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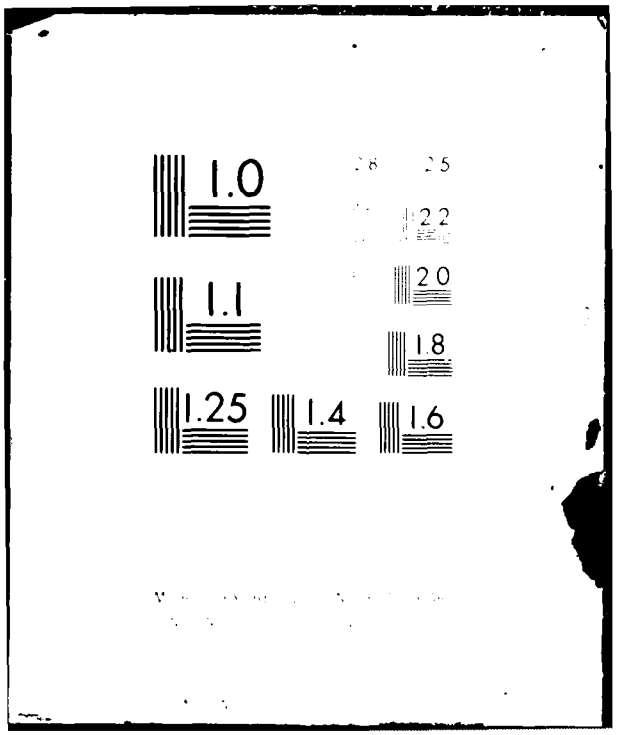
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REPORT NO. S 346-79
SEPTEMBER 1981

AD A111731

MATERIAL HANDLING IN DRY DOCKS

BY

THOMAS SPAIN, I.E.

FINAL REPORT

A PROJECT OF THE
MANUFACTURING TECHNOLOGY PROGRAM
NAVAL SEA SYSTEMS COMMAND

MARE ISLAND NAVAL SHIPYARD
VALLEJO, CALIFORNIA 94592

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ABSTRACT

This project, under the Production Engineering Department, Mare Island Naval Shipyard, conducted a study of material handling operations and equipment in dry dock areas and on shipboard during ship overhauls to identify improvements which would reduce manhour requirements and decrease overhaul duration.

The study included survey trips to Long Beach, Philadelphia and Puget Sound Naval Shipyards and telephone inquiries to the remaining shipyards.

The study results show that substantial benefits can be realized by improving material handling operations. However, the improvements are not quick fixes or isolated projects. They are projects that will require strong project management, top level support and all the effort that is required to make some changes in the way shipyards operate.

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FOREWARD

This is the final report of work completed under Naval Sea Systems Command Work Request N0002470WR9666 to identify segments of drydock material handling which may be improved to achieve reductions in overhaul costs and duration. The study was performed by Mare Island Naval Shipyard, Production Engineering Division, Vallejo, California under the auspices of the Manufacturing Technology Program, project DNS-00346.

NAVSEA, Mare Island, Puget Sound, Long Beach, Portsmouth, Norfolk, Philadelphia, Charleston, and Pearl Harbor Naval Shipyards and many employees from these shipyards are all gratefully acknowledged for their information and assistance contributions.

Thomas Spain

THOMAS SPAIN, I.E., Project Manager

Kurt Doehnert

KURT DOEHNERT, I.E.

"This Manufacturing Technology report
has been reviewed and is approved."

ROY MacGREGOR
Head, Production Engineering Division, Code 380
Mare Island Naval Shipyard
Vallejo, California

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LIST OF ABBREVIATIONS

NAVSEA	Naval Sea Systems Command
MT	Manufacturing Technology
MH	Material Handling
MHE	Material Handling Equipment
IPS	Industrial Planning System (formerly SMS)
SSN	Nuclear Attack Submarine
SEAMOD	Sea Systems Modification and Modernization by Modularity
NS	Naval Shipyard
AS/AR	Automatic Storage/Automatic Retrival
PRODEPT	Production Department
DMCC	Dry Dock Material Control Center
MIS	Management Information System
ILS	Integrated Logistics System
SCIMI	Sea Water Component Integrity Measuring Instrument
SEAMISTS	NAVSEA Material Identification, Storage, and Tracking System
DD	Dry Dock

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SECTION I

INTRODUCTION

1.1 Study Objective. The stated goal of this study is "to identify M/H improvements which would reduce manhour requirements and decrease overhaul duration." In order to get some idea of the relative and absolute size of the potential benefits, some preliminary cost estimates were made and a sensitivity analysis conducted. The calculations are shown in more detail in appendixes A and B. The analysis looks at potential benefits in three general areas. These are:

a. Improved ship availability due to shorter overhauls

b. Increased direct shop productivity due to improved material handling services

c. Reduced material handling (rigging) labor due to better methods and equipment

1.2 General Cost Analysis. Appendix "A" provides a general overview analysis of the operating costs for the eight naval shipyards in 1979. Figure 1-1 provides a graphical display of the results of this analysis. It divides the operating expenses into four general categories. These are:

a. Material and contractual costs

b. Indirect labor costs

c. Direct labor costs (less ships riggers cost)

d. Ships riggers costs

Categories "c" and "d" are the ones most likely to be affected by improvements in M/H methods.

Appendix "B" provides a general analysis of the costs of capital of ships undergoing overhauls. The costs vary greatly depending on the cost of the ship and assumed interest rate. Assuming a ship cost of $200,000,000 and an interest rate of 10%, the cost of capital for that ship is $58,000 per day. With 54,000 ships overhaul days planned in the next three years, the cost of capital for ships undergoing overhauls is $1,044,000,000 per year. It follows from these figures that a 1% reduction in each of these cost categories would result in the following benefit:

[SHIPYARD OPERATING COST BREAKDOWN]

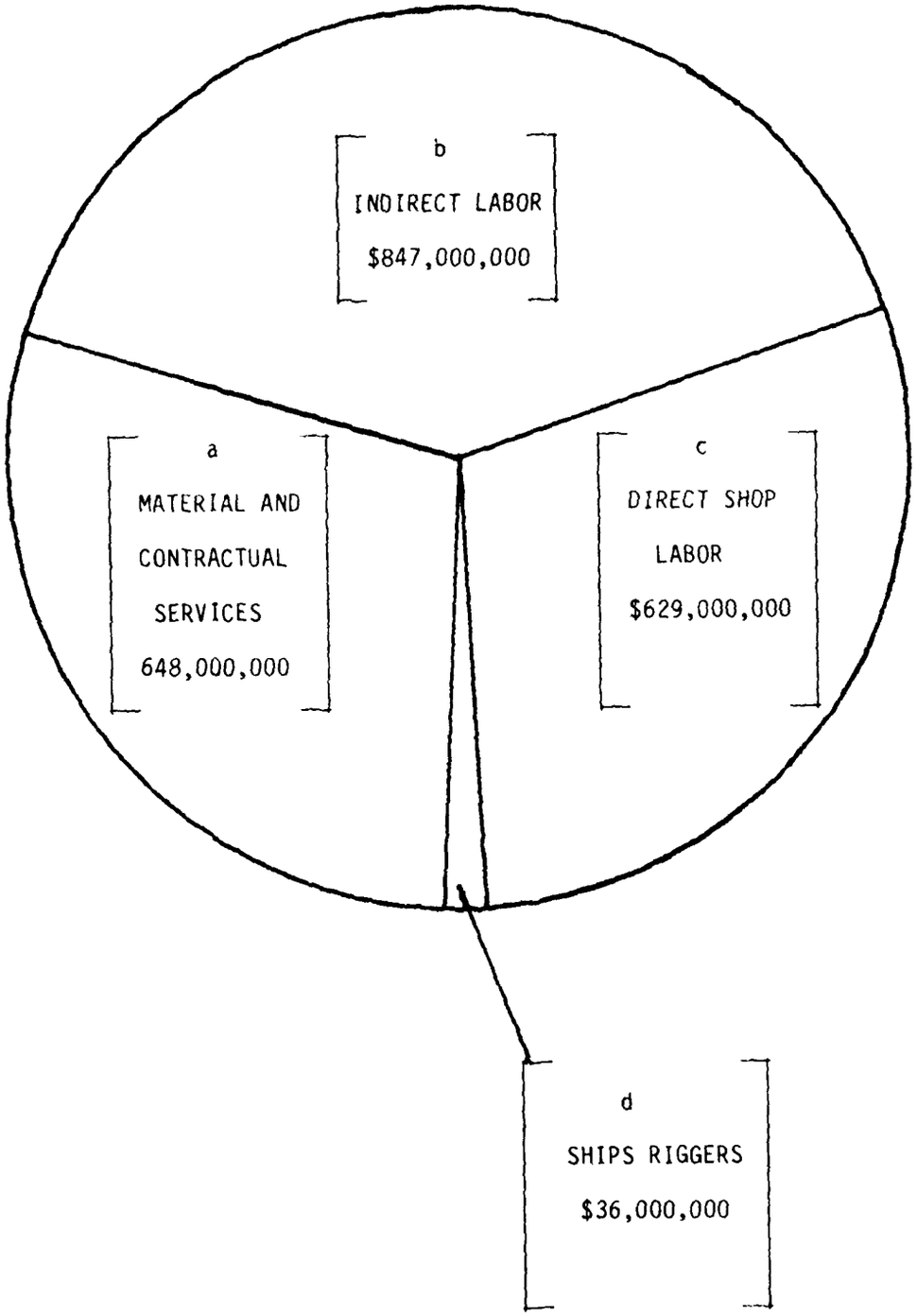


Figure 1-1

	Benefit Per Year
a. 1% reduction in the number of overhaul days	$10,440,000

NOTE: This benefit is received in the form of increased availability of the ship, not reduced cash flow.

b. 1% increase in production shop productivity due to improved material handling services	$ 6,290,000
c. 1% reduction in ships riggers labor due to improved methods and equipment	$ 360,000

Figure 1-2 shows this information graphically.

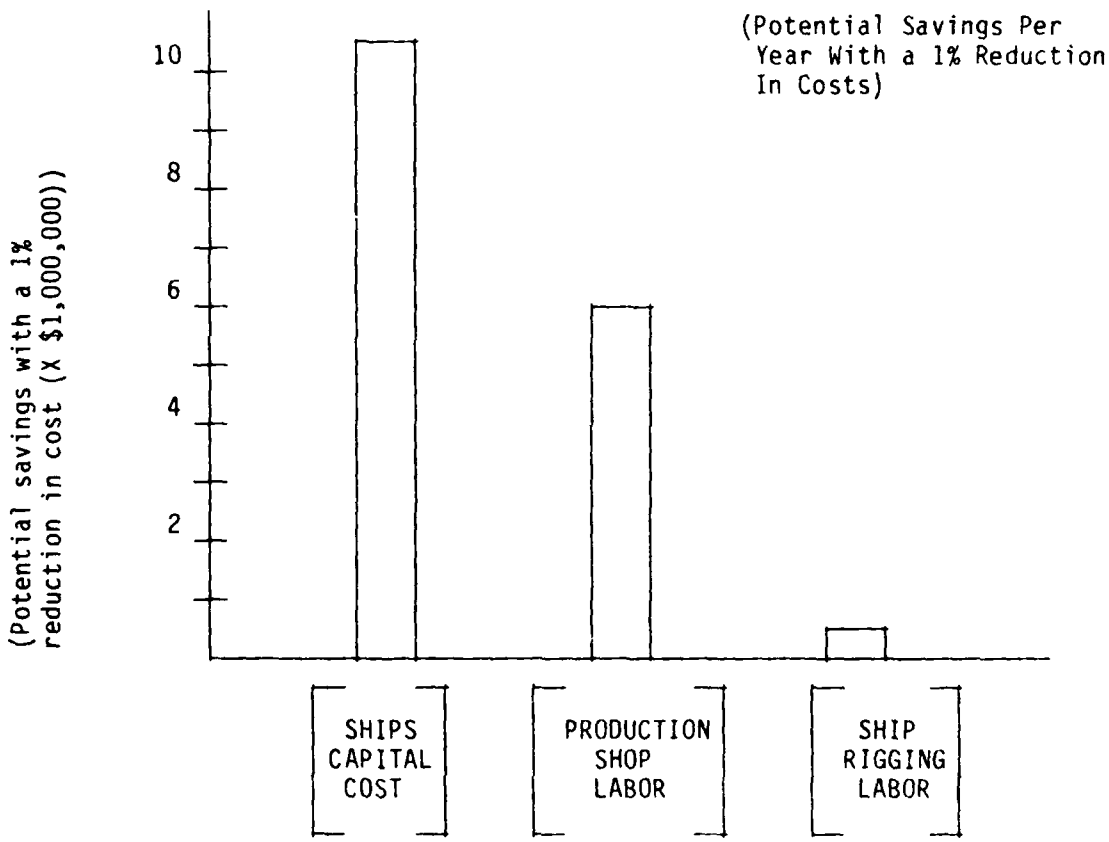


Figure 1-2

This cost analysis is rough and not all inclusive, but it is sufficient to provide some general guidelines for the study objectives. There is more potential benefit from reducing overhaul duration and/or increasing shop productivity, by improving M/H services, than decreasing rigging labor costs.

SECTION II

DRYDOCK MATERIAL HANDLING

2.1 STUDY AND OBSERVATION RESULTS. To obtain data for this project, a number of studies and observations were made of material handling operations in the drydock areas at Mare Island Naval Shipyard. These studies include on site observations, review of Public Works records, review of records in the drydock material control center, analyzing timelapse films of drydock operations and interviews with shipyard personnel. Visits to Long Beach, Philadelphia and Puget Sound Naval Shipyards, and telephone calls to the remaining shipyards confirmed that the other shipyards have many of the same characteristics and problems as Mare Island. Some of the observations made and problems noted include:

2.1.1 The majority of the parts moved off the ship are small

A study was made of the number, destination, time and size of parts moved off a ship (submarine) through the drydock material control center. This study was done over a nineteen week period. It covered the last five weeks of one submarine overhaul and the first fourteen weeks of the next. The results are shown in Appendix C and summarized in the following figures.

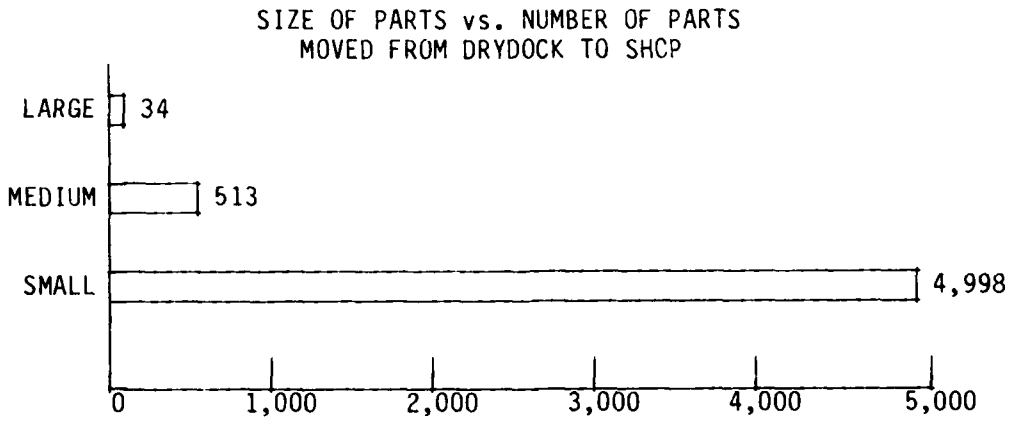


Figure 2-1

Small parts were defined as being able to move in an 18" x 18" x 10" tote bin.

Medium size parts were defined as too large for the above tote bin, but being able to move on a 40" x 48" pallet.

Large parts were defined as anything too large for the above pallet.

2.1.2 The General Characteristics of the Parts Being Moved are Special, i.e., Non Uniform

There is a large variety of shapes and types of parts being moved to and from the ships.

2.1.3 The Destination of the Parts Being Moved from the Ship has a Pareto Type Distribution

i.e., a few shops receive the majority of the parts.

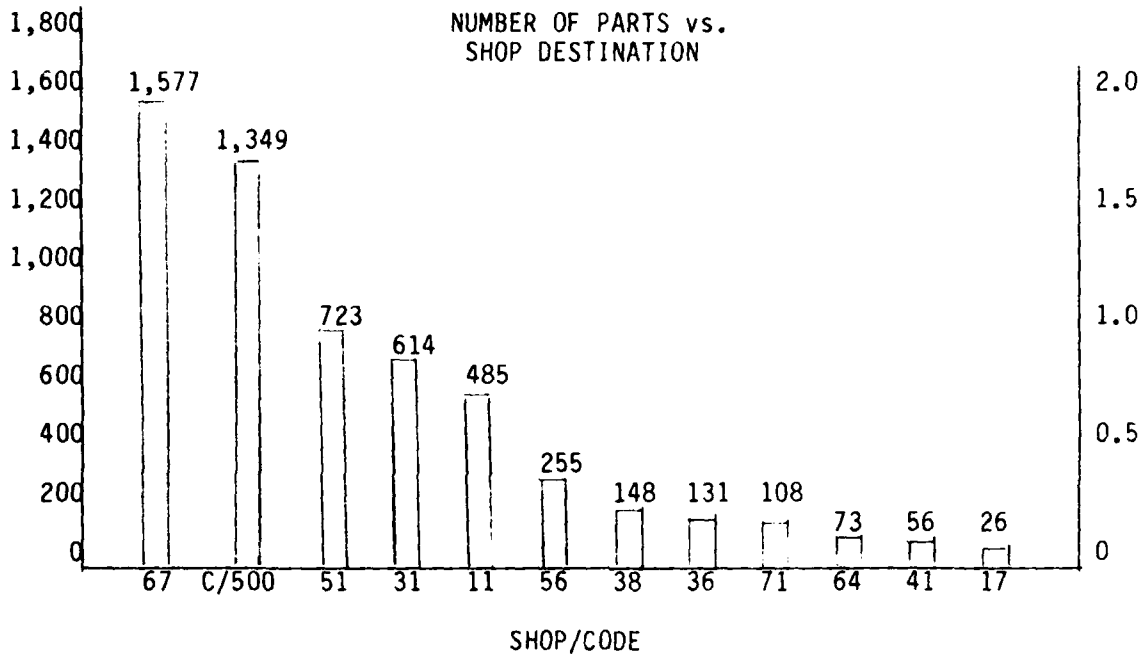


Figure 2-2

2.1.4 The Flow of Material is Very Non-Uniform. There are Extreme Peaks and Valleys in the Number of Parts Moved.

Figure 2-3 shows the number of parts moved from the dock to the shops each week of the study.

Figure 2-4 shows the number of crane lifts for the same dock and time period.

This fluctuating material flow and work load creates equipment and staffing problems. Equipping and staffing for the peak loads results in expensive under utilization the majority of the time. Equipment and staffing for high utilization results in work backlog and delays during peak periods.

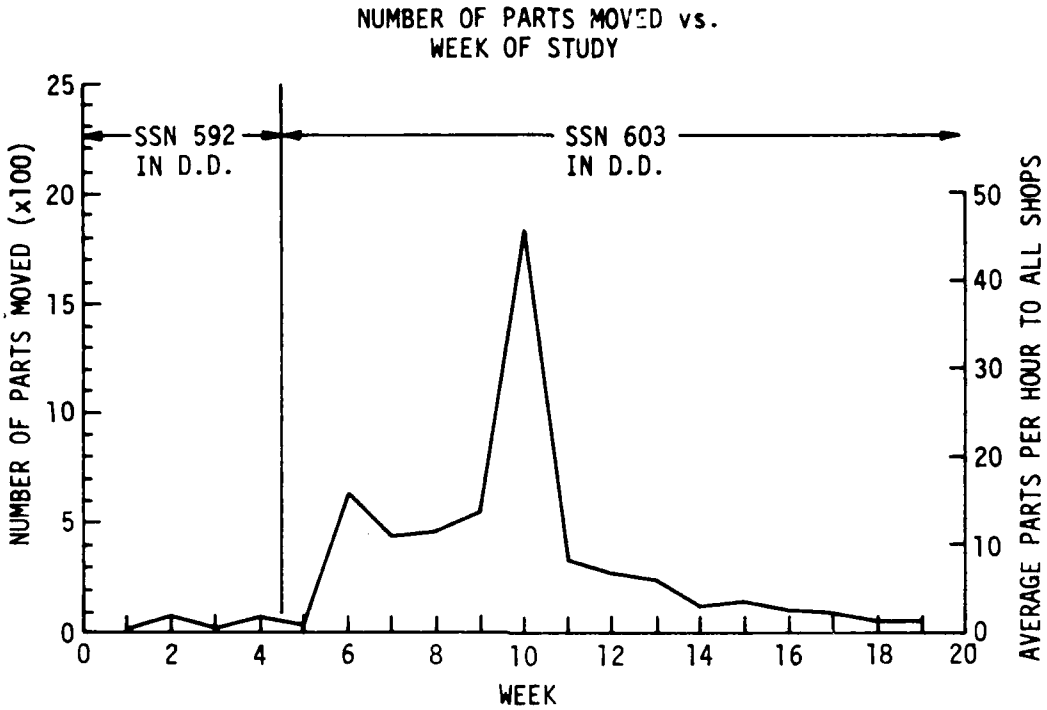


Figure 2-3

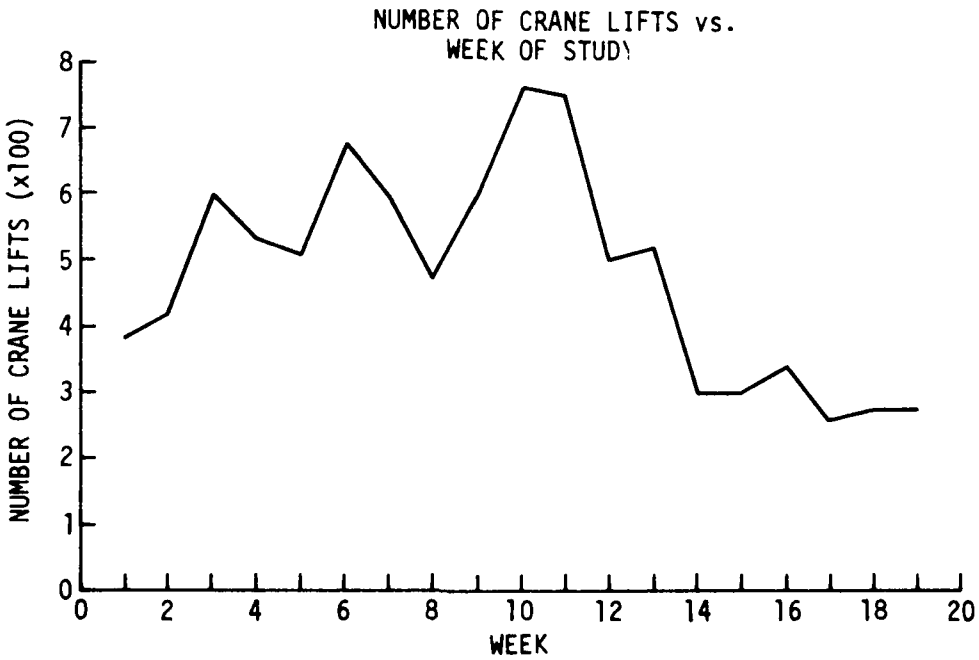


Figure 2-4

2.1.5 The "Average" Volume of Parts Moved is Low

The right side of Figure 2-2 shows the average parts per hour moved from the dock to each shop. It ranges from .03 parts per hour to 2.08 parts per hour.

The right side of Figure 2-3 shows the average number of parts moved per hour each week of the study. The total flow ranges from .03 parts per hour in the slowest week to 45.6 parts per hour in the fastest week. The overall average is 7.3 parts per hour.

2.1.6 The Average (Mean) Lift by a Portal Crane is 9.2 Minutes

The mode (most frequent time) is 5.0 minutes. The median time (50% greater, 50% less) is 6.7 minutes.

A timelapse study of crane operations was done to determine the duration profile of portal crane lifts. This study consisted of filming and analyzing 163 lifts made by portal cranes. The cranes observed range in maximum lift capacity from 56,000 lbs to 112,000 lbs. All cranes were equipped with two or three hooks. The results are shown in Appendix D and summarized in Figure 2-5. Figure 2-5 shows the distribution of the number of lifts versus the duration of the lift. The duration of lift included all the crane time associated with the lift, i.e., move to location, rig part, make lift, return to location.

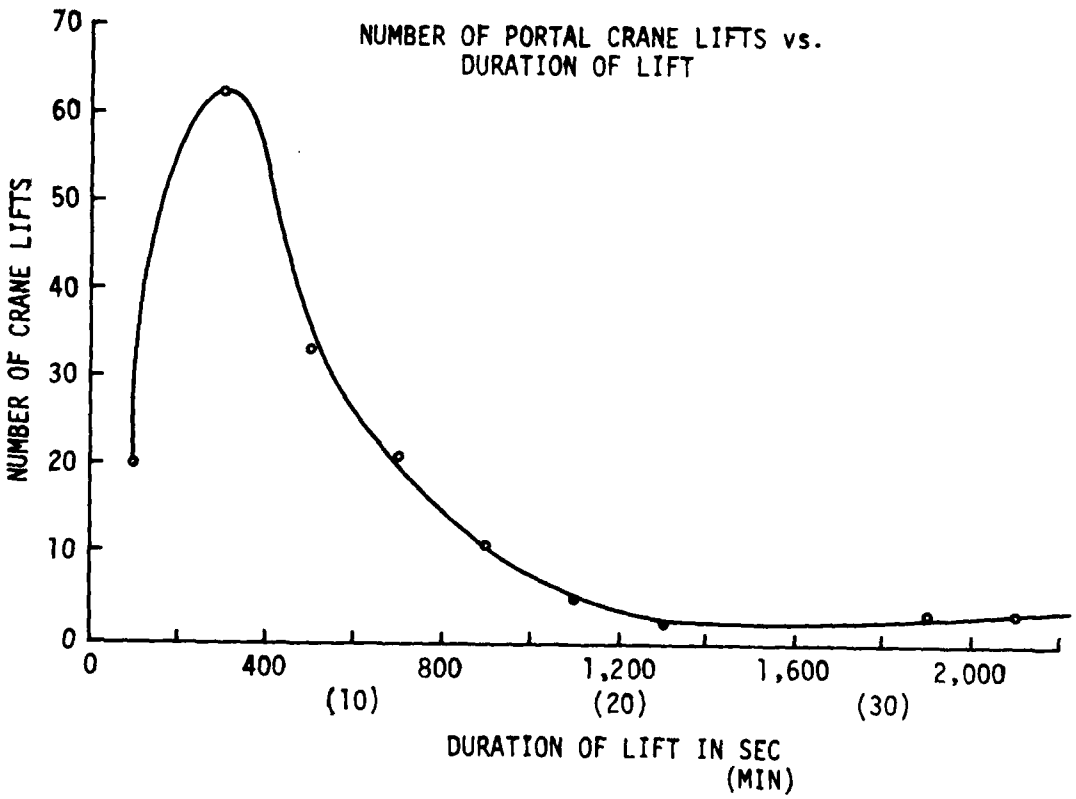


Figure 2-5

2.1.7 With Random (Poisson)* Arrivals for Crane Service, There is a Conflict Between Obtaining a Reasonable Utilization of Cranes and Avoiding the Situation Where Riggers are Having Unreasonable Waits For Crane Service

Appendix E contains the calculation results to determine a number of statistical conditions that exist in crane operations. It includes:

Mean Service Time
Crane Utilization
Probability of Immediate Service
Average Time Arrival Spends in System
Average Number of Units in the System
Average Waiting Time
Average Que Length

These calculations assume that there is one crane on location, that arrivals for service are Poisson fashion,* service is exponential fashion, and mean service time is 9.2 minutes (.153 hours). A summary of the results is shown in the following Table I and Figure 2-6.

TABLE I

EXPECTED WAIT TIME FOR CRANE SERVICE

Arrivals Per Hour For Crane Service	Crane Utilization	Expected Wait For Crane Service
1	15.3%	1.68 minutes
2	30.6%	4.08 minutes
3	45.9%	7.80 minutes
4	61.2%	14.5 minutes
5	76.5%	30.0 minutes
6	91.8%	103. minutes
6.53	100%	∞ minutes

* Poisson Fashion arrivals do not occur at regular intervals in time, but tend to be clustered or scattered in some fashion.

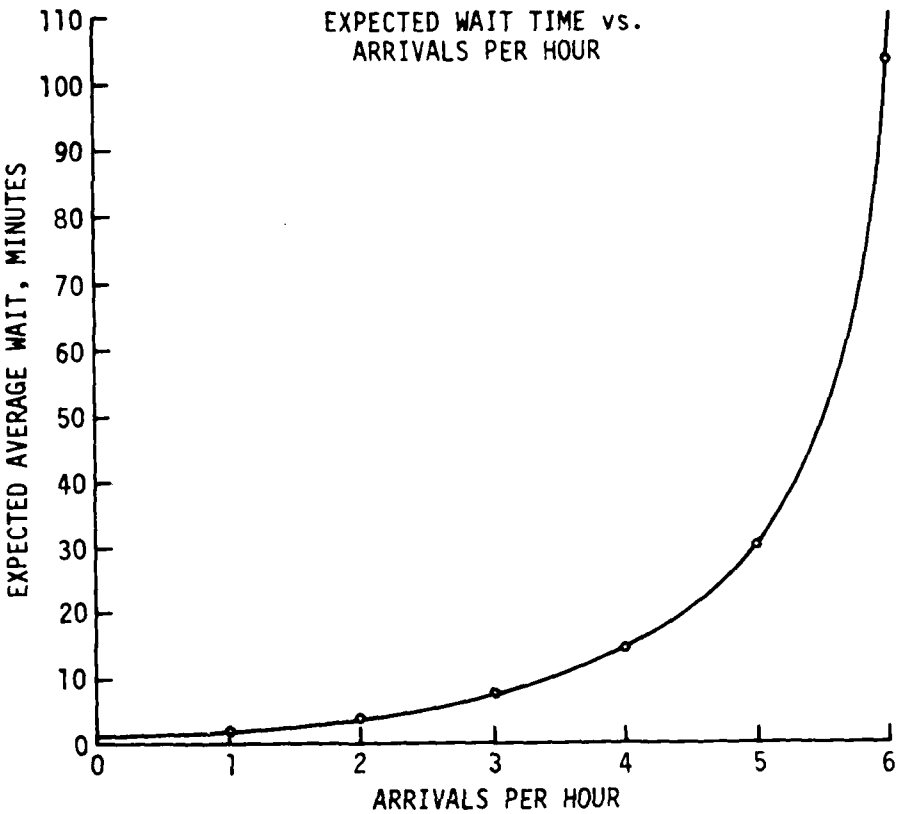


Figure 2-6

2.1.8 There is a Poor Balance Between the Portal Crane Lifting Capacity and the Lifting Capacity of the Majority of the Equipment Servicing the Crane.

Typically a 6,000 to 10,000 lb capacity forklift will service a 56,000 to 112,000 lb capacity portal crane.

2.1.9 95% of the Lifts Made by the Large Portal Cranes are Low Capacity Lifts

This results in a very low utilization of the crane lifting capacity. A study was conducted by observing 171 lifts made by portal cranes. The cranes observed range in maximum capacity of 56,000 lbs. or 112,000 lbs. and were equipped with two or three hooks. The hook used to make the lift was recorded, then this data was converted from hook to hook capacity. The results are shown in Appendix F and summarized in Table II and Figure 2-7.

TABLE II

PORTAL CRANE LIFTING CAPACITY UTILIZATION

95% of the lifts are under 11,200 lbs

96% of the lifts are under 33,600 lbs

98% of the lifts are under 56,000 lbs

100% of the lifts are under 112,000 lbs

CRANE LIFTING CAPACITY UTILIZATION

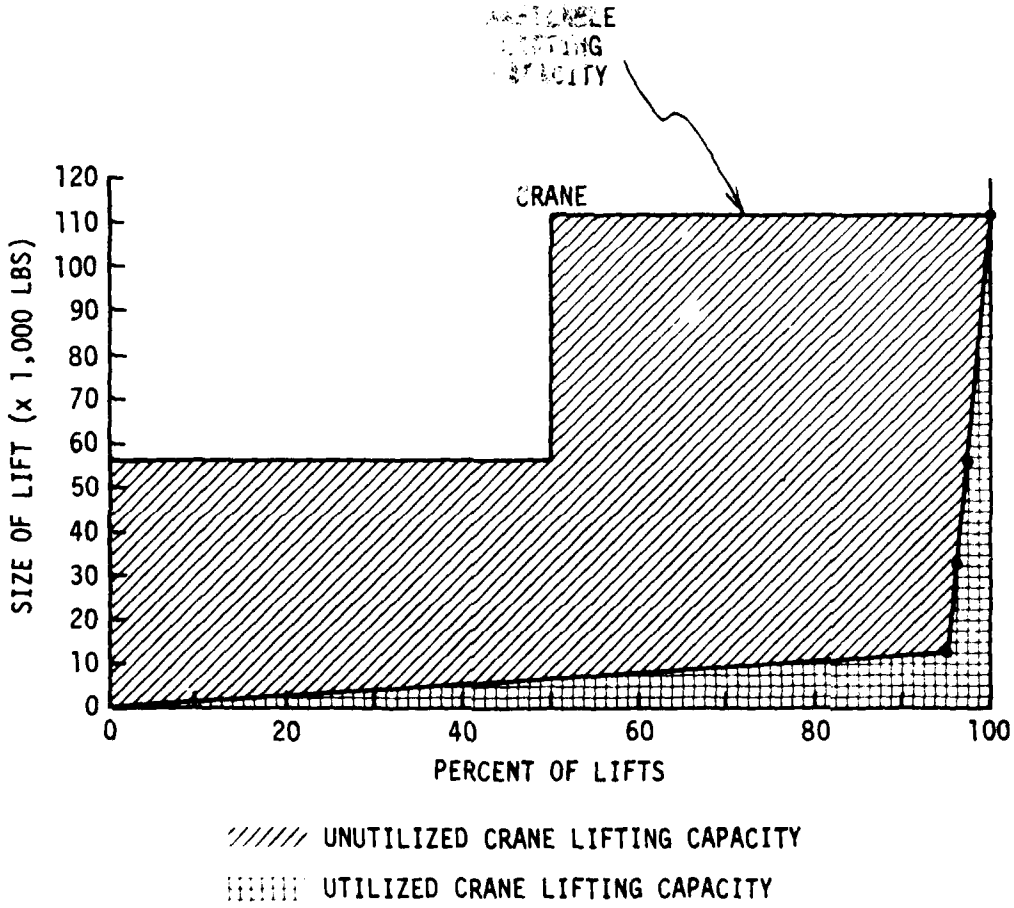


Figure 2-7

2.1.10 The Average Time Utilization of Large Portal Cranes is Low

Public Works records were reviewed for the eight month time period of April 1978 through November 1978. The results are given in Appendix G and summarized in Tables III and IV.

TABLE III

PORTAL CRANE AVAILABILITY

		% of Total
Total Hours Accounted For	32,416	100%
Total Hours Out of Service	11,920	37%
Total Hours Available for Service	20,496	63%
Total Hours Available, Not Manned	2,693	8%
Total Hours Available and Manned	17,803	55%

TABLE IV

PORTAL CRANE TIME UTILIZATION

SHIFT	NUMBER OF LIFTS	HOURS MANNED	AVERAGE LIFTS PER HOUR	AVERAGE LIFT TIME (HR)	AVERAGE UTILIZATION (Operating Hrs) / (Manned Hrs)
Day	14,044	6,755	2.08	.153	31.8%
Swing	9,411	5,638	1.67	.153	25.5%
Graveyard	6,012	5,410	1.11	.153	17.0%
Total	29,467	17,803	1.66	.153	25.3%

2.1.11 The Portal Cranes are Frequently Out of Service

As noted in Table III, Portal Cranes are out of service approximately 37% of the time. This is for both planned and unplanned maintenance. Contributing to this problem is the age of the cranes, tight requirements for Nuclear Lifting Equipment, and the nonstandard designs in use.

2.1.12 The Combined Portal Crane Utilization (Time Utilization and Capacity Utilization) is Extremely Low.

Figure 2-8 combines the time utilization data and lifting utilization data in a diagram format. This illustrates the low utilization of portal cranes. This is both in terms of operting time and in size of part moved. The movement of a large item is an exception, not the rule.

2.1.13 The Majority of the Portal Cranes are Approaching 40 Years of Age

A telephone survey of Public Works personnel at seven of the shipyards, reveals the following data about the age of portal cranes with a capacity of 25 tons or greater: Most of the cranes presently in use were put in service during or before WWII.

PORTAL CRANE UTILIZATION (% of TIME)

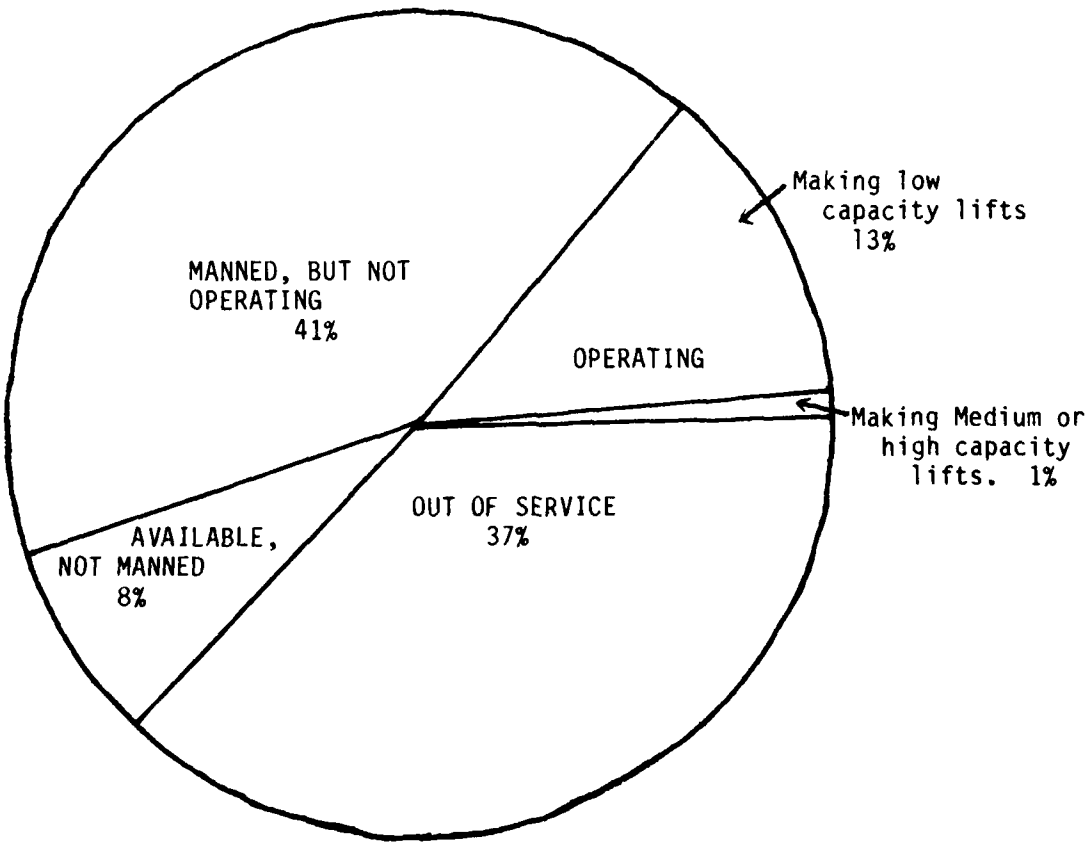


Figure 2-8

TABLE V

AGE OF SHIPYARD PORTAL CRANES

Year Built	Age (Years)	Number of Portal Cranes 25 Tons or Greater
1975 - 79	1 - 5	0
1970 - 74	6 - 10	2
1965 - 69	11 - 15	1
1960 - 64	16 - 20	2
1955 - 59	21 - 25	6
1950 - 54	26 - 30	0
1945 - 49	31 - 35	14
1940 - 44	36 - 40	61
1935 - 39	41 - 45	2

2.1.14 The Demands on Cranes, Level of Activity, is Non Uniform. There are Extreme Peaks and Valleys in the Number of Lifts Per Week.

A study of Public Works records was made to determine the frequency of lifts made by all cranes during two SSN overhauls. The results are given in Appendix H and summarized in Figures 2-9 and 2-10. In the drydock, they range from a high of 804 lifts per week to a low of 176 lifts per week. At the quaywall, they range from a high of 251 lifts per week to a low of zero lifts per week. This fluctuating demand from crane services creates the same equipment and staffing problems noted earlier, i.e., equiping and staffing for the peak load results in expensive under utilization of resources the majority of the time. Equiping and staffing for high utilization results in work backlog and delays during peak periods.

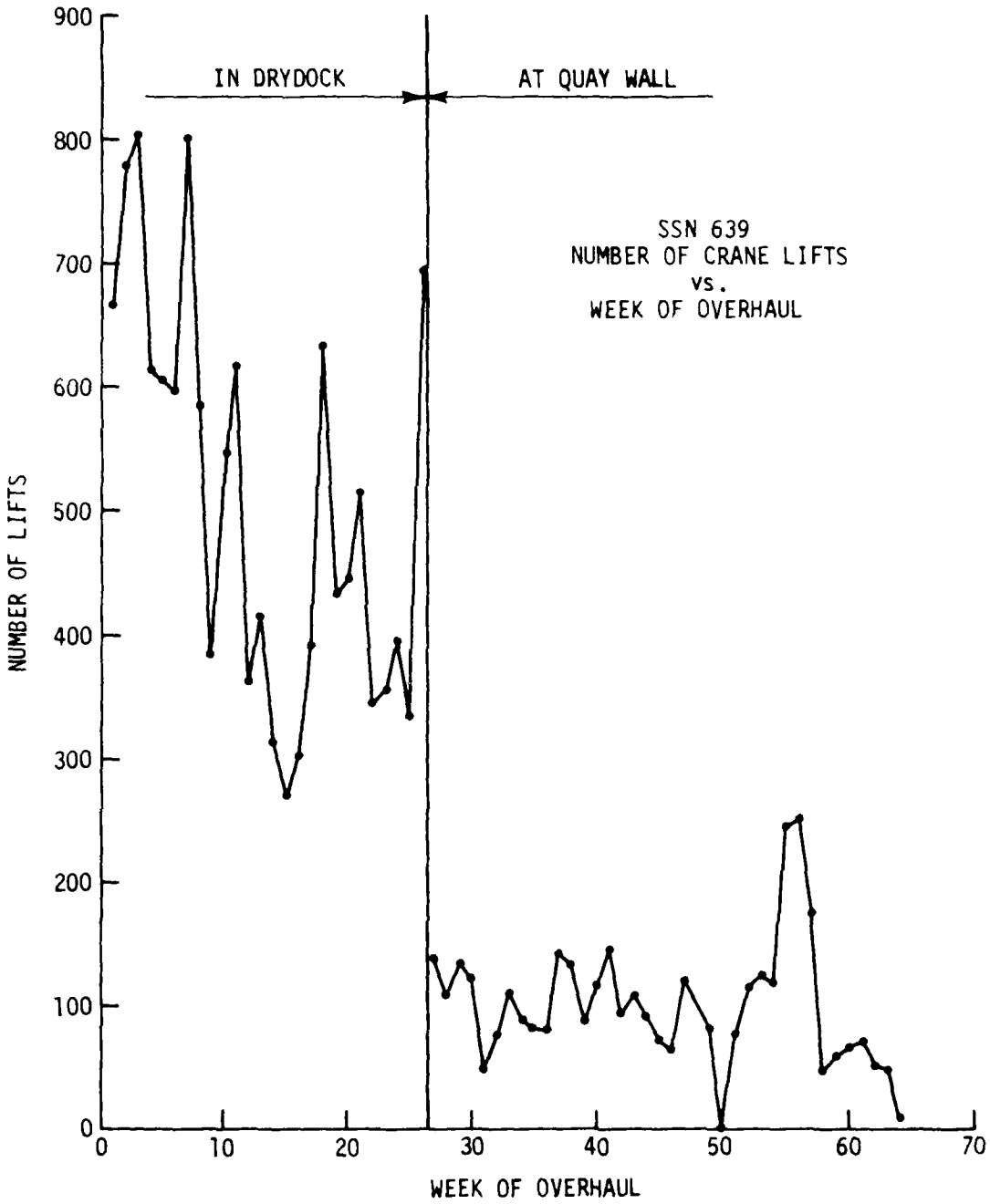

IN DRYDOCK
AT QUAY WALL
SSN 639
NUMBER OF CRANE LIFTS
vs.
WEEK OF OVERHAUL
NUMBER OF LIFTS
WEEK OF OVERHAUL
0
100
200
300
400
500
600
700
800
900
0
10
20
30
40
50
60
70

Figure 2-9

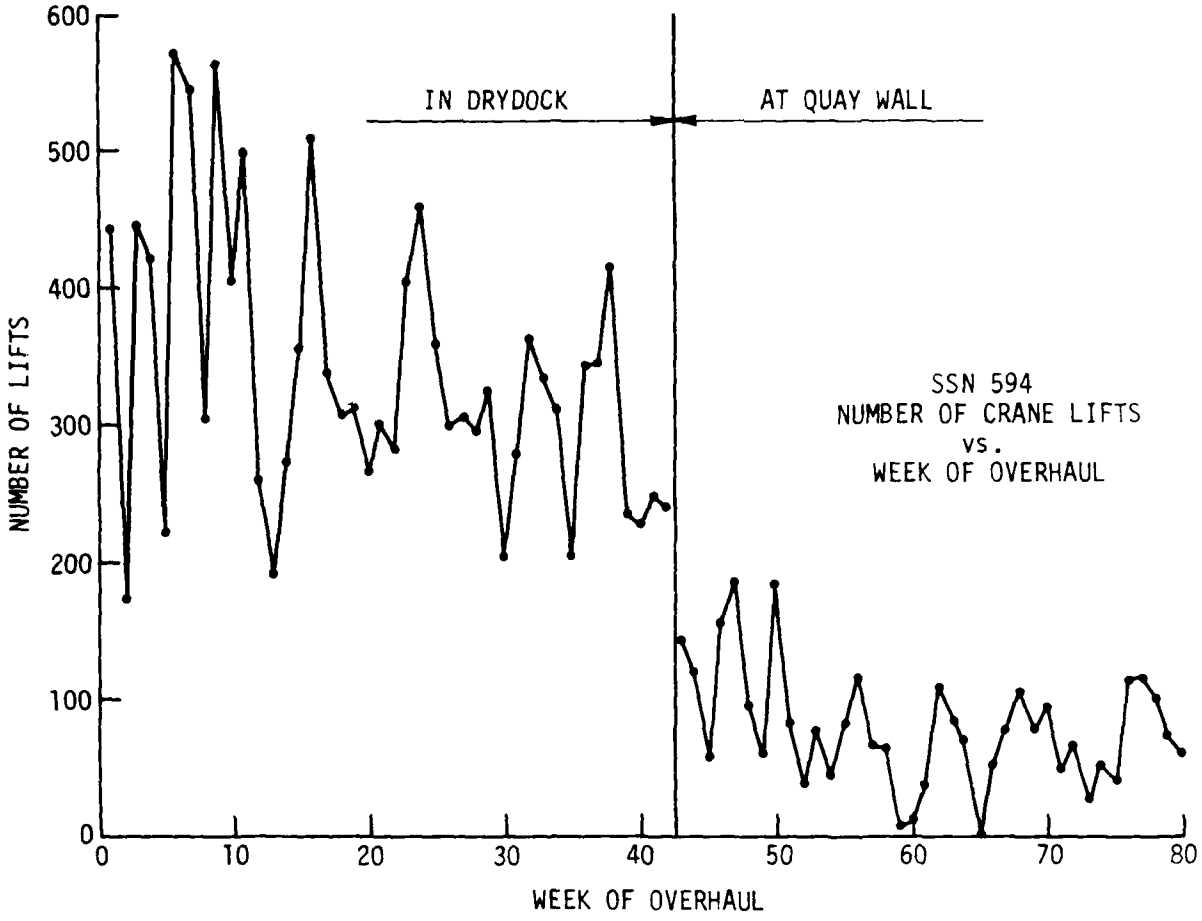

600
500
400
300
200
100
0
NUMBER OF LIFTS
IN DRYDOCK
AT QUAY WALL
SSN 594
NUMBER OF CRANE LIFTS
vs.
WEEK OF OVERHAUL
0
10
20
30
40
50
60
70
80
WEEK OF OVERHAUL

Figure 2-10

2.1.15 The Routes or Paths Parts and Equipment Take During a Crane Lift are Non Uniform.

Attempts were made to detect common crane movement paths or patterns. Internal ships parts move from many locations on the dock to one of several ship's access locations. External parts move to the appropriate location on the hull or superstructure. Support equipment, such as scaffolding, welding, tanks, blast tanks, etc., move to and from many points around the dock. It was not possible to detect a path that accounted for a high percent of the lifts. A common observation was that the crane was frequently used to transport or travel with the part, i.e., it was doing a job that could be done with a forklift. This is an especially poor practice during periods when the crane activity level is high and the cranes are the bottleneck piece of equipment.

2.1.16 Interviews were conducted with approximately 75 shop supervisors, support personnel and riggers at four shipyards. Many problems were noted. Samples of typical comments are given in Appendix I. Comments are arranged by subject, not by any order of priority or frequence. Inclusion of a comment is not intended to support or deny the accuracy. They were included because they were typical comments of people close to the problems.

2.2 Recommendations

In conducting this study a number of potential improvements and recommendations became apparent. Unfortunately many did not fall into the scope of the M/T program. It was just not practical to look for only M/T solutions for many of the problems. The non-M/T recommendations have been retained as brief statements. The M/T recommendations are presented with more detail.

2.2.1 Measures Should be Taken to Level the Material Movement and Crane Work Loads. Reduce the Peak Work Loads by Improving Efficiency and Shifting Work From Peak Periods to Lower Activity Periods.

As noted before, the fluctuating workload creates a conflict between achieving efficiency (cost goals) and meeting the production schedule. Reducing the peak demand periods would reduce the amount of men and equipment required, improve utilization and reduce costs. It is not reasonable to expect a uniform demand, but there are some things that can be done to reduce the peak loads. These include:

a. Move non-critical work from the peak periods to the low periods. Transfer work from the day shift to the swing and graveyard shifts.

b. Have fewer but larger lifts during peak demand periods. Provide for more pre-assembled and modular lifts during the peak demand periods. For example, scaffolds are usually installed or removed during the peak demand periods at the start and finish of a drydock period. Pre-assembly of the scaffolding saves many lifts, i.e., one lift for the assembled unit vs many lifts to assemble and/or place planks.

Norfolk recently purchased a complete set of pre-assembled scaffolding towers. (Contract No. N62470-78-B-4325) This consisted of 11 towers

that cover one side of a submarine. At the time this report was written, it was too early to evaluate these units; but they should be evaluated in the future for possible improvements and application at other shipyards.

2.2.2 Take Measures to Increase the Peak Capacity Without Carrying Excessive Capacity the Majority of the Time. Some improvements that can be done in these areas include:

- Establish more centralized system for allocating rigging labor, i.e., shipyard rigging pool.

- Establish practice of using union hall riggers to supplement shipyard riggers during peak demand periods.

- Cross train other shop personnel to assist riggers during peak demand periods. The Trade(s) selected should have a manning profile that is out of phase with the riggers.

- Do not allow planned maintenance of cranes during peak demand periods.

- Improve the ground support services to the portal cranes with dock equipment. Avoid making dock to dock lifts or using the crane for dock transportation. (Note: The dock material handling section describes a system that would provide better service to the cranes.)

- Where possible, provide alternatives to the portal crane. These alternatives tend to be more of special application and have to be pursued on a case by case basis. Some possible substitutions include:

  - Monorails from ship's access to the dock.

  - Use of condors and manlifts in the drydock.

  - Elevators to drydock floors, or from the drydock floor to the ship. (Note: This is being done in new construction.)

2.2.3 Establish a Program to Evaluate and Replace a High Percent of the Existing Large Portal Cranes With Less Expensive Standard Type Smaller Cranes. If Possible, Have These Smaller Cranes Radio Controlled by Riggers on the Ground.

This would provide the shipyards with a mix of cranes that are more in line with the lifting demands. As noted in Table V, the majority of the Naval Shipyard portal cranes are approaching 40 years old. They have high maintenance costs and high down time. In addition, as noted in Table II, they have substantial unutilized lifting capacity. Some large portal cranes have to be retained for the 5% of lifts that are medium to large capacity lifts. In addition, some new concepts, like SEAMOD (Sea Systems Modification and Modernization by Modularity) would require large cranes, but many old large portal cranes could be eliminated or replaced with less expensive, smaller cranes. Replacement would logically occur when the next major high cost repair is required on the existing portal cranes. Some options for replacing the existing large portal cranes with less expensive, smaller cranes include:

2.2.3.1 Replace existing cranes with mobile truck cranes.

Mobile truck cranes are available with the desired lifting capacity but they have a critical disadvantage. To achieve the required reach, these cranes have to extend their outriggers. With outriggers down, they cannot travel. It is time consuming and inefficient to retract the outriggers, travel to new location and extend the outriggers before making the next lift.

2.2.3.2 Replace existing cranes with mobile truck cranes that have special outriggers. This would require developing a special outrigger with metal wheels, that could ride in existing portal crane tracks. This is shown conceptually in Figure 2-11.

TRUCK CRANE WITH SPECIAL OUTRIGGERS

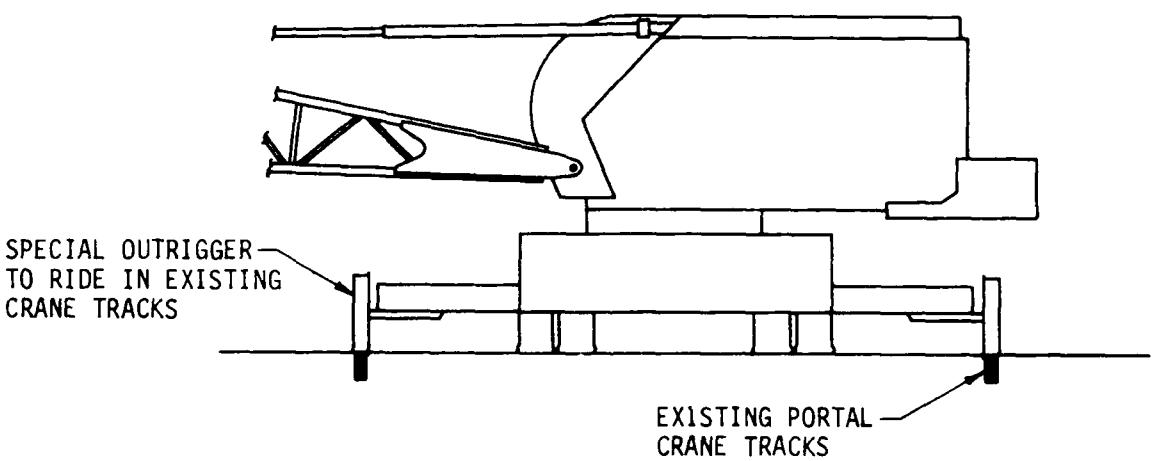


Figure 2-11

The weight would be distributed between special outriggers and the rubber tires, so that outriggers could provide stability while rubber tires provided traction. This would result in a slight reduction of the lifting capacity with outriggers, but would allow a standard mobile truck crane, with special outriggers, to achieve outrigger stability while retaining the ability to travel along the dock.

If the wheel outriggers could be interchanged with flat plate outriggers, the crane could be used where the requirement is the greatest. It could be used efficiently at the dock when required, and around the yard when not needed at the dock.

2.2.3.3 Develop a mobile cart to ride in existing crane tracks and carry a mobile crane. Replace existing portal cranes with these carts and mobile cranes. Figure 2-12 shows this concept.

MOBILE CART FOR TRUCK CRANE

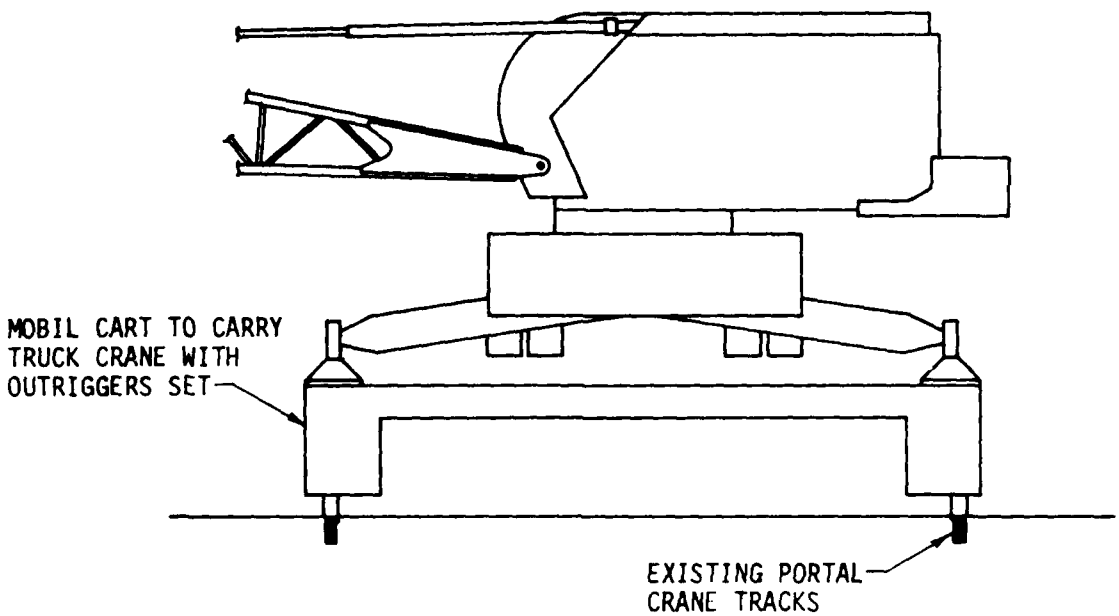


Figure 2-12

This concept has some advantages including:

- Only the cart is limited to dock operations. The crane can be used where the demand is the greatest. It can be used efficiently at the dock when required, and used around the yard when not required at the dock.

- Having a cart would allow for the possibility to contract outside services for efficient dockside crane support.

2.2.3.4 Replace existing portal cranes with standard locomotive cranes, such as shown in Figure 2-13. A number of different types of locamotive cranes are available. They range in price from about $350,000 to $1,000,000. Standard locomotive cranes are available that could make 95% of the required dock lifts. (Note: The recommendation of a recent engineering study of dock cranes in the Norfolk Naval Shipyard, Contract No. N62470-78-C-2973, was to use locomotive cranes around the dock.)

Many riggers and operators do not like to use locomotive cranes because of their lack of stability. In the mobile condition, they only have a

4'8" base (track gage). In the more stable blocked condition, they cannot travel.

2.2.3.5 Replace existing portal cranes with a light duty portal crane that uses a standard locomotive crane cab. This concept would require mounting a standard locomotive cab on a light duty traveling portal structure that fits existing crane tracks. A budget price for this concept is $327,000 per crane, Appendix J. When compared with portal cranes, this concept is relatively low cost. It is flexible, uses existing technology and moves on the existing tracks, and would be able to make approximately 95% of the lifts required in the dock. This concept is illustrated in Figure 2-14.

Appendix K provides a general cost analysis on these options. Table VI provides a summary of that analysis.

TABLE VI

ANNUAL COST OF ALTERNATIVES TO PORTAL CRANES

Option No.	Description	Annual Cost of Capital and Maintenance
2.2.3.1	Mobile Truck Crane	$ 79,000
2.2.3.2	Mobile Truck Crane with Special Outriggers	87,000
2.2.3.3	Truck Crane with Mobile Platform	142,000
2.2.3.4 (a)	Small Locomotive Crane	61,000
2.2.3.4 (b)	Large Locomotive Crane	185,000
2.2.3.5	Light Duty Portal Crane (Modify Locomotive Crane)	61,000
	New 50-ton Portal Crane	468,000

Figure 2-15 provides a chart of the typical lifting capacity vs reach of the proposed alternative cranes.

It should be noted that when the cost of maintenance for a large portal crane exceeds the cost of capital and maintenance for the alternative crane, the large portal crane should be replaced. For alternative light duty portal, that figure is about $61,000 per year.

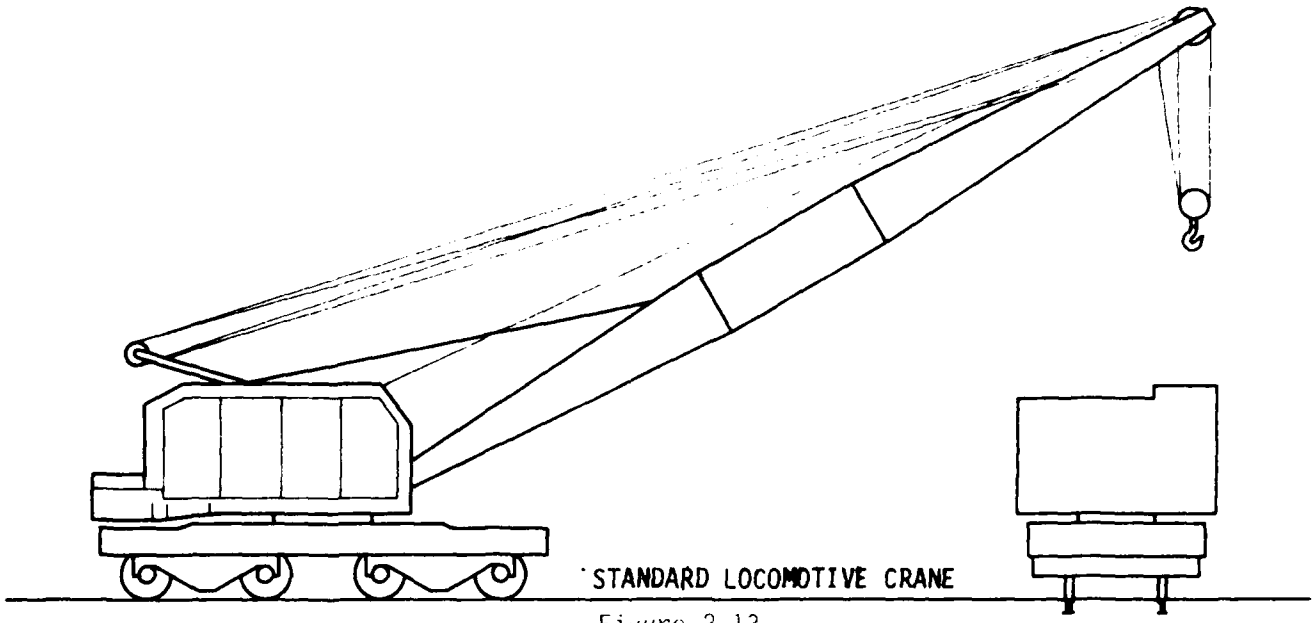
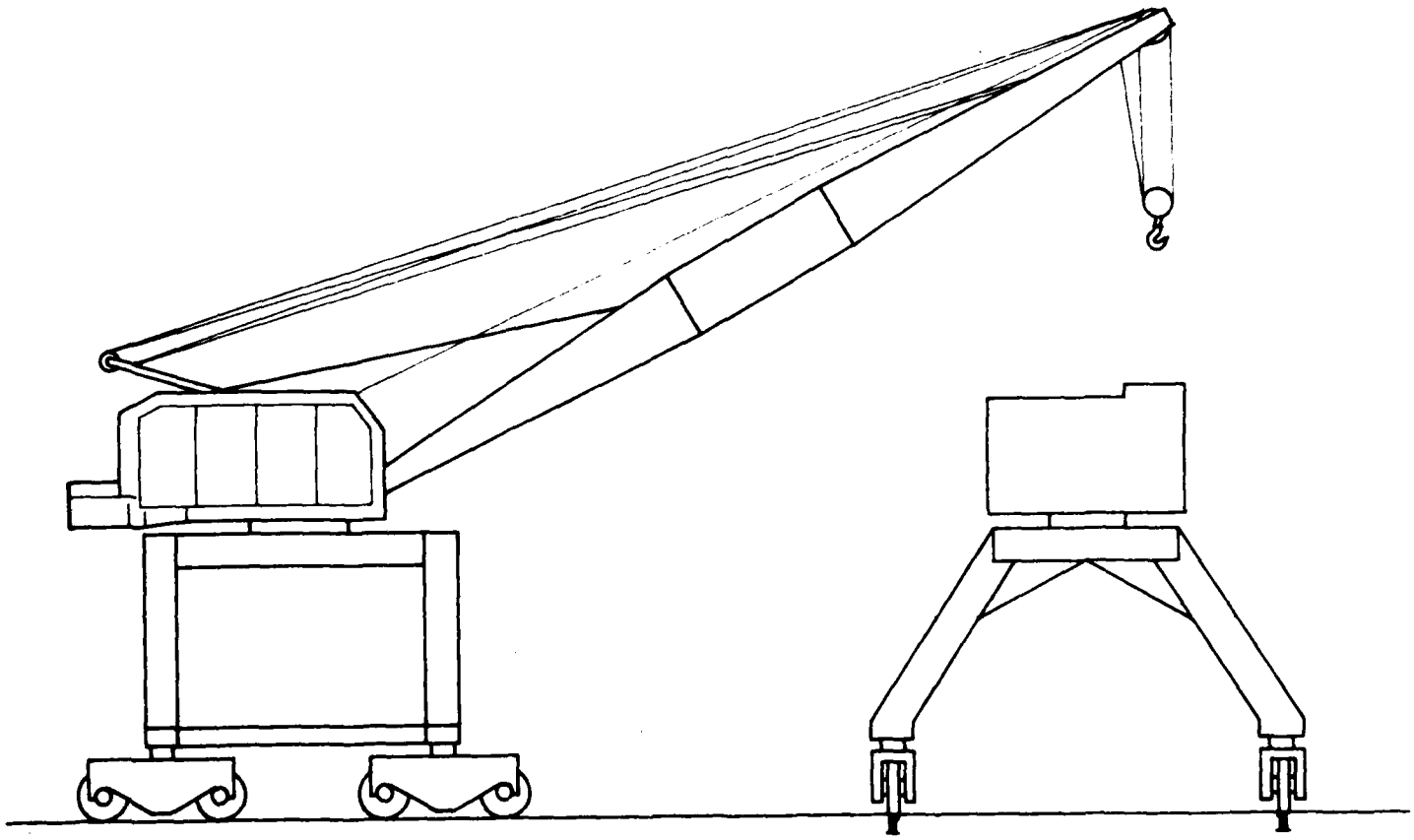


Figure 2-13



MODIFIED LOCOMOTIVE CRANE
TO RIDE ON 20' TRACK GAUGE

Figure 2-14

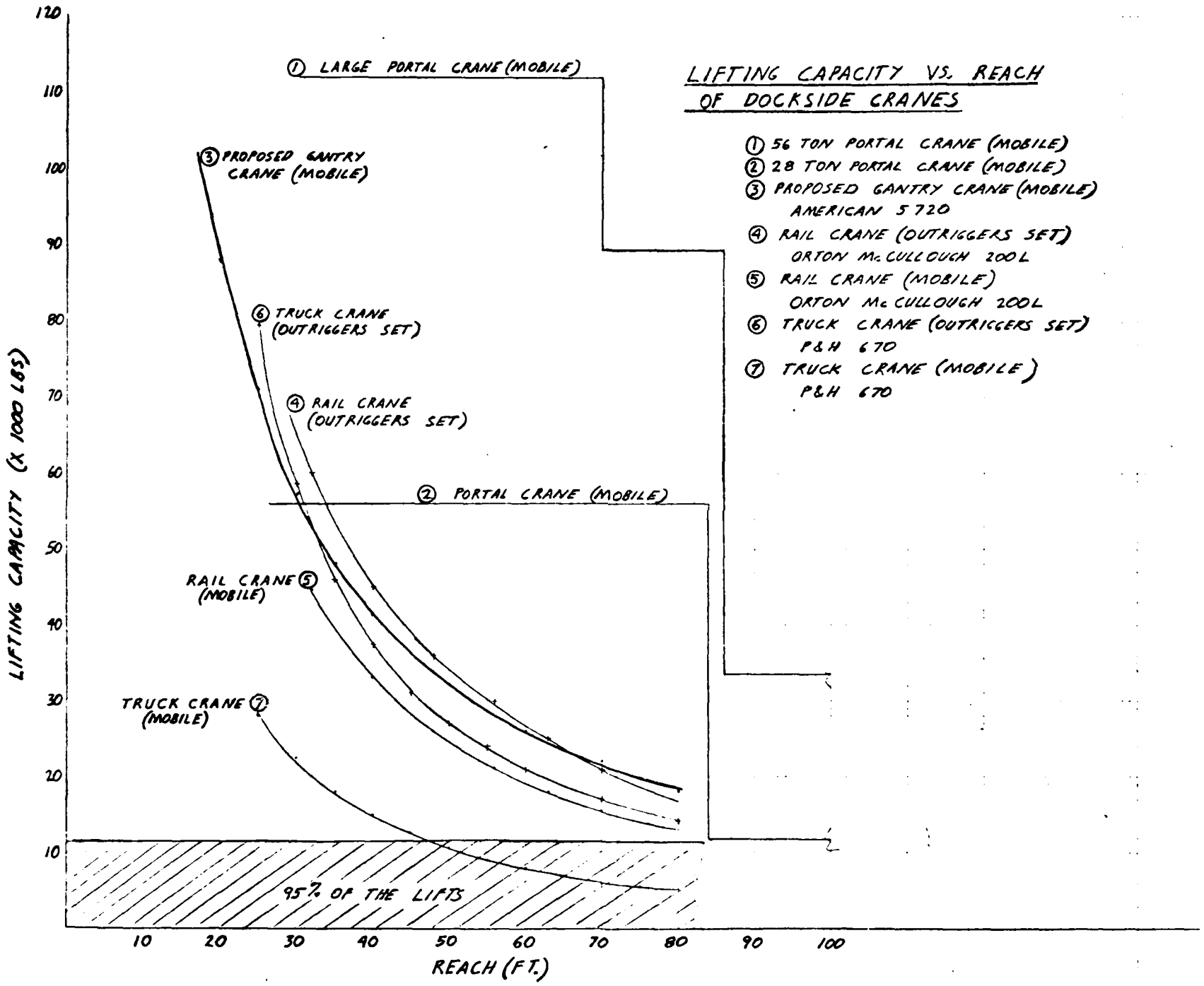

LIFTING CAPACITY VS. REACH OF DOCKSIDE CRANES
① 56 TON PORTAL CRANE (MOBILE)
② 28 TON PORTAL CRANE (MOBILE)
③ PROPOSED GANTRY CRANE (MOBILE) AMERICAN 5720
④ RAIL CRANE (OUTRIGGERS SET) ORTON McCULLOUGH 200L
⑤ RAIL CRANE (MOBILE) ORTON McCULLOUGH 200L
⑥ TRUCK CRANE (OUTRIGGERS SET) P&H 670
⑦ TRUCK CRANE (MOBILE) P&H 670
① LARGE PORTAL CRANE (MOBILE)
③ PROPOSED GANTRY CRANE (MOBILE)
⑥ TRUCK CRANE (OUTRIGGERS SET)
④ RAIL CRANE (OUTRIGGERS SET)
② PORTAL CRANE (MOBILE)
RAIL CRANE ⑤ (MOBILE)
TRUCK CRANE ⑦ (MOBILE)
95% OF THE LIFTS
LIFTING CAPACITY (X 1000 LBS)
120
110
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
REACH (FT.)

FIGURE 2-15

2.2.4 Install radio remote controls on the smaller dock cranes. This would allow the rigger on the ground to remotely control the crane and eliminate the need for a crane operator. It would improve coordination between riggers and cranes since lack of an operator would no longer be a problem.

Radio controls have been installed on a number of bridge cranes, gantry cranes, automated storage/retrieval machines, and locomotives. This includes a radio remote control unit on giant gantry crane for positioning reactor components and materials at the largest nuclear test facility in the world, located at the Hanford Engineering Development Laboratories, near Richmond, Washington.

These remote radio controls are capable of controlling portal cranes and offer many of the advantages achieved in the other equipment. These include:

- Reduced Labor Cost - Elimination of the crane operator.

- Improved Safety - Radio control setup eliminates the need for hand signals, which are subject to misinterpretation. It puts the control with the rigger near the part.

With radio controls, two operators can control a single crane. This arrangement is known as a two box pitch and catch operation. This would allow passing control from a rigger on the ship to a rigger on the dock.

A budget price to install radio controls on a crane is:

Radio control panel, transmitter and receiver	$25,000
Installation	25,000
Total Unit Cost	$50,000
Savings per year by eliminating two operators	$45,000

2.2.5 Install a drydock material handling/storage system

There have been a number of advances in the Material Handling Industry that have potential applications in dock material handling. These include advances in automatic storage and retrieval (AS/AR) systems and advances in wire guided, computer controlled pick-up and delivery vehicles. This section presents a proposal to make use of these advances. To eliminate some redundance, only the operations of moving parts from the ship to the shop are discussed. Similar benefits would be achieved in the reverse flow, i.e., shop to ship material flow.

Presently a typical dock material handling system operates as noted in Figures 2-16 and 2-17.

DRYDOCK MATERIAL FLOW DIAGRAM

1. Pre-move functions (work order, work permit, disconnect tag, etc.)

2. Move request to riggers.

3. Riggers move part from compartment to access in skin of the ship.

4. Portal crane lifts part from ship to pallet on the dock.

5. Part waits on dock.

6. Forklift moves part from dock to dock side storage location (DMCC).

7. Store part for yard transportation pick-up.

8. Yard transportation moves part from dock storage to yard destination.

Figure 2-16

DRYDOCK MATERIAL FLOW DIAGRAM

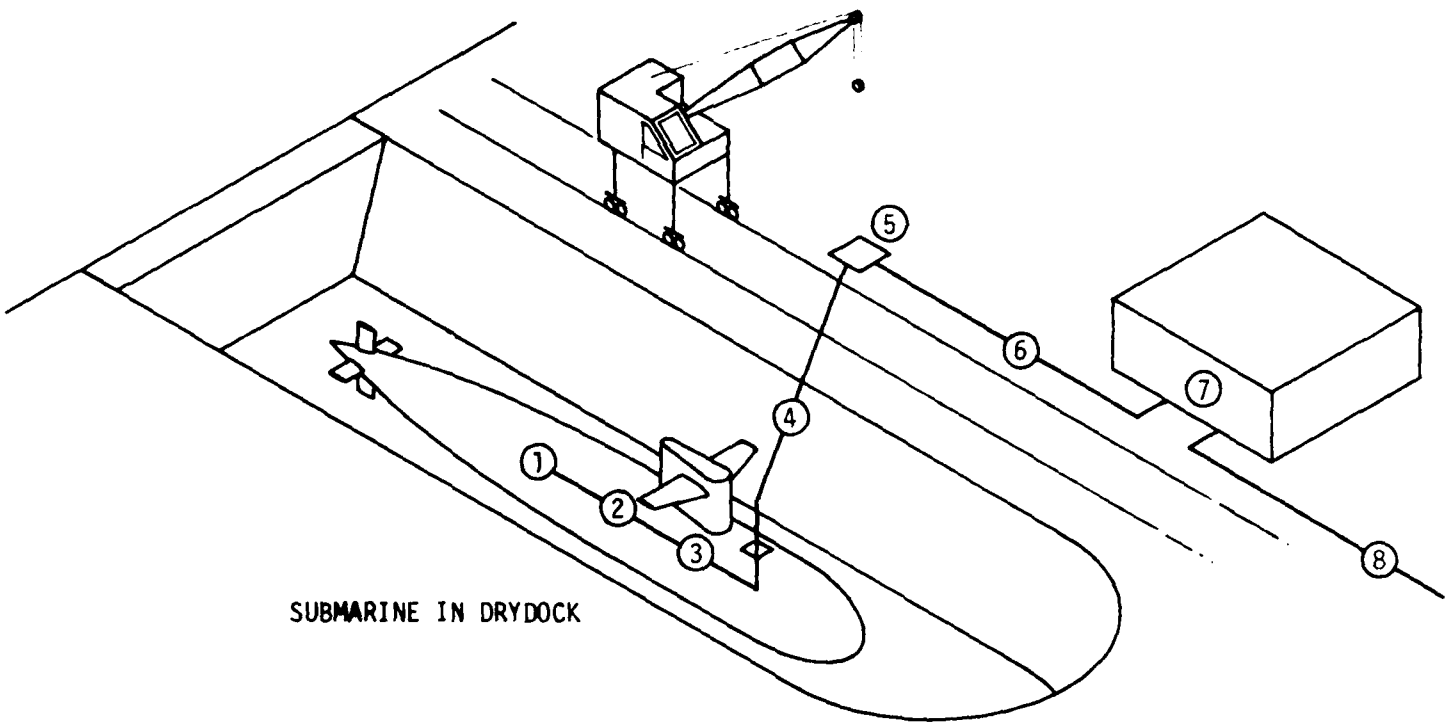


Figure 2-17

This process can take from an hour to several weeks. Special attention should be paid to Step 5, storage on the dock. Many problems occur during this step. These problems include loss, damage and long delays.

A proposed improved dock material handling system would take advantage of several advancements in the M/H Industry. This includes the use of automatic computer controlled carts to transport materials on the dock. This cart would have capabilities similar to that of the Eaton-Kenway Robocarrier® system. (Appendix L) The cart (Figure 2-18) is computer controlled, wire guided, and has the capability to travel to any transfer station, automatically pick-up or deliver loads and travel on to any other transfer station.

Another advancement that has potential application in the DMCC is an Automatic Storage/Automatic Retrieval (AS/AR) system. These are storage systems (usually high stacking) where material transfer are made by computer controlled material handling equipment. Figure 2-19 shows a proposed typical dock material handling system.

AUTOMATIC COMPUTER CONTORLLED CART

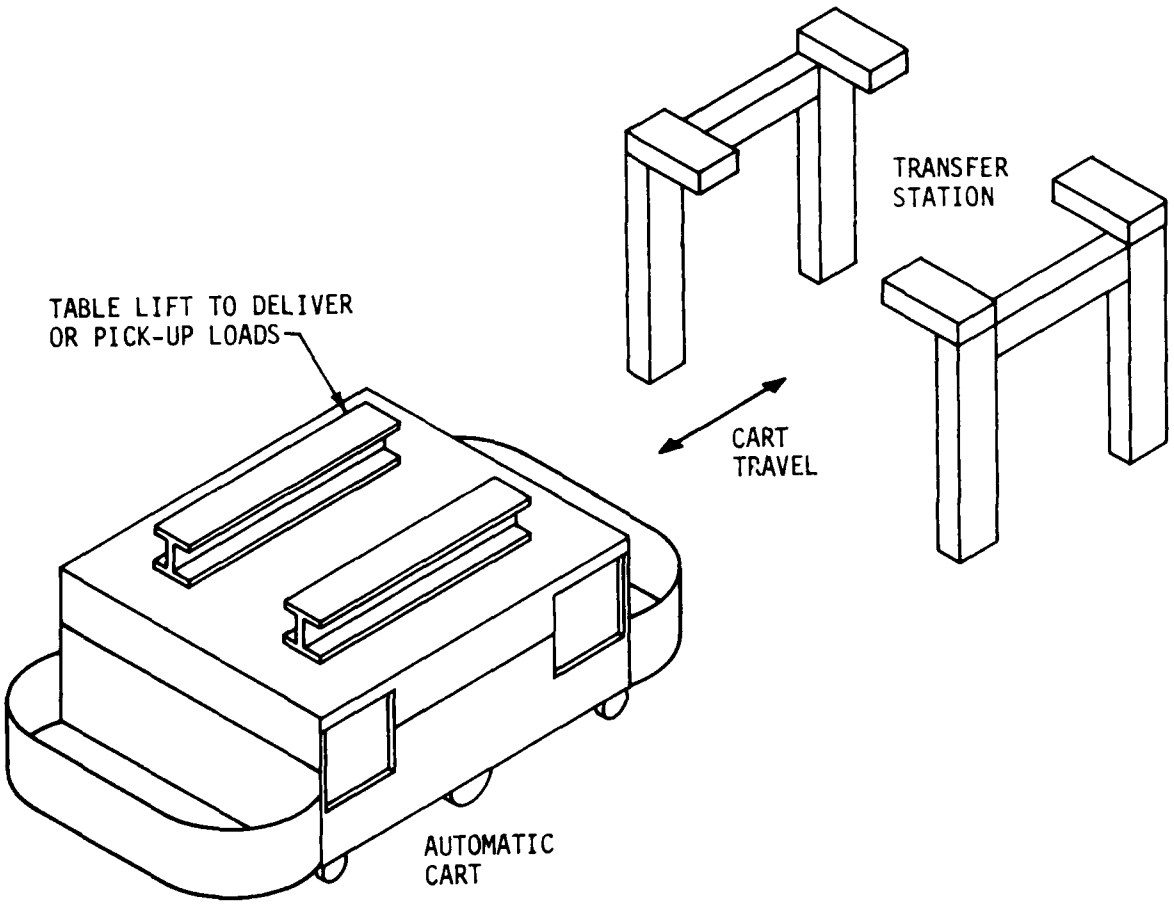


Figure 2-18

PROPOSED DOCK MATERIAL HANDLING SYSTEM

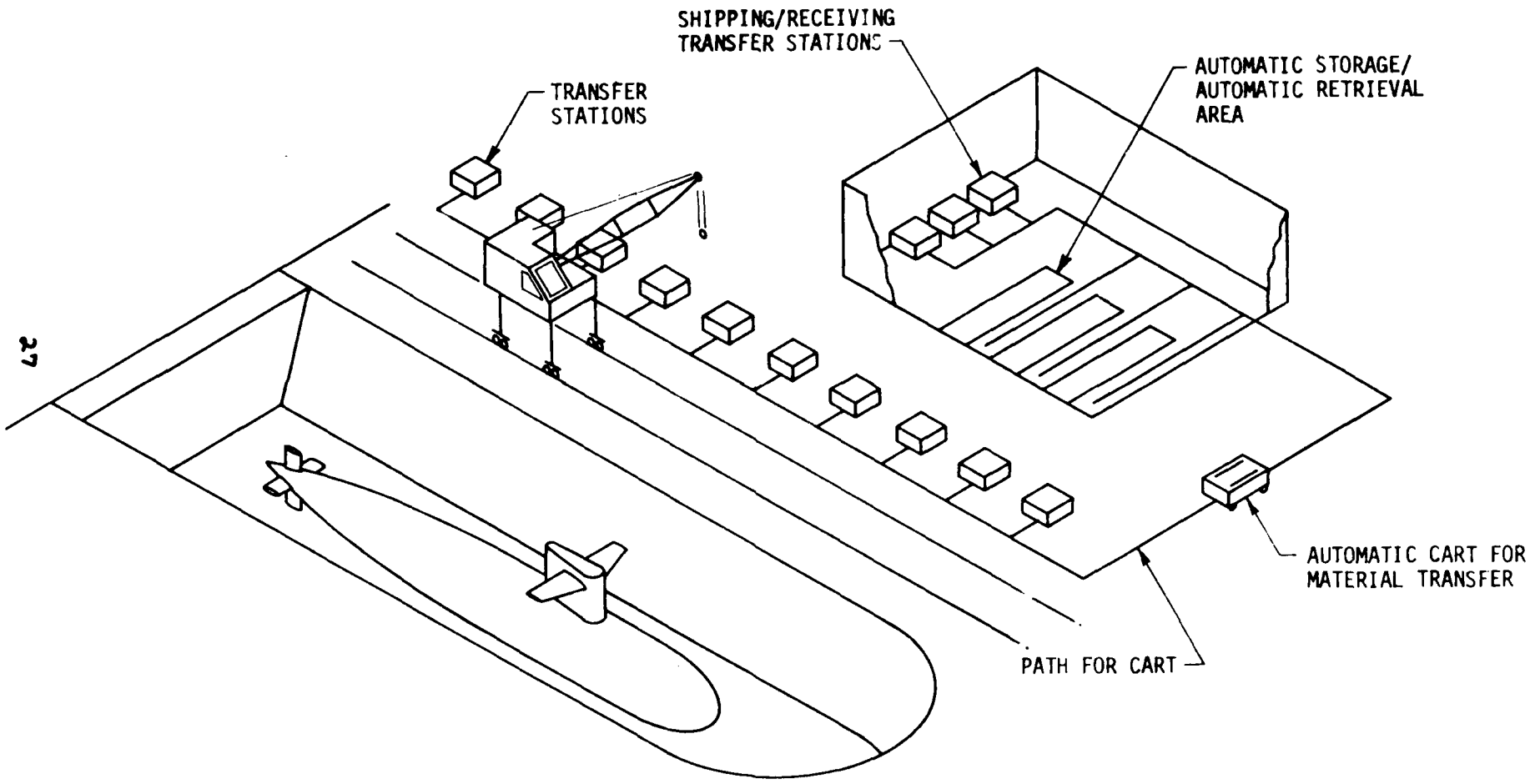


Figure 2-19

Figure 2-20 shows a plan view of a typical proposed dock portion. Figure 2-21 shows the plan view of a typical proposed DMCC.

PLAN VIEW OF PROPOSED DOCK MATERIAL HANDLING SYSTEM

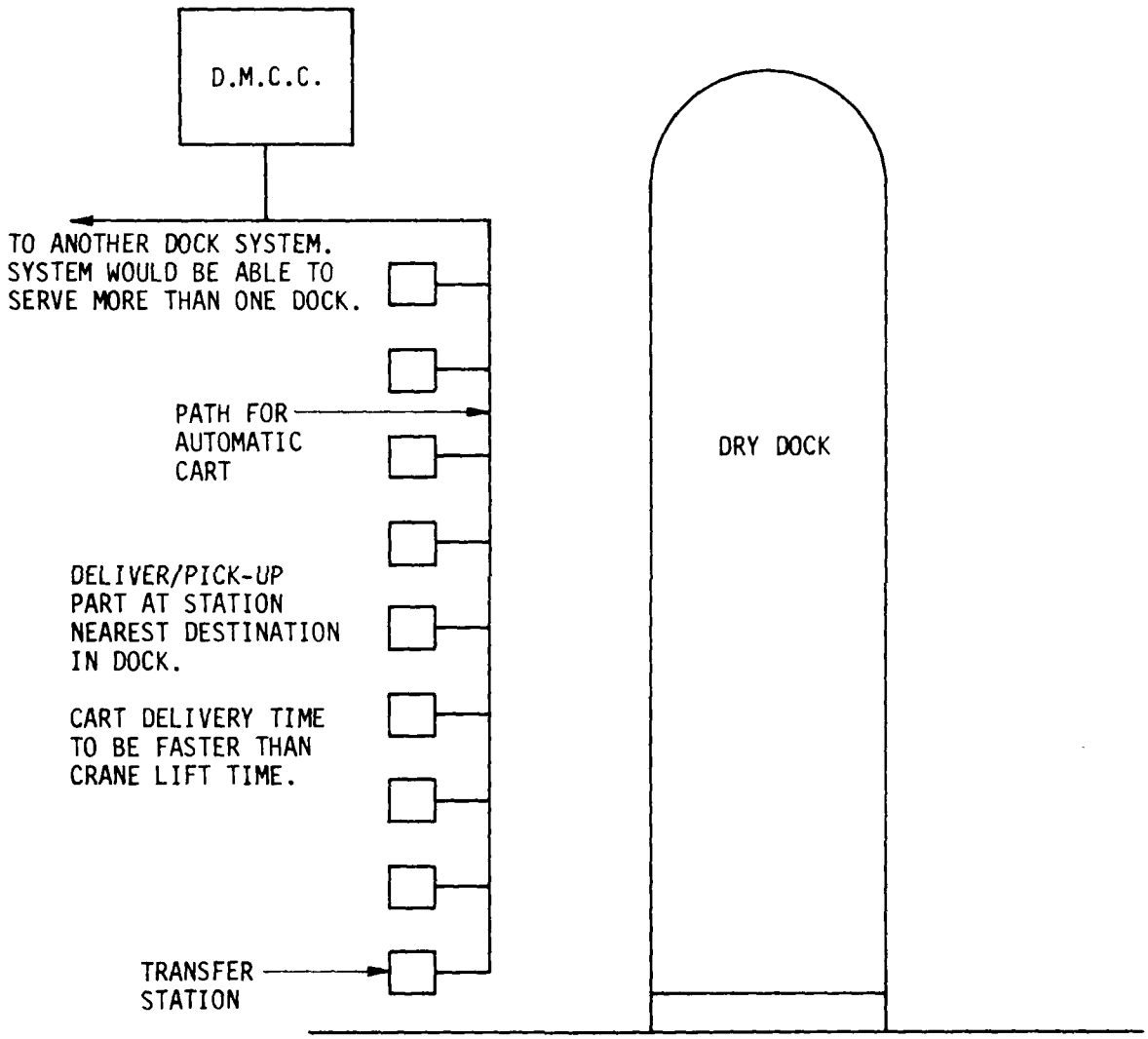
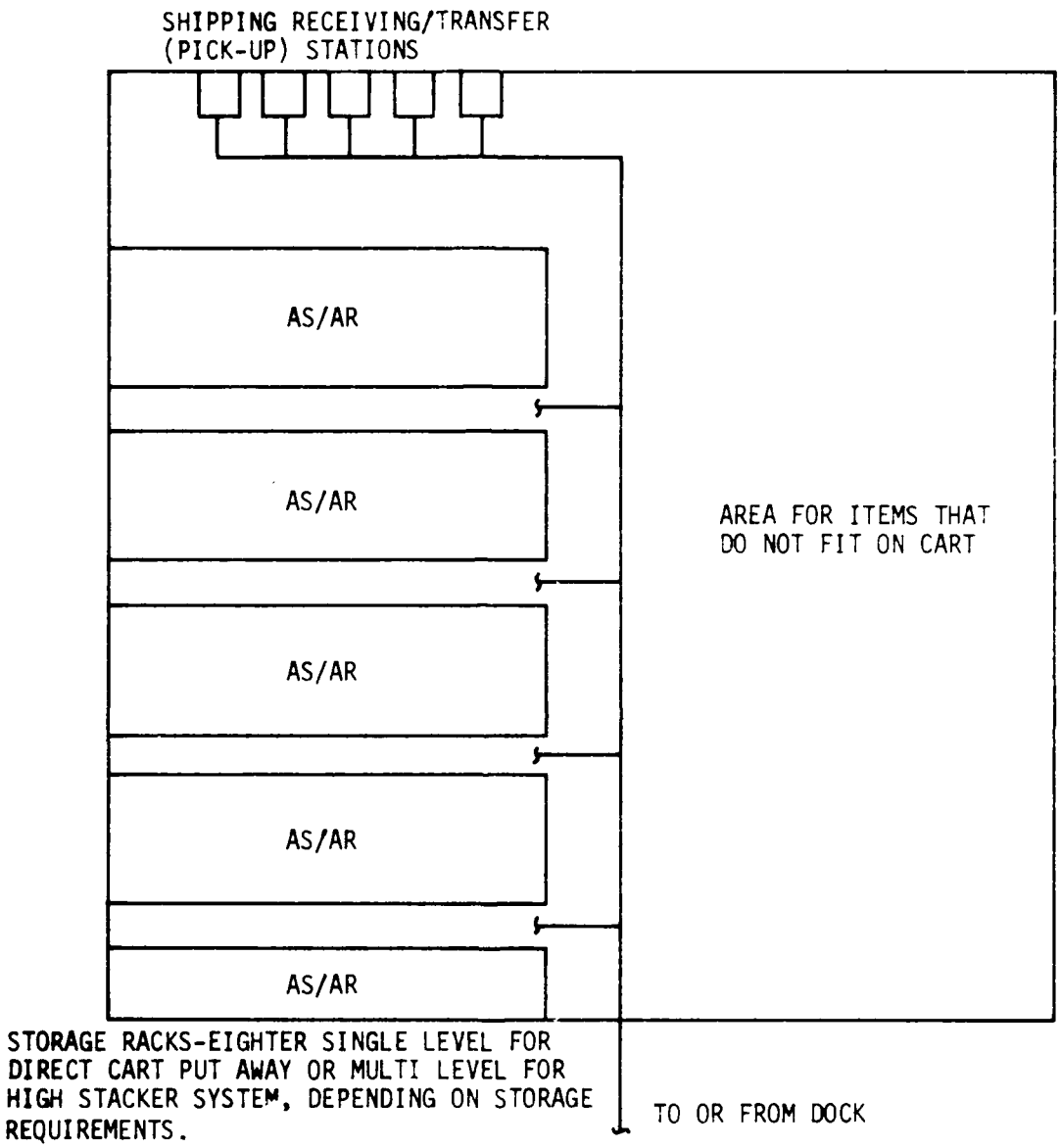


Figure 2-20

D.M.C.C. SET UP FOR AUTOMATIC WIRE GUIDED CART



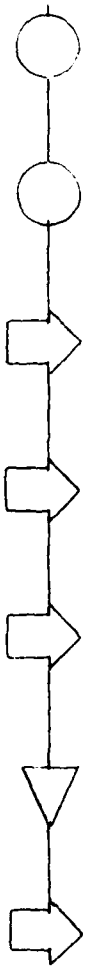
NOTE: PARTS STAY IN SECURED, COVERED STORAGE UNTIL SENT TO SHOP OR NEEDED ON THE DOCK. YET AS/AR SYSTEM WITH AUTOMATIC CART PROVIDE READY ACCESS TO ITEMS IN STORAGE.

Figure 2-21

Figure 2-22 shows a flow diagram for the proposed dock material handling system.

PROPOSED DRYDOCK MATERIAL FLOW DIAGRAM

The typical operation of the system would be:



1. Pre-move functions.

2. Move request.

3. Rigger move part from compartment to access in skin of ship.

4. Portal crane lifts part from ship to pallet on automatic transfer station.

5. Cart moves part to interim DMCC storage or directly to the DMCC shipping transfer station.

6. (If moved to storage, the cart would move from storage to shipping when required.)

7. Yard transportation move part from DMCC shipping transfer station to yard destination.

Figure 2-22

Some of the features or advantages of the proposed system include the following:

a. It provides more of a total system approach to dock material handling operations. The crane, transfer stations, automatic cart and DMCC become a coordinated system. Once an object is picked up by the crane at the ship, it remains in a material movement channel until it is sent to the shop. It does not get set down in an uncontrolled laydown area.

b. The responsibilities and services of the DMCC would be up-graded. The DMCC would have overall responsibility for dock material movement. This would include cart control, storage control, dock/pier material handling scheduling, rigging scheduling and coordination.

The DMCC would provide a secure, covered storage area with some AS/AR capability. This storage would reduce the problems normally associated with laydown areas, such as loss, weather damage, delays, etc. The DMCC would also have shipping and receiving transfer stations that could be served by the automatic cart.

c. It provides for improved control of material flow. It allows for better material planning. The DMCC can obtain better visability and control over dock material movements.

d. Improved speed of services. Material would not get set in laydown areas. It stays in a controlled material movement channel. The proposed system could routinely result in service time of minutes between the ship and the DMCC shipping transfer station.

e. Provide better utilization of dock space. Demands for dock or pier area is high. In many cases large laydown areas occupy an appreciable amount of this prime area. Moving the storage from a single level laydown area to the cube of a building or more compact multi-level DMCC storage frees dock or pier space. The automatic retrieval and delivery capability would provide ready access to the items in storage.

f. It would reduce the number of manually controlled lifts. Between the crane drop and the yard pick-up, the majority of the parts would be handled by automatic equipment. No manual controlled lifts would be required. It would eliminate cost of a forklift driver.

g. It would provide better service to the cranes. The parts could automatically be delivered to the transfer station that minimizes crane travel and lift time. It moves the part to the crane. It does not require the crane to move to the part. If the planning existed, the system could even provide the required tools, instrucitons and rigging equipment at an adjacent transfer station.

h. It is a very flexible system. It provides a system for quick and efficient movement for the majority of parts, yet allows ample room for conventional handling of parts that will not fit on the cart.

Each installation would have different costs and benefits. Each shipyard has unique features on the waterfront. These include the physical layout, the number and size of docks and piers and the type of ships normally worked at specific locations. As such, typical cost and benefit figures were not attempted. The benefit analysis would have to be done on a case by case basis. Also, typical proposals would have to be adapted to specific locations and demands.

SECTION III

MATERIAL TAGGING AND CONTROL

3.1 Introduction

Identification and control of all types and classes of parts during an overhaul is a necessary function. It is required to ensure that the parts are handled and processed in the correct manner, and are available when needed. This process depends heavily on the identification tagging and move tagging systems. Problems with these tagging systems can be as serious and costly as problems with the parts.

3.2 Present Method

The shipyards contacted (Long Beach, Mare Island, Philadelphia, and Puget Sound) reported using similar type tagging systems. A typical ripout tagging system works as follows: identification tags will be made in advance for those items to be removed as identified by Design Division. Tags will also be made on request of the cognizant shop for additional items requiring removal. The Material Management/Control Office at the drydock distributes the tags to the cognizant shops so that they can be attached to the parts. As a general rule, the riggers will not move an item unless it has been properly tagged. Before the part leaves the dock area, the cognizant shop will fill out then file a copy of the move documentation (paperwork) and forward the remaining copies with the tagged material to the drydock material center for shipment. The material center will ensure that the tagging and paperwork have been completed properly, file a copy, and arrange for transportation. The shop will receive the part, file a copy in the pending file, and send the work package to the applicable shop work center. Here, a copy will be filed in the "work in progress" file. Upon completion of the work, additional paperwork and similar procedures are used to route the ripout material to the next cognizant shop, to a temporary storage facility, or back to the drydock material center for reinstallation. At each point, a copy of the paperwork is sent to the material control organization responsible for monitoring work progress and status. Typical information on the identification tag and move documentation (paperwork) includes:

- Part number
- Part nomenclature
- Ship hull number
- Ship area designation
- Cognizant shop
- Ripout job order and key op number
- Ripout drawing number
- Routing
- Shipping instructions

In addition, tags are sometimes color coded or affixed with a tab to convey additional information, such as in process status. Present systems are characterized by a tag for material identificaion and various types of multi-copy move documents for control and tracking, with some duplication in

function. In addition, there are numerous files maintained with near duplicate information. The paperwork portion is often complex, and time consuming. Philadelphia Naval Shipyard PRODEPT Instruction 4460.5 was the most concise instruction located on this subject; yet it still required six pages of flow charts to summarize the paperwork procedure for different situations (e.g., repair item from ship to shop to ship, repair item from shop to shop, repair item from shop to storage, interference item from ship to storage, new manufactured item from shop to ship, etc.)

If there is a breakdown in the tagging/paperwork system, then the ripout material will be delayed in processing or possibly lost. Typical comments about the problems with existing tagging and control systems include:

Tags are not available when part is ready to be moved, especially for interference items identified by the shop.

Tags are issued that are not required, resulting in time and paperwork to cancel the tag.

Tags get separated from the part resulting in loss of the part.

Tags are destroyed or made illegible by the weather or elements in the production environment.

The control paperwork is subject to the same problems as the tags.

Too much time spent preparing and filling our paperwork to get tags or to track the part; confusion with copies to retain, file, retrieve, route, return, sign, cancel, etc.

The required information is not always provided at each destination to track the part; or the information is misread or misinterpreted resulting in deviations from the specified processing.

There is excessive potential for human error.

There is a lack of confidence with the system and therefore reluctance to follow the system.

3.3 Proposed Method.

The greatest potential for improvement to the tagging and move documentation system seems to lie with automatic identification systems. These systems have proved themselves efficient and effective tools in tracking and control in a number of applications. They are available and working today. Present applications include warehouse inventory and distribution control, in-plant inventory control, automatic stock replenishment, invoicing systems, circulating document control, and for product identification and material flow control. Users include libraries, hospitals, assembly plants and defense plants. When the Naval Weapons Support Center in Crane, Indiana, takes inventory, it does it in one-third the time it formerly took at a savings of $100,000, thanks to a technique using an automatic identification system (Reference (2)). They reported eliminating data transcription, improving accuracy, and reducing labor and costs with the system.

An automatic identification system consists of four major elements. They are:

a. The product or part to be identified and controlled

b. A bar code (label) which is attached to the part

c. Optical code reader

d. A data processing or logic control unit to assimilate the data and provide required information to users.

Figure 3-1 provides a conceptual sketch of an automatic identification system.

The first element, the product or part, is the item to be moved or controlled. In this section we are referring to ship components, but the system does not have to be limited to ships parts. It could be expanded to include tools, support equipment, or even the workers on the job.

The second element is a code which, when attached to the part, can be automatically read and identified. There are a number of codes available. Some common examples are shown in Table VII. The code would be on a label. Labels can be made with a variety of materials. Examples of permanent labels include vinyl, vinyl laminated with a clear mylar and ceramic.

The third element is the optical code reader. These can read the code by measuring the difference in reflection of light across the code. There are three basic type readers available; a fixed beam, moving beam and hand-held light pen code readers. Due to the large variety of physical sized and shapes of ships parts to be identified and controlled, the mobile hand-held readers appear to be the most pratical. These units can be on-line devices (connected directly to the computer via wire or radio contact) or store the data in a local memory with batch feed to the computer with a time delay. The on-line type would be most advantageous for shipyards.

The fourth element, the central processing or control unit receives the data from the reader, either in the on-line or batch mode, and presents it as useful data and meaningful information to the users of the system. This system would logically be tied to the material module of the shipyard Management Information System (M.I.S.).

Therefore, all material removed from the ship, which is tagged under the present system, would have a bar code label attached to it under the proposed automatic system. This label would identify the part. The information presently contained on the many copies of documentation would be stored in the computer. It would be accessible through computer terminals.

A typical part move would require reading the part bar code and transaction bar codes. This would be done in less than a minute.

AUTOMATIC IDENTIFICATION SYSTEM

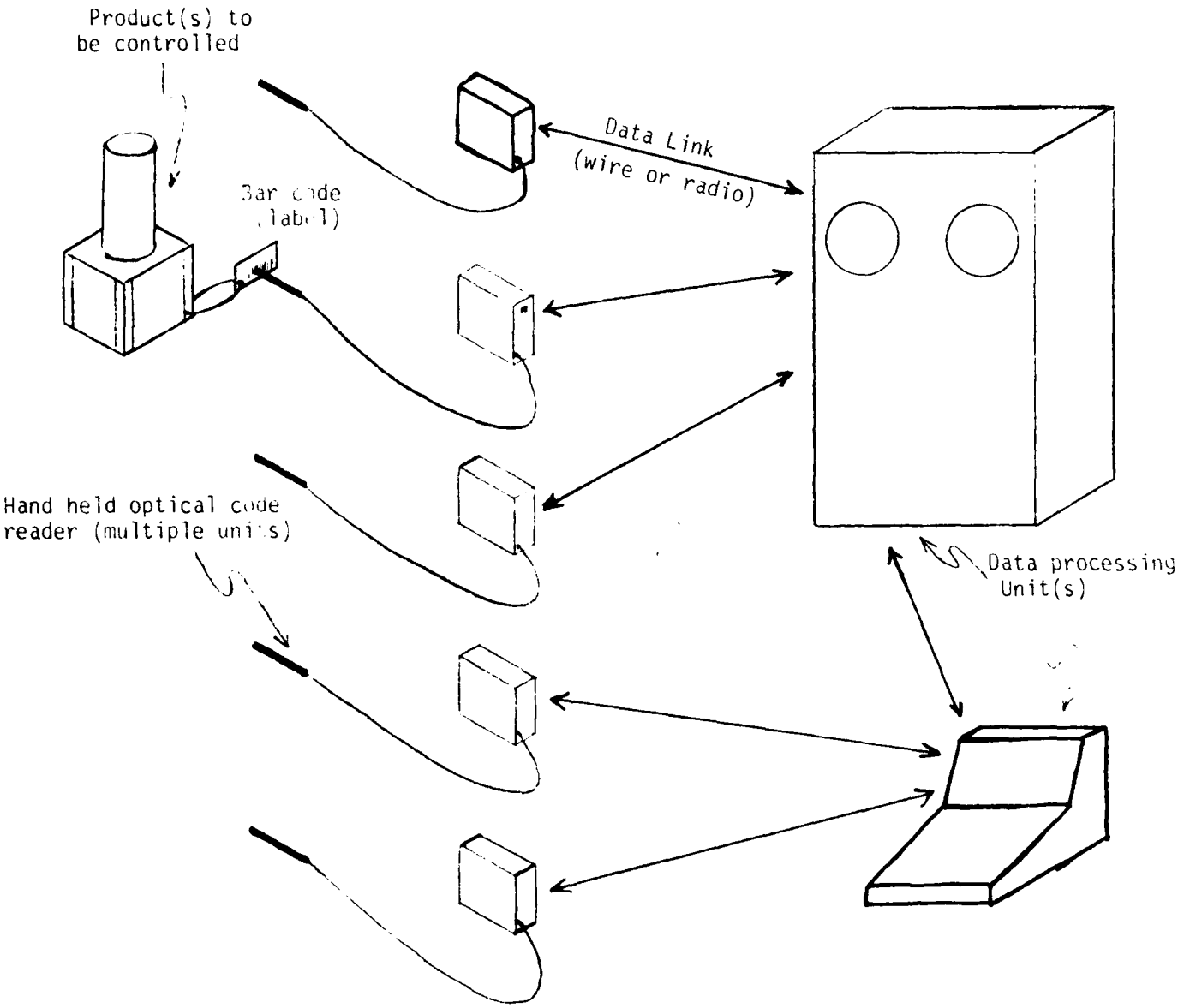
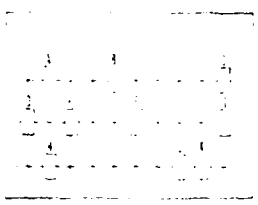


Figure 3-1

GEOMETRIC CODE

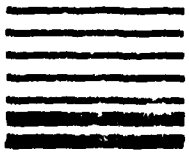


GEOMETRIC CODE A code pattern which is based [illegible] relative position of a code mark [illegible] in a grid of X-Y coordinates.

INTERLEAVED "TWO-OF-FIVE" CODE

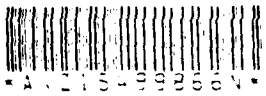
INTERLEAVED "TWO-OF-FIVE" CODE A variation of the two-of-five code which uses space as well as bar encodation.

PERIODIC BINARY CODE



PERIODIC BINARY CODE A binary format using the same amount of space for each bit, narrow bars being 0, and wide bars being 1.

"THREE-OF-NINE" CODE



"THREE-OF-NINE" CODE A code in which a combination of 3 out of 9 bits represent the digits 0-9, a 26 alpha character set, and special characters.

"TWO-OF-FIVE" CODE

"TWO-OF-FIVE" CODE A code in which a combination of 2 bits out of 5 bits define the decimal digits 0-9.

UNIVERSAL PRODUCT CODE (UPC)

UNIVERSAL PRODUCT CODE (UPC) A [illegible] digit bar code pattern adopted by U.S. grocery industry which identifies the product (5 digits) and the manufacturer (5 digits).

Ref. 13

TABLE VII

An automatic identification system for material handling and material management provides many advantages to the Shipyard, some of which were mentioned in the above discussion. These include:

a. The system is much more reliable and, therefore, provides more accurate data. Human errors and mistakes commonly associated with reading and transferring information are minimized. With code readers, reading accuracy can be achieved approaching 100%.

b. The system virtually eliminates the need for hand-written documents. This decreases the complexity of the system, saves personnel time spent filling out and processing paperwork, saves the costs of paperwork, and increases the reliability of the system. It will eliminate the problems of misfiled or lost paperwork, which presently becomes a costly problem with the ripout material.

c. The system increases the pace of production. Codes can be read in a matter of seconds. Delays associated with paperwork are eliminated. With an on-line system, information is put into the system and is available immediately. Time is not required to track the part.

d. Deviations from the expected or required can be detected earlier and reacted to prevent future problems. For example, if material is shown as being sent from the dock material center but not received at the destination after the expected time period, immediate action can be taken to locate and expedite the material. This will lead to significant time, cost and disruption savings.

e. An increase in the efficiency of materials management causes a direct increase in productivity, with a corresponding decrease in costs per unit handled.

f. The system could be expanded to other Shipyard applications, such as Shop Stores inventory, employee identification and reporting, shipyard libraries, document circulation control, shipyard equipment identification and accounting, and security control. Similar advantages could be realized by the shipyard for these applications.

g. Both industry and Defense Department facilities are moving towards more Automatic Storage/Automatic Retrieval systems (AS/AR). Automatic identification systems are compatible and complimentary to many AS/AR systems.

h. Additional valuable information could be provided to the Shipyard by the automatic system. It could feasibly identify bottlenecks in ripout material processing, provide information on repair turnaround time, provide information on rework, monitor production rates, and provide information on employee performance.

i. It could be used to record the sequence of material ripout, since reinstallation is almost the reverse order of ripout (last out is first in) the ripout sequence list can be a valuable tool for reinstallation planning.

3.4 Conclusion.

Automatic material identification and control systems have the capability of saving shipyard dollars through increased productivity, improved data accuracy and reliability, optimal material control, immediate feedback, and minimization of handling delays. On that basis, and due to the problems with present material tagging and control systems, it is recommended that action be taken to implement automatic identification systems for material handling and material management at Naval Shipyards for ripout material identification and control.

SECTION IV

MATERIAL MOVEMENT ONBOARD SHIP

4.1 Introduction

Material movement onboard the ship is an important aspect of the overhaul M/H problem. It becomes a very difficult problem due to the limited access on most ships. While it is sometimes possible to use a forklift on large ships, such as aircraft carriers, the principle methods of material movement on a ship are the time consuming manual methods. They range from hand-carrying items to the use of a hoist with block and tackle. It is generally a manual process of moving parts through a network of restricted horizontal and vertical passages. Frequently many interferences are encountered. In general, ships design do not allow for efficient movement of material.

There are other problems encountered that are not directly related to ships design. These are primarily coordination problems such as waiting for gas test on a compartment, waiting for support shop personnel, waiting for crane service, waiting for equipment tags (paperwork) and waiting for prerequisite work to be completed.

4.2 Areas For Improvement.

Improvements can be made in two general areas. These are:

Ship design improvements
M/H equipment and methods improvements

4.2.1 Changes in ships designs offer the most potential for improving the M/H efficiency. Although it is very difficult to make substantial changes in existing ships, there are some encouraging trends and concepts for new construction. These include provision made in design for material movement in the FFG-7 class guided missile frigate (reference (3)). An even more promising idea is the SEAMOD concept (Sea Systems Modification and Modernization by Modularity) (references (4), (5), and (6)).

The FFG-7 frigate class was the first ship design to be subjected to systematic equipment removal data collection and design. It took advantage of several general principles which seek to minimize time and cost of equipment movement (reference 5). The most important of these is vertical alignment of hatch openings, extending from the weather deck to the lowest compartment level. This eliminates requirements for manual handling in the vertical lift. It allows vertical lifts to be made with the portal crane. Another general principle is minimizing the required horizontal handling. In addition, the designers gave consideration to the equipment anticipated frequency of repair, level of maintenance, physical characteristics and dimensions in order to determine access size, type and location. The design objective was to be able to move high priority items (e.g., those requiring frequent removal) without disturbing adjacent services or the ship's structure. This also was used as a

criterion in the location of equipments relative to vertical accesses, horizontal aisles, and other equipment in the same proximity. The methods for handling equipment along the horizontal paths were predetermined in consideration of the ship's design and type of equipment. They consisted of:

a. Manual carrying

b. Burtoning with appropriate gear suspended from overhead padeyes

c. Using a dolly or pallet truck

d. Rolling on lengths of pipe rolling on short lengths of parallel timbers

e. Using hand trucks

f. Using the portable overhead monorail system

The ship is provided with special handling equipment and riggings in accordance with these methods. As a direct result of the complexity of the M/H plans, detailed equipment removal instructions were developed for effective use of the equipment removal system. These instructions included general rigging information, a listing of all handling material provided on the ship, a detailed description of all the vertical removal routes and the procedure for removal of each item requiring the use of any of the handling equipment, and a description of the basic removal procedure (reference (7)).

The FFG-7 class ship is currently entering the fleet. This provides an opportunity to evaluate and improve on the concept of designing ships to allow for efficient material.

Another design concept which appears to take equipment removal design for surface ships one step further, especially for weapons and electronic systems, is SEAMOD (Sea Systems Modification and Modernization by Modularity). SEAMOD is a concept for designing and constructing Navy surface combatants and their weapon system payloads to resolve the incompatibility between long-life of ships hulls (30 years) and short life of combat weapons systems (5 - 10 years). It is a "Design for Change" philosophy. The concept is characterized by modularity, with the platform consisting of the hull and other long life equipment and the payload consisting of weapons and electronic systems which are usually replaced about every ten years during modernization of the ship. Standardized structural, electrical, fluids, information, and control interfaces are designed into both the platform and module. Figure 4-1 illustrates the SEAMOD concept.

The payload items can be installed and removed quickly and easily. SEAMOD allows for efficient movement of modular blocks of material, in lieu of the current systems of many moves for individual components.

THE SEAMOD CONCEPT (Ref 5)

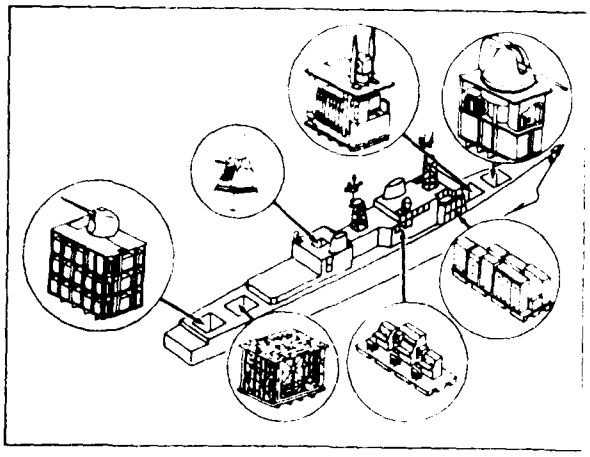


Figure 4-1

4.2.2 Other possible solutions to improve material movement onboard ship can be achieved through methods improvements. These include:

a. Improve the schedule and coordination system. Using the bar code tagging systems mentioned in Section III would allow developing an improved program to schedule equipment installation. The sequence of installation is very close to the reverse of the ripout/removal sequence. By recording, with bar code readers, the actual removal sequence, a more complete and reliable reinstallation plan could be developed.

b. All equipment should be clearly identified as to location and orientation of installation prior to the request for move to ensure the equipment is brought in "right end first." This will minimize handling and positioning and eliminate delays to remove the equipment because it was brought in backwards and space doesn't permit turning it around in place.

c. Check clearances along the proposed handling route and fit in location before a large item is moved. The method used to check could be with conventional templates and measuring devices, or it could take advantage of some state of the art improvements. These would include such things as solid photography and computer generated graphics.

d. Provide automatic gas monitors in compartments to eliminate the delays presently required to obtain gas free certification. Several companies provide this type equipment. Optimally, this equipment would be utilized by the riggers.

e. Improve the method of making and repairing hull cuts for access. (Ref M/T Hull Cut Project D.N.S. 00635) Reducing the cost of hull cuts could lead to their increased use and thereby provide more accessability to interior locations.

4.3 Summary

Studying material handling problems onboard ships is within the scope of this project. Tight ship's arrangements and congestion of equipment and systems makes the movement of equipment a very disruptive and costly process. Some potential improvements were identified and are noted in the body of this section. These were in the following general areas:

Improvements in ship design
Improvements in methods

Progress has been made in recent years in improved ship design. This includes the gains made with the FFG-7 design. In addition, the SEAMOD concept offers great potential gains.

SECTION V

UNDERWATER HULL CLEANING

5.1 *Introduction.*

Presently the most common method of cleaning the exterior hull sections is abrasive air blasting. It removes the marine growth, paint and corrosion in preparation for a new coat of paint.

This method of cleaning requires drydocking the ship, protecting areas not to be blasted, sealing and pressurizing ship sections to prevent abrasive entry, setting up scaffolding, platforms and blasting equipment, and running utility lines. Then the actual blasting process can be performed. This is followed by the tear down, clean up and disposal of the contaminated spent abrasive.

This abrasive air blast method has many inherent problems, including several which have an adverse affect on drydock material handling. These problems include:

a. Manhour requirements are high

b. The nature and undesirability of the work (e.g., hazardous, dirty, difficult, hot, noisy work requiring special suits) leads to personnel problems and large allocations for personnel allowances.

c. The dust, high velocity airborne grit, and noise produced by sandblasting precludes other exterior and interior ship work, causing delays and extensions on the overhaul duration.

d. Air blasting is typically done by personnel on a platform suspended by a crane. This is poor utilization of cranes, especially at times when crane demand is high for other work.

e. The blasting process requires large quantities of abrasive material. The quantity for each job varies depending on the amount of surface area to be cleaned, the specific abrasive material used, the desired level of cleaning, operator skill, working conditions, and equipment condition. However, quantities of one ton per 300 square feet are typical.

f. Cleaning the drydock of spent abrasive is a costly, time consuming manual job. Drydock interference and condition of the material limit the methods presently available to manual broom and shovel techniques, and occasionally a mechanical front-end loader. This is the principle material handling problem associated with sandblasting. Furthermore, increasingly stringent clean-up specifications and standards to prevent pollution have increased the labor and manhour requirements. This trend is expected to continue.

g. Disposal of the spent abrasive is becoming increasingly more difficult due to changing pollution regulations and decreasing number of available disposal sites.

h. The grit and dust from sandblasting sometimes contaminate ships systems and equipment, resulting in additional work to clean and/or repair damage caused by the contamination.

All of the above problems add to the cost of abrasive air blasting. It should be noted that less than half the cost is incurred in the actual hull cleaning process. The majority of the cost is incurred in setting up, providing protection, tear down, and cleaning up the drydock area. This does not even address the additional costs where blasting impacts other jobs or the overhaul schedule.

5.2 Initial Approach to Problem.

The initial approach of the study was to look for potential solutions to the blasting problems that would increase the efficiency and decrease the cost, but maintain abrasive air blast as the method employed. From this standpoint, concepts such as bulk handling systems, pneumatic handling systems, vacuum cleanup equipment, manlift equipment to reduce crane dependence, rescheduling the blast operation in the overhaul sequence, utilizing a different abrasive material, developing a system to contain/control the dust and spent abrasive, and developing new procedures for disposal were considered. However, in evaluating these concepts, it became apparent that some alternative cleaning methods offer greater potential benefits than improvements to the existing air blast method.

5.3 Alternative to Abrasive Air Blasting.

Several alternative cleaning methods, which have the potential to replace abrasive air blasting in many applications, have been or are currently being developed. Some of these alternative methods include:

Shot Blast Cleaning

Roto Peen Cleaning

Cavitating Water Jet Cleaning

CO_2 Cleaning

Laser Cleaning

5.3.1 Shot Blasting

Shot cleaning utilizes a centrifugal (wheel) force instead of a compressed air stream, to propel the abrasive. The blasting media, shot, is fed into the center of a blasting wheel. Abrasive is propelled from blades in the blast wheel to remove any surface coating on the part being cleaned. Figure 5-1 shows the shot blast process.

SHOT BLAST PROCESS

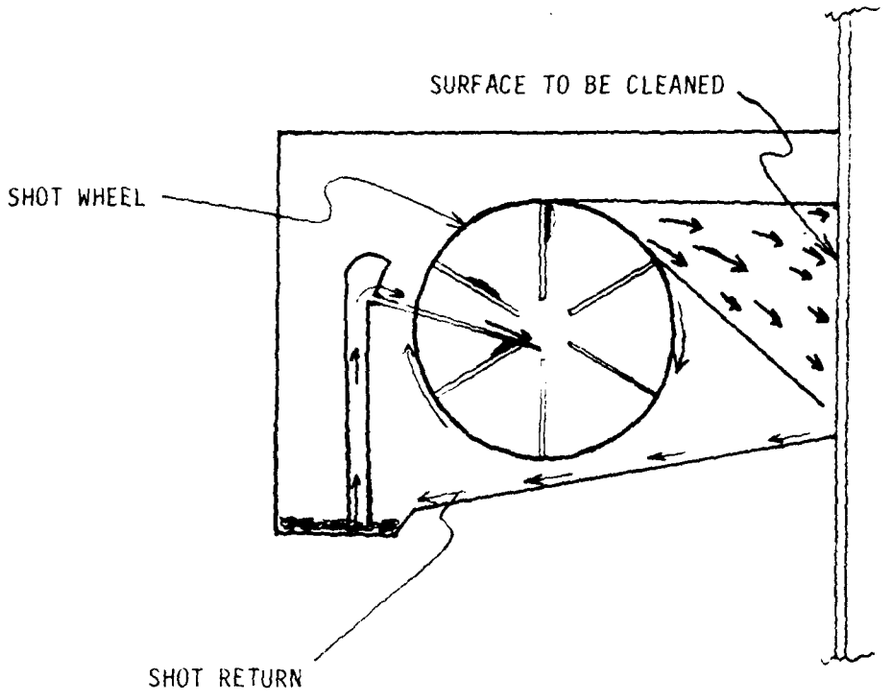


Figure 5-1

In stationary applications this process has been available and economical for many years, but the equipment is generally bulky and therefore has lacked the mobility to be moved to the hull sections. However, recent developments in the technology are making shot cleaning units more portable and therefore applicable to hull cleaning operations.

Shot blasting offers the following advantages over air blasting:

a. Increased cleaning rates

b. Reduced material handling requirements and quantities

c. Greatly reduces drydock cleanup requirements

d. Air, solid, and water pollution significantly reduced

e. Reduced need for masking, seals, and enclosures

f. Improved working conditions (less dust)

g. Less quantity of abrasive needed (1 ton shot vs approx. 35 tons abrasive)

h. Abrasive procurement cost savings

i. Shot can be recycled many times, air abrasive is used once and then disposed of

j. Reduced disposal need and costs

k. Saving energy otherwise needed for generating air pressure

l. More efficient cleaning accomplished

m. Other shipwork can be accomplished simultaneously, reducing overhaul durations

n. Crane dependency minimized

o. Equipment and set-up time reduced

Given proper equipment design and utilization, these advantages offer significant reductions in overhaul costs while providing a superior method of hull cleaning.

Norfolk and Long Beach Naval Shipyards are currently utilizing shot blast equipment and methods for hull cleaning. These include side blasters, bottom blasters, and deck blasters. The general concensus opinion is that the shot blasting process itself is very cost effective and efficient. It has proved to be a superior method to air blasting. There are a couple of reservations or limitations. Shot blasting has restricted accessability, it cannot be used in tight areas, on inside surfaces, or on highly contoured surfaces. In addition, the existing shot blast equipment has significant maintenance problems. A typical comment of Shop 06, Shop 71 and Code 380 personnel at Long Beach and Norfolk is, "The equipment is great when it is working." However, the existing equipment requires excessive downtimes for maintenance. This is expecially true with the side blaster units. Both shipyards are using prototype equipment (Long Beach - Wheelabrator Frye, Inc., Norfolk - Pangborn, Inc.). However, the process of shot blasting for hull cleaning has proven efficient and economical. Furthermore, the problems are minimal on the deck blaster units and the quality of cleaning is exceptional. A design effort is justified and needed to develop the optimum design for shot blast equipment so this method can be effectively applied to most areas of hull cleaning. The new Trident submarine base is procuring a shot blast system due to the significant advantages of the process. The performance of this design should be thoroughly studied and the results furnished to all shipyards.

5.3.2 Roto Peen Cleaning

The 3M Roto Peen® cleaning is a process that utilizes carbide buttons bonded to strong, flexible flaps. A wheel consisting of a hub and the flap assemblies is rotated against the work piece. The rotating action causes the buttons to impact against the work surface, mechanically removing scale and

paint. Optimum hull cleaning application would require a closed system to contain the removed material. The Roto Peen process offers nearly the same advantages as shot cleaning when compared to air blasting. The major difference is that there is no shot handling equipment required with Roto Peen cleaning, though the flap assemblies require reloading (about every 40 operating hours).

ROTO PEEN PROCESS

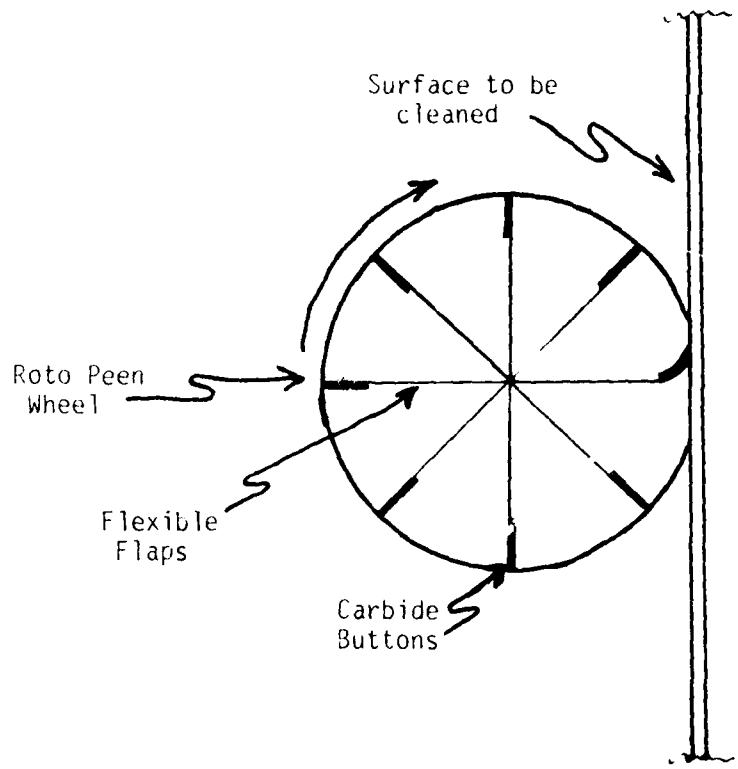


Figure 5-2

This process has not been tried at Naval Shipyards for hull cleaning. Puget Sound has used a roto blaster for deck scaling, and the method and equipment have been cost effective. Figure 5-2 provides a concept drawing of the Roto Peen process.

They are using a 3M brand conversion kit for Shop 71 tennant KDC deck scaler. The Roto Peen(R) process is equal in production performance to their shot blasting deck cleaners and is less costly to procure and operate. Based on this and the elimination of need for abrasive and handling, consideration should be given to developing this equipment and method for hull cleaning applications. Without the abrasive storage and handling components, the chassis and head would be less bulky and therefore have better mobility and accessability. Similarly, clean-up and disposal requirements would be minimized. The demand on the head seal would be reduced since only the removed contaminants would have to be contained. Therefore hull contours and protrusions would not present as large of sealing problem. Additionally, downtime

would be reduced because there would be fewer components to malfunction. In view of these significant advantages over abrasive air blasting and shot blasting, the Roto Blast method is worthy of evaluation for application to hull cleaning.

5.3.3 Cavitating Water Jet Cleaning

Water jet cleaning is a process in which vapor and gas cavities are deliberately stimulated to enhance the erosive action of a liquid jet (cavitating jet). Cavitation amplifies the extremely localized pressure and focuses the energy on the workpiece, creating erosive forces to clean the surface.

Hydronautics, Inc. performed a feasibility study on "Hull Cleaning Systems Using Cavijet® Cavitating Fluid Jets" under the sponsorship of the U. S. Department of Commerce Maritime Administration (reference (8)). This study concluded that "operation of full-scale field equipment has demonstrated that the Cavijet method can provide an alternative to present hull cleaning techniques in drydock operating at equivalent or faster rates of cleaning and at substantially lower costs." However, this is primarily for removal of foulings and loose paint only. The ability to clean to bare metal depends on the hardness of the paint. Blasting to bare metal was not the objective of the study, although it was achieved on hulls coated with relatively soft anti-foulant paint. It was not determined whether it could be achieved with the hard epoxy paint used on Navy ship hulls. Operation at higher pressures or lower translation velocities along with design improvements to the system could feasibly produce the desired results. The design concepts of a drydock water jet hull cleaning system are included in reference (8). Key concepts are total recapture, filtration, and recirculation of the working fluid, a separate power and pumping unit, a "cherrypicker" concept for positioning the cleaning head, and a rotating cleaning head with 6-10 Cavijet nozzles. Given this design and capabilities, water jet cleaning offers potential advantages similar to those for shot blasting. However, the cleaning material is a fluid, generally water, and could be recycled. It should be noted that this system can be used underwater to remove marine foulings without drydocking the ship. For drydock applications, the system would require an anti-corrosive additive to the working fluid. Figure 5-3 provides a concept drawing of the cavitating water jet cleaning process.

A similar process uses a high pressure water jet with an abrasive material injected into the stream for hull cleaning. A system of this type is being procured for the Trident Facility. Though the cleaning rate is slightly slower than air blasting, shorter overhaul durations are expected because other work can be accomplished simultaneously since there is no dust produced. Furthermore, it is estimated abrasive consumption will be reduced by 50% (this system will use copper slag). The system will not be closed, but pollution problems are not anticipated. The spent abrasive and contaminants will be removed from the drydock floor with conventional methods and water pollution standards will be met.

5.3.4 CO_2 Cleaning

Carbon dioxide pellet blast cleaning is currently under development and analysis in NAVSEA Manufacturing Technology projects DNS00355 and DNS00648.

This process utilizes CO_2 as the propellent and CO_2 pellets as the abrasive. Subliming after use, the resultant non-toxic material can be discharged into the atmosphere without polluting, thus eliminating the costly removal of spent abrasive. Preliminary testing indicates that CO_2 blasting can remove epoxy coatings from metal surfaces. However, the feasibility and economics of applying it to hull cleaning are being determined by the above MT projects.

5.3.5 Laser Cleaning

Laser cleaning is an advanced technology method which burns the material off of a surface. It is presently only in the experimental stage. This method is presently unproven and very expensive; it is conceivable that it will provide the acceptable state-of-the-art method in the future. Factors for consideration include the gaseous products of the method, the ability of the laser to incinerate hull foulings and paint, the energy efficiency of the methods, and the system procurement and operating costs.

CAVITATING WATER JET CLEANING

(ref. 8)

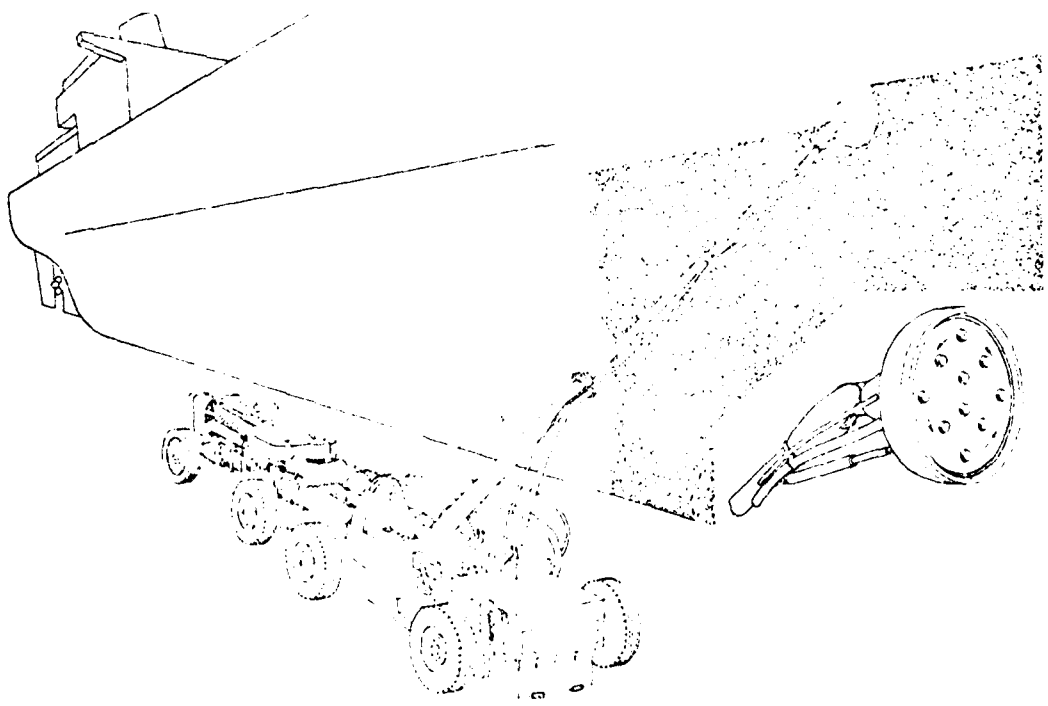


Figure 5-3

5.4 Handling System for Hull Cleaning Equipment.

One of the problems associated with the alternative cleaning methods is the movement, control, and accessability of the cleaning head on the hull surface, as the present systems have awkward methods for manipulation. As a result, it is difficult to maintain the seal around the cleaning head to contain the abrasive. The General Electric Man-Mate(R) Industrial Manipulator is an articulating arm boom for material handling which duplicates man's ability to extend/retract and raise/lower his arm (Appendix M). The terminal positioner duplicates the functions of the wrist. The terminal device is the equivalent of the human hand which can hold an object firmly. The system gives feedback to allow the operator to feel the load forces and is sensitive enough to handle glass or heavy loads to 4500 lbs. This system offers a potential solution to the problem of handling and controlling the cleaning head. It could be mounted on and operated from a mobile chassis, as with the present systems. However, if the design allowed for the cleaning head to be removed from the Man Mate, the Man Mate could then be utilized for other drydock material handling uses (e.g., handling planks, building scaffolding towers, handling ship components). Therefore, the utilization would be maximized. The equipment would not sit idle when hull cleaning work is not in progress.

5.5 Conclusions/Recommendations.

Abrasive air blasting methods for hull cleaning have numerous inherent problems, some of which have an adverse effect on drydock material handling. Analysis of the problems and evaluation of solutions indicates that there is a greater potential in developing replacement methods than to improving air blast. Recent technological advancements relative to applying shot cleaning, roto peen cleaning, and cavitation jet cleaning methods to hull cleaning offer the potential to replace air blast in many applications. With further development and improvements, these alternative methods offer significant advantages over the present method. Significant reductions in material costs, labor costs, manhours required, ancillary operation requirements, and overhaul duration are readily obtainable. Shot cleaning methods have already been implemented at some Naval Shipyards for hull cleaning.

Though potential improvements to the air blast method do exist, it is recommended that further development of alternative methods, primarily shot blast and roto peen, be pursued to allow replacement of the abrasive air blasting method.

SECTION VI

LEAD BALLAST HANDLING

6.1 INTRODUCTION. Lead ballast handling is a segment of drydock/shipboard material handling which may be improved to achieve reductions in manhours and overhaul costs for typical availabilities. Lead ballast loading and unloading requires inordinate amounts of manual material handling, primarily because of the confined working conditions.

The methodology for this study involved observation of lead ballast handling operations and interviews with personnel involved in the various aspects of lead handling. This included the lead shop, assist trades, planning and technical sections. Also, some potential concepts for productivity improvement were tested and will be described in this report. This study is geared primarily to submarines. The methods used for surface craft lead handling are similar, but the problems are not as severe due to increased working space and flexibility of installation.

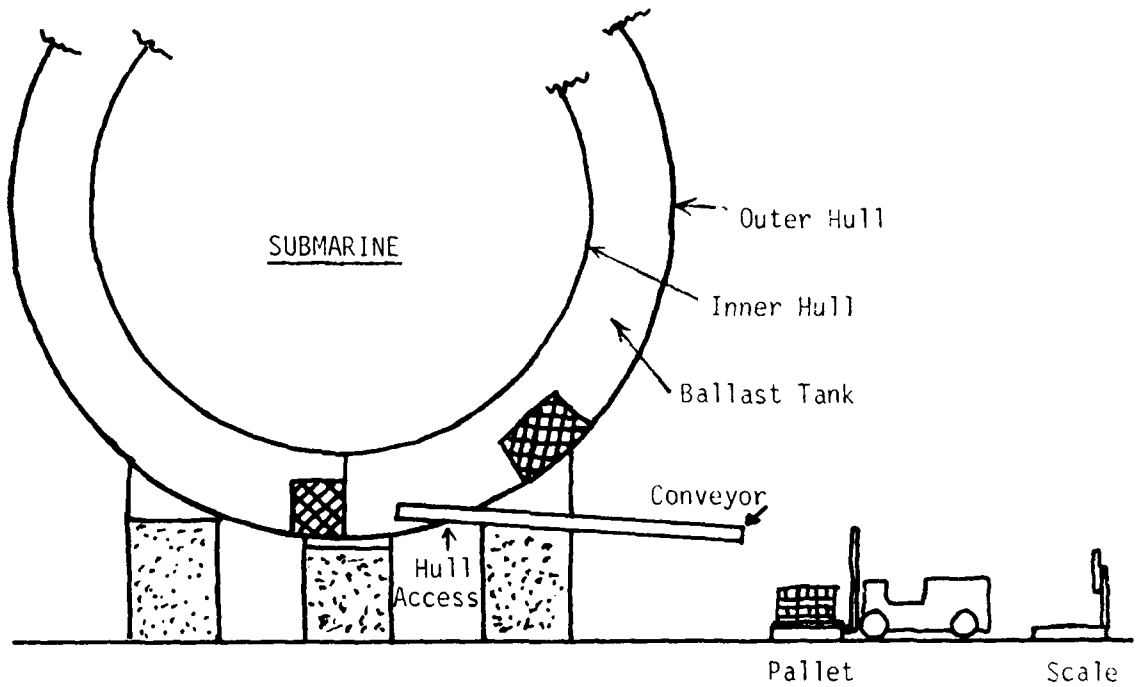
6.2 BACKGROUND. Each submarine has a calculated amount of lead ballast installed, primarily in the free-flooding ballast tanks, for maintaining bouyancy and stability. A certain amount of lead ballast must be removed and/or installed in order to: (1) facilitate visual inspection of the hull and structural members for corrosion, (2) provide access to areas for production work requirements, and (3) reballast the submarine to compensate for weight changes resulting from overhaul work. The amount and location of lead removed/installed varies significantly between each submarine and each overhaul, depending on the specific work package and the condition of structural components. The exact quantity and location of lead to be installed/removed is determined by the stability section based on weight information and stability calculations. Normally, a greater quantity of lead is removed than installed because other weight is added to the submarine during the overhaul. The guidelines for installation is that ballast shall be stowed as compactly and low as possible in the designated pockets. The standard unit of lead ballast varies between shipyards in size and weight. Additionally, shim material and bricks are cut to various shapes to fit a previous stowage pattern. The most important factor affecting lead ballast methods is the space restrictions and interferences within the hull structure and the regulations on this work. All interferences (e.g., piping hydrophones, flood gates, air flasks, and structural members) are all of higher priority. Lead must be installed so as not to interfere with their function.

6.3 DEFINITION OF PROBLEM. Lead ballast handling requires inordinate amounts of manpower, time and manual handling. This is because of the nature of the work and the restricted work space. Space restrictions also limit the applicability of material handling equipment, further compounding the problem.

6.4 PRESENT METHOD. The lead ballast method described here is based primarily on observations and discussions with cognizant personnel at Mare Island. However, telephone conversations with personnel at several other shipyards indicate that the methods used and the problems encountered are very similar for all shipyards. Key differences or innovative methods will be noted. Once

the bin location and size information is available, the lead bin is constructed, painted, and lined with rubber. Then, the lead handling shop sets up the equipment for handling lead. Figure 6-1 shows the typical equipment and layout used by all yards contacted.

LEAD BALLAST HANDLING



Typical lead ballast pocket location
(Usually 0-4 Frames from hull access to pocket)

FIGURE 6-1

Normally, one crew of 5-8 men per submarine is assigned for lead handling. This includes 2 men to load/unload the pallet and conveyor and operate the forklift and scale, 2 at the hull access (interior and exterior), 1 man per frame between the access and lead pocket to manually pass the lead along, 1 to install/remove the lead in the pocket, and a supervisor. The major exceptions found to this are that Charleston uses a portable electric conveyor. The working conditions generally preclude using any material handling equipment in the interior. Normally, the hull access is not cut specifically for lead ballast work. This results in the lead pocket being 0-4 frames away from the existing access, requiring a manual "bucket brigade"

to pass the lead across these frames from access to pocket. This is the heart of the lead handling problem.

It is difficult to establish an average cost for the lead ballasting job due to the extraordinary variance between jobs. However, the data in Table VIII is based on Code 200 planning and funding data, a review of ballast data for 5 previous submarines overhauled at Mare Island, trade knowledge, and then projected to show an annual cost for ballasting submarines for all Naval Shipyards.

TABLE VIII

ANNUAL LEAD BALLAST HANDLING COSTS
(Submarines Only)

Operation	Std Manhour Allowance	Av Qty	Av. Manhours Required	$11.90/direct Labor Hour
Install Bins	125 mh/bin	18 bins	2,250	$26,800
Prep Bin, Install Lead	29.28 mh/ton	100 tons	2,928	34,800
Set-up Removal	2.8 mh/bin	27 bins	76	900
Lead Removal	5.6 mh/ton	150 tons	840	10,000
Removal Bin	35 mh/bin	27 bins	945	11,200
Total cost per Submarine			7,039	$83,700
Total annual cost for all shipyards (based on 15 overhauls per year)				$1,255,500

Of this total annual cost of $1,255,500 requiring 106,000 manhours labor, approximately 55% represents actual lead handling as defined by the problem. It is reasonable to assume a 10% cost savings could be realized by increasing productivity with the recommendations of this study. Therefore, the projected annual savings are $126,000 for submarine overhauls.

6.5 OTHER PROBLEMS. In addition to the handling problem, other problem areas are encountered with lead ballast procedures. These are summarized as follows:

a. The basic design requirement is to stack the lead as densely as possible, this makes the job difficult.

b. Since design must consider all weight changes to the submarine during overhaul, the ballasting plans cannot be made available until a relatively short time before the undocking. This frequently puts the job into a situation with maximum visibility.

c. Due to the nature of the job, the production rate is not constant. Each job is unique in some aspect. Rest periods and changes in assignment (e.g., from stacker to conveyor loader) are required. Also it is difficult for the supervisor to monitor job progress in the interior working area of the submarine because of limited personnel access.

6.6 M/T SOLUTIONS/RECOMMENDATIONS. Improvement to the lead ballast handling problem are grouped into three categories:

a. Reduce the reasons for removal of lead.

b. Modify the size or shape of the lead brick.

c. Develop improved work methods.

Potential solutions are outlined below according to the three areas listed above. Since they may be affected by the limitations on solutions, possible pitfalls are also described. However, all offer potential productivity improvements.

a. Reduce the reasons for lead removal. If the reasons for lead removal can be reduced, then a portion of the problem is eliminated, not "just improved upon." One of the reasons for lead removal is to allow for hull inspection. If inspection could be made without removing the lead, then the problem would be reduced. A step in this direction has already been achieved with the requirement to line each bin with rubber prior to lead installation. This rubber protects the paint, reduces corrosion, and reduces the inspection requirements. If corrosion prevention can be improved further, the necessity to remove lead for inspection can be reduced. It should be noted that if the lining itself is sealed properly and in satisfactory condition after lead removal, the bin shall be considered satisfactory, and the frequency of inspection decreases. This could be accomplished by improving the methods for applying the lining, and/or by strengthening the lining with chemical treatments or wire reinforcement.

Develop inspection methods that do not require lead removal, primarily with ultrasonic techniques. A complete visual inspection could still be conducted on surface areas in the tanks not covered by the lead bin. The ultrasonic method could be used to inspect those surfaces made inaccessible by the lead bin. The feasibility of this would depend on the ability of the inspection device to economically determine the extent of corrosion. Though some modifications would be required, the Sea Water Component Integrity Measuring Instrument (SCIMI) appears to have the required capability. This accurate, portable ultrasonic scanner is a Navy contracted (1978) inspection device developed by Mr. R. H. Grills, General Dynamics, Electric Boat Division, Groton, Connecticut.

b. Modify the size and/or shape of the lead brick. This involves modifying the lead ballast to make manual handling easier or increase the possibility of using material handling equipment. Recommendations from this standpoint are outlined below:

Develop a different sized lead brick to maximize the efficiency of manual handling. Larger bricks would reduce the number of moves, but be more difficult to handle. Smaller bricks would be easier to handle, but would increase the number of moves. An analysis and study is required to determine the optimum point of this trade-off. Tests were conducted at Mare Island as part of this study to determine if changing the brick size/shape would affect productivity. One test involved providing smaller bricks with a special design for installation in a test pocket. These are 3" W x 12" L x 1-1/2" H, 22 lbs. versus the standard 3" x 3" x 12", 45 lbs. bricks. The test bricks had a molded in taper, from 1-1/2" thick at one end to 1-13/32" thick at the other end. This is designed to increase the packing density when the bricks are stacked on the thick end by improving conformance to the curvature of the hull. Because of the holiday season and the urgency of the job, it was not possible to observe the installation of the test bricks. However, feedback from the installing shop indicates that the handling of smaller bricks is easier and faster. The concept is worthy of further evaluation and testing. Figure 6-2 shows a concept drawing of how the taper bricks would stack.

The other test undertaken used a brick design suggested by lead handling personnel. The lead was cast into 6" x 12" sheets of different thicknesses (3/4", 1", 1-1/2") resulting in 22, 30, and 45 pound "sheet" rather than bricks. Feedback from the shop indicated that the sheets are easier to stack than bricks, and that the lighter weight sheets are faster and easier to handle. It was also indicated that these sheets required less strapping to contain them because of greater exposed surface area. This reduces the strapping manhours. Another advantage of the sheet design is that it provides three different dimensions to work with rather than two as with the present bricks. This makes it more adaptable to packing different sized spaces. From both tests, it can be concluded that modifying the size/shape of the lead ballast can affect productivity. Further study and testing is recommended to finalize an optimal design.

Once the optimum brick design is obtained, it should be implemented for new construction. In the long run, this will benefit all yards by allowing for more efficient manual handling and standardization of methods and equiment used for the job.

MODIFIED LEAD BALLAST BRICKS

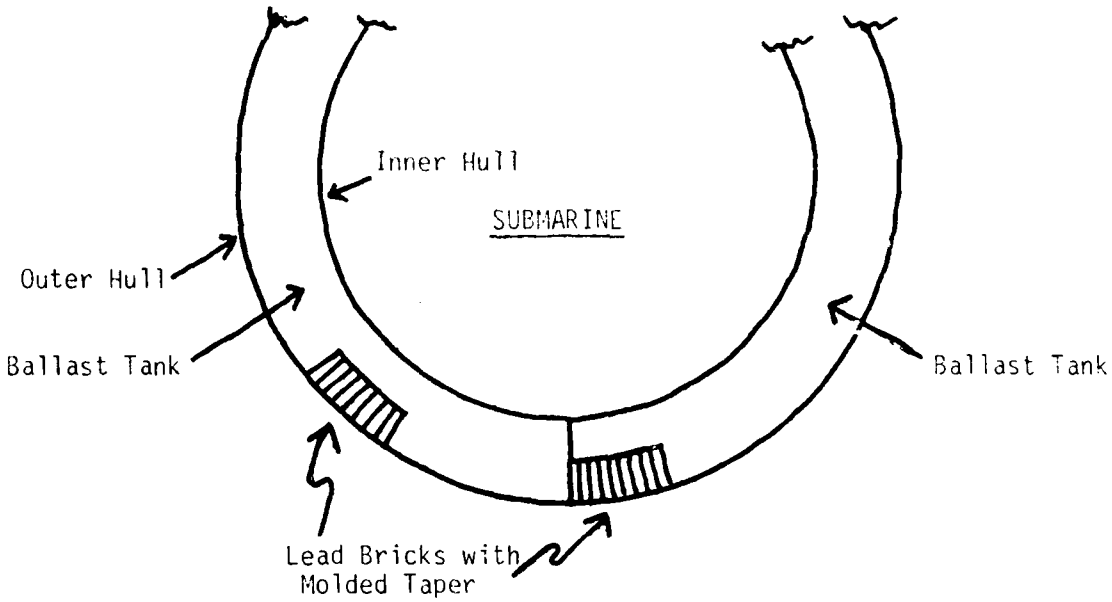


Figure 6-2

c. Develop improved work methods. Perform a feasibility and cost analysis on making direct access cuts to certain lead bins in lieu of manual handling across frames. Determine conditions which would warrant specific access cuts for lead handling, with consideration of Naval guidelines and regulations for hull penetrations. This access would only have to be large enough to allow passing a brick through from the outside into the lead pocket (i.e., small access hole), provided there is access for the stacker through adjacent frames. The lead installer would enter the pocket through the access and frames where the lead would have been normally passed along. The lead would then be passed in directly through a small (e.g., 12" diameter) access cut at the lead bin frame, cut specifically for that purpose. This would reduce the handling manpower requirement for the job by approximately 50%, from 6 or 7 to 3 or 4 personnel. The time required to complete the job would be significantly reduced. The major obstacle to this would be the present requirements to keep hull cuts to a minimum.

Utilize a power conveyor to transport the lead from dock to access and vice versa to simplify the job and reduce manpower requirement. Charleston Naval Shipyard reports already using this concept with success. It would require flexibility of height and adequate control to ensure the safety of the man at the receiving end.

Utilize a hydraulic lift table or forklift to raise and hold the lead at the access. This would greatly reduce the exterior handling and manpower requirements.

Minimize drydock interference and congestion around the lead ballast work area, as it affects production (e.g., prevent forklift access).

Strapping of the lead is a critical part of the overall lead ballast procedure. Though not directly related to lead handling, it must be considered when evaluating possible solutions. For example, changing the standard brick design may alter strapping requirements.

On new construction, consider the access design concept of the FFG-7 Class ships and applying it for lead ballast handling to have critical paths for removing equipment.

When the same lead is reinstalled into its original pocket, attempt to use the last out first in principle to increase packing efficiency.

6.7 SUMMARY.

Lead ballast loading and unloading requires an inordinate amount of manual material handling, primarily because of the confined working conditions. Improvements to the lead ballast handling problems fall into three general categories.

a. Reduce the reason for removal of lead

b. Modify the size and/or shape of lead brick

c. Develop improved work methods

Improvements in hull corrosion protective measures reduce the requirement to remove lead ballast for inspection. In addition, it might be possible to inspect the internal surface for corrosion, without removing the lead, by using a portable ultrasonic scanner on the exterior surface. Tests indicate that changes in the size and shape of the lead brick increase productivity. Reducing the size, from the existing 45 lbs. to about 25 lbs., improved the loading rate. These tests were limited and therefore cannot be considered conclusive.

Improvements in work methods include such things as, cutting special small access holes for lead bricks, and using power lifts and conveyors for delivering lead ballast to the hull access.

SECTION VII

PERSONNEL MOVEMENT AROUND THE DRYDOCK

7.1 Introduction.

A subject closely related to material movement in the dock area is personnel movement. It is very closely related when the people are carrying materials or traveling to obtain materials.

7.2 Background.

General observation reveals that there is a relatively high flow of personnel to and from the dock area, as well as within the dock area. This is undesireable from the aspect that a person travelling is generally adding to the job cost without doing a value added function. Reductions in personnel movement should lead to higher productivity and lower costs.

PERSONNEL MOVEMENT STUDY AREA

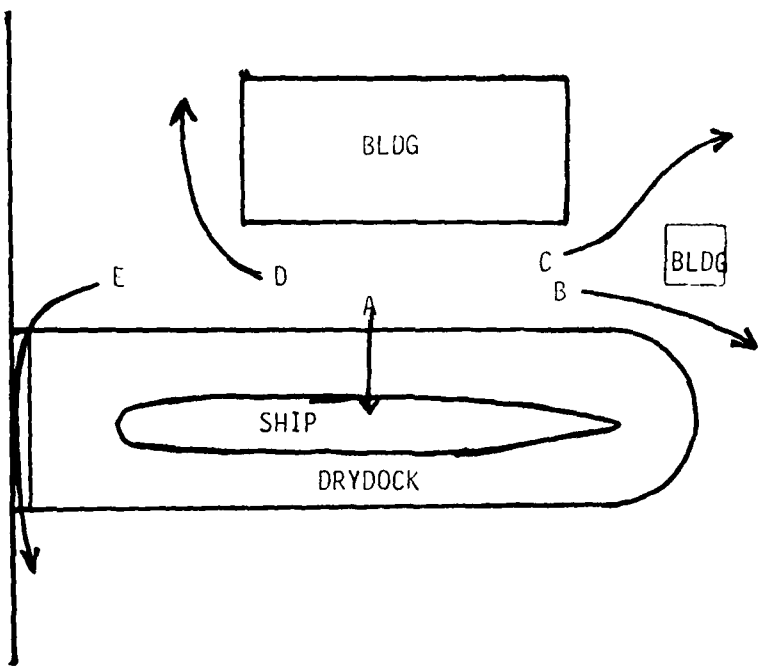


Figure 7-1

A study was conducted at Mare Island to get some objective quantitative numbers on the magnitude of the problem. This study consisted of on-site observations and the taking and analysis of timelapse films showing personnel movement in the drydock area. All observations were made during the day shift with an SSN in for overhaul. A layout of the area around Drydock #1 at Mare Island is shown in Figure 7-1.

The corridors where people travel are designated A, B, C, D, and E. Corridor A is for personnel going to the ship. Corridors B, C, D, and E are for personnel going to various areas of the shipyard. People were counted travelling on foot or by bicycle in the direction of the arrow. This included personnel from all shops and codes as well as Ship's Force and contractors. The results of the study are summarized in Table IX.

PERSONNEL MOVEMENT

TABLE IX

Corridor	Hours of Observations	Average People/Hr One Direction	Average People/Shift One Direction	Average People/Shift Two Directions
A	17.5	147	1176	2352
B	15	57	456	912
C	19.75	54	432	864
D	4	59	472	944
E	14.75	22	176	352
Total				5,424

The last column gives the average number of people (trips) entering and leaving the drydock during the day shift.

Appendix N explains some assumptions and shows a projected total number of trips and total cost at all naval shipyards. Some assumptions made are that the trips per worker in all shipyards is the same as that observed in the study and that the average cost per trip is $2.22.

The Total Projected Trips To and From the Drydock and Waterfront Area for All Naval Shipyards is 59,700,000 Trips Per Year.

Assuming a conservative average cost of $2.22 per trip, the total projected cost for these trips is $132,500,000 per year. With this amount of money involved, the potential for savings is substantial.

The scope of the study was to determine the magnitude of the problem. It did not attempt to determine the reason for the trips, i.e., the cause of the problem.

Future studies could be directed at determining the reasons for the trips. This would be a difficult study, but as noted above, the potential for savings are substantial.

It is reasonable to expect that there are many reasons for the trips. The easier reasons to determine would be those readily admitted to or authorized. They would include:

Start or complete the work day

Start or complete a task

Leave for and return from lunch

Personal reasons (restrooms, injury, etc.)

To obtain tools or materials

To obtain instruction or authorization

To find assist trade

Etc.

Other reasons more difficult to determine would be those not normally authorized, for example:

Social visit

Unofficial personal business

Not prepared for task

Frustration with the job

Unwilling to work

Etc.

7.3 Conclusions.

Generally the correction for the problem would involve decreasing the number of trips, decreasing the duration of the trips or some combination of the two. Many of the potential solutions would not be in the scope of manufacturing technology solutions. Some of the possible solutions include:

Better planning to reduce number of trips

Better material service to the ship workers

Better supervision

Locating support facilities in closer proximity to the docks

Reduction in the number of trips would be expected by providing better material handling service from the DMCC to the ship or from the shop to the ship. This is discussed in the material handling section. As noted, this should reduce the trips to obtain materials. If tools were included in the system, it could also reduce the trips for tools.

Installing the proposed material handling system would free dock space for other uses. This would allow placing support functions, such as restrooms, locker rooms, lunchrooms, etc., closer to the ships, therefore, cutting down on the duration of trips.

Other possible methods to reduce the duration of the movement is to provide some mechanical people movers.

These could include such things as escalators, elevators and moving walkways. In this study it could not be concluded that installation of this equipment would be cost justified. Since each drydock has a unique layout and personnel flow, it is not reasonable to make general recommendations.

It is felt that personnel elevators into the drydock do appear to be cost justified in some docks. Generally speaking, the deeper the dock, the higher the people count and the more concentrated the flow, the more likely an elevator would be justified. They would have to be justified on a case by case basis.

SECTION VIII

GENERAL SUBJECTS

8.1 INTRODUCTION

This study identified other drydock material handling and related problems at Naval Shipyards. Similarly, some innovative solutions or unique concepts for solutions to these problems were found in use at certain yards. These are briefly discussed below so that readers will be made aware of the problems and some potential, as well as some proven solutions to improve Shipyard Material Handling.

8.2 DRYDOCK BLOCKS

One of these existing problem areas is the handling and set-up of docking blocks. They require extensive hoisting and maneuvering to position within tolerance to the docking plan. One common method presently used is to handle and position the blocks one at a time using a dockside portal crane. This method is time consuming and costly. Norfolk Naval Shipyard has purchased two lift trucks with side shifting clamps ("squeezers") to be used for setting dock blocks. They are convinced that squeezers are the most efficient method of positioning blocks in the drydock and estimate annual savings of $66,000. They are faster and more accurate than using a crane, and provide more efficient equipment utilization. It was reported that Newport News Shipbuilding has been successfully using this method.

Different block designs also provide potential reductions in dock block set-up times. Puget Sound Naval Shipyard is developing an 8 foot mainline block design which will significantly reduce the number of blocks and crane lifts required. Additionally, this design includes lifting sockets built into the blocks for use with a special lifting attachment to reduce lift preparation times, make the block easier and more stable to handle, and to eliminate padeyes and protrusions from the block which are currently hinderances to handling and positioning.

Appendix O reports that less blocking could potentially be obtained by not installing every block on the docking plan, but docking the vessels in accordance with overturn criteria (e.g., earthquake and hurricane forces) for that Shipyard area. This could eliminate up to 50% of the blocks presently used at certain Naval Shipyards. This information is defined in NAVSEA Tech Manual 997.

8.3 STAGING TOWERS

Another drydock material handling problem area involves the erection and handling of staging set up around vessels in the drydock. Present methods require excessive manhours, primarily to assemble/disassemble the pipe staging outside the drydock. Stage boards are installed once the staging is in place. A common method of accomplishing this is to use a portal crane to lift the boards from the dockside to the staging, where they are manually placed. This

requires many lifts and results in poor crane utilization. Norfolk Naval Shipyard has purchased a set of prefab staging tower modules, as shown in Appendix P. These towers are designed to fit the contours of submarine hulls. They can be equipped with necessary service and utility outlets, are lightweight and easily handled. They can be left in the drydock when flooded. They have a fold-down platform at each level on which can be set ships components, support equipment or portable tools with good crane access, and they significantly reduce and minimize the manhours required to assemble/disassemble pipe staging. Only a minimum number of stage boards have to be installed, as the tower and platforms remain intact between uses. Although they have not yet been utilized to an extent to provide a valid performance evaluation, it is expected that these staging towers will provide considerable cost and labor savings.

Puget Sound uses aluminum plank stage boards in lieu of wood boards due to difficulty, and cost, in acquiring wood boards to the stringent treatment specifications required. Furthermore, the aluminum is much lighter, more durable, and easier to handle than wood stage boards.

8.4 MECHANICAL MANIPULATOR

The General Electric Company Man-Mate® manipulator (Appendix M) discussed earlier in relation to a hull cleaning application, could also be used to handle stage boards. All boards could be batch lifted into the drydock by a crane in a relatively small number of lifts. The Man-Mate would be used to lift the boards from the dock floor to the staging for installation. This would free the crane for other lifts.

8.5 PROPELLER AND SHAFT REMOVAL

Propeller and shaft removal/installation handling in the drydock is a difficult task because their shape and location prevent the effective use of cranes. This is also true for other items located under the hull such as rudders and sonar domes. Long Beach and Puget Sound both report efficient, satisfactory performance with Elwell-Parker shaft handling equipment. In discussions with Elwell-Parker, they indicated that they have increased the capacity, precision, and versatility of the equipment for propeller and rudder handling applications, as well as for shaft handling.

One important factor that affects the applicability of this and other drydock material handling equipment is the relative smoothness of the drydock floor. Grooves, steps, or obstructions in the drydock floor may limit the mobility of the equipment and/or the abiity of the equipment to function efficiently. Modifications to smooth the drydock floor alleviate the problem in these cases. Similarly, the size of the drydock relative to the vessel in the dock may preclude the use of some equipment. There might be room to utilize the equipment on only one side of the drydock. These limiting factors have to be identified and the solutions developed on a case by case basis. Generally this will not be a problem in every drydock at a given Naval Shipyard, and the desired equipment can be used to generate cost savings and increase productivity in the drydocks where applicable.

8.6 PICK-UP TRUCKS

An area of inefficient equipment utilization is pick-up trucks at Naval Shipyards. While they are designed to transport material observations reveal that these trucks are used almost exclusively to transport people around the yard. Given Shipyard bus, taxi, and bicycle systems and the current emphasis on energy conservation, pick-up trucks do not represent an efficient method to move people. Pick-up truck utilization should be restricted to material handling applications, and more economical and energy efficient me provided and used to transport people.

8.7 STANDARD MODULES FOR WATERFRONT SUPPORT

Certain jobs, which by nature must be done at the ship, require portable equipment/storage facilities in the drydock area (e.g., shop supplies, acid cleaning rigs, ventilation, welders, tanks, load banks, blast equipment, pumps, office, and other temporary support systems). Existing methods use many different sizes and shapes of platforms for handling and transporting this equipment around the drydock. Many systems are not handled as a unit, but must be handled as components in a multiple number of moves. Standardizing these protable systems/facilities on a standard shipping platforms or containers such as the Mil Van and/or the 8' x 20' I.S.O. container offers some advantages. For example:

a. Result in fewer moves because equipment is containerized and can be handled as a unit.

b. Result in reduced costs per unit handled.

c. Allows more set up in shop, reduces dockside set up time.

d. Uniformity would improve dockside housekeeping.

e. Provide ability to use standard commercial handling equipment to transport units around yard.

f. Ability to stack module units would maximize space utilization. This would allow for more efficient use of drydock area and pier area, which is usually in high demand.

g. The economics of having similar type modulars asembled and distributed from one location. A shipyard could specialize in the manufacture of a given module and supply them to other yards.

h. Simplify the procedure and method for loan of equipment between Shipyards. They would be a standard (I.S.O.) shipping size.

i. In emergency situations, they would allow the timely transportation and set-up of support functions away from a Shipyard. Some proposed module concepts are shown in Figure 8-1. Providing standardized shipping platforms or module containers for various overhaul equipment and ship support systems concurs with many of the fundamental principles of material handling, as defined in reference 9. This includes the systems principle, simplification

principle, space utilization principle, unit size principle, standardization principle, equipment selection principle, and the safety principle. By satisfying these principles, the potential for cost and labor savings and increased productivity is maximized through improved material handling.

TYPICAL PROPOSED STANDARD MODULES

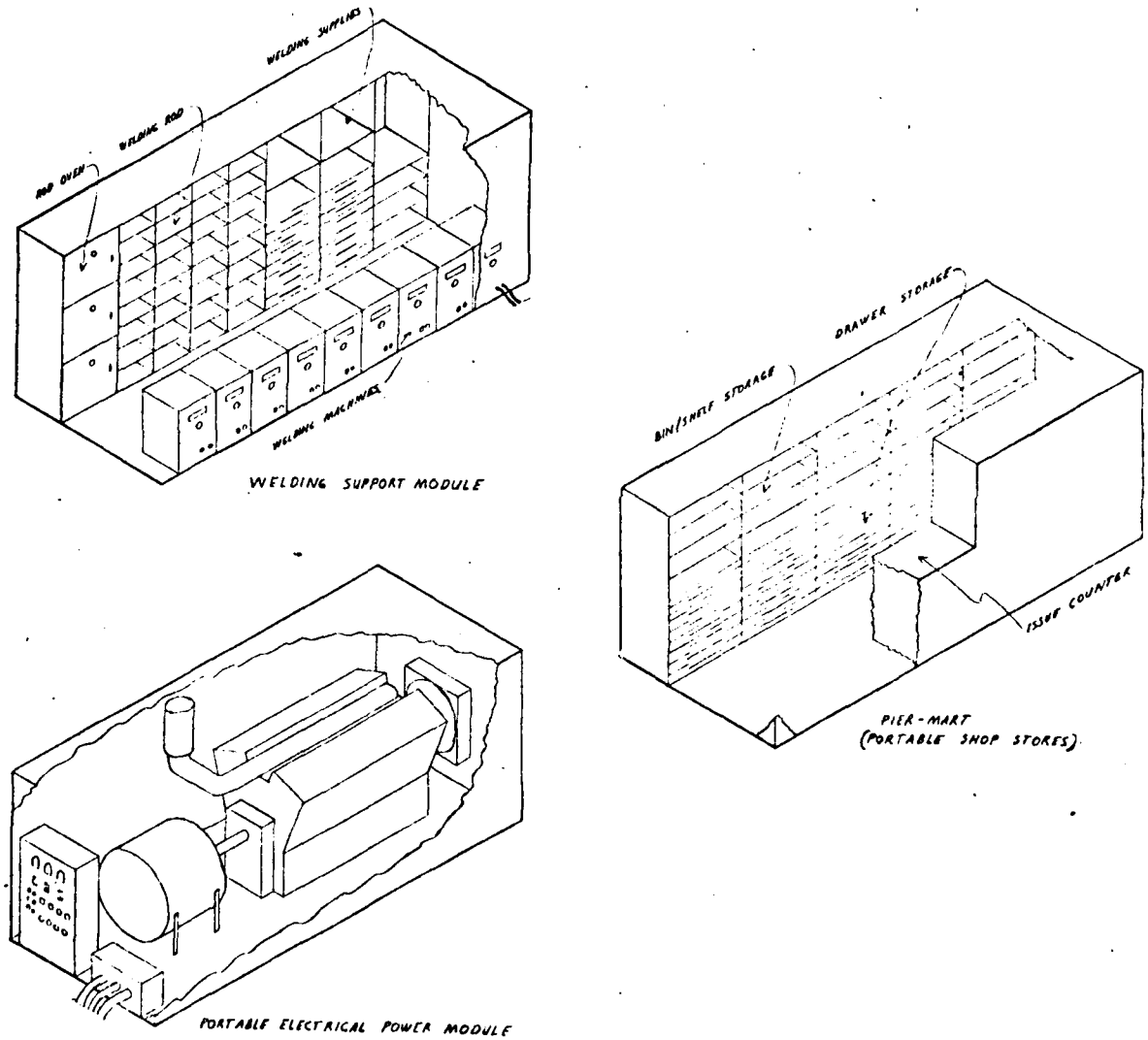


Figure 8-1

SECTION IX

SUMMARY OF RECOMMENDATIONS

9.1 Continue the general study of dry dock material handling methods to identify specific potential profitable projects.

Improvements in material handling methods offer substantial potential benefits. They include reduced direct material handling costs, improved shop productivity due to improved material handling service and reduced overhaul duration due to improved material handling service.

But the general M/H subject is too broad to make detail specific recommendations. Too many times the recommendations depend on the particular location and situation. Recommendations depend on the Shipyard layout, type ship, type overhaul, size of drydock, etc. The general study can identify some of these potential projects but in order to get the attention and effort required for a successful completion, these potential projects should become separate detail projects.

9.2 Develop a standard less expensive light duty portal crane to replace a number of the old large existing portal cranes.

The majority of crane lifts are for small parts. 95% of the lifts are made with the whip hook, i.e., the low capacity hook. Yet the shipyards are spending large sums to operate and maintain a fleet of large old cranes. Less expensive light duty portal cranes could replace many of the existing portal cranes resulting in substantial savings. This could either be achieved by having the same number of cranes operating for less funds, or more cranes operating for the same amount of funds. These replacements would result in a crane inventory more in line with the Shipyard lifting requirements.

9.3 Develop an automated dock material handling and storage system that takes advantage of advancements in automatic material movement carts and AS/AR systems.

Presently the typical dock M/H system requires that parts be set on the dock in laydown areas. The dock movement is done with manned forklift. This laydown by the crane for later pickup by a forklift creates several problems. They include:

a. Delays from time of crane lift until forklift pick-up.

b. Laydown area occupies prime dock space.

c. There is lack of control of parts in the laydown area, this results in the loss and damage of some parts.

d. The highest cost component of a forklift operation is the operator. In recent years M/H equipment has been developed that if used on the dock would reduce or eliminate these problems. This equipment includes wire guided transfer carts, AS/AR systems, and associated control systems.

Development of an automatic dock M/H systems would improve M/H services.

9.4 Develop a material tagging and control system that takes advantage of the advances made in bar codes and scanner readers.

The present tagging and movement systems use a variety of multicopy move tags and associated documents, records and files. They are subject to a number of problems including:

a. Time consuming to fill in, distribute, and file the required forms.

b. Information is subject to introduction of errors when it is transferred from one form to another.

c. Information is not always available in a timely manner. Sometimes tages use the Shipyard mail systems and cross several desks before they reach a central file for information update and control. This can take days or even weeks.

Recent advancements in bar code and scanner systems make it possible to develop a tagging and move the system that would eliminate the above problems.

9.5 Evaluate the design features of the FFG-7 class of ships that were made to accomodate shipboard material handling.

To support the I.L.S. concept, the FFG-7 design group incorporated a number of shipboard material handling features in the FFG-7. The ships are now entering the fleet and as such offer the opportunity to evaluate the M/H design concepts. The results of this evaluation would then be available to other ship design groups for use in future designs or major modifications.

9.6 Experiment with different size and shape of lead bricks, for submarine ballasting, to reduce ballasting labor.

Intuitively there is an optimum size and shape of lead brick for the handling required in submarine ballasting.

The optimum size/shape brick would have to be determined by emperical data, i.e., by conducting a number of experiments. Once determined, the most advantageous time to install this optimum size brick is during new construction.

9.7 Develop a hull cleaning machine that uses the 3M Roto Peen cleaning system or equal cleaning system.

Currently hull cleaning is performed by abrasive air blast. This is an operation that has a number of undesirable effects. These include:

a. It is expensive.

b. It is dirty.

c. It requires supplying, cleaning up, and disposing of large amounts of contaminated material.

d. It requires sealing off areas.

e. It precludes other work.

Some progress has been made by using portable shot blast units to replace abrasive air blast, but there is even more potentially to be gained by developing Roto Peen to replace abrasive air blast.

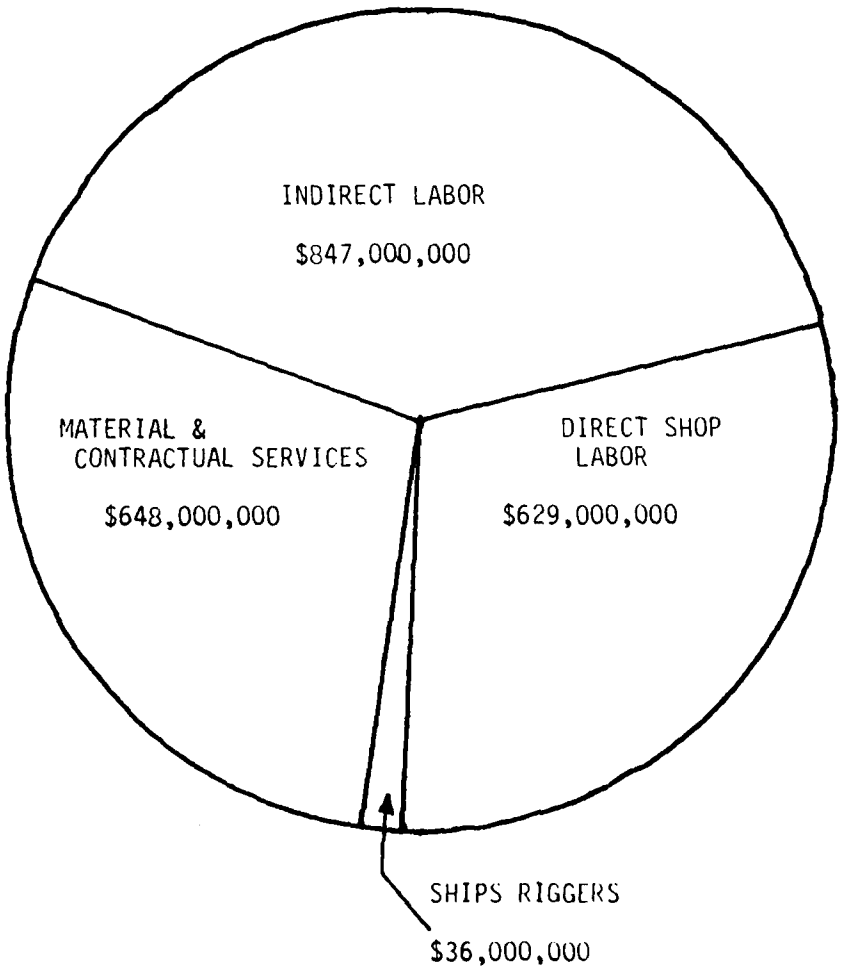
APPENDIX A

OVERVIEW ANALYSIS OF SHIPYARD OPERATING COSTS

Per reference (10), the total business for the eight naval shipyards for 1978 was $2,004,000,000. Seventy percent was for salaries and wages, and thirty percent was for materials and contractual services. Anticipated business for Fiscal 1979 is $2,160,000,000.

Per reference (11), the total employment at the eight naval shipyards is approximately 65,000 personnel. About 28,800 are in the production shops. These include approximately 1560 ships' riggers. The balance (36,200) are non-production shop personnel. This information is shown in diagram form. It assigns dollar cost to labor in the same ratio as the employee count.

SHIPYARD OPERATING COST BREAKDOWN



APPENDIX B

COST OF CAPITAL OF SHIPS UNDERGOING OVERHAUL

Substantial sums of capital are invested in the ships undergoing overhaul. The cost of this capital should not be overlooked when evaluating factors that affect the length of overhaul.

Some typical procurement costs for U.S. Navy ships are listed below these were obtained from reference (12).

Year	Ship	Class	Cost
1978	SSBN	Ohio	$ 889,000,000
1976	SSN	Los Angeles	380,000,000
1971	SSN	Lipscomb	200,000,000
1956	SSN	Skipjack	40,000,000
1976	CVN	Nimitz	1,881,000,000
1960	CVN	Enterprise	451,000,000
1974	CGN	California	200,000,000
1961	CGN	Bainbridge	163,000,000
1980	DDG	Aegis (Lead)	930,000,000
1977	FFG	Perry	45,000,000

Assuming a typical ship cost of $200,000,000, an average ship life of 30 years, and an annual interest rate of 10%, the daily cost of capital for that ship is $58,000 per day.

Yearly cost of capital for one ship:

$$i = 10\%$$
$$n = 30 \text{ years}$$

Capital recovery, compound interest factor = .10608

$$(\$200,000,000)(CR,CIF)$$
$$(\$200,000,000)(.10608) = \$21,200,000/yr$$

Daily cost of capital for one ship:

$$\frac{\$21,200,000/yr}{365 \text{ days/yr}} = \$58,000/day$$

NAVSEA Industrial Planning System (I.P.S.) (formerly S.M.S.) data indicates that there will be 54,000 ship overhaul days in the next three years. At $58,000 per day, this equates a cost of capital of $1,044,000,000 per year for ships undergoing overhaul.

$$\frac{(54,000 \text{ overhaul days})}{(3 \text{ years})} \quad \frac{(\$58,000)}{(\text{overhaul day})} = \frac{\$1,044,000,000}{\text{year}}$$

APPENDIX C

NUMBER OF PARTS MOVED FROM DRYDOCK NO. 1 TO THE SHOPS/STORAGE (THROUGH THE D.M.C.C.) EACH WEEK OF THE STUDY

WEEK	DATE	SHIP IN DRYDOCK	COUNT OF PARTS MOVED SMALL* PARTS	MED* PARTS	LARGE* PARTS	TOTAL PARTS
1	4/09/79	SSN 592	0	0	2	2
2	4/16/79	SSN 592	81	0	0	81
3	4/23/79	SSN 592	11	0	0	11
4	4/30/79	SSN 592	68	2	1	71
5	5/07/79	SSN 592	8	9	11	28
6	5/14/79	SSN 603	608	35	1	644
7	5/21/79	SSN 603	448	0	0	448
8	5/28/79	SSN 603	440	18	0	458
9	6/04/79	SSN 603	511	36	5	551
10	6/11/79	SSN 603	1770	55	0	1825
11	6/18/79	SSN 603	297	32	4	333
12	6/25/79	SSN 603	186	83	8	277
13	7/02/79	SSN 603	161	86	0	247
14	7/09/79	SSN 603	55	78	0	133
15	7/16/79	SSN 603	110	40	2	152
16	7/23/79	SSN 603	94	11	0	105
17	7/30/79	SSN 603	78	18	0	96
18	8/06/79	SSN 603	33	7	0	40
19	8/13/79	SSN 603	39	3	0	42
		Total	4998	513	34	5545

*Small parts were defined as being able to move in an 13" X 18" tote bin.

Medium parts were defined as too large for the above tote bin, but being able to move on a 40" X 48" pallet.

Large parts were defined as anything too large for the above pallet.

NUMBER OF PARTS MOVED FROM DRYDOCK NO. 1 TO EACH SHOP/STORAGE (THROUGH THE D.M.C.C.) DURING THE STUDY

SHOP	COUNT OF PARTS MOVED			
	SMALL* PARTS	MED* PARTS	LARGE* PARTS	TOTAL PARTS
11	414	69	2	485
17	20	6	0	26
31	540	56	18	614
36	110	11	10	131
38	134	13	1	148
41	7	49	0	56
51	669	54	0	723
56	252	3	0	255
64	32	41	0	73
67	1571	5	1	1577
71	51	57	0	108
Code/500	1198	149	2	1349
Total	4498	513	34	5545

*Small parts were defined as being able to move in an 18" X 18" tote bin.

Medium parts were defined as too large for the above tote bin, but being able to move on a 40" X 48" pallet.

Large parts were defined as anything too large for the above pallet.

APPENDIX D

DURATION OF PORTAL CRANE LIFT VS. NUMBER OF LIFTS

DURATION OF CRANE LIFT (IN SECONDS)	NUMBER OF LIFTS
0 - 199	20
200 - 399	62
400 - 599	33
600 - 799	21
800 - 999	11
1000 - 1199	5
1200 - 1399	2
1400 - 1599	0
1600 - 1799	0
1800 - 1999	3
2000 - 2199	3
2200 - 2399	0
2400 - 2599	1
2600 - 2799	1
2800 - 2999	0
3000 - 3199	0
3200 - 3399	1
3400 - 3599	0
Total	163

AVERAGE PORTAL CRANE LIFT TIME

DATE	NUMBER OF CRANE LIFTS	TOTAL LIFT TIME (SEC)
3/20/79	10	10,590
3/21/79	15	6,114
3/22/79	24	22,956
3/27/79	9	2,556
3/28/79	17	9,400
4/02/79	35	13,182
4/03/79	53	24,732
Total	163	89,530

Average Lift Time 549 seconds
9.15 minutes
.153 hours

APPENDIX E

CRANE DATA AND QUE TIME CALCULATIONS

ARRIVALS LIFTS/HR	MEAN TIME BETWEEN ARRIVALS (HR.)	MEAN SERVICE TIME (HR.)	CRANE UTILI-ZATION	PROBABIL-ITY OF IMMEDIATE SERVICE	AVERAGE TIME ARRIVAL SPENDS IN SYSTEM (HR.)	AVERAGE # OF UNITS IN SYSTEM	AVERAGE WAITING TIME OF ARRIVALS (HR.)	AVERAGE QUE LENGTH
1	1.000	.153	15.3%	84.7%	.181	.181	.028	.028
2	.500	.153	30.6%	69.4%	.221	.442	.068	.135
3	.333	.153	45.9%	54.1%	.283	.850	.130	.390
4	.250	.153	61.2%	38.8%	.395	1.58	.242	.968
5	.200	.153	76.5%	23.5%	.654	3.27	.500	2.50
6	.167	.153	91.8%	8.2%	1.89	11.32	1.73	10.4
6.53	.153	.153	100%	0%	-	-	-	-

Arrivals per Hour λ

Mean Service Time per Unit $1/\mu$

Average Time Arrival Spends in System $\frac{1}{\mu - \lambda}$

Average Number of Units in System $\frac{\lambda}{\mu - \lambda}$

Average Wait Time of Arrival $\frac{\lambda}{\mu(\mu - \lambda)}$

Average Que Length $\frac{\lambda^2}{\mu(\mu - \lambda)}$

Assumes - One crane on site
- Arrivals occur in Poisson fashion
- Service Time occurs in exponential fashion

APPENDIX F

TIMELAPSE ANALYSIS OF CRANE OPERATIONS

DATE	CRANE	NUMBER OF LIFTS			
		CAPACITY OF HOOK USED (LBS)			
		112,000	56,000	33,600	11,200
4/27/79	D-4	-	0	-	21
4/28/79	D-4	-	0	-	29
	D-5	1	-	0	0
6/28/79	D-5	0	-	0	13
6/29/79	D-5	1	-	0	7
7/02/79	D-5	0	-	0	11
7/03/79	D-5	0	-	1	36
7/05/79	D-5	1	-	0	0
7/06/79	D-5	1	-	0	0
7/09/79	D-5	0	-	0	5
7/13/79	D-3	-	0	-	22
7/16/79	D-3	-	3	-	19
Totals		4	3	1	163

Lifts by Hook Capacity:

5% of the lifts are over 11,200 lbs. cap.
4% of the lifts are over 33,600 lbs. cap.
2% of the lifts are over 56,000 lbs. cap.
0% of the lifts are over 112,000 lbs. cap.

APPENDIX G

PORTAL CRANE TIME UTILIZATION STUDY

SUMMARY OF PUBLIC WORKS RECORDS (Figures for 8 cranes)

MONTH (1978)	SHIFT	NUMBER OF SHIFTS CRANES WERE IN SERVICE	NUMBER OF SHIFTS CRANES WERE OUT OF SERVICE	HOURS MANNED	NUMBER OF LIFTS	% OF TIME UTILIZED (WHEN MANNED) *
April	GYD	125	59	741	667	13.7%
	SW	121	53	734	1098	22.8%
	DAY	111	42	924	1742	28.8%
May	GYD	128	65	820	817	15.2%
	SW	140	64	965	1561	24.7%
	DAY	133	64	1038	2478	36.4%
June	GYD	97	79	676	988	22.3%
	SW	97	79	690	1422	31.4%
	DAY	90	74	764	1842	36.8%
July	GYD	89	63	578	783	20.7%
	SW	87	61	568	1004	27.0%
	DAY	94	58	701	1356	29.5%
August	GYD	124	61	729	894	18.7%
	SW	124	58	820	1467	27.3%
	DAY	124	52	965	2118	33.5%
Sept.	GYD	94	66	615	560	13.9%
	SW	94	66	611	924	23.1%
	DAY	100	60	791	1322	25.5%
Oct.	GYD	106	63	702	727	15.8%
	SW	108	62	702	1159	25.2%
	DAY	111	63	870	1824	32.0%
Nov.	GYD	89	64	549	576	16.0%
	SW	85	60	548	776	21.6%
	DAY	91	54	702	1362	29.6%

* Assumes .153 hours per lift per Appendix D.

TOTALS FOR THE EIGHT MONTH PERIOD

SHIFT	NUMBER OF SHIFTS CRANES WERE IN SERVICE	NUMBER OF SHIFTS CRANES WERE OUT OF SERVICE	HOURS MANNED	NUMBER OF LIFTS	% OF TIME UTILIZED (WHEN MANNED)	AVERAGE LIFTS PER HOUR
DAY	854	467	6,755	14,044	31.8%	2.08
SW	856	503	5,638	9,411	25.5%	1.67
GYD	852	520	5,410	6,012	17.0%	1.11
All Shifts	2,562	1.490	17,803	29,467	25.3%	1.66

APPENDIX H

STUDY OF CRANE LIFTS PER WEEK

NUMBER OF CRANE LIFTS FOR THE SSN 594 OVERHAUL

WEEK OF OVERHAUL	NO. OF LIFTS	WEEK OF OVERHAUL	NO. OF LIFTS	WEEK OF OVERHAUL	NO. OF LIFTS
1	442	28	296	54	42
2	176	29	325	55	81
3	444	30	201	56	115
4	422	31	279	57	63
5	221	32	361	58	63
6	571	33	334	59	1
7	549	34	307	60	10
8	303	35	202	61	35
9	566	36	342	62	109
10	404	37	345	63	81
11	499	38	417	64	69
12	257	39	232	65	0
13	191	40	225	66	51
14	273	41	248	67	77
15	352	42	237	68	105
16	510	UNDOCK		69	77
17	327	43	143	70	96
18	303	44	118	71	45
19	311	45	59	72	68
20	266	46	157	73	29
21	298	47	184	74	50
22	281	48	95	75	40
23	404	49	59	76	112
24	458	50	184	77	115
25	358	51	82	78	100
26	289	52	38	79	71
27	304	53	79	80	60

NUMBER OF CRANE LIFTS FOR THE SSN 639 OVERHAUL

WEEK OF OVERHAUL	NO. OF LIFTS	WEEK OF OVERHAUL	NO. OF LIFTS
1	665	33	113
2	780	34	90
3	804	35	81
4	613	36	80
5	607	37	146
6	599	38	135
7	801	39	87
8	586	40	117
9	383	41	147
10	548	42	93
11	619	43	110
12	364	44	91
13	414	45	71
14	315	46	64
15	270	47	121
16	303	48	101
17	391	49	82
18	632	50	0
19	435	51	79
20	448	52	113
21	516	53	124
22	346	54	119
23	359	55	247
24	398	56	251
25	334	57	174
26	698	58	48
UNDOCK		59	60
27	138	60	69
28	108	61	71
29	135	62	51
30	122	63	49
31	50	64	6
32	77		

APPENDIX I

TYPICAL SHOP SUPERVISOR COMMENTS ABOUT DOCK M/H PROBLEMS

1. Parts are delayed until paperwork (job orders, material tags, work permit, etc.) is complete.

2. We have to spend too much time on the paperwork.

3. Poorly written job orders result in unnecessary material movement. Sometimes material is removed from the ship that did not have to be removed.

4. Material identification tags are not available when required.

5. The weather destroys papers attached to the parts.

6. Safety (nit-picking) inspection adds costs without improving safety.

7. Reduced Q.A. signoff requirements would cut delays and reduce manpower movement.

8. We need more laydown area on the dock.

   We need more restrooms on the dock.

   We need more lunchrooms on the dock.

   We need more locker rooms on the dock.

   We need more dockside support shops and offices.

   We need more secured storage area on the dock.

9. Shop stores should be close to the ship.

10. Lack of dockside laydown/storage area results in hand to mouth delivery schedule.

11. Shops keep too much stuff just laying around the dock. Items collect on the docks and sit for up to six months.

12. Riggers remove items (from the dock) without notifying the shops. Many of these items are lost.

13. Ships Force will discard material set out for a job.

14. Cranes are not available when needed.

15. Crane service is poor.

16. Public Works will perform scheduled crane maintenance when the cranes are needed most.

17. Public Works will pull cranes out of service for a minor defect.

18. Cranes are frequently on stand-by for a nuclear lift.

19. Cranes are not utilized to capacity. A crane will be manned all weekend (on overtime) and not make a single lift.

20. Lack of forklifts is a big problem.

21. Typically 40% of the forklifts are out of service for maintenance.

22. We have the wrong type of forklifts. We have to use inside forklifts for outside work.

23. Mobile material/personnel equipment in drydock reduces dependence on portal cranes.

24. Abrasive from blasting puts mobile equipment out of service.

25. Riggers are not normally available to make lift.

26. It typically takes 1 to 3 days to get riggers to move parts off the ship.

27. There is a lack of a formal system to set move priorities.

28. Lack of drydock elevator restricts personnel and material flow.

29. An elevator would reduce the number of crane lifts.

30. Typically 5% of the parts are damaged in transit.

31. There is some damage to noise critical equipment.

32. There is some weather damage to parts stored outside.

33. Sometimes part identification tags are separated from the parts. This results in losses or delays.

34. Items with commercial scrap value (Ni, Cu, etc.) are taken if left out.

35. Riggers don't know "real" move priority.

36. There are too many supply storage and issue points.

37. Supply deals only in part numbers. They do not have product knowledge required to provide high quality service.

38. Need more and better storage and shipping containers.

39. Drydock preparation is a slow process.

40. Placing drydock blocks requires extensive hoisting and positioning time.

41. Sand blasting typically ties up cranes and dock when they are most needed for other operations.

AMERICAN HOIST & DERRICK COMPANY · ST. PAUL, MINNESOTA

AMERICAN

Construction Machinery
Division

63 South Robert Street
St. Paul, Minnesota 55107

March 18, 1980

Mr. Tom Spain
Project Manager
Code 380.1, Stop T-6
Mare Island Naval Shipyard
Vallejo, California 94592

Subject: American 5720 Gantry Mounted Pedestal Crane
Our Quotation No. Q-1809

Dear Mr. Spain:

Further to our subject quotation, at long last is a preliminary sketch depicting the gantry portion of our proposal. Our Engineering Department advises this gantry can accommodate either our Model 5720 or 5750 pedestal cranes.

We would, at this time, like to take this opportunity to offer our Model 5750 Pedestal Crane complete with traveling gantry. We feel the ratings achieved with this model will be more in line with your original request and comparable with our Model 5030DE with outriggers set.

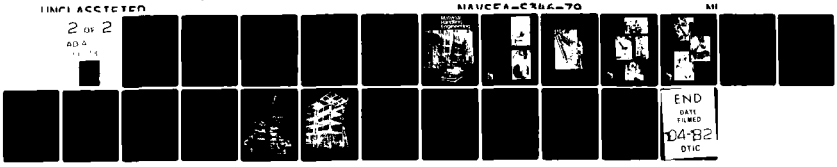
UPPER including:

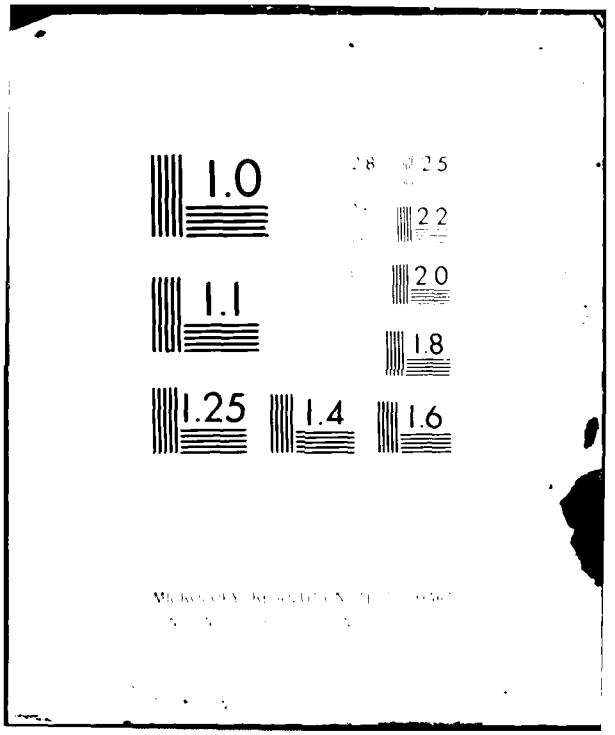
Rotating machinery deck with fully enclosed cab.....9' wide
Detroit Diesel (GM) 4-71N, Model 1043-5000 diesel engine with PTO
Anti-friction bearing load and hook rollers
Metered air clutches
Air line alcohol dispenser
High speed spur gear boom hoist
Controlled boom lowering
Single lever independent boom hoist
Automatic boom hoist shut-off
Basic 40 ft., 47H, 2-piece, pin connected, tubular chord crane boom with 4-sheave boom point
Pendant type boom suspension with 10-part boom hoist line
Telescopic boom stops
Boom angle indicator
Spring set swing brake
Spring set brake actuators on main hoist drums, controllable from operator's stand
Retractable high A-frame
Crane lagging for two drums
Dual swing brake control
Foot throttle
Type "S-S" (34,500#) counterweight
(No load block or rope)

AD-A111 731 MARE ISLAND NAVAL SHIPYARD VALLEJO CA PRODUCTION ENG--ETC F/G 13/10
MATERIAL HANDLING IN DRY DOCKS.(U)
NOV 81 T SPAIN, K DOEHNERT

UNCLASSIFIED NAVSEA-5346-79 NL

2 OF 2
AD A
111731

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2.8
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2.2
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1.1
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amhoist

GANTRY including:

Carbody
Gantry tower
Ladder
Collector ring platform
Gantry counterweight structure
Revolver trucks with 2-wheel 21" anti-friction bearings and two drivers
Two track clamps
2 D.C. shunt wound electric motors rated @ 5 HP @ 650 RPM
D.C. shoe type motor brakes rated 100 lb. ft.
Contact ring assembly
Gantry, machinery base and travel motor conduit
Travel warning gong
Master switch
Magnetic reversing plugging control
Voltage regulator

F.O.B. factory Total Selling Price	$327,404
Approximate shipping weight	145,000 lbs.

OPTIONAL EQUIPMENT:

21 KW generator	$ 18,390
10 Ft. center boom section	2,525
20 Ft. center boom section	4,140
30 Ft. center boom section	5,295
Pair 10 ft. pendants	470
Pair 20 ft. pendants	550
Pair 30 ft. pendants	635
65 Ton, 18" 3-sheave block	3,350
Loadline - 7/8" @ $1.69/ft.	
Third drum	4,675
Controlled load lowering - one drum	3,595
Hot water cab heater/defroster	330
Air operated windshield wiper	250
Air horn	320
RH catwalk	630
LH catwalk	630
Light package	1,590
Light package w/generator	10,060
GM 4-71N diesel engine w/3STC in lieu of standard	9,505
GM 6-71N diesel engine w/3STC in lieu of standard	13,095
High temp/low oil pressure warning	140

Again, these prices are valid for shipment prior to 1/1/81, and include no taxes or levies. Terms of payment are subject to credit approval. Current lead time for the machine plus gantry is 7-1/2 months after receipt of firm order, subject to prior sale.

amhoist

Please review the aforementioned and advise your specific requirements. With our Model 5750, the following ratings would be realized:

102,460# @ 17 ft. radius
88,320# @ 20
71,020# @ 25
57,850# @ 30
48,090# @ 35
41,660# @ 40
31,870# @ 50
26,130# @ 60
21,500# @ 70
17,790# @ 80

For the above listed ratings and 150% stability about rails, a 40 ton gantry counterweight is required.

Please contact us if you require additional information.

Very truly yours,

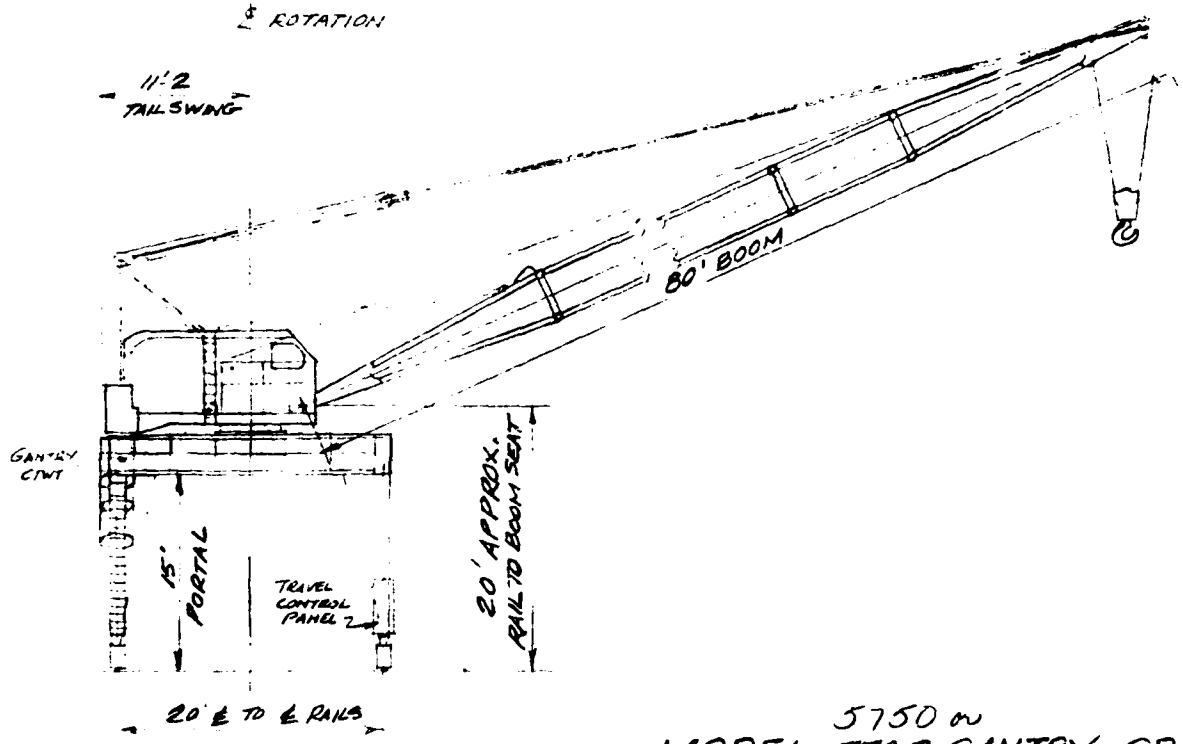
Sandra J. White

Sandra J. White
Sales Product Specialist

SJW:rt

Enc.

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN



5750 ow
MODEL 5720 GANTRY CRANE
SCALE 3/32" = 1'

FOR: MARE ISLAND NAVAL SHIPYARD

DATE 3-14-80 KEO

PROPOSAL S-5234

APPENDIX K

Cost Comparison Table of Alernative Crane Concepts

The following is a general budget comparison of the cost to own, service, and operate several different types of cranes. It includes a yearly cost of capital factor. This is calculated by multiplying the equipment purchase price by the capital recovery factor. The assumed interest rate is 10%; the assumed equipment life is stated on the table. The service cost is assumed to be a percent of the purchase price.

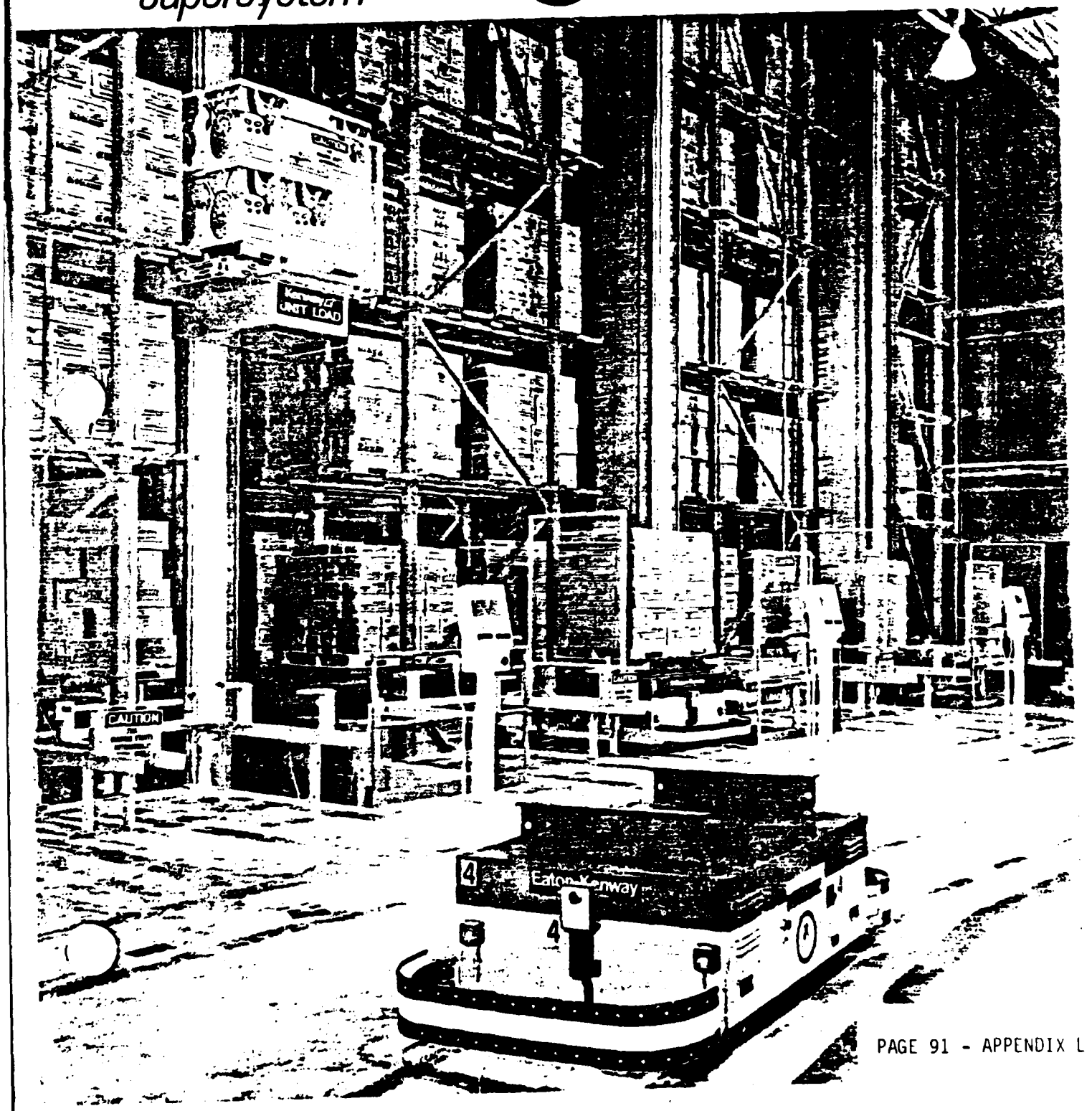
APPENDIX K

TYPE OF CRANE	Assumed Purchase Price	Assumed Equipment Life	Assumed Interest Rate	Captial Recovery Compound Interest Factor	Yearly Cost of Capital	Estimate Yearly Cost of Service	Yearly Operator Costs	Total Yearly Cost
1. Existing Portal Crane	sunk cost	—	—	—	—	$ 177,000	$ 45,000	$ 222,000
2. New Portal Crane	$3,000,000	30 yrs.	10%	.010608	$ 318,000	$ 150,000	$ 45,000	$ 513,000
3. Mobile Truck Crane	$ 325,000	10 yrs.	10%	.16275	$ 53,000	$ 26,000	$ 45,000	$ 124,000
4. Truck Crane with Special Outriggers	$ 358,000	10 yrs.	10%	.16275	$ 58,000	$ 29,000	$ 45,000	$ 132,000
5. Truck Crane on Mobile Platform:								
- Truck Crane	$ 325,000	10 yrs.	10%	.16275	$ 53,000	$ 26,000	$ 45,000	$ 187,000
- Mobile Platform	$ 300,000	15 yrs.	10%	.13247	$ 39,000	$ 24,000	—	
6. Large Locomotive Crane	$ 985,000	20 yrs.	10%	.11746	$ 116,000	$ 69,000	$ 45,000	$ 230,000
7. Small Basic Locomotive Crane	$ 325,000	20 yrs.	10%	.11746	$ 38,000	$ 23,000	$ 45,000	$ 106,000
8. Small (Modified) Loco on 20 ft. Tracks	$ 375,000	20 yrs.	10%	.11746	$ 44,000	$ 26,000	$ 45,000	$ 115,000
9. Small (Modified) Loco on 20 ft. Track w/Radio Remote Control	$ 425,000	20 yrs.	10%	.11746	$ 50,000	$ 30,000	—	$ 80,000

JULY 1979

Material Handling Engineering

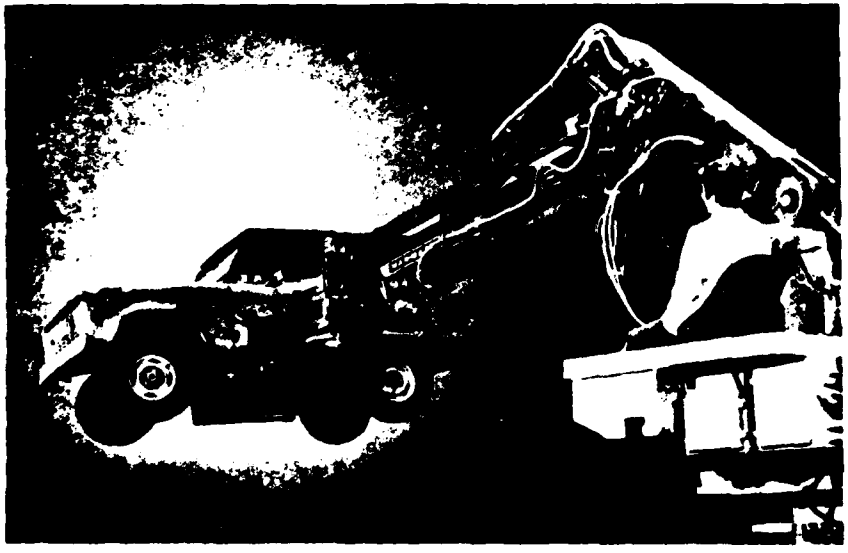
High rise and driverless combine to make Keebler's supersystem

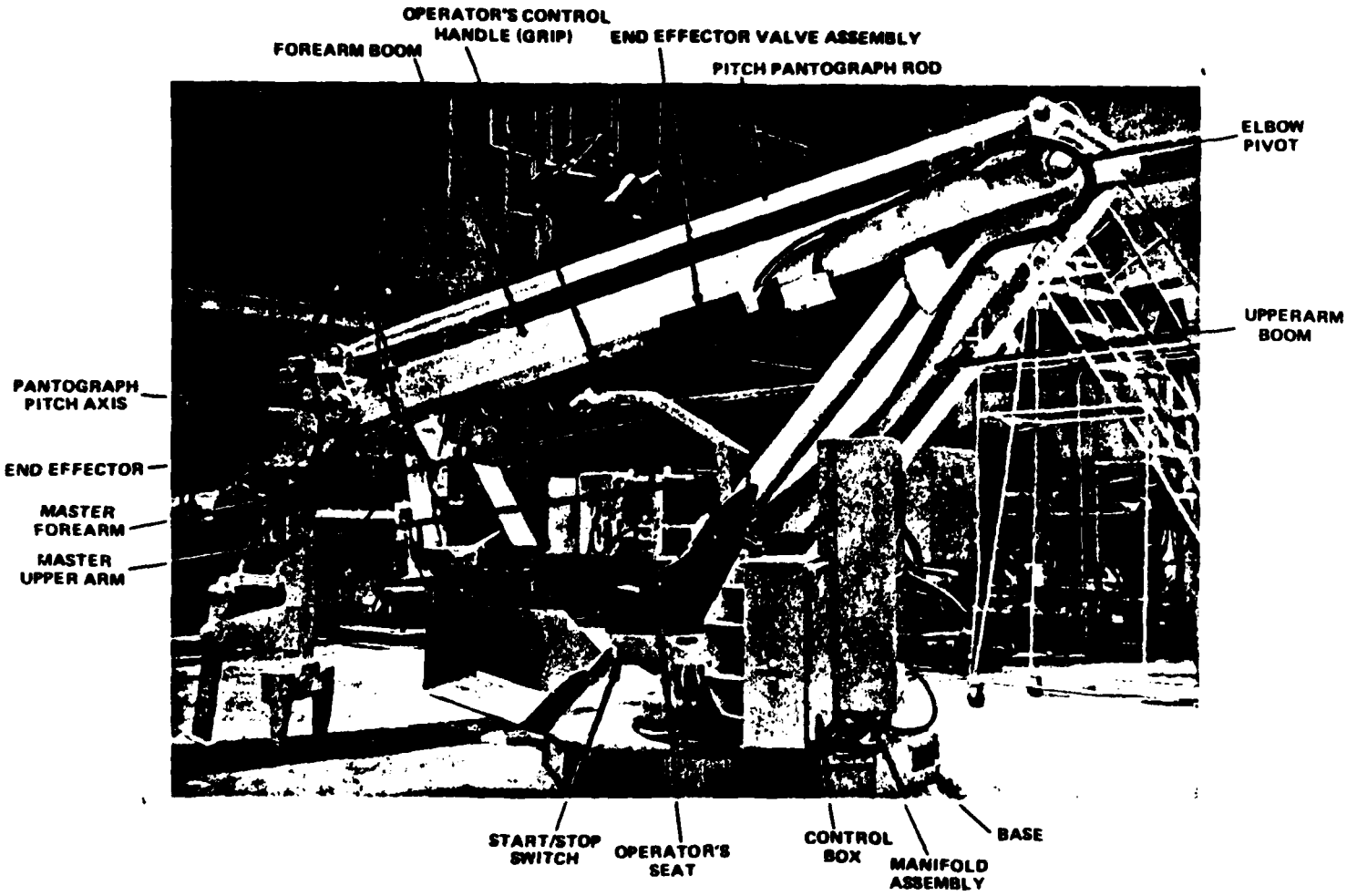


GENERAL FEATURES

INTRODUCTION

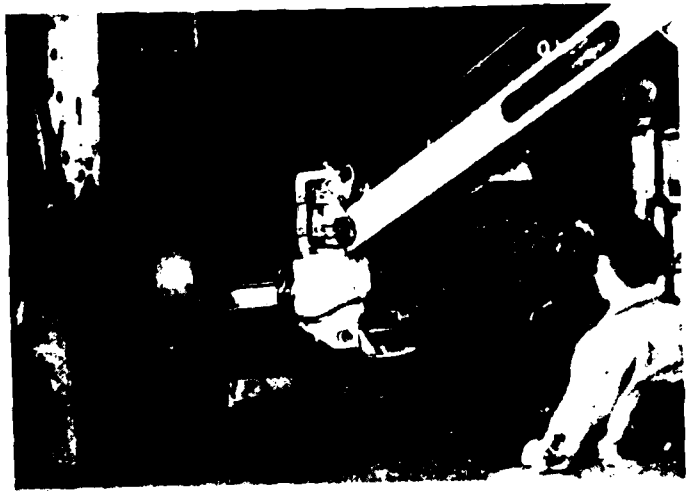
- SPATIAL CORRESPONDENCE BETWEEN MASTER CONTROL AND BOOM PROVIDES INSTINCTIVE CONTROL
- FORCE-FEEDBACK ALLOWS OPERATOR TO SENSE LOADS
- APPLICATIONS TO EXISTING OR NEW INSTALLATIONS
- GROSS LOAD HANDLING TO 7000 LBS
- REACHES TO 28 FEET
- SIMULTANEOUS MOTION IN REACH, HOIST, AND AZIMUTH
- UP TO THREE WRIST MOTIONS
- INTEGRAL OR REMOTE CONTROL



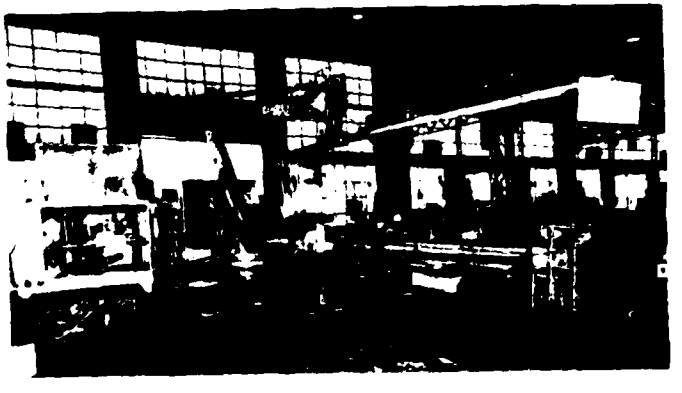

OPERATOR'S CONTROL HANDLE (GRIP)
FOREARM BOOM
END EFFECTOR VALVE ASSEMBLY
PITCH PANTOGRAPH ROD
ELBOW PIVOT
UPPERARM BOOM
PANTOGRAPH PITCH AXIS
END EFFECTOR
MASTER FOREARM
MASTER UPPER ARM
START/STOP SWITCH
OPERATOR'S SEAT
CONTROL BOX
MANIFOLD ASSEMBLY
BASE

INSTALLATIONS

FORGING



DROP HAMMER

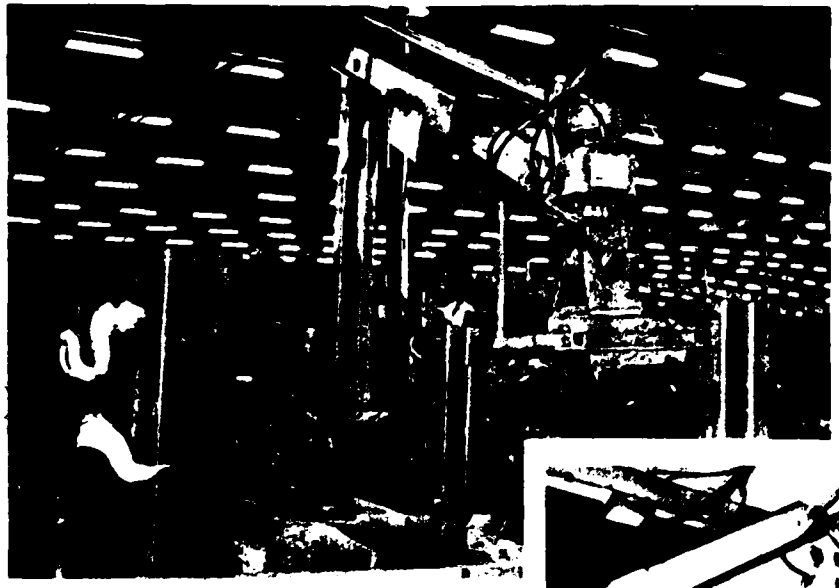


SLAGGING

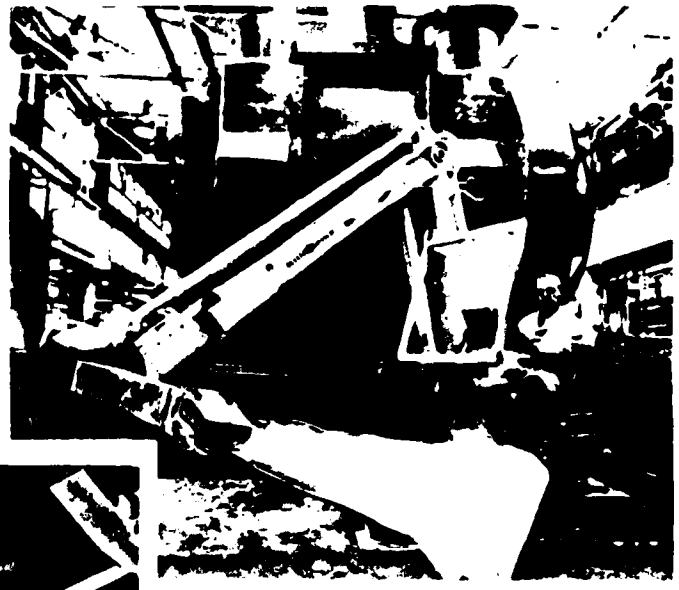
CASTING TRANSFER

INSTALLATIONS

INSTALLATION & APPLICATION DATA



LIGHT ENVIRONMENT



MODERATE ENVIRONMENT

HOT DIRTY ENVIRONMENT

APPENDIX N

COST OF PERSONNEL MOVEMENT

5,424 trips per day shift
958 Production Shop personnel assigned to boat
57% of Production Shop personnel are on day shift

(.57) X (958) = 546 Production Shop Dayshift Personnel

$$\frac{5{,}424 \text{ trips/day}}{546 \text{ men}} = \frac{9.9 \text{ Trips/Day}}{\text{Man}}$$

9.9 Trips per dayshift Production Shop person

28,800 Production Shop personnel for all Naval Shipyards
57% on dayshift

(28,800) X (.57) = 16,400 Day Shift Personnel for all Naval Shipyards
(28,800) X (.43) = 12,400 Back Shift Personnel for all Naval Shipyards

TRIPS

(16,400 Day Shift Personnel) (9.9 Trips/Day) = 162,000 Trips per day

(12,400 Back Shift Personnel) (6.0 Trips/Shift) = 74,000 Trips per shift

Trips on Day Shift	=	162,000
Trips on Back Shifts	=	74,000
Total Trips Per Day	=	236,000

Total Trips Per Year (253 days/year) (236,000 trips/day) = 59,700,000 trips/yr.

COST PER TRIP

Travel Time (6 minutes) Assumes .25 miles @ 2.5 mph	.10 hour
Preparation Time (3.0 minutes each end) Includes gather material, cleanup, lockup, notify supervisor, etc.	.10 hour
Total Time Per Trip	.20 hour

Cost Per Hour = $11.10/hr.

Cost Per Trip (.20 hr) ($11.10/hr) = $2.22

Total Travel Cost = (59,700,000 Trips/year) ($2.22/trip) = $132,500,000/year

DEPARTMENT OF THE NAVY
NORFOLK NAVAL SHIPYARD
PORTSMOUTH, VIRGINIA 23709

(340) gc
12 March 1979

MEMORANDUM

From: Docking Officer
To: Repair Officer

Subj: Drydock Seminar, lessons learned

Encl: (1) Blocking

1. Having recently attended the 12th annual Drydocking Seminar conducted by Crandall Drydock Engineers Inc. and having had the unique opportunity to exchange information with some 60 Dockmasters from shipyards throughout the United States and Canada, the following is some of the more useful information obtained.

2. Dockmaster's Functions. The "purpose" of a dockmaster is principally to assure shipowner and yard management that one person is responsible for the safe and efficient docking and undocking of ships. Having this responsibility, he must have commensurate authority and absolute control of the operation. Contravention of this authority by anyone, of the yard or of the ship, can lead to disastrous consequences. Every Dockmaster should have one or more assistants to assist him and be apprenticed so that his skills and knowledge of facilities are passed on. Formal training helps, but acquisition of experience is essential.

NAVSEA intends to devote a great deal of attention to the qualification of dockmasters in the very near future.

At present, NNSY has no dockmaster, but appropriate paperwork is in routing to establish a position for continuity. Since the policy at NNSY is to assign an ED as Docking Officer for one year periods, it is rather difficult to obtain the expertise and experience demanded by this highly responsible position. I would suggest consideration be given to having a civilian in the role as docking officer (GS-12 Engineer type) for continuity and who could train and qualify any or all ED's as Docking Officers who may desire to obtain the qualification.

3. Dock Build Up Times. I was amazed to learn that other yards can construct a dock build for a Nuclear Submarine in one day, while NNSY averages four days. The methods utilized to enable quicker build ups are: less blocks, different block types, utilization of "squeezers" to position blocks and rail cars to deliver blocks to dock site.

Less blocking is obtained by not installing every block on the docking plan, but docking the vessels in accordance with seismic overturn criteria

(Earthquake and Hurricane forces). All nuclear vessels, except CVNs must be docked IAW Earthquake criteria, regardless of geographical area, which can eliminate anywhere from 1/3 to 1/2 of the blocks required and meet an additional requirement not to exceed 500 lb/in^2 pressure on the blocks. Even greater reductions can be obtained on non nuclear surface vessels. The FF1052 class, for example, has a docking plan listing 18 side blocks per side - for resisting earthquake forces only 9 blocks per side are required and, for hurricanes, the requirement is 6 per side. Since this class vessel is docked on a 12' build with sideblocks reaching up to 17' consisting of 42" X 48" X 5' composite pier blocks, a considerable amount of time and labor can be saved by reducing the quantity of blocks to meet the hurricane criteria since NNSY is not considered to be in an earthquake area. This information is clearly defined in NSTM 997, but never implemented at NNSY until now. The USS KENNEDY is being docked with approximately 40 sideblocks omitted which still gives the vessel 4 times the number of blocks required to resist earthquake forces, as a result a considerable amount of overtime was cut. This shall be standard procedure in the future for all vessels. No one can explain to me why this was not done in the past, I was trained to believe "thou shall not deviate from the docking plan" and "don't make changes for the one year of filling the Docking Officer billet." It's the same old story of "we have always done it this way", well, not anymore!

Different block types also enable reductions in construction times of builds. The most recent innovations are steel piping constructions depicted in enclosure (1) for side blocks. Various other types are available, or can be made, which reduce build times of stacking pier blocks atop one another requiring numerous additional blocks and considerable crane service.

"Squeezers" are perhaps the most efficient method for positioning blocks in the dock. Newport News Shipbuilding claims that they can do a submarine build in 10 hours by hauling blocks to the dock on rail cars, lowering them into the dock by crane and positioning them with two "squeezers".

This, and other yards also enjoy the benefit of docking the same class vessel in their docks and can maintian their mainline continuously. At NNSY, we seldom enjoy this benefit.

Various lifting capacities of squeezers are available in units made by Catipillar. Two 10 ton or greater units would be worth their weight in gold in cutting build times. NNSY presently has an old unit, but cannot keep it operational. I suggest that two units be purchased and utilized for all they are worth. This would also free up our much needed cranes, which are frequently OOC for various reasons. "Squeezers" are similar to fork lifts, except the arms squeeze the sides of the blocks to lift and position vice lifting from the bottom.

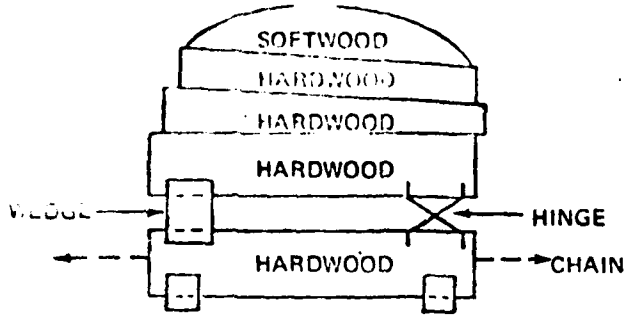
4. Shiphandling. Various methods were discussed, and it appears, for graving docks, NNSY has the most efficient and safe system. Our utilization of the sea mules, row boats, bridge facility and line make ups were considered to be ahead of most other yards. Our sighting techniques and

accuracy in landing ships is by far one of the best. New sonar systems are now being used to give the vessel's position over the build and laser techniques are now on the market. I feel our present method of using transits is by far the best for our graving docks.

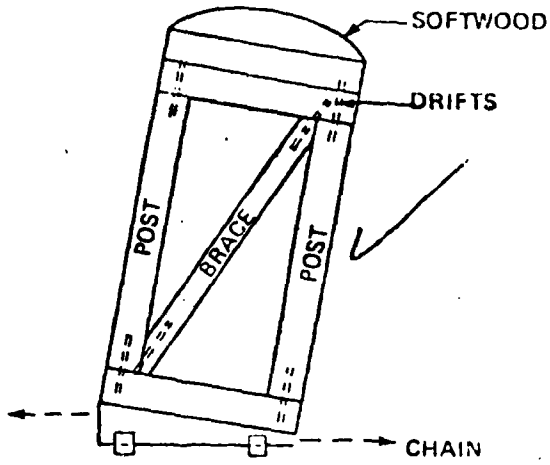
5. Various other aspects of drydocking procedures and dock maintenance were discussed, but too numerous to put in writing. The drydocks at NNSY are in poor condition. I have submitted a lengthy detailed report to Public Works describing the repairs required. Of particular concern are the floors and walls of the docks which are badly deteriorated. Drydocks 4 and 8 have such deteriorated flooring that it is becoming very difficult to set blocks. The walls in Dock 4 are cracked through 5' of cement and leak into the pumpwell creating what could be a serious disaster and less of the facility which was recently overhauled and modernized by private contractors at a considerable expense. The old capstans are constantly breaking down and X03 has initiated increased efforts to maintain them. The lighting in and around the docks is either unsat or non existant which prohibits docking evolutions from safely being carried out after sunset. I often cannot allow the dock to be washed down after docking a vessel at night due to the absence of adequate lighting in and around the docks. There are too many broken or missing dock grates in the floor of the docks and the floors themselves are so badly deteriorated that it is unsafe to walk the dock without proper lighting.

I believe the drydocks and associated facilities and equipment are deserving of a great deal more attention than is given them; one damaged ship or injured individual is far more costly than the cost of maintaining a safe and efficient docking facility.

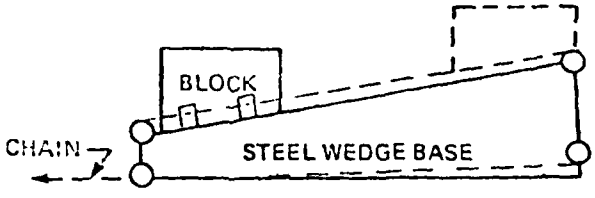
J D Thompson
J. D. THOMPSON



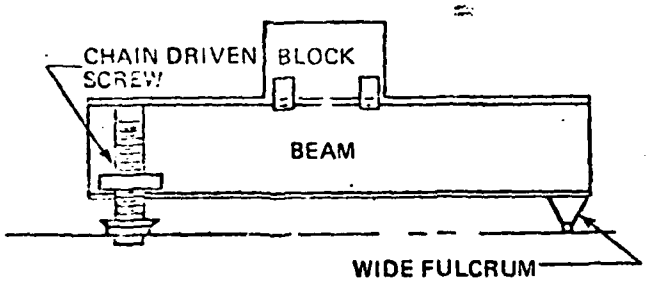
(a)
Releasing Bilge Block, Sliding Type



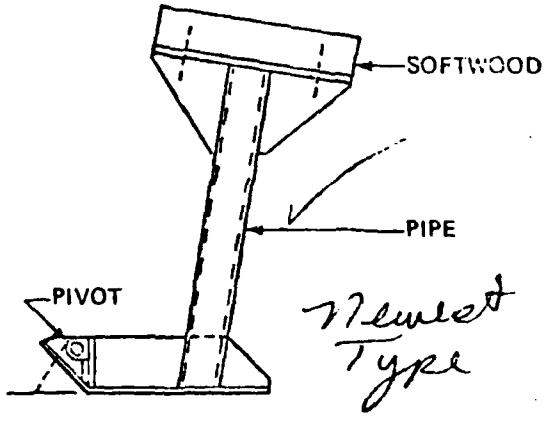
(b)
CRANDALL High Sliding Bilge Block



(c)
Dutch Type Sliding Bilge Block

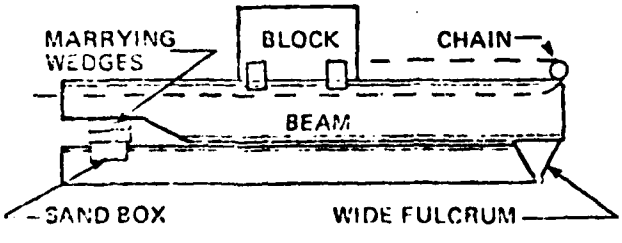


(d)
German Type Adjustable Bilge Block

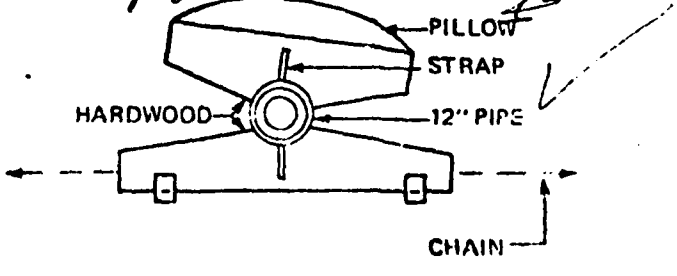


(e)
High Pivoting Pipe Shore

Could mount these on top of new pier blocks



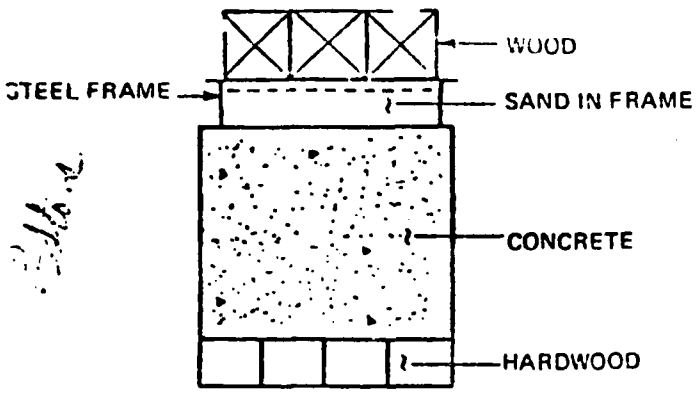
(f)
Danish Releasing Bilge Block



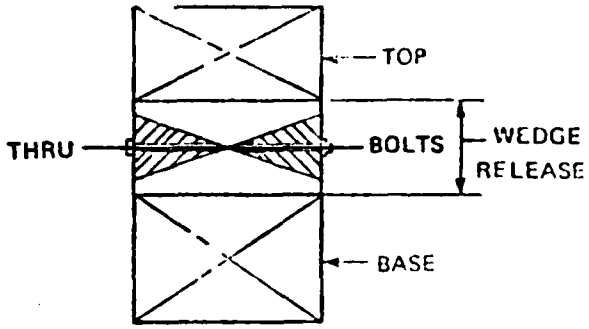
(g)
Self-Adjusting Sliding Bilge Block
(for Small Docks)

Fig. 3 2
Bilge Blocks

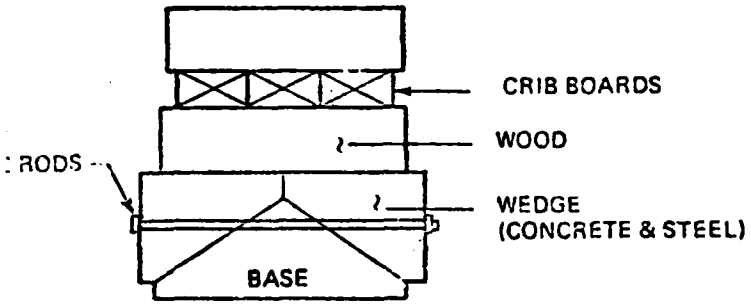
NNSY BLOCK



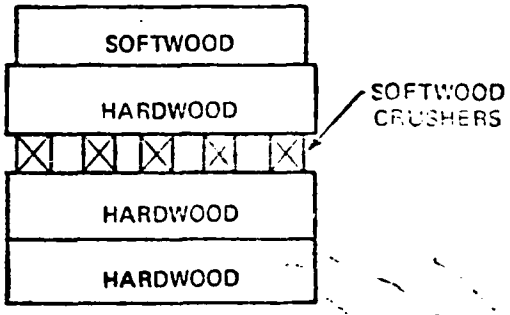
(a)
High-Capacity Releasing Block



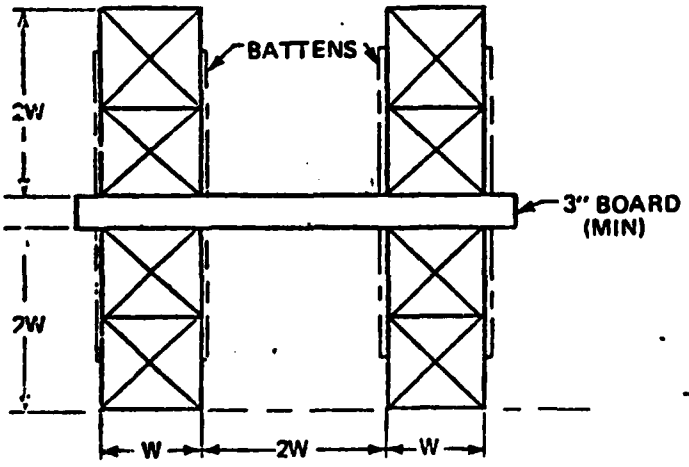
(b)
Conventional Wedge-Release Blocks



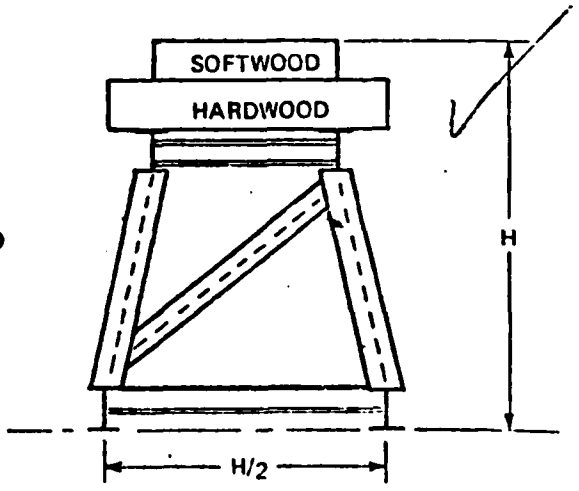
(c)
Wedge-Release Block



(d)
Compressible Keel Block



(e)
Recommended Keel Block Cribbing



(f)
Proportions for High
Keel Block Towers

Fig. 3-1
Keel Blocks

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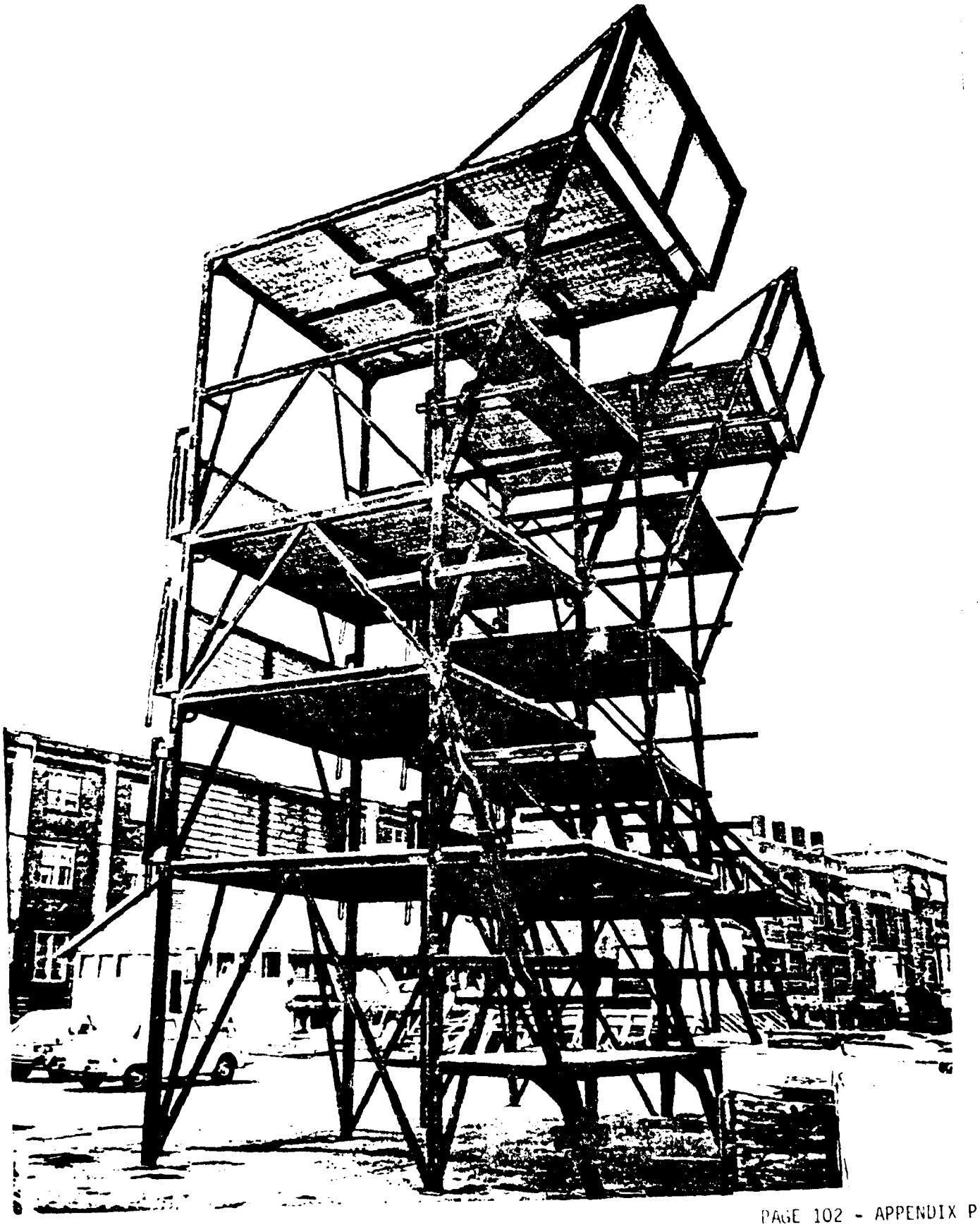
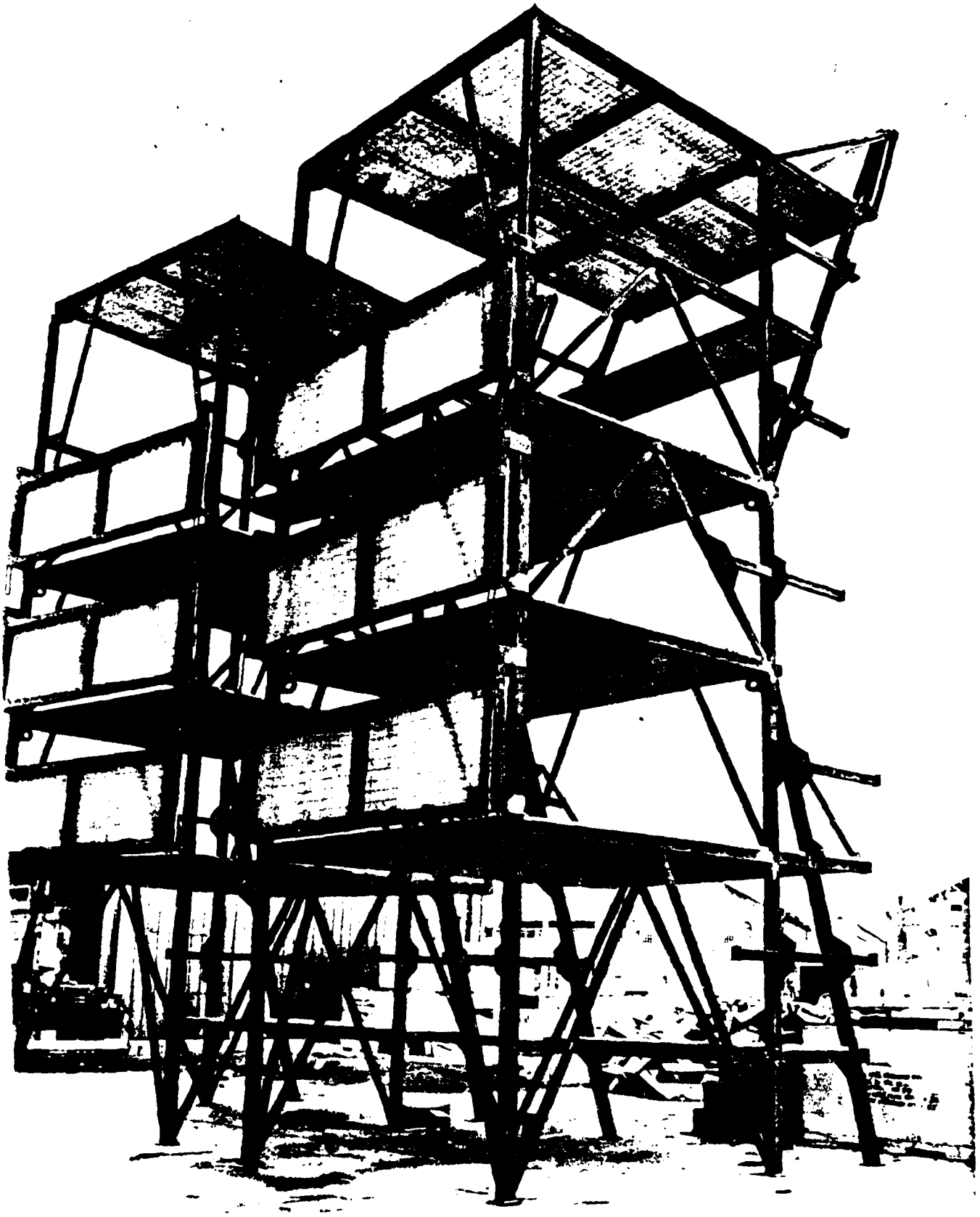
APPENDIX O





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20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

This is the report of a study of material handling operations in Drydock and Waterfront areas during ship overhauls. The scope of the study was too broad to allow specific recommendations.
General Observations and Recommendations include:

1) Evaluation of portal crane usage and recommendations to obtain more economical cranes that are more in line with the lifting demands.

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2) Proposals to provide an automated material handling system in the Drydock and Waterfront areas.

3) Proposal to develop an automatic material identification and tagging system.

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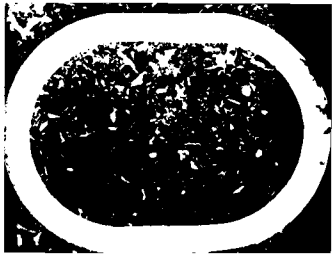
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