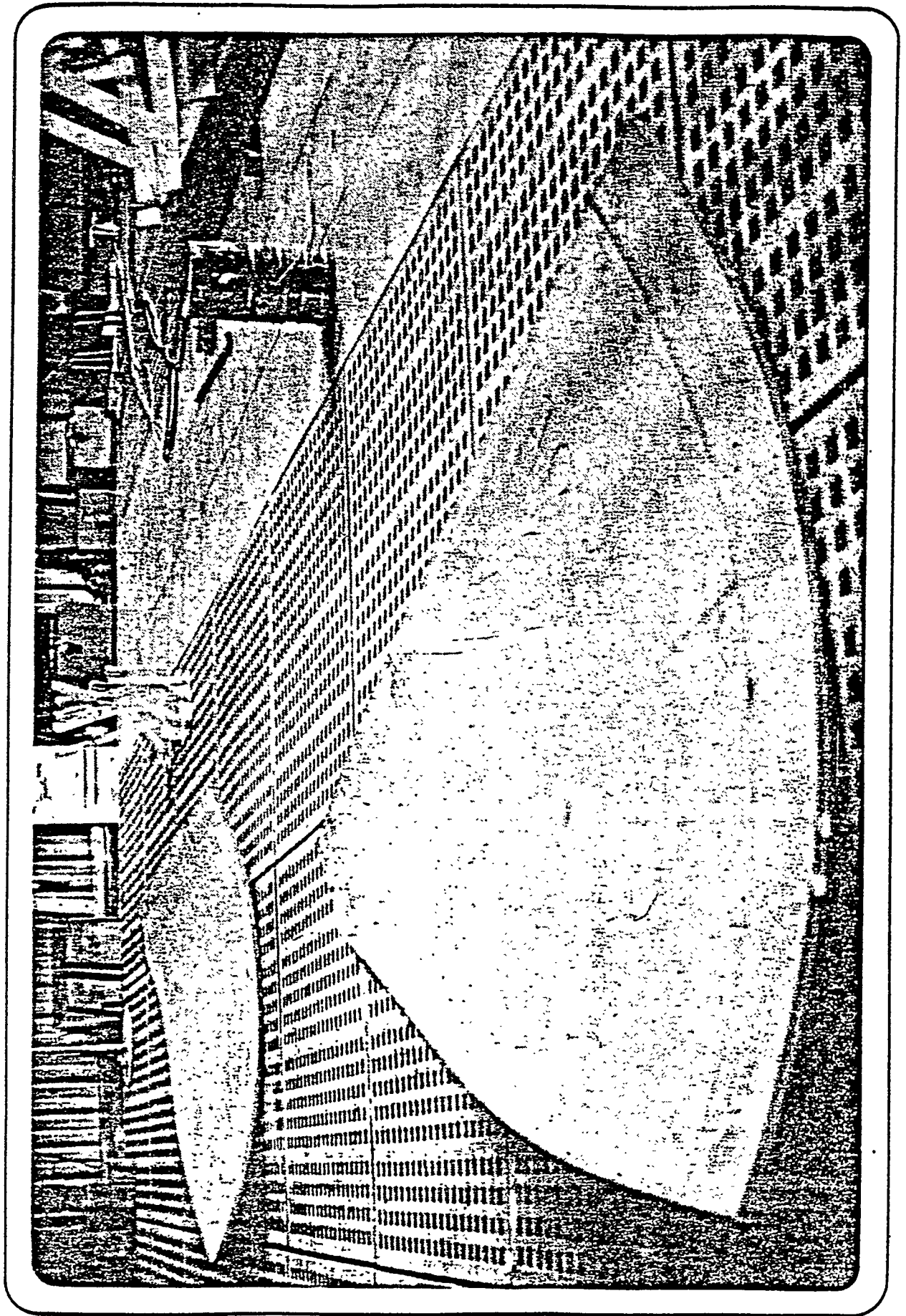


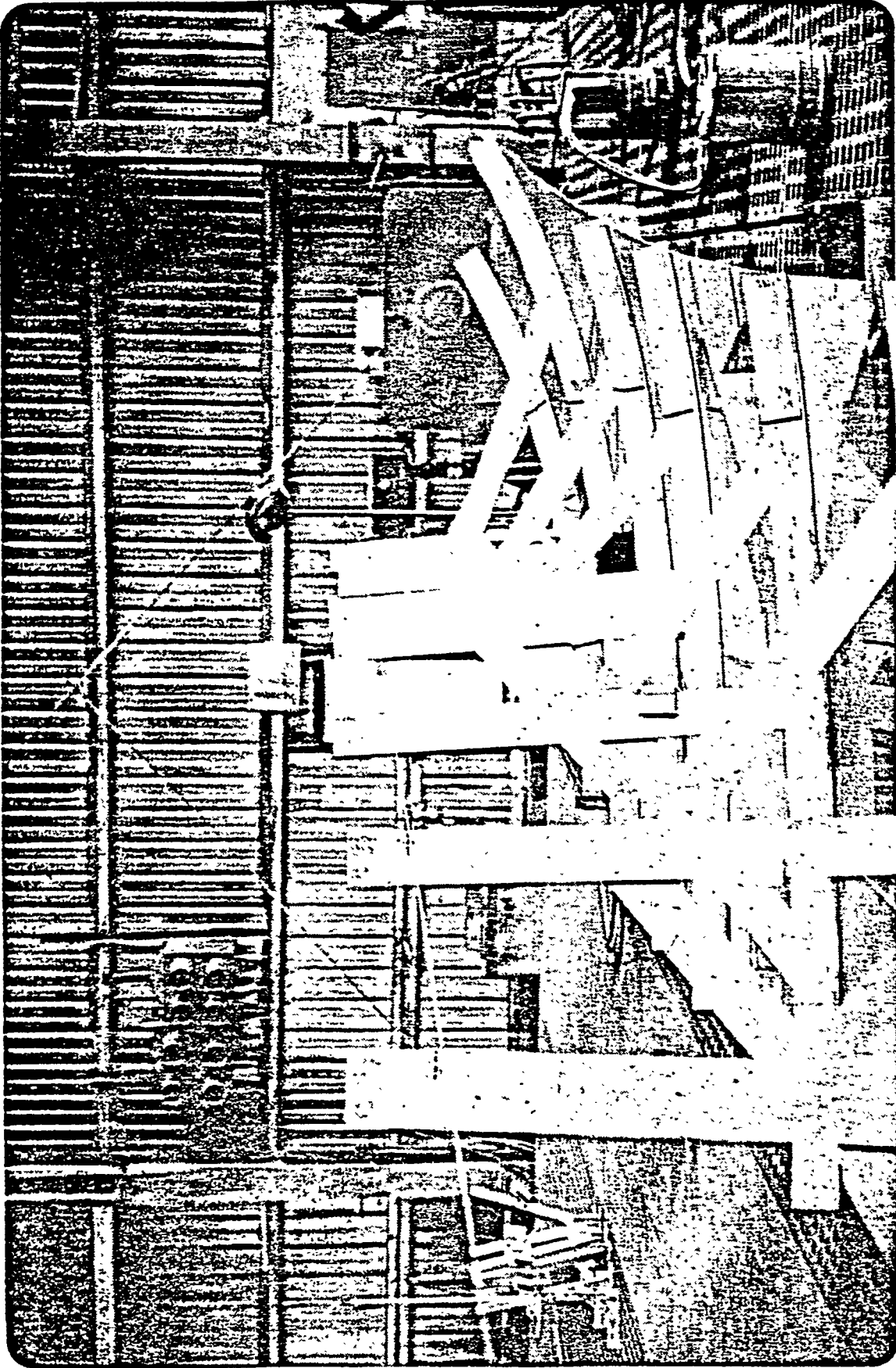


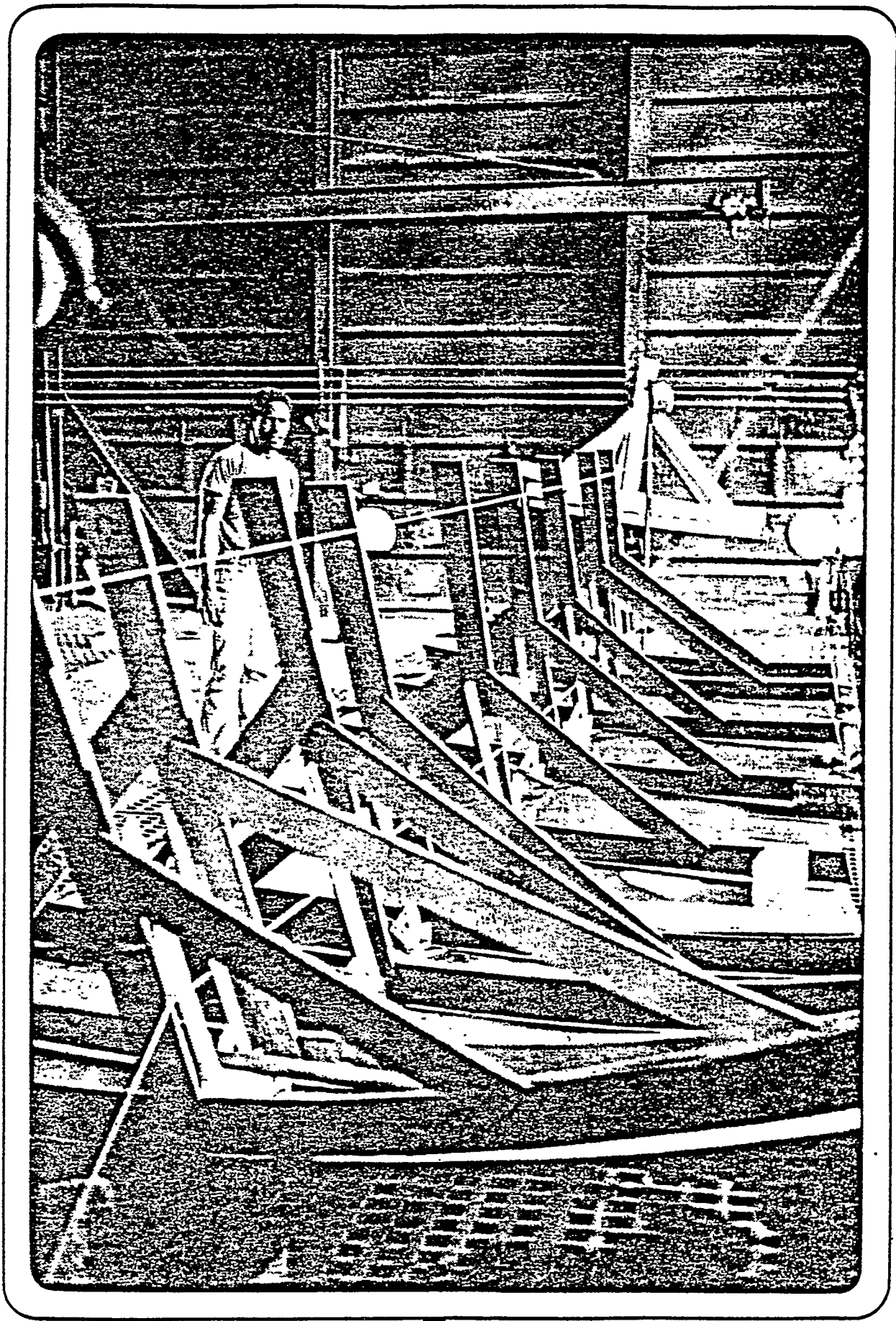


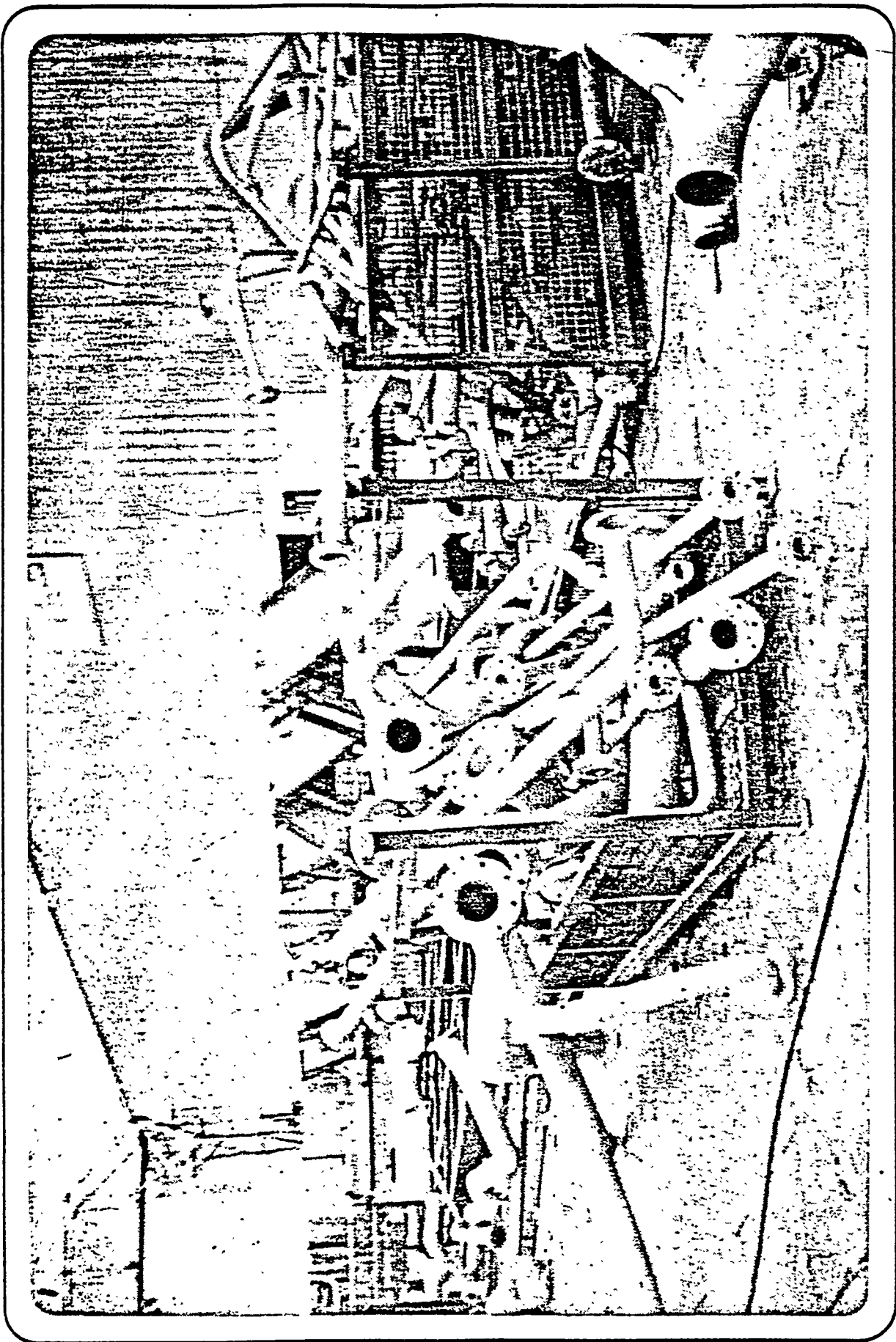


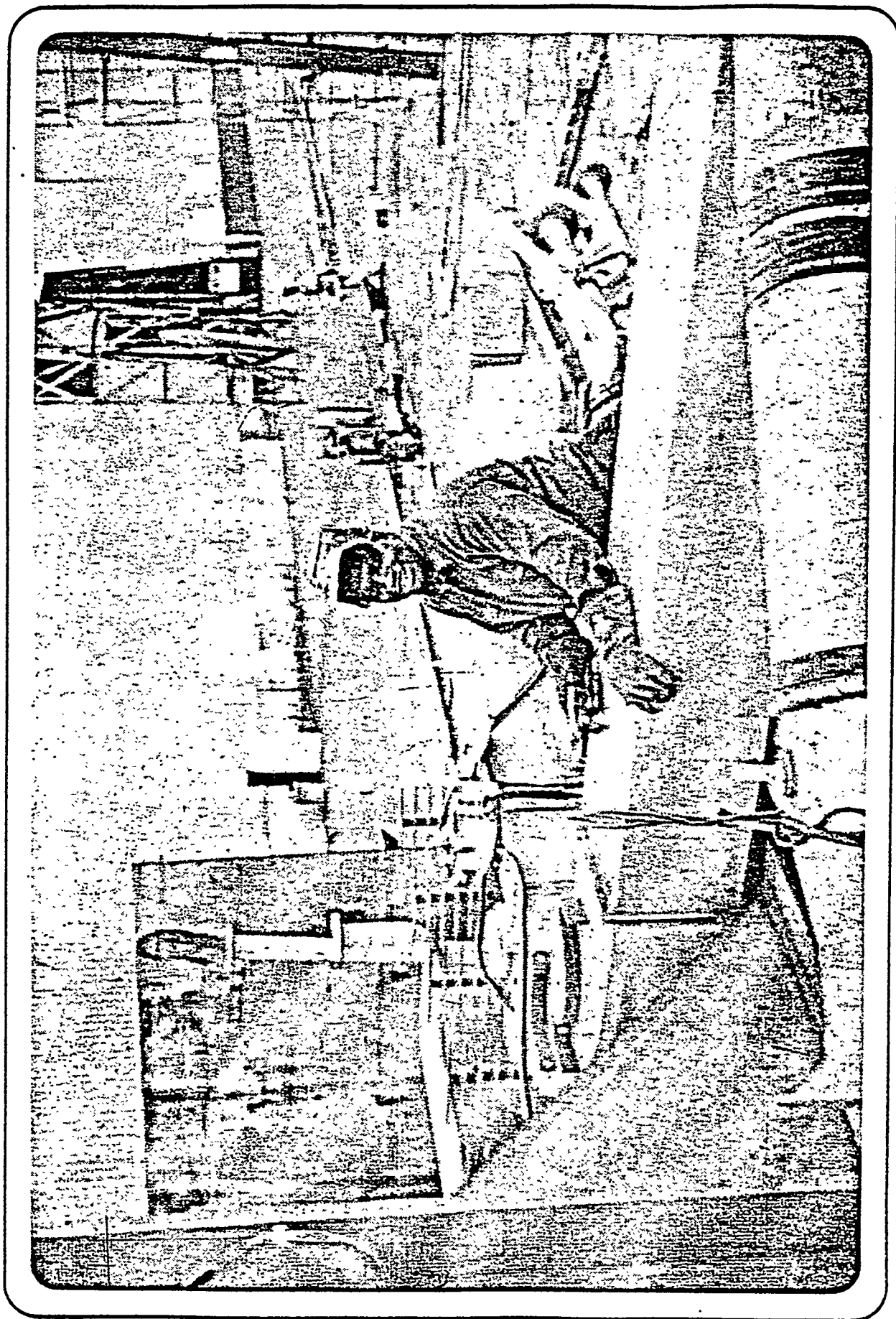


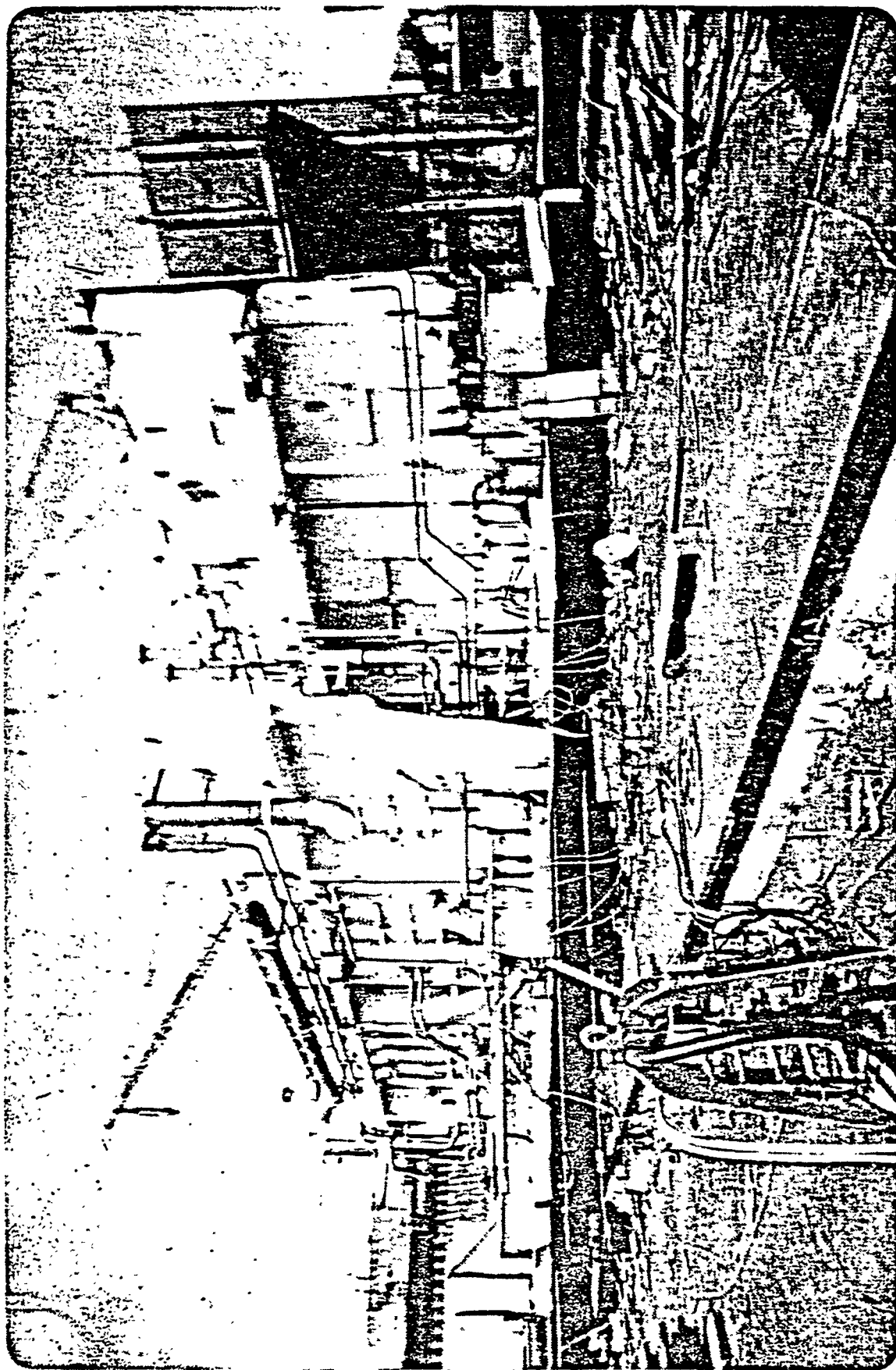


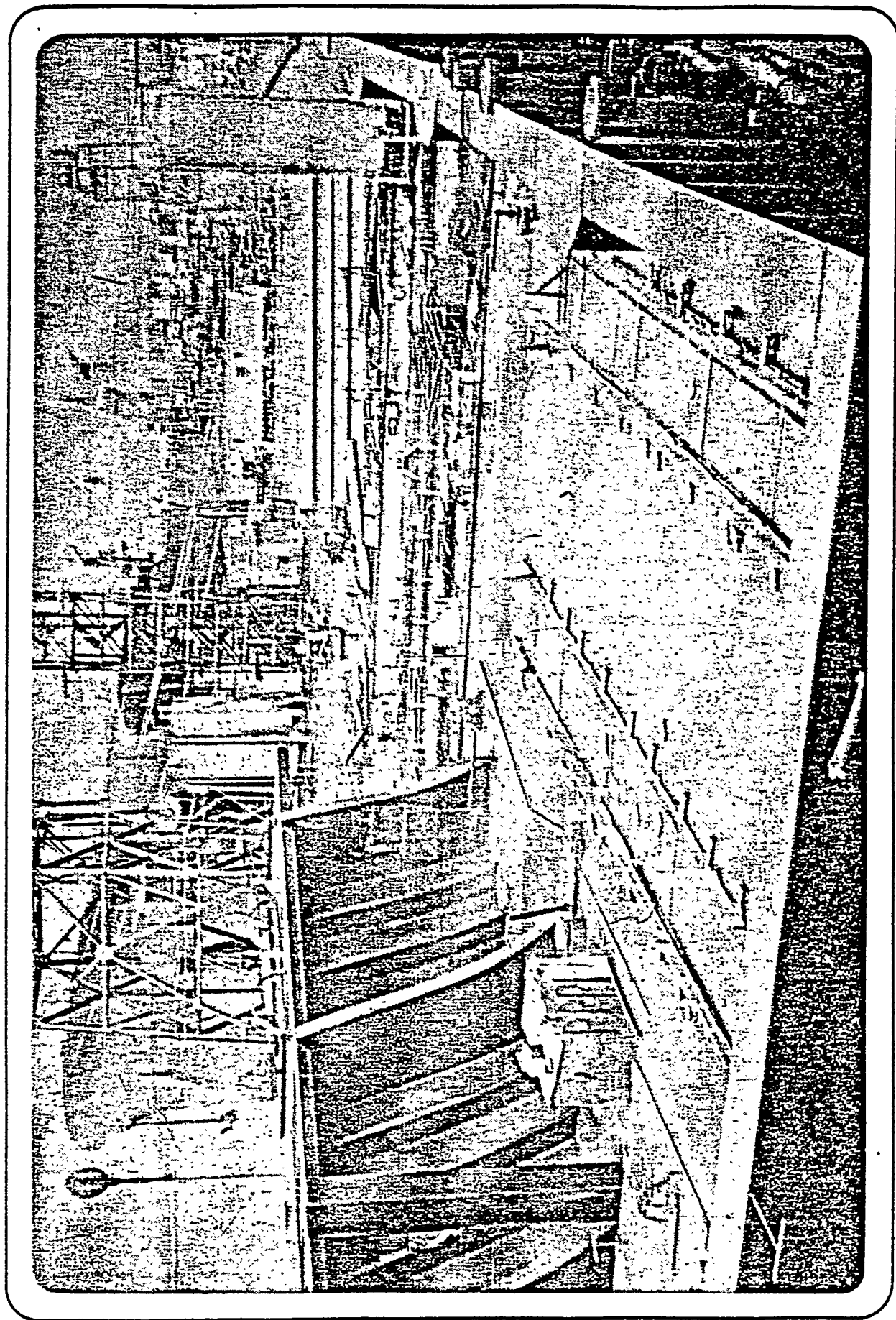


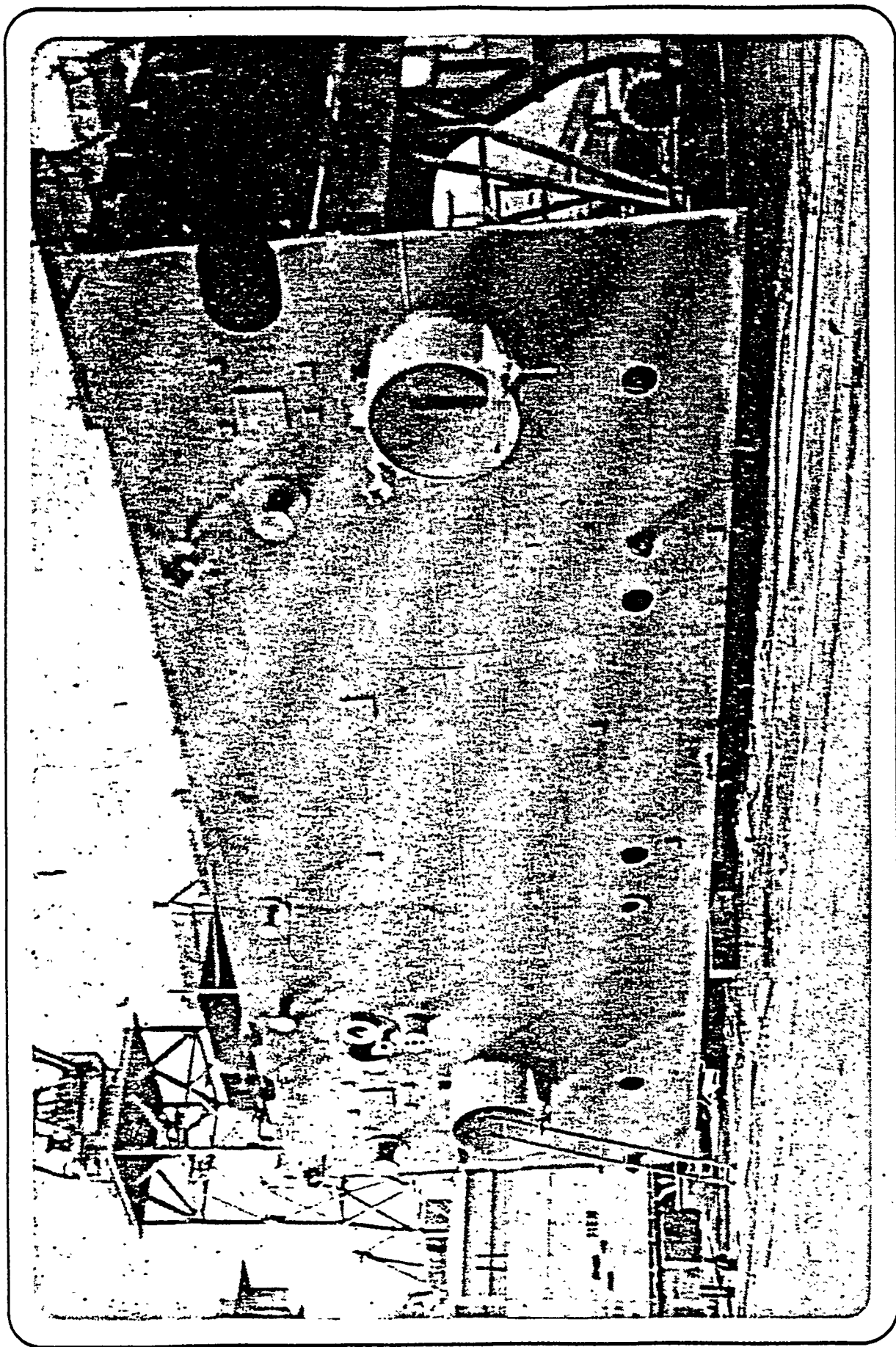


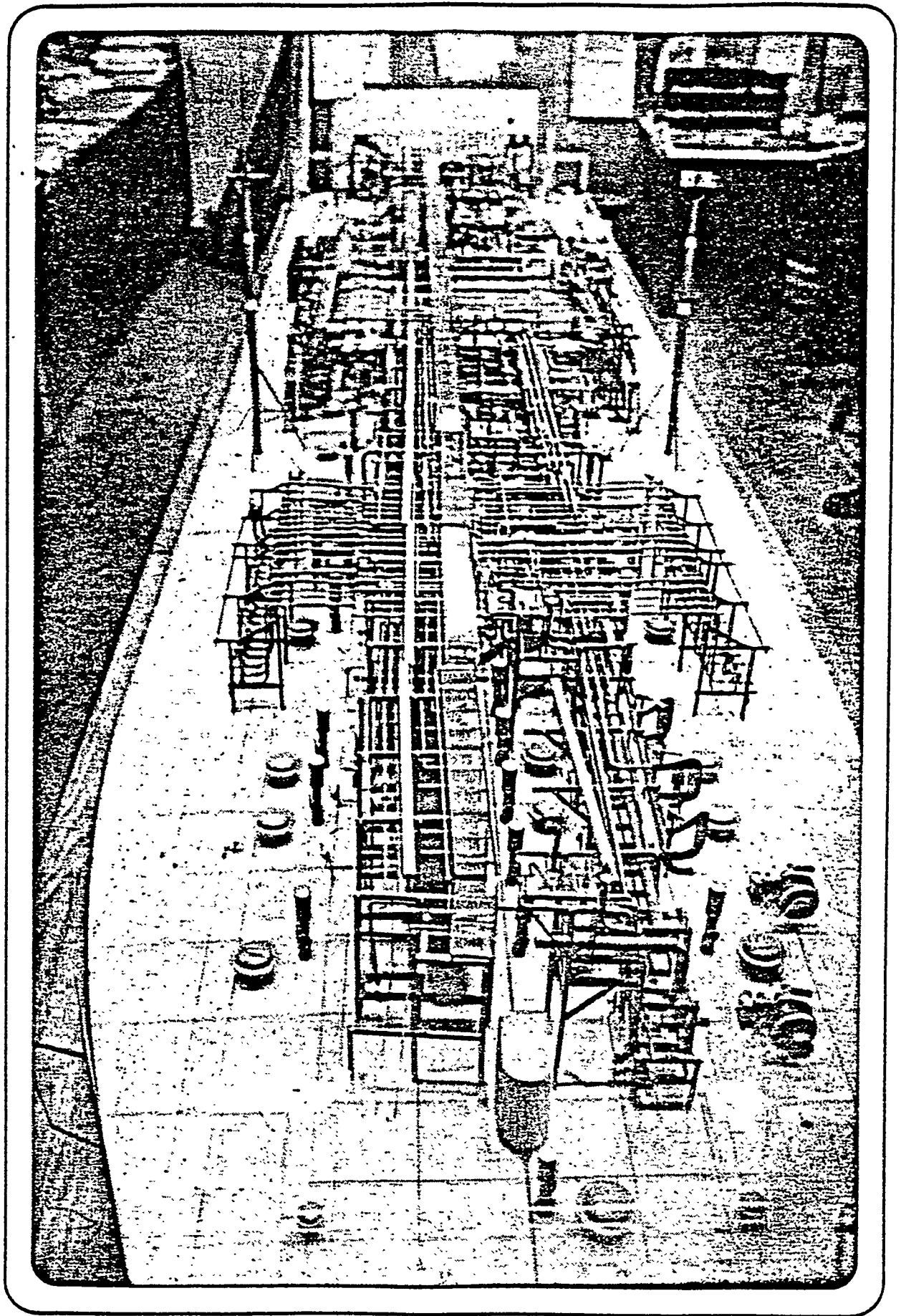


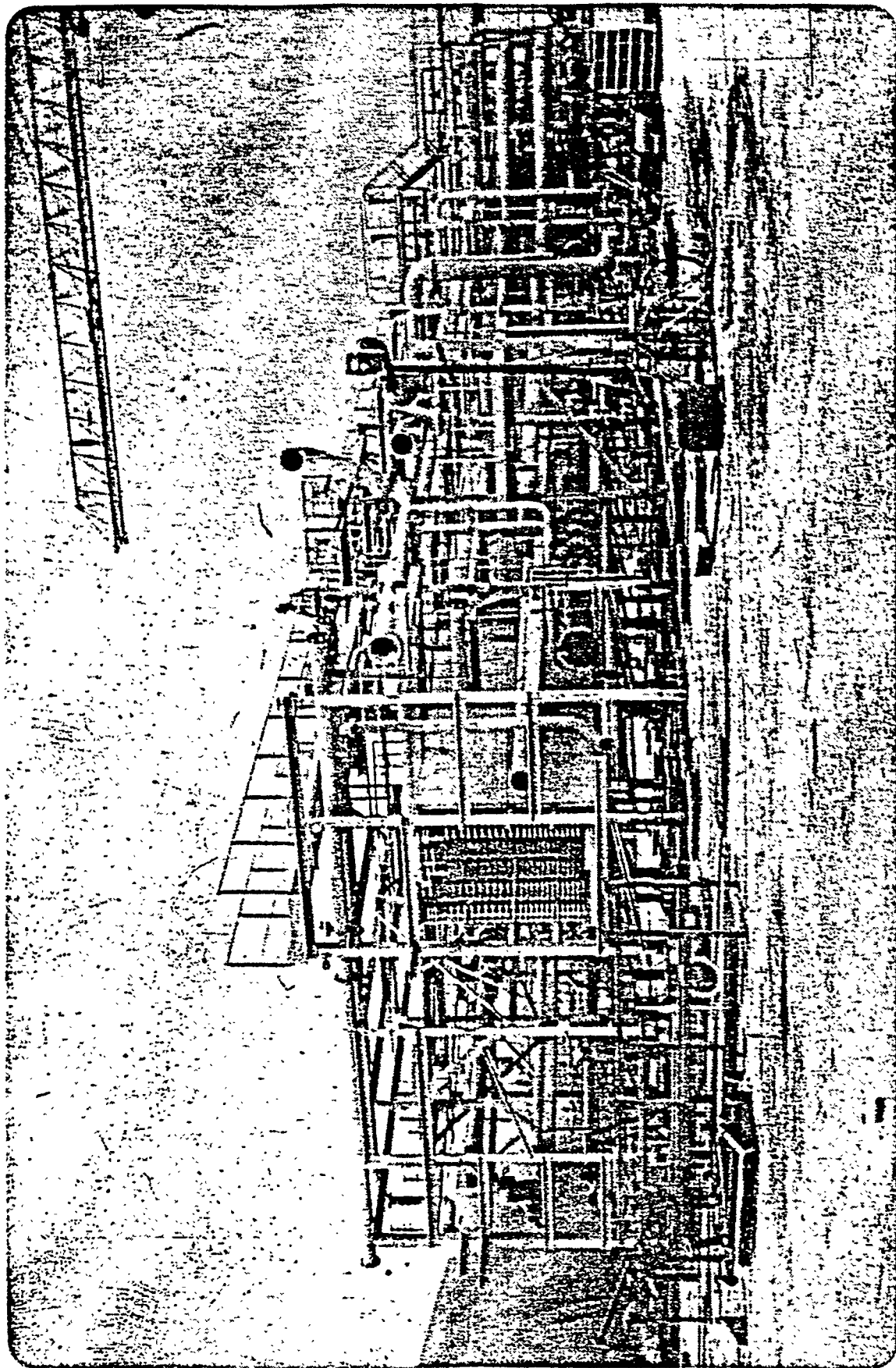


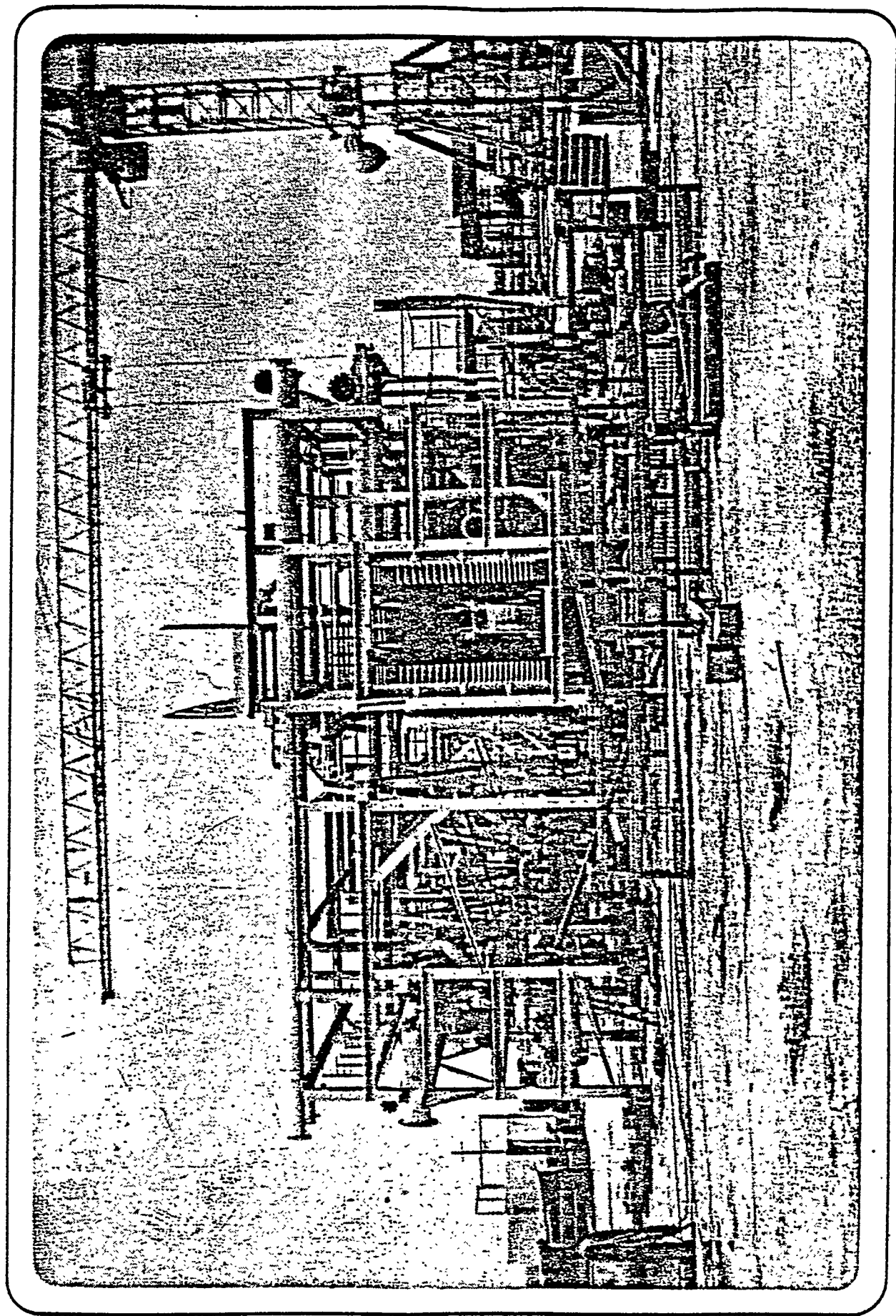












MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

ENGINEERING DEPARTMENT INTERFACE

Prepared by: T. H. DOUSSAN

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MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL ENGINEERING DEPARTMENT INTERFACE

I. INTRODUCTION

Yesterday you heard the presentations on Production Engineering, Moldloft, Material Control, and Accuracy Control for Zone Outfitting; today Engineering will provide a "thumbnail sketch" of the impact of zone outfitting on its operation and procedures. As will be explained in the brief presentations which follow, Avondale Engineering has had to change the type and method of preparation of much of the documentation it prepares in order to accommodate the implementation of zone outfitting technology at Avondale Shipyards. In reviewing engineering operating practices and procedures, the goal was always to change only what had to be changed so that the impact of the move to zone outfitting could be cushioned as much as possible with things familiar. Avondale Engineering has demonstrated that zone outfitting can be absorbed into the design organization without the need for violent internal reorganization.

Because design development under zone outfitting proceeds unit-by-unit rather than system-by-system, the engineering work effort must be accomplished in an earlier time frame than is the case, utilizing conventional design methodology. The earlier the start that Engineering has, the better the chance that all required engineering work will be completed at start of prefabrication. To this end it is most desirable that engineering work start prior to contract signing, if at all possible. This can be done through a "letter of intent" arrangement or through some other means, but the owner, as well as the shipyard, will reap benefits for money spent during the "pre-contract" phase. If a "pre-contract" start is not possible, the engineering effort must commence immediately upon contract signing. In either case, potential problems will come to light at an early stage, the chance for timely material procurement of long lead items will be enhanced, the shortened building period that zone outfitting offers will be protected and initial regulatory reviews can be conducted early.

Pre-contract engineering effort should include work on mechanical system diagrams, weight estimate, longitudinal strength, hydrostatics, tank capacities, bon jeans curves, intact trim and stability data, loading conditions, damaged stability evaluation, wake survey, resistance and self-propelled tests, electric load analysis, electric one-line diagram, vent system development and duct opening, as well as the development of

procurement specifications on long-lead material items such as main propulsion engines, diesel generators, cargo oil pumps, anchor windlass, steering gear, etc.

During the pre-contract phase, a constant dialogue must be maintained between Engineering and Production concerning such areas as preliminary unit definition, identification of construction method, the establishment of outfitting zones for purchasing and the preliminary assignment of machinery package units and pipe racks for main deck. This dialogue which begins during pre-contract is essential to the successful implementation of zone outfitting techniques and must continue throughout contract design development and construction. In fact, the major beneficial "fall-out" of the implementation of zone outfitting at Avondale has been the renewed spirit of cooperation between the Engineering and Production organizations.

Thus far, Avondale Engineering's implementation of zone outfitting techniques has been most satisfactory. By and large, the problems encountered are many of the same ones which plague the engineering effort utilizing conventional design techniques -- lack of vendor information, lack of industry standards, customer changes, etc. However, with zone outfitting, the consequences of these problems are more acute than with conventional design techniques.

The following sections are brief presentations on the way in which Avondale's Engineering Sections have been affected by the implementation of zone outfitting. The Hull Technical and Design Section and the Hull Section have been emphasized because they interface most closely with the Moldloft and Accuracy Control Sections in the Production Department.

II. HULL TECHNICAL AND DESIGN SECTION ("DESIGN SECTION")

The Design Section is composed of naval architects, civil engineers, computer programmers, weight programmers, and drafting support personnel. The responsibility delegated to the Design Section under the conventional shipbuilding system is the design and preparation of midship sections and associated scantling plans, fairing of lines, naval architectural calculations and drawings, weight estimates, and support functions for other sections on an "as-needed" basis. These responsibilities are common throughout the shipbuilding industry and generally must be the very first tasks accomplished. Although early completion of all engineering functions is desirable under any system of shipbuilding, one of the main features of zone outfitting technology is to have all major engineering efforts completed by a pre-determined accelerated date which corresponds to the start of prefab by Production.

The main impact of zone outfitting technology on the Design Section has been to add several new responsibilities. Some of these functions are completely new to the shipbuilding scheme, while some are functions that were the responsibility of other departments under the conventional system. These new responsibilities are, as will be seen later, such that they must be finished very early so that the accelerated completion date can be met by all Engineering Departments. These new responsibilities are:

- Development of Structural Key Plans
- Creation and Maintenance of the Data Base
- Review of Unit Drawings
- Production/Engineering Liaison

A. DEVELOPMENT OF STRUCTURAL KEY PLANS

Structural key plans are very detailed scantling plans that show all aspects of the vessel's structure. The vessel is divided into three main divisions with each division having its own key plan. The first area is the forward structure from the stem to the collision bulkhead; the second is the cargo hold structure between the collision bulkhead and forward machinery bulkhead; and the third is the after body structure, including the machinery space and after peak structures. All frames, bulkheads, decks, flats, stringers, stiffeners, shell plates, and major penetrations, along with most major equipment foundations, are included on each respective key plan.

The primary purpose of the key plans is to provide a document depicting all details related to the vessel's major structural components for use by all departments, both Engineering and Production, in their own respective functions or tasks related to the shipbuilding effort. For example, the Hull Drafting Section uses the data shown to develop the yard plans or unit drawings. The Piping Section uses the plans to locate major interferences of their piping runs. Production uses the plans to aid in the unit breakdown development and other functions. Since the key plan is a tool for other departments, the drawings must obviously be completed very early to allow the accelerated Engineering completion dates to be met. This obviously requires all support tasks necessary for the development of the key plans to likewise be completed earlier.

The scantling plans and midship section should be finished with regulatory body approval prior to the start of the key plans. Finite element studies must be finished in support of the scantling and midship drawings. The vessel's lines should be completely faired and loaded to the data base. Basic damage stability calculations depicting intended vessel compartmentation, as well as longitudinal strength studies, should be concluded pre, or at least during, key plan stage.

B. CREATION AND MAINTENANCE OF THE DATA BASE

This function was the responsibility of Production's Mold-loft under the conventional system. The data base is a storehouse of information that, through the use of designated computer programs, defines all structures within the vessel inclusive of the vessel's shell contours. The data base is developed or created in a systematic manner starting with the definition of the vessel's final faired lines. Then surfaces such as decks and bulkheads are added, along with shell longitudinals, traces and shell seams. This data base is updated and maintained through the span of the contract to reflect any and all developments that occur as production proceeds.

The data contained within the data base is used to develop computer prepared drawings. Any frame bulkhead or deck contour can be retrieved and drawn depicting the associated stiffeners. Once the drawings have been developed and the data base verified, the data is used to control the N/C burning machines in the Plate Shop, the generation of templates, bending of frames, etc.

C. REVIEW OF UNIT DRAWINGS

Once the key plans are issued, the Hull Section will use them to develop the yard structural plans or "yard plans" that are sub-divided into each particular hull construction/erection unit. These unit drawings are complete with the smallest detail shown and defined to allow the preparation of the unit parts list, "UPL's," from which the Moldloft prepares the unit construction manuals, "UCM's." The UCM's are the documents from which the steel is nested, marked, punched and burned within the construction sequence. Therefore, in order to assure the accuracy of the data released to Production, the Design Section will review the unit drawings to verify that all details are in accordance with the intended design and latest developments.

D. PRODUCTION/ENGINEERING LIAISON

Since the Design Section is responsible for the development of the key plans, questions and problems that arise during development of yard plans and N/C burning are channeled through the Design Section for resolution. Although this is not a new function of the Design Section, the amount of day-to-day involvement has intensified due to the increased detail of the actual design work now undertaken. Also, since the data base maintenance requires daily involvement, the flow of input to and from the Design Section has increased drastically.

III. HULL SECTION

Prior to the introduction of zone outfitting at Avondale, the hull structural drawings were developed and presented to the Production Department utilizing a system-by-system approach. The drawings were developed presenting the decks as a system, the shell as a system, the web frames as a system, and so on.

The system-by-system approach presented the entire shell, deck or longitudinal bulkheads to the Loft, from which the various structural units had to be extracted. The system-by-system drawings did indicate the unit breaks or erection joints, but the individual unit's demarcation lines and extent was not so discernible graphically. Additionally, the system-by-system approach required the user to possess other system plans in order to obtain the knowledge of all of the components of a particular unit. Many reference plans were necessary.

The greatest influence that zone outfitting has had on the functions of the Hull Section is in the development of the hull structural plans.

Zone outfitting introduced four (4) major concepts regarding production of the structural drawings:

- The structure would be developed and presented unit by unit.
- The individual units would be developed from a Key Plan rather than a rough scantling plan.
- The structural drawings would have their respective unit's various components identified by a designation system that was keyed to the intended construction sequence or stages for that particular unit.

- Each unit drawing (or "yard plan" as they are called) would be accomplished by a complete accounting list of material for that unit, known as a Unit Parts List.

ASI still maintains the obviously required system drawings, such as the rudder support system, mooring system, and anchor handling system. Their development has essentially remained unchanged under the zone outfitting concept.

A. UNIT PARTS LIST

The UPL is a document that accounts for all pieces in a unit. The pieces are presented to the user in the order of ascending stages of construction, grouped into the various partial sub units, sub units, and pieces required for both the assembly and erection stages of construction. The UPL is an accounting system that presents its information in the same order as the document produced by Production known as the "Unit Breakdown Summary Sheet."

The UPL is constructed from the "Unit Breakdown Summary Sheet." There are additional items of information that are contained in the UPL. These additional items of information are notations to the Loft as to what pieces required "lofted" dimensions, what pieces require stock, what pieces require special attention in the lofting and manufacturing stages, etc. The UPL is used at the various work stations.

The UPL is a baseline document that can be used by other groups or departments in the Production Establishment for such functions as material accounting, sorting, routing, storage, etc.

B. PROCESS LANES INTEGRATION

The concept of process lanes has been incorporated into the yard plan. The notations for the various structural components, designating them as sub units, partial sub units, combined partial sub units or just individual pieces to be left loose until assembly or erection, are a function of the area or location of their manufacture.

This designated manufacturing location is one of the basic concepts of the Process Lanes principle. The yard plan notations are obtained from the Unit Breakdown Summary Sheet. By knowing the meaning of the process lane coding notations, one can determine the location of manufacture of a particular structural component.

C. INTERFACE WITH PRODUCTION

Interface between the Hull Section and the Production Establishment can be broken down into two (2) broad types. The first type of interface is one which is necessary for the accomplishment of Hull Section responsible work. This type of interface is termed:

1. Primary Interface

The primary interface between the Hull Section and Production lies in the information that Production provides to the Hull Section prior to, and for use in, preparing the yard plans. This primary interface provides information for three (3) distinct "systems" which appear on the yard plans:

- Ship Erection Breakdown
- Plate Edge Preparation
- Ship Unit Construction Method

The three (3) above mentioned "systems" are governed by production considerations, and the need to accommodate production techniques and methods. The three (3) "systems" and their interaction with Production will be briefly reviewed.

a. Ship Erection Breakdown

Ship erection breakdown starts with Production "breaking up" the vessel's hull into main and sub assemblies. Once the major planes of division are established by Production, this information is passed to the Hull Section in the form of a document known as the "Hull Unit Arrangement," whereby the yard plans are developed incorporating the desired erection planes. If a Production-Department-desired erection plane is not desirable from an Engineering consideration, then this structural division line is brought back to Production where a compromise new erection joint line is established. This interface, therefore, establishes a structural erection line that preserves both sound technical "parameters and production fabrication methodology.

b. Plate Edge Preparation

Every yard plan addressing itself to main hull and superstructure construction displays plate edge preparation weld identification notations. The selection of the proper edge preparation is the result of interfaces among the Production Welding Department, the

Production Planning Department, and the Hull Section, whereby the joint design is discussed, and Production Department recommendations are incorporated.

c. Ship Unit Construction Method

Production issues a document to the Hull Section known as a "Unit Breakdown Summary Sheet." This document describes in great detail the intended methods to be used to manufacture the unit in question. This document assigns partial sub-assemblies, sub-assemblies, and main assemblies of the unit to the specific manufacturing process lanes. This document is utilized to develop the yard plan and Unit Parts List. Interaction discussion is carried on between Production and the Hull Section, whereby refinements are made to the Unit Breakdown Summary Sheet incorporating Engineering considerations.

2. Secondary Interface

The secondary interface between the Hull Section and Production exists primarily in providing Production with information on Hull Section responsible material and providing Production with yard plans and shop drawings in the case of systems such as mooring, anchor handling, etc. For example, discussions with the Machine Shop superintendent are carried on during the development of the rudder support system in order to apprise the shop of specific engineering requirements as well as receive information on manufacturing limitations, procedures, requirements, etc.

With regard to the yard plans, the Hull Section is in constant communication with the Moldloft during the Loft's development of the Unit Control Manuals. The Hull Section works closely with Production's Accuracy Control Section in its research and investigations. An area of particular concern for the Hull Section and Accuracy Control is welding design to minimize distortion. Where possible, suggestions made by the Accuracy Control Section are implemented at once. Another area which demonstrates the close cooperation between these two groups is in the inclusion of at least one datum line within each structural unit to facilitate Production operations. This suggestion was made by Accuracy Control and implemented by the Hull Section.

IV. MECHANICAL SECTION

A. GENERAL

The concept of producing zone outfitting type drawings for the various mechanical systems requires a new design philosophy and requires that the Mechanical Section change its method of developing drawings. We will touch on the major engineering/design effort required by the Mechanical Section and try to briefly show design incorporating zone outfitting.

B. SCOPE OF THE JOB

The scope of the engineering required for any job is put into definition by formulation of the plan schedule required for the job. Traditionally, this has been easily obtainable by the Mechanical Section at the beginning of the contract, since engineering drawings were system oriented. The plan schedule developed an early and fairly accurate definition of the job.

However, with zone outfitting, most Mechanical Section drawings are not system oriented but rather are unit or zone oriented. After a unit breakdown is made by Production, the Mechanical Section must determine its drawing breakdown by units. Time must be spent for advanced planning in order to define what systems are contained in various units. This is accomplished with a comprehensive advance planning program for system routing.

At ASI, the Mechanical Section has implemented what is called "Advance Design Composite Study" (ADCS). ADCS's are produced by top designers taking the functional system diagrams and making a schematic one line routing of the systems on scaled arrangement drawings. When the designers are routing the system, they must insure that the routing shown is realistic and can be obtained. The ADCS is greatly improved if the designer has good scantling drawings and major equipment drawings. A well thought-out ADCS by top designers will completely define the scope of the job. Then, from the ADCS, a realistic plan schedule for Mechanical Section drawings can be obtained.

It should be noted that as the zone outfitting method is being developed at Avondale, the Engineering scope of work is constantly being changed as Production realizes additional information they require on the drawings. This has made it difficult at times to estimate manhours required for drawing completion. As both Production and Engineering at Avondale become more familiar with zone outfitting, this problem of expanding work scope should be minimized.

C. COMPOSITES

Development of detailed composites has changed from the traditional development methodology as follows:

- The breakup of the composite area follows the unit breakups rather than the traditional level breakups.
- Development of the composites is done basically unit-by-unit in lieu of system-by-system. The proposed routing which has previously been determined on the ADCS's is followed as closely as possible.

D. ARRANGEMENT DRAWINGS

Since Production personnel are outfitting small pieces of the ship which are basically unrelated to the ship as a whole, arrangement drawings are done unit-by-unit with accompanying lists of material done unit-by-unit in lieu of the traditional system-by-system. In addition, all material and pipe spools must be coded to the unit, so that Material Control can palletize the material and deliver it to the unit outfitting site.

E. PACKAGE UNITS

Engineering has organized, within the Mechanical Section, a Package Unit Design Group. This group is responsible for the complete design of all Machinery Package Units, including pipng, structure, outfitting, instrumentation, painting, label plates, etc. Having this design in one group insures the integration of all design facets. This method also simplifies the development of the Machinery Space Composites, since a package unit becomes a "mini-composite."

F. PIPING RACKS

As much as possible, ASI tries to rack piping on structural frames which then can be installed as one complete assembly. The Mechanical personnel responsible for the piping racks are also responsible for the detailing of the rack structure in order to insure integration of structure and piping.

G. COMPUTER AIDED DRAFTING

ASI is presently developing a computer-aided drafting system with Lockheed and IBM known as CADAM. A pipe spooling program is presently being used to improve the accuracy of the pipe spools and increase productivity.

H. MATERIAL PROCUREMENT

Material procurement must be done at a very early stage of the contract for all systems due to the possibility that the first unit planned by Production for zone outfitting may have contained within that unit a small portion of many systems. Therefore, in order to have material in time for Production's needs, advanced ordering of material must take place. Advanced ordering of long lead material is done from the completed ADCS's, rather than the functional schematic diagrams, since a more accurate material take-off can be obtained. All material on systems is coded to coincide with actual fabrication and installation sequences. This requires close working contact with Production personnel.

V. OUTFITTING SECTION

A. GENERAL OVERLOOK

As a result of the implementation of zone outfitting, Outfitting Engineering has had to undergo a significant change. It's not that Outfitting Engineering had to create new data, but that the old data had to be expanded and placed in different order on the drawings and, in some cases, additional details developed in order to support the zone outfitting concept.

The major impact of zone outfitting on the Outfitting Section is the pallet system of material numbering for handling and routing. Following is a more detailed view of the various changes which Outfitting Engineering had to undergo in order to implement zone outfitting.

B. PALLETIZING SCHEDULES AND PALLET NUMBERS

The assigning of material to "pallets" has caused Outfitting Engineering, like all Engineering sections, to generate material lists broken down for one unit (or "pallet") at a time and to provide the field with a list of all units (pallets) which may be covered in the drawing. Generally, this has been handled by adding schedules of pallets included and for material per pallet to the drawing.

C. UNIT DIVISIONS IN LARGE DRAWINGS

The Outfitting Section's large drawings had to be broken down into unit books to accommodate zone outfitting. On some drawings, such as walkways which extend into more than one unit, it is necessary to provide "fit-up" details to be used when the units are assembled into the hull form.

D. METHOD OF DIMENSIONING DRAWINGS

"Datum lines" and "nearest structure" type dimensions, in lieu of the conventional off-centerline and off-frame dimensions, had to be utilized on drawings. This problem was common to all Engineering Sections.

E. PRE-PLANNING OF DRAWINGS

Pre-planning of drawings, while not new to Outfitting Engineering, has assumed a much more important role. It provides an efficient method of pin-pointing potential problem areas and provides a vehicle for communication within the Engineering Department which is more effective than was the case with the conventional method of drawing development.

F. SEPARATION OF FABRICATION & INSTALLATION INFORMATION

Because more and more Outfitting material is coming to the assembly site in a "finished" or "package" state, the need for fabrication information at the assembly site has greatly diminished. As the workmen at the assembly site become more and more "installers" and "handlers," their need for installation information supersedes their need for other types of information. This has led to a natural separation of the two types of information (fabrication and installation) on the drawings.

While the need for more information and planning increases the Engineering effort, this is expected to be more than compensated for by savings in Production time. A spin-off of this development is the possibility of increased reuse of details for future jobs and easier standard development and application.

G. ADDITION OF WEIGHT INFORMATION

With much more material being added to the units before they are assembled one to another, the weight of the added Outfitting material becomes an important factor in unit handling. It has, therefore, become necessary to indicate the weight of the Outfitting material (sub-assemblies) on the drawings.

H. MISCELLANEOUS

The use of automated equipment for material control, palletizing schedules, and generation of work orders, while not part-of zone outfitting per se, are logical extensions of the system and in themselves generate changes to Outfitting Engineering procedures. Standard raw material catalogues, sub-assembly concepts and sub-assembly parts lists are among some of the items that have had to be developed.

The learning curve, unit break recognition, the frustration factor of suddenly finding that the "old way" is not good enough and the increased time and degree of difficulty in drafting and checking in the new procedures, all combine to produce a need for re-education of engineers, designers and drafters; a need which is continuous as we become more familiar with the new methods.

VI. ELECTRICAL SECTION

A. INTRODUCTION

The impact of the Electrical Engineering implementation of zone outfitting primarily concerns wireway design changes and changes in the list of material format for deck plans and isometric wiring diagrams. Most electrical equipment and cabling is installed during the "on board" phase of zone outfitting. This is necessary to insure that the electrical components are not subjected to adverse factors such as weather, sandblasting, dust and paint spray, during the early stages of zone outfitting. Electrical equipment installed "on unit" tends to be concentrated on vendor supplied module packages and shipyard built machinery package units.

B. WIREWAY DESIGN

Wireway design is well suited to modular construction techniques. The wireway hangers are made of steel and can, therefore, be phased in with the orderly erection of a unit during main assembly prior to blast and paint. In designing the wireways for "on unit" installation, ASI has experienced an increase in design time of approximately 50 percent due to the increased level of detail required for modular construction as opposed to the manner in which wireways have historically been designed.

Using the zone outfitting concept, wireway arrangement drawings are segmented by unit number to allow the production foreman to identify exactly which hangers are in each unit. The list of material is broken down by unit to show the number of hangers of each type required. Each type of hanger is detailed. For zone outfitting, the number of hanger types can be in the hundreds. Each slight variation of one hanger from another generates a new hanger detail. The end result of the additional detailing is to generate a unique piece mark number for each hanger which can then be entered into a computer program for tracing purposes by Production Planning and Management.

The fabrication and installation of wireway non-watertight collars is an area where zone outfitting has made a significant contribution. Using the traditional manner of collar fabrication, the production foreman obtained dimensions from hole lists and then had the collars constructed by a specialist in his Electrical Department. Before installation of the collars in the bulkheads, the holes would be burned out by the layout crew utilizing dimensions provided by the hole list. In zone outfitting, the production field crew's work effort is reduced considerably. Collars are standardized to a limited number of commonly used sizes.

Early in the design of the vessel, dimensional information for numerical hole cutting by automatic burning machines is provided to the Moldloft. This allows the holes for the wireways to be accurately cut by the automatic burners during the erection of the unit in main assembly. Effectively, the electrical field production crew's responsibility for non-watertight collar fabrication and installation is reduced to simply obtaining the pre-made non-watertight collars and installing these collars in pre-cut holes.

C. DRAWING FORMAT CHANGES

To facilitate zone outfitting, the formats of electrical deck plans and isometric wiring diagrams have been revised to include additional unit construction information. Previously, these drawings depicted the electrical system in the body of the plan with a list of material which listed total quantities for the material distributed throughout the drawing. For zone outfitting, these same drawings now have leader lines in the body of the plan which segment the ship into the various zones. Also, the front of the drawing has a table above the title block which flags for cursory drawing reviewers that the drawing contains material which must be installed in any of twelve different stages of construction, such as, during subassembly on unit, or before closing in onboard. As a further aid, the title block itself identifies the ship zones affected by the electrical system shown on the drawing.

The list of material for deck plans and isometric drawings is sub-divided by the pallet codes associated with each unit or zone. Under each pallet code is listed the electrical material contained on the drawing which will be installed in a particular unit or zone. An exception to this technique of material listing is the listing of cable quantities. Cables are summarized at the end of the list of material with no reference to any particular unit or zone. The reason for this apparent anomaly is related to the manner in which cable is handled and installed in the shipyard.

Cables are purchased, stored, and transported to the work-site on reels. As the cable is being installed, the electrical crew cuts the length required for the installation from the reel. The Production foreman coordinates the overall cable installation to minimize cable waste. Since cable is expensive and is a long lead item for procurement, cable footage must constantly be monitored. Therefore, to identify specific cable lengths in each pallet would not contribute to a more efficient, less costly installation.

D. PACKAGE UNITS

Machinery package units constructed by the shipyard require coordination during the design phase of a job to insure that all devices belonging on the package unit are installed during assembly of the package unit. Typical electrical devices which are installed on the package unit are motors, motor controllers, pushbutton stations, solenoids, sensors, and heat tracing cabling. The locations of these devices are established by the package unit designers with inputs supplied from the various Engineering disciplines, including

Electrical. Particular attention is paid to electrical equipment and cabling which will be installed on tanks, that are a part of the package unit, to insure that the proper provisions have been made for foundations and cable studs. Since the tank will be fully constructed and tested before it leaves the package unit shop, any welding to the tank exterior in the field would result in damage to the tank interior coating and require the tank being retested. In some instances, the machinery package unit is designed before certified drawings are received from the electrical equipment vendors. To minimize the disruption to the package unit design, the size of devices such as motor controllers and pushbutton stations is estimated based on previous experience with the particular equipment. Also, by using motor control centers, many of the vagaries of motor controller sizes are eliminated as the controllers would then be part of a motor control center remote from the package unit.

On the main deck of the Exxon Multi-Product Carriers, presently being designed at ASI, there are a number of pipe rack package units. As an integral part of these pipe rack package units are a number of wireways. In the past, wireways were provided for the main deck based on capacity requirements of the wireways at various points along the main deck. This technique allowed wireway sizing to proceed in the early stages of the ship design without the knowledge of exact locations of equipment on the main deck. It was left to the production foreman to run local runs of cables from the wireways to individual pieces of equipment scattered around the main deck. Since the pipe rack package units are essentially complete when installed on the ship, exact locations of main deck cabling must be known much earlier in the contract to allow the wireway development to be complete on the pipe rack package units. This requires a significant increase in the work effort of the wireway designer since he must now determine exact locations of electrical equipment and provide small branch wireways to this equipment from the main wireway runs.

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

STEEL CONTROL INTERFACE

Prepared by: F. MARKS

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
STEEL CONTROL INTERFACE

I. INTRODUCTION

A. DESCRIPTION - GENERAL OVERVIEW OF FUNCTIONS

- Screen all job requests in order to utilize the Stock Inventory.
- Follow-up Purchase Orders to assure that all steel not screened was purchased and delivery of same will meet job requirements.
- Plan storage of purchased steel and have storage area ready to accommodate incoming shipments.
- Verify shipments of steel and make receiving reports in order that proper invoice payments are made.
- Maintain Steel Status Report (semi-monthly) on all purchased steel.
- Furnish Moldloft (by job) steel sizes, either purchased or screened.
- Deliver steel to proper job prefabrication site by means of the steel transfer system.
- Maintain job Steel Cost Report (by cost code and vessel).
- Physical inventory of all steel with yearly computation of inventory.

B. OBJECTIVES - PRINCIPLE OBJECTIVES OF STEEL CONTROL

The main objective of Steel Control consists of ensuring all jobs-that steel will be readily available in accordance with the Long-Term Schedule. Further, Steel Control maintains Steel Tonnage Reports, debits, credits by cost code and vessel, with the objective of making cost projections in the early stages of the subject job.

II. STEEL PROCUREMENT

A. STEEL REQUEST

Engineering (Hull Section) prepares a Steel Request or Steel Summary from the advance hull drawings. The Steel Summary is grouped by unit, broken down in plates and structural, by grades. In the process of preparing the Steel Summary, Engineering does preliminary nesting of plates and structural in order that the most economical and feasible sizes are purchased.

The Steel Summary includes hull, superstructure, and also fittings and foundations which are normally drawn as part of hull drawings, such as main engine foundations or container guides.

B. SCREENING AND PROCESSING

Upon receipt of an advance copy of the Steel Summary, Steel Control inputs all requested items into a computer program for weight computation, sorting, and sequencing. All screening information is added to the program so that deviations of requested weights and purchase weights are accountable. Each Steel Summary item is assigned a specific date needed in yard (4 weeks prior to prefab), as per the Long-Term Schedule.

This computer run actually replaces the written steel request and it is used by Purchasing in order that Purchase Orders are issued in the same basic order as prefab.

Outfitting and fitting requests basically follow the same procedure as the Steel Summary. The request goes to Production Planning for the date needed in yard before it is screened by Steel Control. VIEWGRAPH NO. SC-1

C. PLANNING OF PROCUREMENT

In conjunction with the Long-Term Schedule and Process Lanes concept (using the Exxon contract as an example), it was established that the total steel (tonnage for 3 ships) for hull and superstructure purchasing would be divided into 5 "buys" of approximately 7,700 tons per "buy."

Green - 1st buy - portions of Hull 1 & 2

Pink - 2nd buy - portions of Hull 1, 2, & 3

Yellow - 3rd buy - portions of Hull 1, 2, & 3

Blue - 4th buy - portions of Hull 2 & 3

Orange - 5th buy - portions of Hull 2 & 3

VIEW GRAPH NOS. SC-2, SC-3, SC-4

A time frame schedule for all phases of procurement was determined by the prefabrication dates on the Long-Term Schedule. VIEW GRAPH NO. SC-5 The release of the Steel Summary from Engineering is to be 12 weeks before the commencement of delivery from the Steel Mill for a given "buy," or 22 weeks before prefabrication. The 12 weeks allow one week for Steel Control screening, one week for release of Purchase Orders by Purchasing, and 10 weeks for Steel Mills to schedule and roll.

Plates are normally rolled in 8 weeks. Structural are rolled in accordance with the Steel Mill's rolling schedule for that section of structural.

The computer run before mentioned is used for the expediting of the final delivery of "buy."

III. STORAGE OF STEEL

At the same time as the requesting and purchasing of the steel, the storage area is being elevated and organized to receive same. Grids for storage are set up by "Units" in the same order as the prefabrication of Units. Therefore, the storage area becomes available for future jobs as the subject job progresses.

Once again, using Exxon purchases as an example, we see in VIEW GRAPH NO. SC-6 that steel tonnage in storage would peak at 13,000 tons in the middle of the 3rd quarter. Receivment began in middle of 1st quarter and yard issues began in middle of 2nd quarter. VIEW GRAPH NO. SC-7

As the shipments are received from the Steel Mills, all plates are sorted and stored in their proper grid. Sorting is necessary because the Steel Mills ship with no date preference or order preference. Their rollings and shipments are governed by their production efficiency.

Structural are stored by sections, sizes, and grades. Unlike plates, a specific structural member is not allocated for a specific Unit until such time when it is picked up for delivery by the transfer system.

All job steels are certified upon receipt by matching the die-stamped heat numbers and grades on plates and structural with the mill certificates. Any non-conformances are stored in a temporary holding area until resolved.

Receiving reports are made in accordance to individual invoices and forwarded, to Accounting Department for matching and processing.

IV. STEEL TRANSFER SYSTEM

A steel transfer is a document, bearing an individual control or identification number, used for controlling the movement and accountability of any steel.

Upon receipt of the released U.C.M. from the Moldloft and in accordance with the Long-Term Schedule, the Steel Control Department prepares the necessary transfers for a given Unit. These transfers list purchased sizes of plates or structural for a given unit and specify which components of the unit are cut from same. At all times, a cross-reference between procurement and usage is maintained by use of the Steel Summary item number. Separate plate transfers are always written for different burning operations or functions (for example, tapeograph, exactograph, servograph, shears). Structural transfers require less of a breakdown because all cutting of structural is done in one area, under one supervisor.

Transfers are issued a minimum of three weeks before the scheduled start of prefabrication. This allows enough time for Production Engineering to process and time for the prefabrication supervisor to program into the burning schedule.

Copies of the transfers are forwarded to the Production Engineering Department who, in turn, writes work orders completing a work package. These work packages (work orders, transfers, and U.C.M.) are sent to the Prefabrication Department.

V. BLASTING, PAINTING AND DELIVERY

In accordance with their work load and schedule, the prefabrication supervisors will order out the transfers, designating the delivery location. This is normally done five work days before the burning date. Upon being ordered, transfers are put on an active or working board and a pick-up work sheet is made

in accordance to the ordered sequence of the prefabrication supervisor. Plates and structural are then picked up from their respective storage area and processed through the Plate and Structural Shot Blast Systems.

A Plate Shot Blast Sheet records all plates processed through Shot Blast. These sheets are used as a sign off or delivery acceptance by prefab supervisors and also used for computation of tons issued for the Weekly Steel Disbursement Report. Yard Movement Documents serve the same purpose as the Shot Blast Sheet for the accountability of structural.

VI. INVENTORY.

One of the important supporting services to any job progress is its inventory. The Kardex Card System is the main tool used in keeping inventory control. Information from the Purchase Orders are posted on the top card and always reflects quantities on order, summary item numbers, and unit numbers. As steel is received, all receiving reports are posted on cards, and as steel deliveries are made, the steel transfer is also posted. The Kardex Cards always reflect an on-hand balance and storage location. Physical counts are done annually and corrective action is prompt. VIEW GRAPH NO. SC-8

VII. STEEL HANDLING-PROCESS LANES

The efficiency of steel handling depends greatly on the detailed information available at the time of purchasing. We have progressed tremendously since the days of the steel request ordering square feet of plate and lineal feet of structural.

Up to the time of the Exxon contract, our Steel Summary was written to the drawing concept. For example, the shell expansion drawings for the entire ship would have been three drawings - forward, mid-body, and aft. Like-size plates would have been under one summary item number per drawing, regardless of the units involved. No unit breakdown was maintained.

In our concept of storing by units in the past, we did not accomplish our potential. We were creating over-size storage grids and much unnecessary digging in order to deliver required steel plates.

At present, with the Process Lanes implementation, drawings are produced by Units giving us a steel summary by units and allowing us greater efficiency in our storage area.

Our cost of receiving steel has increased by 8%. This is caused by our ordering sequence not being adhered to by the Steel Mills. Sorting of plates is required on arrival.

Our cost of delivering steel to the prefab work area has decreased by 16%. This reduction is realized because all the steel is stored by units.

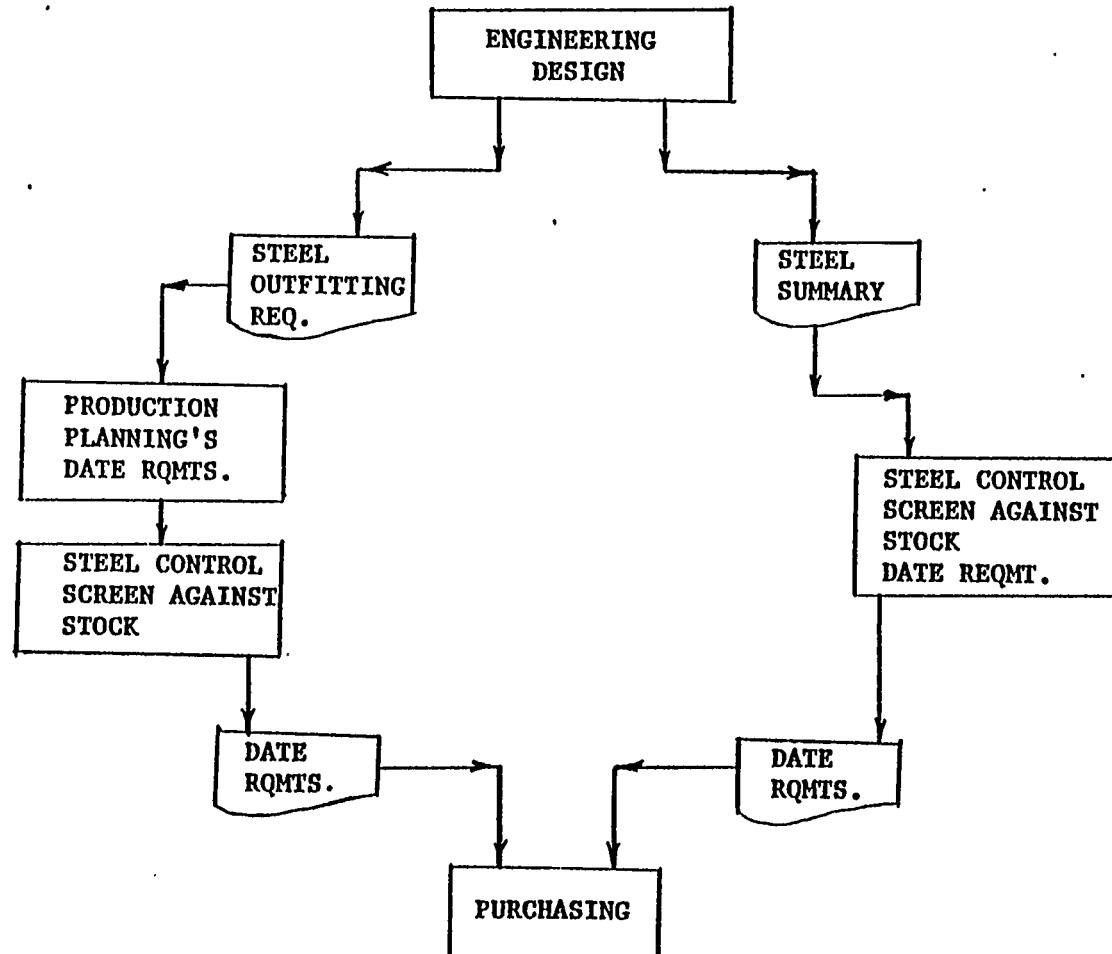
As a combined effort in receiving and delivery, we are realizing an 8% reduction in our handling of raw steel.

Also in the past, we were accustomed to spending 18% of our entire handling time, storing and delivering bevel plates. These were all deck, bulkhead, shell, innerbottom, and rectangular plates burned ahead of schedule. These plates were generated by multi-hull burning and out-of-sequence burning. With the elimination of multi-ship burning and proper scheduling, bevel plate storage has been completely eliminated.

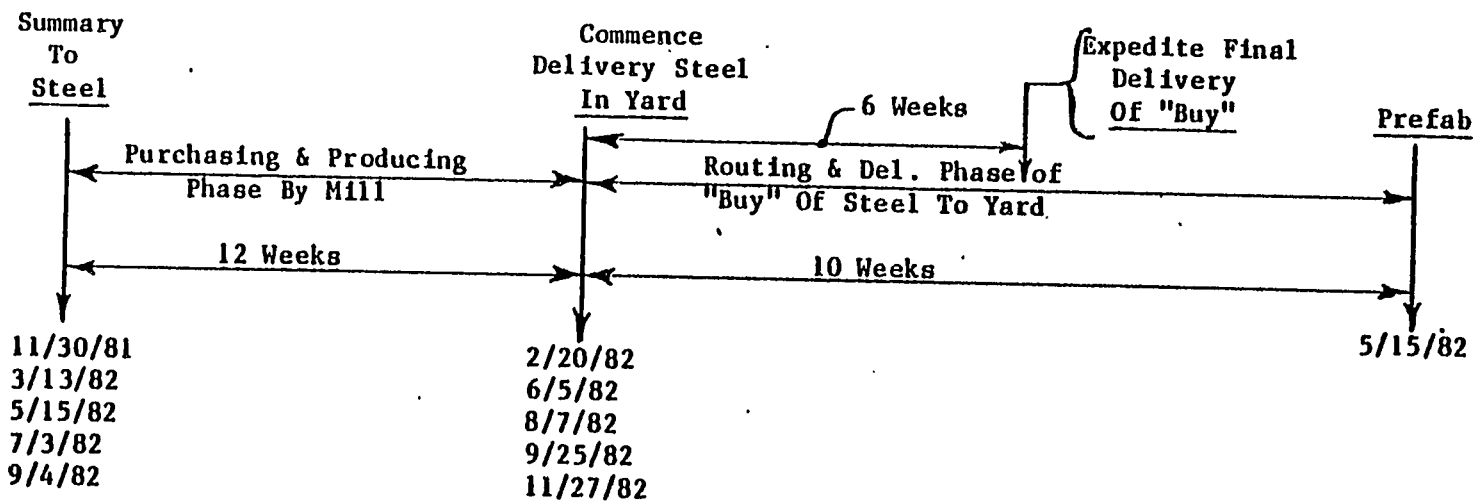
In conclusion, it is important for us to realize that steel handling is a major cost to shipyard operations. In many cases, it requires capital that is not working for the production operation; thus, steel handling procedures should be established which allows shipyard operations to work efficiently. It is imperative to have a steel control system which will insure that shipyard production is not hampered due to lack of the required steel.

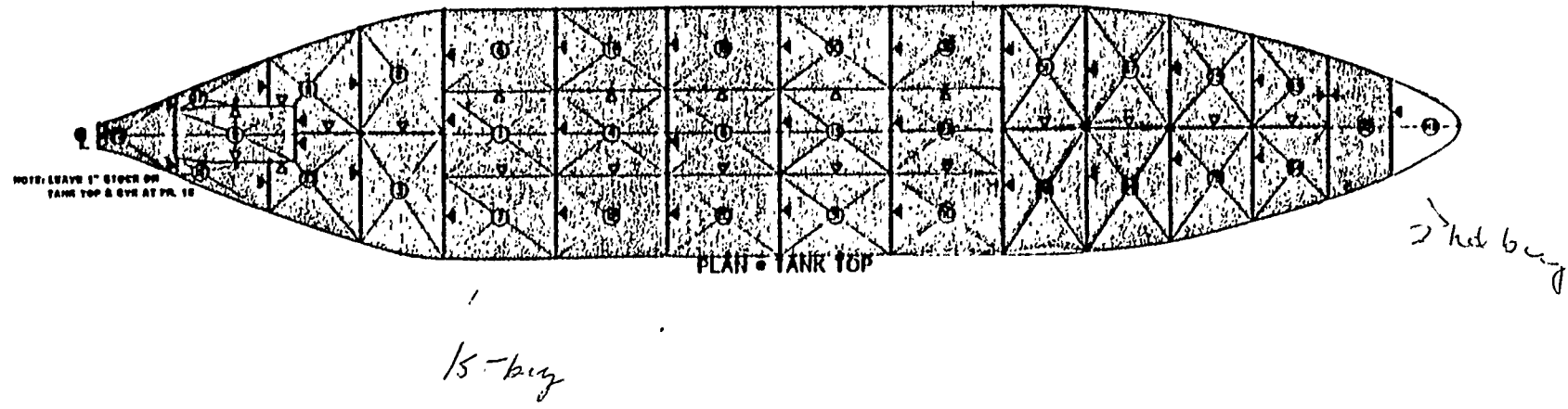
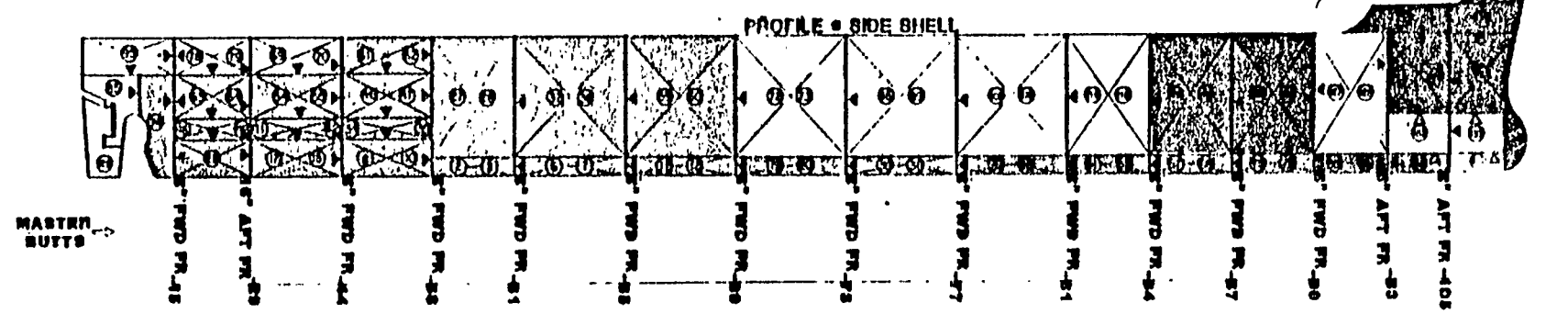
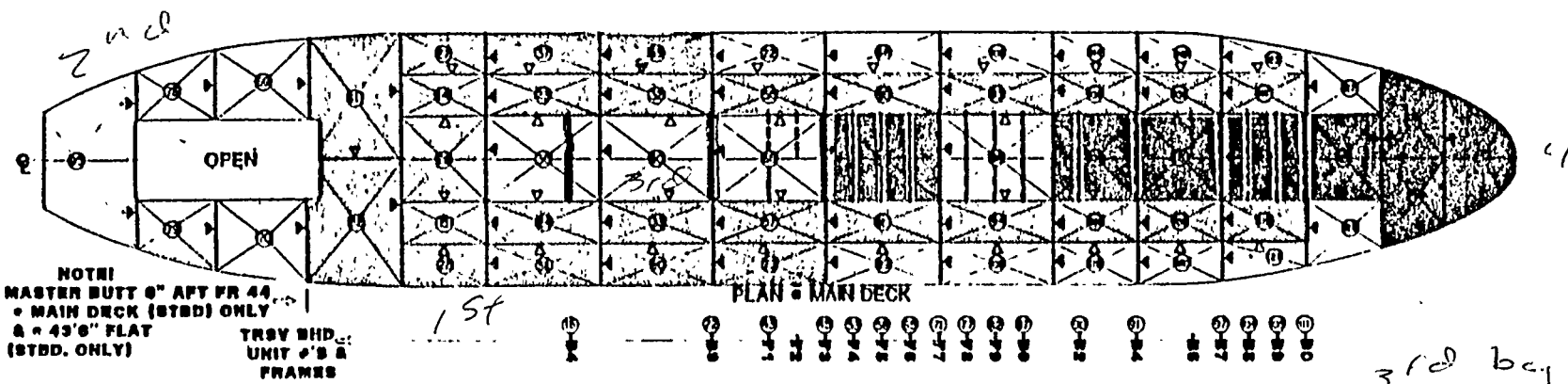
Process Lanes is certainly proving itself to be a cost saving method of ship construction at Avondale Shipyards on the Exxon contract, and I feel certain that with future jobs our efficiency will be evident throughout all stages of ship construction.

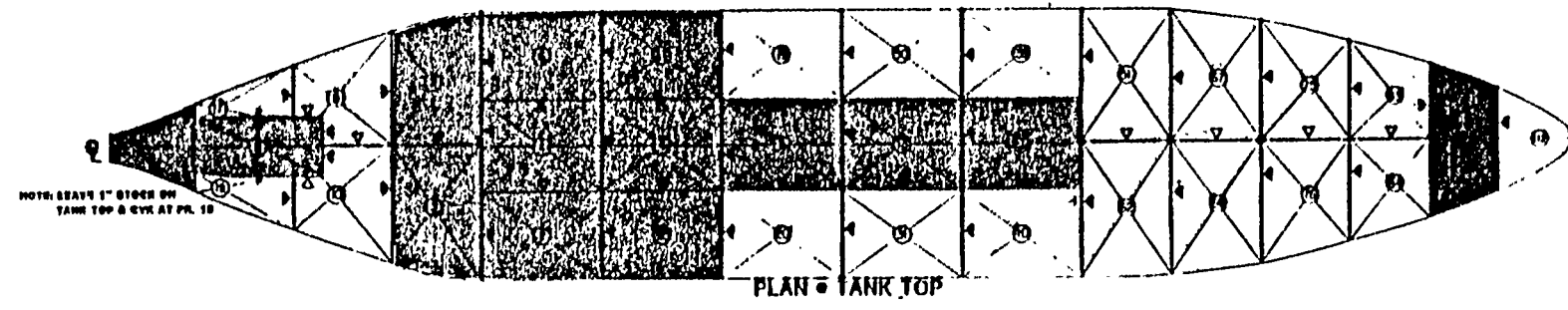
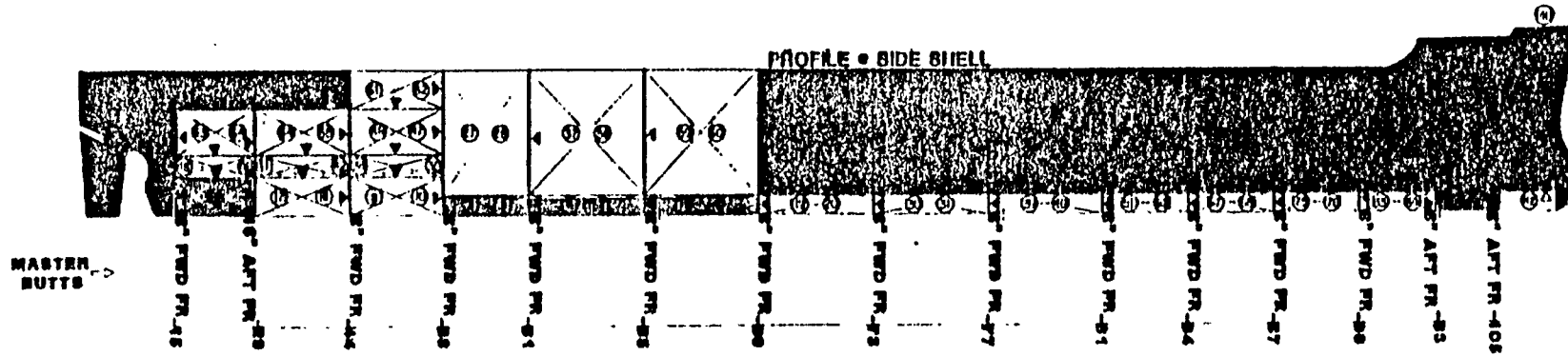
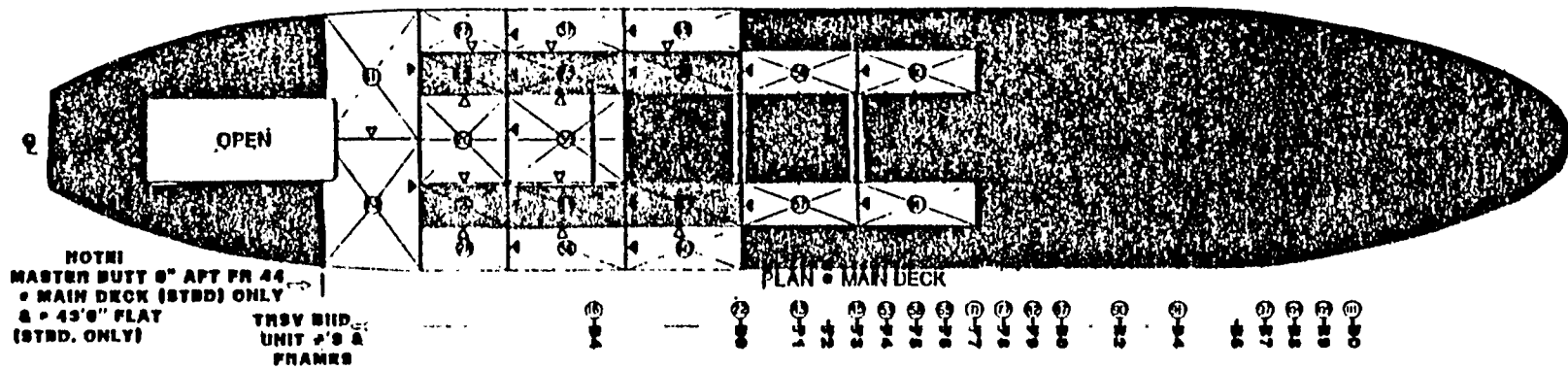
ADVANCE PROCUREMENT CYCLE



Procurement Schedule
Time Frame

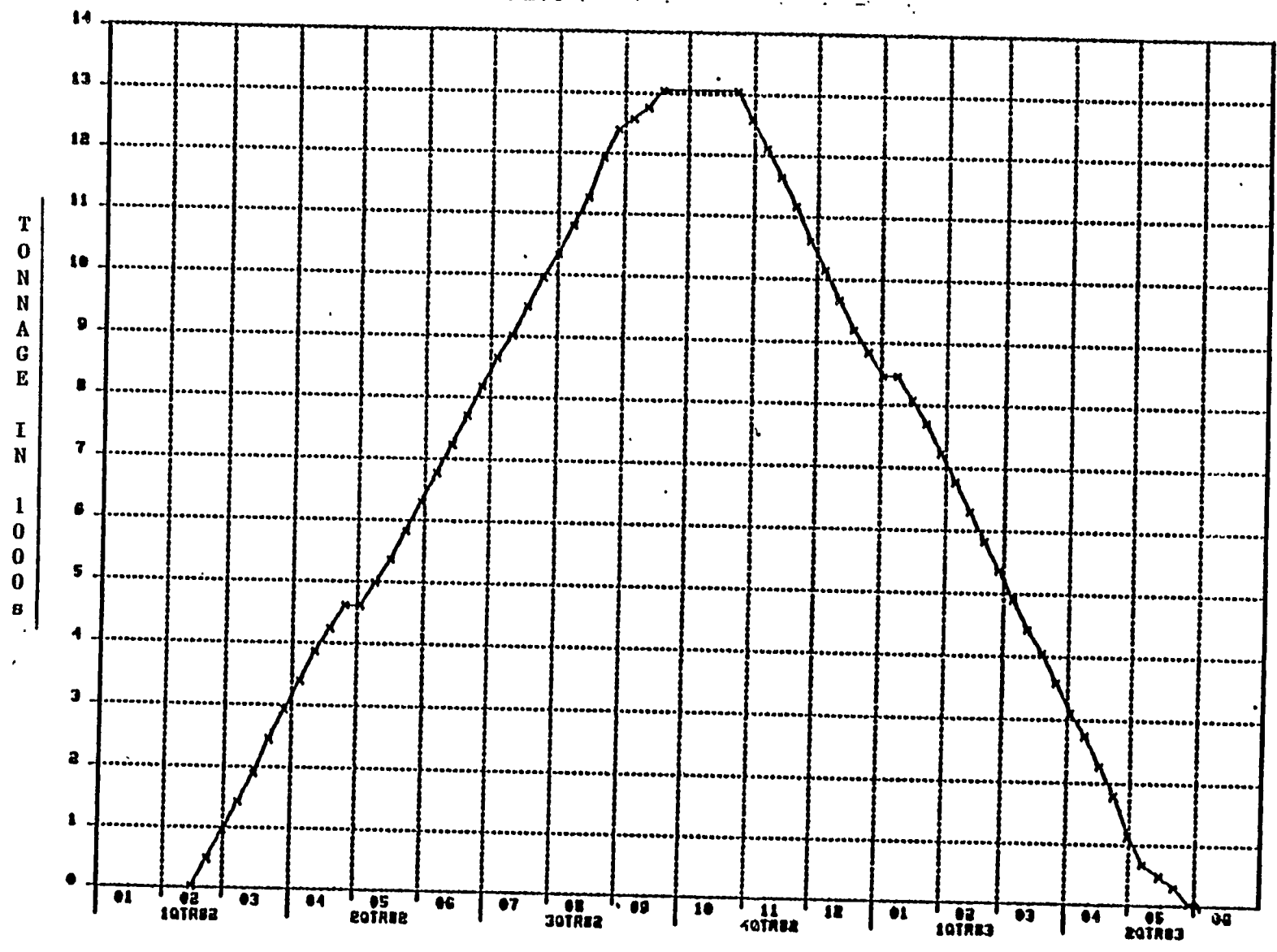




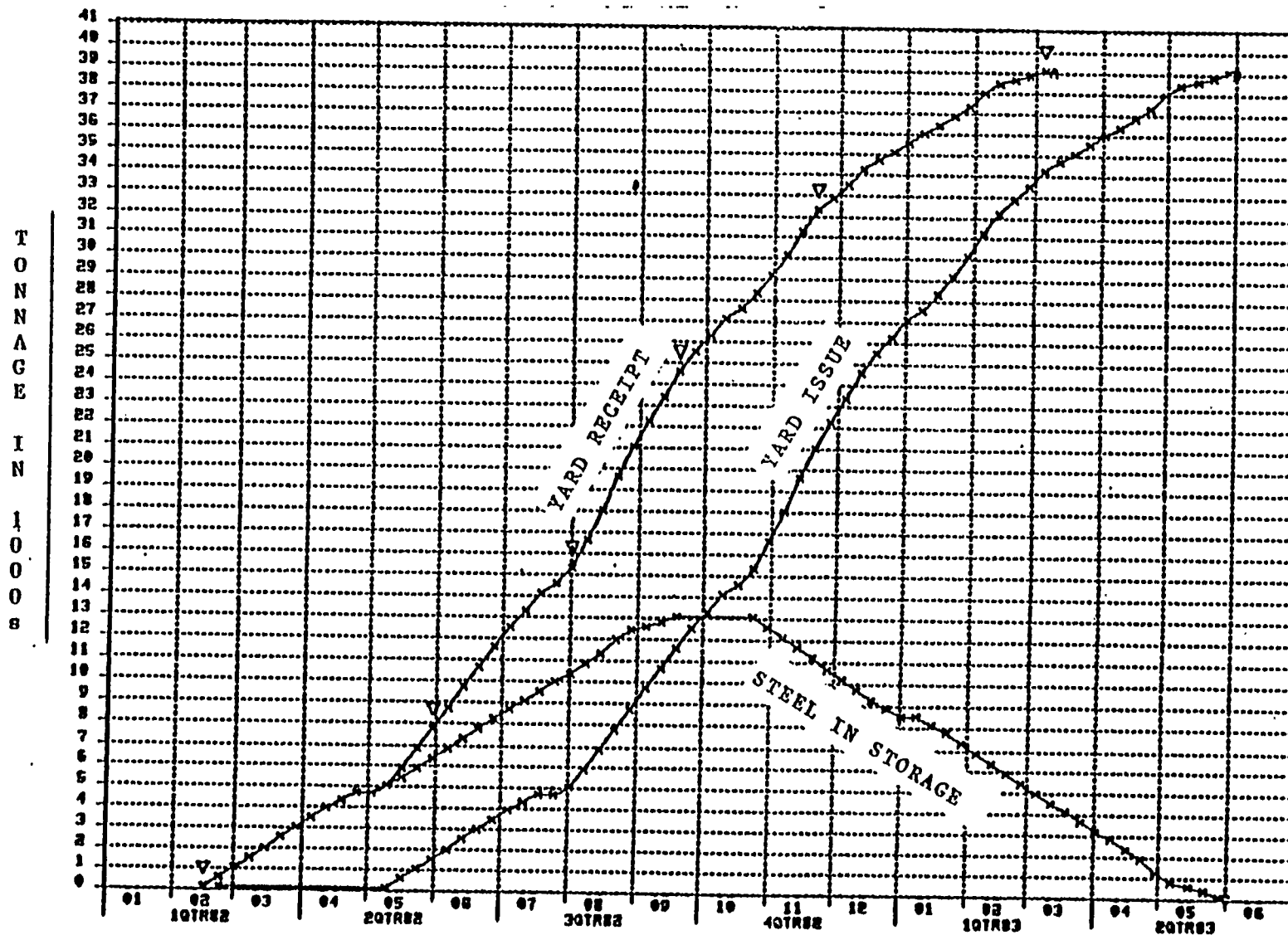


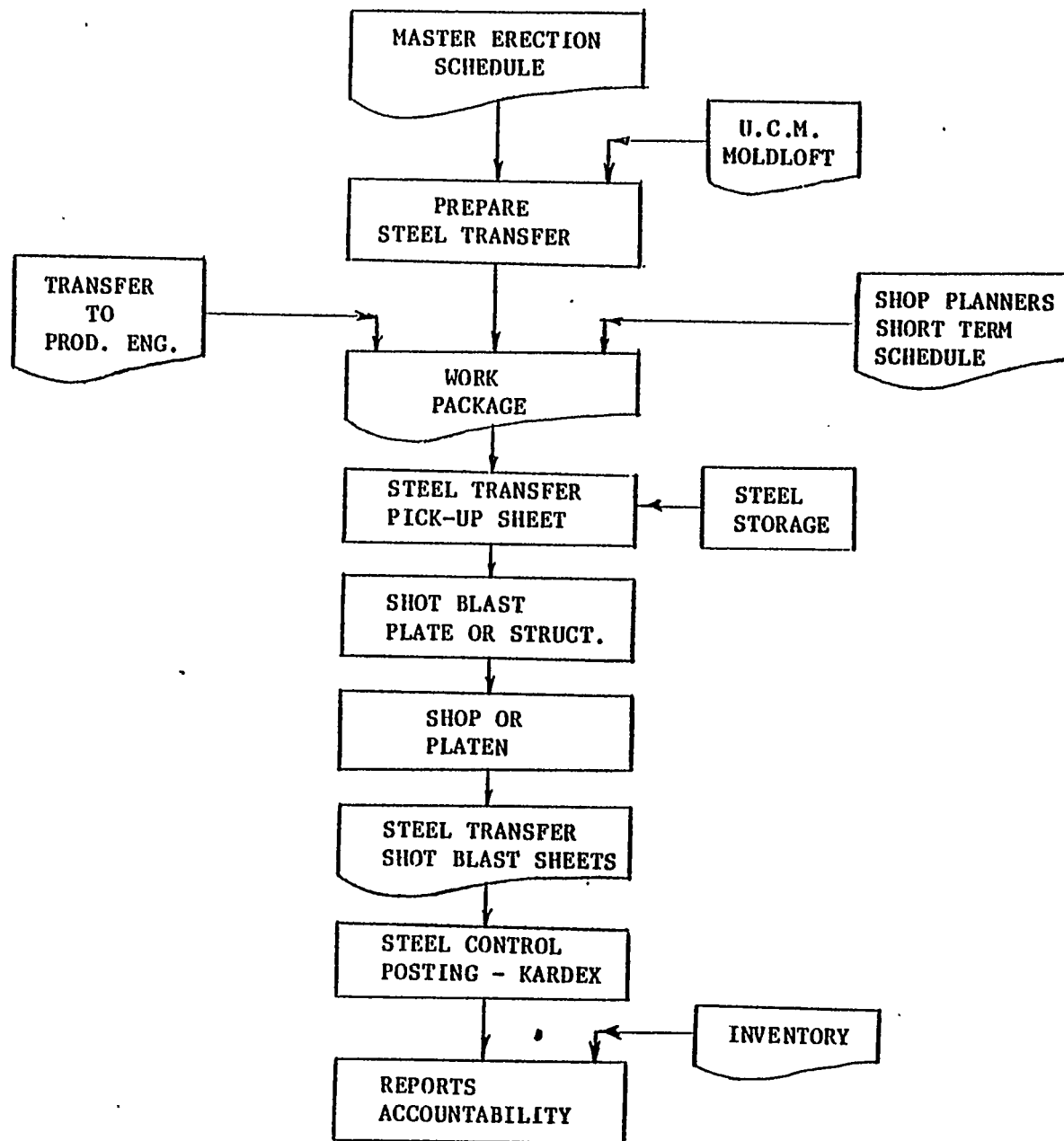
#6

CI-15 STEEL STORAGE REQUIREMENTS



C1-15 STEEL CURVES





MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
AVONDALE SHIPYARDS, INC.

PRE-FABRICATION DEPARTMENT
SHOP PLANNING, SCHEDULING AND PRODUCTION INTERFACE

Prepared by: E. TAYLOR and J. HARTMAN

MOLDLOFT, PRODUCTION CONTROL, ACCURACY CONTROL
PRE-FABRICATION DEPARTMENT
SHOP PLANNING, SCHEDULING, AND PRODUCTION INTERFACE

I. SUBJECT

Interface of Japanese technology concepts between Production Trades and the support activities at ASI (Production Planning, Production Engineering, and Moldloft).

Many phases of Japanese technology transfer have been presented in detail previously. Some of the phases will be repeated in general to better explain the interface of production activities.

II. INTRODUCTION

For a clear understanding, it is necessary to define the Shop Planner and the necessity for him in a complete production system.

The Shop Planner is the final link between production activities and the production support activities which provide necessary documents required at the various construction stages.

At the time basic production planning begins, the only documents available for hull planning are the contract drawings. Details are not yet available and will not be until feedback from hull planning in the form of unit breakdown sheets, based on these contract drawings and the yard production system, are sent to Hull Engineering.

Basic production planning is necessary to give proper direction to the sequencing and detail development of engineering drawings, construction methods and Unit Control Manuals (UCM's). Erection joints, master butts, unit arrangement, unit breakdowns, construction methods, and erection sequences are determined at an early stage by the Production Planning Department. This direction coordinates Engineering's scheduling of unit drawing development, material ordering, and sequencing to suit the construction needs at the various production stages.

The basic production planning procedure following and the section on Shop Planner duties and responsibilities will show the natural interface of the ASI Shop Planner and the development of the production documents necessary to manufacture the parts when needed, provide feedback required to monitor efficiency, hull status, completion, and accuracy control.

III. BASIC PLANNING PROCEDURES

A. PRIOR TO CONTRACT AWARD

1. Rough categorization of units (at the unit level) from contract plans.
2. Based on estimate weight, determine rough assembly schedule and key events. If different than customer desire, check to see disruption caused by modification.
3. Give all data to Estimating that concerns the amount of work projected in each category.

B. SUBSEQUENT TO CONTRACT AWARD

1. Firm up unit breaks and establish erection sequence and schedule based on level loading the erection area and maintaining key events.
2. Send data to Engineering
3. Upon receipt of key plans, firm up unit categories.
4. Categorize sub-units and partial sub-units.
5. Piece code the sub-units and partial sub-units and send the data to Engineering and Scheduling.

C. LONG TERM SCHEDULES

1. Group like units within each category.
2. List all units within each group by each stage of construction that the unit must encounter.
3. Utilizing the key plans and stage groupings, along with data collected from Outfitting Planning concerning the erection, the category recap sheets are made. (The category recap sheets is a listing of the unit groups within the categories by stage of construction.)
4. Determine the number of platforms necessary for each type of unit at each stage of construction.
5. Using the erection schedule plot the critical dates for the last construction stage prior to erection. Remember to account for blast and paint and pre-outfitting. The last construction stage for each unit is shown on the

sheet where the grouping of unit types by construction stage was accomplished. This is the last date that the unit can be completed and still meet the erection date.

6. Plot these dates against the weeks of schedule, using the standard work day.
7. Where the number of units exceeds the number of platforms available for that unit type, adjustments will have to be made to the start dates of units at that stage of construction. This will mean that some units' will be constructed early.
8. The first schedule to be completed is the Grand Assembly Schedule. The second is the main assembly schedule, and so on down the line. The main assembly critical dates are based on the erection dates, or if the unit has grand assembly, then main assembly critical date will be based on grand assembly start date. Sub-assembly critical date will be based on the established main assembly start date, etc.
9. The level loading of the work centers occur because units are scheduled across the entire contract by types within the categories, giving at any given point in time an even mix of those types being worked simultaneously.
10. This method of scheduling can be used for all hull construction, including conversions, jumboizing, etc.

D. FINAL PLANNING

As the yard plans are received, the planner can finalize the construction method to be used by the production effort by picking up and planning detail work that is not shown on the earlier key plan drawings, thus completing development of documents required for shop planning use.

The yard plans mentioned above are the final product of the Hull Engineering Section. These show all of the necessary details required by the Moldloft to develop the Unit Control Manual. These yard plans and subsequent UCM'S are the result of combining the Hull Planning Section's unit construction procedures, the Hull Technical Section's key plan, and the Hull Engineering Section's details. The UCM'S further clarify this information for use by the shop planners and the production activities.

IV. DUTIES AND RESPONSIBILITIES OF THE ASI SHOP PLANNERS

The basic areas of responsibilities for the Shop Planners are as follows:

A. THE ISSUANCE OF SHORT TERM SCHEDULES

The short term schedules prepared by the Shop Planners are detailed instructions to the work centers. A work center is instructed by way of the schedule work package indicating what portions of a unit to work, where to work them, and when to work them. This data is determined by the Shop Planner by utilizing the unit summary sheet, the long term schedules, the Unit Control Manual, and the status of active job sites. The length of time covered by these varies, depending on the stage of construction. For example:

- Pre-fabrication short term scheduling is accomplished over a three-week period and is refined and updated as information becomes available.
- Fabrication short term schedules cover a six-week period and are updated monthly.
- Assembly schedules, however, cover a three-month period. The assembly schedules are updated on a monthly basis.

IV. PRE-FABRICATION SHOP PLANNING

A. PRE-FABRICATION SHORT TERM SCHEDULING PROCEDURE (SPECIFIC)

Upon receipt of the Unit Control Manual, the following procedure is required to properly time phase the subsequent events necessary for cost accounting, material allocation, scheduling, completion, and work center efficiency.

Receive UCM'S fifteen (15) days prior to pre-fab cutting, indicated by the long term schedule.

Shop Planners then develop short term schedules by utilizing summary sheets and long term schedules to determine the needed dates at the first stage of construction. By the special instructions in the UCM, he determines the necessary cut date by allowing the established time required for each subsequent pre-fab operation such as punch, roll, line heat, or form. These dates are written on the cutting list by every piece to indicate the items due at various times and the routing to the next operation.

Also at issuance of UCM'S fifteen (15) days prior to pre-fab date, as per long term schedule, the Steel Section begins development of steel transfers to be issued to pre-fab planners twelve (12) days prior to pre-fab cut date.

The planner first pulls all N. C. tapes listed in the UCM'S. He then examines all pieces on the listed tape to determine the earliest need date of any one piece.

Note: this is necessary because subsequent pieces for sub-units and units may be nested together and are to be burned early and stored. All pieces listed on tapes are scheduled to cut with the earliest piece needed. All pieces cut early are marked on the tape to insure that when the sub-unit is scheduled, the piece will show as cut with earlier needed pieces and not be duplicated in the future.

The next step is to send a copy of the date-marked cutting list to Production Engineering, where it is used to insure all items are covered by work orders as scheduled and as a basis for filing work orders. This reduces Production Engineering logging and piece verification effort.

Upon determining the piece cut dates, the weekly pre-fab and panel line work packages are developed for each work center and become the schedule part of the work package. This is done based on the dates now indicated in the UCM. Upon receipt of the transfers twelve (12) days prior to pre-fab cut date, as indicated by long term schedule, the short term schedule is then adjusted to accommodate material type issued.

For example: $\frac{3}{4}$ x 4 F.B. cut out of $\frac{3}{4}$ " plate. This is shown as a structural in the UCM and is normally worked on structural platen. In this case, the piece will be layed out and burned from plate in the manual burn area of the Plate Shop, thus reducing material movement. Also, at receipt of material transfers twelve (12) days prior to pre-fab cut date, the material order list is compiled and given to steel stock yard five (5) days prior to pre-fab cut date.

The enclosed examples are weekly short term schedules, for various pre-fabrication stages. They are due to Production Engineering ten days prior to pre-fab cut date as indicated by the long term schedules.

The Production Engineer currently writes work orders based on the short term work package. Upon receipt of the pre-fab work package, Production Engineering distributes to the physical loft where all templates, servo, etc. are gathered and issued to the proper stage in time for preparation the next week. The prepared work orders are issued to pre-fab seven days prior to pre-fab cut date.

Upon receiving work orders, the pre-fab work center package is developed. The planner combines the short term schedule, copies of the appropriate Moldloft cutting sketches, copies of material transfers, and material order list, and the work order data processing time charge card. Upon completion of the work package, it is issued to appropriate foremen five days prior to pre-fab cut date for template and material preparation.

B. MATERIAL AND INFORMATION CONTROL

The Shop Planner via various forms of communication, such as correspondence and face-to-face communication, insures that proper material and information is received in the work centers in an orderly and timely fashion. This includes templates and UCM'S from the Moldloft, material transfers from the Steel Department, work orders from the Production Engineering Department, etc.

C. PROCESS CONTROL

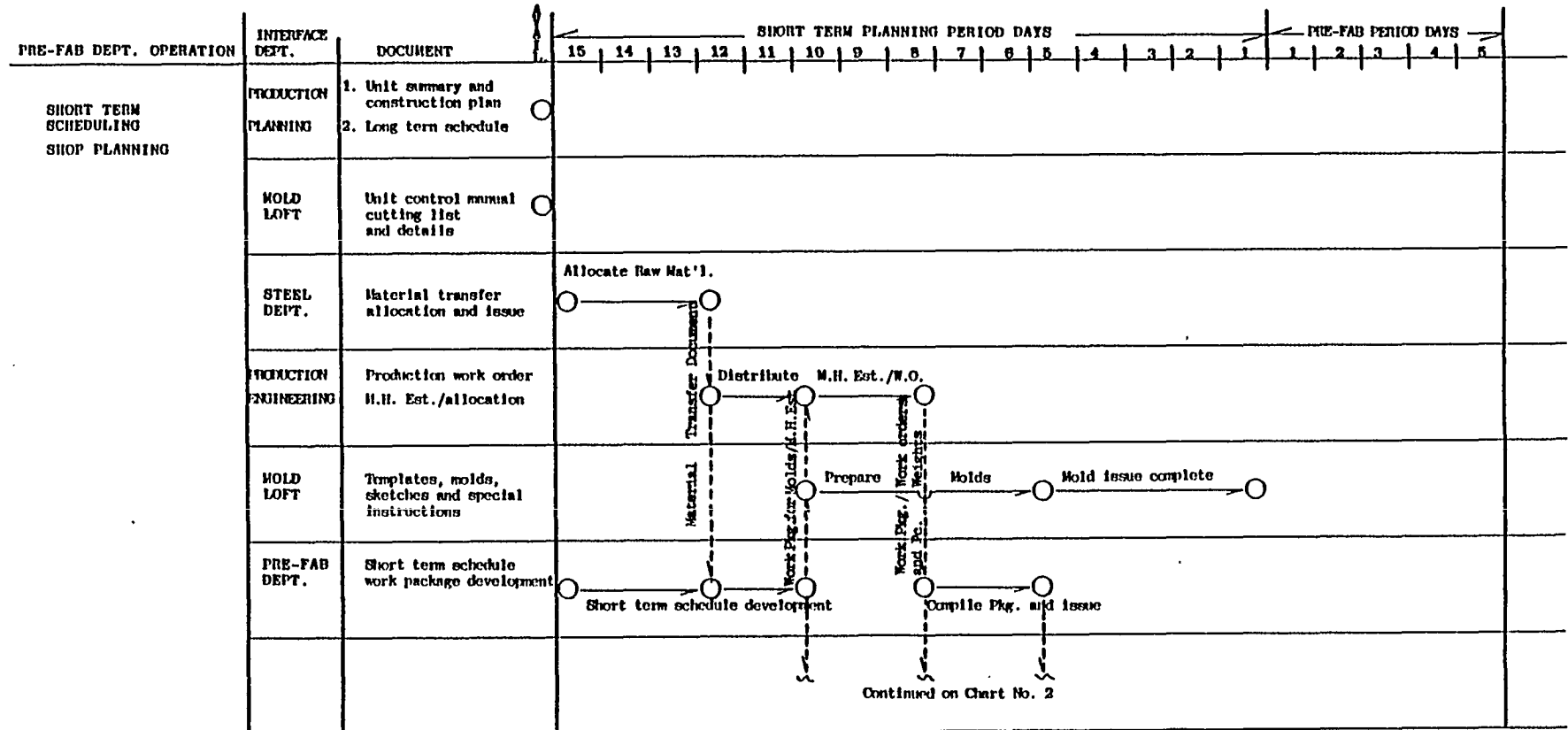
The Shop Planner, by use of completion data feedback from the various work centers, is able to determine on an accurate basis the status of units in relation to the projections made by the long term schedules. He also has the ability to see problems in the production effort by this feedback and on-site inspection of work centers. His information is then turned over to the appropriate action party for corrective measures.

D. EFFICIENCY CONTROL

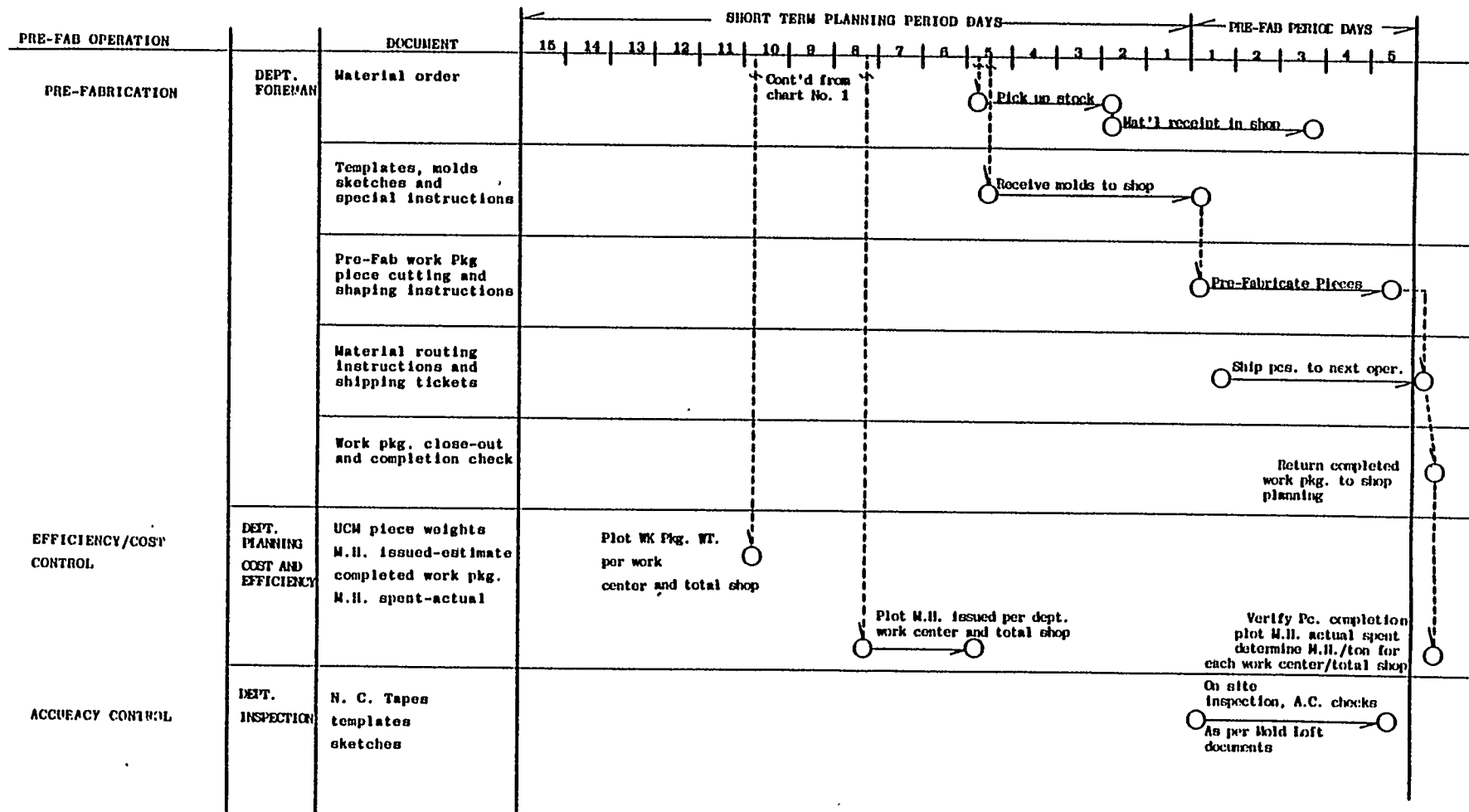
Efficiency control data is collected and correlated by the Shop Planners. The efficiency of the work center is judged in ways such as linear feet per manhour, or by manhours per ton. The method used is dictated by the work center. However, all hull work centers are judged on a manhours-by-tons-produced basis. With the cost centers being the same as the work centers, budget status can be maintained by use of this information and completion data. The charts and graphs utilized in efficiency control show trends in efficiency as they occur. Manning levels can also be adjusted by use of this data.

By virtue of constant inter-departmental communication, the Shop Planner also serves as a liaison in resolving everyday problems of production.

PRE-FABRICATION INTERFACE CHART NO. 1



PRE-FABRICATION INTERFACE CHART NO. 2



PRE-FABRICATION

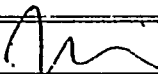
SHORT TERM

SCHEDULING

- WORK CENTER Structural
DATE 10-4-82

JOB	HULL	UNIT	TRANSFER	DIMENSIONS	LINE ITEM	GR.	QTY	MACH
C1-15	1	97	27689	✓ $\frac{1}{4}$ " F13@31.8x37'	1	A#32	3	
	1	97	27688	✓L 8x4x $\frac{1}{2}$ x24'10"	1	A#32	4	
	1	103	27456	✓FB $\frac{1}{2}$ x6x40	3,4	A36	6	
	1	103	27412	✓UM.875x10x30'2"	1	A#32	2	
	1	103	27414	✓UM.625x9x26'10"	1	A#32	1	
	1	103	27414	✓UM.875x10x30'2"	2	A#32	2	
	1	103	27415	✓UM.4627x14x32'7"	1	A#32	1	
	1	103	27457	✓FB $\frac{5}{8}$ x6x40	3	A#32	2	
	1	103	27457	✓FB $\frac{1}{2}$ x6x40	4	A#32	1	
	1	103	27457	✓FB $\frac{1}{2}$ x4x40	5	A#32	3	
	1	102	27451	✓ $\frac{F26}{F22}$.4627x17x $\frac{54}{32}$ x $\frac{5}{2}$	1	A#32	12	
	1	102	27451	✓ $\frac{F26}{F22}$.50x17x1x5 $\frac{1}{2}$ x36	2	A#32	6	
	1	102	27404	✓UM 875x10x30'2"	2	A#32	2	
	1	102	27450	✓FB $\frac{3}{4}$ x5 $\frac{1}{2}$ x21	6	A#32	1	
	2	20	26924	✓UM 625x9x48'3"	1	A#32	6	
	2	20	26928	✓ $\frac{1}{4}$ " F13@31.8x34'3"	1,2	A#32	2	
	2	20	26925	✓FB $\frac{5}{8}$ x6x40	1 thru 8	ABA	8	
	1	103	27413	✓UM.4627x14x32'7"	3	A#32	1	
	1	127	27489	✓L 7x4x $\frac{1}{2}$ x36'10"	1	A#32	4	
	1	127	27489	✓L 8x6x $\frac{1}{2}$ x33'2"	3	A#32	3	
	1	128	27714	✓FB $\frac{5}{8}$ x6x40	1,2	ABA	15	
	1	128	27712	✓FB $\frac{1}{2}$ x6x40	1	A#32	1	
	1	128	27712	✓FB $\frac{5}{8}$ x6x40	2	A#32	4	
	1	127	27490	✓ $\frac{1}{4}$ " F13@31.8x34'3"	1	A#32	1	
	1	127	27490	✓ $\frac{1}{4}$ " F13@31.8x32'8"	2	A#32	3	
	1	127	27490	✓ $\frac{1}{4}$ " F15@33.9x32'8"	4	A#32	3	
	1	127	27490	✓ $\frac{1}{4}$ " F15@33.9x36'11"	5	A#32	1	
	1	127	27490	✓ $\frac{1}{4}$ " F18@42.7x32'8"	8	A#32	4	
	1	77	27538	✓FB $\frac{1}{2}$ x8x34	2	A#32	1	
	1	82	27680	✓FB $\frac{1}{2}$ x8x34	2	A#32	1	
	1	82	27679	✓L 8x4x $\frac{1}{2}$ x40	1	A#32	7	

TRANSFER ASI 24 B (R 9/74)

Transfer No. 27489	Date 6/10/81	Transfer From H.H.	Code 	Hull No.	Transfer To C1-15	Code 02-02-03-000003	Hull No. 011	Voucher No. 1
ITEM NO.	LOCATION FROM TO		QTY.	DESCRIPTION			WEIGHT	UNIT PRICE
7131	ZB-18	J.G.	4	Angle 7 x 4 x 1/2 x 36'10" AH-32 Blast & Paint J. Taylor			2636	
				(Note: Cut In.1)				
7131	ZB-17	J.M.	3	Angle 7 x 4 x 1/2 x 39'0" AH-32 Blast & Paint			2094	
				(Note: Cut In.4,5,6)				
7134	ZB-61	J.M.	1	Angle 8 x 6 x 1/2 x 33'2" AH-32 Blast & Paint			2289	
				(Note: Cut LN.1)				
7132	ZB-18	J.M.	3	Angle 3 x 6 x 1/2 x 40'0" AH-32 Blast & Paint			2760	
				(Note: Cut In.4,5,6)				
Box				Unit #127 Rev. 0				
Delivery				Main Dk. Wing Fr 90-93				
A.D.				Hull #1				
Weighed By			Posted By			Priced By		
Extended By			Transferred By			Received By		

PRE-FABRICATION STRUCTURAL FRBD

DATE WRITTEN : 08/25/82

SUPPLEMENTARY INSTRUCTION SHEET

SHEET NO. 1

DATE RELEASED:

N/C ID: EXN1 3070-405-2

SEQ. NO.:

DEPT.:

COST GROUP:

ASSY. NO.: 012702-0

APPLY TO SHIP R. & P. SHT. NO.:

DWG. NO.: 127-005

HULL NOS.:

HSTR PC: 012702-000-12 (TSU)
COPY PC: 012802-000-12 (OSU)

TSU = MARK WELD ON BACK SIDE; OSU = MARK WELD ON FLANGE SIDE; +OFFSET = FROM WELD TO FLG.; -OFFSET = FROM FLG. TO WELD

----- INVERSE BEAM CONTOUR -----

LONG FRAME S 34 P ON SURFACE M P CHORD SPACING: 4/00/00 PT. OFFSET CHORD REFERENCE

BEAM SIZE : L 8X6X.5

END CUT TMPL. FOR HSTR PC. (TSU)

CLUSTER DWG. 3070-405-2

WELD -E-

FLG -F- 150CT

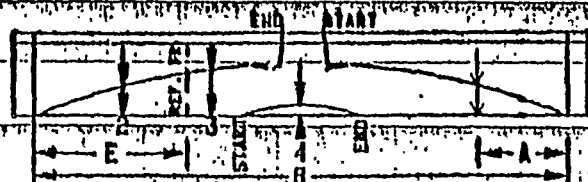
WELD -A-

FLG -A- 50CT

PT.	OFFSET	CHORD	REFERENCE
1	/00/00	/00/00	-F-
	/00/06	/04/09	F 92.9 *R
	/00/08	/06/00	END R
	/03/04	3/08/07	2 54.00 H024
2	/03/08	4/00/00	
	/05/08	6/11/01	2 57.00 H024
3	/06/02	8/00/00	
	/07/04	10/01/08	F 92
	/07/07	10/06/13	
END	/00/00	10/01/01	
STR	/00/13	12/00/00	
4	/01/07	14/06/06	2 64.00 H024
5	/01/11	16/00/00	
	/01/13	18/06/14	2 68.00 H024
6	/01/11	20/00/00	
	/01/01	22/09/01	F 91
7	/00/10	24/00/00	
END	/00/00	25/06/12	
STR	/07/07	24/11/00	
	/06/06	26/10/14	2 76.00 H024
8	/05/11	28/00/00	
	/03/06	31/00/06	2 80.00 H024
9	/02/09	32/00/00	
	/00/05	34/02/07	AET R
	/00/01	34/05/07	F 90.9
10	-/00/00	34/06/07	-A-

A	2/06/07		
B	34/06/07	LENGTH	STK REQ'D
E	/04/09	DIST. TO	F 92.9 FROM

** USE SKETCH # 3 **



SKETCH NO. 3

NO FORMING STOCK REQ'D

27489

SEP 28 1982

STRUCTURAL CUTTING LIST

LN	UNIT-SUB-PSU-PC	PRE FAB INFO	QTY	LOCATION	DIMENSIONS	SPECIAL INSTRUCTIONS					REMARKS	WGT	HALL
						P	R	F	L	K			
1	127-1-1-214	MICSK-35	4	LONG'L BHD	32' 7"	✓				✓	10/4. Punch	2333	"B16"
2	- - -												
3	- - -												
4	127-2-0-7	FR. BD.	1	SHELL	34'-1 1/4"	✓				✓	10/11 Punch	612	
5	127-2-0-8	FR. BD.	1	SHELL	34'-2 1/6"	✓				✓	↓	613	
6	127-2-0-9	FR. BD.	1	SHELL	34'-11 1/6"	✓				✓	↓	627	
7	- - -												
8	- - -												
9	- - -												
10	- - -												
11	- - -												
12	- - -												
13	- - -												
14	- - -												
15	- - -												
16	- - -												
17	- - -												
18	- - -												
19	- - -												
20	- - -												
21	- - -												
22	- - -												
23	- - -												
24	- - -												

LEGEND

P = PUNCH
 R = ROLL
 F = FORM
 LH = LINE HEAT
 K = KNUCKLE

△ = AMOUNT OF STOCK FOR N.T.-
 "DIMENSIONS" INCLUDES
 AMOUNT OF STOCK ADDED.

NOTE: THE LENGTH SHOWN ON THE MICSK IS TO BE USED FOR CUTTING PURPOSES & SUPERCEDES DIMENSION ON THE STRUCTURAL CUTTING LIST.

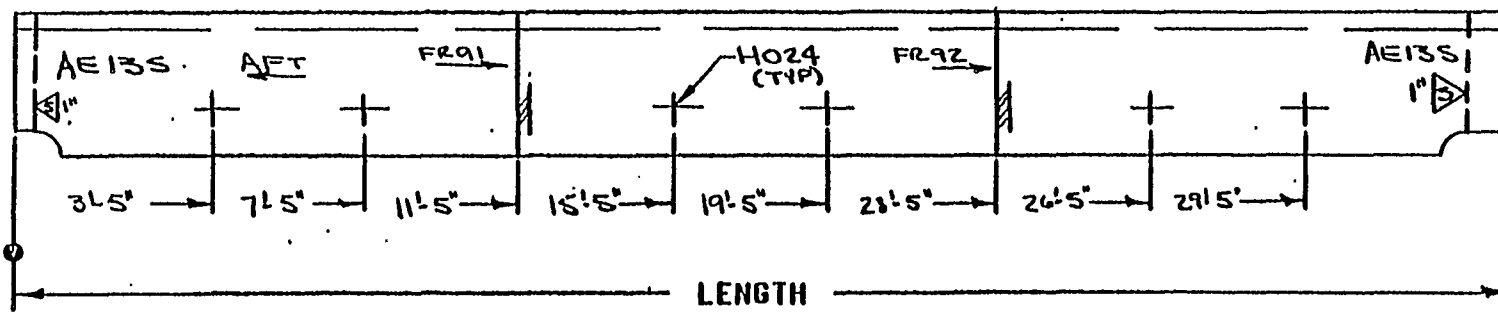
SIZE B	DRAWN BY T. DUFRENE	JOB C1-15	MATERIAL SIZE AND GRADE 7"X 4"X 1/2" L GRADE AH-32		ASI DWG NO CL 127 SII NO 29
	CHECKED BY M. J. J. J.				
		REVISION 1/1			
		0			

UCM

SEP 9 1982

MOLD LOFT CUTTING SKETCH								
△	LN	UNIT-SUB-PSU-PC	QTY	LOCATION	MATERIAL	GRADE	LENGTH	SPECIAL INSTRUCTIONS
	1	127-1-1-244	4	LONG'L BHD, FR 92 L-40, 39, 38, 37	7x4x1/2 L	AH-32	32'-7"	PUNCH HULLS 'B' & 'G' ONLY
	2	127-1-1-245	3	LONG'L BHD, FR 92 L-36, 35, 34	8x6x1/2 L	AH-32	32'-7"	PUNCH HULLS 'B' & 'G' ONLY
	3	127-1-1-247	3	LONG'L BHD, FR 92 L-32, 31, 30	13x4x3/8 C/L	AH-32	32'-7"	PUNCH HULLS 'B' & 'G' ONLY
	4	127-1-1-248	3	LONG'L BHD, FR 92 L-29, 28, 26	15x3 1/2 x 3/8 C/L	AH-32	32'-7"	PUNCH HULLS 'B' & 'G' ONLY

(FOR CONTINUATION SEE SH-T-2)



SHOP ORDER

intendant
Taylor. 12

• *Null*

YOU ARE INSTRUCTED TO PERFORM THE FOLLOWING WORK:

[illegible]

SEP 27 1982

SEP 27 1982 - TOTAL HOURS ALLOWED, Including Supervision → 541.6

GENERAL INSTRUCTIONS:

GENERAL INSTRUCTIONS:

ABOVE Pcs Burn Per SHORT TERM Sch FOR
Week of 9-27-82

NOTE: Foreman to report actual date started, inspected and completed. Return to Production Dept. office when completed.

DATE STARTED

DATE INSPECTED AND COMPLETED

Signed

DATE 10-5-82
 JOB C1-15
 W/O 44947 HULL 1
 QTY, LW 1 MI
 DEST. 127-RTN-16
 128-STORE

DATE
 JOB
 W/O HULL
 QTY, LW MI
 DEST.

DATE
 JOB
 W/O HULL
 QTY, LW MI
 DEST.



HULL 1 UNIT 127+128

PRE-FABRICATION WORKCENTER SCHEDULE

OPERATION: N/C 2 AxisSCHEDULE DATE: 9/27/82

TRANSFER NO.	LINE NO.	NO. PLS.	PLATE DIMENSIONS	GRADE	LOFT INFORMATION
			96" X 35' X .4687	AH-32	1611280

ROUTING INFORMATION - Unit 127 - PLATEN 16
Unit 128 - STORAGE

B.D.B.

SIGNATURE

9/6/82

DATE PREPARED

PRE-FABRICATION MATERIAL ORDER SHEET

WORK CENTER Plates

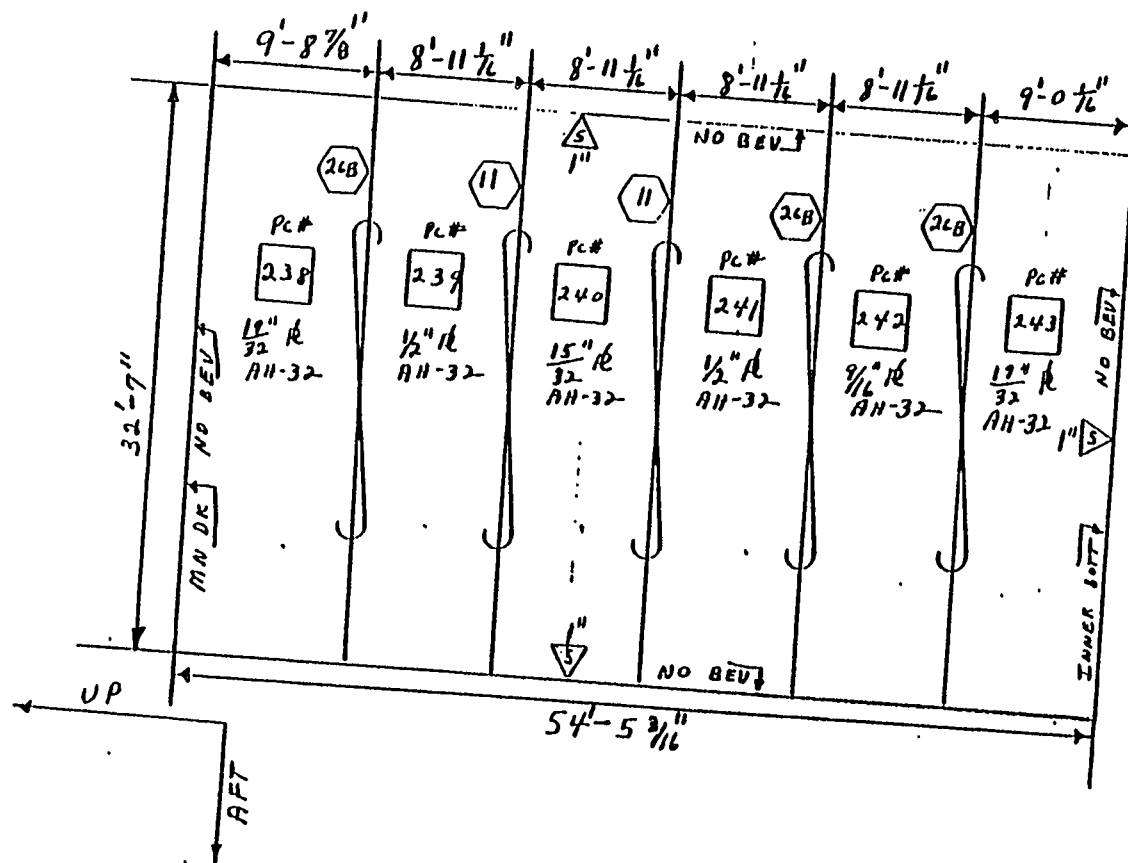
DATE 9-27-82

PAGE 2

JOB	HULL	UNIT	TRANSFER	DIMENSIONS	LINE ITEM	GR.	QTY	MACH
C1-15								
	2	20	26922 ✓		1	AH32	1	exacto
	2	30	26983 ✓		2	AH32	4	exacto
	2	31	26997 ✓		2	AH32	4	exacto
	1	127/128	27475 ✓	1300	1	ABA	1	2 axis
	1	127/128	27474 ✓	1292, 1273, 1274 1285, 1286, 1287	1 thru 7	AH32	11	2 axis
	1	127/128	27473 ✓	8720, 8724, 8725	1, 3, 4	AH32	6	3 axis
	1	127/128	27473 ✓	8721 *	2 Partial order *	AH32	2	3 axis
	1	127/128	27469 ✓	1279, 1280, 1284, 1283 1291, 1272, 1271, 1282 1274	1 thru 8	AH32	13	2 axis
	1	127	27468 ✓	1275, 1278	1, 2	AH32	2	2 axis
	1	127/128	27460 ✓	1297, 1281, 1290	1, 2, 3	AH32	3	2 axis
	1	127	27462 ✓	1296	1	A36	1	2 axis
	1	127/128	27461 ✓	1289	1	AH32	2	3 axis
	1	85	26383 ✓	1119.	4	1	1	3 axis

TRANSFER ASI 24 A (R 9/74)

Transfer No.	Date	Transfer From	Code	Hull No.	Transfer To	Code	Hull No.	Voucher No.	
27469	9/10/82	A.D.			61-15			V	
ITEM NO.	LOCATION FROM TO		QTY.	DESCRIPTION				WEIGHT	UNIT PRICE
7059	21-L	J.S.	1	sht. 2 of 2 Plate .4687 x 96 x 35'0" AH-32 Blast & Paint				5359	
				Cut 1 Plate Tape #1611280 Rev. 0					
7056	21-L	J.S.	2	Plates .4687 x 85 x 20'4" AH-32 Blast & Paint				5514	
				Cut 2 Plates Tape #1611279 Rev.0					
7076	21-L	J.S.	1	Plate .5313 x 98 x 29'0" AH-32 Blast & Paint				5138	
				Cut 1 Plate Tape #1611294 Rev.0					
Orgeron				Main Dk. Wing Fr. 90-93					
Dewey				Unit#127/128 Sub-1 Rev.0					
A.D.				Hull #1					
Weighed By			Posted By			Priced By			
Extended By			Transferred By			Received By			



SEP 9 1981

PRE-FABRICATION
COST AND EFFICIENCY
CONTROL

T-BEAM FABRICATION DAILY WORKCENTER STATUS

DATE _____

TOTAL MANHOURS SPENT

NUMBER OF BEAMS

TOTAL LINEAR FEET

MANHOURS LOST DUE
TO DOWNTIME

TRANSFERS COMPLETED

TRANSFERS STARTED BUT
NOT COMPLETED

TRANSFERS NOT
STARTED

WORKORDER NUMBER

JOB NUMBER

EXPLAIN DOWNTIME AND ACTION TAKEN:

NON-PRODUCTION LOST TIME IN MANHOURS

1	MACHINE MALFUNCTION	
2	COLD	
3	RAIN	
4	unload trailer OTHER clean out blaster	

SIGNATURE OF SUPERVISOR

Distribution:

Original: Superintendent

Copy: Retain in file

ACCURACY CONTROL FOR PANEL BINS

TYPE OF PANEL

 Shell
 Main Deck
 Tank Top
 Trans. Bhd.
 Long. L'Bhd.
 Flat's W. L.

HULL #

UNIT #

DATE:

INSPECTOR:

NO. OF PL.'S PER PANEL

NOTE ALL PROBLEM'S W/E SIZE'S:

PROBLEM'S W/BEVEL'S:

PROBLEM'S W/E OR PANEL SQUARES:

PROBLEM'S W/PANEL STOCK (excessive plate):

PROBLEM'S W/STIFFNER SIZES, LENGTHS, OR DECLIVITY:

DATUM OR CONTROL LINES LAYED OUT: NAME:

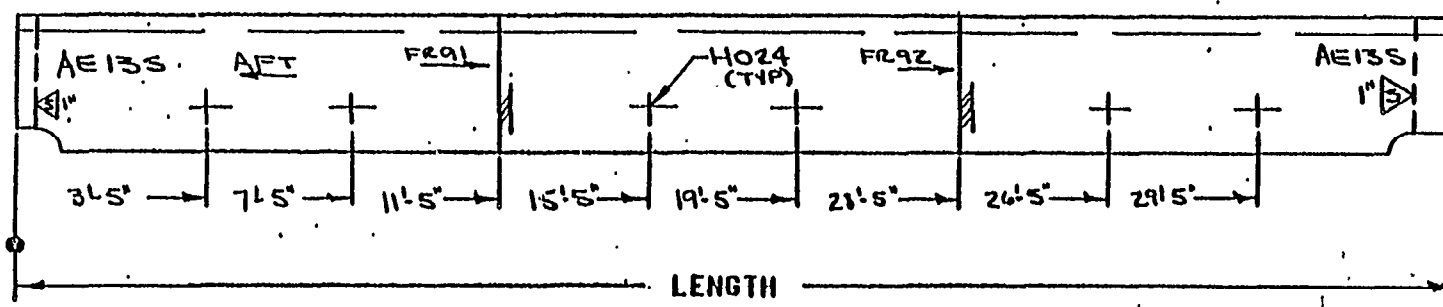
PROBLEM'S W/MOLD LOFT'S BATTENS OR PANEL LINE SKETCHES:

REMARKS:

SEP 9 1962

MOLD LOFT CUTTING SKETCH							
LN	UNIT-SUB-PSU-PC	QTY	LOCATION	MATERIAL	GRADE	LENGTH	SPECIAL INSTRUCTIONS
1	127-1-1-244	4	LONG'L BHD, FR 92 L-40, 39, 38, 37	7x4x1/2 L	AH-32	32'-7"	PUNCH HULLS 'B' & 'G' ONLY
2	127-1-1-245	3	LONG'L BHD, FR 92 L-35, 35, 34	8x6x1/2 L	AH-32	32'-7"	PUNCH HULLS 'B' & 'G' ONLY
3	127-1-1-247	3	LONG'L BHD, FR 92 L-32, 31, 30	13x4x1/2 C/L	AH-32	32'-7"	PUNCH HULLS 'B' & 'G' ONLY
4	127-1-1-248	3	LONG'L BHD, FR 92 L-29, 28, 26	15x3 3/8x33.9 C/L	AH-32	32'-7"	PUNCH HULLS 'B' & 'G' ONLY

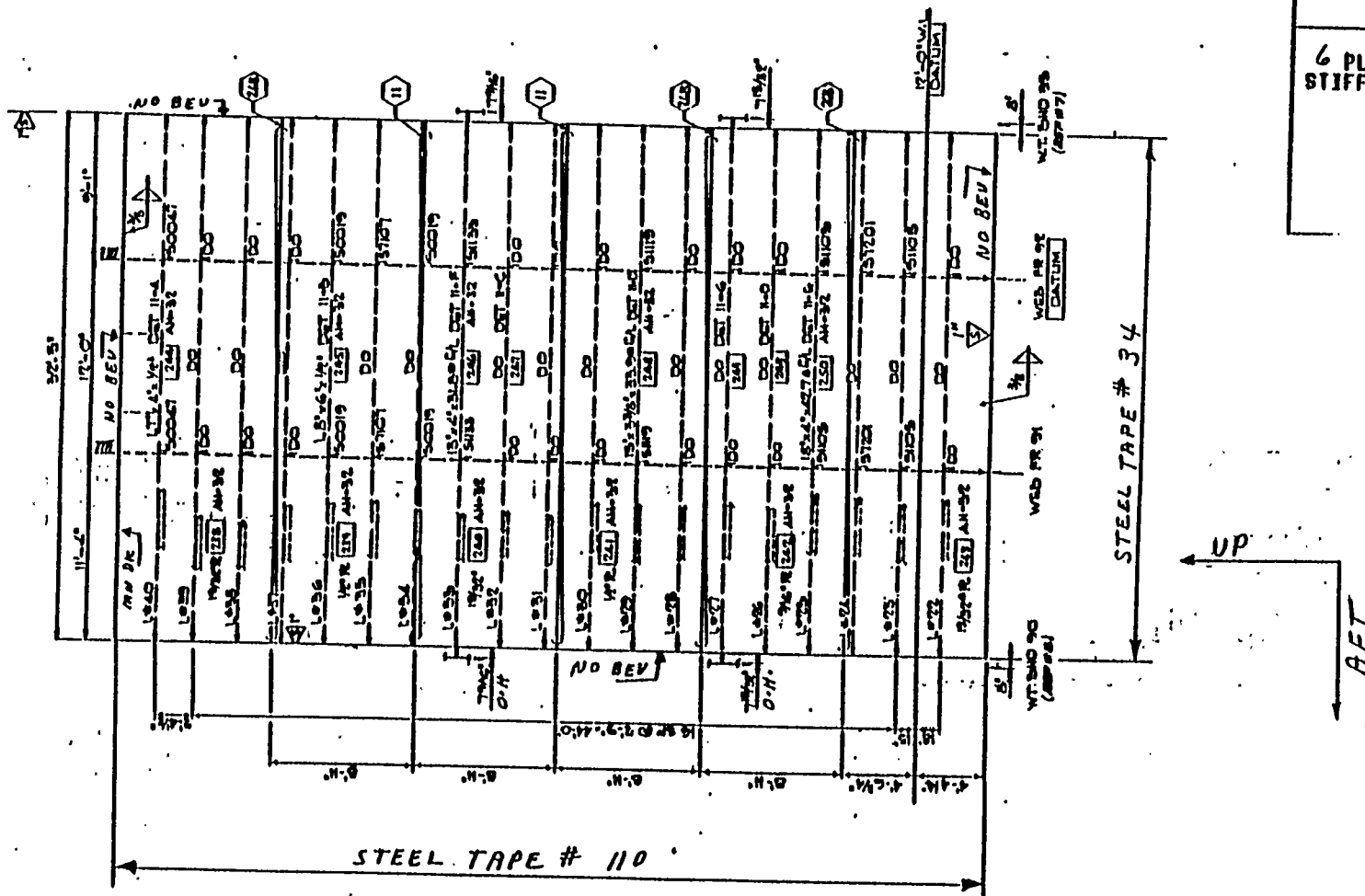
(FOR CONTINUATION SEE SH-T-2)



SEP 9 1982

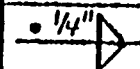
NOTES

6 PLATE PANEL
STIFF OTHER SIDE



DETAIL 10-A
LOUGHRAN DIP (PORT LUG OUTLET)

TYP WELD



3171

DRAWN BY
D. TASSIM

CHECKED BY
ELMET

JOB 61-15

141410E

LONG'L BHD 18'-6 $\frac{1}{4}$ "
OFF E PORT
FR'S 90-93

ASI DWG NO
PL/27-1-1
SHT NO 5

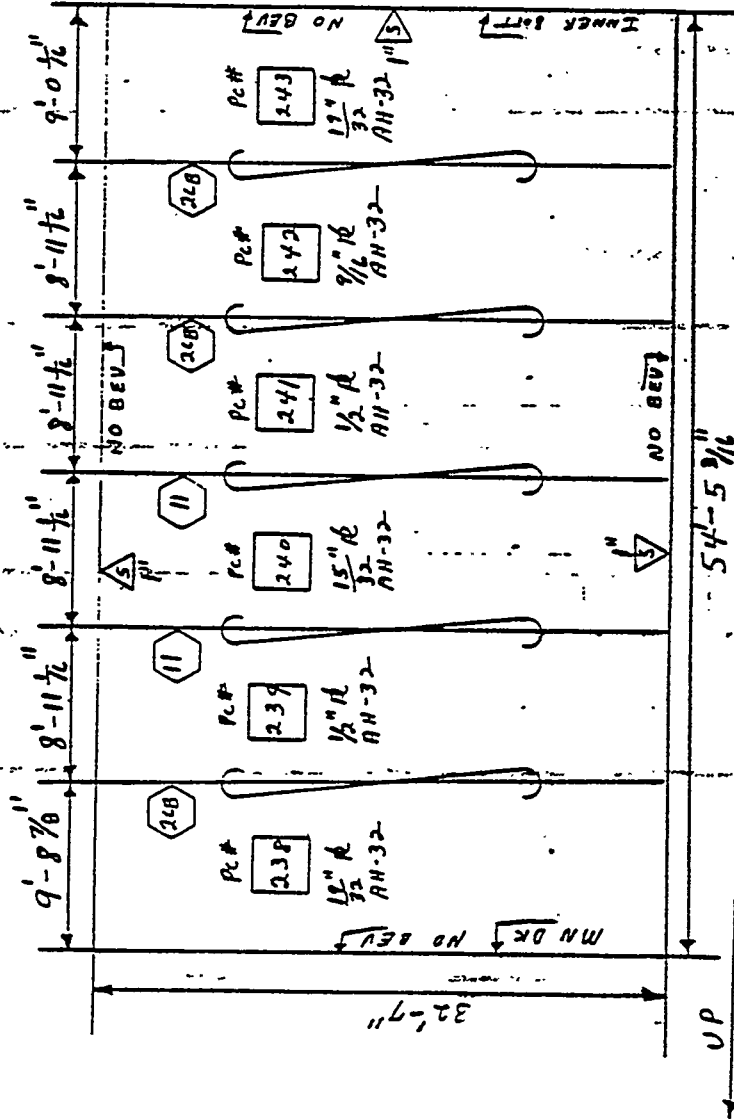
1876 - 1913

PLATE BURNING QUALITY INSPECTION REPORT

[illegible]

"NOTE"
STIFF OTHER SIDE

UP RIVER



ASI DWG NO
PL 127-1-1
SHT NO 4

LONG-L AND 18'-6 1/4"
OFF OF PORT
FR's 90-93

JOB CI-15

DRAWN BY
D TASSIM
CHECKED BY
E. CUFF

TYP WELD	B
	

WORK SHEET NO. 1 9/61

OCT 29 1984

NOV 20 1984
DEC 7 1984

**Transportation
Research Institute**