

UNTRI

70459



TECHNOLOGY TRANSFER PROGRAM [TTP]

FINAL REPORT

ENGINEERING & DESIGN

ENGINEERING & DESIGN VOLUME 2 APPENDICES

Prepared by:

Levingston Shipbuilding Company
in conjunction with:
IHI Marine Technology, Inc.

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APPENDIX A
BRIEF EXPLANATION OF IHICS



BRIEF EXPLANATION
OF
IHICS

Integrated Hull Information Control System



OCT. 1978

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Heavy industries Co., Ltd.
TOKYO JAPAN

REF. No.

HL-781003

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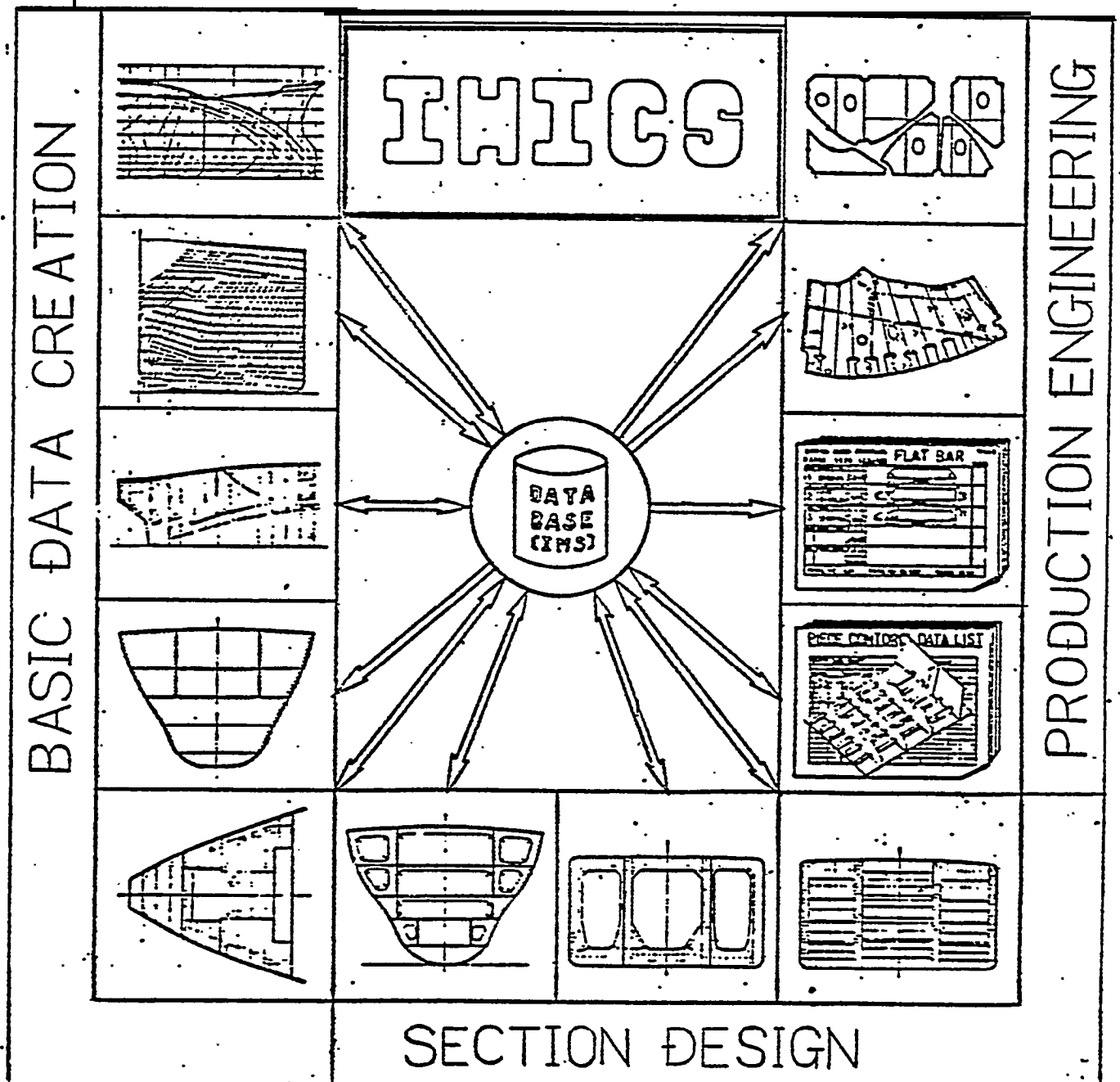
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INTRODUCTION

IHICS (Integrated Hull Information Control System) is a series of program packages which assists engineers in the fields of design and production engineering of hull construction, and also furnishes them with all information necessary for the execution of production.



1. Problems in Manufacturing Division.

There are many problems in the manufacturing division of shipbuilding today.

(A) Increase of ship's type to be constructed which has been caused by ship's market.

(B) The method of transmission of the large volume information and data from the design division to the manufacturing division, for instance,

-Numerical Control Data

-Production Engineering Data

-Production Control Data

(C) Requirements of highly precise data and information.

(D) Delivery in short time

◀ 2. IHICS solves the above problems.

(A) Generates the engineering and production data from a small volume of input data prepared by engineers.

(B) Assists engineers in the design and production engineering activity.

(C) Creates the full part data base which supplies following information to the manufacturing division.

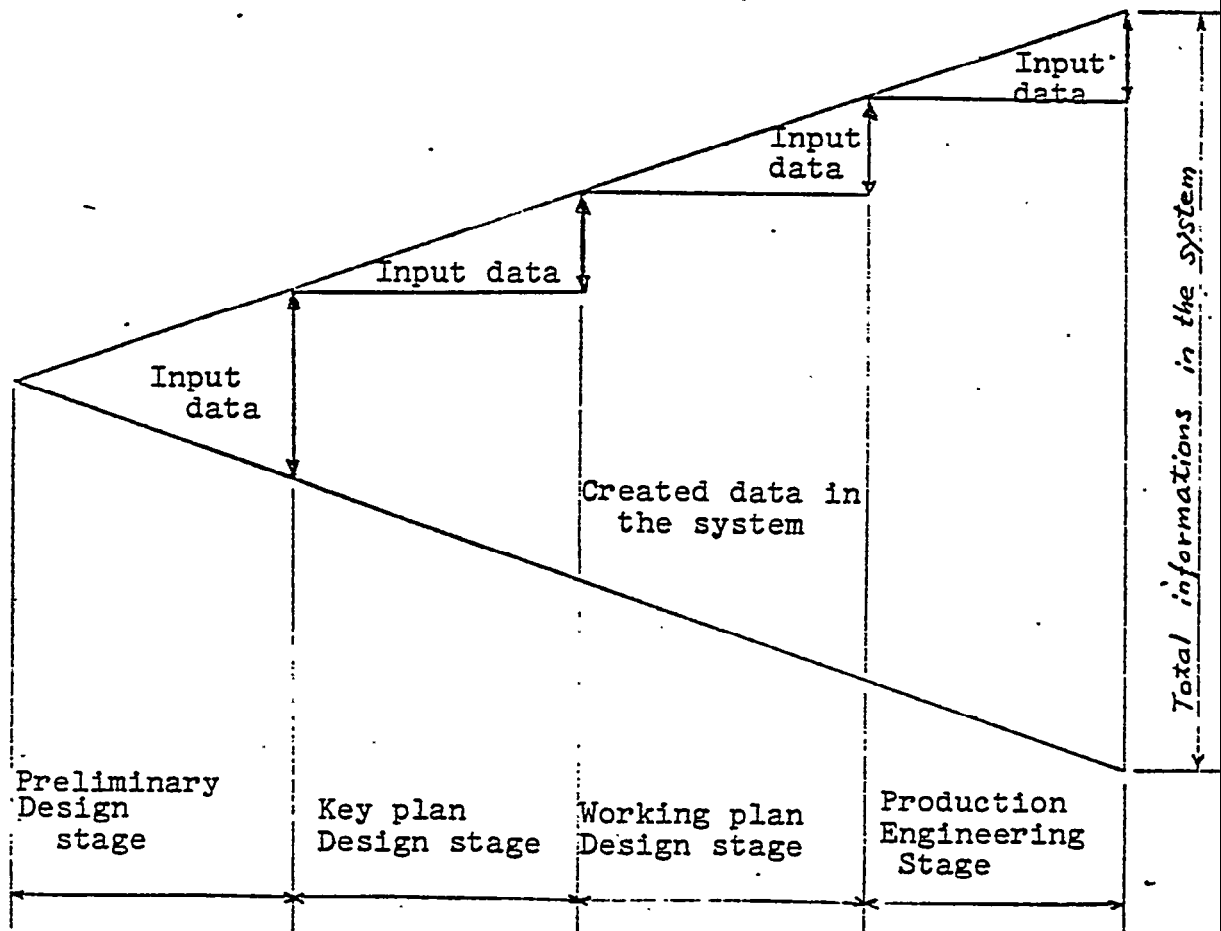
Information of production engineering.

Numerical Control Data.

Piece list for each stage.

3. Scope of the System.

- * Covers the detailed design and production engineering for hull.
- * Excludes the functions of origination of design concept nor structural analysis.
- * Maximum output from minimum input.
- * Illustration of the proportion of the input required at each stage to the whole information in the system is shown in following figure.



4. Ships having been applied in IHI (as of May, 1978)

- * 470,000 DWT Tankers
- * 250,000 DWT Tankers
- * 100,000-150,000 DWT Tankers
- * 15,000-100,000 DWT Bulk carriers
- * 20,000-100,000 DWT Combination Carriers
(Ore/Oil, Bulk/Oil)
- * 20,000- 30,000 DWT Containers
- * 15,000- 30,000 DWT cargos

- * Floating docks
- * Platform-mounted pulp plant
- * Large derrick barge

5. Specific Features of the System.

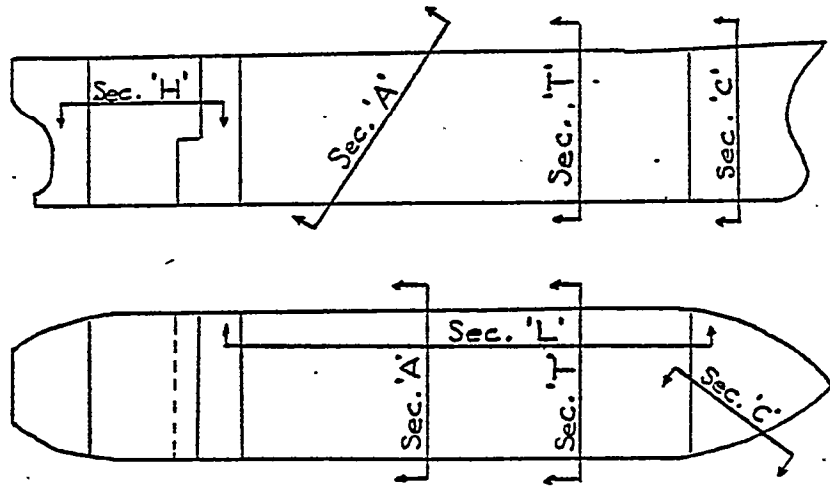
Specific features of IHICS are the following.

(A) System is based on data base concept.

System data base is under the control of
IBM Information Management System (IMS).

(B). 3-D Process and Functional Offset Data.
(Theree dimensional Process)

This technique allows to retrieve geometric data
in any position and any section.



Transverse Sec.	Sec. 'T'	} These section data can be obtained through 'Cut plane program.'
Horizontal Sec.	Sec. 'H'	
Longitudinal Sec.	Sec. 'L'	
Any other cut sec.	Sec. 'A', 'C'	

(C) "LINE" Statements.

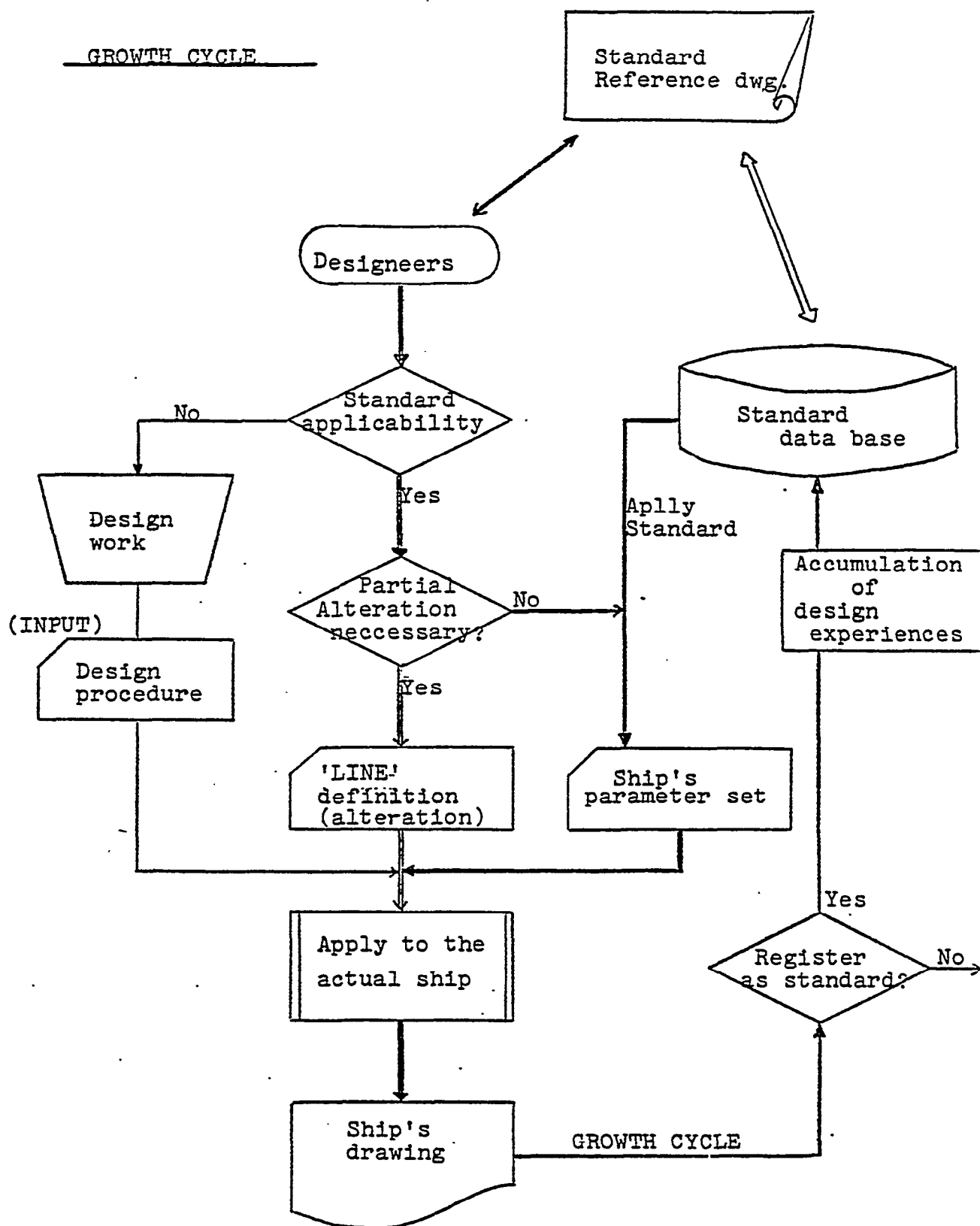
- * "LINE" Statements (Language for IHI Numerical control Engineering) are developed for means of inter communication between designers and the system.
- * -Easy expression of ship's design figures and descriptions of design standard data are possible by use of these statements.

(D) Isolation of Technology and Accumulation of Standards.

- * The system is isolated from design technology.
- * The "STANDATD" is maintained by engineers followed by the progress of the design technology.
- * These standards will be accumulated in the system and will grow towards a high technical design system with time in the same way as the accumulation of a designer's experiences would make him an expert.

STANDARD

- Shape standard: slot (Longitudinal cut out), hole, scallop Bracket, Stiffener
- Standard how to select/apply standards
- Fabrication standard
excess, edge preparation



(E) Relative expression of Data format

"LINE" is designed to describe objective figures to be designed in relative expression as far as possible so as to minimize corrections caused by the alteration of design.

This concept is coherent in all subsystems.

(F) Flexible operation

IHICS can be selected the most convenient usage of each subsystem against the given circumstances such as ;

- Applied ship
 - * Newly designed ship
 - * Sister ship
 - * Repaired or reconstructed ship
- Allowable designing period
- Computer Hardwares & Machinery for Fabrication

Typical selection can be seen in the following table.

2. Composition and usage of Subsystems

case Subsystem	A	B	C	D	Notes
Basic data creation subsystem	*	*	*	*	* Program language for applications : PL/I Optimizing compiler.
Section design Subsystem		*	*	*	
Production engineering subsys.	*	*	*	*	
Data base control system	*	*	*	*	* Data base control : IMS DB/DC
D/C-I Character display			*	*	* Required core size : 512KB
D/C-II Graphic display				*	

(G) Online Capability (Option)

IHICS supports many online terminals under
IMS/DB.DC capability.

6. Background of IHICS

IHICS is based on the total hull design systems
developed by IHI in 1971.

The new IHICS includes the suggestions obtained from
the past ten year's experience.

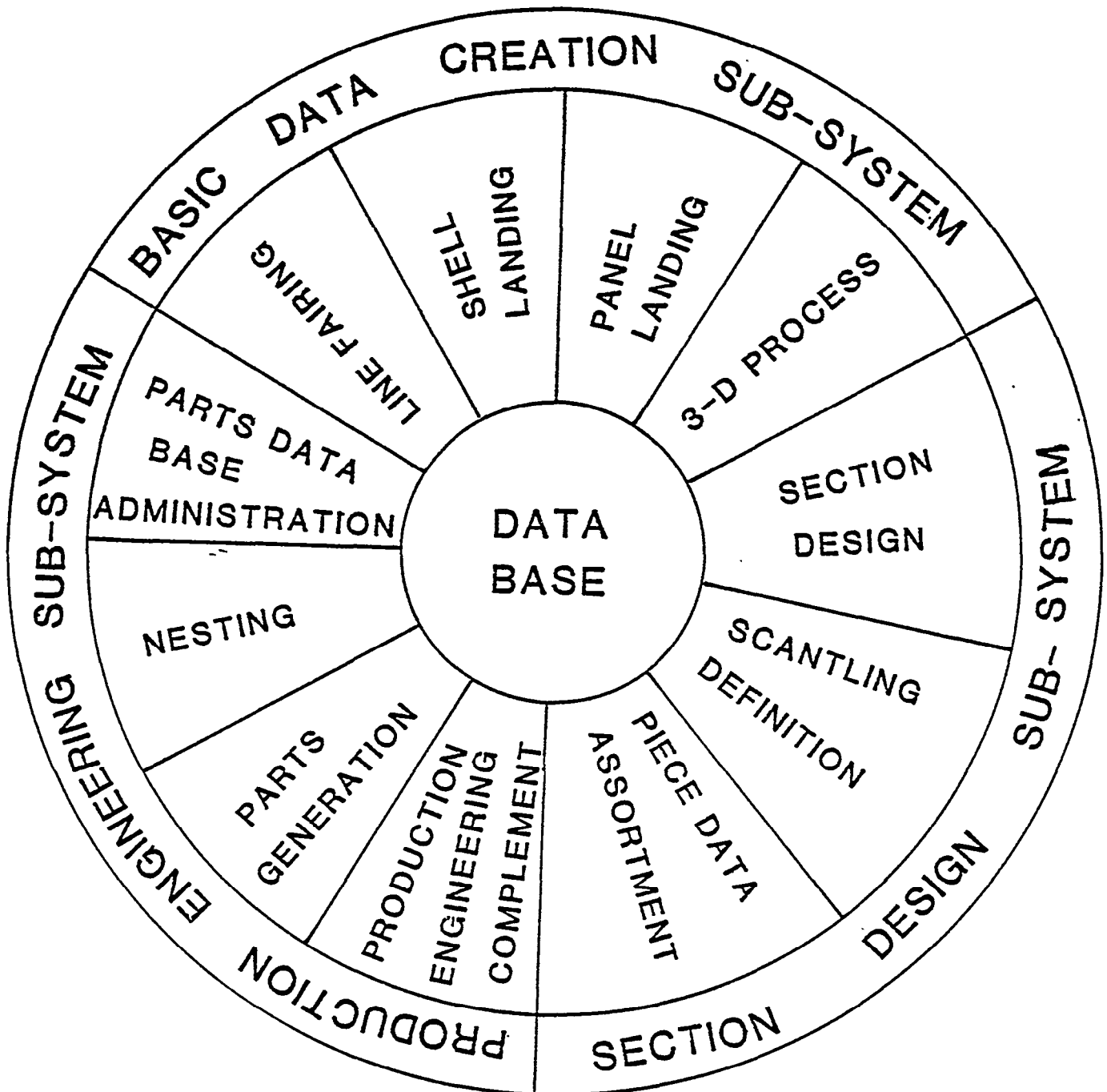


IHICS PERSPECTIVE

IHICS is composed of the following three sub-systems:

- * Basic Data Creation Sub-system
- * Section Design Sub-system
- * Production Engineering Sub-system

The system perspective and outline are shown in the following figure.



BASIC DATA CREATION SUB SYSTEM

FAIRING OF A SHIP'S HULL

LINES FAIRING PROGRAM

:* SHELL LANDING PROGRAM

- CONSISTS OF
- SEAM/BUTT LANDING PROGRAM
 - . LONGITUDINALS LANDING PROGRAM
 - . SCANTLING DEFINITION PROGRAM

* PANEL LANDING PROGRAM

- CONSTSTS OF
- SEAM/BUTT LANDING PROGRAM
 - LONGITUDINALS LANDING PROGRAM
 - SCANTLING DEFINITION PROGRAM

* 3-D PROSESS PROGRAM

- CONSTSTS OF
- . PANEL DEFINITION PROGRAM
 - COMPARTMENT DEFINITION PROGRAM
 - . CUT PLANE PROGRAM
 - . PANEL COMPOSITION PROGRAM.

...OUTPUT...

. GEOMETRY DATA BASE, PANEL DATA BASE, SCANTLING
DATA BASE

- A COMPLETE DRAWING OF ANY DESIRED PORTION OF
LINES DRAWING

- THE BOOK OF MOLD LOFT OFFSETS

- STRUCTURAL BODY PLAN(1/10, 1/50)

. SHELL EXPANSION PLAN

- PANEL PLAN DECK/BULKHEAD/FLAT/.....

SECTION DESIGN SUB SYSTEM

* SECTION DESIGN PROGRAM

CONSISTS OF .WEB'S FIGURE DEFINITION
 .STIFFEMER & JOINT ARRANGEMENT ON
 A WEB

* SCANTLING DEFINITION PROGRAM

CONSISTS OF .WEB/FACE PLATE SCANTLING DEFINITION
 PROGRAM
 • STIFFENER SCANTLING DEFINITION
 PROGRAM

* PIECE DATA ASSORTMENT PROGRAM

CONSISTS OF .PIECE DATA ASSORTMENT PROGRAM

•••OUTPUT•••

.SECTION PLAN(1/10, 1/50)
 .PIECE CONTROL DATA LIST

.PRESENTS PIECE LISTS EACH ASSEMBLY
 UNIT.
 .INCLUDES PIECE NAME, QUANTITY,
 SCANTLING, WEIGHT, PIECE DWG FORMAT,
 FABRICATION PROCESS, AND OTHER
 PRODUCTION CONTROL DATA.
 • AFFORDS FACILITIES FOR DATA
 CORRECTION.

PRODUCTION ENGINEERING SUB SYSTEM

* EDITTING PROGRAM

CONSISTS OF .PART PROGRAM GENERATOR
 .PLATE EDGE MODIFIER PROGRAM

* PART GENERATION PROGRAM

CONSTSTS OF .SHELL PLATE DEVELOPMENT AND ASSEMBLING
 DATA CALCULATION (SHELL)
 .LONGITUDINAL/TRANSVERSE FRAME DEVELOPMENT
 PROGRAM (LODACS)
 .INTERNAL STRUCTURE DEVELOPMENT (LINE
 SYSTEM)
 (WEB PLATE, FACE PLATE, STIFFENERS
 AND OTHERS)

* NESTING PROGRAM

CONSISTS OF • MANUAL NESTING PROGRAM
 .INTERACTIVE NESTING PROGRAM BY CADS
 .POST PROCESSOR FOR NUMERICAL CONTROL
 MACHINE

* PART DATA BASE

ADMINISTRATIVE PROGRAM

CONSISTS OF .PART DATA BASE HANDLER
 • PIECE LIST EDITTING PROGRAM
 FOR FABRICATION
 SUB-ASSEMBLY
 ASSEMBLY
 ERECTION

... OUTPUT ...

.PIECE DRAWING (INCLUDING TABLE FORMAT)

.NUMERICAL CONTROL DATA/TAPE

.PIECE LIST FOR EACH STAGE

- TEMPLATE FOR BENDING (SHELL PLATE AND LONGITUDINAL
FRAME)

.BLOCK MARKING DATA FOR SHELL

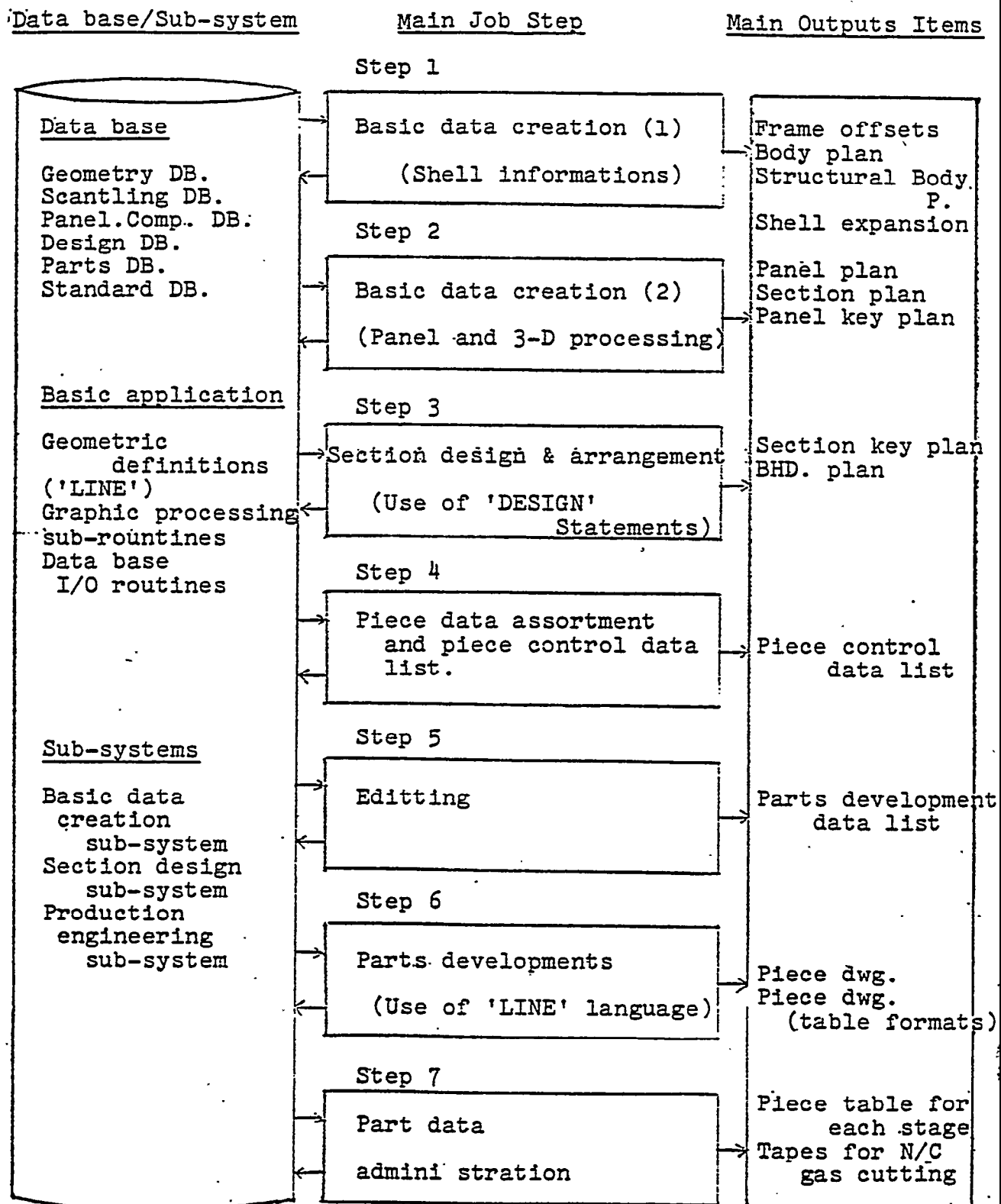
.JIG HEIGHT FOR ASSEMBLING CURVED SHELL BLOCK

'APPLICATION AREA'

STAGE	ITEM.	PROGRAM	DATA BASE
PRELIMINARY DESIGN	GENERAL ARRANGEMENT & PLANNING SCANTLING CALCULATION LINES		U
DETAILED DESIGN	SHELL & PANEL LANDING SECTION DESIGN LOCAL SCANTLING CALCULATION WORKING PLAN		
PRODUCTION ENGINEERING	LINES FAIRING PIECE LIST ISSUE PARTS GENERATION BLOCK ASSEMBLY NESTING N/C DATA		
PRODUCTION CONTROL	SCHEDULING & OTHER PRODUCTION CONTROL		V

GENERAL SYSTEM OPERATION FLOW

The diagrammatic general system operation flow is shown in the following figure, in which main job steps, main output and main program modules are indicated. The detailed explanations of each step are to be referred to the following sections.



FUNCTIONS OF "LINE" STATEMENT

1. Objection for 'LINE' statements

'LINE' statement is developed for common language of the geometric expression of hull form and structures.

It is a kind of problem oriented language of which format is free.

2. Functions of 'LINE' statements

(A) Geometric definitions

Geometric expressions such as point, straight line, circle, tabcyl and thier composed line can be defined at any stage.

The definition method adopts rather relative expression.

(B) Auto-reference function to standard data

(C) Contouring definition (Web plate definition)

This gives contouring of figure

(it is called as 'Motion'). Cutter location data of plates are created through this program.

(D) Opening definition

Man holes, drain holes, etc. are defined by this statement.

(E) Plate edge information

Edge preparation for welding and margin amount of material are indicated.

(F) Data base reference

Easy access to or reference to geometry, design and data base is available.

(G) Marking line definition

For the definiiion of marking line only (water line etc.)

(H) Stiffner development (Bracket, Flat bar, Inverted Angle)
exact shape of a stiffener taking account of **plate**
thickness

- Precise shape at its both end.
- Bevel angle calculation.
- Calculation for many types of stiffeners (more than 400) are built in program.
- Any new type of stiffener can be easily registered.

(I) Face plate development.

(J) Collar plates and others.

(K) Weight, Area, Marking length calculation.

Example expressions are shown in the next page.



3. An example of 'LINE' descriptions

(An example for corner part of transv. section)

Geometric Definition

```

T      F60
T1=F60----GEOMETRY DB REFERENCE
PA1=PA-UD,ML---PANEL DB REFERENCE
P11=OUT(SL,UD,1)----DESIGN DB REFERENCE
S1=PA1,P11
S11=PR-SL,L=2000,D
LONG=SL,L40,L59    GEOMETRY,SCANTLING
LONG=UD,L20,L21    DB REFERENCE
...
...
C1=TD-S11,T1,-S2
P1=CP-C1
P2=SLOT-PC2,UD-L20
S5=PT-P2,PT-P1
P3=INT(S5-C1),U
P4=ON-C1,FROM-P3,GL=150,D
P5=UD-L20,TOP
A1=P100,S11,C1,S2,-----COMPLEX SURFACE
S24=PT-P4,PT-P5,SCS=UD-L20,ECS=A1
S21=SL-L57,      SCS=SL-L57,ECS=A1
S25=UD-L21,      SCS=UD-L21,ECS=S23
...
...

C      -----,T1,MSL(SL,L40,L59),T1,MSC(100),PA1,      } CONTOURING
      MSL(UD,L21,L21),PA1,MBS(S5,UD,L20,P3,21),C1} DEFINITION
      ----- , &

H      MH(1,P51,150)      ----- OPENING
                                DEFINITION

X      S21=F,FIT=A,PD=D,MRK=U,TYP+FC1S1,NAM=F15      }
X      S22=B,FIT=A,PD=D,MRK=U,TYP=BC1S1S1,NAM=B16 } PARTS EXPANSION
...
...

E

```

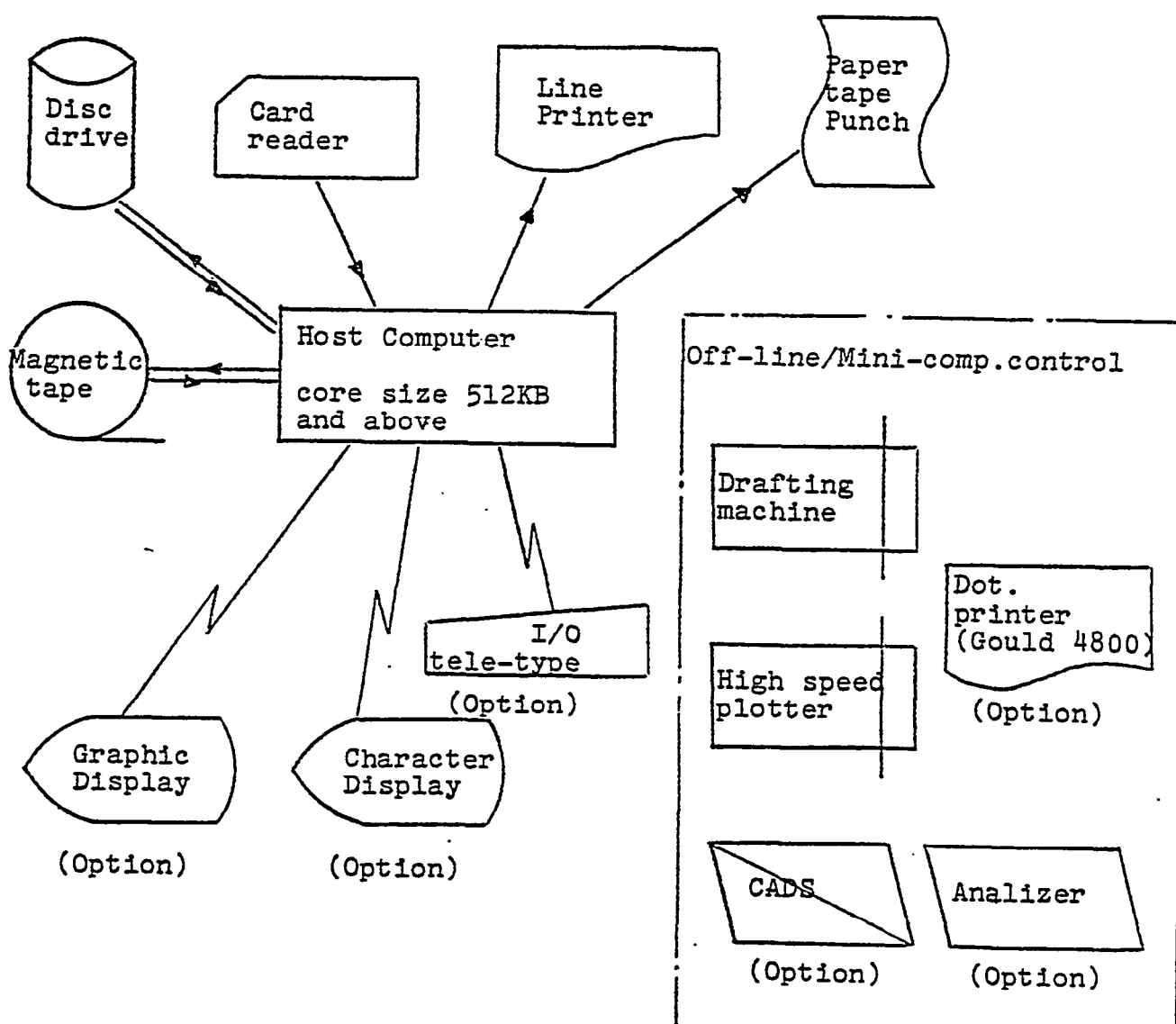
END OF PART PROGRAM

COMPOSITION OF AVAILABLE HARDWARES AND SUBSYSTEMS.

Required hardware and subsystems for smooth operations of this system are as follows.

1. Available hardware for this system

Facility of host computer should be determined taking any other system's applications into consideration.



APPENDIX B

IHICS - ACTUAL OUTPUT EXAMPLES



IHICS

Actual Input/output Examples



OCT. 1978

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TOKYO JAPAN

REF. N O.

LINE ----- Language for Parts Generation

 ***** LINE DEFINITION SECTION_1. 02/06/78 *****

Geometric definition

INPUT_NO DEFINITION

```

TITLE.....T2715SL32      23      W1      P160F      APFF23      1ER12TLE00050
0001      C009 = IN(C009,R2)      IN000100
0002      S014 = IN(S014,R2)      IN000150
0003      C010 = IN(C010,R2)      IN000200
0004      S005 = IN(S005,R1)      IN000250
0005      C003 = IN(C003,R1)      IN000300
0006      S006 = IN(S006,R1)      IN000350
0007      S013 = IN(S013,R2)      IN000400
0008      C004 = IN(C004,R1)      IN000450
0009      LONG = SL , F23 , L25 , L318      L4G00500
0010      LONG = EF02, F23 , L6 , L10      LNG00550
0011      T011 = F23      AUX00650
0012      PA11 = FF02      AUX00700
0013      S506 = PT-P( 7579.9, 10849.9), PT-P( 6579.2, 10096.0)      AUX00750
0014      S509 = PT-P( 4555.9, 9081.2), PT-P( 5130.9, 9081.2)      JD100800
0015      S512 = PT-P( 5476.7, 4500.0), PT-P( 4023.0, 5038.8)      JD100050
0016      P150=INT(S509-S005)
0017      P151=IN(S006,C074,R1)
0018      S011 =SL-L300,ECS=S049,SCS=SL -L300      STF00950
0019      S022 =SL-L30,ECS=P300,SCS=SL -L30      STF01050
0020      S023 =SL-L30A,ECS=S044,SCS=SL -L30A
0021      P300=INT(S22-C3),0
0022      S024 =SL-L306,ECS=S050,SCS=SL -L306      STF01100
0023      S025 =SL-L31,ECS=S026,SCS=SL -L31      STF01150
0024      S030 =EF02-L10,ECS=S027,SCS=EF02-L10      STF01300
0025      S039 =SL-L308,ECS=A11,SCS=SL -L308      STF01450
0026      S041 =SL-L29,ECS=A11,SCS=SL -L29      STF01500
0027      S044=PR-S(1),L=5100,0,SCS=S039,ECS=S022
0028      S046 =SL-L30E,ECS=S009,SCS=SL -L30E
0029      S049=PR-S(1),L=5100,0,SCS=S054,ECS=S039
0030      S050 =EF02-L8,L=0,0,SCS=S055,ECS=S102      STF01700
0031      S021=IN(S014,R2,P)      STF01750
0032      C022=IN(C010,R2,P)      STF02200
0033      S010=IN(S005,R1,P)      STF02300
0034      S017=IN(S012,R2,P)      STF02350
0035      P030=SL0T-PC2(1),EF02-L9      STF02400
0036      PA02=EF02      STF02500
0037      S003=EF02-L8,L=0,0      STF02550
0038      C020=IN(C009,R2,P)      STF02600
0039      P504 = 5731.0, 10334.9      STF02700
0040      P505 = 3194.2, 3039.7      STF02750
0041      P023=INT(S049-S039)      STF02150
0042      S009 =PR-SC21,L=15,0,SCS=S100,ECS=S011      STF00900
0043      P025=INT(S009-S011)      STF02000
0044      S004=PA02,S003      STF02250
0045      S054 =PT-P(ICP-C022),PR-S004,SCS=S010,ECS=S017      STF02050
0046      P031=CP-C020      STF02450
0047      S055 =PT-P130,PT-P031,SCS=P030,ECS=A11      STF02100
0048      P033=DN-S024,FRQM-P(INT(S024-S050)),GL=550,0      STF01800
0049      S026 =PT-P(EF02-L9,ST),PT-P033,SCS=EF02-L9,ECS=S024      STF01200
0050      P032=DN-S026,FRQM-P(INT(S025-S026)),GL=350,U      STF01850
0051      S027 =PT-P(1SL-L31A,ST),PT-P032,SCS=SL-L31A,ECS=S026      STF01250
0052      S100=FQ-S050      02601
0053      S101=EQ-S009      02602
  
```

Example of partprogram

generated by an editing program
 in Design-subsystem.

Element surface of a web figure
 (Retrieved from the Design-DQ)

Longitudinal data retrieved

Frame-line retrieved (curved line)
 Inner-panel data at the section retrieved

P*** ----- Point definition

S*** ----- Straight line definition

C*** ----- Circle definition

PA*** ----- Inner panel surface
 definition

T*** ----- Curved line definition

AA*** ----- Grouped surface
 definition

0054 S102=EQ-S046
0055 A11=P150,S035,C003,S006,P151
0056 P034=INT(S044 -S022)
0057 S033 =PT-P034,PP-S022 ,SCS=S022 ,ECS=S041
0058 P024=DN-S039 ,FROM-P023,GL=500,0
0059 S039 =PT-P024,PT-P025,SCS=S011 ,ECS=S039
0060 S333=PR-S1CL,L=5100,0,SCS=S509,ECS=S22
0061 S336=PR-S333,L=545,0
0062 S334=SL-L305,SCS=S333,ECS=S336

02603

STF01900
STF01350
STF01950
STF01400

2.

***** STEP WAS EXECUTED - COND CODE 0000

0040 P000 104
 0041 P005 3
 0042 P005 104
 0043 P005 3
 0045 S100 444
 0047 S102 444
 0049 P034 104
 0051 P024 502
 0052 S705 303
 0052 S336 102

0041 P033 502
 0042 S076 2
 0043 P032 502
 0044 S027 2
 0046 S101 444
 0048 A011 200
 0050 S033 4
 0052 S038 2
 0052 S333 102
 0052 S334 202

3

***** STEP WAS EXECUTED - COND CODE . 0000

C

T011, MSL(SL , L29 , L31A ,10), T011,
 MSC(100),
 PA11, MSL(EF02, L10 , L10 ,10), PA11,
 MRS(S506, EF02, L9 , P507, 12),
 C009, SC14, C010,
 S509,
 S005, C003, S006,
 S512,

MTN02800
 MTN02850
 MTN02900
 MTN02950
 MTN03000
 MTN03050
 MTN03100
 MTN03150
 MTN03200
 MTN03250

Contouring definition of a web plate

E

UNDEFINED SYMBOL=(P507)VVVV UNDECK

G FC11=ALL, TYP=T, SCN= 300.0*25.0

GEX03300 Face plate definition used for stiffeners' development
 EXP03450 Stiffener (flat bar) definition

X S022 =F, TYP=FC151, PD=U, NAM=3, MRK=D, FIT=A

***** EXPANSION SURFACE (S022) *****
 * SCS=SL-L30 ECS=P300
 * SCS_ANGLE= 67.4 ECS_ANGLE= 90.0 EXP_ANGLE= 79.7
 * SCS_THETA= 90.9 ECS_THETA= 90.0 STR_THETA= 0.0
 * E_XS= 5.4686 E_YS= 5.7359
 * E_XE= 4.4562 E_YE= 6.1746
 * SYMS(1)=S INDXS(1)=246 SYMS(2)=L INDXS(2)= 6
 * SYME(1)=S INDXE(1)=247 SYME(2)= INDXE(2)= 0
 * SCS_PLANE= 0.3815 -0.8427 0.3799 -4.8565
 * ECS_PLANE= 0.0000 0.9336 -0.3584 -1.9304
 * EXP_PLANE= 0.1790 -0.3526 -0.9185 3.7772
 * SCANTLING= 150.0 12.5 0.0 0.0
 * LENGTH= 1.0844
 * WEIGHT= 13.9523
 * EXP_NAME= F2

Results of a stiffener above defined

X S039 =B, TYP=BC2C6F1, PD=U, NAM=124/B1.F1

MRK=D

EXP03900

FIT=A, DATA(C=150, R=300)

EXP03950

Stiffener (bracket) definition
 [Bracket development built in program]

--- SGT CL_DATA COUNT = 33

Results of a stiffener above defined

0.0000	0.0000	20001.0000	1.5821	0.0000	20002.0000	1.5821	-0.126*	20011.0000	0.5396
-0.4457	30012.0000	405000.0700	0.6273	-0.7326	0.2999	0.3361	-0.6605	20013.0000	0.3226

-0.6670 20004.0000 0.0233 -0.0492 402200.0000 406000.0000 0.0149 0.0000 0.0499 0.0649
 0.0000 402210.0000 999.0000 -0.0492 402200.0000 406000.0000 0.0149 0.0000 0.0499 0.0649

--- BKT MK_DATA COUNT = 13

405000.0000 0.2846 -0.5080 405100.0000 1.5471 -0.1220 405000.0000 404100.0000 0.9541 -0.2533
 0.9158 -0.2650 999.0000 405100.0000 1.5471 -0.1220 405000.0000 404100.0000 0.9541 -0.2533

--- BKT CH_DATA COUNT = 1

F1

----- CL_DATA STORE END -----

----- MK_DATA STORE END -----

----- UP_DATA STORE END -----

----- VI_DATA STORE END -----

----- CH_DATA STORE END -----

```

***** EXPANSION SURFACE (S039) *****
* SCS=SL-L30R ECS=A11
* SCS_ANGLE= 64.2 ECS_ANGLE= 90.0 EXP_ANGLE= 90.0
* SCS_THETA= 89.2 ECS_THETA= 86.9 STR_THETA= 0.0
* E_XS= 6.1358 E_Y= 7.1020
* E_XE= 4.5560 E_YE= 7.1876
* SYMS(1)=S INDXS(1)=246 SYMS(2)=L INDXS(2)= 8
* SYME(1)=S INDXE(1)= 2 SYME(2)=F INDXE(2)= 1
* SCS_PLANE= 0.4354 -0.8981 0.0623 -3.2476
* ECS_PLANE= 0.0000 1.0000 0.0000 -4.5560
* EXP_PLANE= 0.0000 -0.0541 -0.9985 7.4235
* SCANTLING= 12.5 100.0 11.0 0.0 0.0
* LENGTH= 1.5821
* WEIGHT= 50.8340
* EXP_NAME= YZ B1 F1
  
```

Stiffener development

- * parts generation
 - graphical data and dimension
 - store results into DB
- * edge preparation (Bevel & excess)
- * consideration of plate thickness
- * marking data of a stiffener for the web:
 - marking location
 - direction of plate thickness
 - fitting angle against the web

X S041 =B,TYP=SC2C6F1,PD=U,NAM=13V/B1.F1

,NRK=D

,EXP04030

FIT=A,DATAIC=150,R=300)

EXP04050

additional data

}--- Bracket with a flat bar definition

--- BKT CL_DATA COUNT = 33

0.0000 0.0000 20001.0000 1.1209 0.0000 20002.0000 1.1206 -0.1289 20011.0000 0.4406
 -0.3367 30012.0000 406000.0000 0.5283 -0.6236 0.2999 0.2365 -0.5542 20013.0000 0.2226
 -0.5597 20004.0000 0.0197 -0.0497 402200.0000 406000.0000 0.0149 0.0000 0.0499 0.0649
 0.0000 402210.0000 999.0000 -0.0497 402200.0000 406000.0000 0.0149 0.0000 0.0499 0.0649

--- BKT MK_DATA COUNT = 13

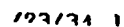
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 0.6404 -0.2100 999.0000 405100.0000 1.0856 -0.1239 405000.0000 404100.0000 0.6786 -0.1983

SNO	BLOCK	PA_SUP	DATE
2715	SL22		70/06/02

Processed parts list for summary

SUB	PA_SUP	PIECE	LENGTH	CUT_LNG	MRK_LNG	WEIGHT	ER_COD	SURFAC
23		F2	1.0044	0.000	0.000	13.9		S022
23	Y2	B1	1.5821	3.878	1.320	50.8		S039
23	Y2	F1	1.3202	0.000	0.000	11.4		S039
23	Y1	B1	1.1209	2.908	0.931	30.3		S041
23	Y1	F1	0.9311	0.000	0.000	8.0		S041
23		F11	0.7508	0.000	0.000	9.3		S033
23		F12	0.0000	0.000	0.000	0.0		S044
23		F3	0.6022	0.000	0.000	8.0		S023
23		A14	1.9105	0.000	0.000	60.4		S049
23		F4	1.6884	0.000	0.000	24.2		S011
23		F13	1.1400	0.000	0.000	13.6		S038
23		F16	1.5198	0.000	0.000	30.7		S004
23		A15	1.3428	0.000	0.000	30.9		S050
23		F6	0.9827	0.000	0.000	12.4		S024
23		F5	0.8080	2.286	0.000	22.2		S046
23		F9	1.3062	0.000	0.000	17.6		S026
23		F7	0.7938	0.000	0.000	9.6		S025
23		F8	1.1156	0.000	0.000	14.3		S027
23		F10	0.3243	1.092	0.000	5.8		S030
23		F18	3.2304	0.000	0.000	277.0		S333
23		F17	0.4850	1.664	0.000	12.2		S334
23		W1	0.0000	29.123	45.103	1467.6		

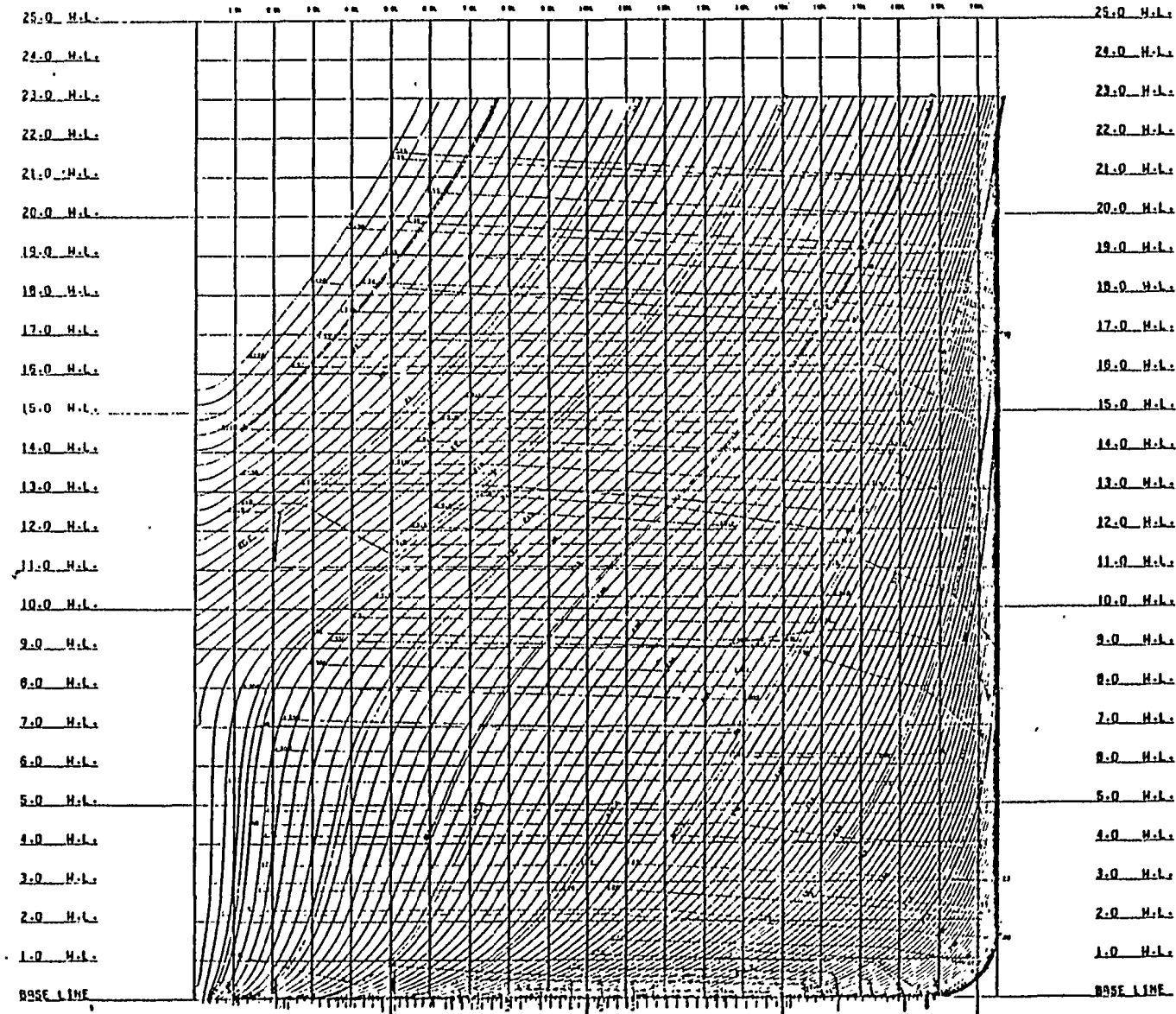
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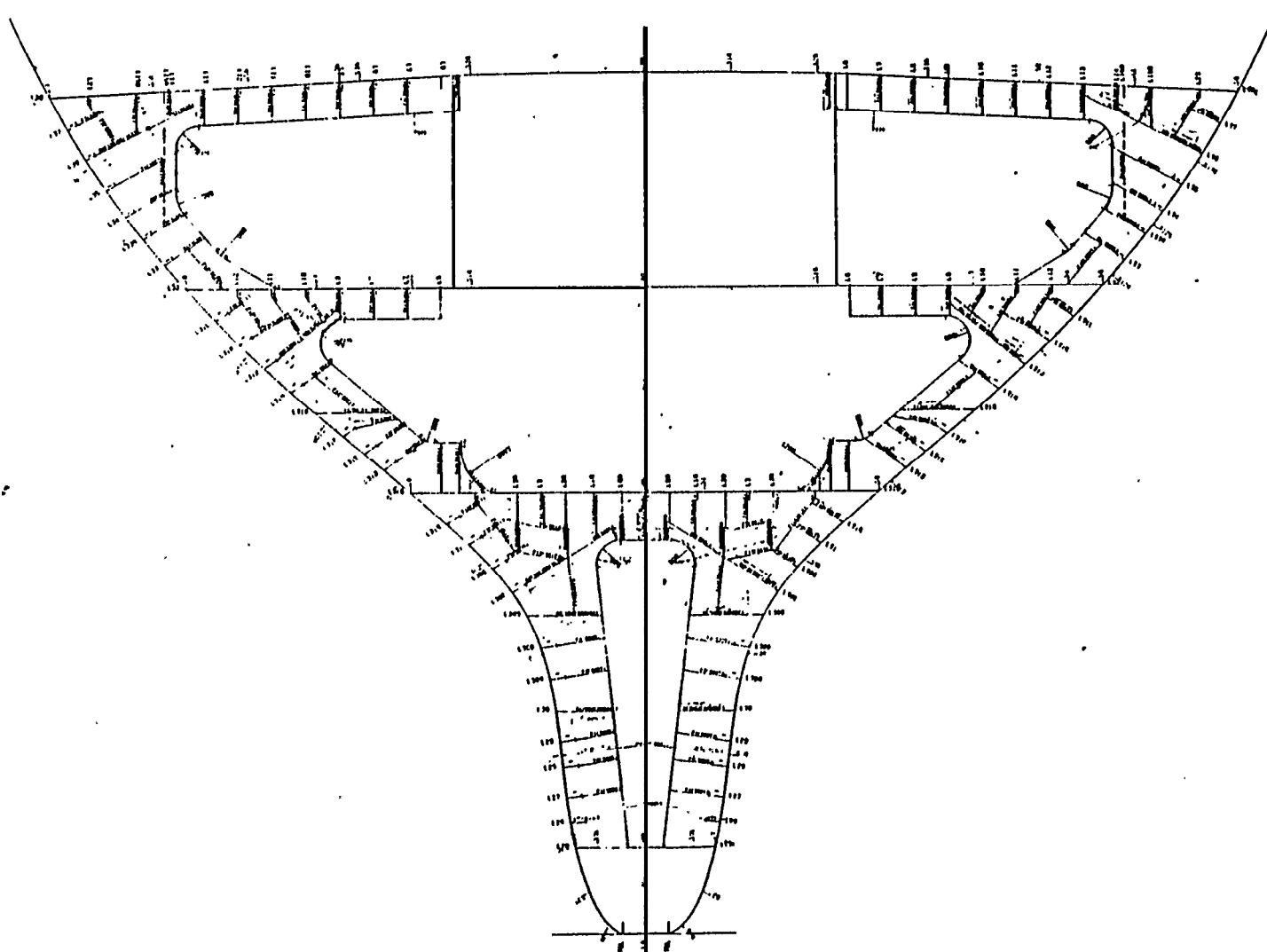
S No 2715	Page 1
Case No K 1111202	13
F23 SEC	

STRUCTURAL BODY PLAN

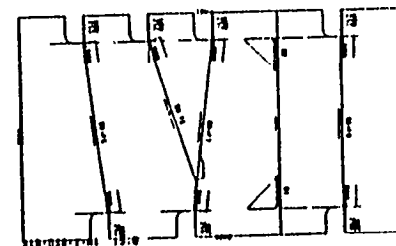
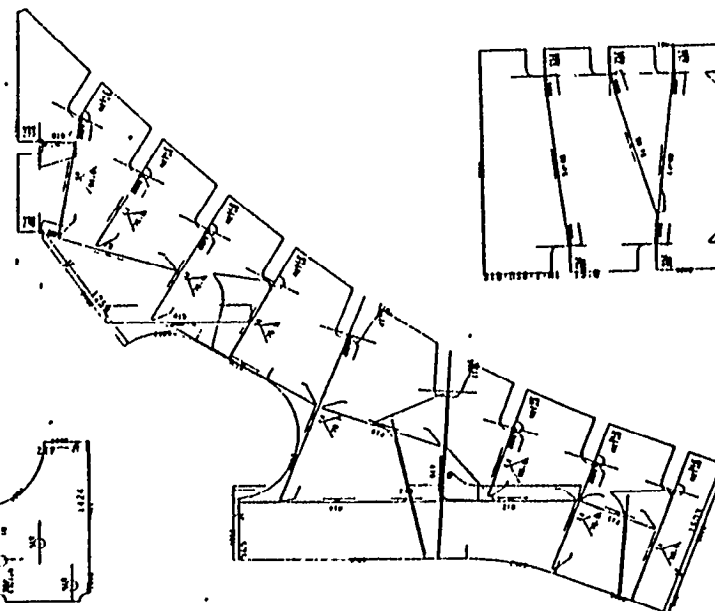
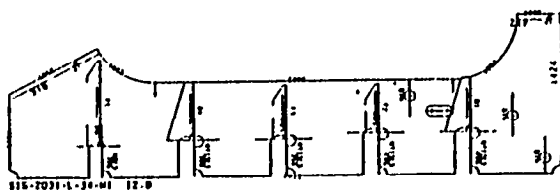
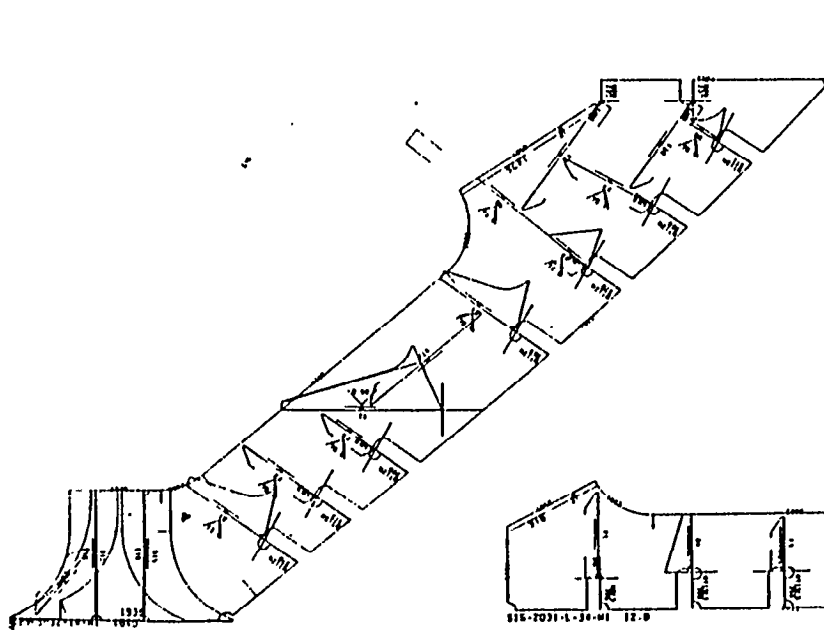
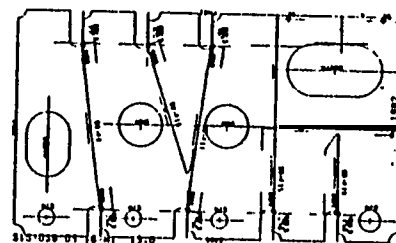
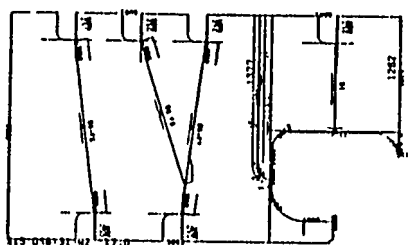
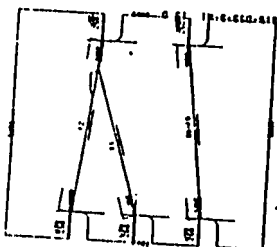
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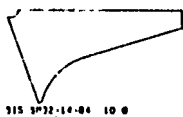
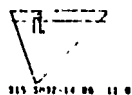


SECTION DRAWING

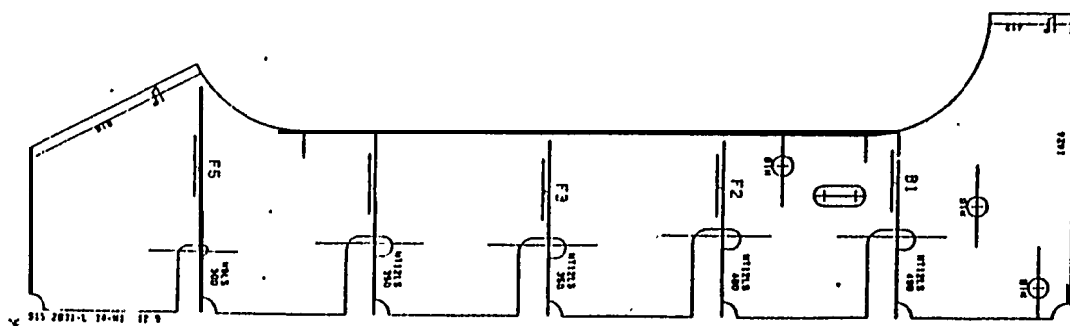
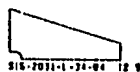
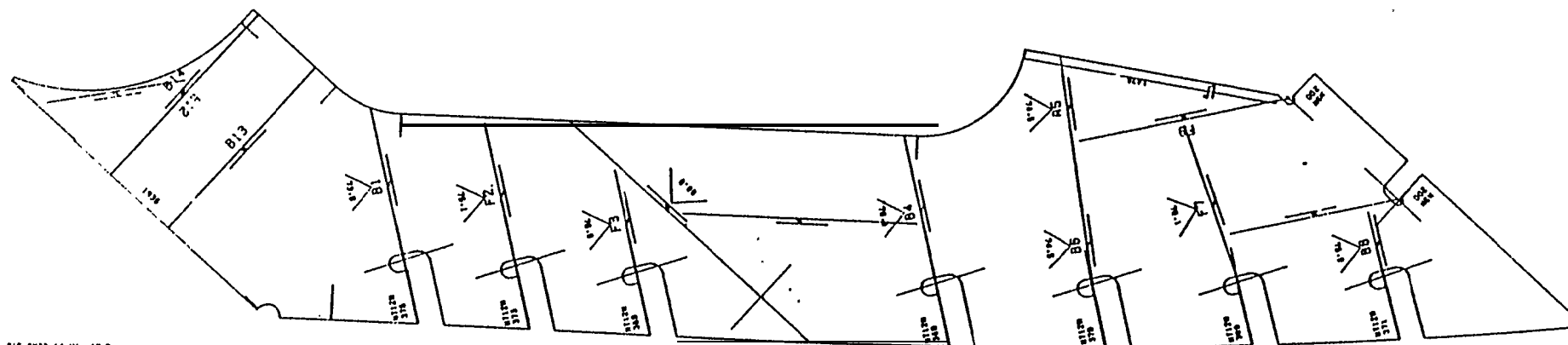


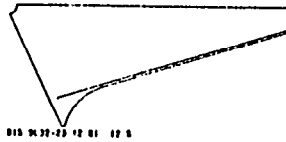
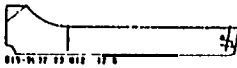
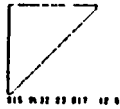
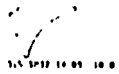
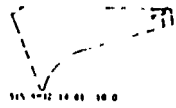
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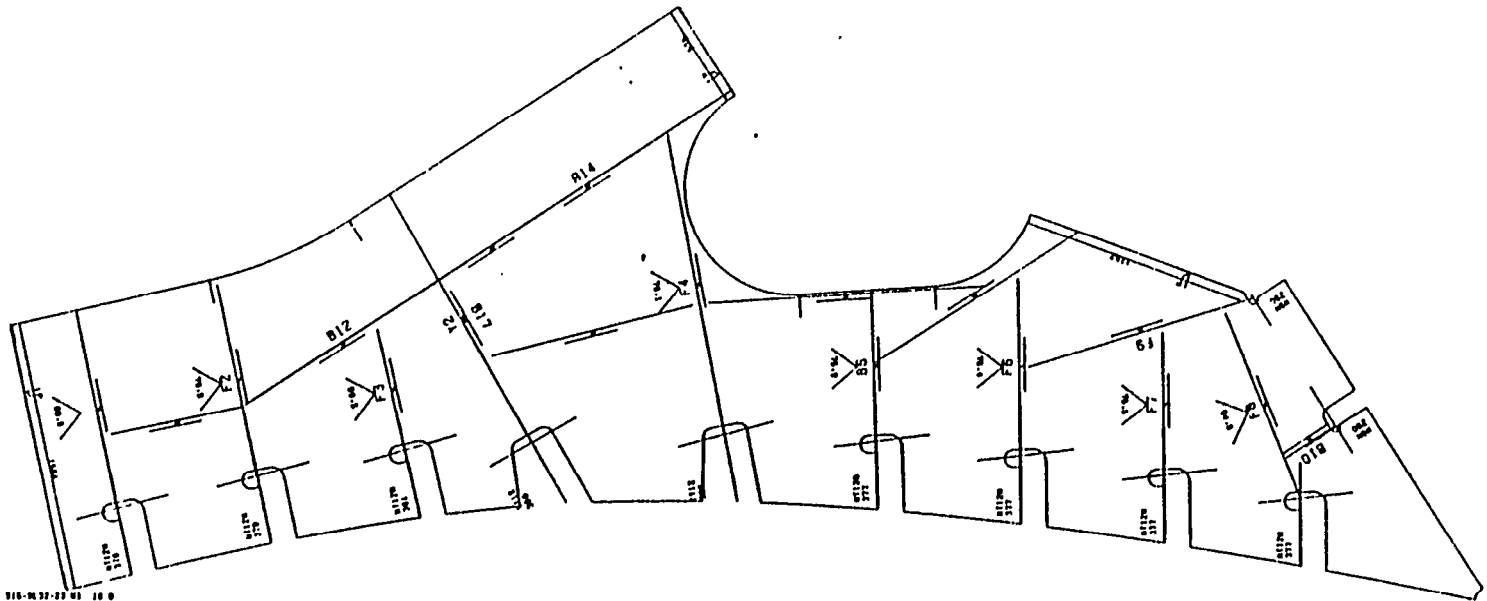
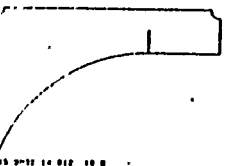
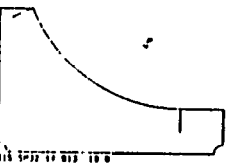
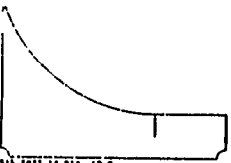
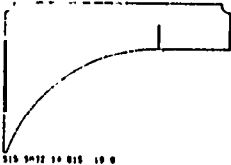


PARTS DRAWING





PARTS DRAWING



SHIP NO PANEL SCANTLING FAB.SHOP

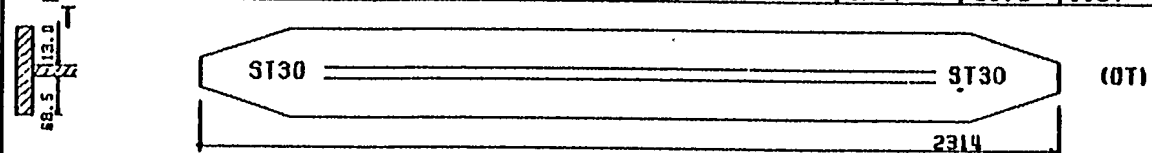
FACE PLATE

2715 DS 150 X 13.0

DATE 78.5.23

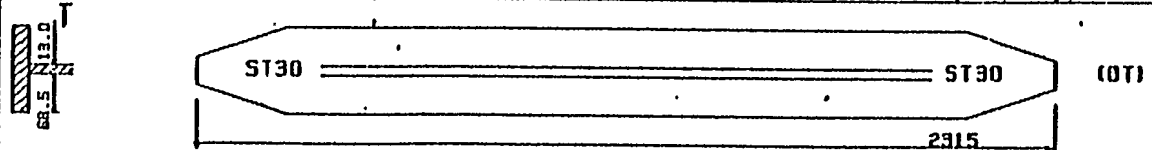
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NO	PART	CODE	DS-T1	SHOWN	SCANTLING	H. LENGTH	HEIGHT	C. OF G	NOTES
1				P-DN	150 X 13.0	2314	35.0	1157	



	1	2	3	4	5	6	7	8	9	10	11	12	13	13A	13F					TOTAL
P						1														
C																				
S						1														

NO	PART	CODE	DS-T2	SHOWN	SCANTLING	H. LENGTH	HEIGHT	C. OF G	NOTES
2				P-DN	150 X 13.0	2315	35.0	1158	



	1	2	3	4	5	6	7	8	9	10	11	12	13	13A	13F					TOTAL
P						1														
C																				
S						1														

TOTAL HEIGHT 0.0

TOTAL LENGTH 0.0

PANEL DS

SHIP NO	BLOCK	SCANTLING	FAB. SHOP
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
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10	10	10	10
11	11	11	11
12	12	12	12
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100	100	100	100

FACE PLATE

2715 · DSG 150 * 13.0

DATE 78. 5 .23

PAGE

[illegible]

SHIP NO	PANEL	SCANTLING	FAB. SHOP
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
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9	9	9	9
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14	14	14	14
15	15	15	15
16	16	16	16
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18	18	18	18
19	19	19	19
20	20	20	20
21	21	21	21
22	22	22	22
23	23	23	23
24	24	24	24
25	25	25	25
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96	96	96	96
97	97	97	97
98	98	98	98
99	99	99	99
100	100	100	100

FLAT BAR

2715 DS 75 X13.0

PAGE 1

DATE 78.5.23 NOTES

[illegible]

SHIP NO. BLOCK SCANTLING FAB. SHOP
 2715 056 150 X13.0

FLAT BAR

PAGE 1

DATE 70.5.23 NOTES

NO	PART CODE	P	C	S		
1	-34-F1	1		1		(UP)
		SHOWN				
		S-OT				
NO	PART CODE	P	C	S		
2						
		SHOWN				
NO	PART CODE	P	C	S		
3						
		SHOWN				
NO	PART CODE	P	C	S		
4						
		SHOWN				
NO	PART CODE	P	C	S		
5						
		SHOWN				
NO	PART CODE	P	C	S		
6						
		SHOWN				

TOTAL WEIGHT 32.0

TOTAL LENGTH 2424.0

BLOCK 056

SHIP NO	PANEL	SCANTLING	FAB. SHOP	
2715	DS	150 X 13.0		FLAT BAR

PAGE 1

NO		PART CODE	SHOWN	DATE 70. 5. 23																				NOTES		
1	DS-F1	S-OT																					(UP)			
	P	1	2	3	4	5	6	7	8	9	10	11	12	13	13A	13F						TOTAL				
	C					16																				
	S					16																				
2	DS-F2	S-OT																					(UP)			
	P	1	2	3	4	5	6	7	8	9	10	11	12	13	13A	13F						TOTAL				
	C					16																				
	S					16																				
3	DS-F3	S-OT																					(UP)			
	P	1	2	3	4	5	6	7	8	9	10	11	12	13	13A	13F						TOTAL				
	C					16																				
	S					16																				
TOTAL WEIGHT		0.0					TOTAL LENGTH										0.0					PANEL DS				

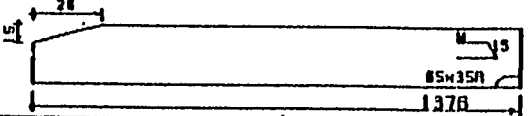
28

SHIP NO PANEL SCANTLING FAB. SHOP FLAT BAR

2715 DS 200 X 13.0

PAGE 1

DATE 70. 5. 23 NOTES

NO	PART	CODE	SHOWN																	DATE 70. 5. 23	NOTES							
1	DS-F5		S-OT																	(UP)								
				1	2	3	4	5	6	7	8	9	10	11	12	13	13A	13F									TOTAL	
	P								5																			
	C																											
	S								5																			
2	DS-F6																											
				1	2	3	4	5	6	7	8	9	10	11	12	13	13A	13F									TOTAL	
	P								4																			
	C																											
	S								4																			
3	DS-F6A		S-OT																	(UP)								
				1	2	3	4	5	6	7	8	9	10	11	12	13	13A	13F									TOTAL	
	P								1																			
	C																											
	S								1																			

TOTAL WEIGHT 0.0

TOTAL LENGTH 0.0

PANEL DS

SHIP NO BLOCK * FAB. SHOP

2715 056

ANGLE

DATE 78.5.23 PAGE 1

NO	PART	P	C	S	SHOWN	SCANTLING	HOLE	GRADE	S. PAR	HEIGHT	C. OF G
1	CODE -AL1	8		8	S-IN	250 X 90 X 10 / 15	P35	AM		360.0	FW N+3
2	CODE -AL2	1		1	S-IN	250 X 90 X 10 / 15	P35	AM		226.0	
3	CODE -AL3	1		1	S-IN	250 X 90 X 10 / 15	NSU	AM		133.0	
4	CODE -AL4	1		1	S-IN	250 X 90 X 10 / 15	P35	AM		293.0	

TOTAL WEIGHT 7064.0

TOTAL LENGTH 243459.1

BLOCK 056

SHIP NO BLOCK FAB. SHOP

2715 D56

ANGLE

DATE 78.5.23 PAGE 2

NO	PART	P	C	S	SHOWN	SCANTLING	HOLE	GRADE	S. PRM	HEIGHT	C. OF G
1	CODE -AL5	1		1	S-IN	250 X 90 X 10 / 15	P35	AM		386.0	
2	CODE -AL7	3		3	S-IN	250 X 90 X 10 / 15	P35	AM		226.0	
3	CODE										
4	CODE										

TOTAL WEIGHT 2128.0

TOTAL LENGTH 73400.1

BLOCK D56

SHIP NO BLOCK FAB. SHOP

2715 D56

ANGLE

DATE 78.5.23 PAGE 1

NO	PART	P	C	S	SHOWN	SCANTLING	HOLE	GRADE	S. PARAM	HEIGHT	C. OF G
1	CODE -S-AL2	1		1	P-IN	250 X 90 X 12 / 16	DR3L	AM		336.0	
2	CODE -S-AL3	1		1	P-IN	250 X 90 X 12 / 16	DR3L	AM		96.0	FW N+6
3	CODE -S-AL4	5		5	P-IN	250 X 90 X 12 / 16	C 33L	AM		486.0	FW N+6
4	CODE -S-AL4A	2		2	P-IN	250 X 90 X 12 / 16	DR3L	AM		486.0	FW N+6

TOTAL WEIGHT 7868.0

TOTAL LENGTH 230465.9

BLOCK D56

SHIP NO BLOCK FAB. SHOP

2715 056

ANGLE

DATE 78. 5. 23 PAGE 2

NO	PART	P	C	S	SHOWN	SCANTLING	HOLE	GRADE	S. PAM	WEIGHT	C. OF G
1	CODE -S-AL5	2	2	P-IN	250 X 90 X 12 / 16	DA3L	A4			486.0	FW N+6
2	CODE										
3	CODE										
4	CODE										

TOTAL WEIGHT 1944.0

TOTAL LENGTH 58424.0

BLOCK 056

SHIP NO BLOCK FAB.SHOP

ANGLE

2715 036

DATE 78.5.23 PAGE 1

NO	PART	CODE	P	C	S	SHOWN	SCANTLING	HEIGHT	C. OF G
1	-43-A1=T		1		1	P-FW	200 X 90 X 9 / 14	34.0	748

									NOTES
35R 1497 (UP)									

NO	PART	CODE	P	C	S	SHOWN	SCANTLING	HEIGHT	C. OF G
2									

									NOTES

NO	PART	CODE	P	C	S	SHOWN	SCANTLING	HEIGHT	C. OF G
3									

									NOTES

NO	PART	CODE	P	C	S	SHOWN	SCANTLING	HEIGHT	C. OF G
4									

									NOTES

TOTAL WT. 68.0

TOTAL L. 2994.0

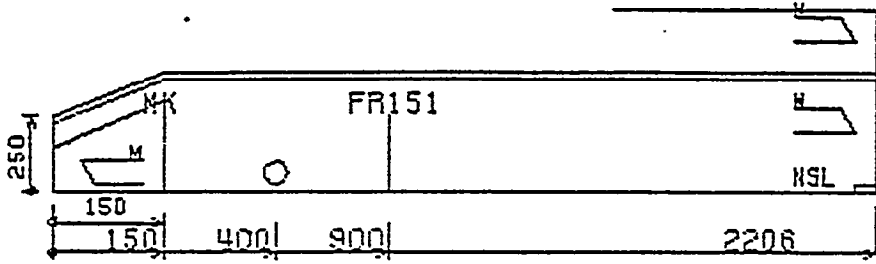
BLOCK 036

SHIP NO BLOCK FAB.SHOP

ANGLE

2715 DSG

DATE 78.5.23 PAGE 1

NO	PART	CODE	P	C	S	SHOWN	SCANTLING	HEIGHT	C. OF G
1	-AL6		12	12	S-IN	300 X 90 X 11/16	78.0		
									NOTES
									FW N+6
NO	PART	CODE	P	C	S	SHOWN	SCANTLING	HEIGHT	C. OF G
2									
									NOTES
NO	PART	CODE	P	C	S	SHOWN	SCANTLING	HEIGHT	C. OF G
3									
									NOTES
NO	PART	CODE	P	C	S	SHOWN	SCANTLING	HEIGHT	C. OF G
4									
									NOTES

TOTAL WEIGHT 1872.0

TOTAL LENGTH 2206

船 殻
HULL PARTS LIST
部 品 表

for Assembly

注1) 1サマ内個数
上段ワP支
下段ワS支
注2) 製造 数
上段ワ所屬支
下段ワ存在支

△
△ △
△ △ △
△ △ △ △ △
△ △

36

CEG No.	名 称			形 状			(kg) 単品重量	製造数	改 正	国 産 品	テ ー タ	
	品 名	品 番	品 目	(M) 長	(MM) 巾	(MM) 厚						
01												
02	** SKIN **						30544.					
03												
04	C					32.	10259.	1	1			
05												
06	D					32.	10259.	1	1			
07												
08	E					32.	10259.	1	1			
09												
10	F					32.	9767.	1	1			
11												
12												
13												
14												
15												
16												
17												
18												
19												
20	** BAPA **						5751.					
21						10/15						
22	AL1		124	250*	90*		360.	8	8		I	
23						10/15						
24	AL2		78	250*	90*		226.	1	1		I	
25						10/15						
26	AL3		4506	250*	90*		133.	1	1		I	
27						10/15						
28	AL4		101	250*	90*		293.	1	1		I	
29						10/15						
30	AL5		133	250*	90*		386.	1	1		I	
31						11/16						
32	AL6		22	300*	90*		78.	12	12		I	
33						10/15						
34	AL7		78	250*	90*		226.	3	3		I	
35												
36	ZQE2L	A					8.		16			
37												
38	ZQE2Q	A					11.		1			
39												
40	ZQE3L	A					8.	16				
41												
42	ZQE3Q	A					11.	1				
43												
44	ZCB4G	A					2.	15	15			
45												
46	ZCB4L	A					3.	5	5			
47												
48	F1			180*	11.		10.	1	1			

(4730)

年 月 日 開 航
1978 05 23

ASS LIST -01-

番 船
2715

ブロック名
DS6

中 組

P 01-

船 殻
HULL PARTS LIST
部 品 表

for Assembly

注1) 1サブ内組数
上段ワP主
下段ワS主
注2) 製造数
上段ワ所属主
下段ワ存在主

A
A A
A A
A A A A
A A

No.	名 称	形 状	(M)	(MM)	(MM)	材 質	単品重量 (kg)	1サブ内組数	製造数			改 正	図 面 頁	デ ー タ
									P	C	S			
01														
02	F2			200	12		18		1	1				
03														
04	R1				10		7		1	1				C
05														
06														
07														
08														
09														
10														
11														
12														
13														
14	** SUB **						31983							
15														
16	1						991		1	1				
17														
18	2						168		1	1				
19														
20	3						82		1	1				
21														
22	31						1266		1	1				
23														
24	32						528		1	1				
25														
26	33						527		1	1				
27														
28	34						192		1	1				
29														
30	41						3613		1	1				
31														
32	42						3449		1	1				
33														
34	43						3401		1	1				
35														
36	44						3782		1	1				
37														
38	DS-1						501		2	2				
39														
40	DS-1A						502		1	1				
41														
42	DS-1B						502		1	1				
43														
44	DS-2						503		3	3				
45														
46	DS-2A						504		1	1				
47														
48	DS-3						503		4	4				

(4730)

年 月 日 調 査
1978 05 23

ASS LIST -02-

多 結
2715

ブロック名
AS6

中 結

P 02-

船 殻
Hull PARTS LIST
部 品 表

for Assembly

注1) 1サブ内蔵
上段ワP立
下段ワS立
注2) 製造数
上段ワ所収立
下段ワ存在立

△
△ △
△ △
△ △ △ △
△ △

品名	名 称	図 番	形 状	(M)	(MM)	(MM)	材 質	(kg)	1サ ブ 内 蔵	製 造 数			改 正	図 面 頁	デ ー タ
										P	C	S			
01				22	27	31		40	45	48			54	57	60
02	DS-4			.		.		792.		2		2			
03															
04	DS-4A			.		.		895.		1		1			
05															
06	DS-4B			.		.		701.		1		1			
07															
08	DS-6			.		.		655.		1					
09															
10	DS-6B			.		.		655.				1			
11															
12	DS-7			.		.		655.		1		1			
13															
14	DS-8			.		.		655.		1		1			
15															
16	DS-9			.		.		170.		1		1			
17															
18	DS-10			.		.		168.		1		1			
19															
20	DS-11			.		.		167.		1		1			
21															
22	DS-13			.		.		496.		1		1			
23															
24	DS-14			.		.		496.		1		1			
25															
26	DS-15			.		.		496.		1		1			
27															
28	DS-16			.		.		726.		1		1			
29															
30				.		.		.							
31				.		.		.							
32				.		.		.							
33				.		.		.							
34				.		.		.							
35				.		.		.							
36				.		.		.							
37				.		.		.							
38	** M-ASS **			.		.		29099.							
39				.		.									
40	S			.		.		29099.		1		1			
41				.		.		.							
42				.		.		.							
43				.		.		.							
44				.		.		.							
45				.		.		.							
46				.		.		.							
47				.		.		.							
48				.		.		.							

(4730)

年 月 日 調査

107P 05 23

ASS LIST -03-

番 船
2715

ブロック名
DS6

中 組

P 03-

船 殻
HULL PARTS LIST
部 品 表

for Sub assembly

注1) 1サブ内個数
上段ワP玄
下段ワS玄
注2) 製造数
上段ワ所属玄
下段ワ存在玄

SSSS
S
SSS
S
SSSS

CC2 No	名 称	品 番	形 状			材 質	(kg) 単品重量	177 内 個数	製造数			改 正	図 面 頁	テ ー タ	
			(M) 長	(MM) 巾	(MM) 厚				P	C	S				
01			21	22	27	31	40	45	46			54	57	60	62
02	1		.		.		601.		1	1					
03															
04	W1		.		15.		849.		1	1				C	
05															
06	B1		.		11.		4.		1	1				C	
07															
08	B2		.		11.		4.		1	1				C	
09															
10	DS-F5		1609	200*	13.		32.		1	1				I	
11															
12	DS-F6		1383	200*	13.		28.		1	1				I	
13															
14	DS-F7		1609	200*	13.		32.		1	1				I	
15															
16	DS-F8		1597	200*	13.		32.		1	1				I	
17															
18			.		.		.								
19			.		.		.								
20			.		.		.								
21			.		.		.								
22			.		.		.								
23			.		.		.								
24			.		.		.								
25			.		.		.								
26	2		.		.		168.		1	1					
27															
28	W1		.		13.		133.		1	1				C	
29															
30	T1		2315	150*	13.		35.		1	1				I	
31			.		.		.								
32			.		.		.								
33			.		.		.								
34			.		.		.								
35			.		.		.								
36			.		.		.								
37			.		.		.								
38			.		.		.								
39			.		.		.								
40	3		.		.		82.		1	1					
41															
42	W1		.		13.		65.		1	1				C	
43															
44	T1		1114	150*	13.		17.		1	1				I	
45			.		.		.								
46			.		.		.								
47			.		.		.								
48			.		.		.								
			21	22	27	31	40	45	46			54	57	60	62

(4730)

年 月 日 調査
1978 05 23

SUB LIST -01-

番 船
2715

ブロック名
DS6

中 組

P 04-

APPENDIX C
SUMMARY OF IHI SHELL

SUMMARY OF THE

SHELL



Ishikawajima-Harima

Heavy Industries Co., Ltd.

TOKYO JAPAN

C o n t e n t s

1. General aspect of SHELL system	3
1-1 Purpose of the development of SHELL system	3
1-2 Characteristics of SHELL system	4
1-3 Scope of application of SHELL system	12
1-4 Operation of SHELL system	13
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2-2 System composition	
2-3 Input/output system	25

1. General aspect of SHELL system

1-1 Purpose of the development of SHELL system

This system constitutes an integrated, computerised data processing system that provides various highly accurated and utilizable informations pertaining to all the process in production of curved shell blocks from the shell expansion in design section or mould loft to the block assembly in shop.

In the conventional system, shell expansion, jig calculation of the curved shell blocks, etc., are also carried out by numerical calculation by the medium of an offsets data bank (as original data file) and they were improving and brushing up passing through a lot of trials and errors based on the fed back data from the production field. However, the system was merely constituted single-purpose programs being concerned to the jobs in mould loft.

Purpose of the new development of SHELL system is to obtain the most optimum informations to meet the needs in the respestive process in production. For the purpose of it, a certain number of standardized production technologies and application know-hows are stored in the system and the planners are able to put their option into the system by means of inputs according to the situation of the shop. The standardization of production technologies and analysis of application know-hows in SHELL system have been established by mobilizing of the engineering power in IHI's five shipyards.

The said standardization and analysis are the another significant fruit of the new development of SHELL system.

1-2 Characteristics of SHELL system

1-2-1 Designing policy of SHELL system

The following considerations were put into

- 1) Lines on the optional cut plane at designer's direction to be used for the calculations, in the system.
- 2) Lines data to be stored in the bank by a certain concurrence of points on the respective line which is approximated by straight lines.
- 3) A common offsets data bank to be installed in the system, to which required data to be shifted from the respective data base in each subsystem passing through a certain conversion program.
- 4) The templates to check the curvature of shell plates are to be designed standing at right angle against the mean level of the curved plate when it is on the bending slab.
- 5) Figure of a expanded shell plate to be calculated as a part of the ship's surface including surrounded
- 6) Geodestic line method and rolling method to be adopted in the system as the developing logics for shell expansion.
- 7) A corrective routine to be installed in the system to modify the shape of expanded shell plate after running

1-2-2 Characteristics of SHELL system

- 1) SEELL system is a composite system for the geometri calculation and data processing system relevant to the production of curved shell blocks in ship

follows:

- 2) The calculating logics are of simple and higher level of accuracies are uniformly displayed in the outputs by the system, since the lines in the offsets bank are drawn by the concurrences of points approximated by a certain supplementary straight lines.
- b) The higher accurated shell expansions are achieved *easily by this system*, since the optional cut plane method is fully adopted for the expansions.
(Refer to Fig.1)
- c) Unified accuracy on the peripheral parts of an expanded shell plate is ensured, since the desired plate is cut out of a larger expanded plan including the surrounded area of the plate.
- d) The *geometrical* formal **check** of the curved plate by the templates becomes easier to ensure the accuracy, since the templates are set up at the right angle against the mean level of the curved plate.
(Refer to Fig. 2 & 3)
- 4) A remarkable improvement on the workability and accuracy in the assembly stage can be expected, since the various working practices in the Shop are taken into consideration from the first step of the system running, as follows:

- 2) SINGLE PANEL ASSEMBLY system is available.

Refer to Fig. 4 & 5)

b) Since the intersections of datum planes in the *supporting jig lines* and shell plates are marked on each shell plate and, in addition, the datum planes *are* orthogonal to the platform surface, the accuracy of angles between contiguous seam and butt can be maintained easily.

(Refer Fig. 6 & 7)

c) **Instructions** can be given in connection with the *position* for plate setting, position of stopper and the height of additional supporting jigs, if required.

d) Data for accuracy *control relating to- the dimension* of block, diagonal dimension, date of curvature on seam and butt, etc., are output by the system.

e) The availability of automatic welding on the block can be checked by the system, if required.

5) Easy to maintenance of the system.

The partial revision of the system, *rather easy*, since the system of working with modules is adopted and the logical constitution of the system is simpler.

6) Easy to replacement of data in the data files.'

Since the system has 2 main offsets data bank and peripheral data files separatory, replacement of data

can be made indipendently when it becomes necessary.-

7) Easy to manual correction of the outputs.

Partial manual correction for the output of shell expansions available in accordance with the change-ment of working process and/or *expansion* method.

8) Easy recording of fed back data.

Quantative data such as **distortion caused** by locked-in stress due to press or heating, in particular, can be fed into the system from-time to time and recorded them-as reference data *for system*. improvement in-future.

Fig. 1 ONE EXAMPLE OF OPTIONAL CUT PLANE PROCESS

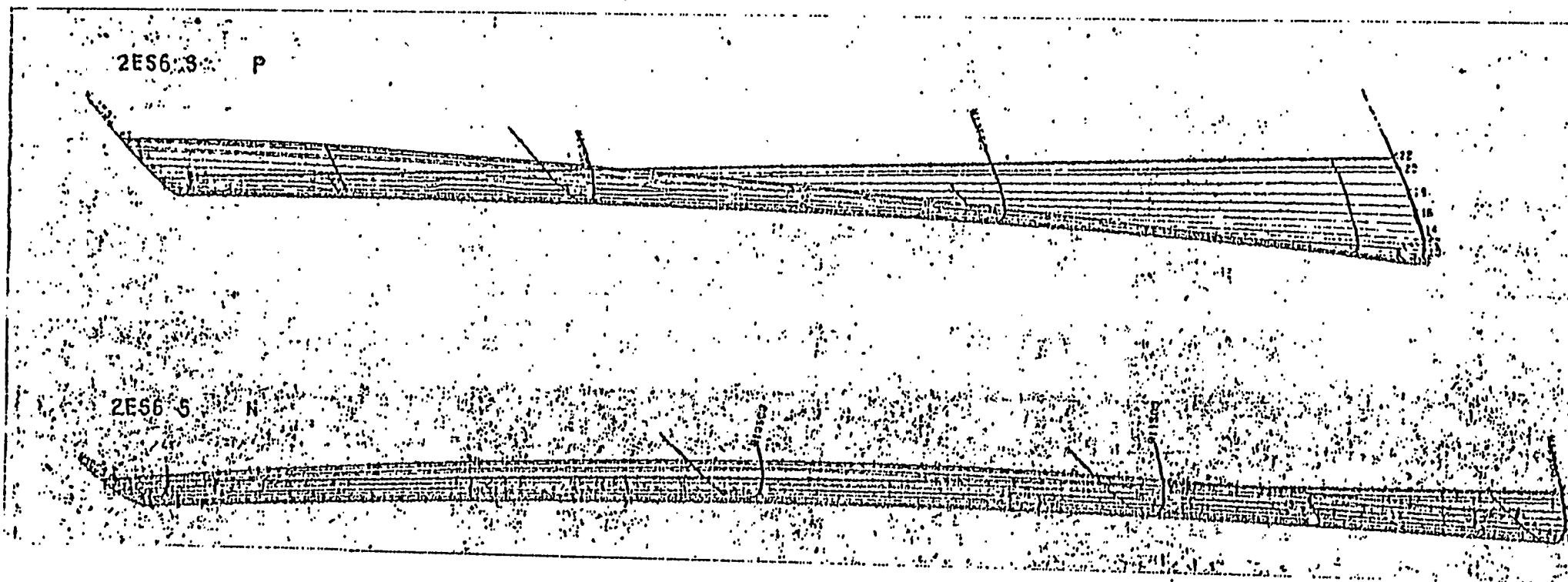
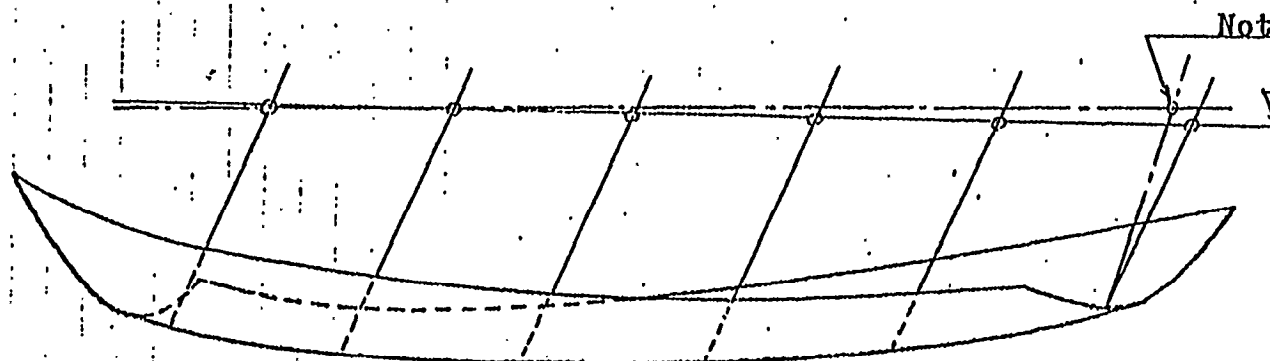
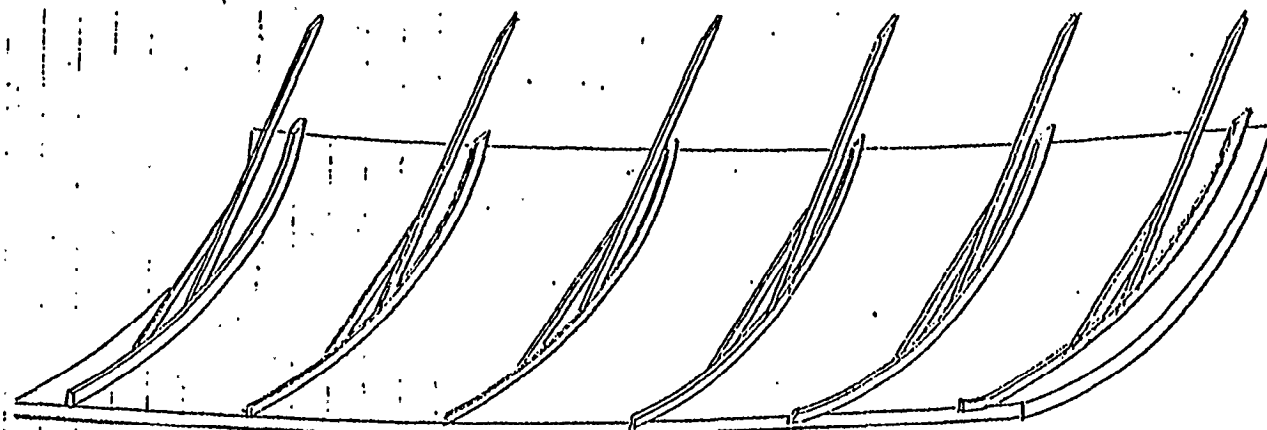
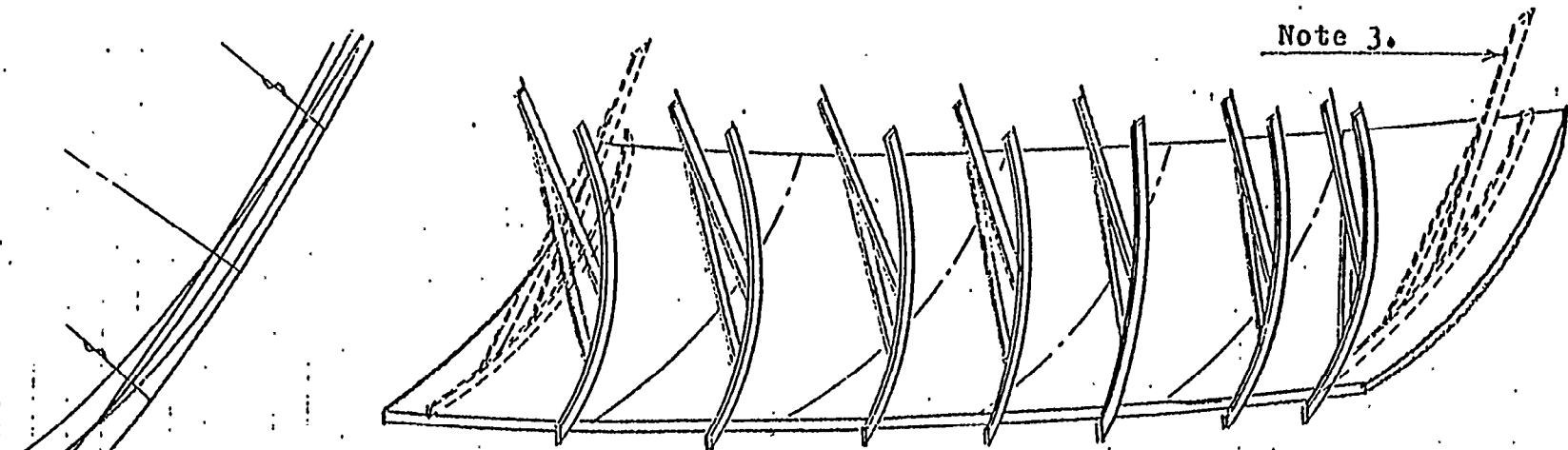


Fig. 2 ARRANGEMENT OF TEMPLATES BY THE CONVENTIONAL SYSTEM



Note 1.
When the setting angle of the templates against the mean level of the curved plate are far from right angle, the errors of setting angle become a source of big error of sight line to the check. In the other words, the accuracy of longitudinal curvature shall be debased by the errors of the setting angles.

Fig. 3 ARRANGEMENT OF TEMPLATES BY " SHELL " SYSTEM



Note 3. Template for the final check

Note 1.
The errors in the setting angle of templates have few effects for the accuracy of the longitudinal curvetures of the plate.

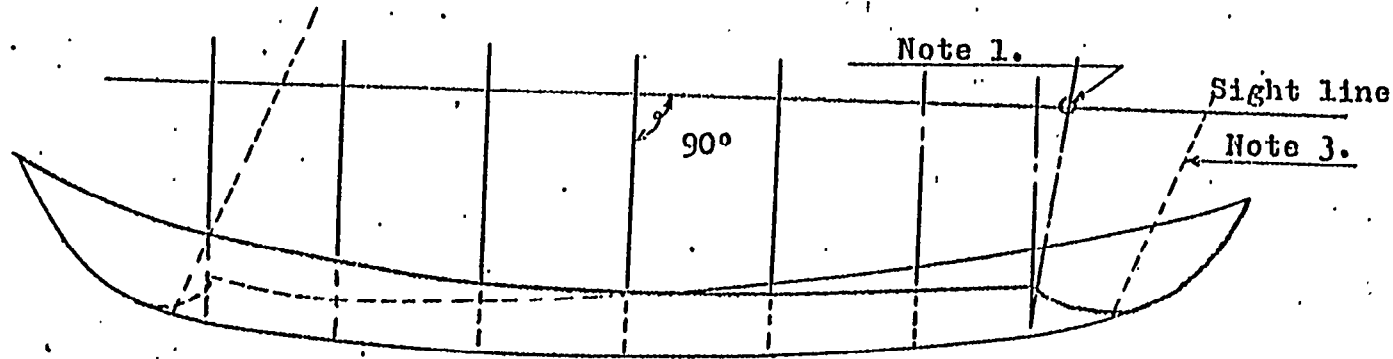
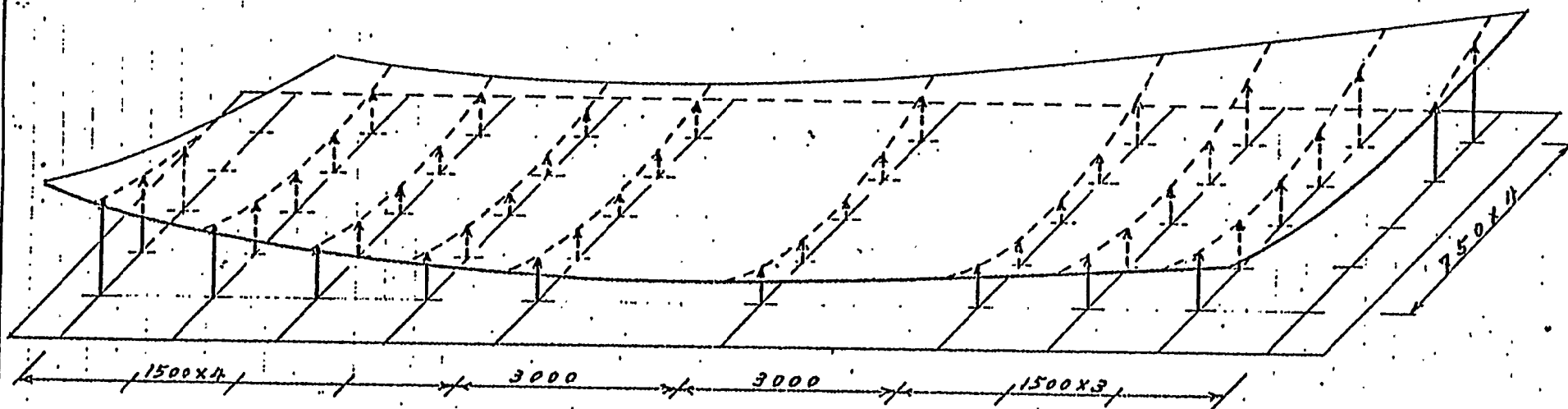


Fig. 4 SUPPORTING JIGS FOR SINGLE PANEL

Longitudinals are subassembled on each curved plate before panel assembly.



Height of jigs are adjusted automatically according to the input by paper tape.

Fig. 5 BLOCK SUPPORTING JIGS IN SINGLE PANEL ASSEMBLY SYSTEM

Subassembled panels are assembled on the jigs.

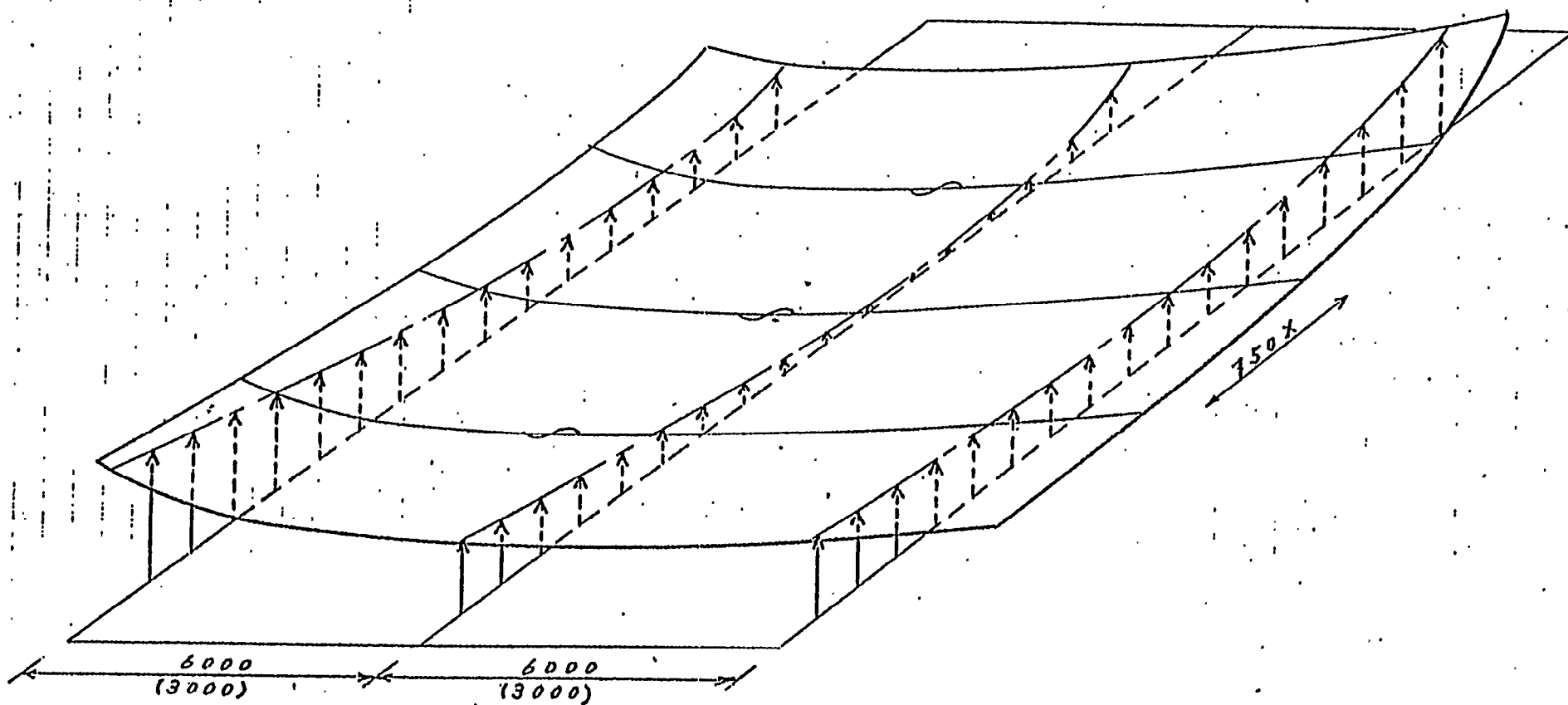
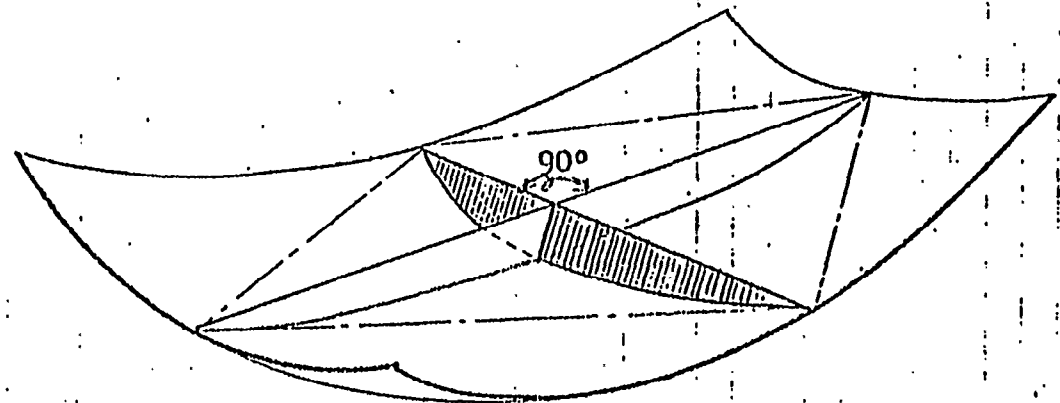


Fig. 6 DATUM PLANE FOR BLOCK ASSEMBLY (1/2)

1. Conventional method

Datum planes in which the datum lines for the block marking are involved, are not orthogonal to the platform, since the datum planes are determined from the cross-section body plan.



2. SHELL method

Datum planes are orthogonal to the platform plane. Transit and laser are the available tools to get the higher accuracy of the block assembly.

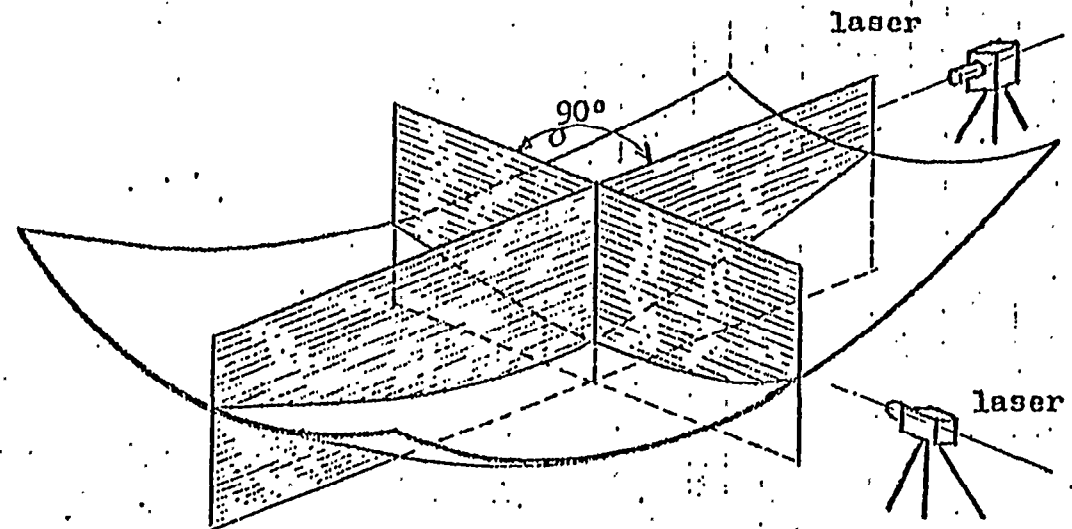
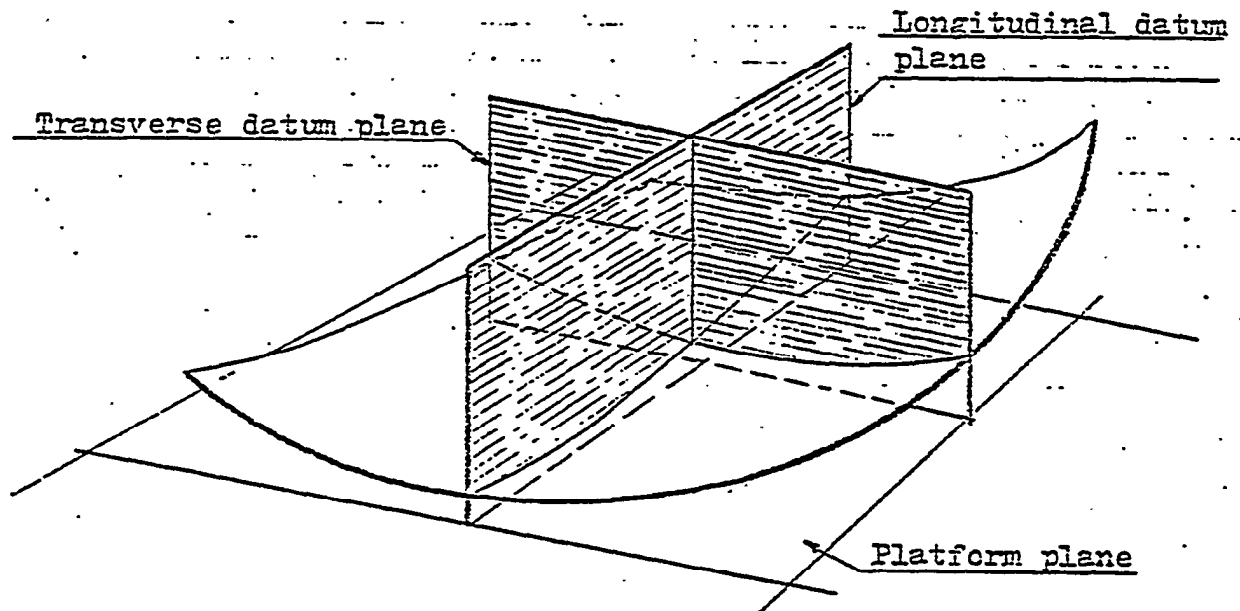


Fig. 7 DATUM PLANES OF SUPPORTING JIGS



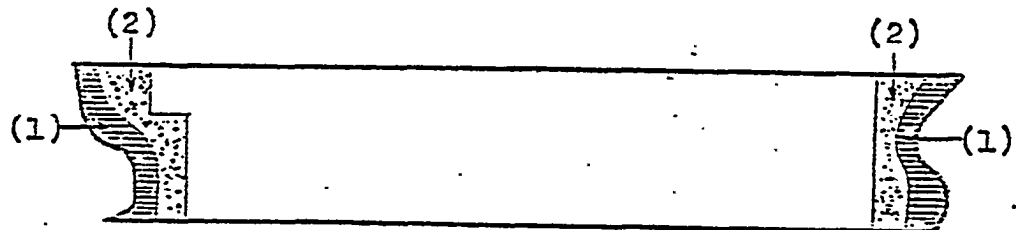
1. The datum planes of the transverse and longitudinal supporting jig lines are mutually orthogonal and also are orthogonal to the platform plane.
2. The inter section of the datum planes and shell plates are the datum lines for the block marking.
3. Those datum lines of block marking are marked on each shell plate in the fabrication shop.
4. Since both datum planes are orthogonal to the platform plane, the check of datum lines will be easy. In addition, these planes become the vital medium to maintain the accuracy of block marking. Accordingly, the accuracy as well as the workability are improved in the field.

1-3 Scope of application of SHELL system

According to the current version, SHELL system is applicable to all shell plates other than stern plates and stem plates. Preparation are being advanced, however, to include even stern and stem plates in the scope of application of SHELL system in the near future.

1) Functional limitations

- a) SHELL system can not be applied to the processing of stern and stem plates. ----- (1)
- b) As for the plates adjacent to stern and stem plates, it is required to supplement the offsets data to process. (PAN valet system) ----- (2)



2) Operational limitations

- a) When the offsets data bank is not available to the processing, a certain supplemental offsets data will be required by the manual input.
- b) When the system is applied for a part of the ships, such as repair ships, etc., PAN valet system will be available to supplement the incomplete offsets data.
- c) The operational limitations are also depending on the function of the gas cutting machines to be used for.

1-4 Operation of SHELL system

1-4-1 Establishment of the operation system

SHELL system incorporates a wide scope of the application know-how in production and is designed for working with all kinds of related facility and production methods. For this very reason, its most optimum operation system be displayed only by the establishment of a suitable system for inducing it into the ship yards taking into consideration of computer or numerical control system and also working process in production. Namely, sufficient preliminary deliberation will be necessary to coordinate functional aptitude with the fabrication and the assembly stage, as follows:

- * Preparation of base data ----- Functional design
- * Formal geometrical development ----- Applied design
- * Post processor --Outpost of production data

To elaborate, 2 silent characteristics of SHELL system lies in the fact that system demands preliminary institution of a comprehensive production process engineering prior to its application.

1-4-2 Type of the application system

The the of the application systems may roughly classified into the followings:

- a) Hand marking oriented type
- b) Electro-photo marking oriented type
- c) NC cutting oriented type
- 2) Hybrid electro-photo marking and NC cutting oriented
- e) SINGLE PANEL ASSEMBLY system-oriented type

SHELL system provides highly accurated output data coducing to excellent workmanship for the all type

of application systems listed in the above listed.

1-4-3 Standardization of production technologies and ifs application know-hows

SHELL system is an advanced and fruitful system constructed on the basis of the systematic standardized production technologies and higher leveled application know-hows in the each stages of production, such as cutting, bending, assembling, welding, etc., showing in the following Figs..

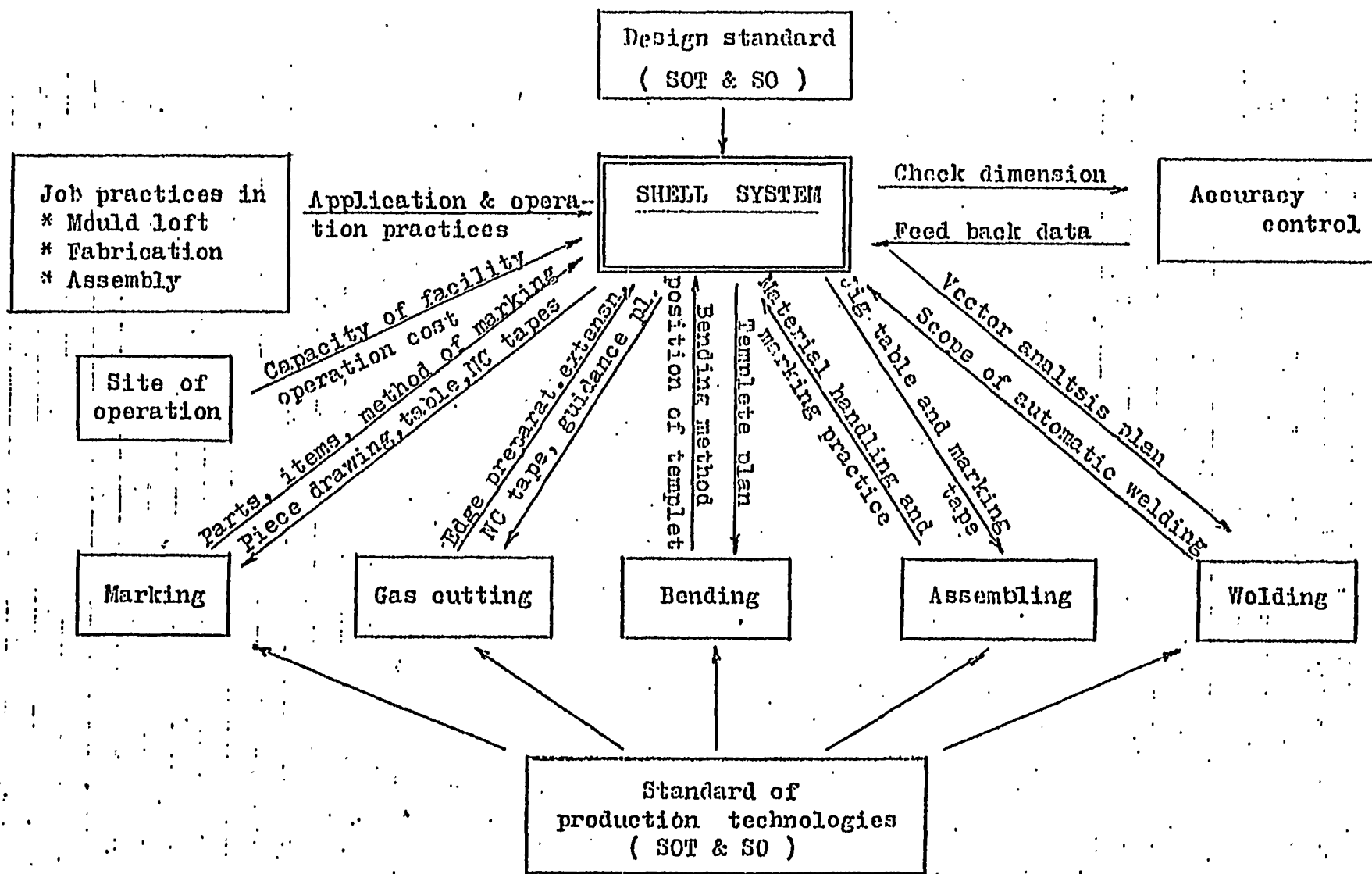
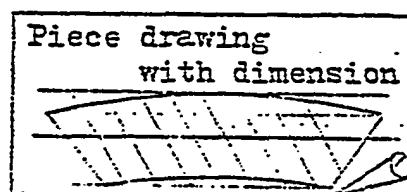
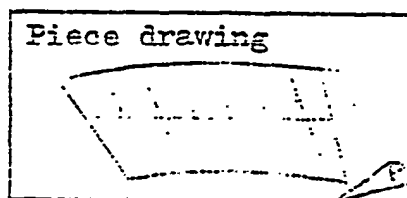
Fig. 8 RELATIONSHIP BETWEEN SHELL AND PRODUCTION PROCESSES

Fig. 9 OUTPUT CORRESPONDING TO WORKING PROCESS

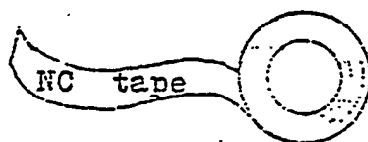
A. Marking and gas cutting in fabrication stage.



Manual marking



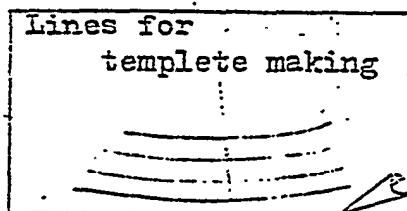
Electro-photo marking



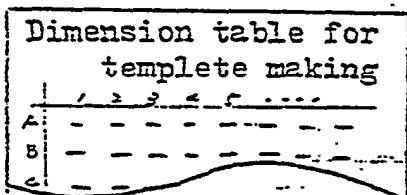
NC marking

NC gas cutting

B. Plate bending



Wooden templete



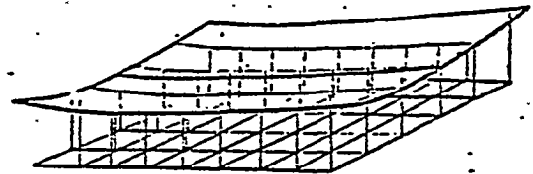
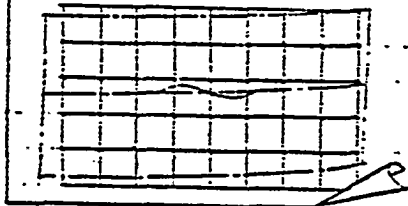
Universal templete

Supporting jigs in
SINGLE PANEL assembly

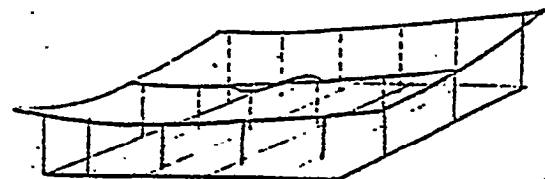
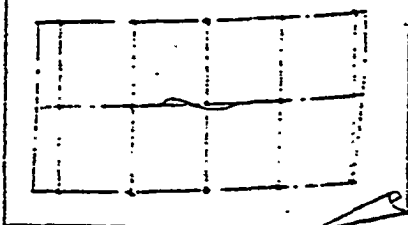
C. Supporting jigs in assembly stage.

(Dimension plan - Jig heights)

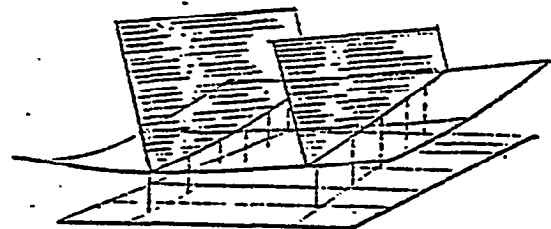
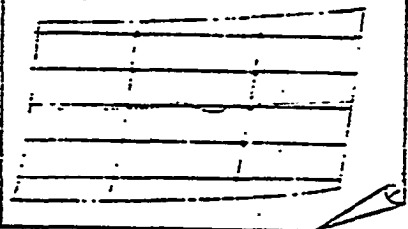
Fixed position jigs



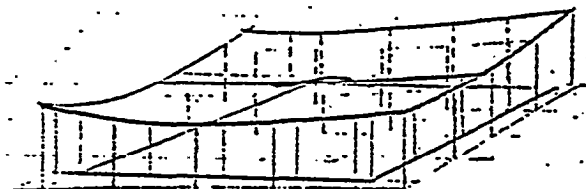
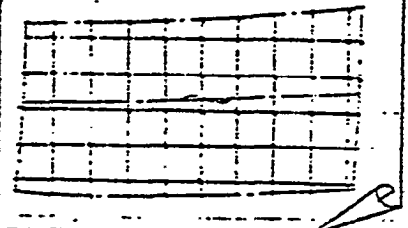
Seam line jigs



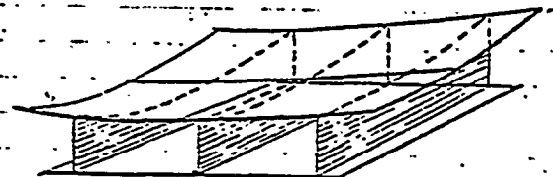
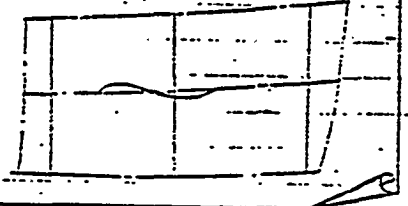
Frame line jigs



SINGLE PANEL ASS.



Solid jigs



2 System composition and Out line input/output of the system

2-1. Main computer and its terminal equipment

1) Main computer

- a) IBM s/370 - 135/158 are available.
- b) vs 1,2 to be used for the CS.
- c) FORTRAN-G is available for the programming.
- a) 3330-1 (N=1) to be used for the disk handling.

2) Terminal equipments

The terminal equipments for the outputs primarily consists of the drafting devices, for which the users are free to select the desired terminal equipments, which may consist of any of the followings:

a) Graphic display

Available for shell landing.

b) X-Y p l o t t e r

Available for the piece drawing, dimension table in piece drawing, dimension table of the supporting jigs in, assembly stage, check drawing, etc..

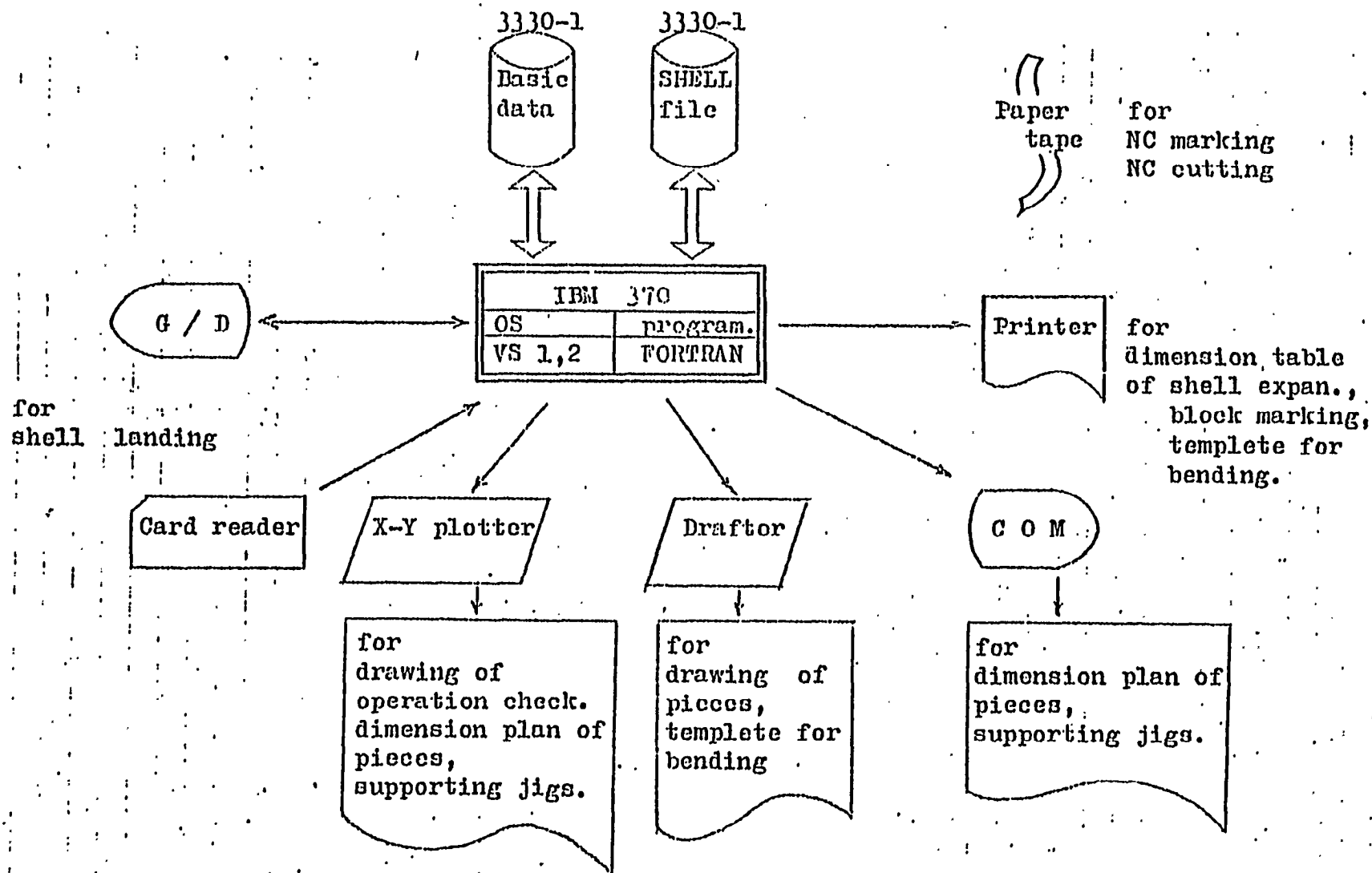
c) Drafting machine

Available for drawings, to which higher accuracy of lines will be required such as a certain kinds of piece drawing, lines for templete making, etc.

d) COM:

Available for the dimension table of pieces, supporting jigs, etc...

Fig. 10 MAIN COMPUTER AND ITS TERMINAL EQUIPMENTS



2-2 System Composition

2 - 2 - 1 D a t a b a s e

The most effective application of SHELL system in the processes of ship building field will primarily depend on how well the original offsets data file of the system can be prepared in the shortest time possible.- Shell landing to generate the offsets data should be advanced by the computer processing wherever possible, *&me the data base of the system requires the most accurated offsets data as an original data. *However, when the computer processing shell landing is unavailable for the preparation of the data base, SHELL system so designed as to permit the system operation even through manual preparation of the offsets data.*

1) Kinds of preparation methods

a) FAIRLAND

FAIRLAND system (fairing and landing system) *is available* for the preparation of the offsets data.

b) DACSSI/ S

The base data can be provided by the output from the offsets data file of DACSSI/S in which the offsets data are generated by means of conversational inputs with graphic display and/or input cards.

c) Card inputs from offsets table

The base data are provided directly by input cards in this system when it is required to process for the repaire ships and so on.

d) Conversion from the other systems

The base data are provided by the outputs of other systems through 2certain conversion program.

2) E d i t t i n g of base data

a) Editting method.

Editting on the sequential file in 80 columns card

f o r m a t

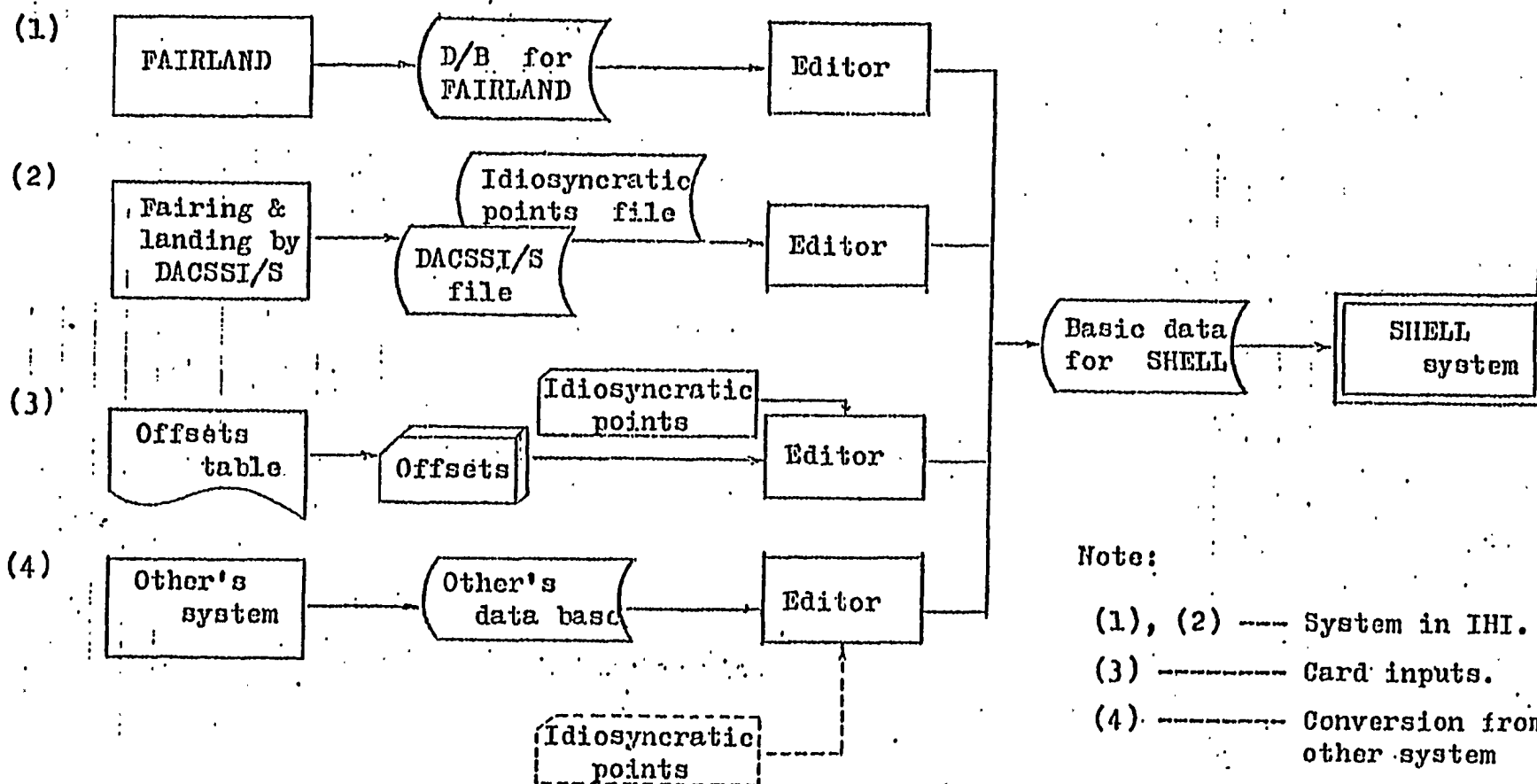
b) Access

SAM system is adopted to the access.

c) Data format

X—, Y—, Z—, pen, element, structural points,
nature of points,

Fig: 1.0 PROCESS CHART FOR THE PREPARATION OF DATA BASE



Note:

- (1), (2) --- System in IHI.
- (3) ----- Card inputs.
- (4) ----- Conversion from other system

2-2-2 System flow

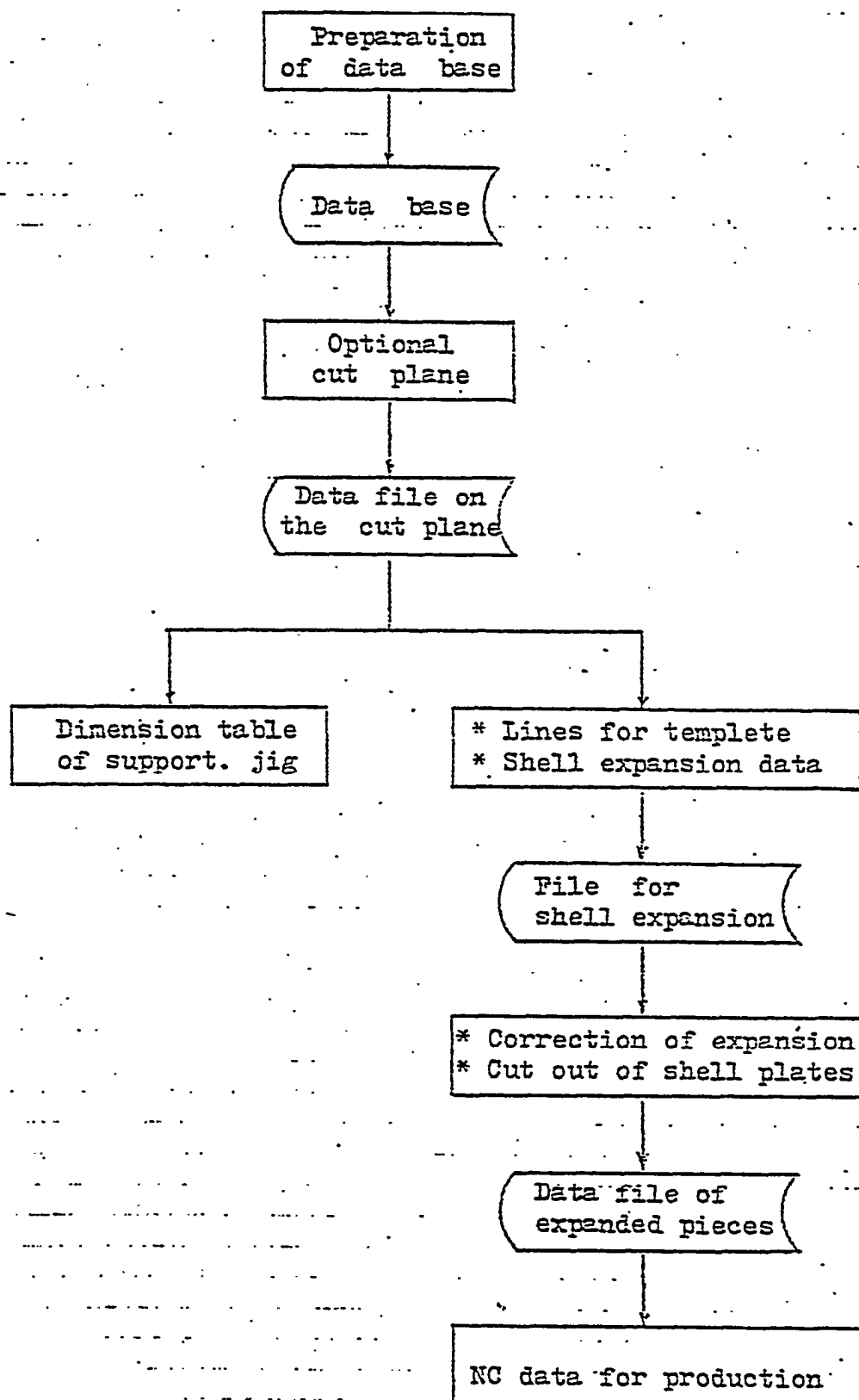


Table 1. STEPS INVOLVED IN SHELL SYSTEM

Step Items		Base data	Optional cut plane	Expansion	Calculations of Ass. data	Shape formation	Post processor
Input		*Station offset *Landing data *Idiosyncratic points data *Fabrication data (bevel, extension, etc)	*Block name *Option for cut plane	*Method of shell expansion	*Type of supporting jigs	*Correction of fabrication data	*Piece name
Data process		*Fairing & landing *Storing of idiosyncratic points data & fabricat'n data	*Preparation of concurrence of points *Preparation of data file on the cut plane	*Calculation of shell expansion *Calculation of lines for bend. templates	*Height of supporting jigs *Dimension plan for block mark. *Vector analysis plan	*Correction of shell expansion *Cut out of shell plates	*NC post processor
File	Input		*Base data file	*Data file on the cut plane	*Data file on the cut plane	*Shell expansion data file *Fabrication data file	*Nesting data file
	Output	*Base data file	*Concurrence of points file *Data file on the cut plane	*Shell expansion file *Bending template file		*Nesting data file	
Output		*Body plan *Offsets table *Check drawing of data base	*Rough block arrangement *Body plan by optional cut plane		*Dimension plan of support. jig *Block mark. plan *Sectional plan of support. jig *Assembly plan	*Piece drawing *Dimension plan of piece *Lines for templates making	*NC tape

2-3 Input/Output system

2-3-1 Input data

The input data system in SHEEL is so designed as to conserve the labour by avoiding duplication of input data. Principal items of inputs are as follows :

- 1) Name of block and structure
- 2) Instructive data relating to the fabrication practice.
- 3) Instructive data relating to the assembly practice.

2-3-2 Output data (Other than NC tape for marking & cutting

- 1) Check drawing of the operation
 - a) check drawing for the data base (fig.11A)
 - b) Check drawing of body plan the optional 'cut plane (Fig. 11 B)
 - c) Sectional plan of supporting jigs. (fig. 12)

The check drawings in the above are using the check of the operation conditions of the outputs as are in option controlled by the inputs,

2) Output of shell expansion

- a) Dimension plan of shell plate

Shell plate marking can be made directly by this output without any full scale marking tape the the manual marking. (Fig. 13)

- b) Expanded plan of shell plate
negatives for the electrophoto marking are output by the system by means of drafting machine as the expanded plan of shell plate, (Fig, 14)

Note: Outputs of the dimension table for the preparation of full scale marking tapes are also provided by this system, if required.

Fig. 11 A CHECK DRAWING OF DATA BASE

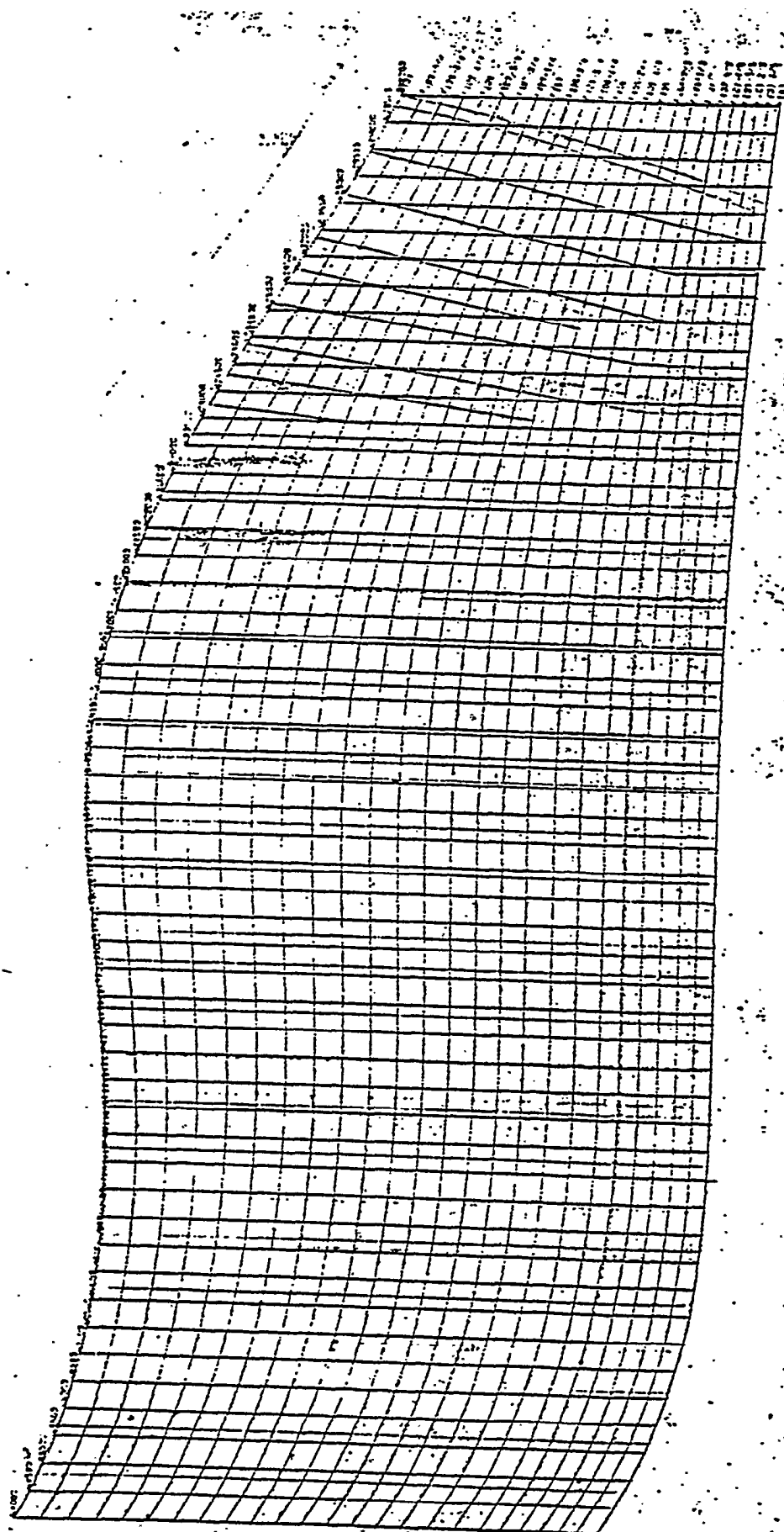
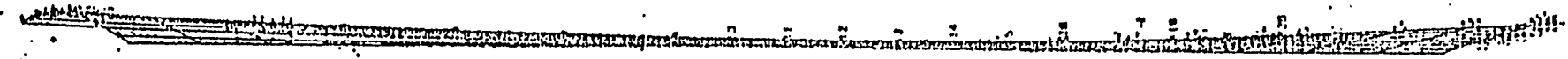
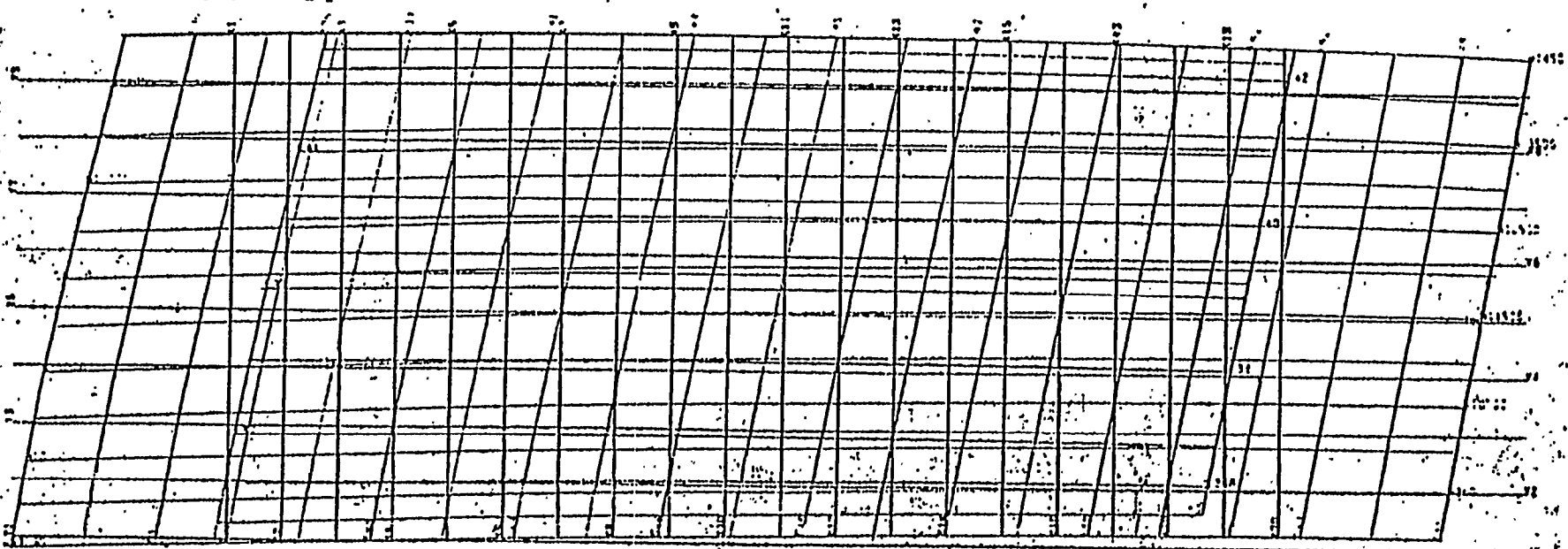


Fig. 11 B CHECK DRAWING OF OPTIONAL CUT PLANE PROCESS

2E56 S YOKO.SEC



2E56 S JOBAN.PL



2E56 S K.FR.SEC

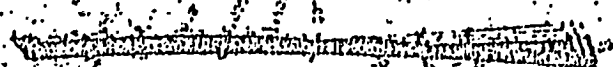
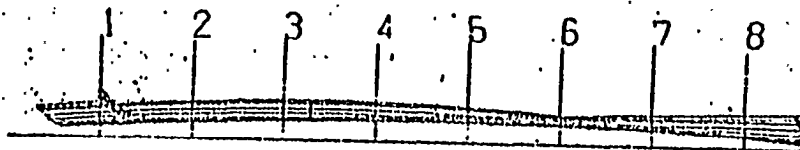


Fig. 12 SECTIONI PLAN OF SUPPORTING JIG LINE

S. 2436 2ES6 S ()

SCALE=1/44

TATE-KOOSHI SECTION



YOKO-KOOSHI SECTION

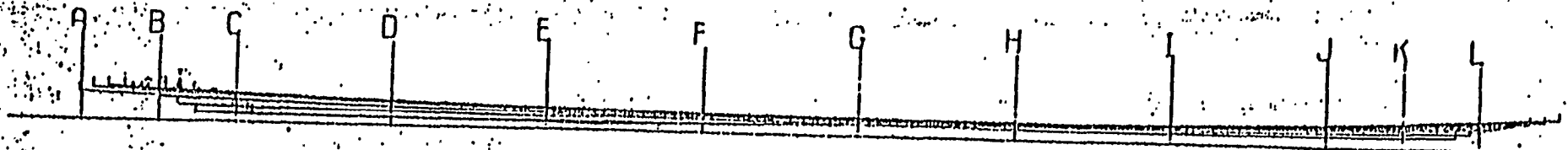


Fig. 13 DIMENSION PLAN OF SHELL PLATE

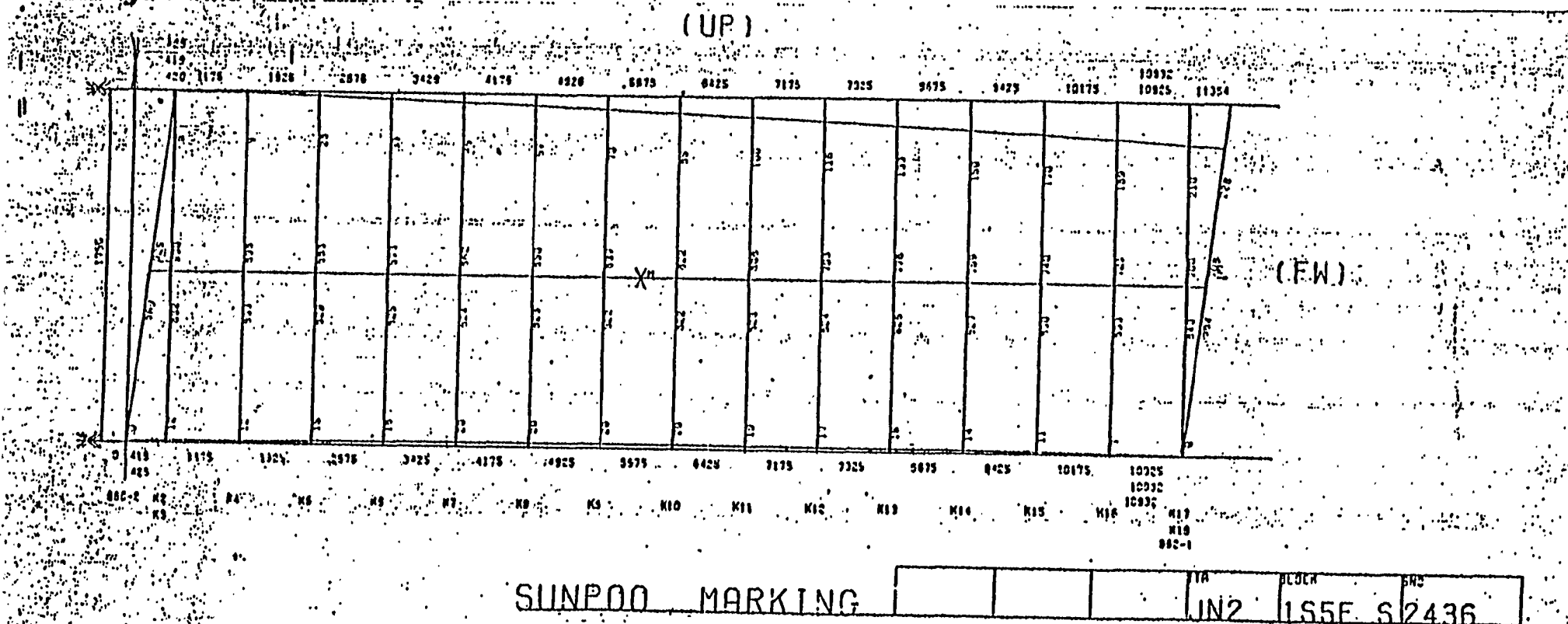
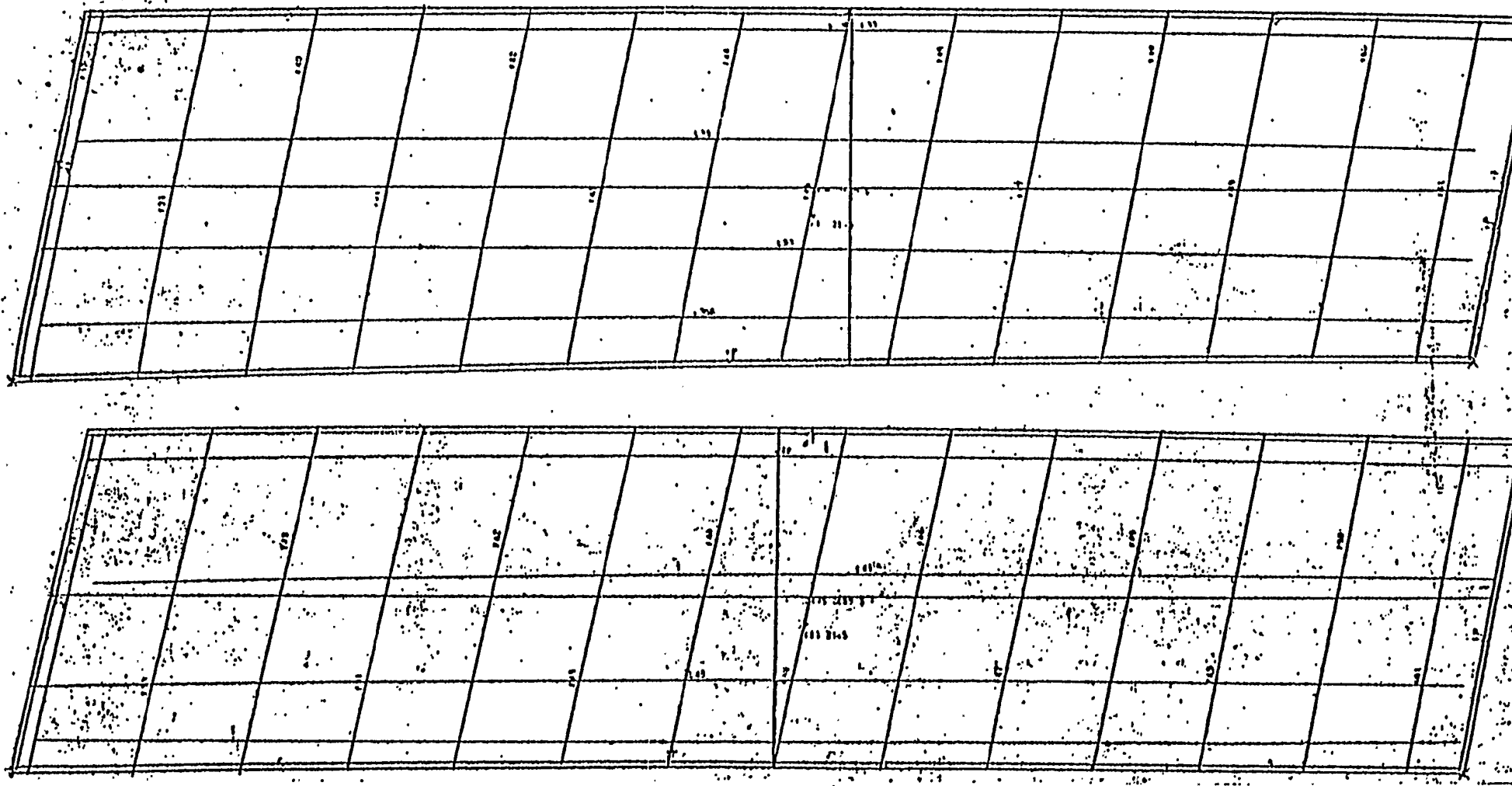


Fig. 14 EXPANDED PLAN OF SHELL PLATE



3) Output of template for bending

a) Lines for templates marking

The most optimum position determined by a given logic as well as the shape (lines) of templates at 2 designated position are prepared by means of lines drawn by drafter. (Fig.15)

b) Dimension table for universal template

When a certain type of universal template are available in the shop, suitable dimension table can be provided by the system to set the figure of the template. (Table 2)

4) output data for supporting jigs in assembly

The output mode of Sheel system is diversified into various modes owing to the inclusion of data relating to the type of supporting jigs as well as the data relating to the methods of block marking. The users can therefore, select any desirable output met to the working practices to be done.

a) Dimension plan for block supporting jigs.

- * For fixed position jigs * (fig. 16)
- * For seam line jigs (fig. 17)
- * For frame line jigs (Fig.18)
- * For SINGLE system jigs (fig.19)
- * For solid tape jigs

While the five kinds of dimension plans, listed above, are available, they can be used also in combination, if necessary.

b) Sectional plan of jig lines (Fig.20)

Sectional plan of jig lines can be drafted to indicate the curvetures at the transverse or longitudinal section of jig lines including the ends height of the block at the cross points of jig line; and seam or butt line of the block, if required.

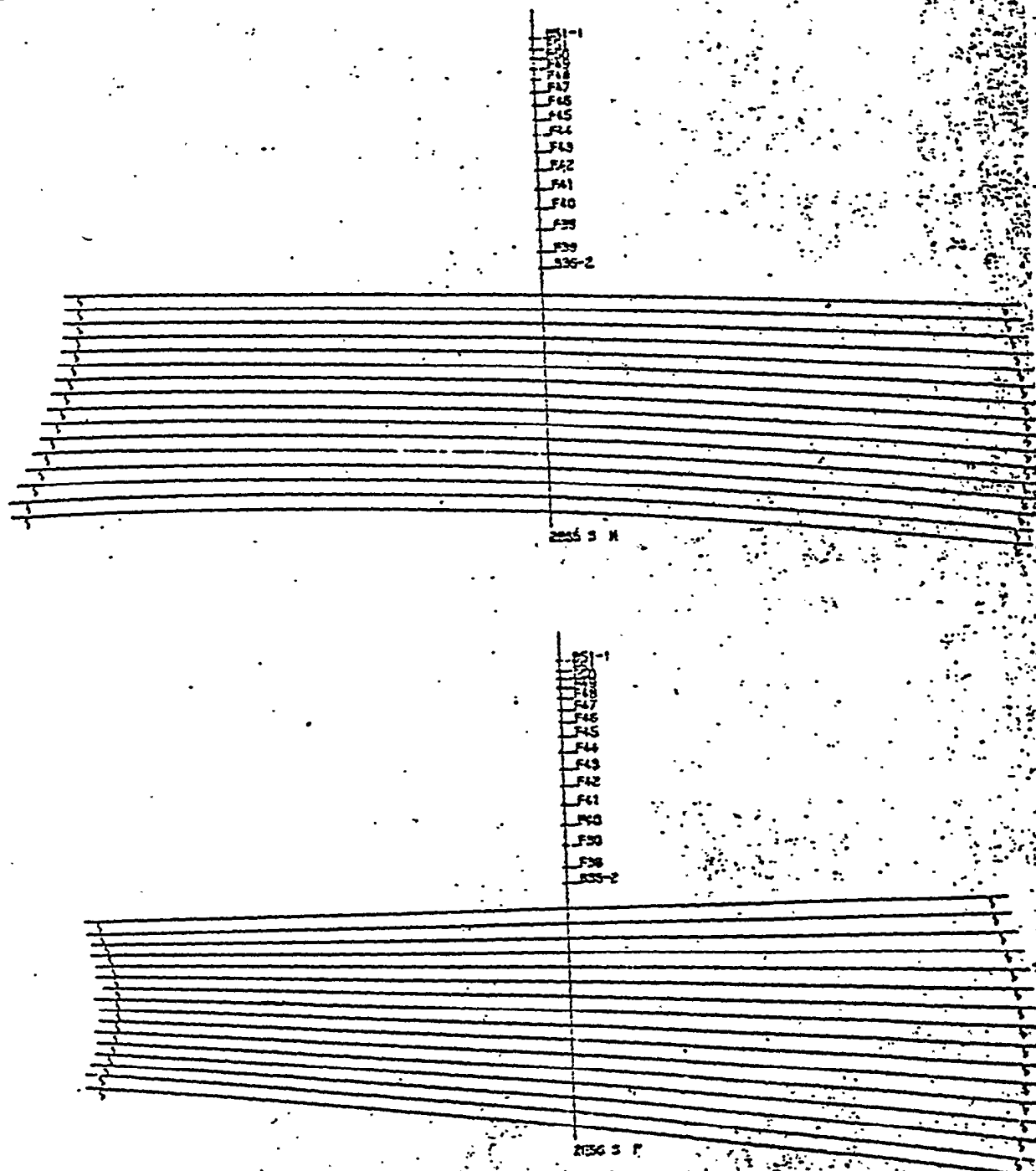
Fig. 15 LINES FOR BENDING TEMPLET MAKING

Table 2. DIMENSION TABALE FOR UNIVERSAL TEMPLATE

	FRAME	M.H	M.H	L.L	L.S4	A	B	C	D	E	F	G	H	I	J	K	U.S.N	E.N	U.L
○	B115-2	G	1382	191	326	300	341	377	407	430	448	*459	464	483	488	444	452	J	152
○	K3	F	1350	270	318	317	338	357	369	373	*373	365	350	379	300		316	I	123
○	K4	F	1344	214	314	315	336	355	363	372	*372	375	350	379	300		315	I	129
○	K5	F	1350	179	309	301	324	340	362	368	*268	362	348	378	300		311	I	169
○	K6	F	1267	148	312	300	326	349	364	372	*372	377	355	385	308		315	I	203
○	K7	F	1227	121	315	300	328	351	365	375	*376	371	350	341	316		318	I	231
○	K8	F	1134	98	328	309	336	362	375	387	*389	385	374	337	332	300	321	J	6
○	K9	F	1140	79	325	304	333	357	374	384	*386	383	372	365	331	300	326	J	25
○	K10	F	1095	64	327	305	335	358	375	385	*388	381	375	355	334	300	329	J	39
○	K11	F	1046	54	325	300	331	356	373	384	*387	384	374	357	334	300	328	J	46
○	K12	F	1000	47	326	300	331	356	373	384	*387	385	375	358	334	303	326	J	52
○	K13	F	950	45	326	300	331	356	373	384	*387	385	374	358	334	302	328	J	52
○	K14	F	900	46	327	301	332	356	374	384	*387	384	374	356	332	300	327	J	47
○	K15	F	846	52	332	307	337	362	379	389	*392	385	378	360	335	300	331	J	37
○	K16	F	794	62	333	309	339	363	380	390	*392	388	377	368	333	300	330	J	22
○	K17	F	734	75	339	317	347	370	386	396	*397	392	380	361	334	300	334	J	2
○	K18	F	682	93	320	300	330	353	368	377	*377	372	359	338	310		313	I	228
○	K19	F	624	115	317	300	329	351	366	373	*373	367	353	331	301		309	I	198
○	K20	F	564	140	324	310	331	355	373	378	*378	371	355	332	300		313	I	165
○	K21	F	503	170	331	321	344	368	380	385	*383	374	357	332	300		317	I	127
○	K22	F	440	203	340	335	361	379	390	393	*390	379	360	334	300		324	I	84
○	K23	F	376	240	350	349	373	390	400	401	*397	384	364	336	300		331	I	37
○	K24	G	346	8	355	324	356	380	397	405	*401	388	366	337	300	335	J	15	
○	B118-1	G	315	207	371	300	341	376	405	429	*427	422	402	457	445	454	J	97	

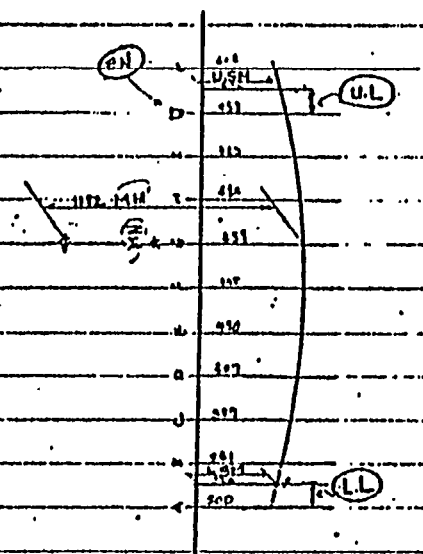
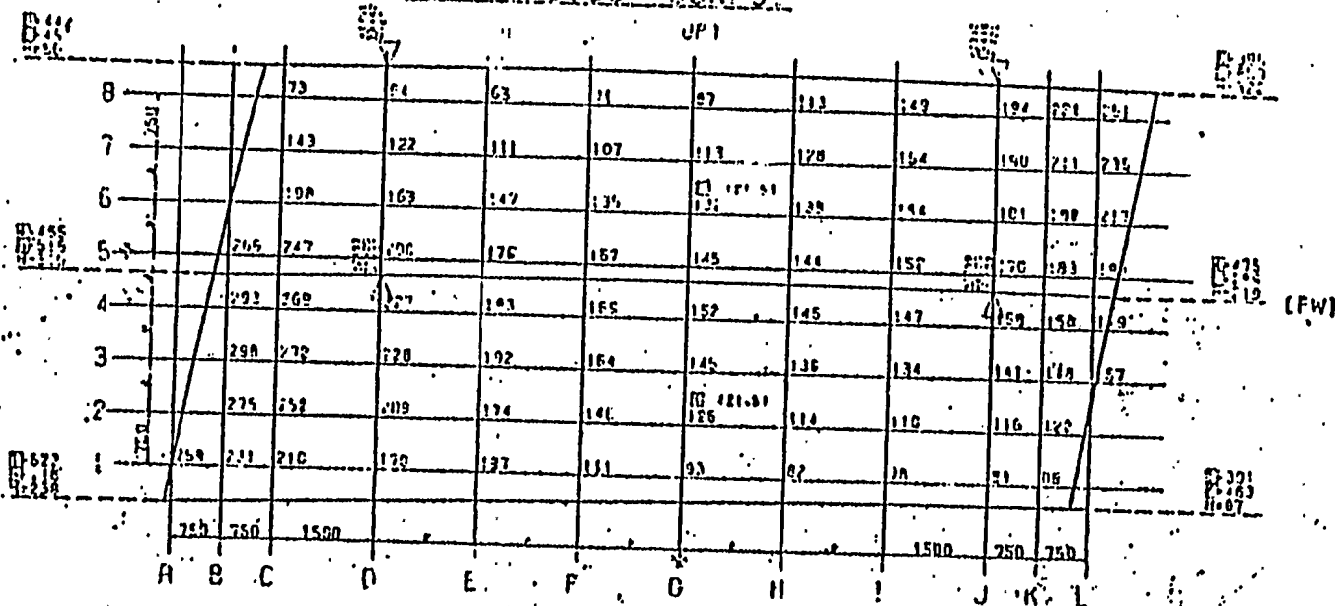


Fig. 16 DIMENSION PLAN FOR FIXED POSITION JIGS

3.2435 2ESC 8

SCALE - 1/84

TEIEN-JIGU SUNPOC



1 BLOCK SIZE = 0253 * 144071

TRANS FURISHOF-02

SIGNI-DIE	KAKUDO	A	B
A	17.0	321	765



TRANS IORI-TUKE-00

FR. NO	TYPE	(L)	(K)	(H)
F40	A	69.8	71.2	79.4
F44	A	70.6	71.8	75.7
F47	A	71.2	72.3	74.0

Fig. 17 DIMENSION PLAN FOR SEAM LINE JIGS

S.2436 2E56 S ()

SCALE=1/50

SEAM-JIGU PLAN

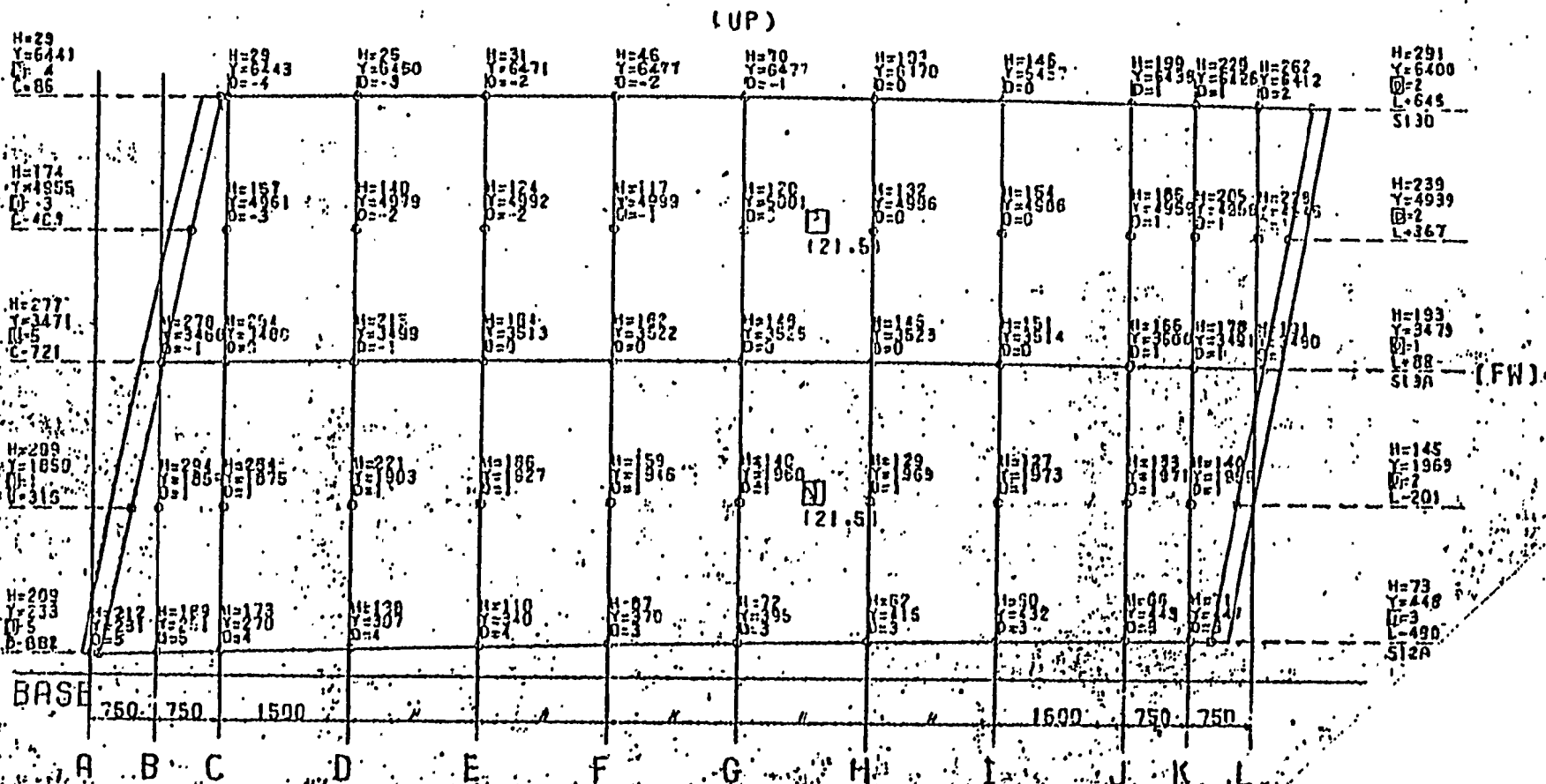


Fig. 18 DIMENSION PLAN FOR FRAME LINE JIGS

S 2436 2ES6 S ()

SCALE=1/54

BUTT & TRANS JIGU (UP)

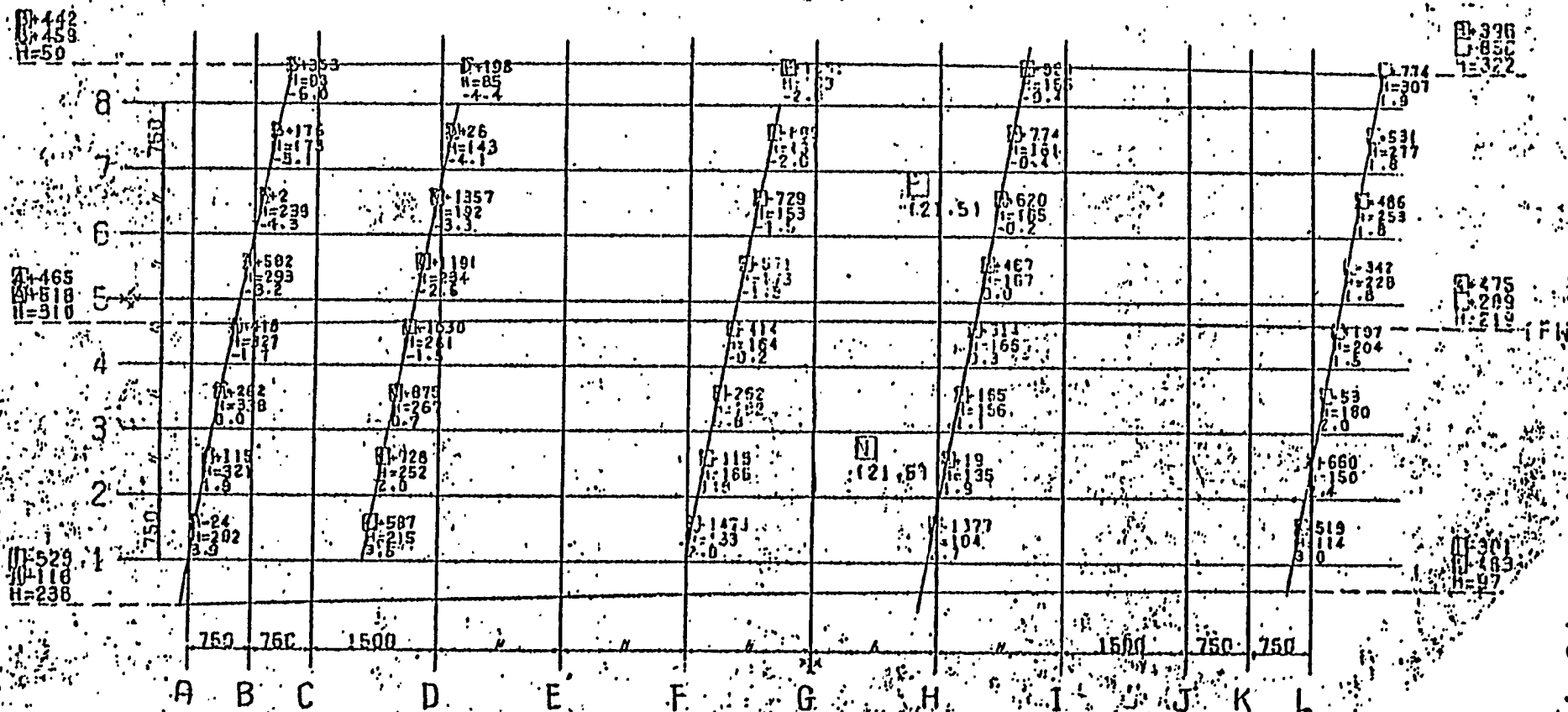


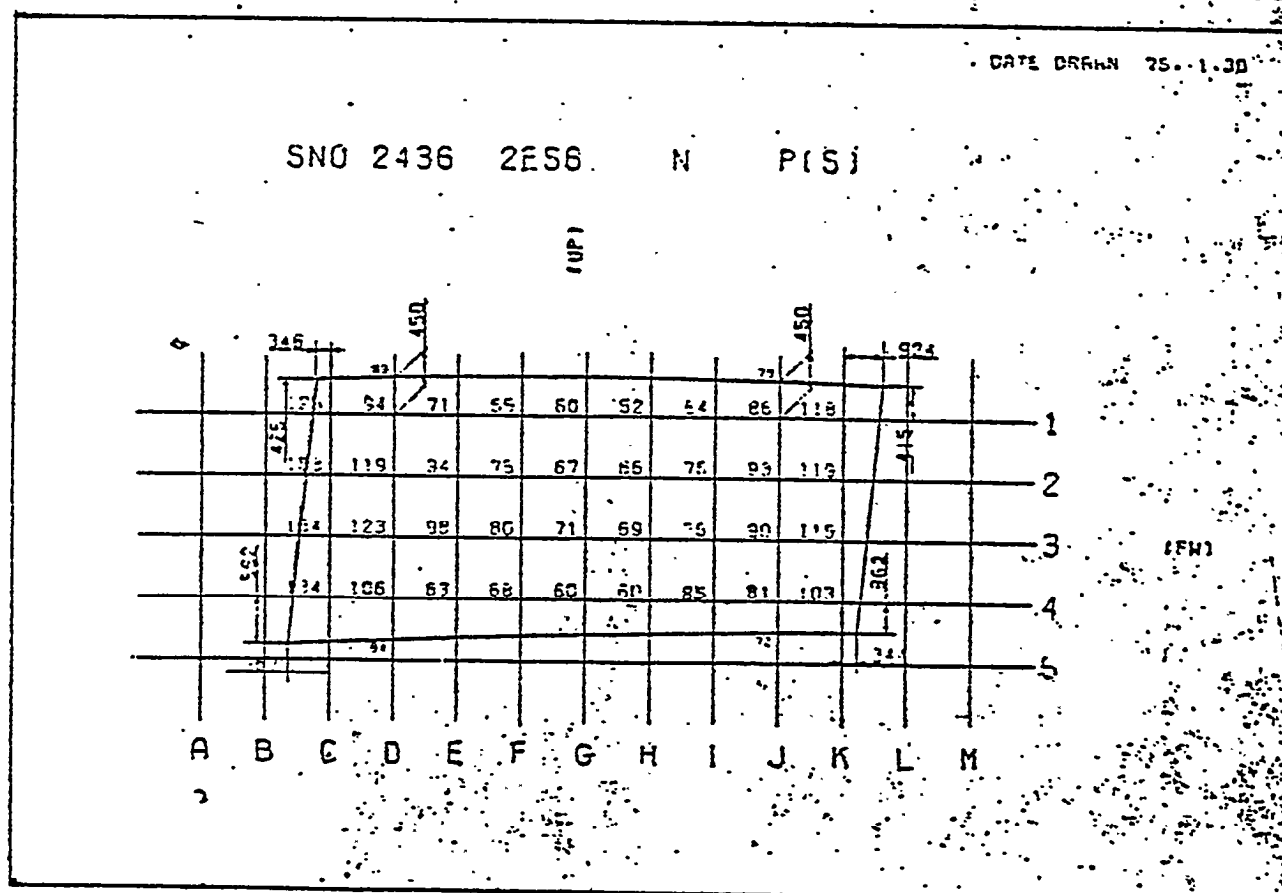
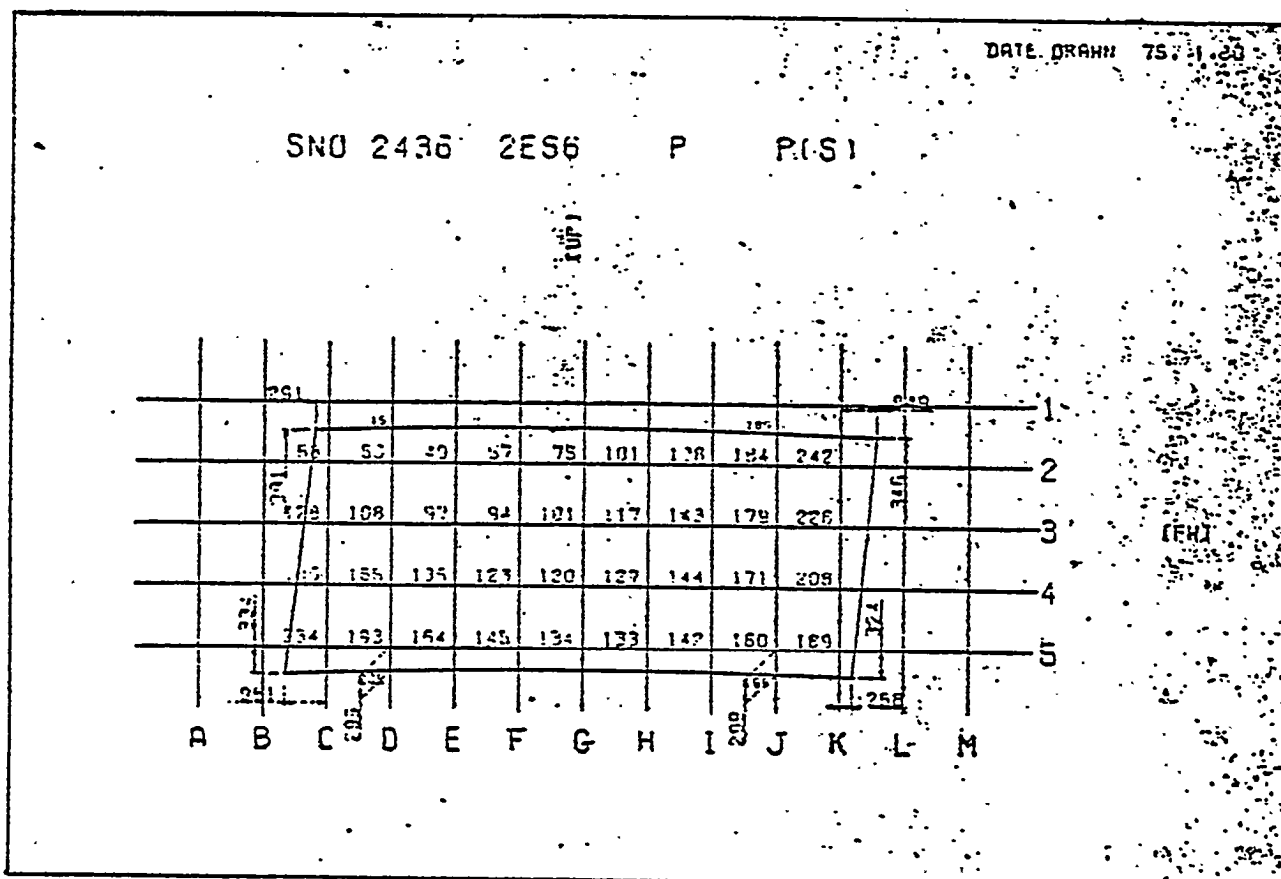
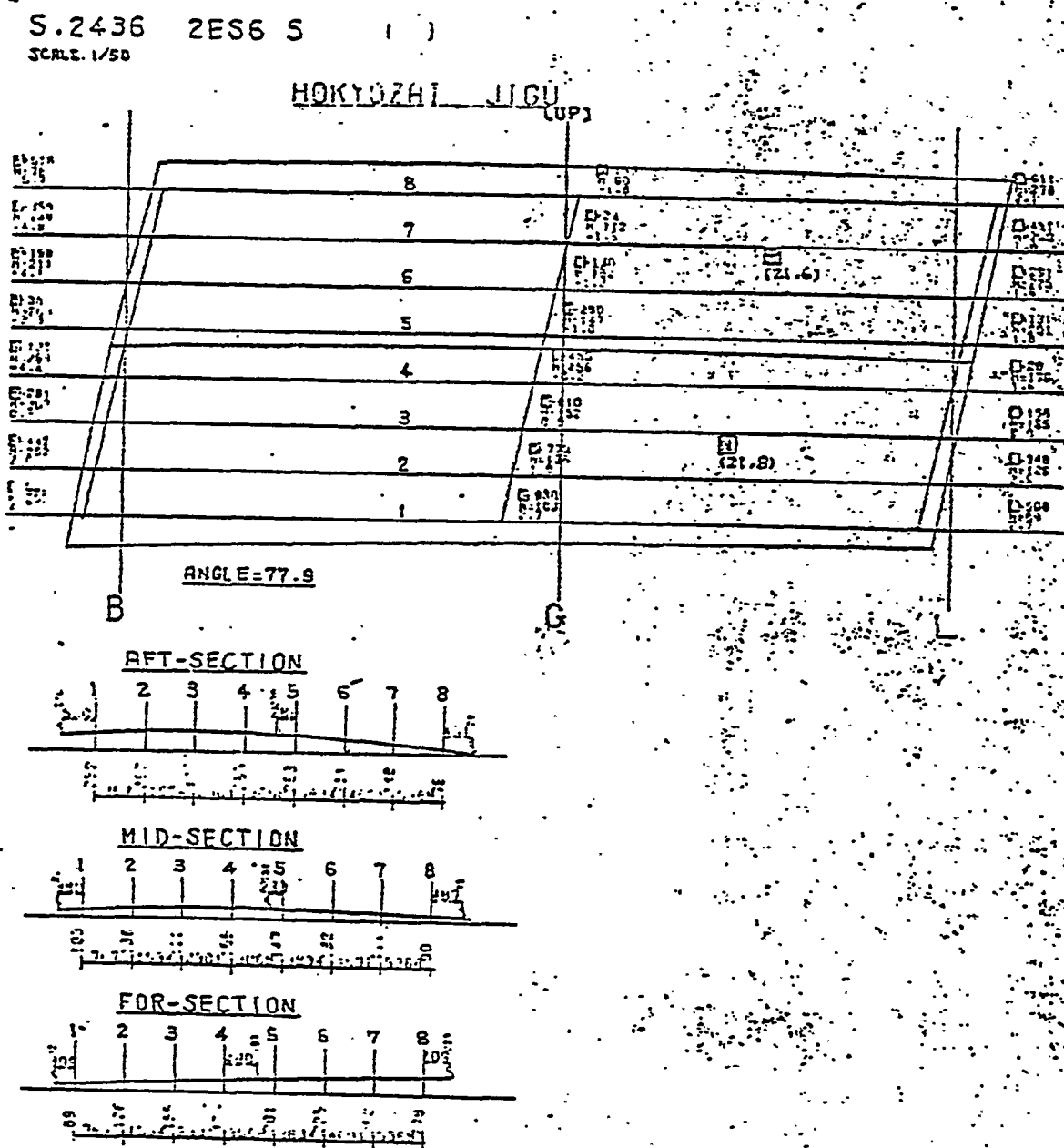
Fig. 19 DIMENSION PLAN FOR SINGLE PANEL SYSTEM

Fig. 20 SECTIONAL PLAN OF JIG LINES

5) Dimension table for block marking

The dimension table for the block marking is printed out by the system and full scale marking tape can be made from the output in mould loft. In the dimension table, length and width of the block are shown on the frame lines either of ordinally and optional cut plane.

Block marking is made using the transverse and longitudinal datum lines on the block. Since those datum lines are marked on the each shell plate of the block in beforehand, easier working procedures will be expected to maintain the accuracy, so far as the previous stages are keeping their accuracy in the tolerance.

6) Check data for the automatic welding

The maximum slope of the seam lines against ground level are output in the vectoral indication to check the availability of automatic welding on the block.

7) Accuracy control data

a) Geometrical check of block

Dimension plan is provided for the accuracy control of geometrical form of the block.

b) Positioning of materials

Data relating to the size of shell plate and location of the positioning jig for the shell plate are indicated in the dimension table of supporting jigs. These data will be available to secure the right position of Shell plate on the platform and it ensure the geometrical form of block.

c) Datum planes

The datum planes for the block marking are orthogonally mutually and also to the platform plane.

It means that working condition is better for the ensuring of block accuracy.

(Ordinary frame)

LINE-NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
L42	1	7621	7621	1268	1429	2395	33.7	4333	5293	6261	7222	8192	9175	10075	11049	
L41	1	(A) 7621	(A) 7621	(A) 1319	(A) 1172	(A) 2148	(A) 3122	(A) 4354	(A) 5064	(A) 6032	(A) 6908	(A) 7962	(A) 8925	(A) 9895	(A) 10543	
L40	1	7621	7621	803	766	1944	1920	3893	4264	5034	6907	7769	8733	9895	17655	
L39	1	7621	7621	597	761	1740	2717	3691	4664	5636	6605	7573	8539	9573	10465	
L38	1	7621	7621	398	562	1541	2517	3493	4466	5438	6409	7377	8344	9300	10273	
L37	1	7621	7621	211	375	1353	2329	3304	4277	5249	6219	7188	8155	9121	10085	
L36A	1	7621	7621	87	251	1230	2208	3184	4159	5132	6104	7074	8043	9011	9978	
S150	1	(B) 7621	(B) 7621	(B) 1329	(B) 1490	(B) 2459	(B) 3426	(B) 4390	(B) 5354	(B) 6315	(B) 7275	(B) 8234	(B) 9191	(B) 10145	(B) 11098	
S13A	1	7621	7621	637	801	1779	2756	3731	4704	5675	6644	7611	8577	9541	10503	
S12A	1	7621	7621	0	164	114	2122	3099	4075	5050	6023	6995	7964	8934	9904	
L. KISHI	1-3X	(C) 7621	(C) 7621	(C) 701	(C) 864	(C) 1838	(C) 2812	(C) 3784	(C) 4754	(C) 5723	(C) 6691	(C) 7659	(C) 8624	(C) 9584	(C) 10551	
L. KISEN	1	7621	7621	701	864	1838	2812	3783	4754	5723	6691	7659	8624	9584	10551	

Fig. 21 EXPLANATORY PLAN OF Table 3.

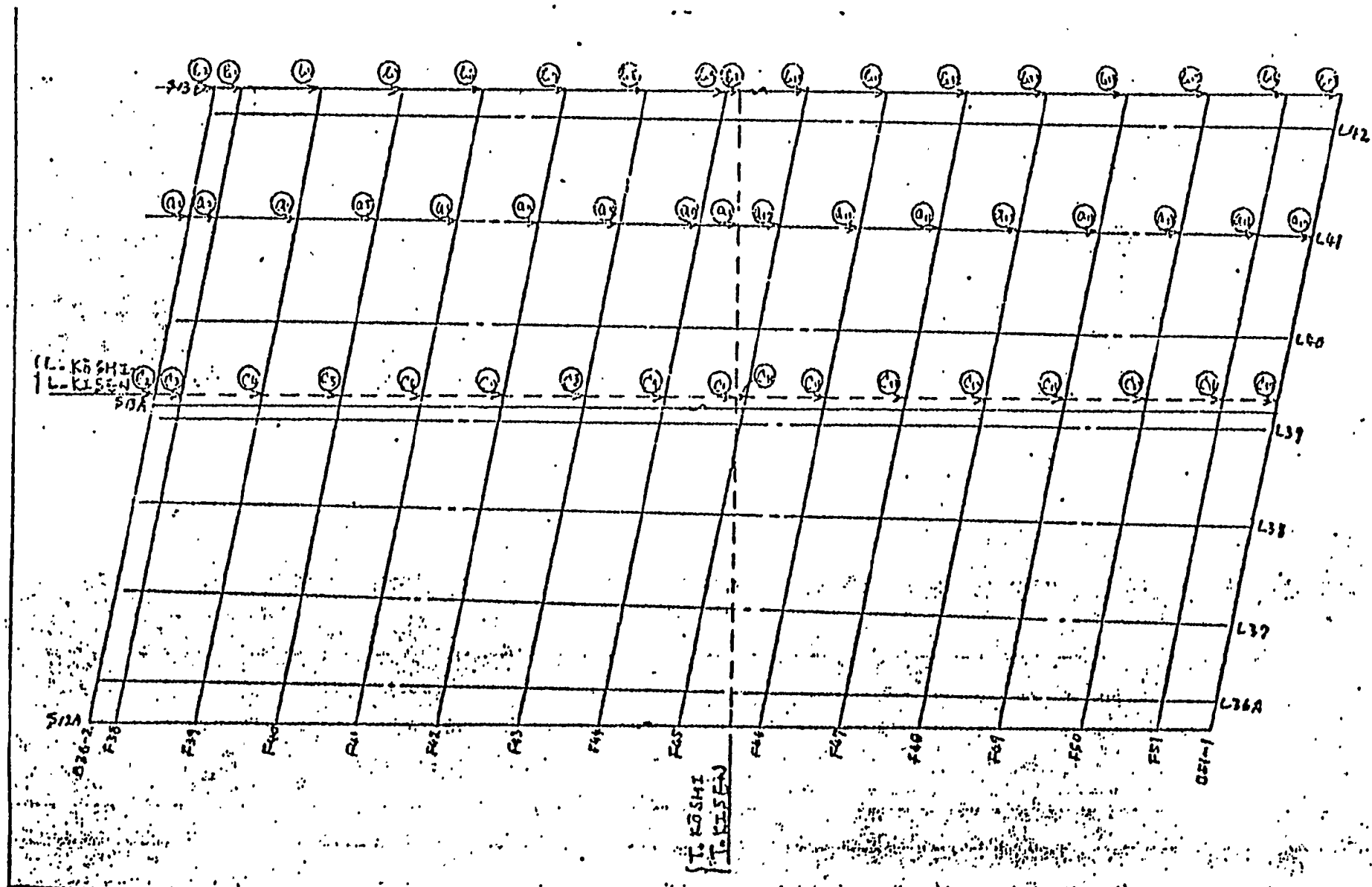


Table 4 DIMENSION TABLE FOR BLOCK MARKING

(Cut plane frame base)

NAGASA SURFACE KIRINAGASHI FRAME															
LINE-NAME	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15
L42		7621	7621	*****	1621	2371	3121	3871	4621	5371	6121	6871	7621	8371	9121
L41		(A)7621	(B)7621	*****	(A)1620	(B)2370	(C)3121	(D)3871	(E)4621	(F)5371	(G)6121	(H)6871	(I)7621	(J)8371	(K)9121
L40		7621	7621	869	1620	2370	3120	3871	4621	5371	6121	6871	7621	8371	9121
L39		7621	7621	869	1620	2370	3120	3871	4621	5371	6121	6871	7621	8371	9121
L38		7621	7621	869	1619	2370	3120	3870	4621	5371	6121	6871	7621	8371	9121
L37		7621	7621	869	1620	2370	3120	3870	4621	5371	6121	6871	7621	8371	9121
L36A		7621	7621	869	1619	2370	3120	3870	4621	5371	6121	6871	7621	8371	9121
S130		(A)7621	(B)7621	*****	(A)1621	(B)2371	(C)3121	(D)3871	(E)4621	(F)5371	(G)6121	(H)6871	(I)7621	(J)8371	(K)9121
S13A		7621	7621	869	1620	2370	3120	3871	4621	5371	6121	6871	7621	8371	9121
S12A		7621	7621	869	1619	2369	3120	3870	4620	5370	6121	6871	7621	8371	9121
L. NISHI		(A)7621	(B)7621	(C)870	(D)1620	(E)2370	(F)3121	(G)3871	(H)4621	(I)5371	(J)6121	(K)6871	(L)7621	(M)8371	(N)9121
L. NISEN		7621	7621	870	1620	2370	3120	3871	4621	5371	6121	6871	7621	8371	9121

Fig. 22 EXPLANATORY PLAN OF Table 4.

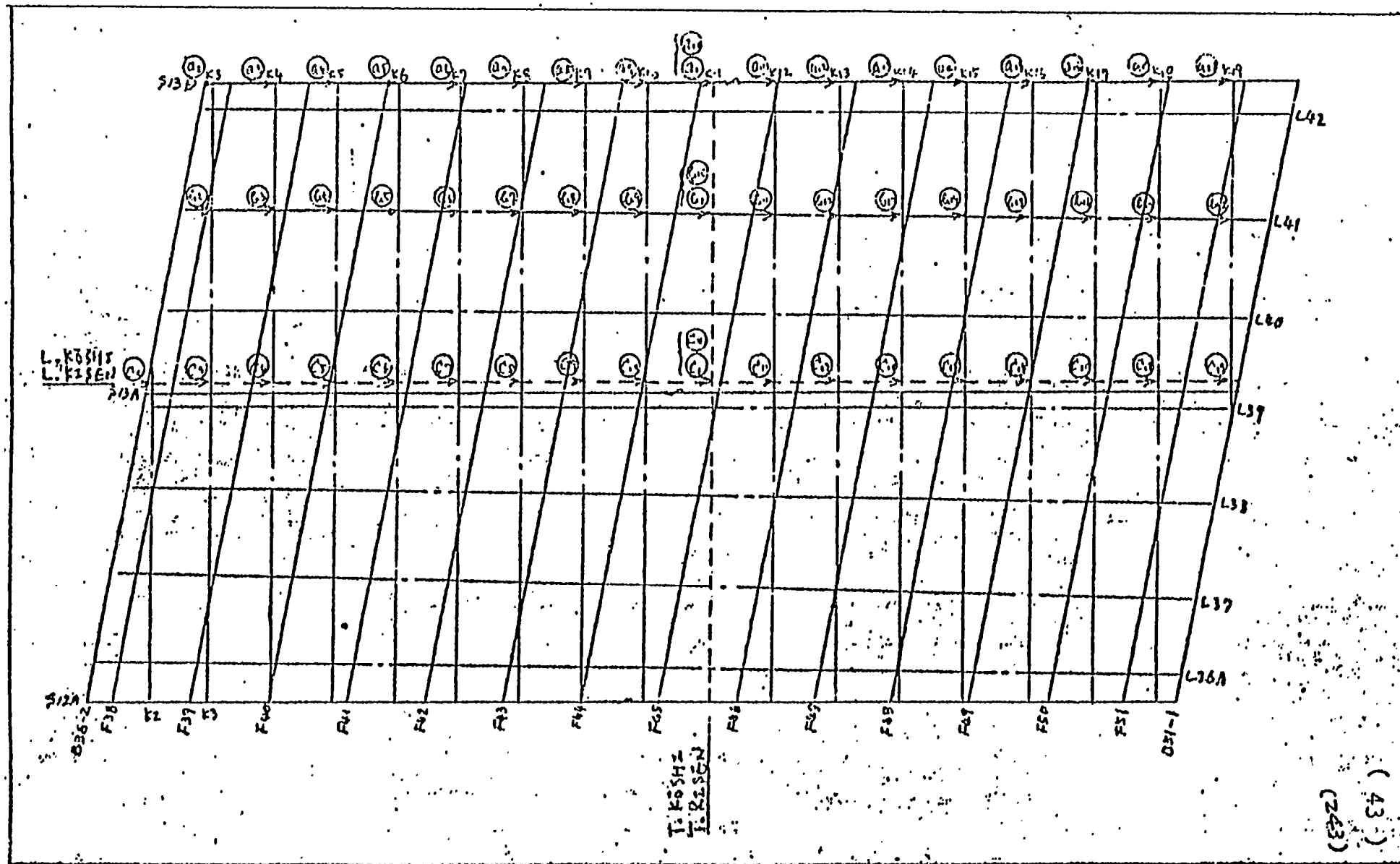


Fig. 23 CHECK DATA FOR AUTOMATIC WELDING

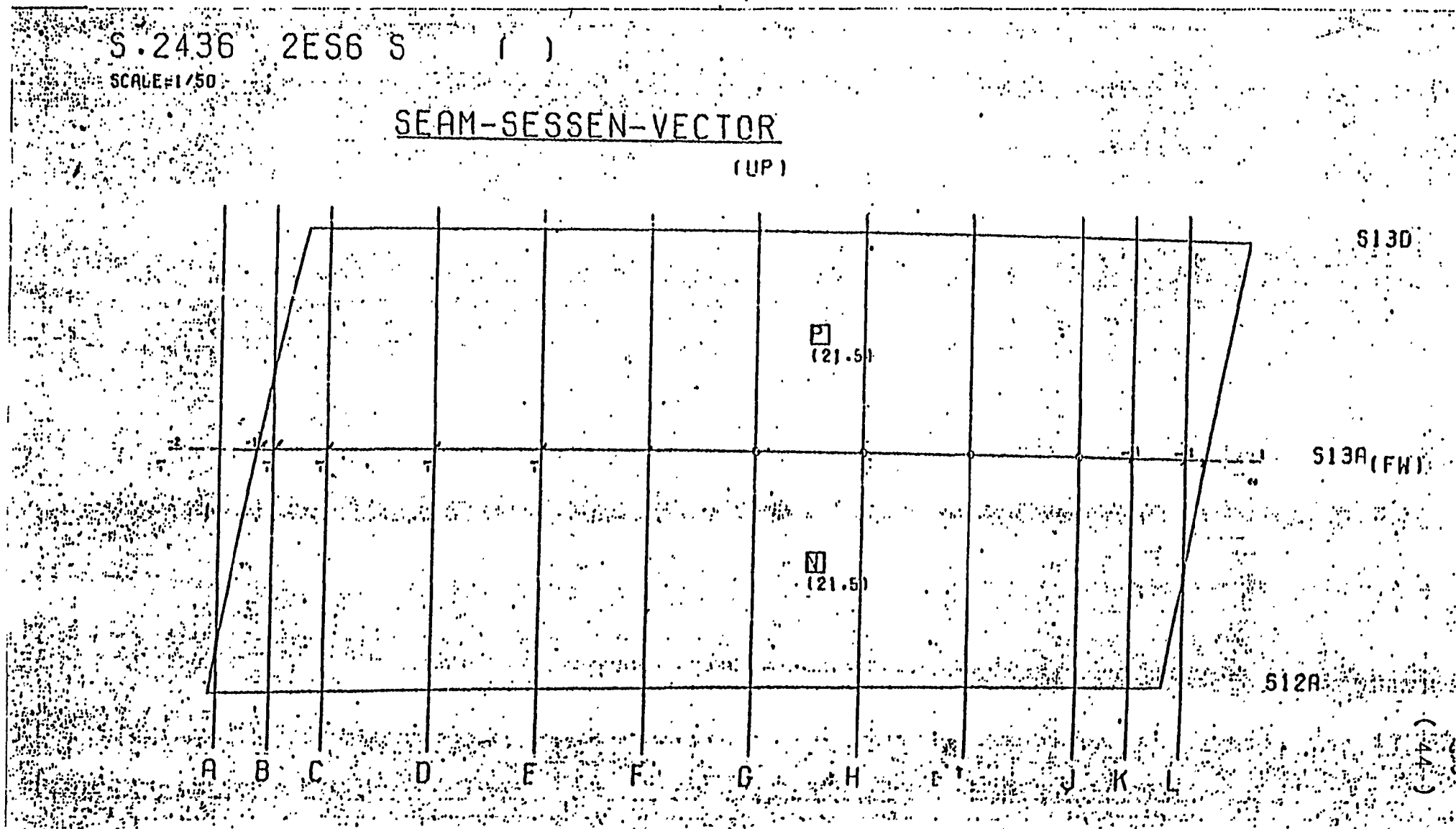
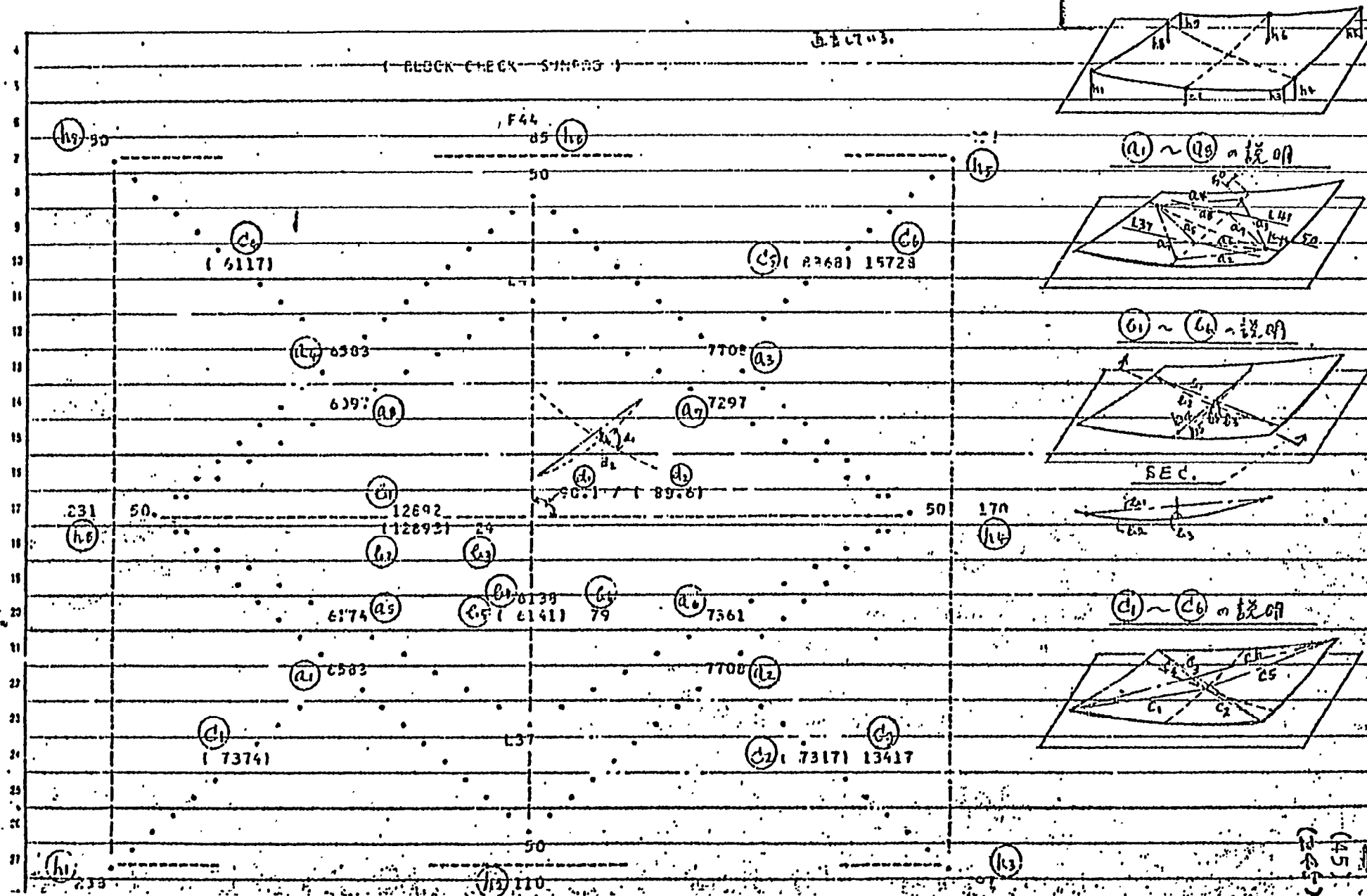


Fig. 24 CHECK DIMENSION OF BLOCK



APPENDIX D

LODACS - SHIP FRAME DATA PROCESSING SYSTEM

Development of LODACS, a Ship Frame Data Processing System

By:

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Almost all of the previous ship framing computer programs which have been developed and utilized individually at each IHI shipyard not only contained several weak points such as troublesome operation, difficult expression of output showing graphical images by a line printer, and insufficient functions for data processing, but also could not keep pace with the recent progress in the Numerical Control Machines such as steel marking, flame cutting and hydraulic bending equipment. To cope with these circumstances, by standardizing the design and the fabrication procedures and rationalizing graphical output by the dot-printer, X-Y plotter and COM, we have developed a newly integrated system called LODACS (Longitudinal frame Developing And Conducting System), a system applicable to all shipbuilding facilities and equipment of our shipyards. LODACS, a ship frame data processing system, is now contributing to the improvement of quality and accuracy of framing parts and to the saving of manpower in the design and the fabrication stages. This paper provides an outline of LODACS with actual examples of its outputs.

1. Introduction

Computerization in the field of mold loft work for shipbuilding was initiated in the area of curved shell plate expansion calculation. The storing of the hull offset data into the computer file as an input in such calculations contributed much to the subsequent speedy acceleration of the development of the hull lofting system and promoted the establishment of a comprehensive fundamental system that became an integral part of the hull design system. What is more, the establishment of this hull offset file has had the effect of establishing the method of the longitudinal frame development as the next phase of computerization. Nine years have elapsed since this system was first developed, and seven years have passed since the techniques were universally adopted by our shipyards. The tremendous effects in the areas of work speed-up and labor saving that have resulted from the replacement of the conventional manual lofting system by the computer-aided lofting system can hardly be overstressed.

Following the development of the above method, a twisting mold program for longitudinal members was developed as an associated technique with the primary system, and its extended application to the internal members including end-bracket development was attempted as the component module of the integrated hull design system which, in fact, has been partly implemented.

These, however, involved the following problems:

1. There was a lack of mutuality among the programs, due to differences in the time of development, and operational difficulties were observed in the management of the files and program maintenance with their inherent complexities. Such is considered attributable to the difference in their development stages. Further, in the case of the component module of the integrated system, the partial system operation independent from the entire system was not readily obtainable due to the system structural restrictions.
2. The part dimension plans of the longitudinal frames which are the main product of the system were produced in the form of the line printer output, thus the statements had to be expressed only with the code and symbols limited by alpha numeric. As a result, special knowledge was required to read off the statements — one of the causes that lead to erroneous productional operation.

In the meantime, development in the area of NC cutters, NC marking devices and NC frame benders was aggressively advanced in association with the application and implementation of the main system. To keep up with the development in such NC techniques, a basic integrated system has become necessary. The above is the background that lies behind the development of the LODACS (Longitudinal frame Development And Conducting System). In accordance with the changing demands

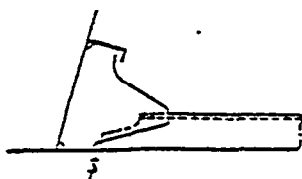


Fig. 1 Example of Frame-end Having Data Common to the End-bracket

at present for ship forms ranging from tankers to cargo boats, efforts are being made to incorporate the transverse frame development program, and practical fields of application of this system have been widened regardless of the limits implied by the original naming of the system.

2. Development

In the system development, emphasis was placed on the following points:

1. The system should be capable of processing normal curveless frames, those to be fitted to the shell plates, and also frame-end brackets.
2. The part dimension plans should be output in the form of X-Y plotter, dot printer and COM (Computer Output Microfilm), and be visualized from the dimension tables into dimension plans. No special knowledge or experience is required for reading off the information. English letter or code are used as they provide better access to external users including overseas users.
3. To allow simple operation, each program should be well systematized and unified.
4. The output required for common manual marking should be obtained as basic information, and it should be designed in such a way that the control information can be provided to all the NC devices through the postprocessors.

The features of this system thus developed provide for easy access to the part dimension plan, and outstanding flexibility allowing applications of the system in any type of shipyard production facilities. Fairly long time was required before determining the suitable specification of a part dimension plan; extensive process standardization was developed by analyzing the marking procedure. A system development should always be based on the end user's requirements; and it is important that the user should not compromise his needs, reasoning that the system producer is limited by restrictions in computer hardware composition or complications in programming. The hull-shop production facilities of our five shipyards are varied in operation systems, ranging from the all NC system to the all manual system; the flexibility of this system has been realized through its application to all the facilities. This system uses the IBM model 370/135 ~ 158 computers at present. The program language employed is principally FORTRAN, and ASSEMBLER is partly used.

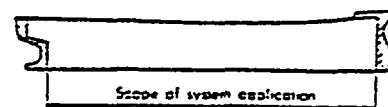


Fig. 2 System Application Range

3. Function

This system is designed to deal mainly with the development processing of the hull panel stiffener such as the transverse frames, longitudinal frames and their end-brackets with the added function of a variety of associated application programs. (Hereinafter the transverse frame and longitudinal frame are simply called frames; the frame-end brackets are simply called end-members.) The added capability to handle the end-members was provided mainly because these members are always connected to the frames, and they have elements determining the cutout shapes of frames (Fig. 1). Also, it not only enables the system to simultaneously process the data common to the frames and end-members by a single input operation but also provides ability to process the frame or end-member alone independently.

The scope of application of this system covers the frames and end-members to be fitted to the side shell, upper deck, longitudinal bulk-heads, and various flat decks except for those highly complicated parts at the end of the bow and stern (Fig. 2). As shipbuilding materials, not only the angles and built-up sections, but also slabs and bulb angles are taken into consideration.

4. Setting Up

As shown in Fig. 3, the development program is implemented by producing the input data from the hull design, and taking the offset information from the hull base-data file. The results of such a development operation will then be put into the storage of the dimension data file in the case of the frames and standard type end-members, and those off-standard end-members will be stored in the cutter location data file. Subsequent system flow will be processed into the output program groups adaptable to the production facilities being set up in the shipyard under consideration.

4.1 Setting Up of System

4.1.1 Development Program

The development program is the vital part of the system and handles the development processing of the frames and end-members as mentioned above. To simplify the input data as much as possible, the system was elaborated to yield the following functions:

1. According to the kind of section type, dimension, and bending direction (i.e., outward bending or inward bending), different bending neutral axis is calculated automatically⁽³⁾.

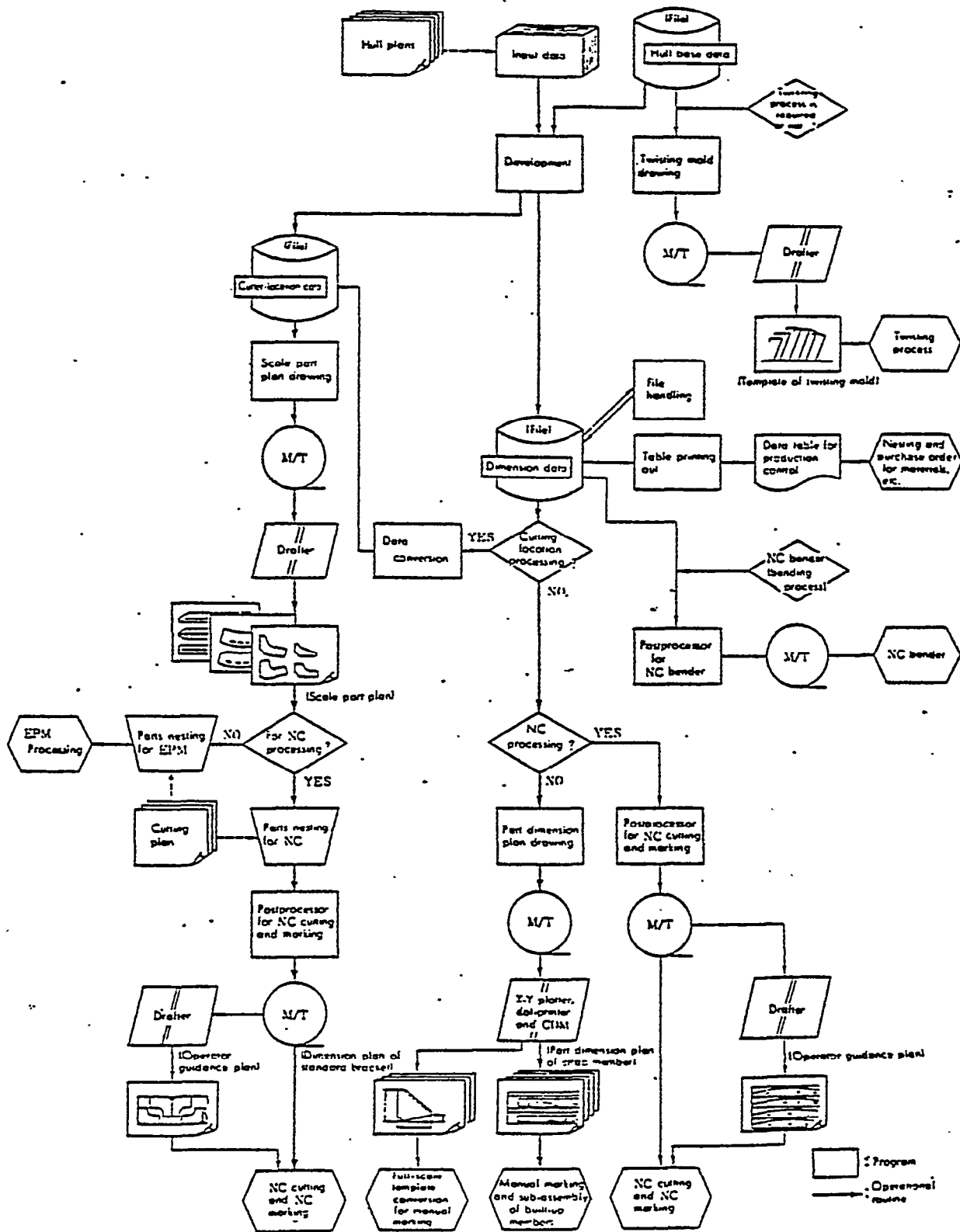


Fig. 3 Flow Diagram

2. Inclined fitting angles of frames, their beveling of edge preparation, and marking surface arc determined automatically.
3. Shapes of frames in detail (cut-off dimension (a), dimension (b), scallop (r) and bevel angles to be profiled (θ , etc.) are decided automatically (Fig. 4).

In addition to the above, automatic generation of the data for the secondary members such as face plates and flat bars is made possible; the computing function of weight, cutting length, and center of gravity are also provided, and their results are put into the storage of the file. The frame bending lines (Fig. 5) to be made straight after the bending process are computed to a maximum of three lines on judging the scantlings of frames and their bending requirements.

4.1.2 File Handling program

The programs that control the dimension data File are:

1. The initializing program that is set when the system operation is initiated.
2. ship to ship data file transfer program to be used partially or entirely for a sister ship or a ship of similar construction and dimensions.
3. Corrective or cancellative program to be used for partial modification when the design is to be changed in part.

All of the above help to facilitate system operations.

4.1.3 Production Control Data printing Our program

To grasp and verify the contents of the dimension data file, and check adequacy of material size for a purchase order and fabrication work scheme this program prints out the parts data such as the block name, code, length, scantling and weight.

4.1.4 Part Dimension Plan Drawing Program

A part dimension plan is drawn by the X-Y plotter (Fig. 6), dot printer (Fig. 7), or by COM with the required output from the dimension data file for the manual marking and built-up guidance plans. In this process, data are not only assorted according to groups of classified materials such as slabs, angles and built-ups or bend pieces and straight pieces but also assorted based on the fabrication lines, scantlings and the order of lengths to suit the intended purposes.

All the shapes are unified in figures and/or terms of actual images and the title code and the like are stated in English in consideration of possible license agreement with shipyards in foreign nations (Fig. 8 - Fig. 11).

Namely:

PART CODE	Code of parts	
- SCATLING	Sectional dimensions	--
SHOWN	Surface shown on the plan	
s .PRM	Preliminary surface treatment & Shop prima painting	

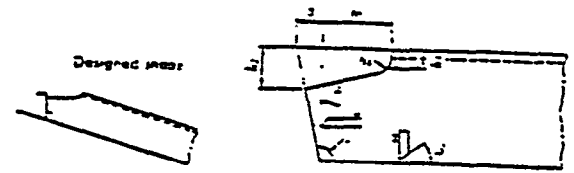


Fig. 4 Example of Fram-end Decided Decided Automatically

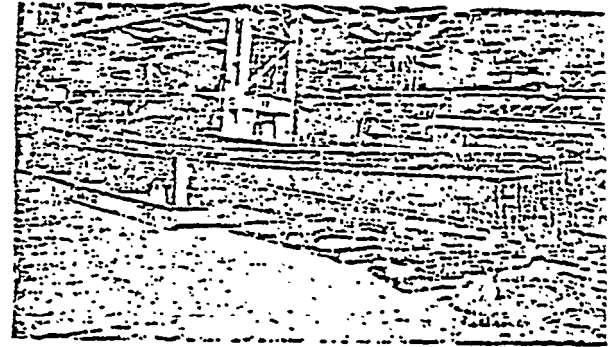


Fig. 5 Frame Bending Line Straightened after Bending.

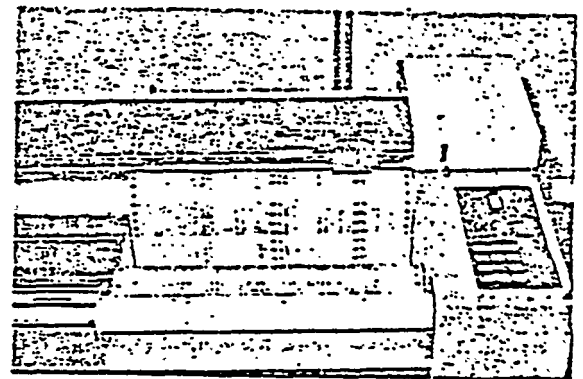


Fig. 6 Drawing View of Pan Dimension Plan by the X-Y Plotter

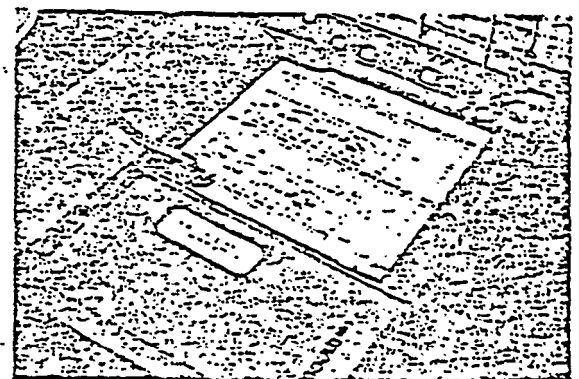


Fig. 7 Drawing View of Part Dimension Plan, by the Dot Printer

BEND Bending method
 TWIST Twisting in fabrication shop
 These represent only a few examples. To facilitate
 manual marking, due considerations were taken on the
 following points:

1. Marking length is shown on the & basis of the cumulative dimensions, and in particular the end Cut out sequence is made identical to those in manual marking procedure.

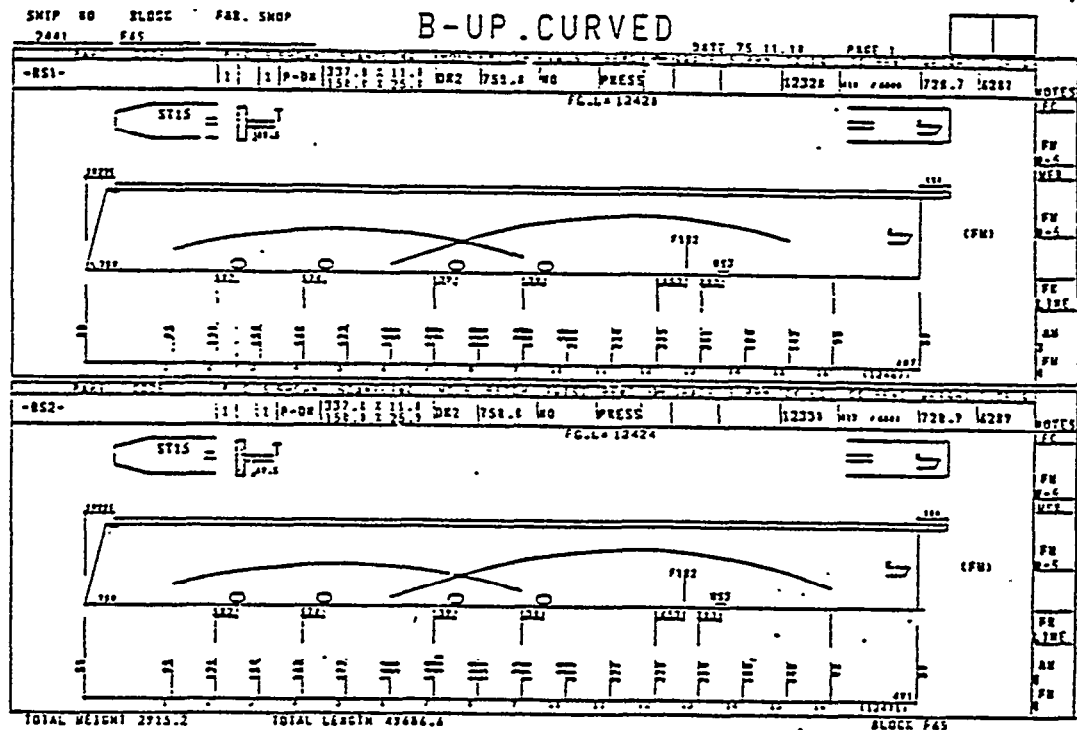


Fig. 8 Part Dimension Plan of Curved Built-up Frame (by COM)

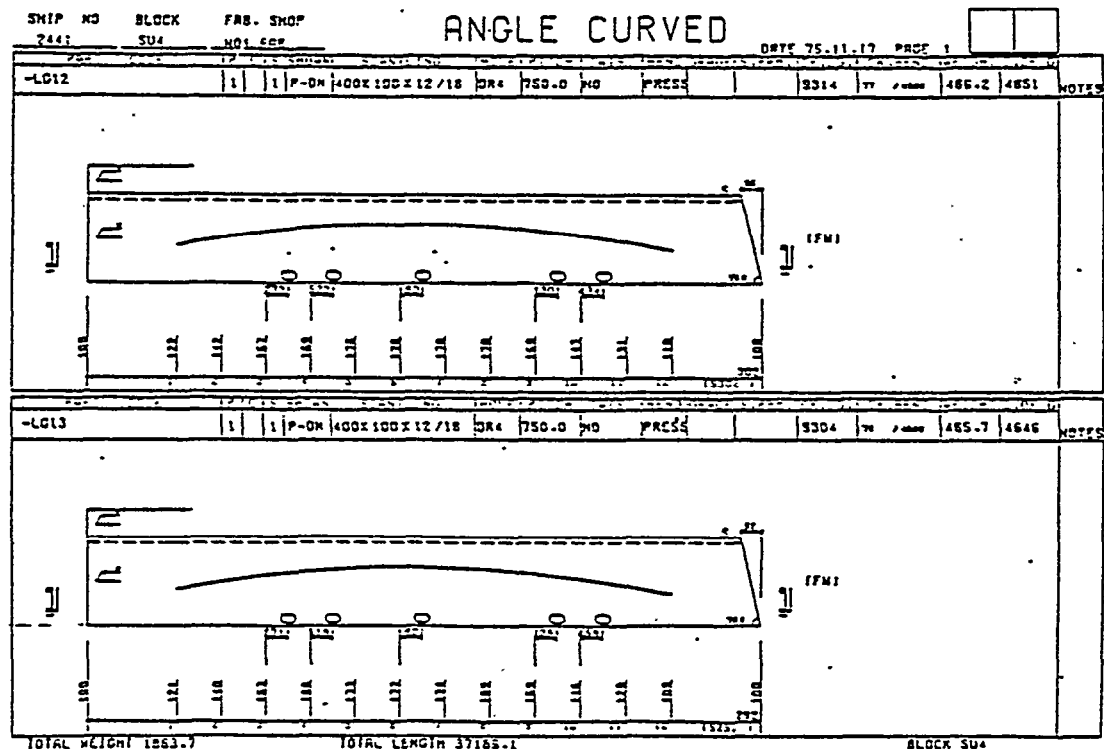


Fig. 9 Part Dimension Plan of Curved Angle Frame (by Plotter)

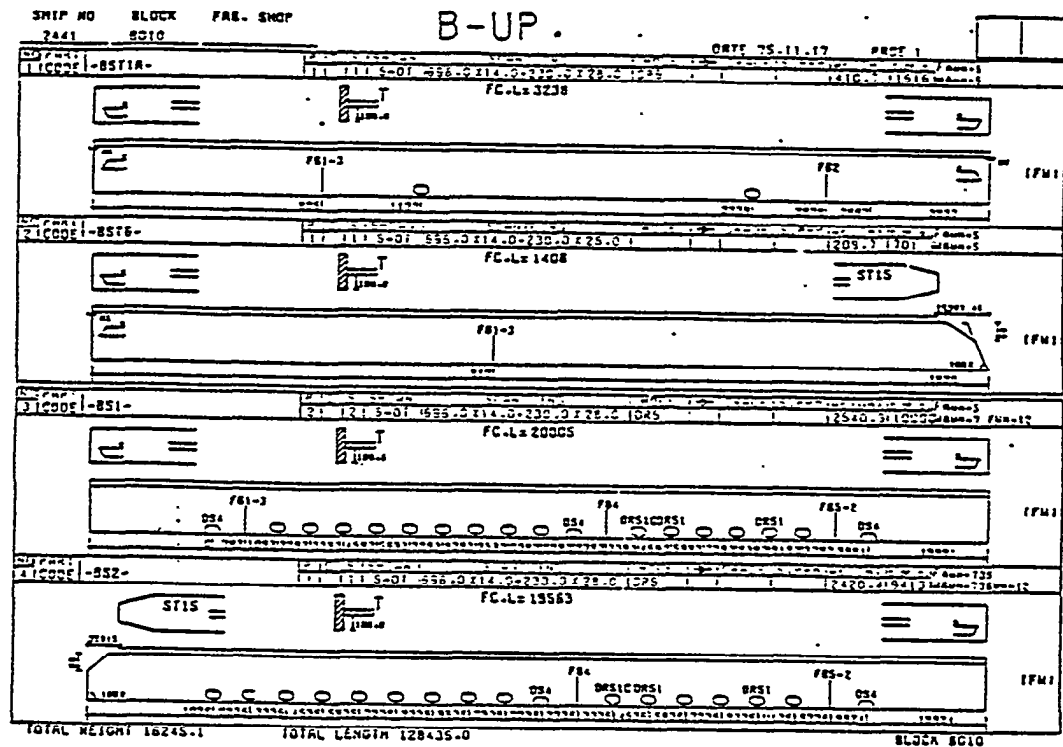


Fig. 10 Part Dimension Plan of Straight Built-up Frame (by Plotter)

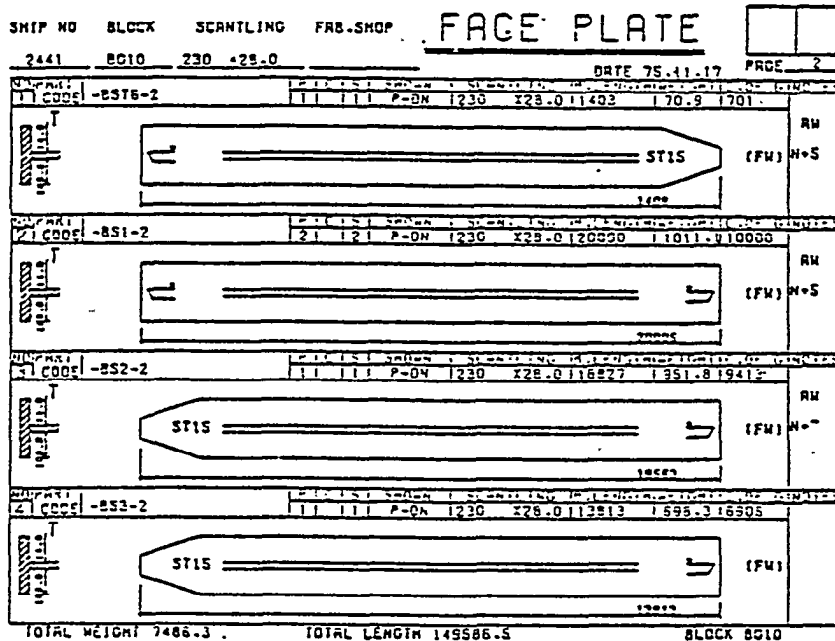


Fig. 11 Part Dimension Plan of Face Plate of Built-up Frame (by Plotter)

2. Drawing is made with the same side view as marking is.
3. End shapes and bending line curves are expressed in a somewhat exaggerated manner to improve presentation of images.

The part dimension plan (Fig. 12) of the curve cutout frame differs from that in the ordinary bending process

effected by referring to the frame bending the in that an analogous pattern requiring no bending process can be restored by marking through the dimensional con from one base line. In the case of the standard brackers the program also provides the dimension output aSSum possible requirements for the marking with a given of dimensions or full-scale template conversion.

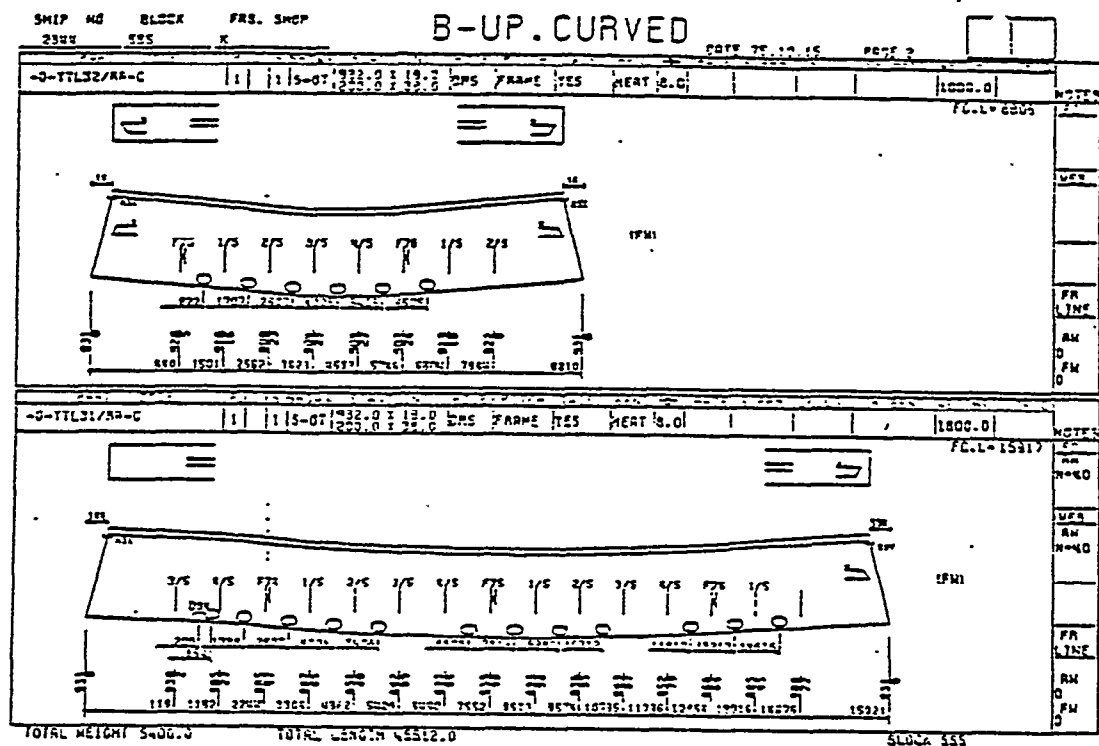


Fig. 12 Parr Dimension Plan of Cut-out Frame [by Dot-printer]

4.1.5 *Posiprocessor for Numerically Controlled Framing and Marking*

This program outputs NC tape, by which the cutting of drain holes on the frame and frame-ends, the marking of the frame bending line and other necessary lines are conducted by the NC frame cutter (Fig. 13). It also carries out parts nesting automatically with the given information from the dimension data file as required; output in the form of magnetic tape or punched tape is provided. This punched tape will then be fed into the drafter capable of checking the contents of the information to draw a plan in a 1/20 scale which will further be supplied to an operator of the NC cutter as a guidance plan (Fig. 14).

4.1.6 *Posrprocessor for Frame NC Bender*

This is a postprocessing program that acts to subject the cut frames to the automatic bending process by the NC frame bender (Fig. 15). The data necessary for frame bending is obtained from the dimension data file to determine the distance between the points of press action in accordance with the bending requirements, and the computed magnitude of bending action will be output to magnetic tape as the control numerical data in terms of angular quantity.

4.1.7 Production Program of Twisting Mord

When twisting of the frame is judged necessary by the design criteria, the essential data arc obtained from the hull base data file in accordance with the name of

longitudinals, and designations specifying the range. In the case of manual Operation, necessary information should be obtained from the ship's body plan. Thus the twisting mold is made so as to be set on the transverse

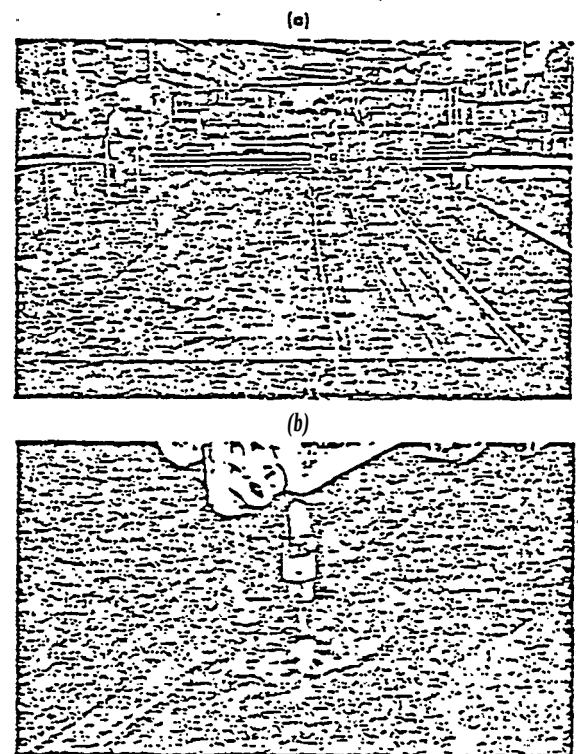


Fig. 13 Frame Fabrication by the NC Frame Cutter

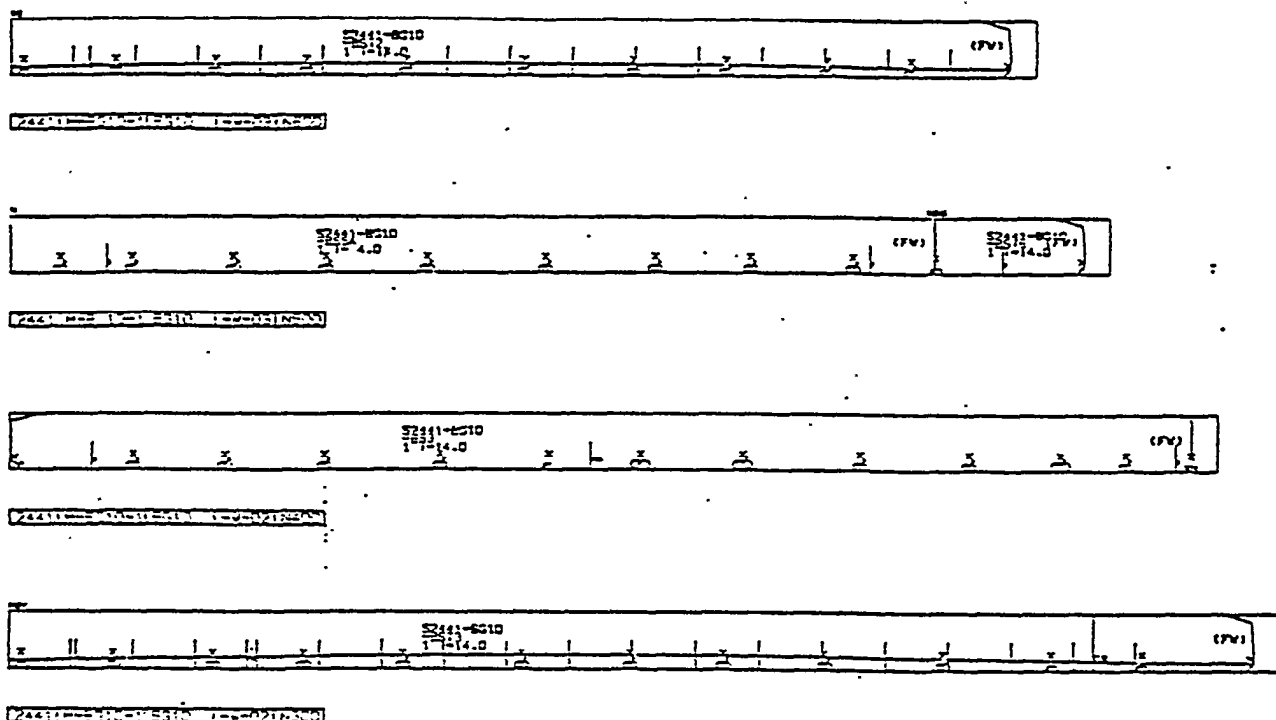


Fig. 14 Operator Guidance Plan for Frame NC Cutting

frame lines; further, it involves a certain degree of angle to the web surface of the longitudinal. This program provides the output of twisting mold at a right angle to the shell line and web surface. With the processing of this program, not only can the marking of transverse frame lines be omitted but also the twisting operation itself has improved significantly (Fig. 16).

4.1.8 Data Conversion Program

When the standard brackets, cutout frames and face plates being stored in the dimension data file are to be drawn as output in the form of EPM film or full-scale contour templates, the dimensional data can be expressed as cutter location data which are stored in the cutter location data file.

4.1.9 1/10 Scale Part Plan Drawing Program.

This program outputs magnetic tape for drawing by designating the block name or the part code from the cutter location data file. This magnetic tape will then be used to draw a 1/10 scale part plan film (Fig. 17) by the drafter. This part plan is used for multiple purposes such as EPM, film for projector marking, and parts nesting for NC marking or NC cutting.

4.1.10 Postprocessor for NC Cutting

The parts nesting produced by the above part plans will be channelled through this postprocessor to output data in the form of magnetic tape or punched tape per every unit of steel plates. As with the case in the postprocessor (4.1.5) for frame NC cutting and marking,

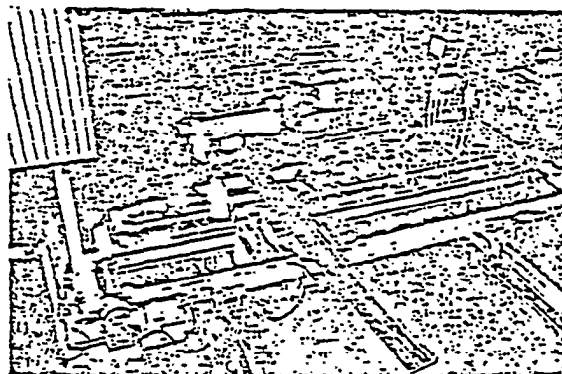


Fig. 15 Frame Bending by the NC Bender

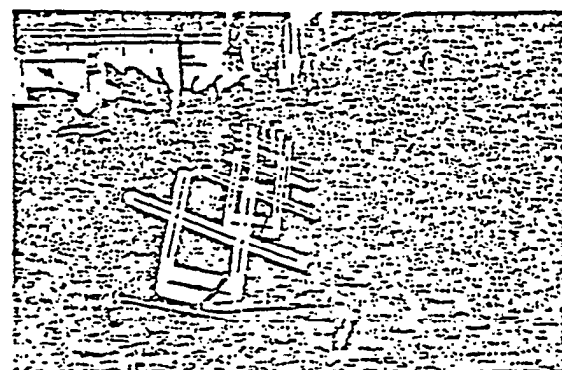


Fig. 16 Frame Twisting

such tape will be supplied to the work site together with the operator guidance plan drawn by the drafter. In other words, this program can follow up either the NC cutter or NC marking device (Fig. 18).

4.2 Setting Up of File

4.2.1 Hull Base Data File

The Direct Access Method type file is used wherein the hull offsets, scantlings of the longitudinals, those section types, and specific data of the longitudinals such as the thickness side of webs against mold line and the direction of the flanges are contained. Furthermore, this file is not only utilized for the LODACS but also for the shell plates expansion and internal members development processes.

4.2.2 Dimension Data File

This Direct Access Method type dimension data file contains the indices of block names. Here, the developed

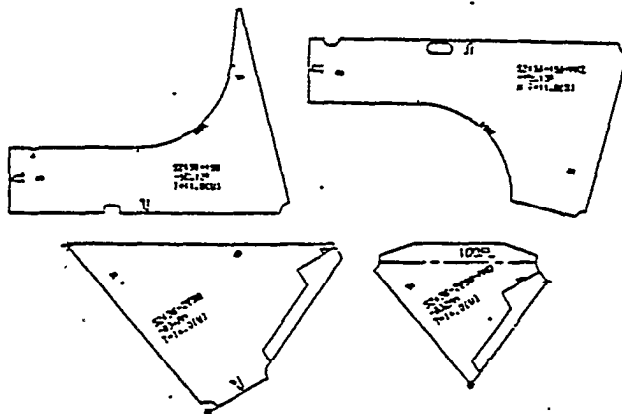


Fig. 17 Part Plan of Frame End-bracket (by Drafter)

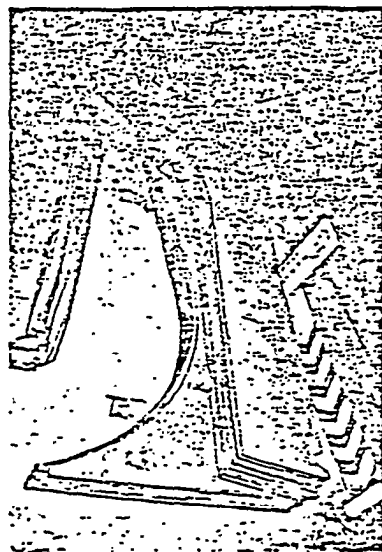


Fig. 18 Frame End-bracket by NC Cutting

frames, face plates and flat bars known as the strap members, and standard type brackets and cutout frames are included in the dimensional forms. Each component member has its corresponding record, and the information consists of the general items such as the part code, scantling, length and control parameter for production activity, the common graphical items such as end shape and scallops, bending information, data regarding drain holes, and marking information.

4.2.3 Cutter Location Data File.

This Direct Access Method type cutter location data file contains the cutter location data which are to be output in the form of the analog patterns. In addition to the end-members, the standard type brackets, face plates and cutout frames data converted from the above dimension data file can be put into the storage of this file- as required. This file, as with the cases above, can be utilized also for other systems covering the expansion

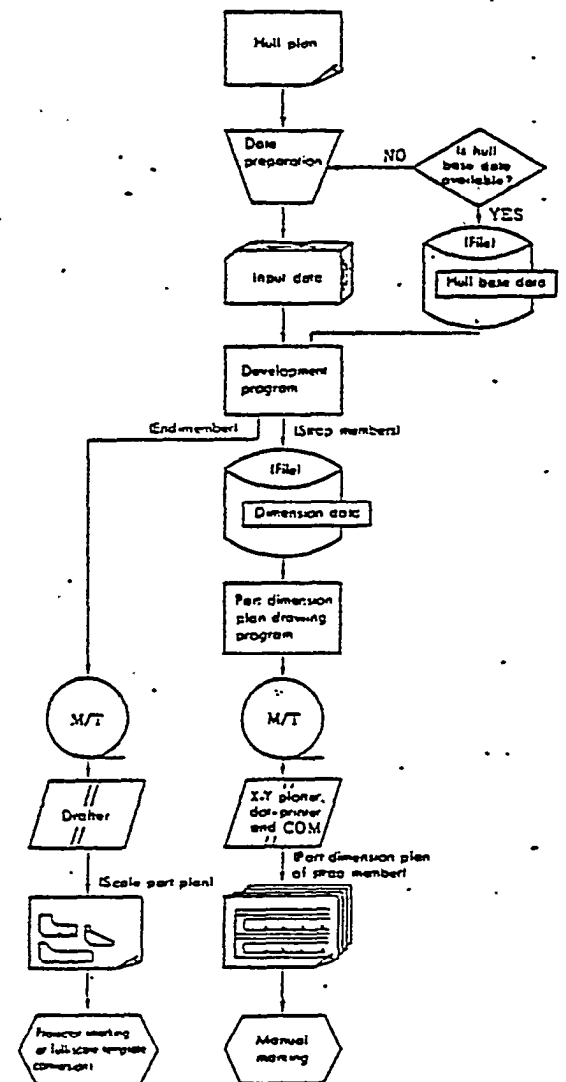


Fig. 19 Example of System Operation Flow Chart

curved shell plates and development of internal members.

5. Operation

5.1 Preparation for System Operation and Its Simplified Operation

With respect to the flow diagram shown in Fig. 3, a variety of operational methods can be taken. Namely, only those necessary programs can be selected after development programs.

The preparation of the dimension data file is indispensable for the control of the files, but in an emergency as: as in the quick repairs of a vessel, specific data can be input even when the hull base data file is not available. When the preparation of EPM films or full-scale templates is intended, the cutter location data file may be bypassed, and magnetic tape or punched tape for NC drafting can be output directly from the development program. Shown in Fig. 19 is an example of the system operation without utilizing the hardware techniques of numerical control fabrication.

5.2 Standardization

It goes without saying that computerization and standardization go hand in hand. Extensive standardization which resulted in distinct simplification both in design and in input operation was developed in this system. In particular, five types of frame-end shapes and more than ten types of end-members have been standardized. Consequently, the necessity to write down all the details of end-members in the design phase has been eliminated. All that is required is to note the designated type number of end-member shown in the standard specifications. Similarly, only the designated type number of end-member shown on the relevant design plan is required to be input. The newly provided access permitting the input of those principal dimensions related to design functions allows added system flexibility to deal with the hull members of special types, and contributes significantly to even greater labor saving.

5.3 Input

Input items of the system, aside from the development program, contain the block names, part codes and selective machine code, hence description on these items is omitted here. In this article the input for the development program will be shown. Generally, processing is made for every building block where data are broadly classified as those data common to blocks and those concerning each frame member.

5.3.1 Data Common to 10 Blocks

These data cover the ship number, block name, and drain holes which require only one input operation at the initial stage of each block processing. Of these, the input operation for drain holes is cumbersome; however, simplification has been made in such a way that the

type of drain holes can be omitted where they are identical to those on the immediately preceding member.

5.3.2 Data Specific to Each frame

To minimize the input operation frequency, the name of the longitudinal, type number of the end-member, range of frames processed and specific data other than the standard type are required to be input for the first member only, but all such data for the subsequent members can be largely omitted, except for the name of the longitudinal and part code: name, providing that they are dimensionally identical to the first one.

6. Conclusion

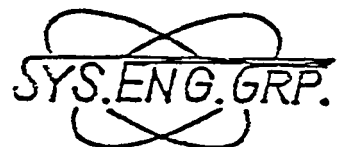
With comprehensive coverage and sophisticated functions, LODACS has become an extremely useful system that meets the multiple requirements of the shipbuilding design and production system. As already mentioned, this system is a longitudinal frame development and conducting system incorporating the groups of programs developed and implemented by MI with added functions later developed. This system does, however, have some unsolved problems in dealing with the transverse frame end-brackets, beams and beam-knees etc. Other problem areas include such items as the automatic drawing of the sectional view of frames in the course of hull plan preparation, supplying those control data to the production control system, and the like, to name but a few. A greater corporate effort will therefore be made in the future to solve these remaining problems.

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APPENDIX E

SPECS - SHIP'S PRELIMINARY AND EXACT CALCULATION SYSTEM



SPECS

SHIP'S PRELIMINARY AND EXACT CALCULATION SYSTEM



OCT. 1978

Ishikawajima-Harima

Heavy Industries co, Ltd.

TOKYO JAPAN

REF. No.

HL-781002

(1) ABSTRACT OF 'SPECS' SYSTEM

This system shall be applied to detailed design in ship's preliminary calculation on Hull Form and its capacities. The system design concepts and aims are as below.

- * Expansion of application by widely used
p r o g r a m s
- * Easy Maintenance of both programs and Data.
- * Reconsideration of design system and Pursuit of
man power saving.

This is a totalized system which can make designers possible to prevent from duplicate input by registration the results of each step in the Data Bank through which next programs shall retrieve them.

(2) APPLICATION AND RESTRICTIONS

1) Applied ship's type

Applied tankers and carriers up to D/W 1,000,000
In addition to the ordinary ships, following type
can be also applied.

Ship's type ----- naval vessels, patrol
ships, fishing boats

Hull form ----- Initial trim, Knuckled
shell

Inner hull structure -----

Almost all types of ship
shall be applied using
MAP-method developed by
IHI.

2) Other restrictions

ORDINATE ----- Max, 50 (w.L = 60)

FRAME ----- Max, 500 (w.L = 150)

TANK / HOLD ----- Max, 70 block

Loading condition --- Max, 100

(3). FEATURE OF THE SYSTEM

1. Operating methods

* Using as total system which can save input data by retrieval the preceding results from the data Bank.

* Independent RUN method

Related data to be INPUT directly for each program.

Both running method are available.

2. Drawing shall be generated as output.

3. Calculated results in the Bank can be applied to another sister ship for effective process.

4. FRAME & ORDINATE OFFSETS shall be automatically applied, in case that LINES FAIRING has been complexed.

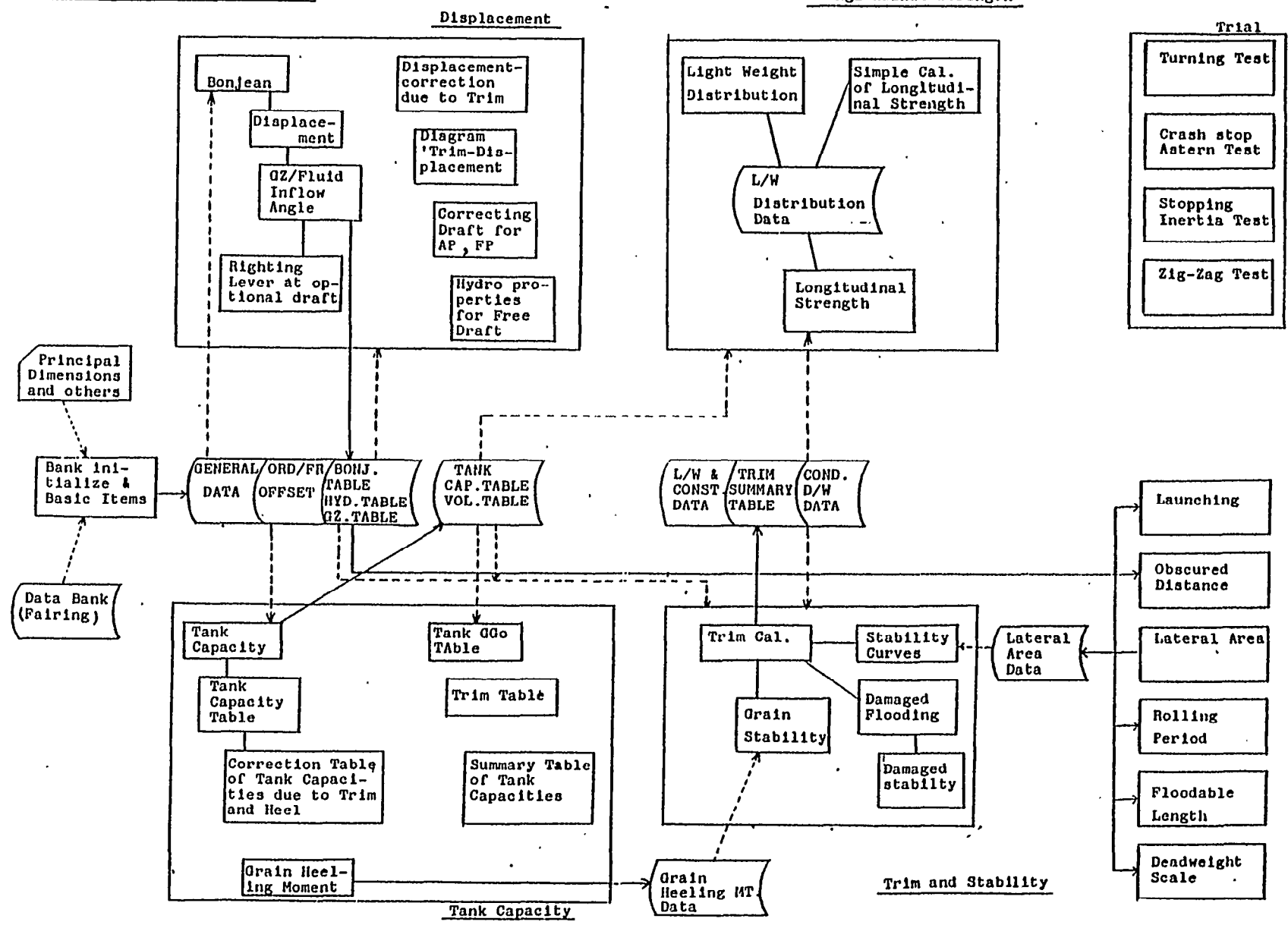
5. FRAME OFFSETS can be provided from ORDINATE OFFSETS' by OPTION FUNCTION.

Various studies in initial design stage can be proceeded by this function.

6. MAP- method developed by IHI shall make it easy to apply the system for the complexed shapes of ship.

7. New Rules of IMCO are applied.

GENERAL SYSTEM FLOW OF SPECS



(4) FUNCTION AND OUTPUT OF EACH PROGRAM

Program name	Function of Program	Output
BANK INITIALIZE & Basic items	Preparation for I/O process of all calculations shall be done. Basic items such as principal dimensions, FRAME SPACE and etc. are stored.	
Bonjean Cal.	Bonjean calculation of MLD and EXT are executed.	Bonjean (EXT) Bonjean (MLD) Bonjean Curves
Hydrostatic Properties Cal.	HYDRO PROPERTIES TABLE is generated.	MAP APPEN
GZ and FLUID INFLOW ANGLE Cal.	Calculation of GZ (Righting Lever) at any angle. Calculation of the displacement at the start of INFLOW of sea water.	Cross Curve of stability Curve of INFLOW angle
Righting Lever at optional draft	GZ TABLE at optional draft is generated.	GZ for operational information GZ-Healing Curves
Displacement- correction Cal. due to Trim	Displacement correction Table in optional draft-Trim is generated.	Displacement correction table due to Trim
'Trim-Displacement' Diagram	Generating Diagram 'Trim-displacement' for finding draft at bow and stern.	Diagram 'Trim-Displacement'
Draft Correction Table at the point of draft Mark	Values for correction which shall be used for calculating drafts at the both of AP and FP from the apparent drafts at the Draft-Mark position.	Draft correction table for Draft-Mark
HYDRO Properties Cal. for Free Draft	Calculation of HYDROSTATIC PROPERTIES at any part of the ship, at Trim-status and at HOG & SAG status.	HYDRO PROPERTIES for Free Draft
Read in frame offsets	Frame offsets read by eyes.	Frame distance table Frame offsets

Program name	Function of Program	Output
Tank Capacity Cal.	Capacity, center of Gravity INERTIA etc. are calculated.	Tank capacity table Tank capacity curves
Tank Capacity Table Cal.	Tank capacity table is generated due to SOUNDING and ULLAGE.	Tank capacity table
Correction Table of Tank capacities due to Trim and Heel	Value for correction against EVEN KEEL at TRIM HEEL is calculated.	Correction value table
Grain Heeling Moment Cal.	TRANSVERSE & VERTICAL HEELING Moment are calculated.	Grain Heeling Moment table
GGO Table for Operational Information	Decrease of GM by free surface effect is calculated.	Table
TRIM Table	Estimation of the change of Trim when a load of 100t added to optional Tank.	Trim Table
Summary of capacities of Tanks and etc.	Final drawing of Tank Capacity.	Tank Capacity Summary Table
Trim Cal.	HOMOGENEOUS LOADING at optional Tank and Trim adjustment by two fixed tank.	Loading condition Drawing
Lateral area Cal.	Lateral area and center of Lateral area are calculated.	Curve of Lateral Area
Stability Curves Cal.	GZ angle of vanishing stability and GZ maximum. Coefficient C_1 , C_2 considered DYNAMICAL STABILITY of IMCO Rule, maximum allowable heeling angle, wind and oscillation.	Diagram 'GZ-Heeling angle-Dynamical stability'
Grain Stability Cal.	Residual Area, Heeling angle, Allowable Heeling Moment etc. are calculated.	Table of Heeling Moment Diagram 'GZ-Heeling Angle'

Program name	Function of Program	output
Damaged flooding and damaged stability Cal.	Final balanced CONDITION after damaged by method of lost Buoyancy is generated. DYNAMICAL STABILITY considered wind and oscillation can be also calculated.	Diagram GZ-Heeling Angle
Light weight distribution Cal.	Light weight, center of Gravity are calculated and distributed	Light weight Distribution Curve
Longitudinal strength Cal.	SF. BM DEFLECTION in case of STILL, SAG, HOG are calculated.	Comparison Table for Bending Moment Diagram Bending Moment-Shearing Force Envelope Curve of Shearing Force Envelope of Bending Moment
Simple Cal. of Longitudinal Strength	BASE VALUE such as Coefficient of Weight Distribution Shearing Force etc. at the point of Bending Moment are calculated.	Coefficient of Weight Distribution for Shearing Force Lever for Bending Moment Longitudinal strengthen Data
Launching Cal.	Launching particulars, Float condition, launching speed etc. are calculated.	Launching Curves Launching Speed and Travel Curves
Obscured distance in relation to various Draft and Trim	Table of Obscured Distance at the designated draft and Trim is generated.	Table of Obscured Distance in relation to various Draft and Trim
Rolling period Cal.	Table of GoM at every designated draft and oscillation period is generated. BY Kato's equation or results of experiment.	Bolling Period-Table

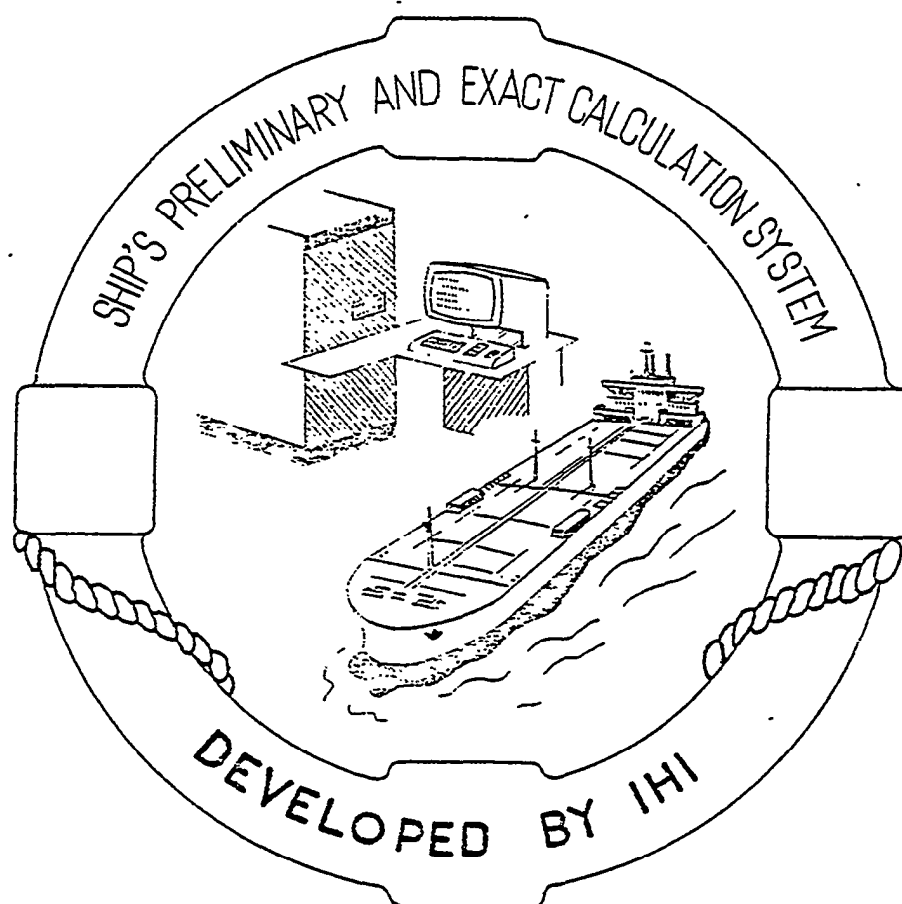
Program name	Function of <i>Program</i>	Output
Floodable length Cal.	Floodable and Permissible length at optional points are calculated. By the standard of Ministry of Transport or Floodable length detailed Bonjean Method.	Floodable Length Curve
Dead Weight-Scale Drawing	D/W SCALE unit in METRIC or FEET.	Dead weight-Scale
Turning Test	Measured results such as Speed and Turning Angle at the Trial are analyzed and calculated.	Drawing on Turning Test
Crash Stop Astern Test and stopping Inertia Test	Results of Crash Stop Astern Test and stopping inertia test are analyzed. Its wake and speed curve are drawn.	Results of crash stop Astern test Course of Crash stop Astern Test Result of Stopping Inertia Test Course of Stopping Inertia Test
Zig-Zag Test	Results of Zig-Zag steering Test are analyzed.	Table of Maneuvability

APPENDIX F

SPECS - ACTUAL OUTPUT EXAMPLE

SPECS

ACTUAL OUTPUT EXAMPLE
OF
SHIP'S PRELIMINARY AND EXACT
CALCULATION SYSTEM



IHI 石川島播磨重工業株式会社

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*** PRINCIPAL PARTICULARS ***

LENGTH OVER ALL	187.730 M
LENGTH BETWEEN PERPENDICULARS	178.000 M
DRAUGHT (MOULDED)	20.400 M
DEPTH (MOULDED)	15.300 M
DRAFT (DESIGNED MOULDED)	9.750 M
DRAFT (DESIGNED EXTREME)	9.768 M
INITIAL TRIM	0.0 M
DISTANCE AFT. END FROM A.P.	5.000 M
DISTANCE FWD. END FROM F.P.	4.730 M
RISE OF FLOOR AT MIDSHIP	0.0 M
STARTING POINT OF RISE OF FLOOR	1.095 M
RADIUS OF BILGE CIRCLE	1.200 M

* SEA GRAVITY = 1.02500 *

11

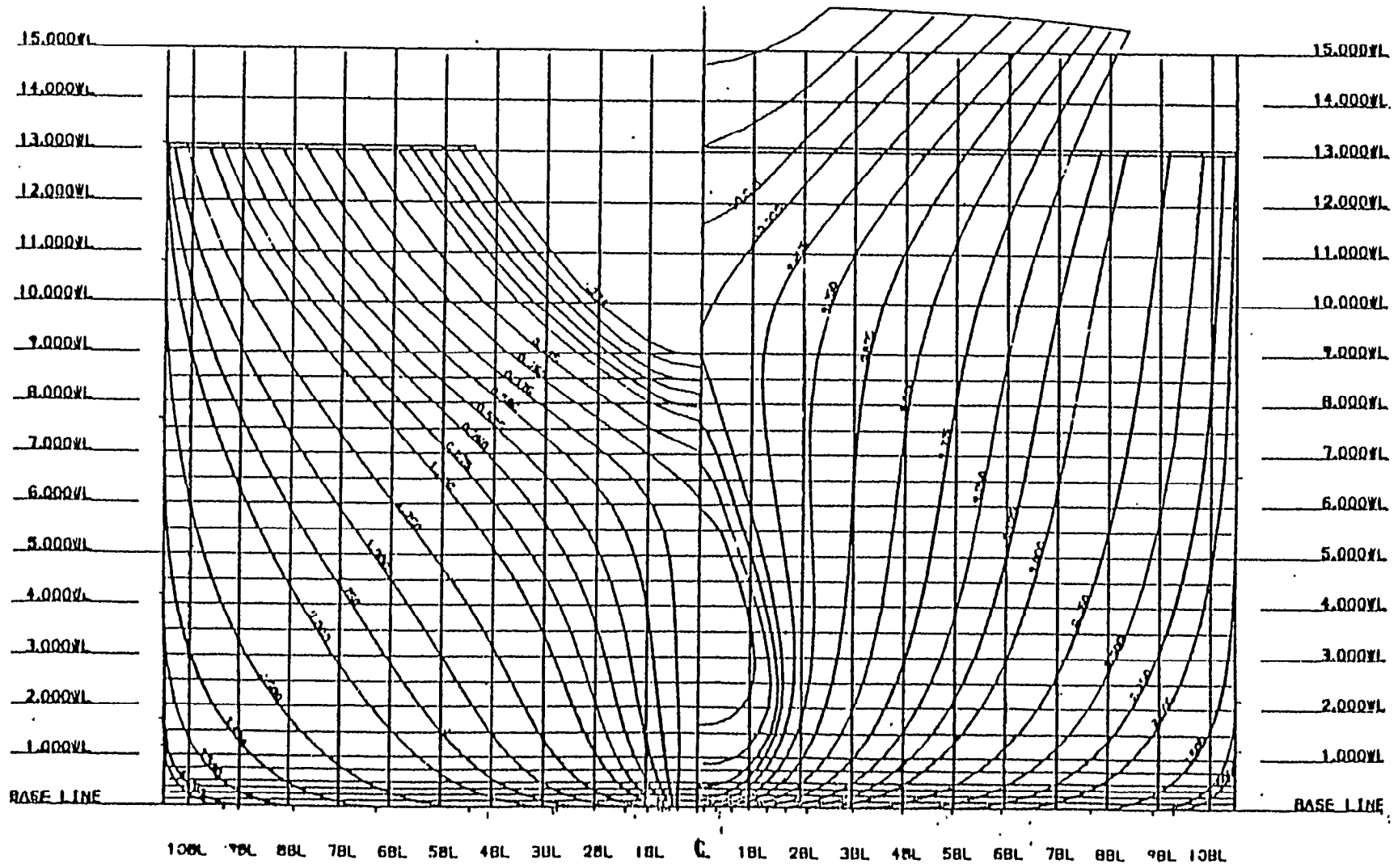
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ORDINATE NO.	0.050 M W.L.	0.125 M W.L.	0.250 M W.L.	0.375 M W.L.	0.500 M W.L.	0.750 M W.L.	1.000 M W.L.	1.500 M W.L.	2.000 M W.L.	3.000 M W.L.	4.000 M W.L.	5.000 M W.L.
-0.2878												
-0.2368												
-0.2714												
-0.2079												
-0.1443												
-0.0722												
0.0												
0.1250												
0.2500	0.400	0.400	0.400	0.400	0.245	0.175	0.135	0.100	0.090	0.090	0.090	0.090
0.3750	0.465	0.483	0.504	0.531	0.554	0.607	0.653	0.734	0.800	0.891	0.970	1.064
0.5000	0.574	0.634	0.731	0.819	0.905	1.055	1.185	1.378	1.514	1.707	1.863	2.070
0.6250	0.785	0.917	1.098	1.247	1.377	1.598	1.783	2.057	2.250	2.537	2.782	3.088
0.7500	1.119	1.317	1.572	1.768	1.931	2.204	2.429	2.771	3.022	3.394	3.725	4.127
0.8750	1.533	1.785	2.088	2.321	2.514	2.838	3.094	3.497	3.798	4.261	4.682	5.168
1.0000	1.965	2.282	2.630	2.898	3.122	3.468	3.780	4.235	4.582	5.131	5.634	6.190
1.1250	2.495	3.373	3.803	4.131	4.401	4.837	5.185	5.724	6.149	6.847	7.482	8.124
1.2500	4.154	4.585	5.069	5.436	5.739	6.224	6.608	7.203	7.680	8.480	9.178	9.833
1.3750	5.421	5.878	6.390	6.778	7.098	7.609	8.011	8.631	9.135	9.972	10.641	11.263
1.5000	6.757	7.215	7.729	8.119	8.440	8.955	9.354	9.970	10.470	11.275	11.890	12.390
1.6250	9.455	9.853	10.301	10.639	10.919	11.364	11.712	12.231	12.633	13.196	13.543	13.775
1.7500	11.804	12.095	12.411	12.645	12.837	13.138	13.370	13.699	13.912	14.117	14.185	14.200
1.8750	13.180	13.381	13.593	13.741	13.854	14.016	14.117	14.199	14.200	14.200	14.200	14.200
2.0000	13.343	13.515	13.721	13.863	13.968	14.109	14.182	14.200	14.200	14.200	14.200	14.200
2.1250	13.343	13.515	13.721	13.863	13.968	14.109	14.182	14.200	14.200	14.200	14.200	14.200
2.2500	13.343	13.515	13.721	13.863	13.968	14.109	14.182	14.200	14.200	14.200	14.200	14.200
2.3750	13.343	13.515	13.721	13.863	13.968	14.109	14.182	14.200	14.200	14.200	14.200	14.200
2.5000	13.226	13.424	13.633	13.780	13.890	14.045	14.137	14.200	14.200	14.200	14.200	14.200
2.6250	12.333	12.600	12.896	13.112	13.283	13.542	13.727	13.964	14.094	14.191	14.200	14.200
2.7500	10.632	10.995	11.400	11.703	11.949	12.388	12.635	13.064	13.358	13.706	13.870	13.920
2.8750	9.501	9.905	10.360	10.696	10.972	11.410	11.740	12.274	12.645	13.119	13.363	13.448
3.0000	8.204	8.647	9.132	9.495	9.742	10.270	10.655	11.237	11.664	12.234	12.545	12.678
3.1250	6.771	7.330	7.740	8.115	8.430	8.932	9.335	9.956	10.417	11.035	11.382	11.560
3.2500	5.250	5.715	6.224	6.607	6.920	7.428	7.834	8.458	8.918	9.530	9.881	10.077
3.3750	4.478	4.935	5.440	5.815	6.126	6.628	7.027	7.637	8.083	8.670	9.014	9.212
3.5000	3.711	4.155	4.640	5.010	5.313	5.801	6.186	6.775	7.200	7.757	8.080	8.270
3.6250	2.467	3.385	3.846	4.220	4.484	4.994	5.322	5.875	6.272	6.787	7.085	7.261
3.7500	2.244	2.430	3.061	3.387	3.657	4.091	4.436	4.940	5.301	5.760	6.032	6.184
3.8750	1.570	1.910	2.291	2.589	2.829	3.215	3.518	3.970	4.292	4.700	4.925	5.044
4.0000	0.974	1.265	1.584	1.820	2.020	2.337	2.590	2.975	3.248	3.588	3.762	3.844
4.1250	0.540	0.792	1.070	1.268	1.426	1.667	1.852	2.128	2.319	2.568	2.682	2.704
4.2500		0.375	0.704	0.910	1.070	1.315	1.485	1.708	1.848	2.004	2.047	1.987
4.3750			0.170	0.455	0.874	1.184	1.554	1.560	1.724	1.820	1.830	1.710
4.5000						0.835	1.151	1.420	1.545	1.660	1.618	1.410
4.6250								1.030	1.280	1.370	1.273	0.935
4.7500										0.625	0.523	

ORD. OFFSETS

ORD. OFFSETS 作 画



B O N J E A N * SQUARE METRE, BOTH SIDE (EXT) *										
ORDINATE NO	31	32	33	34	35	36	37	38	39	40
DISTANCE FROM AP	157.67M	162.525M	167.456M	172.375M	177.300M	179.762M	182.225M	184.687M	187.150M	189.612M
DRAFT EXT (M)										
0.075	1.02	1.69	1.53	1.33	1.09	0.96	0.83	0.69	0.55	0.41
0.150	3.06	3.60	3.27	2.05	2.36	2.08	1.80	1.50	1.21	0.92
0.275	7.34	6.06	6.25	5.40	4.56	4.05	3.51	2.96	2.40	1.84
0.400	15.00	10.20	9.31	8.19	6.05	6.10	5.31	4.50	3.67	2.85
0.525	14.49	13.60	12.43	10.97	9.21	8.23	7.19	6.11	5.01	3.92
0.775	21.02	20.53	18.85	16.72	14.12	12.67	11.12	9.51	7.86	6.22
1.025	29.29	27.62	25.43	22.65	19.24	17.31	15.26	13.10	10.90	8.69
1.525	44.53	42.17	39.02	34.98	29.45	27.09	24.01	20.76	17.41	14.04
2.025	60.06	57.08	53.05	47.79	41.19	37.30	33.27	28.91	24.30	19.81
2.525	75.71	72.19	67.34	60.94	52.79	40.05	42.90	37.41	31.67	25.86
3.025	91.56	87.56	81.96	74.46	64.78	59.10	52.99	46.25	39.28	32.19
3.525	107.49	103.00	96.79	88.23	77.05	70.43	63.16	55.33	47.10	38.70
4.025	123.49	118.72	111.79	102.21	89.53	81.97	73.63	64.67	55.10	45.37
4.525	139.53	134.45	126.91	116.35	102.20	93.70	84.28	74.06	63.25	52.14
5.025	155.60	150.24	142.13	130.61	115.01	105.56	95.07	83.63	71.49	59.00
5.525	171.73	166.12	157.47	145.01	127.95	117.57	105.99	93.33	79.85	65.94
6.025	187.03	182.00	172.02	159.43	140.95	129.64	116.97	103.00	88.25	72.89
6.525	203.44	197.90	188.70	173.90	154.00	141.76	128.01	112.89	96.69	79.87
7.025	219.04	213.00	203.61	188.41	167.09	153.92	139.09	122.74	105.17	86.86
7.525	236.15	229.71	219.02	202.92	180.20	166.11	150.21	132.62	113.67	93.86
8.025	252.25	245.67	234.45	217.44	193.37	178.32	161.34	142.52	122.19	100.85
8.525	268.36	261.53	249.07	231.96	206.44	190.52	172.40	152.43	130.71	107.04
9.025	284.46	277.44	265.29	246.40	219.56	202.73	183.62	162.35	139.24	114.82
9.525	300.57	293.35	280.71	261.01	232.67	214.93	194.76	172.26	147.76	121.70
10.025	316.67	309.26	296.13	275.53	245.79	227.13	205.89	182.18	156.28	128.74
11.025	340.80	341.08	326.97	304.57	272.02	251.53	228.16	201.99	173.32	142.62
12.025	361.09	372.90	357.81	333.61	298.25	275.91	250.42	221.81	190.33	156.47
13.025	413.30	404.72	386.65	362.65	324.40	303.33	272.70	241.62	207.33	170.34
14.025	445.44	436.47	419.42	391.63	350.66	324.69	294.94	261.42	224.37	184.31
15.025	477.65	468.29	450.26	420.67	376.91	349.16	317.33	281.41	241.68	198.67
16.025	509.85	500.11	481.10	449.71	403.22	373.73	339.88	301.65	259.36	213.57
17.025	542.06	531.92	511.93	478.75	429.61	398.46	362.67	322.26	277.58	229.21
18.025	574.27	563.74	542.77	507.79	456.13	423.40	385.80	343.37	296.50	245.79
19.025	597.23	584.58	563.30	527.68	475.04	441.62	403.18	359.75	311.69	259.63
20.025	595.23	584.58	563.30	527.68	475.04	441.62	403.18	359.75	311.69	259.63
21.025	595.23	584.58	563.30	527.68	475.04	441.62	403.18	359.75	311.69	259.63
22.025	595.23	584.58	563.30	527.68	475.04	441.62	403.18	359.75	311.69	259.63
UPP.DK.S.L. HEIGHT	18.326	18.335	18.360	18.404	18.464	18.501	18.542	18.587	18.634	18.685
BONJEAN	543.97	573.61	553.11	518.01	467.84	435.38	397.94	355.52	308.45	257.34
UPP.DK.C.L. HEIGHT	18.858	18.858	18.858	18.858	18.858	18.858	18.858	18.858	18.858	18.858
BONJEAN	595.23	584.58	563.30	527.68	475.04	441.62	403.18	359.75	311.69	259.63

ボンジヤン(EXT)

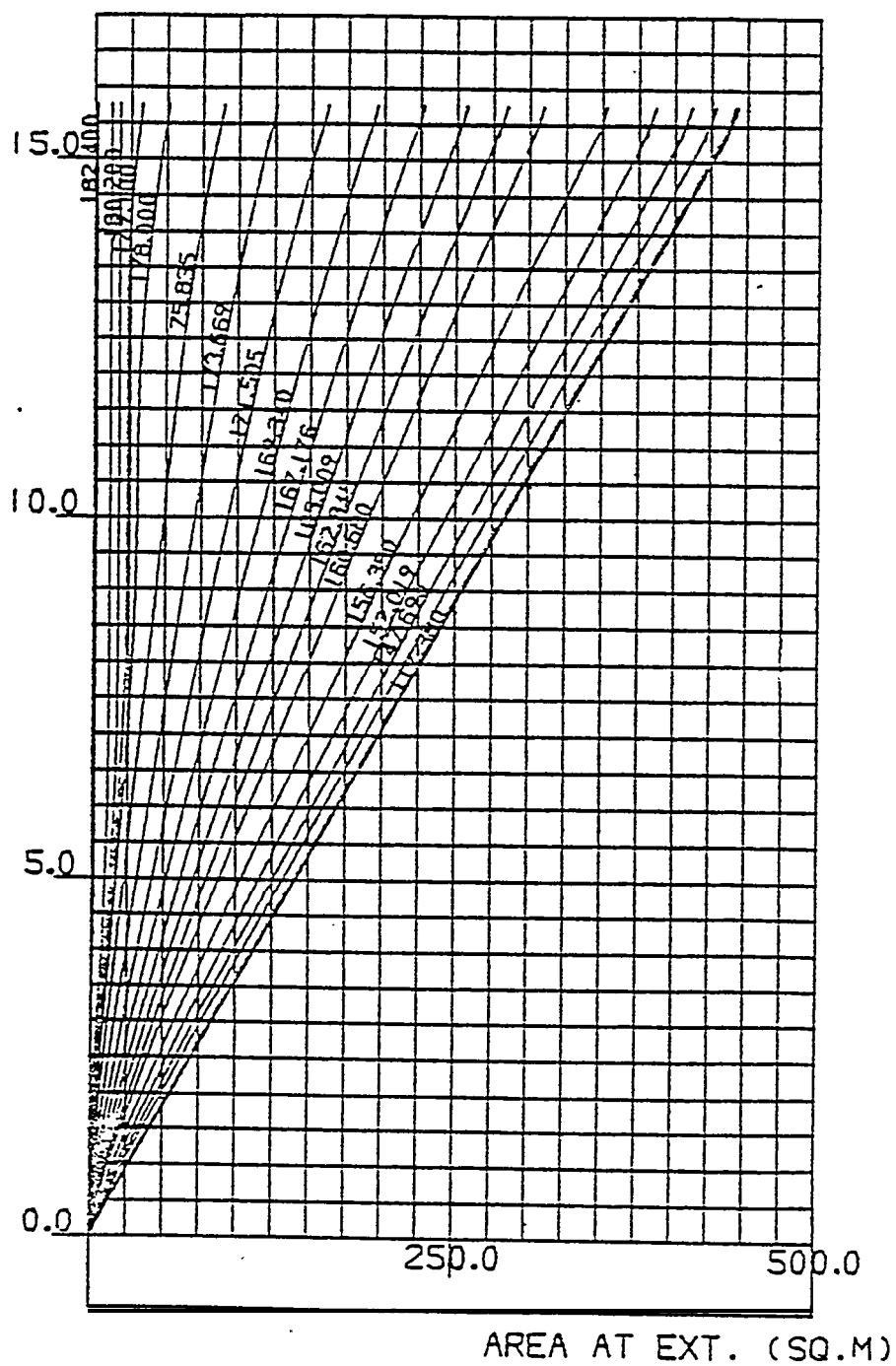
G I A Y H L E N G Y H * METER, BOTH SIDE *										
ORDINATE NO	31	32	33	34	35	36	37	38	39	40
DISTANCE FROM AP	157.633M	162.525M	167.450M	172.375M	177.300M	179.762M	182.225M	184.607M	187.150M	189.612M
DRAFT MLD (M)										
0.050	26.748	24.952	22.607	19.703	16.255	14.357	12.373	10.333	8.275	6.244
0.125	27.393	25.627	23.335	20.472	17.043	15.143	13.140	11.086	9.001	6.944
0.250	28.106	26.393	24.150	21.345	17.945	16.045	14.040	11.957	9.840	7.737
0.375	28.663	26.918	24.795	22.024	18.681	16.755	14.742	12.643	10.499	8.369
0.500	29.140	27.498	25.342	22.605	19.255	17.361	15.344	13.230	11.063	8.901
0.750	29.953	28.370	26.279	23.604	20.294	18.405	16.378	14.243	12.038	9.826
1.000	30.653	29.125	27.093	24.469	21.190	19.304	17.271	15.116	12.882	10.632
1.500	31.876	30.444	28.511	25.974	22.747	20.868	18.817	16.630	14.343	12.028
2.000	32.979	31.622	29.760	27.302	24.115	22.234	20.173	17.956	15.630	13.266
2.500	34.078	32.723	30.931	28.572	25.365	23.484	21.416	19.170	16.812	14.411
3.000	35.050	33.782	32.037	29.671	26.526	24.654	22.570	20.312	17.930	15.561
3.500	36.061	34.816	33.104	30.770	27.652	25.770	23.679	21.407	19.006	16.557
4.000	37.046	35.826	34.146	31.835	28.724	26.847	24.750	22.468	20.053	17.509
4.500	38.069	36.847	35.171	32.875	29.780	27.897	25.797	23.508	21.084	18.607
5.000	39.070	37.854	36.186	33.899	30.810	28.929	26.827	24.533	22.102	19.617
5.500	40.070	38.857	37.194	34.912	31.827	29.947	27.845	25.549	23.112	20.621
6.000	41.070	39.859	38.198	35.918	32.836	30.957	28.855	26.558	24.118	21.623
6.500	42.070	40.859	39.199	36.921	33.841	31.962	29.861	27.562	25.121	22.624
7.000	43.070	41.859	40.200	37.922	34.843	32.965	30.864	28.565	26.123	23.624
7.500	44.070	42.859	41.200	38.922	35.843	33.965	31.865	29.566	27.124	24.624
8.000	45.070	43.859	42.200	39.922	36.843	34.965	32.865	30.567	28.124	25.624
8.500	46.070	44.859	43.200	40.922	37.843	35.965	33.865	31.567	29.124	26.624
9.000	47.070	45.859	44.200	41.922	38.843	36.965	34.865	32.567	30.124	27.624
9.500	48.070	46.859	45.200	42.922	39.843	37.965	35.865	33.567	31.124	28.625
10.000	49.070	47.859	46.200	43.922	40.843	38.965	36.865	34.567	32.124	29.625
11.000	50.070	48.859	47.200	44.922	41.843	39.965	37.865	35.567	33.124	30.625
12.000	51.070	49.859	48.200	45.922	42.843	40.965	38.865	36.567	34.124	31.625
13.000	52.070	50.859	49.200	46.922	43.843	41.965	39.865	37.567	35.124	32.625
14.000	53.070	51.859	50.200	47.922	44.843	42.965	40.865	38.567	36.124	33.625
15.000	54.070	52.859	51.200	48.922	45.843	43.965	41.865	39.567	37.124	34.625
16.000	55.070	53.859	52.200	49.922	46.843	44.965	42.865	40.567	38.125	35.627
17.000	56.070	54.859	53.200	50.922	47.843	45.965	43.865	41.567	39.125	36.627
18.000	57.070	55.859	54.200	51.922	48.843	46.965	44.865	42.567	40.130	37.642
19.000	58.070	56.859	55.200	52.922	49.843	47.965	45.865	43.567	41.130	38.642
20.000	59.070	57.859	56.200	53.922	50.843	48.965	46.865	44.567	42.130	39.642
21.000	60.070	58.859	57.200	54.922	51.843	49.965	47.865	45.567	43.130	40.642
22.000	61.070	59.859	58.200	55.922	52.843	50.965	48.865	46.567	44.130	41.642
23.000	62.070	60.859	59.200	56.922	53.843	51.965	49.865	47.567	45.130	42.642
24.000	63.070	61.859	60.200	57.922	54.843	52.965	50.865	48.567	46.130	43.642
25.000	64.070	62.859	61.200	58.922	55.843	53.965	51.865	49.567	47.130	44.642
26.000	65.070	63.859	62.200	59.922	56.843	54.965	52.865	50.567	48.130	45.642
27.000	66.070	64.859	63.200	60.922	57.843	55.965	53.865	51.567	49.130	46.642
28.000	67.070	65.859	64.200	61.922	58.843	56.965	54.865	52.567	50.130	47.642
29.000	68.070	66.859	65.200	62.922	59.843	57.965	55.865	53.567	51.130	48.642
30.000	69.070	67.859	66.200	63.922	60.843	58.965	56.865	54.567	52.130	49.642
31.000	70.070	68.859	67.200	64.922	61.843	59.965	57.865	55.567	53.130	50.642
32.000	71.070	69.859	68.200	65.922	62.843	60.965	58.865	56.567	54.130	51.642
33.000	72.070	70.859	69.200	66.922	63.843	61.965	59.865	57.567	55.130	52.642
34.000	73.070	71.859	70.200	67.922	64.843	62.965	60.865	58.567	56.130	53.642
35.000	74.070	72.859	71.200	68.922	65.843	63.965	61.865	59.567	57.130	54.642
36.000	75.070	73.859	72.200	69.922	66.843	64.965	62.865	60.567	58.130	55.642
37.000	76.070	74.859	73.200	70.922	67.843	65.965	63.865	61.567	59.130	56.642
38.000	77.070	75.859	74.200	71.922	68.843	66.965	64.865	62.567	60.130	57.642
39.000	78.070	76.859	75.200	72.922	69.843	67.965	65.865	63.567	61.130	58.642
40.000	79.070	77.859	76.200	73.922	70.843	68.965	66.865	64.567	62.130	59.642
41.000	80.070	78.859	77.200	74.922	71.843	69.965	67.865	65.567	63.130	60.642
42.000	81.070	79.859	78.200	75.922	72.843	70.965	68.865	66.567	64.130	61.642
43.000	82.070	80.859	79.200	76.922	73.843	71.965	69.865	67.567	65.130	62.642
44.000	83.070	81.859	80.200	77.922	74.843	72.965	70.865	68.567	66.130	63.642
45.000	84.070	82.859	81.200	78.922	75.843	73.965	71.865	69.567	67.130	64.642
46.000	85.070	83.859	82.200	79.922	76.843	74.965	72.865	70.567	68.130	65.642
47.000	86.070	84.859	83.200	80.922	77.843	75.965	73.865	71.567	69.130	66.642
48.000	87.070	85.859	84.200	81.922	78.843	76.965	74.865	72.567	70.130	67.642
49.000	88.070	86.859	85.200	82.922	79.843	77.965	75.865	73.567	71.130	68.642
50.000	89.070	87.859	86.200	83.922	80.843	78.965	76.865	74.567	72.130	69.642
51.000	90.070	88.859	87.200	84.922	81.843	79.965	77.865	75.567	73.130	70.642
52.000	91.070	89.859	88.200	85.922	82.843	80.965	78.865	76.567	74.130	71.642
53.000	92.070	90.859	89.200	86.922	83.843	81.965	79.865	77.567	75.130	72.642
54.000	93.070	91.859	90.200	87.922	84.843	82.965	80.865	78.567	76.130	73.642
55.000	94.070	92.859	91.200	88.922	85.843	83.965	81.865	79.567	77.130	74.642
56.000	95.070	93.859	92.200	89.922	86.843	84.965	82.865	80.567	78.130	75.642
57.000	96.070	94.859	93.200	90.922	87.843	85.965	83.865	81.567	79.130	76.642
58.000	97.070	95.859	94.200	91.922	88.843	86.965	84.865	82.567	80.130	77.642
59.000	98.070	96.859	95.200	92.922	89.843	87.965	85.865	83.567	81.130	78.642
60.000	99.070	97.859	96.200	93.922	90.843	88.965	86.865	84.567	82.130	79.642
61.000	100.070	98.859	97.200	94.922	91.843	89.965	87.865	85.567	83.130	80.642
62.000	101.070	99.859	98.200	95.922	92.843	90.965	88.865	86.567	84.130	81.642
63.000	102.070	100.859	99.200	96.922	93.843	91.965	89.865	87.567	85.130	82.642
64.000	103.070	101.859	100.200	97.922	94.843	92.965	90.865	88.567	86.130	83.642
65.000	104.070	102.859	101.200	98.922	95.843	93.965	91.865	89.567	87.130	84.642
66.000	105.070	103.859	102.200	99.922	96.843	94.965	92.865	90.567	88.130	85.642
67.000	106.070	104.859	103.200	100.922	97.843	95.965	93.865	91.567	89.130	86.642
68.000	107.070	105.859	104.200	101.922	98.843	96.965	94.865	92.567	90.130	87.642
69.000	108.070	106.859	105.200	102.922	99.843	97.965	95.865	93.567	91.130	88.642
70.000	109.070	107.859	106.200	103.922	100.843	98.965	96.865	94.567	92.130	89.642
71.000	110.070	108.859	107.200	104.922	101.843	99.965	97.865	95.567	93.130	90.642
72.000	111.070	109.859	108.200	105.922	102.843	100.965	98.865	96.567	94.130	91.642
73.000	112.070	110.859	109.200	106.922	103.843	101.965	99.865	97.567	95.130	92.642
74.000	113.070	111.859	110.200	107.922	104.843	102.965	100.865	98.567	96.130	93.642
75.000	114.070	112.859	111.200	108.922	105.843	103.965	101.865	99.567	97.130	94.642
76.000	115.070	113.859	112.200	109.922	106.843	104.965	102.865	100.567	98.130	95.642
77.000	116.070	114.859	113.200	110.922	107.843	105.965	103.865	101.567	99.130	96.642
78.000	117.070	115.859	114.200	111.922	108.843	106.965	104.865	102.567	100.130	97.642
79.000	118.070	116.859	115.200	112.922	109.843	107.965	105.865	103.567	101.130	98.642
80.000	119.070	117.859	116.2							

ボンジャン(作画)

BONJEAN CURVES

(FORE BODY)

DRAFT IN M
(EXT)



***** APPEN MAP VOLUME *****

SONHAR DOOM 1

COMPARTMENT NO. = 1

W.L.	VOLUME	K.G.MT.	C.L.MT.	LCB MT.	M.P.A.	LCF MT.	CL.F MT.	I.(TRV.)	I.(LONG)	
-2.900	0.20	0.	-1.	-0.	29.	7.	962.	-0.	3.	137670.
-2.800	1.11	0.	-3.	-0.	150.	11.	1523.	-0.	8.	217650.
-2.600	3.71	0.	-10.	-0.	529.	16.	2321.	-0.	19.	330797.
-2.500	5.45	0.	-15.	-0.	778.	18.	2635.	-0.	25.	374047.
-2.400	7.43	0.	-19.	-0.	1039.	21.	3044.	-0.	31.	432545.
-2.300	12.10	0.	-30.	-0.	1723.	26.	3629.	-0.	42.	514691.
-2.000	17.50	0.	-42.	-0.	2498.	29.	4088.	-0.	52.	578930.
-1.800	21.60	0.	-53.	-0.	3362.	32.	4572.	-0.	61.	646261.
-1.600	30.30	0.	-65.	-0.	4308.	34.	4869.	-0.	68.	687467.
-1.500	35.90	0.	-70.	-0.	4805.	36.	5074.	-0.	71.	715846.
-1.400	37.54	0.	-75.	-0.	5319.	37.	5208.	-0.	73.	734341.
-1.200	45.07	0.	-85.	-0.	6379.	38.	5381.	-0.	76.	756184.
-1.000	52.84	0.	-94.	-0.	7472.	40.	5565.	-0.	77.	783100.
-0.800	60.79	0.	-101.	-0.	8592.	40.	5614.	-0.	75.	789540.
-0.600	68.76	0.	-106.	-0.	9711.	40.	5566.	-0.	71.	782559.
-0.500	72.70	0.	-109.	-0.	10264.	39.	5505.	-0.	68.	773665.
-0.400	76.59	0.	-110.	-0.	10811.	39.	5425.	-0.	64.	762357.
-0.200	84.14	0.	-113.	-0.	11872.	37.	5166.	-0.	55.	725967.
0.0	91.23	0.	-113.	-0.	12868.	34.	4781.	-0.	44.	671874.
0.050	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.100	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.150	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.200	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.250	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.300	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.350	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.400	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.450	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.500	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.550	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.600	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.650	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.700	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.750	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.800	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.850	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.900	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
0.950	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.000	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.050	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.100	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.150	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.200	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.250	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.300	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.350	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.400	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.450	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.500	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.550	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.600	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.650	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.700	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.750	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.800	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.850	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.900	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
1.950	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.000	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.050	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.100	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.150	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.200	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.250	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.300	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.350	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.400	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.450	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.500	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.550	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.600	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.650	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.700	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.750	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.800	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.850	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.900	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
2.950	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.000	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.050	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.100	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.150	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.200	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.250	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.300	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.350	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.400	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.450	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.500	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.550	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.600	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.650	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.700	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.750	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.800	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.850	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.900	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
3.950	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.000	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.050	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.100	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.150	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.200	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.250	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.300	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.350	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.400	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.450	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.500	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.550	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.600	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.650	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.700	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.750	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.800	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.850	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.900	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
4.950	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.000	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.050	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.100	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.150	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.200	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.250	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.300	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.350	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.400	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.450	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.500	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.550	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.600	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.650	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.700	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.750	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.800	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.850	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.900	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
5.950	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
6.000	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
6.050	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
6.100	91.23	0.	-113.	-0.	12868.	0.	0.	0.	0.	0.
6.150										

DATA FOR HYDROSTATIC CURVES * METRIC SYSTEM *													
DRAFT (EXT) (M)	DISPL (MT)	DISPL (4LO) (MT)	APPRN (MT)	D.CONR (MT)	M T C (MT-4)	T P C (MT)	K D (M)	L C B (M)	L C F (M)	T K H (M)	L K H (M)	T C B (M)	T C F (M)
0.073	211.43	156.72	54.76	24.31	330.52	31.95	0.025	-5.510	-5.524	961.544	27069.039	-0.001	-0.000
0.144	456.78	400.31	56.55	26.09	297.22	32.95	0.063	-5.531	-5.564	400.004	11769.984	0.001	-0.000
0.273	877.02	819.29	58.60	27.17	297.71	34.04	0.127	-5.551	-5.581	200.442	5873.617	-0.000	-0.000
0.394	1310.21	1230.00	60.72	27.81	305.15	34.85	0.191	-5.564	-5.592	143.217	4036.061	-0.000	-0.000
0.523	1751.39	1649.70	61.60	28.27	312.60	35.49	0.255	-5.572	-5.601	109.939	3691.839	-0.000	-0.000
0.773	2654.34	2543.33	64.00	28.95	327.45	36.52	0.304	-5.591	-5.634	75.941	2137.078	-0.000	-0.000
1.023	3579.66	3512.60	66.06	29.40	339.30	37.24	0.513	-5.602	-5.624	58.305	1643.057	-0.000	-0.000
1.523	5471.48	5401.60	69.61	29.96	359.14	38.25	0.771	-5.619	-5.653	40.066	1137.626	-0.000	-0.000
2.023	7405.43	7332.17	73.26	30.32	373.43	38.94	1.029	-5.622	-5.656	30.863	874.420	-0.000	-0.000
3.013	11356.11	11277.29	78.89	30.80	393.85	39.40	1.544	-5.576	-5.567	21.764	607.726	-0.000	-0.000
4.023	15383.93	15299.64	84.33	31.10	407.76	40.57	2.059	-5.476	-5.010	17.372	461.132	-0.000	-0.000
5.023	19461.54	19374.80	89.78	31.31	418.34	40.91	2.572	-5.327	-4.509	14.847	374.617	-0.000	-0.000
6.023	23586.47	23491.75	95.22	31.47	427.72	41.35	3.086	-5.130	-3.868	13.404	317.171	-0.000	-0.000
7.023	27744.91	27645.81	101.63	31.63	430.40	41.75	3.599	-4.002	-3.081	12.489	277.307	-0.000	-0.000
8.023	31951.37	31844.67	106.91	31.78	432.37	42.24	4.113	-4.582	-2.126	11.941	249.598	-0.000	-0.000
9.013	36222.51	36099.64	112.87	31.94	473.67	42.60	4.631	-3.771	-0.403	11.647	231.181	-0.000	-0.000
10.023	40549.77	40421.83	118.95	32.10	496.60	43.57	5.151	-3.749	0.373	11.517	217.311	-0.000	-0.000
11.023	44940.27	44816.47	124.78	32.25	521.58	44.30	5.676	-3.332	1.499	11.514	206.693	-0.000	-0.000
12.023	49411.14	49280.27	130.57	32.40	545.28	45.00	6.204	-2.855	2.333	11.614	197.435	-0.000	-0.000
13.023	53950.03	53813.80	136.29	32.44	567.87	45.66	6.734	-2.390	2.953	11.785	189.043	-0.000	-0.000
14.023	58551.90	58413.64	142.01	32.63	591.17	46.33	7.267	-1.952	3.349	12.014	182.129	-0.000	-0.000
15.023	63225.77	63077.49	147.73	32.74	613.65	46.90	7.802	-1.552	3.543	12.267	175.741	-0.000	-0.000

DATA FOR HYDROSTATIC CURVES * METRIC SYSTEM *							
DRAFT (EXT) (M)	C B	C P	C W	C H	A H (SQ.M)	A M (SQ.M)	H S A (SQ.M)
0.073	0.6217	0.6683	0.6336	0.9303	3116.70	1.32	3117.17
0.146	0.6350	0.6760	0.6535	0.9394	3214.29	3.33	3218.94
0.219	0.6500	0.6843	0.6752	0.9499	3321.02	6.74	3335.26
0.292	0.6611	0.6907	0.6913	0.9571	3400.30	10.19	3427.63
0.321	0.6703	0.6961	0.7040	0.9629	3462.70	13.67	3506.00
0.371	0.6850	0.7050	0.7243	0.9717	3567.60	20.70	3643.02
1.023	0.6967	0.7175	0.7307	0.9778	3633.35	27.77	3760.47
1.521	0.7142	0.7250	0.7507	0.9851	3731.82	41.97	3973.52
2.023	0.7271	0.7353	0.7724	0.9888	3799.34	56.17	4169.66
3.023	0.7456	0.7512	0.7913	0.9926	3892.20	84.57	4542.49
4.023	0.7586	0.7629	0.8035	0.9944	3952.07	112.97	4904.03
5.023	0.7686	0.7720	0.8176	0.9955	3997.13	141.37	5261.87
6.023	0.7765	0.7794	0.8282	0.9963	4034.36	169.77	5619.37
7.023	0.7833	0.7858	0.8381	0.9968	4073.46	198.17	5977.66
8.023	0.7895	0.7917	0.8478	0.9972	4120.91	226.57	6339.36
9.023	0.7956	0.7975	0.8565	0.9975	4183.46	254.97	6720.34
10.023	0.8017	0.8035	0.8641	0.9978	4250.50	283.37	7102.56
11.023	0.8081	0.8097	0.8706	0.9980	4321.75	311.77	7497.03
12.023	0.8145	0.8160	0.8763	0.9981	4390.25	340.17	7867.54
13.023	0.8210	0.8224	0.8815	0.9983	4454.59	368.57	8243.90
14.023	0.8276	0.8289	0.8869	0.9984	4520.14	396.97	8623.29
15.023	0.8341	0.8353	0.8930	0.9985	4575.70	425.36	9000.57

排水量 (BANK 2/2)

排水量テーブル(1/2)

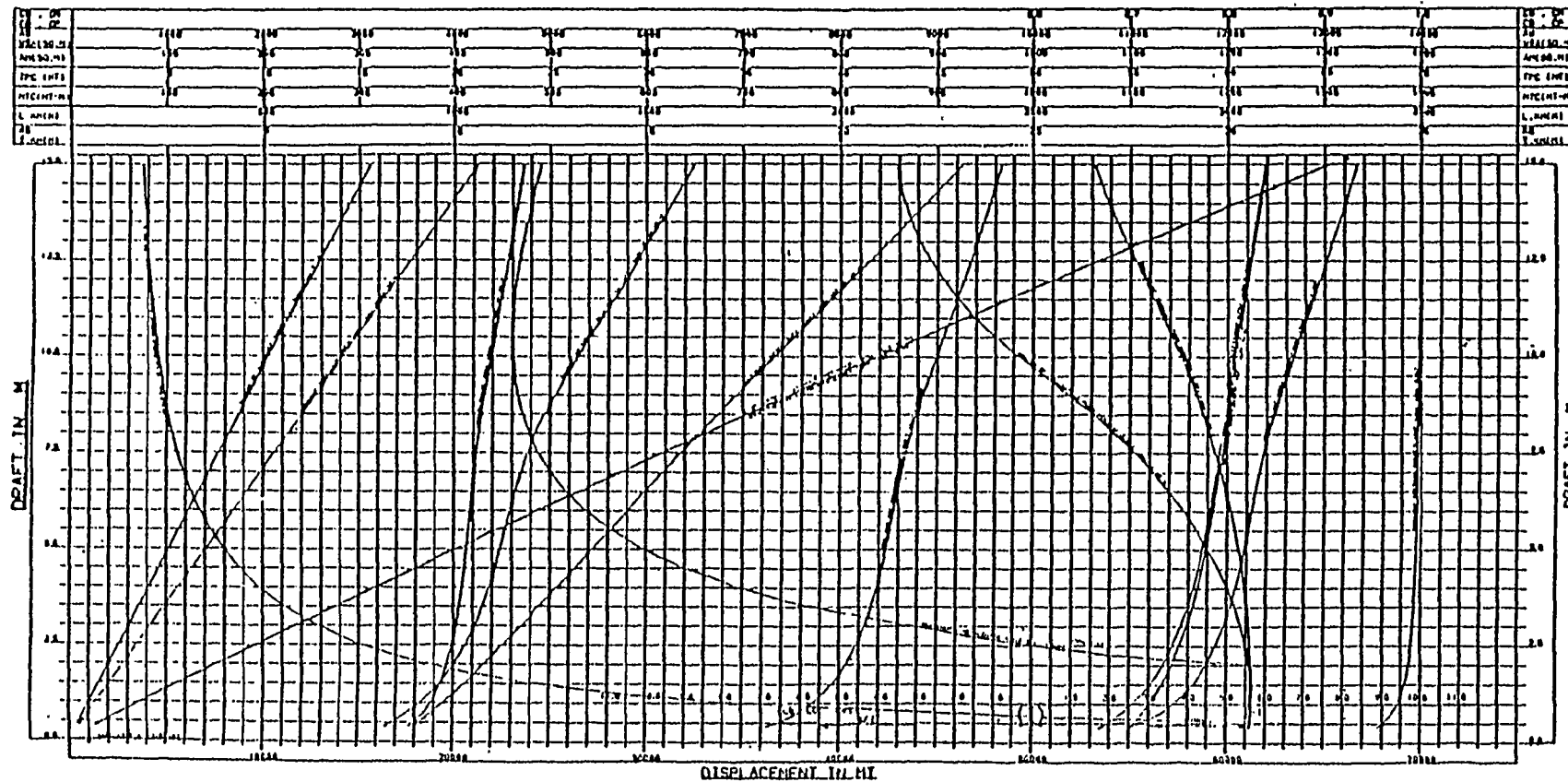
ORIFT (TEXT)	DISPT (M)	DIFF (MT)	D.CONQ. (MT)	H.T.C (MT-M)	L.C.P (M)	L.C.P (M)	T.MH (M)
2.00	9399.	0.0	39.10	542.63	-9.17	-8.74	39.77
2.10	9899.	501.00	39.18	546.40	-9.15	-8.72	37.62
2.20	10401.	1002.00	39.25	549.97	-9.13	-8.68	36.09
2.30	10904.	1503.00	39.32	553.38	-9.11	-8.64	34.68
2.40	11409.	2003.00	39.40	556.65	-9.09	-8.60	33.39
2.50	11915.	2504.00	39.45	559.80	-9.06	-8.56	32.20
2.60	12424.	3009.00	39.51	562.83	-9.04	-8.52	31.12
2.70	12934.	3510.00	39.54	565.75	-9.02	-8.48	30.11
2.80	13446.	4012.00	39.62	568.54	-9.00	-8.44	29.18
2.90	13959.	4515.00	39.67	571.24	-8.98	-8.40	28.31
3.00	14473.	5018.00	39.72	573.85	-8.96	-8.36	27.50
3.10	14988.	5521.00	39.77	576.37	-8.94	-8.32	26.75
3.20	15504.	6024.00	39.82	578.81	-8.92	-8.28	26.04
3.30	16021.	6527.00	39.86	581.17	-8.89	-8.24	25.37
3.40	16539.	7030.00	39.91	583.44	-8.87	-8.19	24.77
3.50	17058.	7533.00	39.95	585.66	-8.85	-8.15	24.19
3.60	17577.	8036.00	39.99	587.82	-8.83	-8.11	23.64
3.70	18097.	8539.00	40.02	589.90	-8.81	-8.07	23.12
3.80	18618.	9042.00	40.06	591.92	-8.79	-8.02	22.64
3.90	19140.	9545.00	40.10	593.90	-8.77	-7.98	22.18
4.00	19663.	10048.00	40.13	595.83	-8.74	-7.93	21.74
4.10	20186.	10551.00	40.16	597.72	-8.72	-7.89	21.33
4.20	20710.	11054.00	40.20	599.55	-8.70	-7.84	20.94
4.30	21235.	11557.00	40.23	601.34	-8.68	-7.79	20.57
4.40	21761.	12060.00	40.26	603.09	-8.66	-7.74	20.22
4.50	22287.	12563.00	40.29	604.79	-8.63	-7.70	19.89
4.60	22813.	13066.00	40.32	606.46	-8.61	-7.65	19.57
4.70	23340.	13569.00	40.34	608.09	-8.59	-7.60	19.26
4.80	23868.	14072.00	40.37	609.68	-8.57	-7.54	18.98
4.90	24397.	14575.00	40.40	611.24	-8.54	-7.49	18.70
5.00	24927.	15078.00	40.42	612.78	-8.52	-7.44	18.44
5.10	25457.	15581.00	40.45	614.29	-8.50	-7.38	18.19
5.20	25988.	16084.00	40.47	615.78	-8.48	-7.33	17.95
5.30	26521.	16587.00	40.50	617.28	-8.45	-7.27	17.72
5.40	27054.	17090.00	40.52	618.74	-8.43	-7.22	17.50
5.50	27587.	17593.00	40.54	620.18	-8.40	-7.16	17.29
5.60	28122.	18096.00	40.56	621.59	-8.38	-7.10	17.09
5.70	28653.	18599.00	40.58	622.99	-8.36	-7.04	16.90
5.80	29186.	19102.00	40.60	624.36	-8.33	-6.98	16.72
5.90	29720.	19605.00	40.62	625.72	-8.31	-6.92	16.54
6.00	30255.	20108.00	40.64	627.08	-8.28	-6.85	16.38
6.10	30790.	20611.00	40.66	628.43	-8.26	-6.79	16.21
6.20	31324.	21114.00	40.68	629.77	-8.23	-6.72	16.06
6.30	31859.	21617.00	40.70	631.10	-8.20	-6.66	15.91
6.40	32394.	22120.00	40.72	632.42	-8.18	-6.59	15.77
6.50	32931.	22623.00	40.74	633.74	-8.15	-6.52	15.64
6.60	33469.	23126.00	40.76	635.04	-8.12	-6.45	15.51
6.70	34007.	23629.00	40.78	636.33	-8.10	-6.38	15.38
6.80	34544.	24132.00	40.79	637.61	-8.07	-6.31	15.26
6.90	35083.	24635.00	40.81	638.91	-8.04	-6.23	15.14
7.00	35622.	25138.00	40.83	640.23	-8.01	-6.15	15.04

排水量テーブル(2/2)

DRAFT (FXT) (M)	DISPT (MLO) (MT)	T P C (MT)	W S A (SQ.M)	A M (SQ.M)	A W (SQ.M)	K N (M)	L K H (M)	C D	C P	C W	C H
2.00	9297.	50.12	5256.3	62.0	4699.4	1.62	3130.3	0.7240	0.7424	0.7730	0.9752
2.50	11921.	50.41	5473.0	70.1	4957.2	1.27	926.0	0.7346	0.7494	0.7715	0.9802
3.00	14376.	51.37	5685.9	94.2	5017.0	1.53	702.6	0.7432	0.7556	0.7901	0.9836
3.50	16957.	51.04	5894.2	110.3	5057.3	1.79	678.2	0.7505	0.7612	0.7972	0.9859
4.00	19559.	52.23	6100.1	126.4	5095.5	2.05	599.0	0.7568	0.7662	0.8033	0.9877
4.50	22179.	52.57	6354.5	142.5	5128.6	2.30	536.9	0.7623	0.7707	0.8005	0.9901
5.00	24815.	52.07	6507.9	158.6	5157.6	2.56	486.9	0.7671	0.7747	0.8131	0.9902
5.50	27469.	53.13	6710.9	174.7	5183.7	2.82	445.7	0.7715	0.7705	0.8172	0.9911
6.00	30129.	53.38	6913.8	190.8	5207.6	3.07	411.4	0.7755	0.7819	0.8209	0.9918
6.50	32803.	53.61	7116.7	206.9	5230.0	3.33	382.4	0.7791	0.7851	0.8245	0.9925
7.00	35489.	53.83	7320.7	223.0	5251.4	3.59	357.7	0.7825	0.7880	0.8270	0.9930
7.50	38186.	54.05	7542.9	239.1	5273.7	3.84	336.5	0.7857	0.7900	0.8313	0.9935
8.00	40894.	54.29	7743.2	255.2	5296.9	4.10	318.6	0.7886	0.7935	0.8350	0.9939
8.50	43615.	54.56	7940.9	271.3	5322.7	4.36	303.4	0.7915	0.7961	0.8391	0.9942
9.00	46350.	54.86	8156.6	287.4	5351.8	4.62	290.5	0.7943	0.7986	0.8437	0.9946
9.50	49102.	55.19	8377.2	303.5	5384.4	4.88	279.7	0.7970	0.8012	0.8488	0.9948
10.00	51864.	55.52	8589.4	319.6	5416.6	5.13	269.9	0.7997	0.8037	0.8539	0.9951
10.50	54634.	55.86	8803.8	335.7	5449.6	5.39	261.2	0.8024	0.8062	0.8591	0.9953
11.00	57435.	56.20	9019.4	351.8	5483.7	5.65	253.4	0.8051	0.8087	0.8644	0.9955
11.50	60274.	56.55	9235.5	367.9	5517.1	5.91	246.4	0.8078	0.8113	0.8697	0.9957
12.00	63110.	56.90	9451.8	384.0	5551.2	6.18	240.0	0.8105	0.8139	0.8751	0.9959
12.50	65963.	57.25	9667.7	400.1	5585.0	6.44	234.1	0.8132	0.8164	0.8804	0.9961
13.00	68834.	57.59	9883.3	416.2	5618.8	6.70	228.7	0.8159	0.8190	0.8858	0.9962
13.50	71722.	57.94	10097.5	432.3	5652.8	6.96	223.7	0.8186	0.8216	0.8911	0.9964
14.00	74628.	58.29	10311.4	448.4	5686.5	7.23	219.0	0.8213	0.8242	0.8964	0.9965
14.50	77550.	58.62	10526.2	464.5	5718.9	7.49	214.6	0.8240	0.8268	0.9015	0.9966
15.00	80499.	58.95	10741.1	480.6	5751.0	7.75	210.4	0.8267	0.8294	0.9066	0.9967
15.50	83445.	59.28	10954.0	496.7	5783.7	8.02	206.6	0.8293	0.8319	0.9118	0.9968
16.00	86417.	59.62	11168.9	512.8	5816.4	8.28	203.1	0.8320	0.8345	0.9169	0.9969

HYDROSTATIC CURVES

LENGTH O.D. 107.73M
 LENGTH O.D. 170.00M
 BREADTH (M) 25.00M
 DEPTH (M) 10.00M
 SEA DENSITY 1.025



排水量等曲線

STABILITY CROSS CURVES									
** ASSUMED KG = 7.000 M **									
SUBMERGED DISPLACEMENT									
98649.75 MT									
UNDER UPPER DECK									
ANGLE	0.0 DEG.	ANGLE	5.0 DEG.	ANGLE	10.0 DEG.	ANGLE	15.0 DEG.	ANGLE	20.0 DEG.
DISPT	GZ	DISPT	GZ	DISPT	GZ	DISPT	GZ	DISPT	GZ
(T)	(M)	(T)	(M)	(T)	(M)	(T)	(M)	(T)	(M)
5749.99	0.0	1417.73	13.782	932.27	15.431	790.97	15.365	737.02	14.787
11499.97	0.0	5670.91	0.150	3779.00	12.381	3163.88	13.224	2940.07	13.175
17249.96	0.0	2219.37	3.697	8395.43	9.331	7118.70	11.383	6633.16	11.562
23099.96	0.0	18975.46	2.398	14916.30	6.281	12655.49	8.941	11792.26	9.949
28749.96	0.0	25731.57	1.719	22666.88	3.984	19774.71	6.800	18425.43	8.337
34499.96	0.0	32407.68	1.249	30444.47	2.912	28337.13	4.788	26532.65	6.724
40249.96	0.0	39243.75	1.129	38222.23	2.336	37168.54	3.658	36064.23	5.148
45999.96	0.0	45999.86	0.972	45999.95	2.004	45999.95	3.057	45999.87	4.178
51749.96	0.0	52755.98	0.807	53777.72	1.811	54831.28	2.730	55935.47	3.684
57499.96	0.0	59512.04	0.655	61555.37	1.703	63662.69	2.562	65610.37	3.374
63249.96	0.0	66268.12	0.627	69333.12	1.653	72340.37	2.454	74361.62	3.018
68999.96	0.0	73024.25	0.617	77078.00	1.639	80187.00	2.236	82119.50	2.635
74749.96	0.0	79780.25	0.618	84264.94	1.528	87074.62	1.943	88584.19	2.222
80499.87	0.6	86473.19	0.815	90558.44	1.300	92605.75	1.577	93574.81	1.814
86249.81	0.6	92453.62	0.687	95463.44	0.983	96559.12	1.214	97091.44	1.465
92049.75	0.0	98649.75	0.325	98649.75	0.648	98649.75	0.968	98649.75	1.277

INFLOW ANGLE				
DISPT	DISPL	DISPT	DISPT	DISPT
91999.41	83934.94	75177.75	67350.62	58514.70
** FOR REFERENCE **				
INFLOW ANGLE 14.03 DEG				
AT DISPT 68999.87 MT				
X = 20.000 M FROM A.P.				
Y = 20.000 M FROM C.L.				
Z = 20.000 M FROM B.L.				

G Z (BANK)

RIGHTING LEVER (G°2) TABLE ** UNIT - MEYER **							
UNDER UPPER DECK							
INCLIN. ANGLE VALUE OF SIN	5 0.087	10 0.174	15 0.259	20 0.342	25 0.423	30 0.500	35 0.574
DISPT (MT)							
10000.	1.337	2.409	3.545	3.985	4.122	4.083	3.928
10500.	1.249	2.474	3.398	3.860	4.017	4.000	3.869
11000.	1.175	2.338	3.252	3.740	3.918	3.921	3.811
11500.	1.101	2.212	3.121	3.625	3.822	3.844	3.757
12000.	1.036	2.093	2.996	3.511	3.737	3.774	3.705
12500.	0.981	1.980	2.865	3.404	3.642	3.703	3.653
13000.	0.929	1.877	2.747	3.298	3.558	3.637	3.605
13500.	0.884	1.781	2.638	3.196	3.474	3.572	3.557
14000.	0.839	1.690	2.530	3.098	3.393	3.508	3.510
14500.	0.800	1.608	2.422	3.003	3.317	3.448	3.467
15000.	0.767	1.532	2.321	2.908	3.242	3.388	3.424
15500.	0.728	1.466	2.224	2.820	3.167	3.330	3.381
16000.	0.695	1.401	2.133	2.733	3.097	3.275	3.341
16500.	0.663	1.343	2.042	2.647	3.027	3.220	3.302
17000.	0.633	1.286	1.961	2.567	2.957	3.166	3.263
17500.	0.606	1.233	1.882	2.488	2.883	3.116	3.230
18000.	0.582	1.184	1.803	2.413	2.828	3.066	3.196
18500.	0.559	1.134	1.734	2.339	2.764	3.019	3.163
19000.	0.537	1.092	1.671	2.266	2.700	2.972	3.132
19500.	0.516	1.050	1.613	2.195	2.641	2.926	3.102
20000.	0.498	1.008	1.554	2.126	2.582	2.882	3.074
20500.	0.480	0.972	1.503	2.062	2.523	2.839	3.046
21000.	0.462	0.938	1.453	1.998	2.469	2.796	3.017
21500.	0.445	0.907	1.403	1.935	2.415	2.754	2.989
22000.	0.429	0.874	1.359	1.878	2.361	2.715	2.961
22500.	0.416	0.844	1.316	1.823	2.310	2.676	2.933
23000.	0.402	0.821	1.273	1.767	2.261	2.636	2.905
23500.	0.389	0.796	1.236	1.717	2.212	2.597	2.875
24000.	0.377	0.773	1.200	1.668	2.165	2.561	2.845
24500.	0.367	0.750	1.163	1.626	2.120	2.526	2.813
25000.	0.356	0.728	1.131	1.584	2.075	2.490	2.782
25500.	0.346	0.706	1.100	1.544	2.032	2.451	2.751
26000.	0.336	0.690	1.072	1.508	1.990	2.424	2.719
26500.	0.326	0.672	1.046	1.473	1.951	2.397	2.688
27000.	0.319	0.654	1.019	1.437	1.912	2.361	2.656
27500.	0.311	0.637	0.997	1.404	1.873	2.330	2.625
28000.	0.304	0.623	0.974	1.376	1.837	2.299	2.593
28500.	0.296	0.608	0.952	1.346	1.802	2.268	2.561
29000.	0.292	0.596	0.934	1.318	1.768	2.237	2.528
29500.	0.285	0.584	0.915	1.292	1.734	2.204	2.495
30000.	0.279	0.572	0.897	1.267	1.704	2.174	2.461

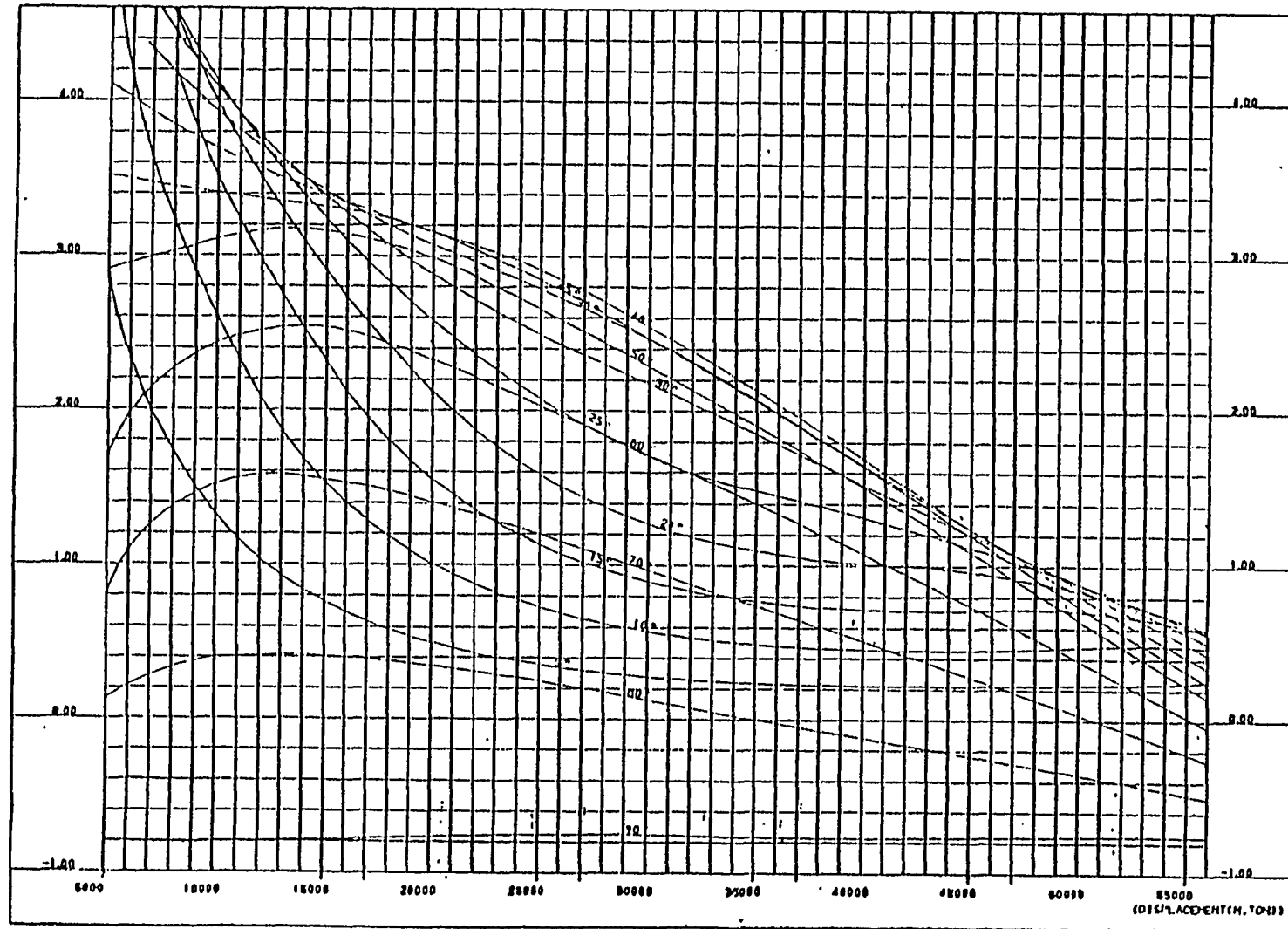
CROSS CURVE OF STABILITY

NOTE :

----- CROSS CURVE AT UNDER UPP. DECK
 _____ AT INCLUDE STRUCTURE

(ASSUMED GZ (H))

ASSUMED KG = 9.000 (H)



G Z (作 画)

IN FLOW ANGLE

UND. UPP. DECK

INCLIN. ANGLE	0	5	10	15	20
DISP'T (HT)	66177.20	66170.44	66176.37	66078.01	64557.16
INCLIN. ANGLE	25	30	35	40	45
DISP'T (HT)	61569.74	57738.21	53199.02	47940.11	42196.07
INCLIN. ANGLE	50	55	60	65	70
DISP'T (HT)	36636.00	31989.85	27714.17	23839.45	20220.76
INCLIN. ANGLE	75	80	85	90	
DISP'T (HT)	17007.75	14009.29	11220.92	8624.49	

** FOR REFERENCE **

INFLOW ANGLE 43.89 DEG
AT DISP'T 43465.42 HT

INFLOW ANGLE POINT
X = 24.000 M FROM A.P.
Y = 9.600 M FROM C.L.
Z = 21.481 M FROM B.L.

海 水 流 入 角

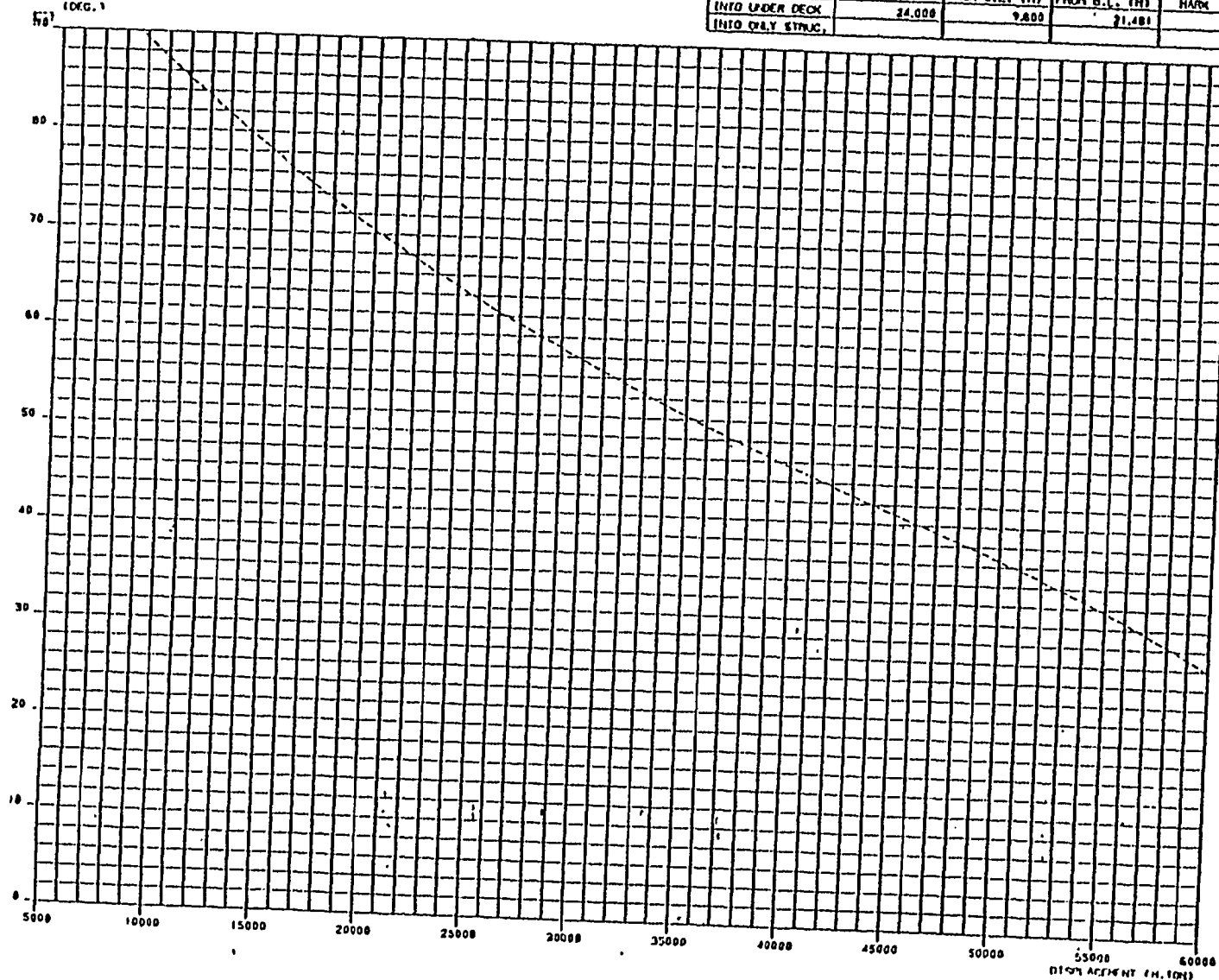
海水流入角

(17)

CURVE OF INFLOW ANGLE

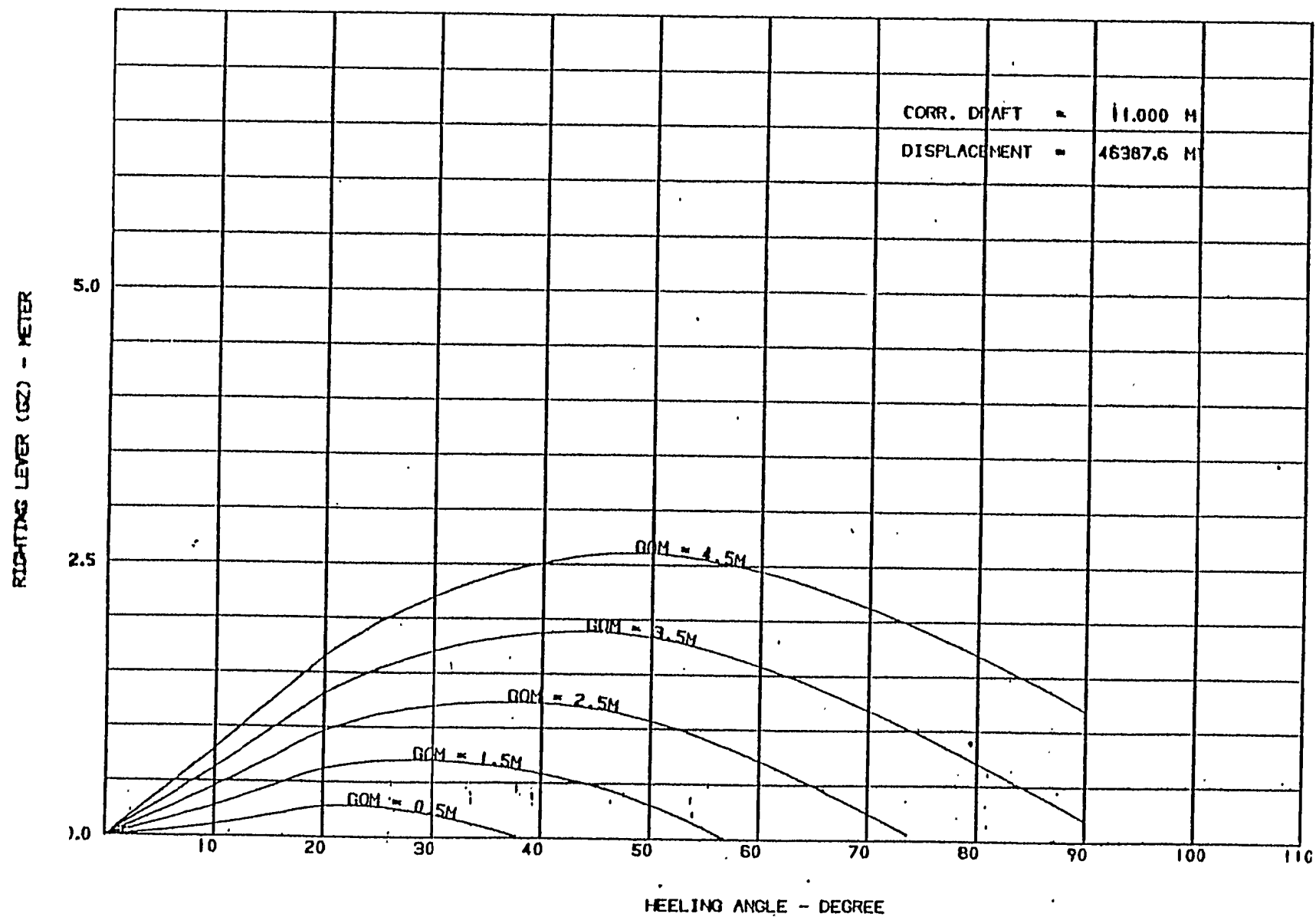
INFLING ANGLE
(DEG.)

INFLOW POINT	FROM A.P. (M)	FROM C.L. (M)	FROM B.L. (M)	MARK
INTO UNDER DECK	24.000	9.800	21.481	
INTO ONLY STRUC.				



RIGHTING LEVER (GZ) FOR OPERATIONAL INFORMATION (UNIT BY METRIC)										
NO. 1	DRAFT = 10.000 M	DISPLACEMENT = 195609.7 MT								
INCLINING ANGLE (DEG.)	10	20	30	40	50	60	70	80	90	ON BUT NOT REACHED
8.000	GZ 1.473	GZ 2.913	GZ 2.547	GZ 1.020	GZ -1.669	GZ -3.051	GZ -8.665	GZ -12.216	GZ -15.432	
10.000	1.820	3.597	3.547	2.305	-0.137	-3.319	-6.786	-10.246	-13.435	
12.000	2.167	4.281	4.547	3.591	1.395	-1.587	-4.906	-8.276	-11.438	
14.000	2.514	4.965	5.547	4.076	2.927	0.145	-3.027	-6.307	-9.441	
16.000	2.862	5.649	6.547	4.162	4.459	1.877	-1.147	-4.337	-7.442	
18.000	3.209	6.333	7.547	7.448	5.991	3.609	0.732	-2.368	-5.443	
20.000	3.556	7.017	8.547	8.733	7.523	5.341	2.611	-0.398	-3.445	
22.000	3.904	7.701	9.547	10.019	9.055	7.073	4.491	1.572	-1.444	
24.000	4.251	8.385	10.547	11.304	10.587	8.805	6.370	3.541	0.558	
26.000	4.598	9.069	11.547	12.590	12.119	10.537	8.249	5.511	2.561	

吃水別復元力曲線



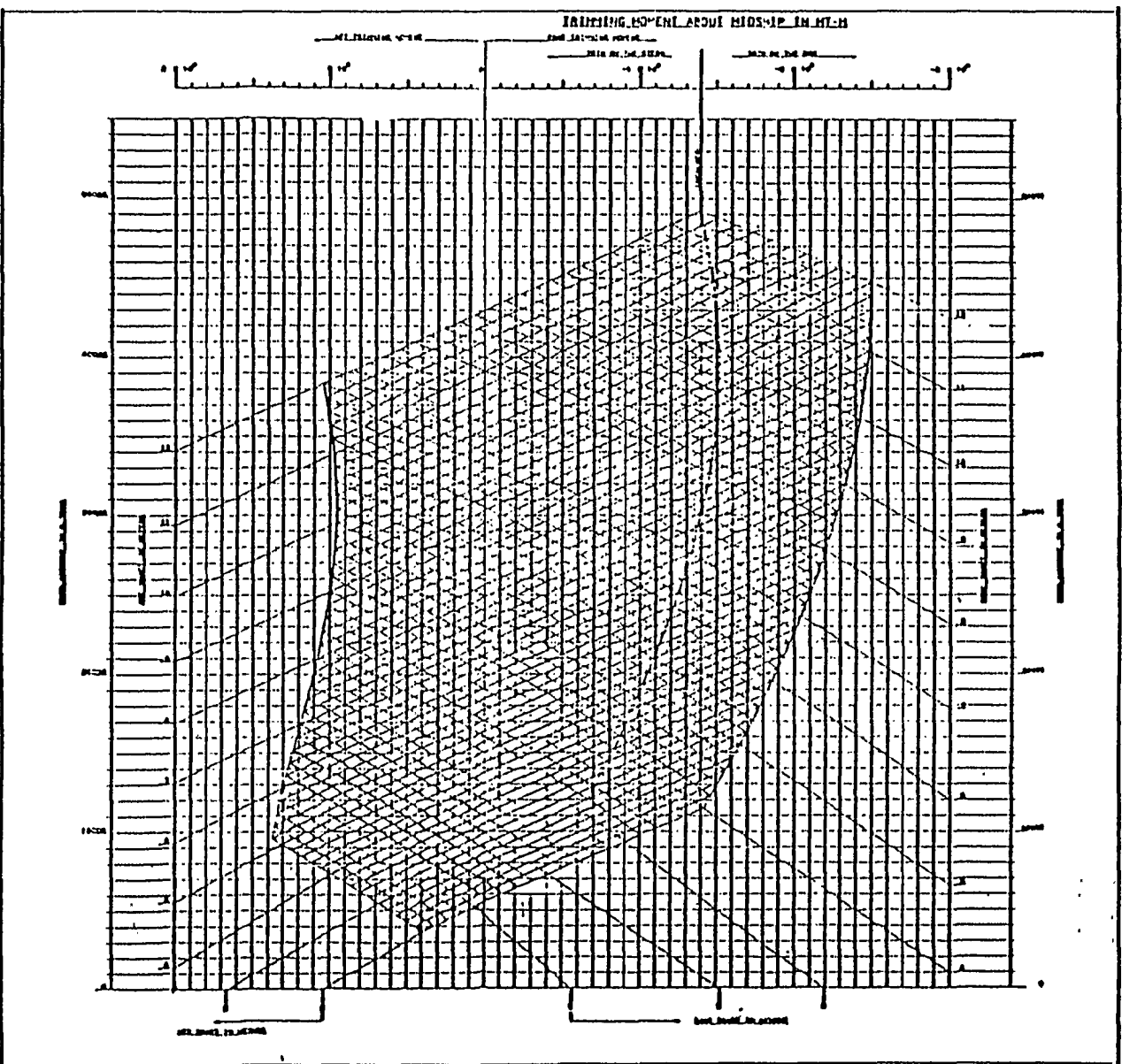
吃水別復元力曲線

DISPLACEMENT CORRECTION TABLE DUE TO TWIN (MT)

MEAN DRAFT (m)	-0.50	0.0	0.50	1.00	1.50	2.00	2.50	3.00
3.00	617	0	-602	-1192	-1772	-2340	-2900	-3448
3.50	613	0	-601	-1192	-1772	-2343	-2906	-3459
4.00	610	0	-599	-1189	-1769	-2341	-2903	-3460
4.50	606	0	-596	-1183	-1762	-2333	-2897	-3452
5.00	602	0	-592	-1176	-1752	-2321	-2882	-3435
5.50	598	0	-588	-1165	-1737	-2302	-2861	-3413
6.00	593	0	-580	-1154	-1721	-2282	-2839	-3389
6.50	588	0	-575	-1144	-1707	-2265	-2819	-3366
7.00	584	0	-569	-1133	-1692	-2246	-2796	-3341
7.50	580	0	-564	-1122	-1676	-2226	-2772	-3313
8.00	575	0	-558	-1111	-1660	-2204	-2747	-3270
8.50	570	0	-551	-1097	-1638	-2175	-2708	-3236
9.00	566	0	-546	-1086	-1609	-2139	-2668	-3193
9.50	564	0	-532	-1060	-1584	-2137	-2629	-3140
10.00	560	0	-525	-1044	-1561	-2077	-2591	-3102
10.50	550	0	-517	-1028	-1537	-2044	-2551	-3054
11.00	541	0	-506	-1012	-1512	-2011	-2509	-3004
11.50	531	0	-499	-994	-1485	-1975	-2464	-2949
12.00	520	0	-490	-975	-1456	-1936	-2414	-2889
12.50	501	0	-479	-954	-1423	-1893	-2360	-2822
13.00	481	0	-468	-931	-1390	-1847	-2300	-2750
13.50	460	0	-455	-904	-1349	-1792	-2233	-2670
14.00	445	0	-441	-876	-1307	-1737	-2164	-2587
14.50	427	0	-427	-848	-1263	-1681	-2094	-2504
15.00	407	0	-413	-821	-1224	-1624	-2034	-2419
15.50	383	0	-399	-792	-1181	-1567	-1971	-2330
16.00	359	0	-383	-764	-1137	-1508	-1905	-2238
16.50	333	0	-359	-731	-1086	-1443	-1794	-2141
17.00	307	0	-332	-699	-1030	-1377	-1712	-2043
17.50	281	0	-317	-668	-993	-1315	-1634	-1949
18.00	251	0	-292	-638	-948	-1254	-1557	-1854
18.50	219	0	-266	-605	-898	-1188	-1473	-1755
19.00	186	0	-239	-571	-848	-1122	-1391	-1656
19.50	150	0	-211	-539	-800	-1057	-1310	-1559
20.00	119	0	-187	-507	-751	-992	-1229	-1461
20.50	85	0	-161	-473	-703	-928	-1150	-1366
21.00	46	0	-134	-433	-655	-864	-1070	-1271
21.50	2	0	-109	-411	-608	-801	-990	-1174
22.00	205	0	-143	-360	-541	-718	-911	-1079
22.50	191	0	-178	-349	-514	-676	-834	-987
23.00	177	0	-163	-319	-469	-616	-760	-900
23.50	168	0	-152	-295	-432	-567	-690	-823
24.00	155	0	-141	-274	-401	-524	-644	-750
24.50	146	0	-132	-257	-373	-487	-593	-677
25.00	137	0	-125	-240	-349	-452	-548	-609
25.50	128	0	-114	-220	-319	-412	-500	-562
26.00	110	0	-103	-199	-289	-377	-453	-527
26.50	105	0	-95	-182	-263	-338	-411	-470
27.00	99	0	-87	-166	-240	-308	-373	-433

トリム時排水量修正

トリム—排水量ダイヤグラム



AFT DRAFT	FORE DRAFT (M)																		
(M)	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	
4.00	-0.2	0.3	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
5.00	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	
6.00	-0.7	-0.4	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	*****	*****	*****	*****	*****	*****	
7.00	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	*****	*****	*****	*****	*****	
8.00	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	*****	*****	*****	*****	
9.00	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	*****	*****	*****	
10.00	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	*****	*****	
11.00	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	*****	
12.00	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	*****	
13.00	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	*****	
14.00	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	*****	
15.00	-2.7	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	1.2	
16.00	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	0.9	
17.00	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	0.7	
18.00	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	0.5	
19.00	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	0.2	
20.00	*****	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	0.0	
21.00	*****	*****	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	-0.2	
22.00	*****	*****	*****	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	-0.5	
23.00	*****	*****	*****	*****	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	-0.7	
24.00	*****	*****	*****	*****	*****	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	-0.9	
25.00	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	-1.2	
26.00	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	-1.4	
27.00	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	-2.8	-2.5	-2.3	-2.1	-1.8	-1.6	

前後部吃水修正表

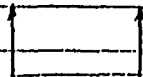
*** RESULT OF SECTIONAL AREA DATA FOR FREE DRAFT (CASE NO. 1) ***

** FOR ORD. DATA **

DRAFT DATA

		(D-1)	(D-2)	(D-3)	(D-4)	(D-5)
DRAFT	(M)	6.500	9.500	0.0	0.0	0.0
POS. (FROM AP) (M)		0.0	178.000	0.0	0.0	0.0

	DIST. (FROM AP)	DRAFT	SEC. AREA (BOTH S.)	AREA RATIO	GIRTH LENGTH		DIST. (FROM AP)	DRAFT	SEC. AREA (BOTH S.)	AREA RATIO	GIRTH LENGTH
	(M)	(M)	(SQ.M)	(SA/AH)	(M)		(M)	(M)	(SQ.M)	(SA/AH)	(M)
1	4.131	6.570	0.0	0.0	0.0	31	167.176	9.318	125.345	0.50973	28.829
2	4.331	6.573	1.652	0.00672	14.116	32	169.340	9.354	108.643	0.43368	26.965
3	4.530	6.576	2.591	0.01054	14.135	33	171.505	9.391	86.738	0.35273	25.039
4	5.513	6.593	7.273	0.02958	14.274	34	173.669	9.427	65.728	0.26729	23.145
5	6.495	6.609	12.052	0.04901	14.492	35	175.835	9.464	45.608	0.18547	21.608
6	8.660	6.646	22.923	0.09322	15.251	36	176.859	9.481	37.752	0.15344	22.304
7	10.824	6.682	34.383	0.13982	16.685	37	177.883	9.498	30.485	0.12397	21.626
8	12.990	6.719	46.387	0.18864	18.364	38	178.000	9.500	29.697	0.12077	21.458
9	15.155	6.755	58.625	0.23041	20.115	39	178.117	9.502	28.890	0.11749	21.204
10	17.319	6.792	70.929	0.28044	21.877	40	179.100	9.519	22.753	0.09253	18.938
11	21.650	6.865	95.247	0.38733	25.294	41	180.200	9.537	17.245	0.07013	16.191
12	25.981	6.938	118.386	0.48143	28.431	42	181.300	9.556	10.878	0.04424	12.640
13	31.310	7.011	139.678	0.56802	31.715	43	182.400	9.574	2.121	0.00863	5.399
14	36.641	7.084	158.500	0.64456	33.634	44	182.515	9.576	1.207	0.00491	4.430
15	43.300	7.230	187.569	0.76277	37.526	45	182.630	9.578	0.0	0.0	0.0
16	51.960	7.376	204.539	0.83178	40.402						
17	60.620	7.522	212.211	0.86298	42.174						
18	69.279	7.668	216.573	0.88072	42.645						
19	89.000	8.010	226.012	0.91911	43.310						
20	106.800	8.300	234.532	0.95376	43.910						
21	117.380	8.470	239.596	0.97435	44.266						
22	126.040	8.624	243.604	0.99065	44.436						
23	134.700	8.770	245.904	1.00000	43.796						
24	143.359	8.916	248.737	0.97899	42.198						
25	147.690	8.989	232.170	0.94395	40.877						
26	152.019	9.062	218.406	0.88818	39.089						
27	156.350	9.135	199.039	0.80942	36.772						
28	160.680	9.208	173.735	0.70651	33.925						
29	162.845	9.245	158.920	0.64627	32.321						
30	165.009	9.281	142.770	0.58059	30.617						



(EXT.)

任意(区画, 吃水)排水量

*** RESULT OF HYDROSTATIC PROPERTIES FOR FREE DRAFT (CASE NO. 1) ***

DRAFT DATA

	(D-1)	(D-2)	(D-3)	(D-4)	(D-5)
DRAFT (M)	6.500	9.500	0.0	0.0	0.0
POS. (FROM AP) (M)	0.0	170.000	0.0	0.0	0.0

DISPT (MT)	DISPT (HLD) (MT)	APPEN (MT)	T P C (MT)	L C B (M)	L C F (M)	T K H (M)	L K H (M)	H T C (MT-M)	T C B (M)	T C F (M)
33183.	33072.	112.	43.00	-8.82	-3.11	11.87	252.77	463.47	0.0	0.0

D. CORR. (MT)	W S A (SQ.M)	A H (SQ.M)	A W (SQ.M)	K B (M)
32.59	6524.9	204.5	4195.6	4.16

C B	C P	C W	C H
0.9847	0.8862	0.8300	1.1111

任意(区画)排水量

SEQ.NO	FR.NAME	FR.NO	FR.SPAC	DIST.(AP)	DIST.(MID)
1	PH	-8.000	0.0	-4.800	91.400
2	FG	-7.000	0.600	-4.200	90.800
3	FF	-6.000	0.600	-3.600	90.200
4	FE	-5.000	0.600	-3.000	89.600
5	FD	-4.000	0.600	-2.400	89.000
6	FC	-3.000	0.600	-1.800	88.400
7	FB	-2.000	0.600	-1.200	87.800
8	FA	-1.000	0.600	-0.600	87.200
9	F0	0.0	0.600	0.0	86.600
10	F1	1.000	0.600	0.600	86.000
11	F2	2.000	0.600	1.200	85.400
12	F2-1/2	2.500	0.600	1.800	84.800
13	F3	3.000	0.600	2.400	84.200
14	F4	4.000	0.600	3.000	83.600
15	F5	5.000	0.600	3.600	83.000
16	F5-1/2	5.500	0.600	4.200	82.400
17	F6	6.000	0.600	4.800	81.800
18	F7	7.000	0.600	5.400	81.200
19	F8	8.000	0.600	6.000	80.600
20	F8-1/2	8.500	0.600	6.600	80.000
21	F9	9.000	0.600	7.200	79.400
22	F10	10.000	0.600	7.800	78.800
23	F11	11.000	0.600	8.400	78.200
24	F12	12.000	0.600	9.000	77.600
25	F13	13.000	0.600	9.600	77.000
26	F14	14.000	0.600	10.200	76.400
27	F15	15.000	0.600	10.800	75.800
28	F16	16.000	0.600	11.400	75.200
29	F17	17.000	0.600	12.000	74.600
30	F18	18.000	0.600	12.600	74.000
31	F19	19.000	0.600	13.200	73.400
32	F20	20.000	0.600	13.800	72.800
33	F21	21.000	0.600	14.400	72.200
34	F22	22.000	0.600	15.000	71.600
35	F23	23.000	0.600	15.600	71.000
36	F24	24.000	0.600	16.200	70.400
37	F25	25.000	0.600	16.800	69.800
38	F26	26.000	0.600	17.400	69.200
39	F27	27.000	0.600	18.000	68.600
40	F28	28.000	0.600	18.600	68.000
41	F29	29.000	0.600	19.200	67.400
42	F30	30.000	0.600	19.800	66.800
43	F31	31.000	0.600	20.400	66.200
44	F32	32.000	0.600	21.000	65.600
45	F33	33.000	0.600	21.600	65.000
46	F34	34.000	0.600	22.200	64.400
47	F35	35.000	0.600	22.800	63.800
48	F36	36.000	0.600	23.400	63.200
49	F37	37.000	0.600	24.000	62.600
50	F38	38.000	0.600	24.600	62.000

FR. DIST. TABLE

FRAME NO.	4.000 M W.L.	7.000 M W.L.	8.000 M W.L.	9.000 M W.L.	10.000 M W.L.	11.000 M W.L.	12.000 M W.L.	13.000 M W.L.	14.000 M W.L.	15.000 M W.L.	16.000 M W.L.	17.000 M W.L.
PH						1.084	2.394	3.456	4.330	5.855	5.444	5.664
PF						1.469	2.718	3.773	4.653	5.393	6.012	6.012
PE					0.095	1.731	3.024	4.087	4.971	5.723	6.355	6.355
PD					0.442	2.053	3.337	4.399	5.286	6.048	6.693	6.693
PC					0.827	2.374	3.647	4.708	5.596	6.367	7.024	7.024
FA					1.180	2.692	3.956	5.014	5.905	6.680	7.346	7.346
FO					1.525	3.009	4.263	5.318	6.211	6.985	7.639	7.639
FI					1.849	3.324	4.565	5.616	6.509	7.284	7.942	7.942
F2-1/2				0.445	2.210	3.442	4.864	5.910	6.801	7.575	8.235	8.235
F3				0.819	2.547	3.954	5.161	6.199	7.049	7.861	8.541	8.541
F4				1.190	2.880	4.263	5.455	6.484	7.373	8.141	8.820	8.820
F5				1.558	3.239	4.561	5.746	6.745	7.652	8.436	9.091	9.091
F6			0.458	1.924	3.332	4.872	6.035	7.042	7.925	8.684	9.355	9.355
F7			0.834	2.288	3.851	5.171	6.319	7.315	8.191	8.945	9.612	9.612
F8-1/2		0.221	0.834	2.448	4.167	5.666	6.978	7.982	8.851	9.500	9.863	9.863
F9		0.613	1.254	3.002	4.481	5.757	6.971	7.944	8.704	9.447	10.107	10.107
F10	0.348	0.813	1.459	3.351	4.794	6.045	7.139	8.100	8.950	9.688	10.344	10.344
F11	0.666	1.003	2.060	3.495	5.108	6.379	7.402	8.353	9.190	9.921	10.579	10.579
F12	0.984	1.389	2.455	4.034	5.415	6.608	7.680	8.594	9.424	10.148	10.803	10.803
F13-1/2	1.304	1.771	2.844	4.368	5.717	6.883	7.914	8.834	9.651	10.368	11.019	11.019
F14	1.624	2.149	3.228	4.697	6.015	7.154	8.164	9.068	9.873	10.580	11.228	11.228
F15	2.056	2.644	3.729	5.127	6.403	7.508	8.489	9.372	10.158	10.953	11.693	11.693
F16	2.445	3.135	4.216	5.549	6.780	7.852	8.805	9.644	10.450	11.155	11.744	11.744
F17	2.913	3.617	4.691	5.963	7.147	8.186	9.113	9.945	10.691	11.366	11.985	11.985
F18	3.359	4.087	5.151	6.365	7.504	8.510	9.411	10.217	10.942	11.604	12.209	12.209
F19	3.769	4.546	5.597	6.797	7.849	8.825	9.698	10.480	11.165	11.809	12.415	12.415
F20	4.189	4.993	6.029	7.137	8.185	9.130	9.974	10.734	11.418	12.044	12.604	12.604
F21	4.604	5.430	6.447	7.507	8.515	9.424	10.244	10.978	11.643	12.244	12.763	12.763
F22	5.022	5.855	6.849	7.869	8.835	9.714	10.503	11.213	11.863	12.455	12.945	12.945
F23	5.431	6.289	7.239	8.219	9.147	9.992	10.753	11.438	12.070	12.613	13.095	13.095
F24	5.835	6.672	7.616	8.559	9.449	10.260	10.992	11.652	12.262	12.779	13.232	13.232
F25	6.231	7.065	7.981	8.887	9.740	10.518	11.222	11.854	12.440	12.953	13.358	13.358
F26	6.622	7.447	8.353	9.205	10.021	10.767	11.441	12.050	12.602	13.076	13.472	13.472
F27	7.015	7.818	8.673	9.511	10.291	11.005	11.650	12.233	12.752	13.205	13.572	13.572
F28	7.418	8.178	9.012	9.835	10.551	11.233	11.849	12.406	12.894	13.323	13.662	13.662
F29	7.743	8.525	9.320	10.088	10.800	11.450	12.038	12.568	13.051	13.433	13.744	13.744
F30	8.100	8.842	9.624	10.359	11.038	11.657	12.217	12.728	13.197	13.584	13.819	13.819
F31	8.448	9.187	9.920	10.619	11.245	11.854	12.385	12.861	13.275	13.627	13.884	13.884
F32	8.788	9.501	10.203	10.864	11.482	12.040	12.543	12.992	13.384	13.711	13.944	13.944
F33	9.114	9.804	10.473	11.105	11.666	12.214	12.690	13.113	13.479	13.781	13.994	13.994
F34	9.429	10.094	10.714	11.332	11.882	12.380	12.829	13.226	13.568	13.844	14.037	14.037
F35	9.733	10.377	10.984	11.549	12.068	12.538	12.960	13.332	13.649	13.902	14.075	14.075
F36	10.028	10.658	11.223	11.737	12.242	12.687	13.083	13.430	13.725	13.954	14.108	14.108
F37	10.312	10.907	11.452	11.954	12.413	12.828	13.199	13.522	13.793	14.001	14.155	14.155
F38	10.587	11.155	11.689	12.141	12.570	12.958	13.304	13.604	13.851	14.039	14.154	14.154
F39	10.852	11.391	11.874	12.317	12.718	13.079	13.401	13.678	13.902	14.070	14.167	14.167
F40	11.104	11.614	12.073	12.485	12.858	13.194	13.492	13.747	13.949	14.097	14.178	14.178
F41	11.349	11.832	12.248	12.644	12.993	13.331	13.577	13.810	13.991	14.122	14.188	14.188
F42	11.590	12.037	12.438	12.795	13.115	13.402	13.659	13.868	14.030	14.143	14.195	14.195
F43	11.808	12.231	12.606	12.936	13.231	13.496	13.727	13.928	14.063	14.160	14.200	14.200

FR. OFFSETS

NO.3 CARGO HOLD (FR.104.00 (0.0) - FR.130.00 (0.0)) TANK BOTTOM = 1.017 TANK TOP = 17.320

DRAFT (M)	GROSS V. (CU. M)	NET V. (CU. M)	K.P. (M)	L.C.B. (M)	L.C.F. (M)	CL.B. (M)	CL.F. (M)	A.W. (SQ. M)	I.N.A. (TRV.)	I.N.A. (LONG.)	K.P.
1.017	0.0	0.0	1.017	0.0	-10.600	0.0	0.0	401.3	14705.	25189.	1
2.000	89.70	88.51	1.907	-10.600	-10.600	0.0	0.0	409.0	15506.	25593.	0
3.000	598.79	596.99	2.418	-10.600	-10.600	0.0	0.0	531.0	19861.	27193.	0
3.343	783.66	781.30	2.596	-10.600	-10.600	0.0	0.0	561.7	22442.	32347.	1
4.000	1166.47	1162.97	2.950	-10.600	-10.600	0.0	0.0	547.5	26076.	33484.	0
4.070	1702.80	1697.77	3.419	-10.600	-10.600	0.0	0.0	642.1	31656.	37492.	1
4.899	1715.73	1710.50	3.430	-10.600	-10.200	0.0	0.0	662.5	32750.	40832.	1
5.000	1703.07	1703.51	3.492	-10.584	-10.200	0.0	0.0	667.5	33501.	41143.	0
5.000	2479.21	2471.77	4.043	-10.477	-10.200	0.0	0.0	713.1	40353.	43979.	0
7.000	3115.17	3205.52	4.614	-10.413	-10.200	0.0	0.0	750.8	49209.	46709.	0
7.300	3444.85	3434.51	4.703	-10.349	-10.200	0.0	0.0	772.5	51421.	47635.	1
8.000	3985.59	3973.63	5.327	-10.372	-10.200	0.0	0.0	772.5	51921.	47635.	0
9.000	4744.66	4743.70	5.089	-10.344	-10.200	0.0	0.0	772.5	51921.	47635.	0
10.000	5530.54	5513.94	6.295	-10.324	-10.200	0.0	0.0	772.5	51921.	47635.	0
10.300	5762.70	5744.99	6.399	-10.319	-10.200	0.0	0.0	772.5	51921.	47635.	1
11.000	6100.09	6161.25	6.744	-10.309	-10.200	0.0	0.0	707.0	39008.	43594.	0
11.000	6440.35	6419.53	7.100	-10.299	-10.200	0.0	0.0	613.5	26009.	37622.	0
13.000	7507.04	7404.55	7.599	-10.291	-10.200	0.0	0.0	520.0	15036.	32054.	0
13.943	7973.04	7947.11	7.942	-10.206	-10.200	0.0	0.0	420.0	8834.	26364.	1
14.271	8074.97	8072.56	8.037	-10.291	-10.600	0.0	0.0	307.5	6957.	22502.	1
14.703	8314.52	8204.55	8.208	-10.299	-10.600	0.0	0.0	332.6	4401.	19310.	1
15.000	8364.30	8314.23	8.236	-10.300	-10.600	0.0	0.0	332.6	4401.	19319.	0
15.695	8580.63	8554.07	8.418	-10.308	-10.600	0.0	0.0	332.6	4401.	19319.	1
15.743	8805.99	8501.14	8.451	-10.309	-10.200	0.0	0.0	221.8	2934.	5725.	1
16.000	8655.11	8629.12	8.492	-10.308	-10.200	0.0	0.0	221.8	2934.	5725.	0
17.000	8876.07	8850.21	8.692	-10.305	-10.200	0.0	0.0	221.8	2934.	5725.	0
17.320	8947.04	8920.46	8.759	-10.305	-10.200	0.0	0.0	221.8	2934.	5725.	1

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*** COMPARTMENT SUMMARY TABLE FOR TANK/HOLD ***

NO	TANK/HOLD NAME	PLACE	AFT. BHD.	FRND. BHD.	VOLUME	L C G	K G	T. INERTIA	T C G
			FRND. DIFF.	FRND. DIFF.	(CU. M)	(M)	(M)	(M ⁴)	(M)
1	FRESH WATER TANK (P)	3	11	17	106.92	87.169	16.995	150.	
2	FRESH WATER TANK (S)	4	9	17	176.30	87.879	17.004	183.	
3	DRINK WATER TANK (P)	3	9	11	29.54	90.407	17.035	32.	
4	NO.3 F.O.T. (P/S)	2	147	174	903.06	-32.300	2.156	5408.	
5	NO.5 F.O.T. (P/S)	2	66	93	823.27	31.903	2.106	4616.	
6	NO.7 F.O.T. (P)	3	20	40	96.65	68.908	1.110	240.	
7	NO.7 F.O.T. (S)	4	26	40	104.50	72.838	1.075	249.	
8	NO.6 F.O.T. (P/S)	2	42	66	90.69	52.900	0.997	22.	
9	NO.1 T.S.T. (P/S)	2	202	227	346.45	-73.535	16.972	621.	
10	NO.7 T.S.T. (P/S)	2	175	202	592.05	-54.641	16.607	1219.	
11	NO.3 T.S.T. (P/S)	2	121	175	1191.93	-22.300	16.595	2431.	
12	NO.4 T.S.T. (P/S)	2	67	121	1191.89	20.699	16.595	2431.	
13	NO.5 T.S.T. (P/S)	2	49	67	501.34	53.150	16.654	1232.	
14	NO.1 W.O.T. (P/S)	2	201	227	565.21	-74.287	1.882	3173.	
15	NO.2 W.O.T. (P/S)	2	174	201	872.04	-53.659	2.165	5109.	
16	NO.4 W.O.T. (P)	3	93	147	1067.69	0.100	2.156	10974.	
17	NO.6 W.O.T. (S)	4	93	147	1007.69	0.100	2.156	10974.	
18	NO.6 W.O.T. (P/S)	2	40	66	547.63	53.463	2.782	1100.	
19	F.O.T.	1	224	232	2963.91	-90.252	9.506	5594.	
20	A.P.T.	1	-5	9	270.53	94.055	12.790	2254.	
21	NO.1 CARGO HOLD	1	202	227	7067.02	-74.991	10.613	36162.	
22	NO.2 CARGO HOLD	1	175	202	9923.7	-54.775	10.157	59970.	
23	NO.3 CARGO HOLD	1	140	175	9861.69	-33.273	10.124	60095.	
24	NO.4 CARGO HOLD	1	121	140	9941.45	-11.637	10.121	60095.	
25	NO.5 CARGO HOLD	1	94	121	9967.70	9.900	10.141	60095.	
26	NO.6 CARGO HOLD	1	67	94	9841.78	31.770	10.172	60095.	
27	NO.7 CARGO HOLD	1	40	67	9106.09	52.760	10.569	56087.	
30	BILGE TANK	5	9	10	20.46	87.001	1.101	6.	
31	SEP. BILGE OIL TANK	4	10	26	17.42	79.733	1.266	9.	
32	F. O. OVER FLOW TANK	1	36	40	30.53	65.839	0.990	25.	
33	LUM. OIL SUMP TANK	1	21	20	24.31	78.050	1.695	6.	
34	Cooling Water Tank	1	6	9	24.04	92.111	6.443	21.	
41	NO.3 C.H. (IN DECK)	1	140	175	11331.96	-33.100	10.765	60095.	
41	NO.3 C.H. (CHECK)	1	140	175	8354.66	-33.100	9.600	14400.	
47	FOR W.L. CHECK	1	100	110	2519.79	12.100	11.294	5333.	

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TANK CAPACITY CURVES

FORE PEAK TANK

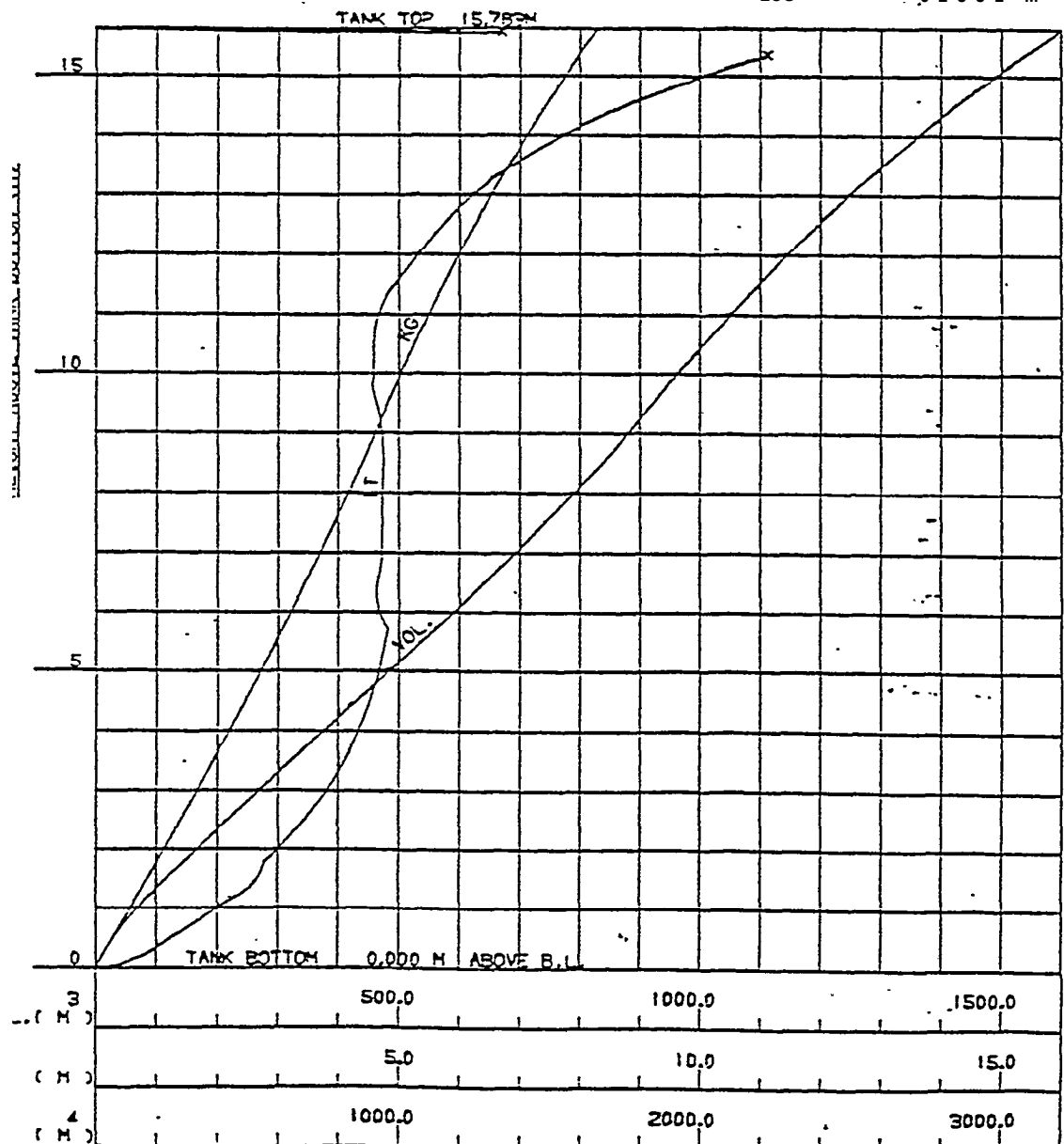
FROM FR. 207.0 TO FR. 215.0

MAX. Va. 1596.000 M³

MAX. KG 8-260 M

MAX.IT 2658330 M'

LCG 62331 M



NO. 7 FUEL OIL TANK (P/3)

SHIPPING				SOUND				TANK NO. (19)			
(4)	CUR. H	M. TON	U.S. GALL	(4)	CUR. H	M. TON	U.S. GALL				
0.0	4.1	3.9	23.8	0.50	158.1	150.7	994.4				
0.01	7.0	6.8	43.9	0.51	161.3	153.2	1014.4	4.08	3.17		
0.02	9.9	9.6	62.4	0.52	164.5	156.2	1034.4	2.91	3.17		
0.03	12.9	12.2	80.9	0.53	167.6	159.2	1054.4	2.94	3.18		
0.04	15.8	15.0	99.4	0.54	170.8	162.3	1074.4	2.96	3.18		
0.05	18.9	17.9	118.2	0.55	174.0	165.3	1094.4	2.98	3.18		
0.06	21.9	20.7	136.9	0.56	177.2	167.3	1114.4	2.98	3.18		
0.07	24.9	23.5	155.0	0.57	180.4	171.4	1134.6	3.00	3.19		
0.08	27.8	26.4	174.7	0.58	183.6	174.4	1154.7	3.00	3.20		
0.09	30.8	29.2	193.6	0.59	186.8	177.5	1174.9	3.01	3.20		
0.10	33.8	32.1	212.6	0.60	19.0	180.7	1194.9	3.01	3.20		
0.11	36.8	35.0	231.6	0.61	193.2	183.5	1215.0	3.01	3.20		
0.12	39.8	37.9	250.6	0.62	196.4	186.5	1235.0	3.01	3.20		
0.13	42.9	40.7	269.7	0.63	199.6	189.6	1255.2	3.03	3.21		
0.14	45.9	43.6	289.9	0.64	202.9	192.6	1275.4	3.04	3.21		
0.15	49.0	46.5	309.9	0.65	206.0	195.7	1295.5	3.05	3.21		
0.16	52.1	49.4	329.9	0.66	209.2	198.7	1315.7	3.05	3.21		
0.17	55.1	52.3	349.9	0.67	212.4	201.8	1335.9	3.06	3.21		
0.18	58.2	55.2	369.9	0.68	215.6	204.8	1356.0	3.06	3.21		
0.19	61.2	58.1	389.9	0.69	218.8	207.9	1376.2	3.06	3.21		
0.20	64.3	61.0	409.9	0.70	222.0	210.9	1396.4	3.07	3.21		
0.21	67.3	64.0	429.9	0.71	225.2	214.0	1416.6	3.08	3.21		
0.22	70.4	66.9	449.9	0.72	228.4	217.0	1436.7	3.08	3.21		
0.23	73.4	69.9	469.9	0.73	231.6	220.0	1456.9	3.08	3.21		
0.24	76.5	72.8	489.9	0.74	234.8	223.1	1477.1	3.09	3.21		
0.25	79.5	75.7	509.9	0.75	238.0	226.1	1497.3	3.09	3.21		
0.26	82.6	78.6	529.9	0.76	241.2	229.2	1517.5	3.10	3.22		
0.27	85.6	81.6	549.9	0.77	244.4	232.3	1537.6	3.10	3.22		
0.28	88.7	84.5	569.9	0.78	247.7	235.3	1557.8	3.10	3.22		
0.29	91.7	87.5	589.9	0.79	250.9	238.4	1578.0	3.10	3.22		
0.30	94.8	90.4	609.9	0.80	254.1	241.5	1598.2	3.12	3.22		
0.31	97.8	93.4	629.9	0.81	257.4	244.5	1618.4	3.12	3.22		
0.32	100.9	96.4	649.9	0.82	260.6	247.6	1638.6	3.12	3.22		
0.33	104.0	99.3	669.9	0.83	263.8	250.6	1658.8	3.13	3.22		
0.34	107.1	102.3	689.9	0.84	267.0	253.7	1679.0	3.13	3.22		
0.35	110.2	105.3	709.9	0.85	270.2	256.7	1699.2	3.13	3.22		
0.36	113.3	108.3	729.9	0.86	273.5	259.8	1719.4	3.13	3.22		
0.37	116.4	111.2	749.9	0.87	276.7	262.9	1739.6	3.14	3.23		
0.38	119.5	114.2	769.9	0.88	279.9	265.9	1759.8	3.14	3.23		
0.39	122.6	117.2	789.9	0.89	283.2	269.0	1780.0	3.14	3.23		
0.40	125.6	120.2	809.9	0.90	286.4	272.1	1800.2	3.14	3.23		
0.41	128.7	123.2	829.9	0.91	289.6	275.1	1820.4	3.14	3.23		
0.42	131.8	126.2	849.9	0.92	292.8	278.2	1840.6	3.16	3.23		
0.43	134.9	129.2	869.9	0.93	296.1	281.3	1860.8	3.16	3.23		
0.44	138.0	132.2	889.9	0.94	299.3	284.3	1881.0	3.16	3.23		
0.45	141.1	135.2	909.9	0.95	302.5	287.4	1901.2	3.16	3.23		
0.46	144.2	138.2	929.9	0.96	305.7	290.5	1921.4	3.16	3.23		
0.47	147.3	141.2	949.9	0.97	309.0	293.5	1941.6	3.16	3.23		
0.48	150.4	144.2	969.9	0.98	312.2	296.6	1961.8	3.16	3.23		
0.49	153.5	147.2	989.9	0.99	315.4	299.7	1982.0	3.17	3.23		

S.G. = 0.950 MT/M³ H
 FULL VOLUME : 767.78 CUB. M 1 AT FULL SHIPPING 1 5,588 M

***** USING DATA CHECK PRINT BY TANK NO 67 *****

TAI/HEEL CHECK TANK

INDICATION OF CALCULATION AND PRINT OUT

PRINT FORMAT

29 (USING UNDER DATA)

TRIN DATA

-1.000	0.0	1.000	1.500	2.000
2.250	3.000	3.500	4.000	

HEEL DATA

-2.000	-1.500	-1.000	-0.500	0.0
0.500	1.000	1.500	2.000	

DRAFT DATA

1.000	1.500	2.000	2.500	3.000
3.500	4.000	4.500	5.000	5.500
6.000	7.000	8.500	9.000	10.000
11.000	12.000	0.0	0.0	0.0

AMENDMENT VALUE

Q

INDICATION OF SCALE

INDICATION OF TUBE

0

SOUNDING

TANK ARRANGE

1

P/S ON C

EXCHANGE RATE

မ.၁

***** TUBE DATA *****

X-6000

Y-0000

2-0000

[illegible]

タンク TRIM/HEEL 修正表

TRIM/HEEL CHECK TANK

CORRECTION TABLE DUE TO TRIM (UNIT : CM)

SOUND, (M)	TRIM (M)								
	BY BOW					BY STERN			
	-1.00	0.0	1.00	1.50	2.00	2.50	3.00	3.50	4.00
1.000	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
1.500	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
2.000	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
2.500	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
3.000	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
3.500	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
4.000	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
4.500	1.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
5.000	-1.	0.	-2.	-4.	-5.	-6.	-7.	-8.	-9.
5.500	-50.	-50.	-50.	-50.	-50.	-50.	-50.	-50.	-50.
6.000	-100.	-100.	-100.	-100.	-100.	-100.	-100.	-100.	-100.
7.000	-200.	-200.	-200.	-200.	-200.	-200.	-200.	-200.	-200.
8.000	-300.	-300.	-300.	-300.	-300.	-300.	-300.	-300.	-300.
9.000	-400.	-400.	-400.	-400.	-400.	-400.	-400.	-400.	-400.
10.000	-500.	-500.	-500.	-500.	-500.	-500.	-500.	-500.	-500.
11.000	-600.	-600.	-600.	-600.	-600.	-600.	-600.	-600.	-600.
12.000	-700.	-700.	-700.	-700.	-700.	-700.	-700.	-700.	-700.

CORRECTION TABLE DUE TO HEEL (UNIT : CM)

SOUND, (M)	HEEL (DEG.)								
	PORT					STARBOARD			
	-2.00	-1.50	-1.00	-0.50	0.0	0.50	1.00	1.50	2.00
1.000	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
1.500	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
2.000	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
2.500	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
3.000	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
3.500	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
4.000	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
4.500	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
5.000	-1.	-1.	-1.	-1.	0.	-4.	-8.	-11.	-15.
5.500	-50.	-50.	-50.	-50.	-50.	-50.	-50.	-50.	-50.
6.000	-100.	-100.	-100.	-100.	-100.	-100.	-100.	-100.	-100.
7.000	-200.	-200.	-200.	-200.	-200.	-200.	-200.	-200.	-200.
8.000	-300.	-300.	-300.	-300.	-300.	-300.	-300.	-300.	-300.
9.000	-400.	-400.	-400.	-400.	-400.	-400.	-400.	-400.	-400.
10.000	-500.	-500.	-500.	-500.	-500.	-500.	-500.	-500.	-500.
11.000	-600.	-600.	-600.	-600.	-600.	-600.	-600.	-600.	-600.
12.000	-700.	-700.	-700.	-700.	-700.	-700.	-700.	-700.	-700.

タンク TRIM/HEEL 修正表

TRIM/HEEL CHECK TANK

CORRECTION TABLE DUE TO TRIM (UNIT : CM)

SOUND, (M)	TRIM (M)								
	BY BOW					BY STERN			
	-1.00	0.0	1.00	1.50	2.00	2.50	3.00	3.50	4.00
1.000	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
1.500	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
2.000	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
2.500	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
3.000	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
3.500	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
4.000	2.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
4.500	1.	0.	-2.	-3.	-4.	-6.	-7.	-8.	-9.
5.000	-1.	0.	-2.	-4.	-5.	-6.	-7.	-8.	-9.
5.500	-50.	-50.	-50.	-50.	-50.	-50.	-50.	-50.	-50.
6.000	-100.	-100.	-100.	-100.	-100.	-100.	-100.	-100.	-100.
7.000	-200.	-200.	-200.	-200.	-200.	-200.	-200.	-200.	-200.
8.000	-300.	-300.	-300.	-300.	-300.	-300.	-300.	-300.	-300.
9.000	-400.	-400.	-400.	-400.	-400.	-400.	-400.	-400.	-400.
10.000	-500.	-500.	-500.	-500.	-500.	-500.	-500.	-500.	-500.
11.000	-600.	-600.	-600.	-600.	-600.	-600.	-600.	-600.	-600.
12.000	-700.	-700.	-700.	-700.	-700.	-700.	-700.	-700.	-700.

CORRECTION TABLE DUE TO HEEL (UNIT : CM)

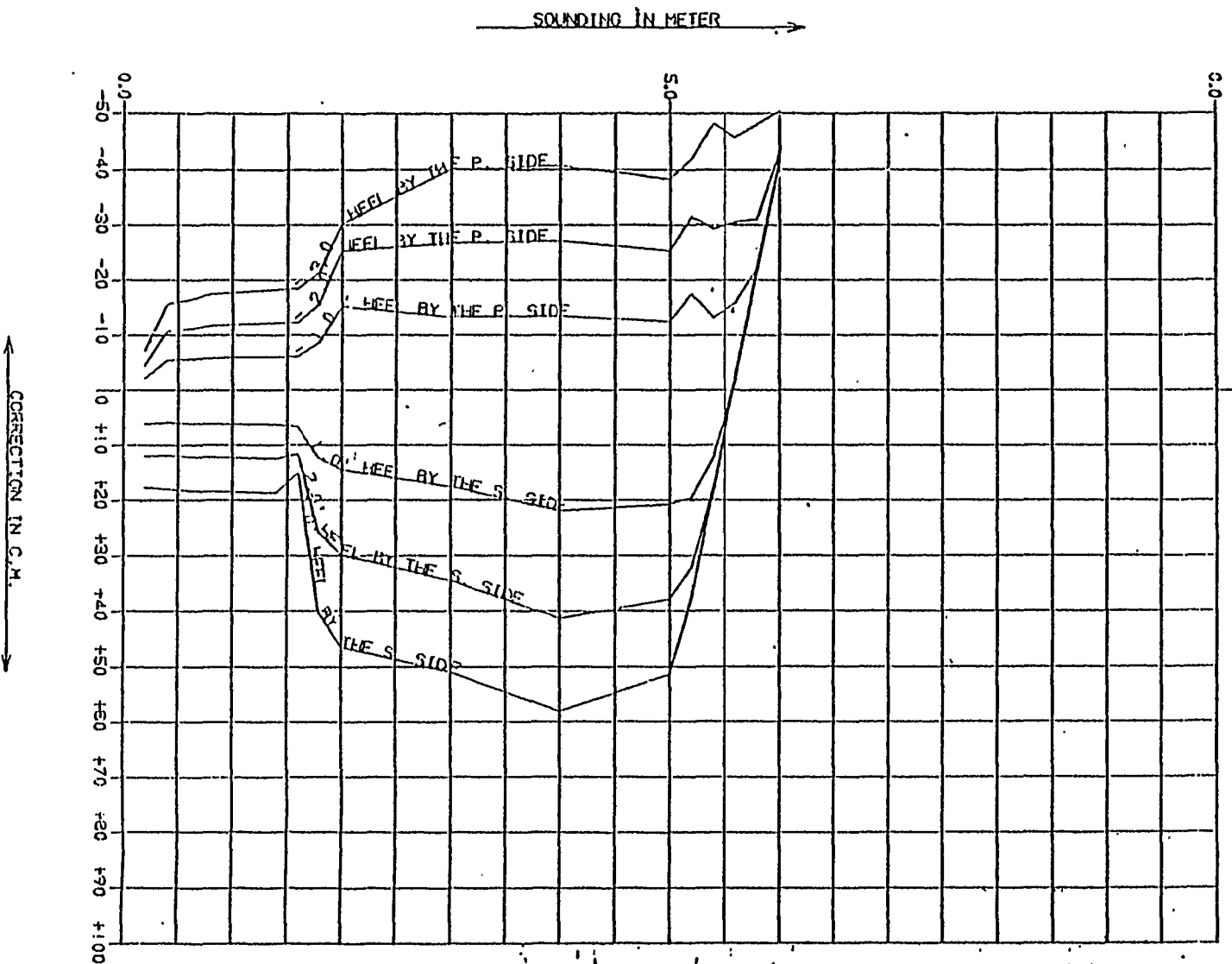
SOUND, (M)	HEEL (DEG.)								
	PORT					STARBOARD			
	-2.00	-1.50	-1.00	-0.50	0.0	0.50	1.00	1.50	2.00
1.000	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
1.500	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
2.000	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
2.500	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
3.000	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
3.500	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
4.000	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
4.500	14.	10.	7.	3.	0.	-3.	-7.	-10.	-14.
5.000	-1.	-1.	-1.	-1.	0.	-4.	-8.	-11.	-15.
5.500	-50.	-50.	-50.	-50.	-50.	-50.	-50.	-50.	-50.
6.000	-100.	-100.	-100.	-100.	-100.	-100.	-100.	-100.	-100.
7.000	-200.	-200.	-200.	-200.	-200.	-200.	-200.	-200.	-200.
8.000	-300.	-300.	-300.	-300.	-300.	-300.	-300.	-300.	-300.
9.000	-400.	-400.	-400.	-400.	-400.	-400.	-400.	-400.	-400.
10.000	-500.	-500.	-500.	-500.	-500.	-500.	-500.	-500.	-500.
11.000	-600.	-600.	-600.	-600.	-600.	-600.	-600.	-600.	-600.
12.000	-700.	-700.	-700.	-700.	-700.	-700.	-700.	-700.	-700.

タソク TRIM/HEEL 修正表

NO.2 F. O. T. (P/S)
NO.4 F. O. T. (P/S)
NO.1 W. 6. T. (P/S)

SOUNDING

CORRECTION FOR HEEL



GRAIN HEELING MT.

** IN PUT DATA (PARTICULAR) ** GRAIN HEELING MOMENT CALCULATION

UNIT (F'DOT PUT) 1 0 0THERIC 1FEET
 SIGN OF GRAIN LEVEL 1 2 1TULLAGE 2TOUNING 3H.L. FROM B.L.
 GRAIN ROLE 1HED.A.1 264
 SIGN OF CALC. (TRAN.) 1 1 0TNOT CALC. 1T.CALL. AND SEC.AREA PRINT 2T.CALL.
 (VERT.) 1 1
 SIGN OF VOID 1 0 0TTRIMMING 1TSELF-TRIMMING 2TVOID DEPH
 HEEL ANGLE OF GRAIN
 (FILLED) 1 15.0 DEG.
 (PARTLY FILLED) 1 25.0 DEG.
 HOLD NO. FOR HEELING MT. CALCULATION

12 23 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

** IN PUT DATA (HATCH AND HATCH COVER) **

HATCH TYPE NO.	HATCH		COAMING LENGTH (M)	HEIGHT AT C.L. (M)	DISTANCE FROM C.L. (M)	HATCH COVER	
	BREADTH FT (M)	FOR (M)				HEIGHT SIDE (M)	CENTER (M)
1	14.400	14.400	12.000	1.312	0.0	0.704	0.704
2	14.400	14.400	11.200	1.312	0.0	0.661	0.661
3	0.800	0.800	0.800	1.000	11.400	0.0	0.0

MAX. 10

** IN PUT DATA (FREEDER HOLE) **

FREEDER TYPE NO.	BREADTH (M)	LENGTH (M)	DISTANCE FROM C.L. (M)
32	14.400	11.200	0.0
33	0.800	0.800	11.400

MAX. 10

125.

FILLED

SECTION AT STA. 148.000 DIFFERENCE 0.440 M				SECTION AT STA. 148.000 DIFFERENCE 0.440 M			
CO. H. W. L.	SPE. AREA	CL. HT.	RG. HT.	CO. H. W. L.	SPE. AREA	CL. HT.	RG. HT.
(M)	(SQ. M)	(M)	(M)	(M)	(SQ. M)	(M)	(M)
1.493	0.0	0.0	0.0	1.493	0.0	0.0	0.0
2.500	0.0	0.0	0.0	2.500	0.0	0.0	0.0
3.006	0.0	0.0	0.0	3.006	0.0	0.0	0.0

GRAIN HEELING MT.

GRAIN HEELING MT.

SUMMARY TABLE OF VOID DATA IN FILLED COMPARTMENT (WEDGE ANGLE 15.0 DEG.)

23	NO.3 CARGO HOLD	(FR.148.000 - FR.175.000)									
	(UNDER UPPER DECK)	DIFF. 0.000 DIFF. 0.000									
		POSITION				NO.	VOID DEPTH	VOID VOLUME	T. VOID VOLUME	VOL.HEEL.MT.	
	COMPARTMENT	AFT		FORE			(M)	(CU.M)	(CU.M)	TRANS.	VERT.
		FR.	DIFF.	FR.	DIFF.					(M**4)	(M**4)
	AFT PART OF HATCH	148.000	0.0	154.000	0.0	1	0.728	27.81			
								SUB. TOTAL	27.8	152.0	-17.5
	HATCH PART	154.000	0.0	169.000	0.0	1	0.150	147.57			
								SUB. TOTAL	147.6	546.5	-74.9
	FORE PART OF HATCH	169.000	0.0	175.000	0.0	1	0.728	50.30			
								SUB. TOTAL	50.3	274.9	-31.7
								DECK TOTAL	225.7	973.4	-124.2
								GRAND TOTAL	225.7	973.4	-124.2

DETAIL OF VOLUMETRIC HEELING MOMENT AT FILLED COMPARTMENT (HEELING ANGLE 15.0 DEG.)

NO.	COMPARTMENT NAME	POSITION		VOLUME (CU.M)	LCG (M)	KG (M)	TCG (M)	TRAN. VOL.	VERT. VOL.
		AFT	FORE					HEEL. MT. (M**4)	HEEL. MT. (M**4)
23	NO.3 CARGO HOLD	{FR. 148.000 - FR. 175.000} DIFF. 0.000 DIFF. 0.000		9861.69	-33.273	10.124	0.0	973.4	124.2
	AFT PART OF HATCH	{FR. 148.000 - FR. 154.000} DIFF. 0.0 DIFF. 0.0						152.0	17.5
	HATCH PART	{FR. 154.000 - FR. 169.000} DIFF. 0.0 DIFF. 0.0						546.5	74.9
	FORE PART OF HATCH	{FR. 169.000 - FR. 175.000} DIFF. 0.0 DIFF. 0.0						274.9	31.7

GRAIN HEELING MT.

23 NO.3 CARGO HOLD		TFR. 148.000 - FR. 175.000		TANK BOTTOM = 1.995 M		TANK TOP = 20.145 M		
		DIFF. 0.000		DIFF. 0.001				
W.L. ABOVE BL (M)	DEPTH ABOVE HD, BOT. (M)	NET V. (CUB.M)	KG (M)	LCG (M)	TCG (M)	HEEL.VOL. HEEL.MT. (25.0 DEG) (M +44)	VERT.VOL. HEEL.MT. (25.0 DEG) (M +44)	KP
1.995	0.0	0.0	1.995	0.0	0.0	0.0	0.0	1
2.500	0.503	235.43	2.516	-33.041	0.0	2616.9	274.2	0
3.000	1.003	472.39	2.659	-33.041	0.0	5099.9	703.7	0
3.240	1.243	507.40	2.726	-33.041	0.0	6220.2	920.6	1
3.500	1.503	723.86	2.811	-33.795	0.0	7536.7	1168.6	0
4.000	2.003	994.46	3.051	-33.741	0.0	9903.9	1661.7	0
4.485	2.483	1268.41	3.311	-33.712	0.0	12017.0	2137.4	1
5.000	3.003	1573.23	3.509	-33.601	0.0	14369.4	2850.5	0
5.500	3.503	1869.71	3.651	-33.531	0.0	16319.8	3124.3	0
6.000	4.003	2202.33	4.119	-33.476	0.0	18124.9	3590.9	0
6.500	4.503	2533.00	4.379	-33.432	0.0	19703.0	4001.1	0
7.000	5.003	2972.48	4.604	-33.398	0.0	20981.0	4327.7	0
7.500	5.503	3216.38	4.958	-33.370	0.0	21911.0	4549.6	0
8.000	6.003	3569.20	5.228	-33.348	0.0	22409.4	4661.3	0
8.500	6.503	3954.18	5.494	-33.330	0.0	22807.9	4760.0	0
9.000	7.003	4240.06	5.758	-33.315	0.0	22928.9	4696.7	0
9.500	7.503	4541.96	6.019	-33.302	0.0	22854.4	4650.1	0
10.000	8.003	4935.86	6.279	-33.291	0.0	22592.2	4565.8	0
11.000	9.003	5623.64	6.795	-33.273	0.0	21513.9	4294.4	0
12.000	10.003	6311.42	7.300	-33.258	0.0	19710.9	3904.9	0
12.500	10.503	6801.66	7.716	-33.249	0.0	17726.9	3512.5	0
13.000	11.003	6992.19	7.770	-33.247	0.0	17157.8	3403.8	0
14.000	12.003	7622.52	8.207	-33.238	0.0	14230.7	2097.6	0
15.000	13.003	8194.50	8.719	-33.232	0.0	11414.1	2473.8	0
16.000	14.003	8670.78	9.191	-33.220	0.0	8663.9	2043.6	0
16.445	14.420	8804.60	9.259	-33.226	0.0	7351.6	1814.8	1
17.000	15.003	9072.59	9.416	-33.235	0.0	6040.4	1560.7	0
17.659	15.664	9300.76	9.607	-33.245	0.0	4541.2	1206.9	1
17.845	15.950	9390.25	9.683	-33.254	0.0	3930.1	1055.5	1
18.715	16.003	9405.61	9.697	-33.256	0.0	3023.5	1025.8	0
18.745	16.750	9613.79	9.885	-33.275	0.0	2271.8	814.9	0
18.833	16.838	9635.66	9.905	-33.277	0.0	2122.3	580.1	1
19.000	17.003	9664.43	9.932	-33.276	0.0	1919.2	517.0	0
20.000	18.003	9836.71	10.099	-33.273	0.0	738.3	110.1	0
20.145	18.150	9861.69	10.124	-33.273	0.0	614.7	84.4	1

EQUAL AT DATA

HOLD 7" 2

GRAIN HEELING MT.

NO. 4 CARGO HOLD

(FR.121.000 - FR.148.000)

DIFF. -0.000 DIFF. 0.000

FULL VOLUME 9941.44 M3

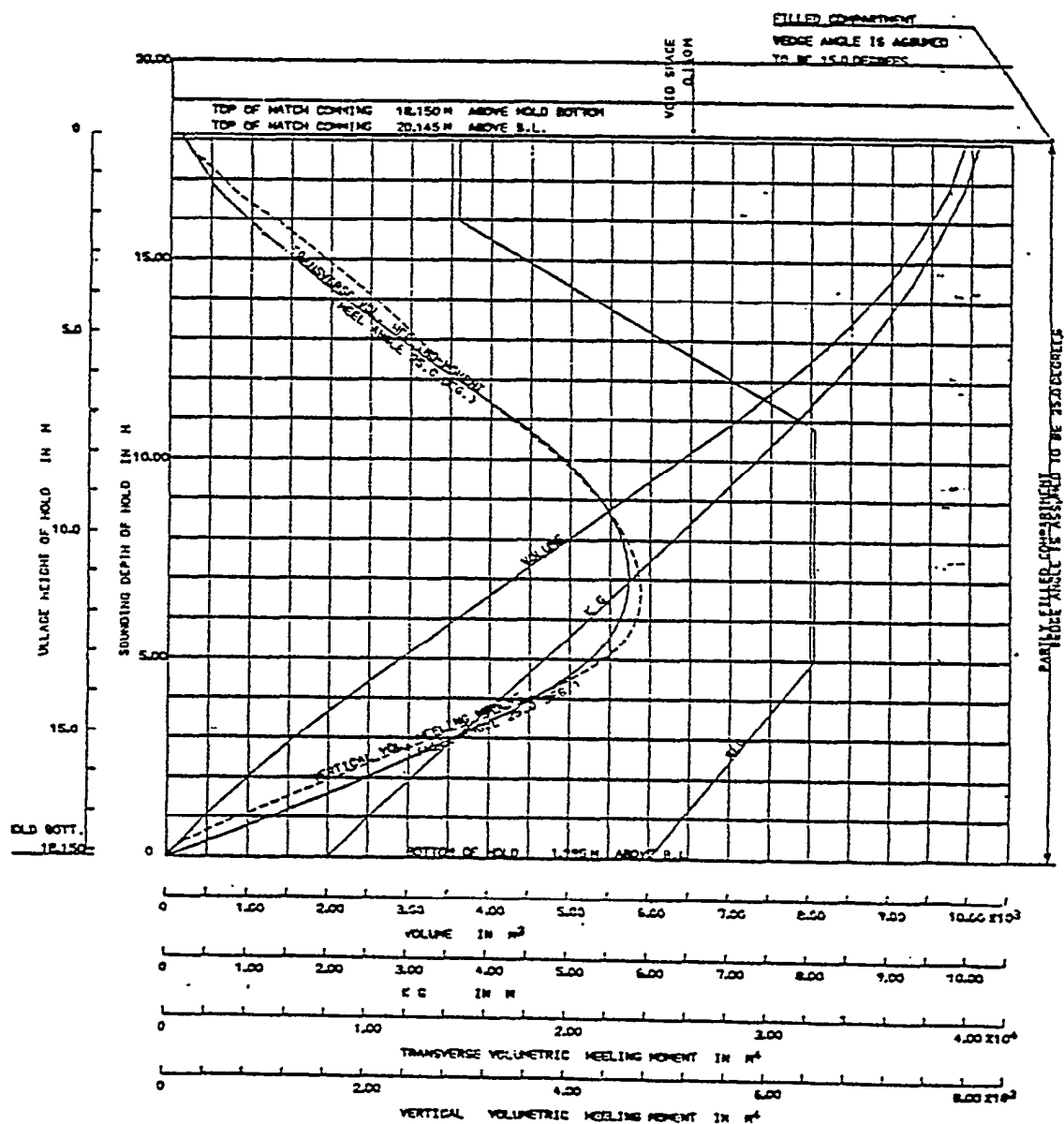
LEG -11.54 N

K G 10.12 M

VOLUMETRIC MEELING MOMENT
OF FILLED COMPARTMENT

TRANSMISSION 1059 40

VERTICAL 105 N⁴



** GGO TABLE FOR OPERATIONAL INFORMATION **

* OUTPUT UNIT SIGN= 0 * MINIMUM DISPT= 20000. * MAXIMUM DISPT= 50000. * INTERVAL DISPT= 500.

TANK NO.	SG	WL(1)	INERTIA(1)	WL(2)	INERTIA(2)	WL(3)	INERTIA(3)	WL(4)	INERTIA(4)
6	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
7	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
8	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
9	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
10	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
11	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
13	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
14	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
15	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
16	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
17	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
18	1.025	0.0	0.	0.0	0.	0.0	0.	0.0	0.
19	0.950	0.0	0.	0.0	0.	0.0	0.	0.0	0.
20	0.950	0.0	0.	0.0	0.	0.0	0.	0.0	0.
21	0.950	0.0	0.	0.0	0.	0.0	0.	0.0	0.
22	0.900	0.0	0.	0.0	0.	0.0	0.	0.0	0.
23	1.000	0.0	0.	0.0	0.	0.0	0.	0.0	0.

** CALCULATION TANK NO. **

* TITLE *

6	7	9	10	11	13	14	15	16	17	0	0	0	0	BALLAST WATER
23	0	0	0	0	0	0	0	0	0	0	0	0	0	FRESH WATER
19	20	0	0	0	0	0	0	0	0	0	0	0	0	FUEL OIL(C-OIL)
21	22	0	0	0	0	0	0	0	0	0	0	0	0	FUEL OIL(A-DIL)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	

*** GGO TABLE DISPLACEMENT DATA ***

* DISPT NO.= 61 * MINIMUM DISPT= 20000. * MAXIMUM DISPT= 50000. * INTERVAL DISPT= 500.

20000.	20500.	21000.	21500.	22000.	22500.	23000.	23500.	24000.	24500.
25000.	25500.	26000.	26500.	27000.	27500.	28000.	28500.	29000.	29500.
30000.	30500.	31000.	31500.	32000.	32500.	33000.	33500.	34000.	34500.
35000.	35500.	36000.	36500.	37000.	37500.	38000.	38500.	39000.	39500.
40000.	40500.	41000.	41500.	42000.	42500.	43000.	43500.	44000.	44500.
45000.	45500.	46000.	46500.	47000.	47500.	48000.	48500.	49000.	49500.
50000.									

* * * GGO

DECREASE OF CH BY FREE SURFACE EFFECT
(UNIT : M)

TANKS DISPT. (MT)	BALLAST WATER				
	NO.1 T. S. (P/S)	NO.2 T. S. (P/S)	NO.3 T. S. (P/S)	NO.4 T. S. (P/S)	NO.5 T. S. (P/S)
	S.G.=1.025	S.G.=1.025	S.G.=1.025	S.G.=1.025	S.G.=1.025
20000.	0.032	0.040	0.040	0.040	0.042
20500.	0.031	0.039	0.039	0.039	0.041
21000.	0.030	0.038	0.038	0.038	0.040
21500.	0.029	0.037	0.037	0.037	0.039
22000.	0.029	0.036	0.036	0.036	0.038
22500.	0.028	0.035	0.035	0.035	0.037
23000.	0.027	0.034	0.034	0.034	0.037
23500.	0.027	0.034	0.034	0.034	0.036
24000.	0.026	0.033	0.033	0.033	0.035
24500.	0.026	0.032	0.033	0.033	0.034
25000.	0.025	0.032	0.032	0.032	0.034
25500.	0.025	0.031	0.031	0.031	0.033
26000.	0.024	0.031	0.031	0.031	0.032
26500.	0.024	0.030	0.030	0.030	0.032
27000.	0.023	0.029	0.030	0.030	0.031
27500.	0.023	0.029	0.029	0.029	0.031
28000.	0.023	0.028	0.028	0.028	0.030
28500.	0.022	0.028	0.028	0.028	0.030
29000.	0.022	0.027	0.027	0.027	0.029
29500.	0.021	0.027	0.027	0.027	0.029
30000.	0.021	0.026	0.027	0.027	0.028
30500.	0.021	0.026	0.026	0.026	0.028
31000.	0.020	0.026	0.026	0.026	0.027
31500.	0.020	0.025	0.025	0.025	0.027
32000.	0.020	0.025	0.025	0.025	0.026
32500.	0.019	0.024	0.025	0.025	0.026
33000.	0.019	0.024	0.024	0.024	0.026
33500.	0.019	0.024	0.024	0.024	0.025
34000.	0.019	0.023	0.023	0.023	0.025
34500.	0.018	0.023	0.023	0.023	0.024
35000.	0.018	0.022	0.023	0.023	0.024
35500.	0.018	0.022	0.022	0.022	0.024
36000.	0.018	0.022	0.022	0.022	0.023
36500.	0.017	0.022	0.022	0.022	0.023
37000.	0.017	0.021	0.022	0.022	0.023
37500.	0.017	0.021	0.021	0.021	0.022
38000.	0.017	0.021	0.021	0.021	0.022
38500.	0.016	0.021	0.021	0.021	0.022
39000.	0.016	0.020	0.020	0.020	0.022
39500.	0.016	0.020	0.020	0.020	0.021

REMARK 1 THESE VALUES ARE SHOWN IN THE CASE OF THE MAXIMUM
FREE SURFACE EFFECTS.

タツカゴ

*** CARD INPUT DATA ***

TITLE TRIM TABLE = DRAFT CORRECTION TABLE BY LOADING UNIT WEIGHT

WEIGHT 100.00 (MT)

MIN. DRAFT 2.000 (M)

MAX. DRAFT 12.000 (M)

INTERVALS 0.500 (M)

UNIT 0

TANK NO.	6	7	8	9	10	11	13	14	15	16	17	18	0	0	0
	19	21	22	23	0	0	0	0	0	0	0	0	0	0	0
	31	33	34	35	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1 行 0 行 1 ページに OUTPUT される。

ADDED DATA	TANK NO	TANK NAME	H.G(M)
	0		0.0
	0		0.0
	0		0.0
	0		0.0
	0		0.0

TRIM TABLE

DRAFT (M)

TANK NAME		2.0	2.5	3.0	3.5	4.0	4.5
NO.1 T. S. T. (P/S)	FWD	9.1	8.9	8.7	8.6	8.5	8.5
	AFT	-5.0	-4.8	-4.7	-4.6	-4.5	-4.4
NO.2 T. S. T. (P/S)	FWD	6.2	6.1	6.0	5.9	5.9	5.9
	AFT	-1.8	-1.7	-1.6	-1.6	-1.5	-1.5
NO.3 T. S. T. (P/S)	FWD	3.0	3.0	3.0	3.0	2.9	3.0
	AFT	1.9	1.8	1.8	1.8	1.8	1.7
NO.4 T. S. T. (P/S)	FWD	-0.2	-0.1	-0.1	-0.0	-0.0	0.0
	AFT	5.5	5.4	5.3	5.2	5.1	5.0
NO.5 T. S. T. (P/S)	FWD	-3.5	-3.3	-3.2	-3.1	-3.0	-3.0
	AFT	9.2	9.0	8.8	8.6	8.4	8.3
NO.1 W. B. T. (P/S)	FWD	9.2	9.0	8.8	8.7	8.6	8.6
	AFT	-5.1	-4.9	-4.8	-4.7	-4.6	-4.5
NO.3 W. B. T. (P/S)	FWD	1.0	2.9	2.9	2.9	2.9	2.9
	AFT	1.9	1.9	1.9	1.9	1.8	1.8
NO.5 W. B. T. (P)	FWD	-3.4	-3.2	-3.1	-3.0	-2.9	-2.9
	AFT	9.1	8.9	8.7	8.5	8.3	8.2
NO.5 W. B. T. (S)	FWD	-3.2	-3.0	-2.9	-2.8	-2.7	-2.7
	AFT	8.9	8.6	8.4	8.3	8.1	8.0
FORE PEAK TANK	FWD	11.6	11.3	11.1	11.0	10.8	10.8
	AFT	-7.9	-7.6	-7.4	-7.2	-7.1	-7.0
AFT PEAK TANK	FWD	-8.3	-8.0	-7.8	-7.6	-7.5	-7.4
	AFT	14.7	14.3	14.0	13.7	13.4	13.2
NO.3 CARGO HOLD (HH)	FWD	3.0	3.0	3.0	3.0	3.0	3.0
	AFT	1.8	1.8	1.8	1.8	1.7	1.7

REMARK : TABLE OF CHANGE IN DRAFT IN CENTIMETERS
FOR EACH 100. TONS ADDED

トリムテーブル

TANK/HOLD CAPACITY SUMMARY TABLE

**SNO2581 **

DATE 77.11.16.

* CALCULATION UNIT SIGN = 0 0 0 0 0 0 0 0 0 0 0

*!-----+ TANK/HOLD APPLICATION DATA +!-----**

KIND OF CARGO 1 TYPE OF TANK 0 CARGO TITLE FRESH WATER TANK

TANK/HOLD NO. SUM1 23 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TANK/HOLD NO. SUM2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TANK/HOLD NO. SUM3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

CAPACITY(1) CUB.M CAPACITY(2) CUB.FT WEIGHT NAME OF CARGO WEIGHT X=100

CONVEY (1) 1.00000 2 CONVEY (2) 35.31467 1 CARGO SPECIFIC GRAVITY 1.00000 0 WEIGHT UNIT MT

*** FRESH WATER TANK ***

S.G. = 1.000

TANK NAME

FR.NO.

CAPACITY

WEIGHT

CENTER OF GRAVITY

CUB.M

CUB.FT

100 % FULL
(MT)

LCG

K.G

FRESH W. T. (P/S)

9 - 17

385.39

13609.8

385.

78.35

12.99

----- TANK/HOLD APPLICATION DATA **-----**

KIND OF CARGO 2 TYPE OF TANK 0 CARGO TITLE FUEL OIL TANK

TANK/HOLD NO. SUM1 19 20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TANK/HOLD NO. SUM2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TANK/HOLD NO. SUM3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

CAPACITY(1) CUB.M CAPACITY(2) BARREL WEIGHT NAME OF CARGO WEIGHT X= 96

CONVEY (1) 1.00000 2 CONVEY (2) 6.20981 1 CARGO SPECIFIC GRAVITY 0.95000 0 WEIGHT UNIT MT

タンク等サマリーテーブル

〔標準 FORM〕

FRESH WATER TANK						
S.G. = 1.000						
TANK NAME	FR.NO.	CAPACITY		WEIGHT	CENTER OF GRAVITY	
		CUB.M	CUB.FT	100 % FULL (MT)	LCG (M)	K G (M)
FRESH W. T. (P/S)	9- 17	385.37	13609.8	385	78.35	12.99

FUEL OIL TANK						
S.G. = 0.950						
TANK NAME	FR.NO.	CAPACITY		WEIGHT	CENTER OF GRAVITY	
		CUB.M	BARREL	96 % FULL (MT)	LCG (M)	K G (M)
NO.2 F. O. T. (P/S)	137- 173	1526.55	9601.7	1372	-36.65	1.45
NO.4 F. O. T. (P/S)	71- 105	1547.53	9733.7	1411	17.58	1.44
TOTAL		3074.08	19335.4	2803	—	—

DIESEL OIL TANK						
S.G. = 0.900						
TANK NAME	FR.NO.	CAPACITY		WEIGHT	CENTER OF GRAVITY	
		CUB.M	BARREL	96 % FULL (MT)	LCG (M)	K G (M)
F. O. T.(A-OIL) (P)	15- 39	97.43	612.8	84	65.03	0.77
F. O. T.(A-OIL) (S)	17- 39	96.44	606.6	83	64.72	0.99
TOTAL		193.87	1219.4	167	—	—

WATER BALLAST TANK						
S.G. = 1.025						
TANK NAME	FR.NO.	CAPACITY		WEIGHT	CENTER OF GRAVITY	
		CUB.M	CUB.FT	100 % FULL (MT)	LCG (M)	K G (M)
NO.1 T. S. T. (P/S)	174- 209	733.28	25895.6	752	-61.55	14.10
NO.2 T. S. T. (P/S)	140- 174	993.68	35091.4	1019	-37.33	13.59
NO.3 T. S. T. (P/S)	106- 140	999.54	35298.4	1025	-10.19	13.89
FORE PEAK TANK	207- 215	1596.00	56362.2	1636	-62.83	8.26
AFT PEAK TANK	-6- 8	283.46	10010.2	291	85.96	10.26
SUB TOTAL		10531.22	371907.0	10797	—	—
NO.3 CARGO HOLD (WB)	106- 140	9447.63	333640.0	9684	-10.42	8.71
SUB TOTAL		9447.63	333640.0	9684	—	—
GRAND TOTAL		19978.85	705547.0	20481	—	—

タンク等サマリーテーブル

〔変則 FORM〕

FUEL OIL TANK					
TANK NAME	FR.NO.	CAPACITY		CENTER OF GRAVITY	
		CUB.M	BARREL	LCS	K G
				(M)	(M)
NO.2 F. O. T. (P/S)	139- 173	1526.55	9601.7	-36.65	1.45
NO.4 F. O. T. (P/S)	71- 105	1547.53	9733.7	17.58	1.44
TOTAL		3074.08	19335.4	—	—

WATER BALLAST TANK				
TANK NAME	FR.NO.	CAPACITY	CENTER OF GRAVITY	
		CUB.M	LCS	K G
			(M)	(M)
NO.1 T. S. T. (P/S)	174- 209	733	-61.55	14.10
NO.2 T. S. T. (P/S)	140- 174	994	-37.33	13.89
NO.3 T. S. T. (P/S)	106- 140	1000	-10.19	13.89
NO.4 T. S. T. (P/S)	72- 106	1000	17.01	13.89
NO.5 T. S. T. (P/S)	36- 72	1045	44.86	13.91
NO.1 W. B. T. (P/S)	173- 209	1081	-62.48	1.31
SUB TOTAL		5853	—	—
NO.3 W. B. T. (P/S)	105- 139	1551	-9.50	1.44
NO.5 W. B. T. (P)	36- 71	667	43.97	2.12
NO.5 W. B. T. (S)	36- 71	581	42.24	1.82
FORE PEAK TANK	207- 215	1596	-82.83	8.26
AFT PEAK TANK	-6- 8	283	85.96	10.86
SUB TOTAL		4678	—	—
NO.3 CARGO HOLD (WB)	106- 140	9448	-10.42	8.71
SUB TOTAL		9448	—	—
GRAND TOTAL		19979	—	—

♦♦ CHECK PRINT OF CARD INPUT DATA ♦♦

REJAIN TATH CALCULATION

TATHG0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

TATH 1 0 0 0 0 0 0 0

TATH 2 520296.00 9.776 8.260 8.958

TATH 3 62679.000 6.660 417440.00 17.7201110670.00

TATH 4 540.000 107.740 59050.00 18.450 9010.00

TATH 1 1 1 0 1.0000 0.0

TATH 2 2 1 0 1.0000 0.0

TATH 3 3 1 0 1.0000 0.0

TATH 4 20 1 0 1.0000 0.0

TATH 5 4 2 0 0.9500 0.0

TATH 6 5 2 0 0.9500 0.0

TATH 7 6 2 0 0.9500 0.0

TATH 8 7 3 0 0.9000 0.0

TATH 9 8 4 0 1.0250 0.0

TATH 10 9 4 0 1.0250 0.0

TATH 11 10 4 0 1.0250 0.0

TATH 12 11 4 0 1.0250 0.0

TATH 13 12 4 0 1.0250 0.0

TATH 14 13 4 0 1.0250 0.0

TATH 15 14 5 4 0.0 0.0

TATH 16 15 5 4 0.0 0.0

TATH 17 16 5 4 0.0 0.0

TATH 18 17 5 4 0.0 0.0

TATH 19 18 5 4 0.0 0.0

TATH 20 19 5 4 0.0 0.0

TATH 21 20 5 4 0.0 0.0

TATH 22 21 5 4 0.0 0.0

TATH 23 22 5 4 0.0 0.0

TATH 24 23 5 4 0.0 0.0

TATH 25 24 5 4 0.0 0.0

TATH 26 25 5 4 0.0 0.0

TATH 27 26 5 4 0.0 0.0

TATH 28 27 5 4 0.0 0.0

TATH 29 28 5 4 0.0 0.0

TATH 30 29 5 4 0.0 0.0

TATH 31 30 5 4 0.0 0.0

TATH 32 31 5 4 0.0 0.0

TATH 33 32 5 4 0.0 0.0

TATH 34 33 5 4 0.0 0.0

TATH 35 34 5 4 0.0 0.0

TATH 36 35 5 4 0.0 0.0

TATH 37 36 5 4 0.0 0.0

TATH 38 37 5 4 0.0 0.0

TATH 39 38 5 4 0.0 0.0

TATH 40 39 5 4 0.0 0.0

TATH 41 40 5 4 0.0 0.0

TATH 42 41 5 4 0.0 0.0

TATH 43 42 5 4 0.0 0.0

TATH 44 43 5 4 0.0 0.0

TATH 45 44 5 4 0.0 0.0

ト リ ム 計 算

TATH 1 1 2 3 4 0 0 0 0

TATH 2 5 6 7 8 9 0 0 0

TATH 3 10 11 12 13 14 15 16 17

TATH 4 18 19 20 21 22 23 24 25

CONDITION No. = 4

*** CONDITION CALCULATION START ***

** CHECK WRITE OF CARD INPUT DATA **

TRCOND	4FULL LOAD	CONDITION	AT UNC ARR.	ONEWAY BUNK.
TRCOND1	0000	0	0	
TRCOND2	513175.000	0.0	0.0	0.0 0.0 0.0 0.0 0.0 0.0
TRCOND1	0 0.0	0.0	14 15 16 17 18 19	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
TRCOND2	0 0.0	0.0	21 22 23 24 25 26 27 28 29 30 31 32 33 34	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
TRCOND3	1			
TRCOND1	1 2 3 20 7 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			
TRCOND2	4 9 10 11 12 13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			
TRIM 1	4	0.0	0.0	0.0 0.0 0.0
TRIM 2	5	0.0	0.0	0.0 0.0
TRIM 3	6	0.0	0.0	0.0

FULL LOAD CONDITION AT DMC ARR. ONEWAY BUNK. (1/2).

FRESH WATER	=	780	MT
FUEL OIL	=	911	MT
DIESEL OIL	=	150	MT
WATER BALLAST	=	0	MT
CARGO OIL	=	448107	MT
CONSTANTS	=	540	MT
DEADWEIGHT	=	450496	MT
LIGHT WEIGHT	=	62679	MT
DISPLACEMENT	=	513175	MT
CORRESPONDING DRAFT	=	24.72	M
T P C	=	225.23	MT
L C G	=	-15.30	M
L C R	=	-15.30	M
M T C	=	5734.5	MT-M
TRIM	=	0.0	M
L C F	=	-4.17	M
DRAFT AT F.P.	=	24.72	M
DRAFT AT A.P.	=	24.72	M
DRAFT (MLN)	=	24.72	M
PROPELLER IMMERSION	=	232	%
T M	=	27.77	M
K G	=	16.34	M
G G	=	1.11	M
G M	=	10.32	M
MOMENT (IN REEL) DEG.	=	92440	MT-M

NOTE 1 - SIGN SHOWS FORWARD FROM MIDSHIP.

FULL LOAD CONDITION . AT UMC ARR. ONEWAY RUNK. (2/2)

ITEMS	N	WEIGHT (MT)	L C B (M)	MOMENT (MT-M)	K G (M)	MOMENT (MT-M)	G GO (M)
LIGHT WEIGHT CONSTANTS		62679	6.66	417440	17.72	1110670	
		549	107.74	59050	14.44	9010	
FRESH WATER T. (P/S)	59	240	170.22	42555	20.50	7125	0.0
DRINK WATER T. (P)	58	137	170.54	22129	20.29	3656	0.0
DIST. WATER T. (P)	53	710	164.34	34511	25.99	5458	0.0
DIST. WATER T. (S)	98	190	164.82	31506	20.26	5369	0.0
(FRESH WATER TOTAL)		(750)		(130730)		(21592)	(0.0)
FORW FUEL OIL TANK	0	0	-157.57	0	0.0	0	0.0
AFT FUEL OIL T. (P/S)	0	0	137.03	0	0.0	0	0.0
FUEL O. SETT. T. (P/S)	53	911	155.95	142070	25.35	23094	0.0
(FUEL OIL TOTAL)		(911)		(142070)		(23094)	(0.0)
DIESEL OIL TANK	79	150	162.02	24303	27.07	4060	0.0
(DIESEL OIL TOTAL)		(150)		(24303)		(4060)	(0.0)
FORW PEAK TANK	0	0	-172.62	0	0.0	0	0.0
NO. 1 W. A. T. (C)	0	0	-99.50	0	0.0	0	0.0
NO. 6 W. A. T. (C)	0	0	23.70	0	0.0	0	0.0
RESERVE W. A. T. (C)	0	0	125.75	0	0.0	0	0.0
RESERVE W. A. T. (P/S)	0	0	127.39	0	0.0	0	0.0
AFT PEAK TANK	0	0	175.05	0	0.0	0	0.0
(W. BALLAST TOTAL)		(0)		(0)		(0)	(0.0)
NO. 1 C. O. T. (C)	47	7194	-151.45	-1089531	8.10	58271	0.04
NO. 2 C. O. T. (C)	94	24581	-119.13	-2928334	16.08	395262	0.06
NO. 4 C. O. T. (C)	90	12271	-60.10	-815655	16.06	197072	0.03
NO. 5 C. O. T. (C)	94	36813	-27.30	-1004994	16.06	591217	0.10
NO. 7 C. O. T. (C)	94	24535	64.50	1582508	16.07	394277	0.06
NO. 8 C. O. T. (C)	94	23615	146.64	2471388	16.57	391350	0.06
NO. 1 C. O. T. (P/S)	94	21172	-150.41	-3104480	17.16	363311	0.02
NO. 2 C. O. T. (P/S)	94	23001	-172.13	-2970119	16.05	369934	0.05
NO. 3 C. O. T. (P/S)	94	24155	-108.69	-2630238	15.87	392132	0.06
NO. 5 C. O. T. (P/S)	94	24224	-02.57	-2143624	15.78	382255	0.04
NO. 6 C. O. T. (P/S)	94	24224	-60.10	-1849854	15.78	382255	0.04
NO. 8 C. O. T. (P/S)	94	24224	-47.74	-115495	15.78	382255	0.04
NO. 7 C. O. T. (P/S)	94	24225	-27.30	-681342	15.78	382270	0.04
NO. 8 C. O. T. (P/S)	94	24225	-0.90	-187146	15.78	382255	0.04
NO. 9 C. O. T. (P/S)	94	24221	13.50	326904	15.70	382207	0.04
NO. 10 C. O. T. (P/S)	93	24127	33.59	317644	15.85	382172	0.04
NO. 11 C. O. T. (P/S)	98	23706	54.25	1286051	16.09	381429	0.06
NO. 12 C. O. T. (P/S)	95	22591	76.56	1876929	16.67	374925	0.05
NO. 13 C. O. T. (P/S)	90	19763	94.79	1873335	17.66	349014	0.06
SLOP TANK	98	15130	115.93	1762796	19.27	295563	0.05
(CARGO OIL TOTAL)		(448107)		(-8625147)		(7218428)	(1.11)
GRAND TOTAL		511175	-15.30	-7849544	16.34	8386154	1.11

NOTE 1 - SIGN SHOWS FORWARD FROM MIDSHIP.

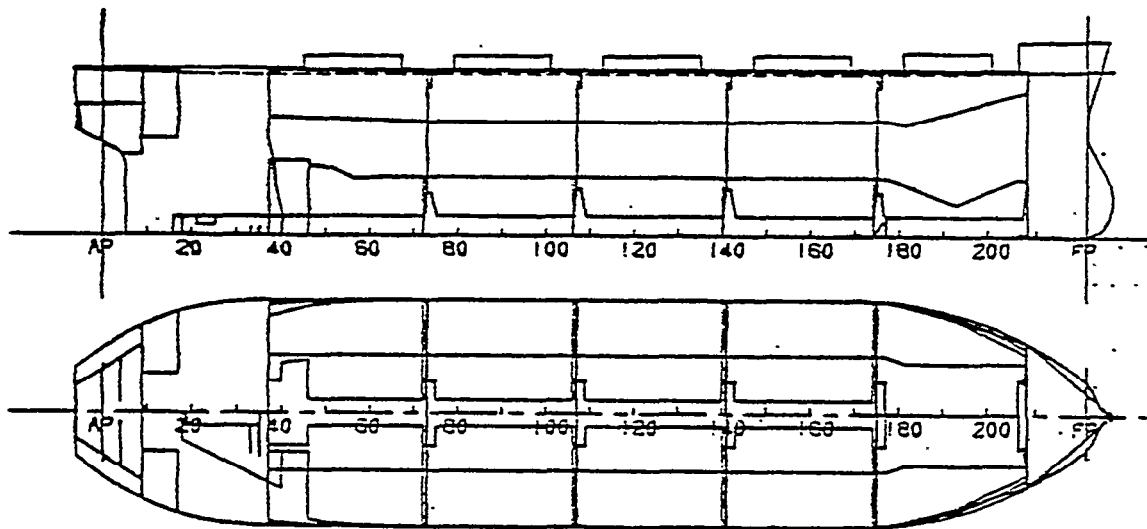
SUMMARY TABLE OF STANDARD LOADING CONDITION (7)									
ITEMS	CONDITIONS	44% UNLOAD. CONDITION AT UKC ARR.	51% UNLOAD. CONDITION AT UKC ARR.	58% UNLOAD. CONDITION AT UKC ARR.	75% UNLOAD. CONDITION AT UKC ARR.	PORT CONDITI TAIL SIAFT DOCKING ON AT MINA A APLDAT CONDITION L AHMADI			
		ONEWAY BUNK.	ONEWAY BUNK.	ONEWAY BUNK.	ONEWAY BUNK.	NEW FACILITY			
FRESH WATER	MT	784	783	743	780	0	780	0	780
FUEL OIL	MT	911	911	911	911	0	797	0	797
DIESEL OIL	MT	150	150	150	150	0	150	0	150
WATER BALLAST	MT	0	45918	30601	19000	0	149300	9861	40147
CARGO OIL	MT	225387	222720	143073	105034	0	0	0	0
CONSTANTS	MT	448	448	448	548	0	548	548	548
DEADWEIGHT	MT	227776	221027	378063	126423	0	151575	10409	42422
LIGHT WEIGHT	MT	62679	62679	62679	62679	0	62679	62679	62679
DISPLACEMENT	MT	290455	333706	430742	199102	0	214254	73008	105101
CORRESPONDING DRAFT	M	14.53	16.74	21.34	9.68	0.0	10.89	3.93	5.55
T P C	MT	211.58	214.30	229.74	209.99	0.0	207.43	195.54	199.53
L C G	M	-9.38	-14.95	-13.91	-4.84	0.0	-10.75	-13.91	-23.14
L C A	M	-20.09	-19.22	-16.76	-21.75	0.0	-21.34	-23.73	-23.14
M T C	MT-M	4795.5	4965.4	5411.2	4470.0	0.0	4546.3	3973.3	4153.7
TRIM	M	6.49	2.87	2.47	7.14	0.0	4.99	1.81	0.0
L C F	M	-14.85	-12.55	-6.99	-18.88	0.0	-18.02	-22.38	-21.44
DRAFT AT F.P.	M	11.55	15.22	20.39	8.48	0.0	8.65	3.14	5.55
DRAFT AT A.P.	M	18.04	18.09	22.66	13.63	0.0	13.64	4.95	5.55
DRAFT (MEAN)	M	14.79	16.65	21.43	10.05	0.0	11.14	4.04	5.55
PROPELLER IMMERSION	%	162	165	210	117	0	110	29	36
T KM	M	30.20	30.36	28.19	41.54	0.0	30.21	89.18	65.43
K G	M	16.26	16.74	16.56	15.56	0.0	16.49	16.54	13.37
G GO	M	1.07	0.82	0.98	1.11	0.0	0.21	0.32	1.37
GO M	M	14.87	12.80	10.65	24.87	0.0	21.51	72.32	50.49
MOMENT TO INFL 1 DEG. MT-M		75411	74579	81584	82114	0	80465	92289	93019

NOTE 1 - SIGN SHOWS FORWARD FROM MIDSHIP.

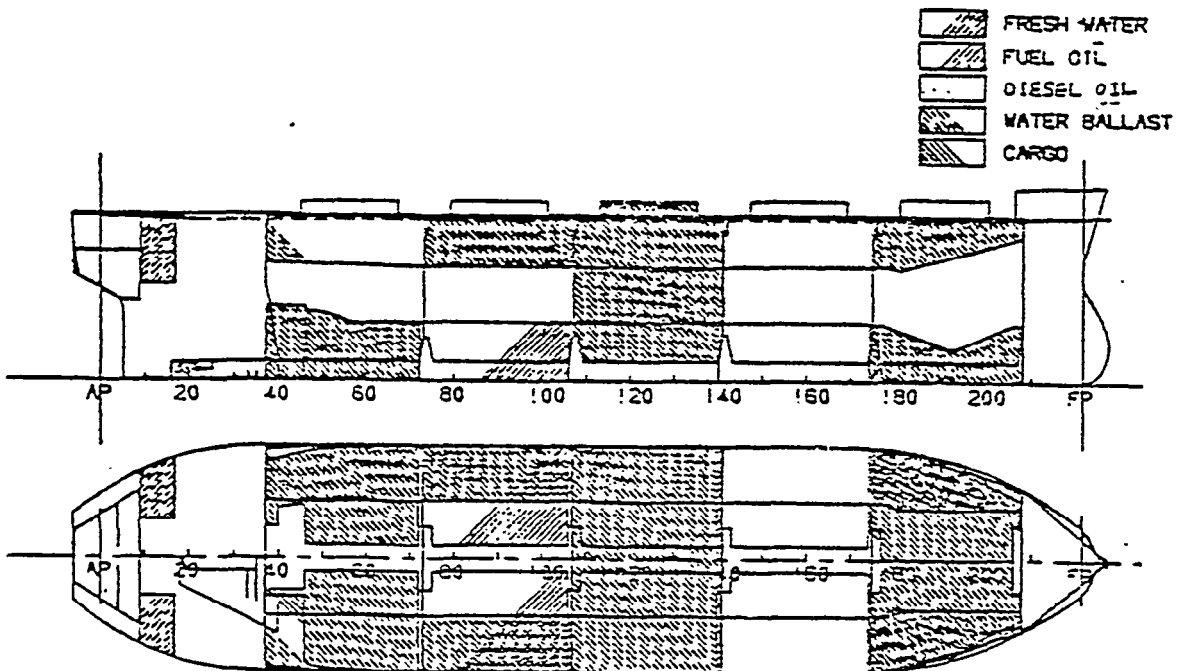
トリム計算 (積付状態作画)

GENERAL ARRANGEMENT

SCALE : 1/1186



(C-1) NORMAL BALLAST DEP.



*** LATERAL AREA CURVE ***

INCLUDE MOVING OBJECT

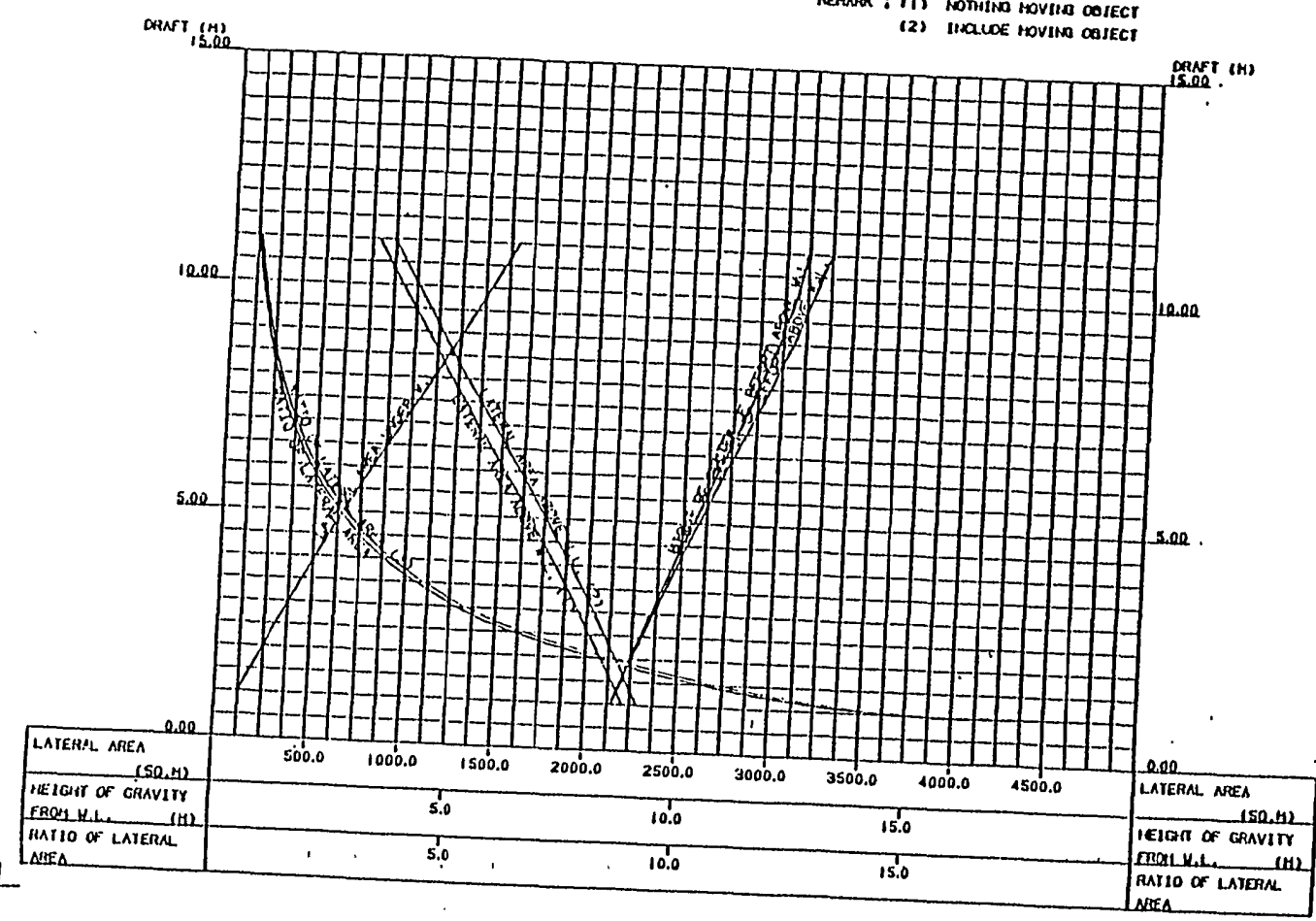
DRAFT (M)	UNDER WATER LINE		ABOVE WATER LINE		AREA RATIO	ABOVE WATER LINE		AREA RATIO
	AREA (SQ.M)	K G (M)	AREA (SQ.M)	K G (M)		AREA (SQ.M)	K G (M)	
1.000	194.30	0.50	3612.14	10.17	18.580	3612.14	10.17	18.580
2.000	390.23	1.00	3416.21	10.66	8.754	3416.21	10.66	8.754
3.000	586.84	1.50	3219.60	11.16	5.486	3219.60	11.16	5.486
4.000	783.76	2.01	3022.68	11.66	3.857	3022.68	11.66	3.857
5.000	980.74	2.51	2825.71	12.16	2.881	2825.71	12.16	2.881
6.000	1177.51	3.01	2628.94	12.66	2.233	2628.94	12.66	2.233
7.000	1373.78	3.51	2432.67	13.15	1.771	2432.67	13.15	1.771
8.000	1569.50	4.00	2236.95	13.65	1.425	2236.95	13.65	1.425
9.000	1765.30	4.50	2041.14	14.14	1.156	2041.14	14.14	1.156
10.000	1962.19	5.00	1844.26	14.64	0.940	1844.26	14.64	0.940
11.000	2160.35	5.51	1646.10	15.14	0.762	1646.10	15.14	0.762
12.000	2359.73	6.01	1446.72	15.64	0.613	1446.72	15.64	0.613
13.000	2560.22	6.52	1246.23	16.14	0.487	1246.23	16.14	0.487
14.000	2761.47	7.03	1044.98	16.65	0.378	1044.98	16.65	0.378
15.000	2963.27	7.54	843.17	17.17	0.285	843.17	17.17	0.285
16.000	3165.77	8.05	640.68	17.69	0.202	640.68	17.69	0.202
17.000	3368.44	8.56	437.50	18.25	0.130	437.50	18.25	0.130
18.000	3572.79	9.07	233.65	18.90	0.065	233.65	18.90	0.065
18.300	3634.08	9.22	172.37	19.17	0.047	172.37	19.17	0.047

風 圧 側 面 積

風 圧 側 面 積

CURVE OF LATERAL AREA

REMARK : (1) NOTHING MOVING OBJECT
(2) INCLUDE MOVING OBJECT



SUMMARY TABLE OF STABILITY CALCULATION						
COND. NO.	31	32	33	34	35	36
HEAVY BALL.	NORMAL BALL.	DRE	HOMOGENEOUS	GRAIN LOAD.	GRAIN LOAD.	
JAPAN DEP.	JAPAN DEP.	ALTERNATE	NOFOLK DEP.	S.F.=40	S.F.=55	
(T.C.=1)	(T.C.=3)	INUSCO DEP.	(T.C.=11)	VANCOUVER	VANCOUVER	
(T.C.=1)	(T.C.=3)	(T.C.=9)	(T.C.=11)	DEPARTURE	DEPARTURE	(T.C.=29)
DISPLACEMENT (MT)	29630.0	32570.0	70965.0	70965.0	70917.0	56137.0
DRAFT (CORR) (M)	7.743	6.434	13.330	13.330	13.330	10.730
DRAFT AT AP (M)	0.680	0.680	13.340	13.330	13.330	10.730
DRAFT AT FP (M)	7.080	4.640	13.340	13.330	13.330	10.730
DRAFT (MEAN) (M)	7.700	6.560	13.340	13.330	13.330	10.730
TRIM (M)	1.400	2.140	0.0	0.0	0.0	0.0
KG (M)	0.670	10.260	10.200	10.190	10.240	10.420
GM (M)	4.740	5.540	2.970	2.900	2.930	2.760
GGO (M)	0.770	0.600	0.260	0.260	0.120	0.220
GOM (M)	3.970	4.940	2.710	2.720	2.810	2.540
OG (M)	1.927	3.026	-3.130	-3.140	-3.090	-0.316
GZ MAX. (M)	3.155	3.120	1.247	1.353	1.413	2.138
THETA MAX. (DEG)	42.265	42.034	30.013	30.021	40.000	40.757
THETA RANGE (DEG)	83.022	81.070	76.150	76.329	77.974	78.621
D.S. (M-RAD)	2.637	2.684	1.111	1.117	1.170	1.609
D.S. (MT-M)	104501.3	87444.1	70817.7	79283.9	83567.4	90313.6
D.S./DISP (M)	2.637	2.684	1.111	1.117	1.178	1.609
FLOOD ANGLE (DEG)						
LAT. W. AREA (M2)	2286.9	2543.5	1170.4	1170.4	1180.1	1499.3
LAT. AREA RATIO	1.428	1.951	0.444	0.444	0.445	0.781
ROLL PERIOD TS	12.120	11.365	13.527	13.502	13.205	14.290
RED. COEFF. N	0.02364	0.02612	0.01985	0.01983	0.01991	0.02214
ROLL ANGLE (DEG)	10.090	19.930	14.814	14.838	15.056	14.616
RESULT C1	11.995	7.965	11.644	11.644	11.665	10.313
GZ REQ. (M)						
GZ MAX./GZ REQ						
THETA MAX/30.	1.409	1.428	1.294	1.294	1.333	1.359
RESULT C2	0.033	0.046	0.023	0.022	0.022	0.026
FREBOARD AT FP	11.709	14.149	5.449	5.459	5.459	8.059
FREBOARD AT MID	10.520	11.740	4.960	4.970	4.970	7.570
FREBOARD AT AP	10.177	10.177	5.317	5.327	5.327	7.927
RES. DISP (MT)	63090.1	70150.1	31771.1	31771.1	31819.1	46599.1
RES. DISP/A. DISP	1.592	2.154	0.448	0.448	0.449	0.830

COND 3 NORMAL RALL. JAPAN DEP.

** PARTICULARS FOR STABILITY

DISPLACEMENT 10662. MT DRAFT AT AP 4.300 M
CORRECTED KG (KGO) 11.220 M DRAFT AT FP 0.470 M
CORRECTED GM (GM) 24.120 M

** RIGHTING LEVER (GZ) CURVE INFORMATION

RANGE OF POSITIVE RIGHTING LEVER FROM 0.0 DEG. TO 76.60 DEG.
MAY. RIGHTING LEVER 5.016 M AT 20.63 DEG.
ANGLE OF FLOODING INTO MAIN HULL NOTHING

INTEGRATED AREA FOR DYNAMICAL STABILITY

AREA-1 2.052 M-RAD. FROM 0.0 DEG. TO 30.00 DEG.
AREA-2 2.795 M-RAD. FROM 0.0 DEG. TO 40.00 DEG.
AREA-3 0.743 M-RAD. FROM 30.00 DEG. TO 40.00 DEG.

HEFLING ANGLE AT 42.42 DEG. (DECK SIDE LINE WILL BE IMMERSD)

** STABILITY STUDY WITH WIND AND ROLLING ** CHECK WRITE **

RIGHTING LEVER AT STEADY WIND OW1 = 0.244 M (COEFF. K1 = 0.0000) LATERAL WINDAGE AREA = 3367.00 SQ.M
RIGHTING LEVER AT GUST WIND OW2 = 0.366 M (COEFF. K2 = 1.5000) LEVER OF WIND MOMENT = 9.650 M
ROLLING ANGLE = 38.82 DEG.

STABILITY AREA(A) 2.026 M-RAD. FROM 30.27 DEG. TO 0.01 DEG. ROLLING PERIOD T = 7.65 SEC. K = 18.701 M
STABILITY AREA(B) 3.474 M-RAD. FROM 0.81 DEG. TO 72.89 DEG. REDUCTION COEFF N = 0.02740
AREA RATIO C1 = B/A = 1.187 GAMMA = 3.11956 P = 0.151

COND 3 NORMAL HALL.

JAPAN

DEP.

** STABILITY STUDY FOR NO.2 CRITERION OF DEFENCE AGENCY

MAX. RIGHTING LEVER GZ1 = 5.026 M AT 20.63 DEG.

DISPLACEMENT D = 10662 MT
 LATERAL WINDAGE AREA A = 3367.00 SQ.M
 LEVER OF WIND MOMENT H = 9.658 M
 WIND PRESSURE COEFF. K = 0.1400

RIGHTING LEVER COEFF. DW2 = 0.500 M

INCLIN. ANGLE COS(THETA) DW2*Q*Q
 THETA (DEG) Q

0.0	1.0000	0.580
5.00	0.9962	0.575
10.00	0.9848	0.561
12.00	0.9701	0.554
15.00	0.9559	0.544
20.00	0.9397	0.512
25.00	0.9263	0.476
30.00	0.8660	0.435
35.00	0.8192	0.389
40.00	0.7660	0.340
45.00	0.7073	0.293
50.00	0.6428	0.239
60.00	0.5000	0.145
70.00	0.3420	0.060
75.00	0.2318	0.031
90.00	0.0000	0.000
78.62	0.1973	0.102
90.00	0.0000	0.000

INTERSECTION BETWEEN GZ-CURVE AND DW2*Q*Q

GZ2 = 0.579 M AT 1.24 DEG.

RIGHTING LEVER RATIO G2 = GZ2/GZ1 = 0.115

復原性計算

DISP 25050.0 MT
 DR AP 7.880 M
 DR FP 4.970 M
 KG0 8.680 M
 GOM 4.370 M

DR AP 7.880 M
 DR FP 4.970 M
 KG0 8.680 M
 GOM 4.370 M

BALLAST CONDITION

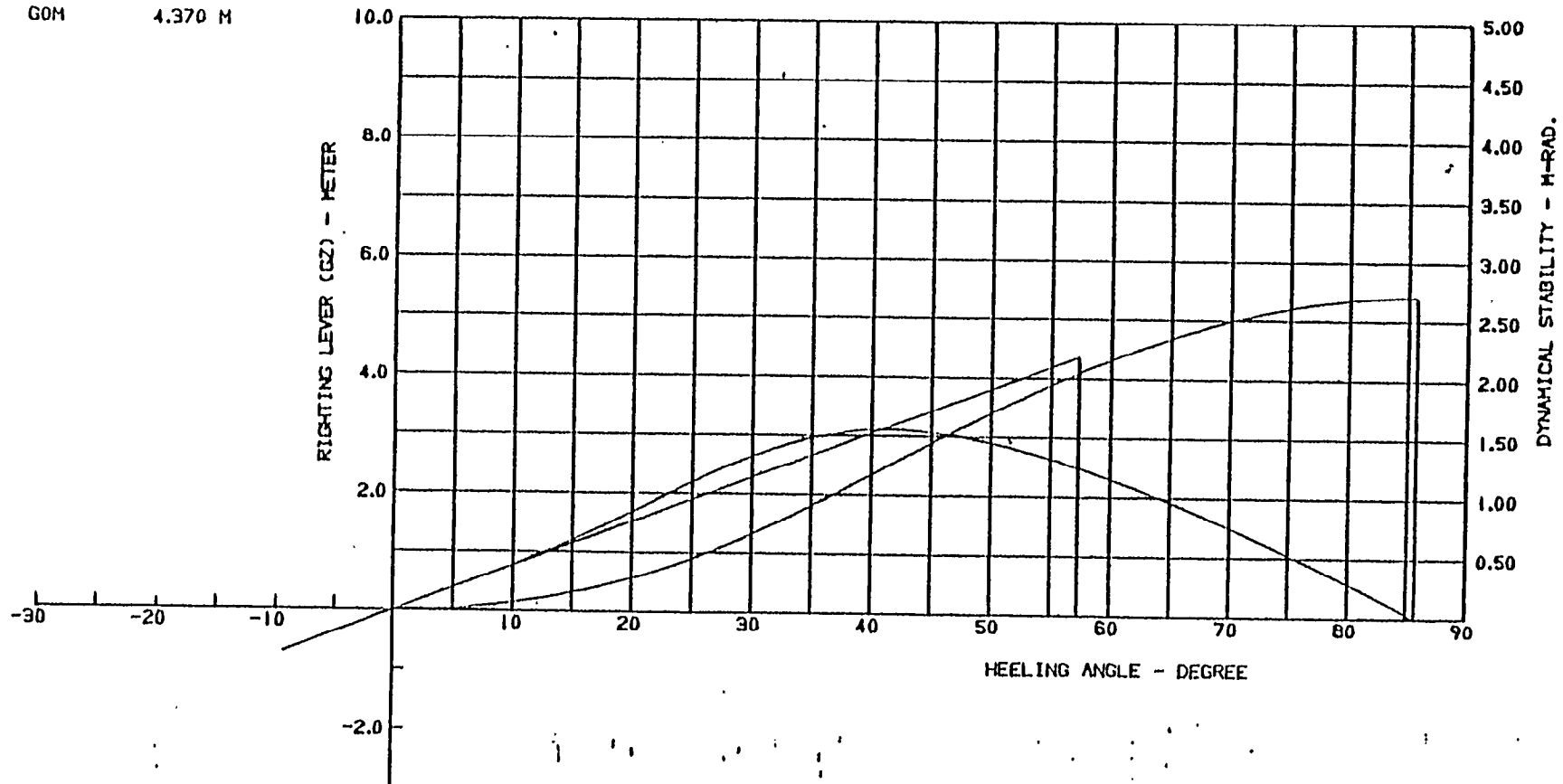
NORMAL

RANGE OF POSITIVE RIGHTING LEVER FROM 0.0 DEG. TO 65.7 DEG.

MAX. RIGHTING LEVER - 3.112 M AT 40.7 DEG

FLOODING INTO MAIN HULL AT ANGLE - 63.6 DEG

FLOODING INTO MAIN HULL AT ANGLE - 63.6 DEG



復原性計算

CHECK STABILITY

SYOHI JYOTAI

DISP 2950.3 MT
OR AP 3.990 M
DR FP 1.610 M
KG0 4.470 M
GOM 2.950 M

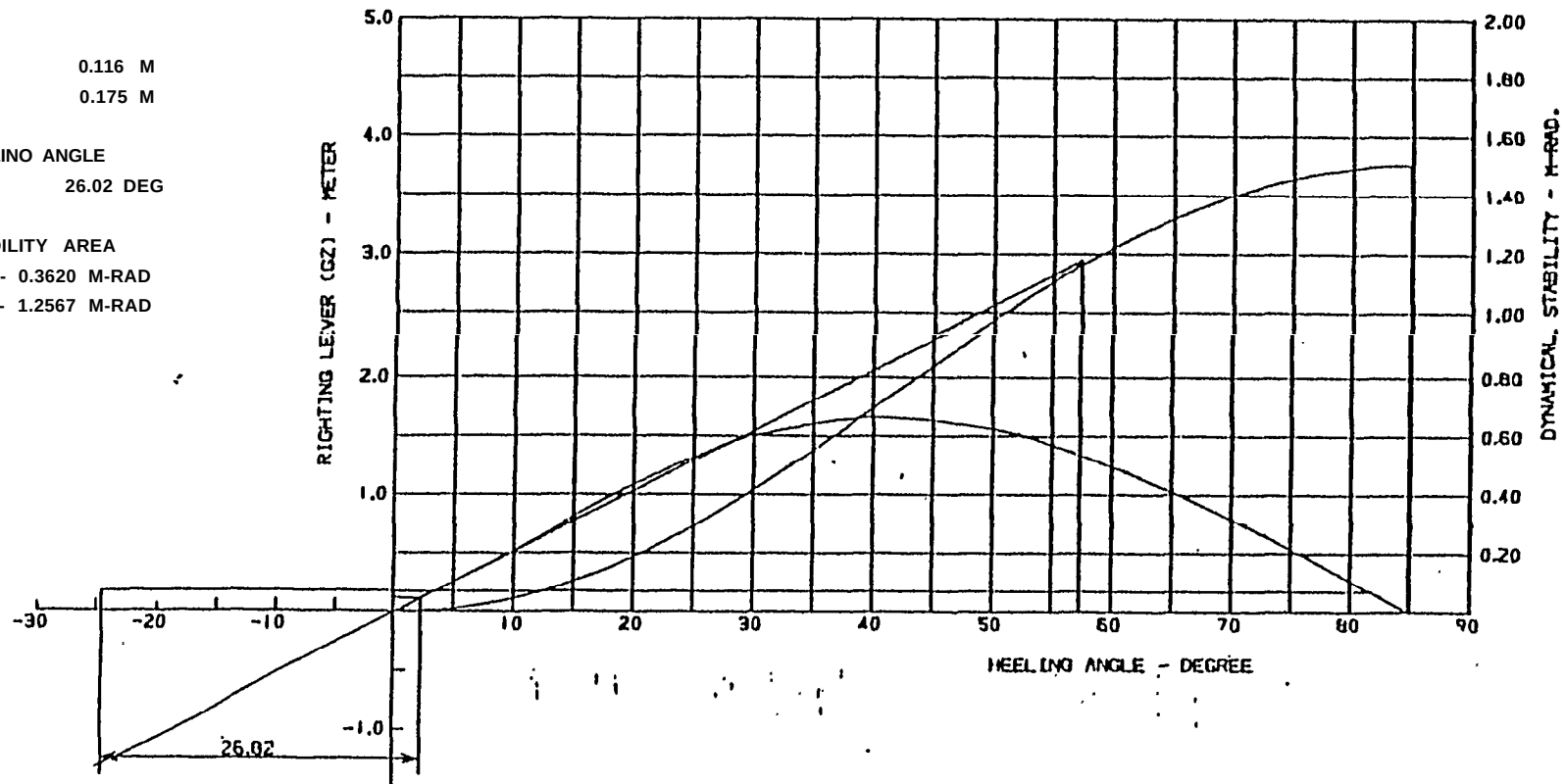
RANGE OF POSITIVE RIGHTING LEVER FROM 0.0 DEG. TO 04.8 DEG.

MAX. RIGHTING LEVER - 1.658 M AT 40.0 DEG

DW1 0.116 M
DW2 0.175 M

ROLLING ANGLE
26.02 DEG

STABILITY AREA
A - 0.3620 M-RAD
B - 1.2567 M-RAD



復原性計算

GRAIN STABILITY

TABLE OF TRANSVERSE HEELING MOMENT FOR GRAIN FILLED LOADED (HEELING ANGLE 15.0 DEG.)

CARGO HOLD	VOL. HEELING MOMENT (H * 4)	STORAGE FACTOR (CUB.FT/LT)			
		40.0000	41.0000	42.0000	
		TRANSVERSE HEELING MOMENT (MT-H)			
NO.1 CARGO HOLD	1022	917	894	873	
NO.2 CARGO HOLD	1131	1015	990	968	
NO.3 CARGO HOLD	973	873	852	832	
NO.4 CARGO HOLD	1050	950	927	905	
NO.5 CARGO HOLD	1132	1016	991	967	
TOTAL	5317	4771	4654	4543	

TABLE OF VERTICAL SHIFTING MOMENT FOR GRAIN FILLED LOADED (HEELING ANGLE 15.0 DEG.)

CARGO HOLD	VOL. HEELING MOMENT (H * 4)	STORAGE FACTOR (CUB.FT/LT)			
		40.0000	41.0000	42.0000	
		VERTICAL SHIFTING MOMENT (MT-H)			
NO.1 CARGO HOLD	100	90	88	86	
NO.2 CARGO HOLD	112	101	98	96	
NO.3 CARGO HOLD	124	111	109	106	
NO.4 CARGO HOLD	105	94	92	89	
NO.5 CARGO HOLD	113	101	99	96	
TOTAL	554	497	486	473	

GRAIN STABILITY

TABLE OF ALLOWABLE HEFLING MOMENT

DISPT (MT)	MIN. GOM	MIN.	G O M (M)										-- CHECK LIST --		
	(M)	HEFL. MT (MT-M)	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	RESID.	HEEL	EFFEC.	
	ALLOWABLE HEFLING MOMENT (MT-M)												S. AREA (M-RAD)	ANGLE (DEG)	RANGE (DEG)
55000	0.30	6260	6260	7477	8693	9910	11124	12343	13559	14776	15992	0.145	12.0	35.0	
56000	0.30	6326	6326	7565	8803	10042	11280	12519	13758	14996	16235	0.140	12.0	35.0	
57000	0.30	6399	6399	7660	8921	10161	11442	12703	13964	15224	16485	0.135	12.0	35.0	
58000	0.30	6490	6490	7773	9056	10339	11622	12905	14187	15470	16753	0.129	12.0	35.0	
59000	0.30	6577	6577	7882	9187	10492	11797	13102	14407	15712	17017	0.123	12.0	35.0	
60000	0.30	6662	6662	7989	9316	10643	11970	13297	14624	15951	17278	0.113	12.0	34.6	
61000	0.30	6745	6745	8094	9443	10793	12142	13491	14840	16189	17539	0.100	12.0	33.7	
62000	0.30	6832	6832	8204	9575	10946	12318	13689	15060	16432	17803	0.085	12.0	32.4	
63000	0.34	7397	6074	8268	9661	11055	12448	13842	15235	16629	18022	0.075	12.0	31.4	
64000	0.47	9305	6901	8397	9812	11228	12644	14059	15475	16890	18306	0.075	12.0	30.9	
65000	0.61	11395	6991	8429	9866	11304	12742	14179	15617	17055	18492	0.075	12.0	30.4	
66000	0.73	13473	7178	8638	10098	11558	13017	14477	15937	17397	18857	0.075	12.0	30.1	
66500	0.78	14361	7235	8715	10176	11647	13118	14589	16060	17531	19002	0.075	12.0	30.1	
67000	0.87	15781	7287	8768	10250	11732	13214	14696	16178	17660	19142	0.075	12.0	29.7	
67500	0.94	16941	7350	8843	10336	11829	13322	14815	16308	17801	19294	0.075	12.0	29.6	
68000	1.02	18276	7406	8910	10414	11910	13422	14926	16430	17934	19438	0.075	12.0	29.4	
68500	1.11	19722	7460	8975	10490	12005	13520	15035	16551	18066	19581	0.075	12.0	29.1	

REMARK GOM : CORRECTED GM WITH GGO

(1-2) HMD, FULL 0-10.753 S.V. ARR.

PARTICULAR OF STABILITY

	THIS SHIP		CRITERIA IMCO		*** CHECK LIST ***	
DISPLACEMENT	4,736 MT	44023 LT	—	—	A : AREA BETWEEN 0.0 DEG. AND 30.0 DEG.	
COLLECTED GY	2,510 M	8,235 FT	0.3 M	—		
RESIDUAL STABILITY AREA	0.475 M-RAD.	1.502 FT-RAD.	0.075 M-RAD.	—	0.369 M-RAD.	1.211 FT-RAD.
HEELING ANGLE	2.9 DEG.	—	12.0 DEG.	—	B : AREA BETWEEN 0.0 DEG. AND 40.0 DEG.	
ACTUAL HEELING MOMENT	3756 MT-M	13506 LT-FT	—	—		
MAX. RIGHTING LEVER	1.392 M	4.507 FT	—	—	0.608 M-RAD.	1.993 FT-RAD.
MAX. RIGHTING LEVER AT ANGLE	37.6 DEG.	—	—	—	C : AREA BETWEEN 30.0 DEG. (A) AND 40.0 DEG. (B)	
ANGLE OF FLOODING	44.5 DEG.	—	—	—		
RANGE OF RESIDUAL AREA	37.6 DEG.	—	—	—		
RAMUA	0.129 M	0.423 FT	—	—		
ALLOWABLE HEELING MOMENT	26283 MT-M	84868 LT-FT	—	—	0.239 M-RAD.	0.784 FT-RAD.

INCLIN. RIGHTING		STATICAL RIGHTING LEVER (M)												
ANGLE	LEVER													
(DEG.)	(M)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0		
0.0	0.0	1.4												
5.00	0.221	1.4	*											
10.00	0.453	1.4												
15.00	0.708	1.4		*										
20.00	0.992	1.4			*									
25.00	1.191	1.4				*								
30.00	1.213	1.4					*							
35.00	1.380	1.4						*						
40.00	1.389	1.4							*					
44.52	1.345	1.4								*				
44.52	0.0	1.4												

IN FLOW POINT

GRAIN STABILITY

GRAIN STABILITY

SUMMARY TABLE OF GRAIN STABILITY CALCULATION					
CONDITIONS		GRAIN LOAD (S.F. = 50)	GRAIN LOAD (S.F. = 52)	GRAIN LOAD (S.F. = 55)	GRAIN LOAD (S.F. = 55)
(ITEM)	(UNITS)	VANCOUVER DEP.	JAPAN ARR.	VANCOUVER DEP.	JAPAN ARR.
S.G. OF SEA WATER	(MT/CUB.M)	1.0250	1.0250	1.0250	1.0250
STOWAGE FACTOR	(CUB.FT/LT)	50.0000	50.0000	55.0000	55.0000
DISPLACEMENT	(MT)	59759	59355	56137	55813
CORRESPONDING DRAFT	(M)	11.38	11.31	10.73	10.68
L C G	(M)	-6.41	-6.45	-6.65	-6.67
L C B	(M)	-6.06	-6.09	-6.33	-6.35
M T C	(MT-M)	734.6	732.7	717.8	716.3
TRIM	(M)	-0.28	-0.29	-0.25	-0.25
L C E	(M)	-1.49	-1.58	-2.23	-2.30
DRAFT AT FP	(M)	11.52	11.45	10.86	10.80
AT AP	(M)	11.24	11.16	10.61	10.55
AT MID.	(M)	11.38	11.30	10.73	10.67
T.M	(M)	13.65	13.06	13.12	13.13
K G	(M)	10.33	10.44	10.36	10.49
GGG	(M)	0.18	0.17	0.22	0.23
GGH	(M)	2.54	2.45	2.54	2.41
HEELING MT. TO 1 DEG.	(MT-M)	2650.0	2539.0	2490.0	2349.0
ACTUAL HEELING MT.	(MT-M)	5474	5474	4977	4977
ALLOWABLE HEELING MT.	(MT-M)	36031	34617	33949	32163
HEELING ANGLE	(DEG.)	2.0	2.1	2.0	2.1
RESIDUAL STABILITY AREA	(M -RAD.)	0.689	0.670	0.726	0.698
ANGLE OF FLOODING	(DEG.)	49.8	50.1	52.2	52.4
MAX. RIGHTING LEVER	(M)	2.00	1.96	2.10	2.11

GRAIN STABILITY

ASSUMED AND REAL GZ VALUES AT 12 DEG. AND 40 DEG.
OF EACH CONDITION

AS 304ED KG - 11.000TH

CONDITION	DISPT	STORAGE	GZ VALUES (MT)			
NAME	(MT)	FACTOR	ASSUMED GZ	REAL GZ		
		TCUR.FY				
		/LT)	12 DEG.	40 DEG.	12 DEG.	40 DEG.
GRAIN LOAD						
(S.F. = 40)						
	70965	40.0000	0.479	0.998	0.608	1.397
VANCOUVIR						
DEP.						
	0	0.0000	0.000	0.000	0.000	0.000

FILLED COMP. A NEELING ANGLE 8.5°
(* SP 95.11 COMP. 8.5°.)

TABLE OF ACTUAL TRANSVERSE BENDING MOMENT OF EACH CONDITION (BENDING ANGLE 15.0 DEG.)
(UNITS: 1 MT-M)

CARGO HOLD	COND. NAME	GRAIN LOAD (S.F. = 40)	GRAIN LOAD (S.F. = 42)	GRAIN LOAD (S.F. = 42)	DRY LOAD (ALTERNATE)
	VOL. HEELING MOMENT (IN **4)	VANCOUVER DEP.	VANCOUVER DEP.	JAPAN ARR.	JAPAN ARR.
NO. 1 CARGO HOLD	1022	7415	0	873	873
		3007	0	1022	1022
NO. 2 CARGO HOLD	1131	1015	0	966	966
		1131	0	1131	1131
NO. 3 CARGO HOLD	973	873	0	832	832
		973	0	973	973
NO. 4 CARGO HOLD	1059	950	0	905	905
		1059	0	1059	1059
NO. 5 CARGO HOLD	1132	1016	0	967	967
		1132	0	1132	1132
NO. 6 CARGO HOLD	1132	1016	0	967	967
		1132	0	1132	1132
NO. 7 CARGO HOLD	1178	1057	0	1007	1007
		1178	0	1178	1178
TOTAL	7627	9342	0	6517	6517

NO. 1 CARGO HOLD

NO. 2 CARGO HOLD

NO. 3 CARGO HOLD

NO. 4 CARGO HOLD

NO. 5 CARGO HOLD

NO. 6 CARGO HOLD

NO. 7 CARGO HOLD

TOTAL

HEELING MT.

HEELING MT.

REMARK :

... PARTLY FILLED COMPARTMENT HEELING ANGLE 25.0 DEG.
HEELING MOMENT = 1.12 * (CALCULATED HEELING MOMENT)

(B-1) HOMO. FULL D-10.763 S.V. DEP.

DISP. 45321.0 MT
 CRAP 10.766 M
 DRFP 10.766 M
 KGO 9.070 M
 GOM 2.440 M

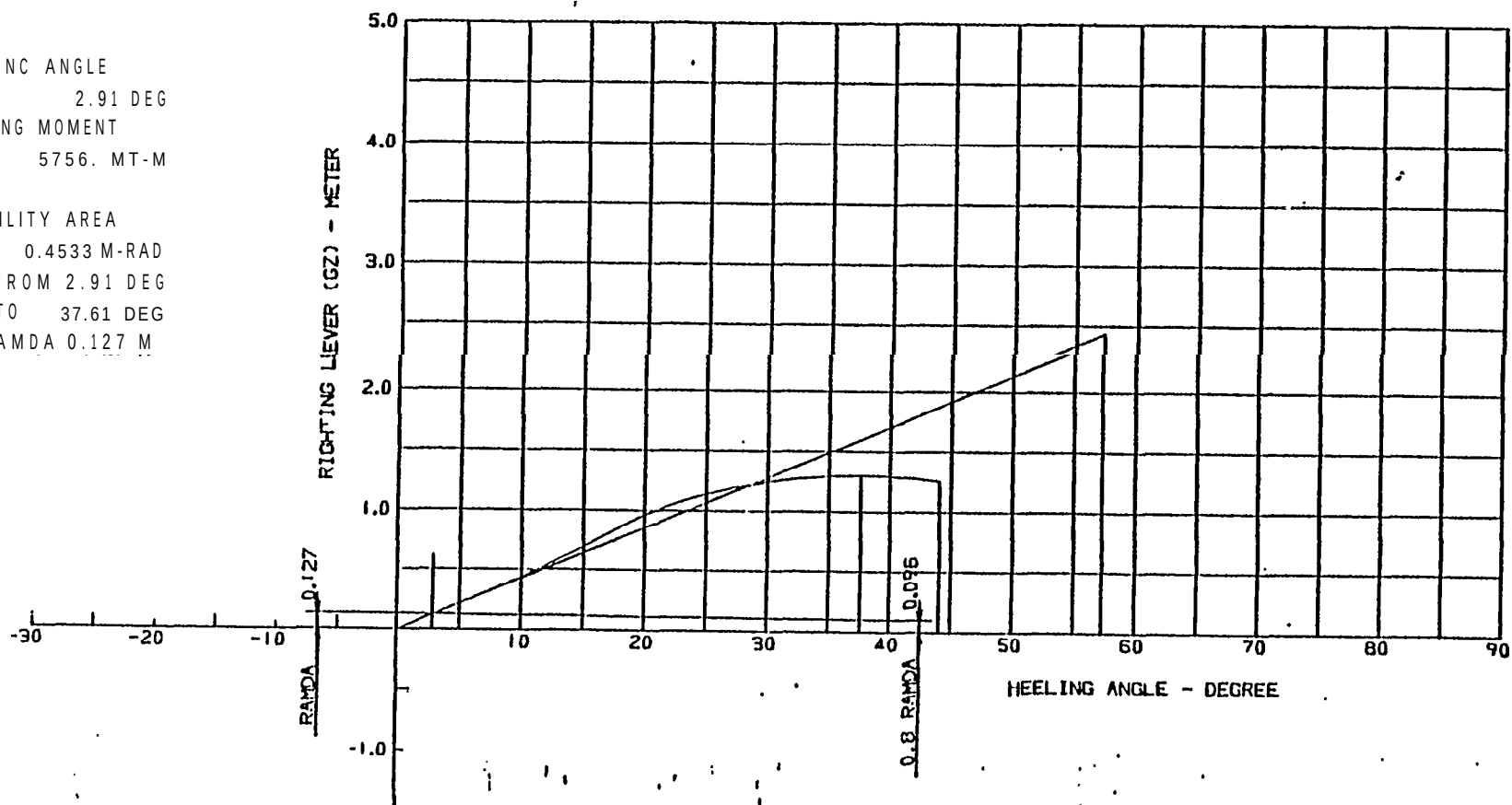
RANGE OF POSITIVE RIGHTING LEVER FROM 0.0 DEG. TO 44.0 DEG.

MAX. RIGHTING LEVER - 1.299 M AT 37.6 DEG

FLOODING INTO MAIN HULL AT ANGLE - 44.0 DEG

HEELING ANGLE
 2.91 DEG
 HEELING MOMENT
 5756. MT-M

STABILITY AREA
 0.4533 M-RAD
 FROM 2.91 DEG
 TO 37.61 DEG
 AT RAMDA 0.127 M



GRAIN STABILITY

CCN 1 FULL LOAD CONDITION AT P.G. PEP.			ROUND RANKER		
DAMAGED FLOODING CALCULATION IN FINAL STAGE					
(1) INITIAL CONDITION					
DISPLACEMENT		298785.0 (M)	LCG	-10.010 (M)	
			TCG	0.0 (M)	
DRAFT AT FP		20.004 (M)	KG	14.070 (M)	
DRAFT AT AP		20.374 (M)			
DRAFT (MEAN)		20.189 (M)			
TRIM		0.270 (M)	HEEL (DEGREE)	0.0	
			(TANGENT)	0.0	
(2) FLOODED COMPARTMENT NAME AND THEIR WEIGHT					
NO	FLOODED COMPARTMENT	PERMFA- DILITY	WEIGHT (MT)	LCG (M)	TCG (M)
15	NO. 3 W.B.T. (C)	1.000	29552.7	-18.135	0.000
					11.030
(3) FLOODED FINAL CONDITION					
	DISPLACEMENT (MT)	LCB (M)	TCB (M)	KB (M)	
MAIN HULL	328341.4	-10.751	0.000	11.303	
FLOODED SUM (-)	29552.7	-18.135	0.000	11.030	
RESULTANT TOTAL	298788.7	-10.021	0.000	11.417	
DRAFT AT FP	22.399 (M)	TONS PER 1 CM IMM.	148.666 (MT)		
DRAFT AT AP	21.670 (M)	TRANSVERSE GOM	8.172 (M)		
DRAFT (MEAN)	22.035 (M)	LONGITUDINAL GOM	391.813 (M)		
TRIM	-0.730 (M)	LOWEST INFLOW POINT			
		FRAME NO. 56 DIFF.	0.0 (M)		
HEEL (DEGREE)	0.000	BREADTH	0.0 (M)		
(TANGENT)	0.000	HEIGHT ABOVE BL	27.903 (M)		
		HEIGHT ABOVE WL	6.125 (M)		

CON 1 FULL LOAD CONDITION AT P.G. PEP. ROUND BANKER

RELATIONS BETWEEN WATER LINE AND DECK SIDE LINE IN FINAL STAGE

NO	STATION	DISTANCE FROM AP (M)	DRAFT AT CL (M)	HEIGHT FROM WL TO DK CL (M)	DRAFT AT SL (M)	HEIGHT FROM WL TO DK SL (M)
1	-0.258	-0.258	21.651	6.252	21.651	6.252
2	0.0	0.0	21.670	6.223	21.670	6.064
3	0.500	16.000	21.706	6.197	21.706	5.672
4	1.000	32.000	21.743	6.160	21.743	5.437
5	1.500	48.000	21.779	6.124	21.779	5.290
6	2.000	64.000	21.816	6.087	21.816	5.197
7	2.500	80.000	21.852	6.051	21.852	5.148
8	3.000	96.000	21.889	6.014	21.889	5.111
9	3.500	112.000	21.925	5.978	21.925	5.075
10	4.000	128.000	21.962	5.941	21.962	5.038
11	4.500	144.000	21.998	5.905	21.998	5.002
12	5.000	160.000	22.035	5.868	22.035	4.965
13	5.500	176.000	22.071	5.832	22.071	4.929
14	6.000	192.000	22.108	5.795	22.108	4.892
15	6.500	208.000	22.144	5.759	22.144	4.856
16	7.000	224.000	22.180	5.723	22.181	4.819
17	7.500	240.000	22.217	5.686	22.217	4.783
18	8.000	256.000	22.253	5.650	22.254	4.746
19	8.500	272.000	22.290	5.613	22.290	4.738
20	9.000	288.000	22.326	5.576	22.326	5.131
21	9.500	304.000	22.363	5.540	22.363	6.568
22	10.000	320.000	22.399	5.504	22.399	8.147

ANGLE AT WHICH DECK EDGE COINCIDES WITH WATER LINE 10.010 DEG.
ABOVE POSITION STATION 8,401 (268.840 (M) FROM AP)

RELATIONS BETWEEN WATER LINE AND INFLOW POINT IN FINAL STAGE

NO	FR. NO.	DIFF. (M)	BREADTH (M)	HEIGHT (M)	HEIGHT FROM WL TO INFLOW POINT (M)	ANGLE AT WHICH I.P. COINCIDES WITH WL (DEG)
1	56.000	0.0	0.0	27.903	6.125	90.000
2	20.000	0.0	20.000	28.500	6.796	18.768
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0

COND 1 HEEL CHECK FOR FLOOD. CAL.

** PARTICULARS FOR STABILITY

DISPLACEMENT	35600. MT	DRAFT AT AP	10.809 M
		DRAFT AT FP	10.809 M
CORRECTED KG (KG01)	10.240 M		
CORRECTED GM (GM)	10.560 M		

** RIGHTING LEVER (GZ) CURVE INFORMATION

RANGE OF POSITIVE RIGHTING LEVER	FROM 16.91 DEG. TO 98.91 DEG.
MAX. RIGHTING LEVER	2.876 M AT 40.67 DEG.
ANGLE OF FLOODING INTO MAIN HULL	NOTHING

** STABILITY STUDY AT FINAL STAGE AFTER FLOODING

** CHECK WRITE **

RIGHTING LEVER AT STEADY WIND	DM3 = 0.004 M (COEFF. K3 = 0.0153)
FIGHTING LEVER AT GUST WIND	DM4 = 0.007 M (COEFF. K4 = 1.5005)
ROLLING ANGLE	= 0.0 DEG.

LATERAL WINDAGE AREA	= 1056.94 SQ.M
LEVER OF WIND MOMENT	= 10.000 M

STABILITY AREA(A)	0.000 M-RAD. FROM 16.94 DEG. TO 16.95 DEG.
STABILITY AREA(A1)	2.360 M-RAD. FROM 16.95 DEG. TO 98.79 DEG.
AREA RATIO C3= D/A	= 0.0

** RIGHTING LEVER AND DYNAMICAL STABILITY CURVES

INCLIN. ANGLE (DEG)	RIGHTING LEVER (M)	RIGHTING LEVER (GZ) IN (M)	DYNAMICAL STABILITY (M-RAD)	DYNAMICAL STABILITY (MT-M)
		0.0 2.0 4.0		
0.0	-2.443	1	0.0	0.0
5.00	-1.781	1	0.0	0.0
10.00	-1.679	1	0.0	0.0
15.00	-0.316	1	0.0	0.0
20.00	1.537	1	0.0141	500.3
25.00	1.497	1	0.1031	3671.6
30.00	2.276	1	0.2695	9595.4
35.00	2.725	1	0.4899	17441.5
40.00	2.874	1	0.7354	26178.8
45.00	2.837	1	0.9853	35075.2
50.00	2.677	1	1.2264	43660.4
55.00	2.130	1	1.6458	58592.1
90.91	0.0	.	0.0	0.0

損傷時復原性計算

HEAVY BALL. FULL BUNKER

DEPARTURE

DISP. 33199.6 MT
 DR AP 8.792 M
 DR FP 8.218 M
 KG0 8.227 M
 GOM 3.866 M

RANGE OF POSITIVE RIGHTING LEVER FROM 3.9 DEG. TO 91.1 DEG.

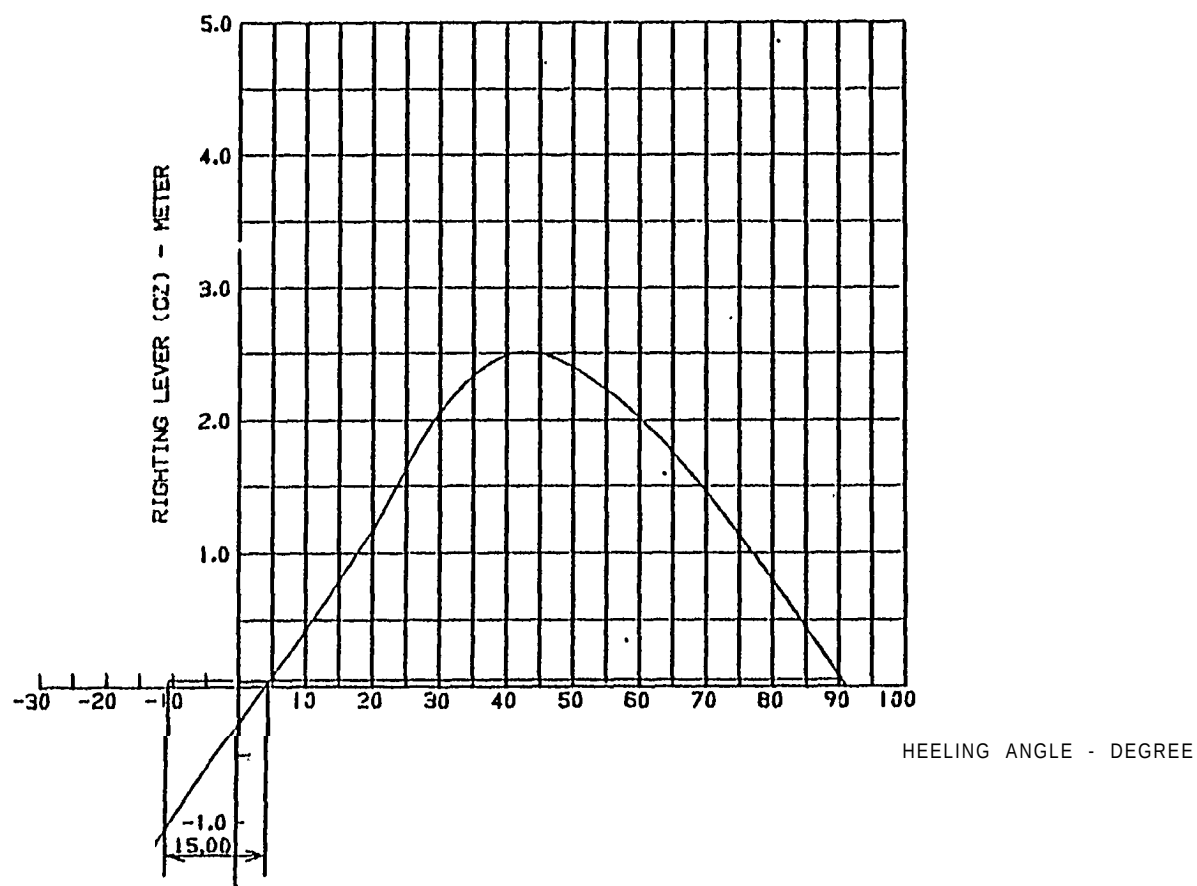
MAX. RIGHTING LEVER 2.499 M AT 42.1 DEG

FLOODING INTO MAIN HULL AT ANGLE - 57.5 DEG

DWI 0.033 M
 DW2 0.049 M

ROLLING ANGLE
 15.00 DEG

STABILITY AREA
 A " 0.1423 M-RAD
 B - 2.1745 M-RAD



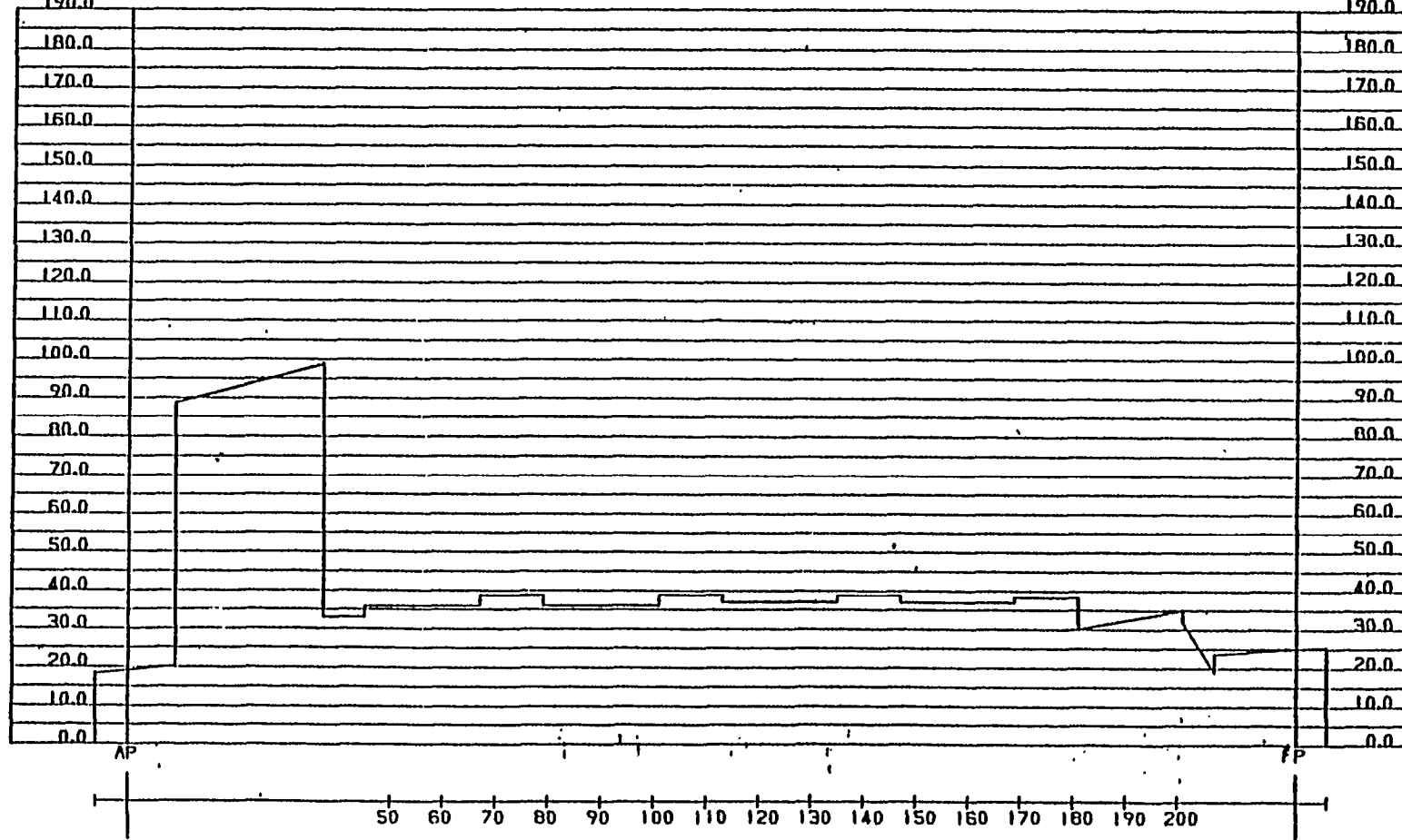
損傷時復原性計算

SNO. 00000 LIGHT WEIGHT DISTRIBUTION CURVE

TOTAL LIGHT WEIGHT = 7644.00 M.TON LENGTH O.A. 187.730 M
 G = 12.420 METER LENGTH B.P 178.000 M
 KO = 9.130 METER BREADTH (MLD) 28.400 M
 DEPTH (MLD) 15.300 M

UNIT WEIGHT
 (MT/M)
 190.0

UNIT WEIGHT
 (MT/M)
 190.0



L/W 分布

COID 1 FULL LOAD CONDITION AT P.G. JEP. AROUND BANKS										
STILL WATER CONDITION										
WAVE LENGTH = 0.3 M HEIGHT = 0.0 M CRFT = 0.0 M FROM AP										
HEADWIND = 261120.4T DRAFT AT AP = 20.5604										
DISPLACEMENT = 299780.4T DRAFT AT EP = 19.8944										
SPECIFIC G = 1.0250										
DOWN MAX SF = -0.5500 HT AT 144.300H FROM AP +MEANS UPDOWN SF										
UPP MAX SF = 0.777 HT AT 209.900H FROM AP -MEANS DOWNUPP SF										
SAG MAX 9H = 2660.6 HT-M AT 273.401H FROM AP +MEANS SAGGING 9H										
HOG MAX 9H = -0.6599 HT-M AT 177.479H FROM AP -MEANS HOGGING 9H										
CAL. POINT	DISTANCE	DRAFT	TOTAL WEIGHT	BUNYANCY	SF	9H	OFFLECTION			
NO. FROM DIFF FROM SP		(M)	(LEFT)	(RIGHT)	(SQ. M)	(MT)	(MT-M)	(SF/M)	(9H/M)	TOTAL
1	-11 0.250	-0.060	20.414	54.063	0.0	0.0	-0.001	0.006	0.005	
2	-10 0.0	-7.500	20.414	54.063	1.426	-27.0	-0.001	0.005	0.004	
3	-9 0.001	-6.749	20.414	54.063	0.062	-41.0	-0.001	0.005	0.004	
4	-8 0.350	-6.400	20.513	54.317	12.355	-41.0	-0.001	0.005	0.004	
5	-7 0.001	-5.251	20.510	57.003	27.758	-125.0	-0.001	0.004	0.003	
6	-6 0.757	-4.500	20.510	59.609	32.444	-163.0	-0.000	0.003	0.002	
7	-5 0.000	-3.750	20.507	59.940	50.240	-170.0	-0.001	0.003	0.002	
8	-4 0.775	-3.000	20.504	62.479	44.030	-206.0	-0.000	0.001	0.001	
9	-3 0.100	-1.500	20.503	62.775	48.726	-210.0	-0.000	0.001	0.001	
10	0 0.0	0.0	20.500	64.058	53.066	-224.0	-0.000	0.000	0.000	
11	1 0.250	1.250	20.498	66.430	66.430	-226.0	-0.000	-0.001	-0.001	
12	2 0.7	1.500	20.498	68.746	67.603	-225.0	-0.000	-0.001	-0.001	
13	3 0.0	2.250	20.496	67.672	77.718	-222.0	-0.000	-0.001	-0.001	
14	4 0.700	3.000	20.494	68.044	78.044	-213.0	-0.000	-0.002	-0.002	
15	5 0.250	4.000	20.493	69.006	83.923	-203.0	-0.000	-0.003	-0.003	
16	6 0.0	4.500	20.492	70.406	102.372	-194.0	-0.000	-0.003	-0.003	
17	7 0.700	5.000	20.491	104.270	90.766	-197.0	-0.000	-0.003	-0.003	
18	8 0.350	6.400	20.488	109.307	106.206	-207.0	-0.000	-0.005	-0.005	
19	10 0.0	7.500	20.486	112.231	112.231	-202.0	-0.000	-0.005	-0.005	
20	11 0.250	8.000	20.485	113.697	124.744	-196.0	-0.000	-0.006	-0.006	
21	14 0.0	10.500	20.480	120.931	145.275	-172.0	-0.001	-0.008	-0.007	
22	16 0.0	12.000	20.478	102.078	192.151	4.0	-0.001	-0.006	-0.006	
23	17 0.7	12.750	20.476	104.925	206.781	70.0	-0.001	-0.009	-0.009	
24	17 0.070	12.000	20.476	166.254	205.621	81.0	-0.001	-0.019	-0.019	
25	20 0.0	15.000	20.472	181.782	203.574	204.0	-0.000	-0.011	-0.011	
26	21 0.100	16.000	20.470	210.760	210.360	254.0	-0.000	-0.012	-0.011	
27	23 0.100	17.000	20.467	221.210	221.210	355.0	-0.000	-0.013	-0.013	
28	25 0.300	19.200	20.464	232.014	232.014	402.0	-0.000	-0.014	-0.014	
29	28 0.225	19.725	20.463	235.541	235.541	529.0	-0.000	-0.014	-0.014	
30	26 0.400	20.000	20.462	237.309	237.309	554.0	-0.000	-0.015	-0.015	
31	30 0.500	20.500	20.461	252.762	242.763	634.0	-0.000	-0.015	-0.015	
32	29 0.000	22.200	20.458	252.130	359.581	787.0	-0.000	-0.016	-0.016	
33	30 0.0	24.000	20.455	264.119	368.055	1012.0	-0.000	-0.018	-0.018	
34	32 0.700	25.600	20.452	274.726	413.090	1218.0	-0.000	-0.019	-0.019	
35	33 0.700	26.700	20.450	281.985	436.120	1477.0	-0.001	-0.020	-0.020	
36	34 0.400	27.200	20.449	301.417	437.827	1481.0	-0.001	-0.020	-0.021	
37	34 0.500	28.000	20.447	315.577	450.608	1500.0	-0.001	-0.021	-0.022	
38	35 0.400	28.900	20.445	330.204	464.564	1738.0	-0.001	-0.021	-0.023	
39	36 0.000	29.500	20.445	337.598	315.306	1803.0	-0.001	-0.022	-0.023	
40	36 0.400	29.800	20.444	322.683	322.683	1879.0	-0.001	-0.022	-0.023	
41	37 0.400	30.700	20.442	336.617	336.617	2021.0	-0.002	-0.023	-0.024	
42	39 0.100	32.000	20.440	357.927	357.927	2236.0	-0.002	-0.024	-0.026	
43	40 0.0	33.000	20.438	374.212	364.133	2401.0	-0.002	-0.024	-0.027	
44	42 0.400	35.200	20.434	413.858	413.858	2745.0	-0.003	-0.026	-0.029	

WAVE COMPONENTS TABLE FOR SUCARING FORCE AND BENDING MOMENT

COND. 1 FULL LOAD CONDITION AT P.C. REP. ROUND BANKER

PROGIONAL WAVE			
WAVE LENGTH	0.0 M	320.000M	320.000M
HEIGHT	0.0 M	9.280M	9.280M
CRST/LMP	0.0	0.100	0.200
CRST/AP	0.0 M	32.000M	160.000M

DIFF = (WAVE - STILL)

BAL. POINT NO	DISTANCE FROM P.C.	SP (MT)	RM (MT-M)	DIFF SP (MT)	DIFF RM (MT-M)	DIFF SP (MT)	DIFF RM (MT-M)
1	-11 0.250	-0.000	0.	0.	0.	0.	0.
2	-10 0.0	-7.500	-27.	-7.	0.	0.	0.
3	-9 0.001	-4.749	-67.	-42.	0.	0.	0.
4	-8 0.350	-6.400	-83.	-67.	3.	2.	-3.
5	-7 0.001	-5.751	-125.	-106.	9.	8.	-23.
6	-5 0.250	-4.050	-163.	-140.	19.	25.	-79.
7	-4 0.000	-3.750	-170.	-150.	21.	30.	-96.
8	-3 0.375	-1.875	-208.	-176.	43.	89.	-301.
9	-2 0.100	-1.600	-210.	-183.	47.	101.	-365.
10	0 0.0	0.0	-224.	-1172.	74.	197.	-674.
11	2 0.250	1.250	-226.	-1454.	100.	305.	-1034.
12	2 0.0	1.500	-225.	-1715.	155.	331.	-1118.
13	4 0.0	2.250	-222.	-1678.	123.	417.	-1295.
14	4 0.200	3.200	-213.	-1885.	144.	544.	-1802.
15	5 0.250	4.000	-203.	-2037.	172.	674.	-2197.
16	6 0.0	4.500	-194.	-2151.	187.	763.	-2489.
17	6 0.250	4.750	-197.	-2210.	197.	821.	-2647.
18	9 0.250	6.400	-207.	-2535.	253.	1181.	-3694.
19	10 0.0	7.500	-202.	-2760.	296.	1482.	-4749.
20	11 0.250	8.000	-198.	-2880.	317.	1635.	-4975.
21	14 0.0	10.500	-122.	-3273.	435.	2571.	-7481.
22	16 0.0	12.000	4.	-3367.	515.	3282.	-9203.
23	17 0.0	12.750	79.	-3336.	558.	3695.	-10209.
24	17 0.250	12.750	81.	-3232.	561.	3713.	-11579.
25	20 0.0	15.000	204.	-3079.	699.	5394.	-13726.
26	21 0.100	16.000	254.	-2800.	767.	5829.	-15446.
27	21 0.100	17.000	345.	-2217.	884.	7149.	-18467.
28	21 0.200	17.200	482.	-1651.	1009.	8667.	-21831.
29	21 0.250	19.750	520.	-1788.	1531.	9202.	-23512.
30	24 0.400	20.000	554.	-1237.	1674.	9494.	-23646.
31	24 0.400	20.800	634.	-767.	1147.	10381.	-25557.
32	24 0.500	23.200	787.	730.	1265.	12065.	-29110.
33	30 0.0	24.000	1012.	1845.	1432.	14491.	-34113.
34	31 0.250	25.600	1238.	3847.	1589.	16907.	-38075.
35	31 0.250	26.750	1407.	5795.	1757.	18717.	-42540.
36	34 0.400	27.200	1481.	5918.	1754.	19580.	-44237.
37	34 0.400	28.500	1599.	7650.	1838.	21017.	-47021.
38	35 0.400	29.900	1738.	8634.	1941.	22612.	-50461.
39	36 0.000	29.400	1803.	9451.	1991.	23697.	-52142.
40	36 0.450	29.850	1879.	10260.	2041.	24605.	-53056.
41	37 0.450	30.700	2271.	11917.	2137.	26105.	-57185.
42	40 0.100	32.000	2236.	14684.	2287.	29256.	-62508.
43	40 0.0	33.000	2401.	17001.	2406.	31607.	-66795.
44	42 0.400	35.200	2765.	22697.	2673.	37187.	-76821.

** COMPARISON TABLE FOR SHEARING FORCE **

(STILL WATER)

COND.NO.		2	4	8	10	11
CAL. POINT	DISTANCE	SF	SF	SF	SF	SF
NO FROM DIFF FROM AP		(MT)	(MT)	(MT)	(MT)	(MT)
65 37 0.0	29.400	711.	711.	695.	730.	-1108.
107 73 0.0	58.800	-4057.	431.	-115.	-4077.	939.
125 90 0.0	72.000	-535.	246.	-715.	-550.	1150.
147 107 0.0	85.600	2974.	-75.	-1458.	2980.	3302.
160 124 0.0	112.200	128.	-9.	-42.	129.	339.
175 141 0.0	112.800	-072.	-131.	1232.	-3063.	-2744.
185 150 0.0	140.800	512.	-161.	831.	575.	-1446.
214 175 0.0	140.000	4143.	-415.	197.	4187.	-97.
257 239 0.0	167.200	-553.	-634.	-651.	-650.	-18.

** COMPARISON TABLE FOR BENDING MOMENT **

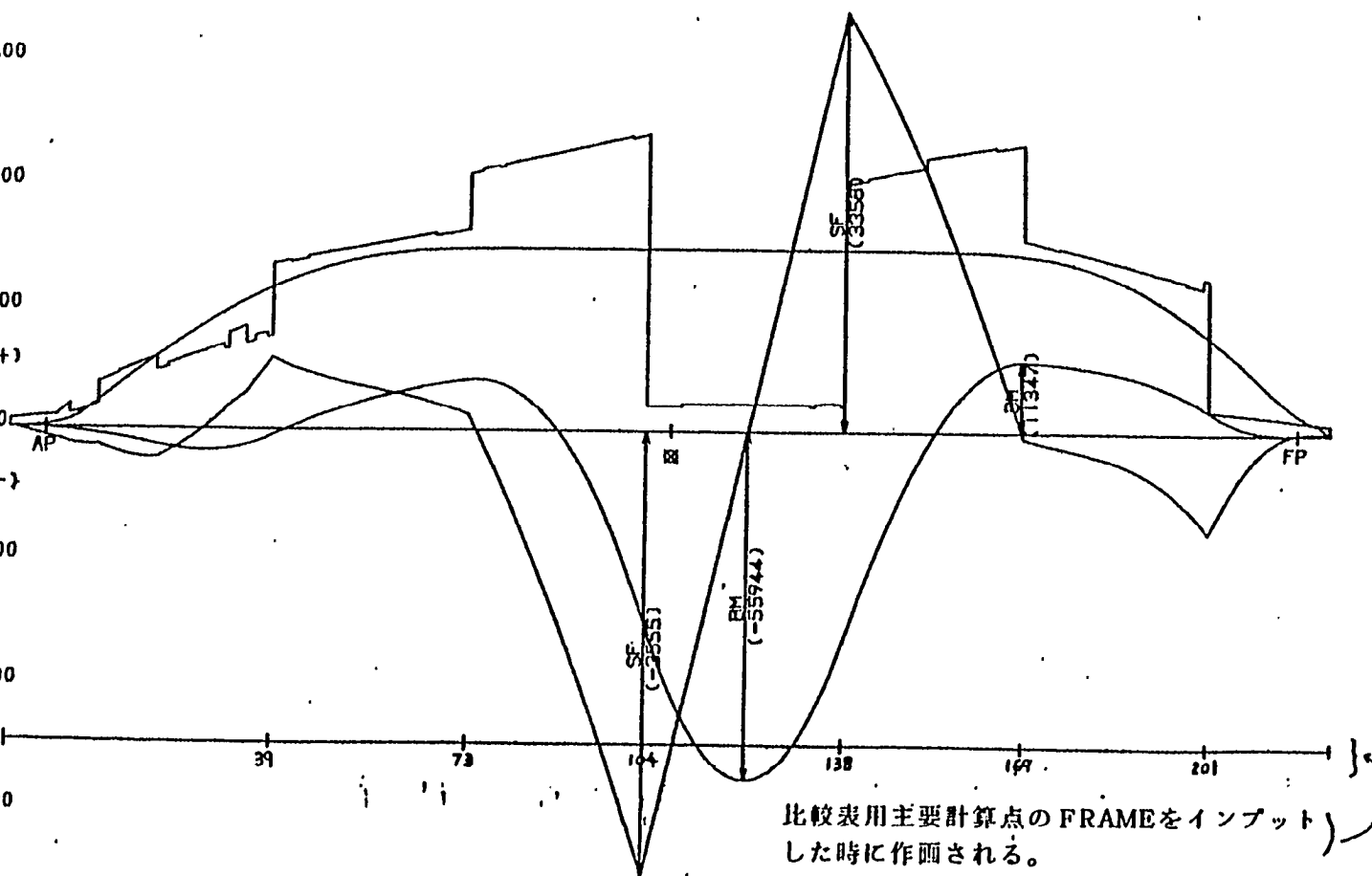
(STILL WATER)

COND.NO.		4	8	10	11
CAL. POINT	DISTANCE	BH	BH	BH	BH
NO FROM DIFF FROM AP		(MT-M)	(MT-M)	(MT-M)	(MT-M)
65 37 0.0	29.400	-3207.	-3207.	-3230.	-2939.
107 73 0.0	58.800	-4760.	13957.	6460.	-47147.
125 90 0.0	72.000	-70017.	10665.	746.	-70771.
147 107 0.0	85.600	-62180.	19972.	-13926.	-62265.
160 124 0.0	112.200	-40029.	12066.	-24082.	-40780.
175 141 0.0	112.800	-60203.	10895.	-15782.	-60282.
185 150 0.0	140.800	-77248.	1745.	-1547.	-77230.
214 175 0.0	140.000	-44759.	13506.	5735.	-44761.
257 239 0.0	167.200	1975.	1975.	1966.	1959.

BM	SF	WT
x104'	X102	X102
(MT-H)	(MT)	(MT/M)
8.00	40.0	8.00
6.00	30.0	6.00
4.00	20.0	4.00
2.00	10.0	2.00
(+)	(+)	(+)
SAG	0	0
HOG	(-)	(-)
-2.00	10.0	2.00
-4.00	20.0	4.00
-6.00	30.0	6.00
-8.00	40.0	8.00

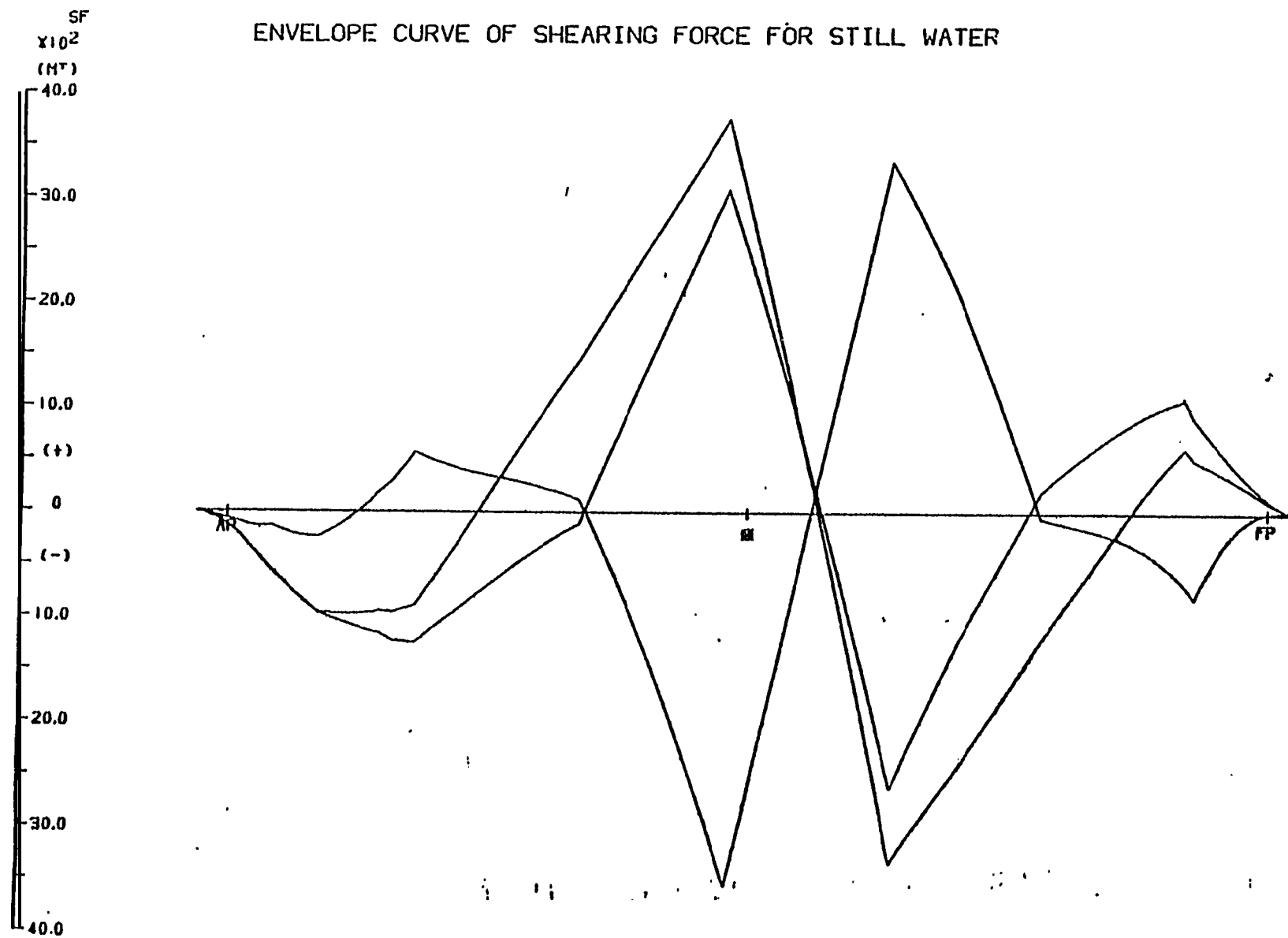
BENDING MOMENT AND SHEARING FORCE DIAGRAM

PHOSPHATE ROCK LOADING CONDITION TESTING
 STILL WATER CONDITION



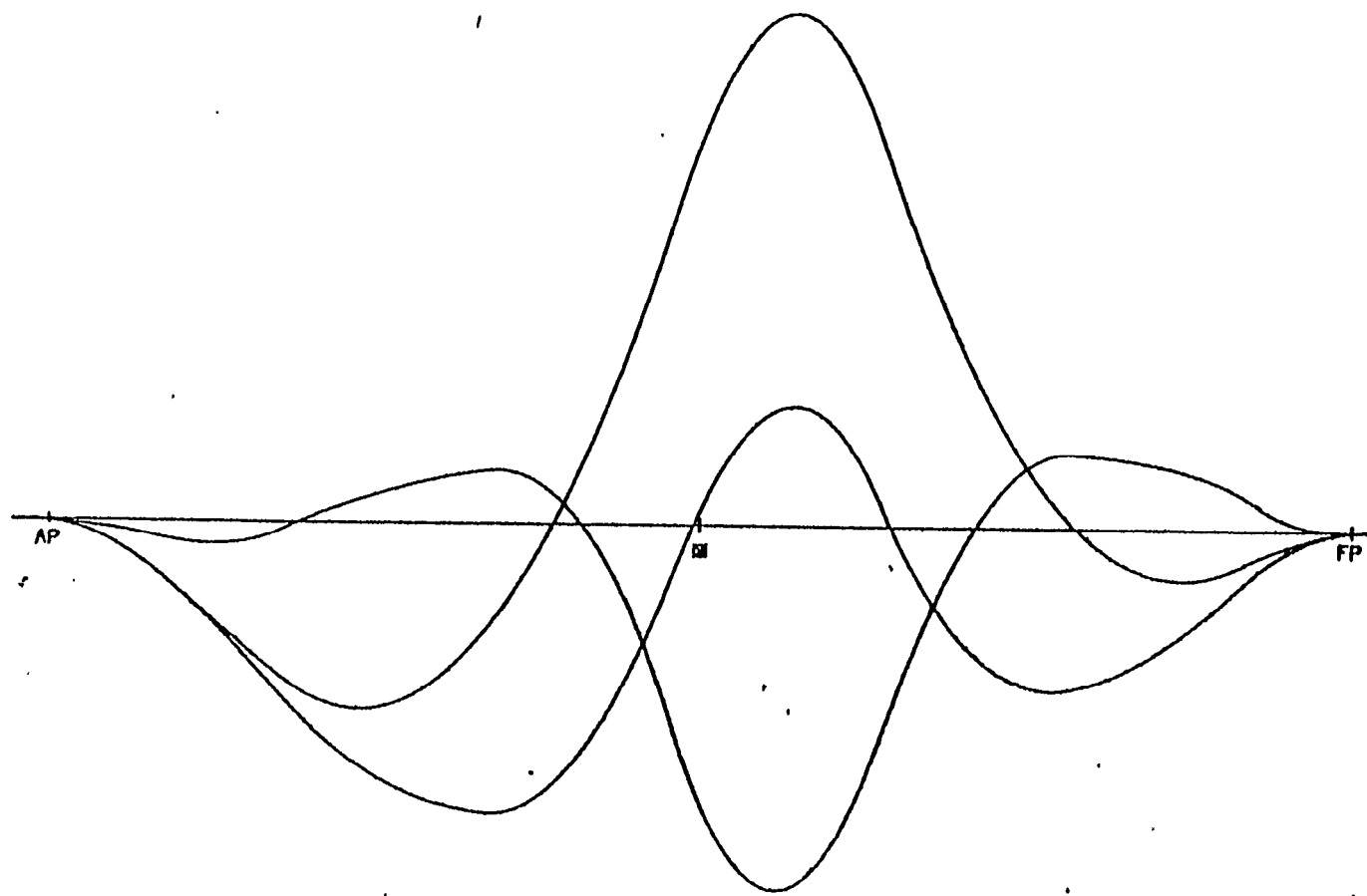
縦強度計算

縱強度計算



ENVELOPE CURVE OF BENDING MOMENT FOR STILL WATER

8M
X104
(MT)-M
-8.00
-6.00
-4.00
-2.00
(+)
0
HOG
(-)
-2.00
-4.00
-6.00
-8.00



** PRINT OUT OF APPLICATION DATA **

R5J530 DATA FOR SIMPLE CAL. OF LONGITUDINAL STRENGTH

DSLA 1 0 UNIT OF OUT PUT METRIC SYSTEM

DSLA 2 1.02500

DSLA 3 3.00 27.00 1.00 -3.00 3.00

DSLA 4

DSLR 1	8	4	14	15	16	17	18	19	21	22	23	24	25	26	27	28	29	30	31	32
DSLR 2	33	34	9	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSLR 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSLR 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DSLC 1	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DSLC 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DSL0 1	61	0.0	14100.	415690.	-415690.
DSL0 2	66	0.0	13080.	577540.	-577540.
DSL0 3	70	0.0	14490.	739380.	-739380.
DSL0 4	74	0.0	13280.	901230.	-901230.
DSL0 5	78	0.0	13280.	940900.	-940900.
DSL0 6	82	0.0	13280.	980560.	-980560.
DSL0 7	86	0.0	13280.	1000390.	-1000390.
DSL0 8	90	0.0	13280.	1000390.	-1000390.
DSL0 9	94	0.0	13280.	1000390.	-1000390.
DSL010	98	0.0	13280.	1000390.	-1000390.
DSL011	102	0.0	13900.	953160.	-953160.
DSL012	106	0.0	14490.	763680.	-763680.
DSL013	110	0.0	13900.	574200.	-574200.
DSL014	114	0.0	13280.	384720.	-384720.
DSL015	119	0.0	11580.	164580.	-164580.
DSL016	0	0.0	0.	0.	0.
DSL017	0	0.0	0.	0.	0.
DSL018	0	0.0	0.	0.	0.
DSL019	0	0.0	0.	0.	0.
DSL020	0	0.0	0.	0.	0.
DSL021	0	0.0	0.	0.	0.
DSL022	0	0.0	0.	0.	0.
DSL023	0	0.0	0.	0.	0.
DSL024	0	0.0	0.	0.	0.
DSL025	0	0.0	0.	0.	0.
DSL026	0	0.0	0.	0.	0.
DSL027	0	0.0	0.	0.	0.
DSL028	0	0.0	0.	0.	0.
DSL029	0	0.0	0.	0.	0.
DSL030	0	0.0	0.	0.	0.

簡易縱強度計算

重量分配係數

COEFFICIENT OF WEIGHT DISTRIBUTION FOR SHEARING FORCE

TANK NAME	FRAME NO. (.57.000)	FRAME NO. (.59.000)	FRAME NO. (.63.000)	FRAME NO. (.69.000)	FRAME NO. (.75.000)	FRAME NO. (.81.000)	FRAME NO. (.87.000)	FRAME NO. (.93.000)	FRAME NO. (.99.000)	FRAME NO. (104.000)
DRAIN WATER TANK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 1 FRESH WATER T.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 2 FRESH WATER T.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DIST. WATER T. (P/S)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 1 FUEL OIL T. (S)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 2 FUEL OIL T. (S)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 162 F.O.S.T.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FRESH OIL TANK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PORT PEAK TANK	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 1 C.O.T. (C)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 1 C.O.T. (P/S)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 2 C.O.T. (C)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 2 C.O.T. (P/S)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 3 C.O.T. (C)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 3 C.O.T. (P/S)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 4 C.O.T. (C)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 4 C.O.T. (P/S)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 5 C.O.T. (C)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NO. 5 C.O.T. (P/S)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SLOP TANK (P/S)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
AST PEAK TANK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

BM 算出用 LEVER

LEVER FOR BENDING MOMENT IN METER UNIT

TANK NAME	FRAME NO. (.57.000)	FRAME NO. (.59.000)	FRAME NO. (.63.000)	FRAME NO. (.69.000)	FRAME NO. (.75.000)	FRAME NO. (.81.000)	FRAME NO. (.87.000)	FRAME NO. (.93.000)	FRAME NO. (.99.000)	FRAME NO. (104.000)
DRAIN WATER TANK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 1 FRESH WATER T.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 2 FRESH WATER T.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DIST. WATER T. (P/S)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 1 FUEL OIL T. (S)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 2 FUEL OIL T. (S)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 162 F.O.S.T.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FRESH OIL TANK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PORT PEAK TANK	254.45	243.65	227.65	197.05	159.55	127.25	75.45	63.65	31.85	6.00
NO. 1 C.O.T. (C)	219.75	209.15	187.95	156.15	124.35	92.55	60.75	28.95	12.95	6.35
NO. 1 C.O.T. (P/S)	217.50	206.90	185.70	153.90	122.10	90.30	58.50	26.70	12.44	6.00
NO. 2 C.O.T. (C)	174.90	164.30	143.10	111.30	79.50	47.70	15.90	0.00	0.00	0.00
NO. 2 C.O.T. (P/S)	174.90	164.30	143.10	111.30	79.50	47.70	15.90	0.00	0.00	0.00
NO. 3 C.O.T. (C)	128.80	118.20	95.00	63.20	31.40	15.00	0.00	0.00	0.00	0.00
NO. 3 C.O.T. (P/S)	127.72	117.12	93.90	62.10	30.30	14.90	0.00	0.00	0.00	0.00
NO. 4 C.O.T. (C)	63.94	52.94	31.74	15.84	0.00	0.00	0.00	0.00	0.00	0.00
NO. 4 C.O.T. (P/S)	63.97	52.97	31.77	15.87	0.00	0.00	0.00	0.00	0.00	0.00
NO. 5 C.O.T. (C)	16.49	10.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO. 5 C.O.T. (P/S)	21.58	10.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SLOP TANK (P/S)	5.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AST PEAK TANK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

** LONGITUDINAL STRENGTH DATA, NOT INCLUDED IN LIGHT WEIGHT **

3.00 METER BASE DRAFT S.G.= 1.02500

UNIT: SHEARING FORCE IN METRIC TON/1000
BENDING MOMENT IN METRIC TON-METER/1000

LOCATION	SHEARING FORCE			BENDING MOMENT		
	BASE VALUE (SF)	DRAFT CORRECT. (CD)	TRIM CORRECT. (CT)	BASE VALUE (BM)	DRAFT CORRECT. (CD)	TRIM CORRECT. (CT)
FR.(119.000)	1.20	0.52	-0.49	9.07	4.29	-4.05
FR.(114.000)	4.51	1.76	-1.61	73.59	30.24	-28.18
FR.(110.000)	8.30	3.10	-2.76	203.32	79.50	-72.67
FR.(106.000)	12.44	4.52	-3.89	414.52	157.28	-140.57
FR.(102.000)	16.66	5.94	-4.95	711.28	263.99	-230.86
FR.(98.000)	20.88	7.37	-5.93	1094.23	399.72	-341.97
FR.(94.000)	25.11	8.79	-6.83	1563.36	564.48	-472.25
FR.(90.000)	29.33	10.21	-7.65	2118.69	758.27	-620.06
FR.(86.000)	33.56	11.63	-8.39	2760.20	981.09	-783.76
FR.(82.000)	37.78	13.06	-9.05	3487.87	1232.93	-961.71
FR.(78.000)	41.89	14.47	-9.62	4300.79	1513.75	-1152.24
FR.(74.000)	45.66	15.82	-10.09	5194.54	1822.90	-1353.47
FR.(70.000)	48.91	17.03	-10.44	6160.22	2158.26	-1563.13
FR.(66.000)	51.49	18.02	-10.68	7185.45	2516.13	-1778.70
FR.(61.000)	53.32	18.76	-10.81	8255.75	2891.70	-1998.15

簡易縱強度計算

COND 1 FULL LOAD CONDITION AT P.G. DEP. ROUND BANKER

AFT DRAFT 25.04 METER UNIT1. SHEARING FORCE IN METRIC TON
 BASE DRAFT 25.00 METER BENDING MOMENT IN METRIC TON-METER
 TRIM 0.01 METER
 S.G. OF S.M. 1.02500

LOCATION	SHEARING FORCE	BENDING MOMENT
FR.(119.000)	-6990.	53630.
FR.(114.000)	-1720.	153990.
FR.(110.000)	1560.	154800.
FR.(106.000)	4650.	91260.
FR.(102.000)	-4150.	86040.
FR.(98.000)	-1040.	139060.
FR.(94.000)	2130.	127890.
FR.(90.000)	5370.	51160.
FR.(86.000)	8530.	-90570.
FR.(82.000)	-190.	-175610.
FR.(78.000)	-8070.	-82960.
FR.(74.000)	-5540.	64280.
FR.(70.000)	-1860.	140490.
FR.(66.000)	2430.	133970.
FR.(61.000)	6290.	44470.

簡易縱強度計算

SEA MATE用 DATA 算出

** LIGHT WEIGHT DATA **

LIGHT WEIGHT (LW) = 3000. MT.
 MIDSHIP G. (XG) = 2.500 M.
 (LW) * (XG) = 7500. MT-M.

CAL.P.NO.	1ST INTEG.	2ND INTEG.
0	120.	328.
1	261.	1304.
2	261.	1304.
3	522.	5217.
4	522.	5217.
5	522.	5217.

** BONJEAN DATA FOR SEAMATE-4,0 **

MINIMUM DRAFT 1.00 METER
 DRAFT INTERVAL 4.00 METER
 NUMBER OF DRAFT 5

MEAN DRAFT

1.00 5.00 9.00 13.00 17.00
 BONJ. NO.

0	40.00	700.00	360.00	520.00	680.00
1	40.00	200.00	360.00	520.00	680.00
2	40.00	200.00	360.00	520.00	680.00

** DIFFERENCE TABLE OF BUOYANCY **

(DIFF. = SIMPSON - TRAPEZOID)

MEAN DRAFT

1.00 5.00 9.00 13.00 17.00

PREP.NO.OF
 CAL.P.NO. BONJEAN DIFFERENCE IN CUB. M.

0	2	-0.	-0.	-0.	-0.	-0.
1	0	0.	0.	0.	0.	0.
2	0	0.	0.	0.	0.	0.
3	0	0.	0.	0.	0.	0.
4	0	0.	0.	0.	0.	0.
5	0	0.	0.	0.	0.	0.

** TANK TABLE FOR SEAMATE-B **

TANK NO.		TANK NAME	EMPTY			MIDDLE		FULL		MAXIMUM T. INERTIA
(OLD)	(NEW)		HID.G. (M)	(VOL)	(KG)	(VOL)	(KG)	(VOL)	(KG)	
				(M**3)	(M)	(M)	(M**3)	(M)	(M**3)	
10	1	FOPE PEAK TANK (C)	-52.500	0.0	0.0	2000.0	5.000	4300.0	10.760	26667.
11	2	NO.1 W. B. T. (PCS)	-45.000	0.0	0.0	600.0	1.000	1500.0	2.500	5625.
12	3	NO.2 W. B. T. (PCS)	-35.000	0.0	0.0	600.0	1.000	1500.0	2.500	5625.
13	4	NO.3 W. B. T. (PCS)	-20.000	0.0	0.0	1200.0	1.000	3000.0	2.500	11250.
14	5	NO.4 W. B. T. (PCS)	0.000	0.0	0.0	1200.0	1.000	3000.0	2.500	11250.
15	6	AFT PEAK TANK (C)	55.000	0.0	0.0	4000.0	5.000	8320.0	10.499	53333.
1	7	FRESH WATER T. (PCS)	24.265	0.0	10.000	700.0	13.357	1700.0	16.402	1667.
5	8	NO.1 F. O. T. (PCS)	20.000	0.0	0.0	1200.0	1.000	3000.0	2.500	11250.
6	9	DIESEL OIL TANK (PCS)	35.000	0.0	0.0	200.0	1.000	500.0	2.500	208.
21	10	NO.1 CARGO HOLD (C)	-45.000	0.0	5.000	2000.0	8.500	6720.0	13.428	53333.
22	11	NO.2 CARGO HOLD (C)	-35.000	0.0	5.000	2000.0	8.500	6460.0	13.792	53333.
23	12	NO.3 CARGO HOLD (C)	-20.000	0.0	5.000	5600.0	8.500	13800.0	13.708	106667.
24	13	NO.4 CARGO HOLD (C)	0.0	0.0	5.000	5600.0	8.500	13666.6	13.633	106667.
25	14	NO.5 CARGO HOLD (C)	20.000	0.0	5.000	5600.0	8.500	13000.0	13.708	106667.

** TANK TABLE FOR SEAMATE-4, B **

TANK NO. (OLD) (NEW)	TANK NAME	HID.G. AFT			FORE			FLAT
		(M)	FRNO	DIFF	FRNO	DIFF	FLAT	
10	1	FORE PEAK TANK (C)	-52.500	100	0.0	105	0.0	0
11	2	NO.1 W. B. T. (PCS)	-45.000	90	0.0	100	0.0	0
12	3	NO.2 W. B. T. (PCS)	-35.000	80	0.0	95	0.0	0
13	4	NO.3 W. B. T. (PCS)	-20.000	60	0.0	80	0.0	0
14	5	NO.4 W. B. T. (PCS)	0.000	40	0.0	60	0.0	0
15	6	AFT PEAK TANK (C)	55.000	-10	0.0	0	0.0	0
1	7	FRESH WATER T. (PCS)	24.265	10	0.0	20	0.0	0
5	8	NO.1 F. O. T. (PCS)	20.000	20	0.0	40	0.0	0
6	9	DIESEL OIL TANK (PCS)	35.000	10	0.0	20	0.0	0
21	10	NO.1 CARGO HOLD (C)	-45.000	90	0.0	100	0.0	0
22	11	NO.2 CARGO HOLD (C)	-35.000	80	0.0	90	0.0	0
23	12	NO.3 CARGO HOLD (C)	-20.000	60	0.0	80	0.0	0
24	13	NO.4 CARGO HOLD (C)	0.0	40	0.0	60	0.0	0
25	14	NO.5 CARGO HOLD (C)	20.000	20	0.0	40	0.0	0

LAUNCHING PARTICULAR						
CASE NO. (1-1-)						
LAUNCHING HEIGHT (WITHOUT SLIDING WAY) = 10411.60 MT						
LCG FROM MIDSHIP = 10.920 M						
KG = 11.150 M						
LAUNCHING HEIGHT (WITH SLIDING WAY) = 10579.96 MT						
LCG FROM MIDSHIP = 10.586 M						
KG = 10.969 M						
LAUNCHING PARTICULAR (No. 2)						
SLIDING WAY :						
DECLIVITY BETWEEN AP AND FP = 7.167 M						
DECLIVITY BETWEEN POPPET = 5.821 M						
(OUTPUT 数 ... 1147.2 数 * 2 数 * 2 数 * 2 数)						
COEFFICIENT :						
STATICAL FRICTINAL COEFFICIENT BETWEEN WAYS = 0.025000						
DYNAMICAL FRICTINAL COEFFICIENT BETWEEN WAYS = 0.022000						
COEFFICIENT OF WATER RESISTANCE = 0.070000						
THE RATE OF INCREASE OF VERTUAL MASS = 0.200000						
AREA OF BEARING SURFACE = 640.0 SQ.M						
MEAN PRESSURE BEFORE LAUNCHING = 16.93 MT/SQ.M						
INITIAL LAUNCHING FORCE AT P.C. = 18.03 MT						
RUNNING DRAG WEIGHT DATA :						
DRAG NO.	DRAG WT. (MT)	TRAVEL (M)		COEFF. BETWEEN DRAG WT. AND GROUND	INCLINATION ANGLE OF GROUND	
		START	FINISH			
1	200.00	10.0	999.0	0.330000	0.036000	
2	100.00	50.0	999.0	0.330000	0.036000	
TOTAL						
DRAG WT. 300.00						

LAUNCHING CALCULATION											
CASE NO. 11-1-1		LAUNCHING WY. (WITH SLIDING WAY)		WEIGHT (MT)		LCC (IN)		FOR CHECK			
		(WITHOUT SLIDING WAY)		17745.04		11.091					
				17480.00		11.300					
HEIGHT OF TIDE		4.35 IN		TIPPING		LIFTING		PRESS. (MT/50.M)			
				MOMENT		MOMENT		AFT FORE			
TRAVEL	DRAFT (M)	BUOYANCY	MOMENT	MOMENT	MOMENT	MOMENT	MOMENT	MOMENT	MOMENT	TRAVEL	LCC
(M)	AT AP	AT FP	(MT)	(MT-M)	(MT-M)	(MT-M)	(MT-M)	(MT-M)	(MT-M)	(M)	(M)
0.0	0.000	-7.966	16.4	2444059.	3255.	34.32	14.27			0.0	98.04
5.0	1.242	-7.805	40.8	2374957.	7089.	34.70	14.33			5.0	92.09
10.0	1.497	-7.643	60.0	2284463.	11503.	34.10	14.37			10.0	89.43
15.0	1.755	-7.479	76.8	2195127.	14613.	34.02	14.41			15.0	87.56
20.0	2.014	-7.312	94.1	2105899.	17712.	33.94	14.44			20.0	85.97
25.0	2.275	-7.144	116.1	2016554.	21818.	33.84	14.48			25.0	83.90
30.0	2.538	-6.974	141.5	1927167.	26075.	33.72	14.52			30.0	81.62
35.0	2.803	-6.802	182.5	1837253.	32981.	33.55	14.58			35.0	78.70
40.0	3.070	-6.628	235.1	1746977.	41831.	33.33	14.66			40.0	75.29
45.0	3.339	-6.452	326.7	1655715.	56672.	32.97	14.77			45.0	71.56
50.0	3.610	-6.274	447.7	1563272.	76182.	32.49	14.92			50.0	67.78
55.0	3.883	-6.094	627.3	1469753.	104554.	32.54	14.75			55.0	64.29
60.0	4.158	-5.913	868.1	1375532.	142304.	34.91	12.99			60.0	61.54
65.0	4.436	-5.729	1169.9	1281100.	188719.	36.85	11.48			65.0	59.53
70.0	4.713	-5.543	1532.6	1187147.	243908.	38.64	9.93			70.0	56.76
75.0	4.991	-5.356	1957.2	1094241.	307430.	40.26	8.39			75.0	54.81
80.0	5.276	-5.167	2443.3	1003515.	379603.	41.65	6.85			80.0	52.33
85.0	5.560	-4.975	2987.9	914273.	458208.	42.81	5.33			85.0	50.97
90.0	5.846	-4.782	3591.6	828957.	544323.	43.77	3.91			90.0	49.17
95.0	6.135	-4.587	4237.1	747068.	635029.	44.37	2.53			95.0	47.50
100.0	6.425	-4.390	4930.2	670295.	731190.	44.58	1.36			100.0	45.92
105.0	6.712	-4.191	5663.7	598210.	831518.	44.37	0.33			105.0	44.43
110.0	7.001	-3.990	6439.9	532183.	936404.	43.72	-0.33			110.0	43.02
115.0	7.296	-3.787	7248.4	472326.	1044317.	42.37	-0.64			115.0	41.68
120.0	7.604	-3.582	8097.1	419859.	1155811.	40.43	-0.56			120.0	40.42
125.0	7.904	-3.376	8977.7	374448.	1271741.	37.23	0.36			125.0	39.26
130.0	8.205	-3.167	9901.0	338078.	1391850.	33.02	2.00			130.0	38.19
135.0	8.509	-2.957	10867.4	310067.	1517037.	26.86	5.12			135.0	37.20
140.0	8.814	-2.744	11875.0	293144.	1647252.	19.07	9.53			140.0	36.32
145.0	9.122	-2.530	12935.4	287034.	1784430.	8.76	16.55			145.0	35.56
150.0	9.432	-2.317	14046.0	292854.	1927888.	-6.36	26.05			150.0	34.87
155.0	9.694	-2.095	15009.2							155.0	34.21
160.0	9.740	-1.875	15309.0							160.0	33.43
165.0	9.573	-1.653	15222.3							165.0	32.54
170.0	9.270	-1.429	15013.8							170.0	31.54
175.0	8.961	-1.203	14730.8							175.0	30.42
180.0	8.674	-0.975	15248.5							180.0	29.67
185.0	8.453	-0.744	15359.7							185.0	28.72
190.0	8.225	-0.516	15473.7							190.0	27.75
195.0	8.595	-0.280	15594.9							195.0	26.74
200.0	8.463	-0.045	15721.9							200.0	25.70
205.0	8.329	0.193	15856.6							205.0	24.61
210.0	8.193	0.432	15998.3							210.0	23.48
215.0	8.054	0.673	16147.4							215.0	22.32
220.0	7.913	0.916	16303.8							220.0	21.12
225.0	7.769	1.162	16464.5							225.0	19.92
230.0	7.623	1.409	16630.5							230.0	18.70
235.0	7.475	1.659	16801.8							235.0	17.46
240.0	7.326	1.909	16978.3							240.0	16.21
245.0	7.175	2.161	17158.3							245.0	14.97

→ IF CASE NO. 11-1-1
○ AS CASE NO. 11-1-1

進水計算

LIFT BY STERN'S

進 水 計 算

CASE NO. (1- 1-1)		LAUNCHING SPEED		WEIGHT(MT)	LCG(M)
LAUNCHING WT. (WITH SLIDING WAY)				17744.04	11.091
(WITHOUT SLIDING WAY)				17400.00	11.700
HEIGHT OF TIDE		4.35 (M)			
TOTAL DRAG WEIGHT		420.00 (MT)			
TRAVEL SPEED		TRAVEL SPEED			
(H)	(M/S)	(H)	(M/S)		
0.0	0.00	250.0	5.38		
5.0	1.11	255.0	5.34		
10.0	1.94	260.0	5.30		
15.0	2.37	265.0	5.26		
20.0	2.76	270.0	5.22		
25.0	3.00	275.0	5.17		
30.0	3.39	280.0	5.10		
35.0	3.67	285.0	5.01		
40.0	3.93	290.0	4.90		
45.0	4.15	295.0	4.80		
50.0	4.30	300.0	4.70		
55.0	4.40	305.0	4.60		
60.0	4.70	310.0	4.50		
65.0	4.94	315.0	4.39		
70.0	5.09	320.0	4.29		
75.0	5.22	325.0	4.19		
80.0	5.33	330.0	4.09		
85.0	5.43	335.0	3.97		
90.0	5.52	340.0	3.86		
95.0	5.59	345.0	3.75		
100.0	5.65	350.0	3.64		
105.0	5.70	355.0	3.53		
110.0	5.75	360.0	3.41		
115.0	5.79	365.0	3.29		
120.0	5.81	370.0	3.17		
125.0	5.82	375.0	3.05		
130.0	5.83	380.0	2.92		
135.0	5.83	385.0	2.79		
140.0	5.81	390.0	2.66		
145.0	5.80	395.0	2.52		
150.0	5.77	400.0	2.37		
155.0	5.74	405.0	2.22		
160.0	5.72	410.0	2.05		
165.0	5.70	415.0	1.90		
170.0	5.69	420.0	1.69		
175.0	5.67	425.0	1.48		
180.0	5.66	430.0	1.24		
185.0	5.65	435.0	0.93		
190.0	5.64	440.0	0.66		
195.0	5.63	445.0	0.30		
200.0	5.62				
205.0	5.61				
210.0	5.59				
215.0	5.57				
220.0	5.55				
225.0	5.53				
230.0	5.51				
235.0	5.49				
240.0	5.45				
245.0	5.42				

進 水 計 算

LAUNCHING CURVES

SNO2323

CASE NO. (1-1-1)

W.L.

1.C.G.

LAUNCHING WT. (WITH SLIDING WAY)

17745.03 MT

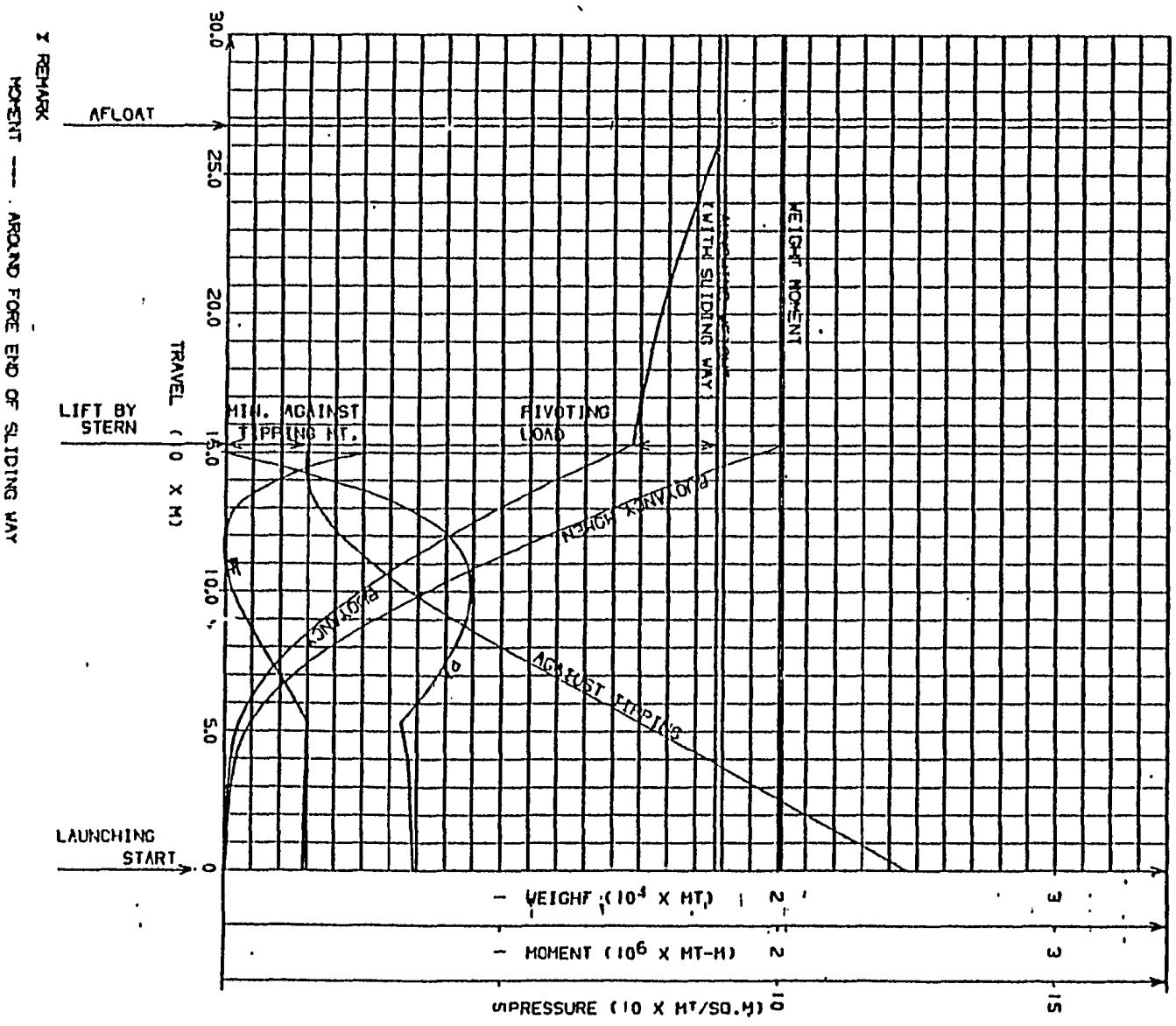
11.09M

(WITHOUT SLIDING WAY)

17410.00 MT

11.30M

HIGHT OF TIDE 4.35 M



進 水 計 算

LAUNCHING SPEED AND TRAVEL CURVES

SNO2323

CASE NO. (1 - 1 - 1)
 LAUNCHING WT. (WITH SLIDING WAY) 17745.03 MT
 (WITHOUT SLIDING WAY) 17480.00 MT
 HIGHT OF TIDE 4.35 M
 TOTAL DRAG WEIGHT 420.00 MT

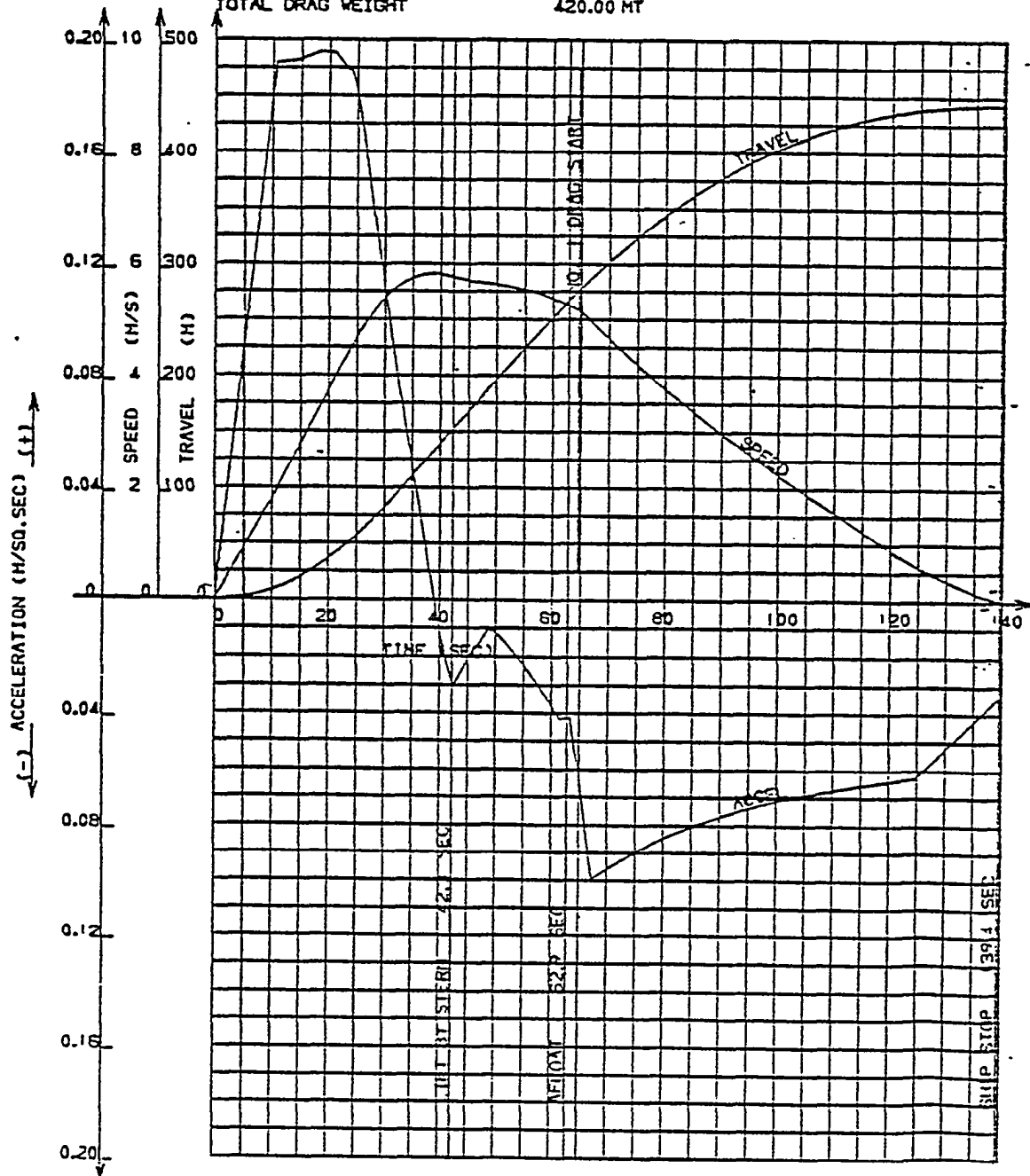


TABLE OF OBSCURED DISTANCE IN RELATION TO VARIOUS DRAFT AND TRIM

NAME OF OBJECT : BOW CHOCK TOP									
OBJECT 329.000 M FROM A.P. 32.850 M ABOVE B.L. 0.0 M FROM C.L.					EYE POSITION 47.400 M FROM A.P. 47.300 M ABOVE B.L. 0.0 M FROM C.L.				
TRIM BY STERN (- MEANS : BY BOW)									
MEAN DRAFT (H)	-2.0	-1.0	0.0	1.0	2.0	3.0	4.0	5.0	6.0
DISTANCE FROM FORE END (UNIT = METRIC)									
4.00	482	520	562	609	663	725	797	882	983
6.00	448	483	523	568	619	677	746	826	921
8.00	413	446	484	526	574	630	694	770	860
10.00	378	410	445	485	530	582	643	714	799
12.00	343	373	406	443	486	534	591	658	737
14.00	309	336	367	402	441	487	540	602	676
16.00	274	299	328	360	397	439	488	546	614
18.00	239	263	289	319	352	391	437	490	553
20.00	204	226	250	277	308	344	385	434	491
22.00	170	189	211	236	264	296	333	378	430

視界距離計算

ROLLING PERIOD - GM TABLE

DRAFT(EXT)	ROLLING PERIOD (SEC)														
(M)	6	7	8	9	10	11	12	13	14	15	20	25	30	35	40
	CORRECTED GM = GOM (M)														
2.50	26.43	19.42	14.87	11.75	9.52	7.86	6.61	5.63	4.85	4.21	2.38	1.52	1.06	0.78	0.59
2.70	24.71	18.16	13.90	10.98	8.90	7.35	6.18	5.26	4.54	3.95	2.22	1.42	0.99	0.73	0.56
2.90	23.25	17.09	13.08	10.34	8.37	6.92	5.81	4.95	4.27	3.72	2.09	1.34	0.93	0.68	0.52
3.10	22.01	16.17	12.38	9.78	7.92	6.55	5.50	4.69	4.04	3.52	1.98	1.27	0.88	0.65	0.50
3.30	20.93	15.38	11.77	9.30	7.54	6.23	5.23	4.46	3.84	3.35	1.88	1.21	0.84	0.62	0.47
3.50	20.00	14.69	11.25	8.89	7.20	5.95	5.00	4.26	3.67	3.20	1.80	1.15	0.80	0.59	0.45
3.70	19.18	14.09	10.79	8.52	6.90	5.71	4.79	4.08	3.52	3.07	1.73	1.10	0.77	0.56	0.43
3.90	18.45	13.56	10.38	8.20	6.64	5.49	4.61	3.93	3.39	2.95	1.66	1.06	0.74	0.54	0.42
4.10	17.81	13.08	10.02	7.92	6.41	5.30	4.45	3.79	3.27	2.85	1.60	1.03	0.71	0.52	0.40
4.30	17.24	12.66	9.70	7.66	6.20	5.13	4.31	3.67	3.17	2.76	1.55	0.99	0.69	0.51	0.39
4.50	16.72	12.28	9.41	7.43	6.02	4.97	4.18	3.56	3.07	2.68	1.50	0.96	0.67	0.49	0.38
4.70	16.26	11.94	9.14	7.23	5.85	4.84	4.06	3.46	2.99	2.60	1.46	0.94	0.65	0.48	0.37
4.90	15.84	11.64	8.91	7.04	5.70	4.71	3.96	3.37	2.91	2.53	1.43	0.91	0.63	0.47	0.36
5.10	15.46	11.36	8.69	6.87	5.56	4.60	3.86	3.29	2.84	2.47	1.39	0.89	0.62	0.45	0.35
5.30	15.11	11.10	8.50	6.72	5.44	4.50	3.78	3.22	2.78	2.42	1.36	0.87	0.60	0.44	0.34
5.50	14.79	10.87	8.32	6.57	5.33	4.40	3.70	3.15	2.72	2.37	1.33	0.85	0.59	0.43	0.33
5.70	14.50	10.65	8.16	6.45	5.22	4.31	3.63	3.09	2.66	2.32	1.31	0.84	0.58	0.43	0.33
5.90	14.23	10.46	8.01	6.33	5.12	4.24	3.56	3.03	2.61	2.28	1.28	0.82	0.57	0.42	0.32
6.10	13.99	10.28	7.87	6.22	5.04	4.16	3.50	2.98	2.57	2.24	1.26	0.81	0.56	0.41	0.31
6.30	13.76	10.11	7.74	6.12	4.95	4.09	3.44	2.93	2.53	2.20	1.24	0.79	0.55	0.40	0.31
6.50	13.55	9.96	7.62	6.02	4.88	4.03	3.39	2.89	2.49	2.17	1.22	0.78	0.54	0.40	0.30
6.70	13.36	9.81	7.51	5.94	4.81	3.97	3.34	2.84	2.45	2.14	1.20	0.77	0.53	0.39	0.30
6.90	13.17	9.68	7.41	5.86	4.74	3.92	3.29	2.81	2.42	2.11	1.19	0.76	0.53	0.39	0.30
7.10	13.01	9.56	7.32	5.78	4.68	3.87	3.25	2.77	2.39	2.08	1.17	0.75	0.52	0.38	0.29
7.30	12.85	9.44	7.23	5.71	4.63	3.82	3.21	2.74	2.36	2.06	1.16	0.74	0.51	0.38	0.29
7.50	12.70	9.33	7.15	5.65	4.57	3.78	3.18	2.71	2.33	2.03	1.14	0.73	0.51	0.37	0.29
7.70	12.57	9.23	7.07	5.59	4.52	3.74	3.14	2.68	2.31	2.01	1.13	0.72	0.50	0.37	0.28
7.90	12.44	9.14	7.00	5.53	4.48	3.70	3.11	2.65	2.28	1.99	1.12	0.72	0.50	0.37	0.28
8.10	12.32	9.05	6.93	5.48	4.44	3.67	3.08	2.62	2.26	1.97	1.11	0.71	0.49	0.36	0.28
8.30	12.21	8.97	6.87	5.43	4.40	3.63	3.05	2.60	2.24	1.95	1.10	0.70	0.49	0.36	0.27
8.50	12.11	8.89	6.81	5.38	4.36	3.60	3.03	2.58	2.22	1.94	1.09	0.70	0.48	0.36	0.27
8.70	12.01	8.82	6.76	5.34	4.32	3.57	3.00	2.56	2.21	1.92	1.08	0.69	0.48	0.35	0.27
8.90	11.92	8.76	6.70	5.30	4.29	3.55	2.98	2.54	2.19	1.91	1.07	0.69	0.48	0.35	0.27
9.10	11.83	8.69	6.66	5.26	4.26	3.52	2.96	2.52	2.17	1.89	1.07	0.68	0.47	0.35	0.27
9.30	11.76	8.64	6.61	5.22	4.23	3.50	2.94	2.50	2.16	1.88	1.06	0.68	0.47	0.35	0.26
9.50	11.68	8.59	6.57	5.19	4.21	3.48	2.92	2.49	2.15	1.87	1.05	0.67	0.47	0.34	0.26
9.70	11.61	8.53	6.53	5.16	4.18	3.46	2.90	2.47	2.13	1.86	1.05	0.67	0.46	0.34	0.26
9.90	11.55	8.48	6.50	5.13	4.16	3.44	2.89	2.46	2.12	1.85	1.04	0.67	0.46	0.34	0.26
10.10	11.49	8.44	6.46	5.11	4.14	3.42	2.87	2.45	2.11	1.84	1.03	0.66	0.46	0.34	0.26
10.30	11.43	8.40	6.43	5.08	4.12	3.40	2.86	2.44	2.10	1.83	1.03	0.66	0.46	0.34	0.26
10.50	11.38	8.36	6.40	5.06	4.10	3.39	2.85	2.42	2.09	1.82	1.02	0.66	0.46	0.33	0.26
10.70	11.34	8.33	6.38	5.04	4.08	3.37	2.83	2.41	2.08	1.81	1.02	0.65	0.45	0.33	0.26
10.90	11.29	8.30	6.35	5.02	4.06	3.36	2.82	2.41	2.07	1.81	1.02	0.65	0.45	0.33	0.25
11.10	11.25	8.27	6.33	5.00	4.05	3.35	2.81	2.40	2.07	1.80	1.01	0.65	0.45	0.33	0.25
11.30	11.21	8.24	6.31	4.98	4.04	3.34	2.80	2.39	2.06	1.79	1.01	0.65	0.45	0.33	0.25
11.50	11.18	8.21	6.29	4.97	4.02	3.33	2.79	2.38	2.05	1.79	1.01	0.64	0.45	0.33	0.25

DRAFT - (K/R)2 CURVE

◆ MARK MEANS THE CORRECTED VALUE
● MARK MEANS THE CALCULATED VALUE

DRAFT
(M)

20.00

15.00

10.00

5.00

(動揺試験結果による修正を行う場合)

1 : (K/R)2

0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60

動揺周期

FLOODABLE LENGTH CALCULATION

VOLUME OF DISPLACEMENT AT FULL LOAD DRAFT (DESIGN DRAFT) 13.325 (M) , 69148.75 (M3)

DRAFT F.	DRAFT A.	SHIP VOLUME	SHIP MID. S.	FLOODING VOLUME	FLOODING MID. S.	CENTER POINT	FLOODABLE LENGTH	PERMISSIBLE LENGTH
(M)	(M)	(M3)	(M)	(M3)	(M)	(M)	(M)	(M)
18.626	10.600	76655.19	111.367	6005.00	162.372	184.232	19.878	19.878
18.647	11.455	79038.81	110.277	7911.90	156.398	156.428	14.560	14.560
18.667	12.309	81463.44	109.182	9851.60	140.367	139.956	17.995	17.995
18.688	13.164	83926.81	108.101	11822.30	128.781	128.530	21.429	21.429
18.709	14.019	86425.00	107.036	13820.85	120.466	120.004	24.538	24.538
18.729	14.874	88934.62	105.979	15828.60	114.009	113.935	28.650	28.650
18.731	15.728	91429.12	104.929	17824.15	108.800	108.986	32.283	32.283
18.627	16.583	93860.62	103.840	19809.35	104.289	104.116	34.204	34.204
18.484	17.438	95782.06	102.749	21306.50	100.328	100.467	37.189	37.189
18.292	18.292	97474.50	101.776	22660.45	97.125	97.075	38.866	38.866
18.292	18.292	97474.50	101.776	22660.45	97.125	97.075	38.866	38.866
17.438	18.460	95887.31	101.041	21390.70	94.212	94.206	37.076	37.076
16.583	18.564	93799.25	100.248	19720.25	90.615	91.004	34.004	34.004
15.728	18.624	91569.31	99.484	17936.30	86.537	86.419	32.439	32.439
14.874	18.649	89232.37	98.735	16066.75	81.702	81.746	29.237	29.237
14.019	18.646	86816.00	97.987	14133.65	75.702	76.208	25.158	25.158
13.164	18.630	84362.06	97.224	12170.50	67.876	67.800	23.000	23.000
12.309	18.612	81905.00	96.424	10204.85	57.084	57.313	19.128	19.128
11.455	18.595	79444.12	95.576	8236.15	41.135	40.884	17.723	17.723
10.600	18.578	76987.25	94.671	6270.65	15.180	4.812	44.565	44.565

可變長計算

*** DATA OF FLOODABLE LENGTH CURVES ***

... FLOODABLE LENGTH ... PERMISSIBLE LENGTH ...

DIS. AP (M)	LENGTH (M)	K.P.	DIS. AP (M)	LENGTH (M)	K.P.
147.000	0.0	1	147.000	0.0	1
173.250	14.275	1	173.250	14.275	1
173.101	14.266	0	173.101	14.266	0
172.806	14.329	0	172.806	14.329	0
172.402	14.277	0	172.402	14.277	0
171.454	14.190	0	171.454	14.190	0
170.884	14.140	0	170.884	14.140	0
169.967	14.066	0	169.967	14.066	0
169.039	14.000	0	169.039	14.000	0
168.410	13.966	0	168.410	13.966	0
167.535	13.910	0	167.535	13.910	0
166.966	13.894	0	166.966	13.894	0
166.397	13.875	0	166.397	13.875	0
166.055	13.867	0	166.055	13.867	0
165.070	13.852	0	165.070	13.852	0
164.513	13.849	0	164.513	13.849	0
163.926	13.851	0	163.926	13.851	0
163.592	13.855	0	163.592	13.855	0
163.016	13.868	0	163.016	13.868	0
162.674	13.878	0	162.674	13.878	0
162.132	13.902	0	162.132	13.902	0
161.180	13.957	0	161.180	13.957	0
160.617	13.926	0	160.617	13.926	0
160.060	14.039	0	160.060	14.039	0
159.732	14.068	0	159.732	14.068	0
159.188	14.121	0	159.188	14.121	0
158.869	14.156	0	158.869	14.156	0
158.371	14.210	0	158.371	14.210	0
157.862	14.291	0	157.862	14.291	0
157.566	14.337	0	157.566	14.337	0
157.107	14.416	0	157.107	14.416	0
156.672	14.502	0	156.672	14.502	0
156.428	14.560	0	156.428	14.560	0
156.956	17.995	0	156.956	17.995	0
156.520	21.429	0	156.520	21.429	0
157.893	21.598	0	157.893	21.598	0
157.518	21.703	0	157.518	21.703	0
156.954	21.867	0	156.954	21.867	0
156.594	21.975	0	156.594	21.975	0
156.056	22.143	0	156.056	22.143	0
155.530	22.314	0	155.530	22.314	0
154.738	22.581	0	154.738	22.581	0
154.410	22.695	0	154.410	22.695	0
153.922	22.873	0	153.922	22.873	0
153.446	23.053	0	153.446	23.053	0
152.735	23.332	0	152.735	23.332	0
152.285	23.517	0	152.285	23.517	0
151.616	23.802	0	151.616	23.802	0
150.969	24.090	0	150.969	24.090	0
150.004	24.538	0	150.004	24.538	0
149.346	24.907	0	149.346	24.907	0
148.804	25.246	0	148.804	25.246	0

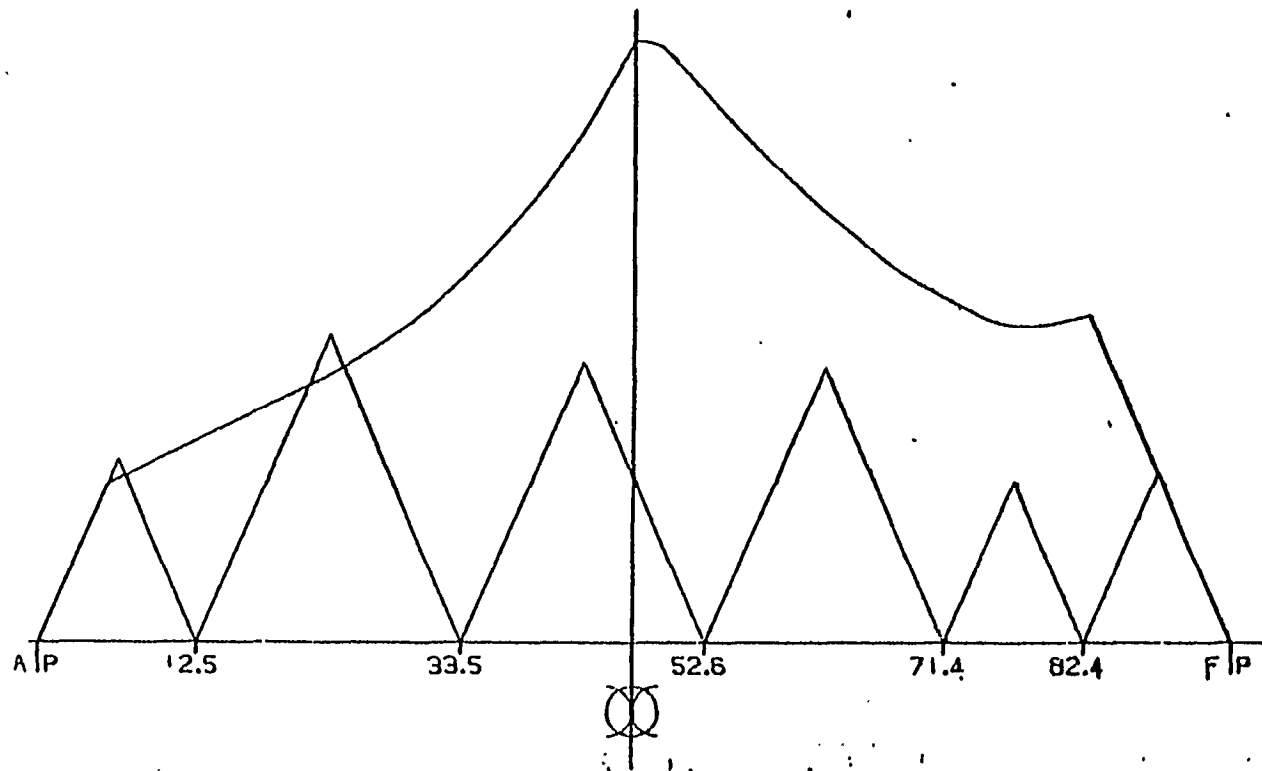
FLOODABLE LENGTH CURVE

△

———— FLOODABLE LENGTH
 - - - - - PERMEABILITY LENGTH
 (SCALE ICM = 4.33M)

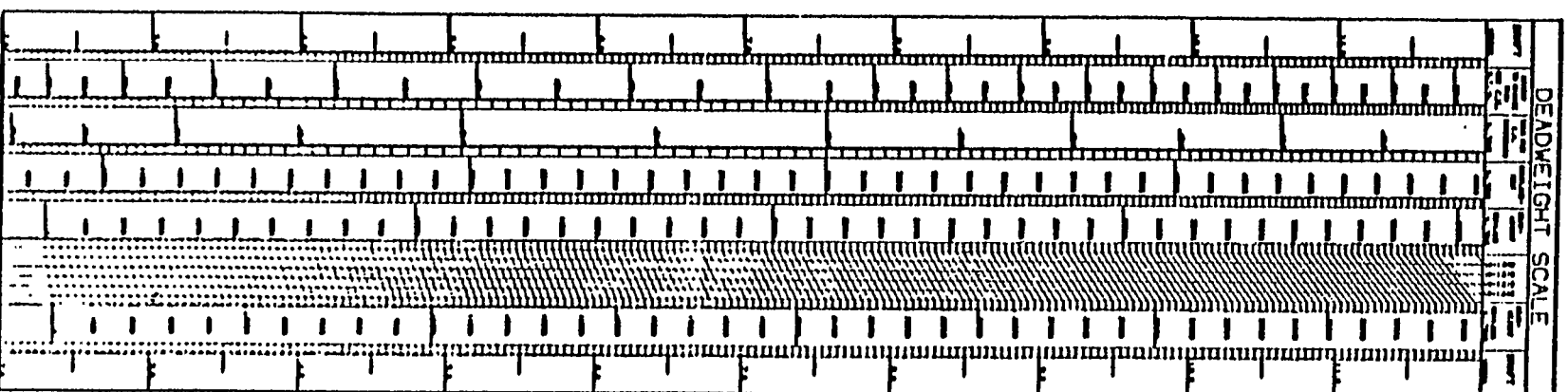
SUBDIVISION LENGTH 94.0 M
 BREADTH 14.0 M
 DEPTH 7.6 M

CRITERION NUMBER 16
 FACTOR OF SUBDIVISION 1.0
 NUMBER OF CREW 325



可
漫
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D/W スケール作画

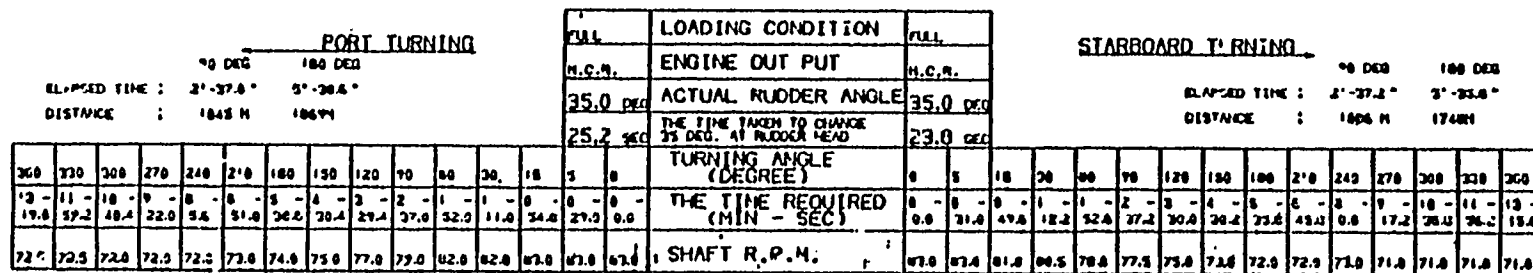


旋回力試験

*** INPUT DATA FOR TURNING TEST ***				*** SPEED DATA ***			
DATE	FEBRUARY 4 1977			MEASURED SPACE OF SPEED			40.0
PLACE	KURE-1 SHIPYARD			DISTANCE FROM C.L. TO MEAN MEASURED BOARD			47.3
COND.	FULL						
WEATHER	BC			(MINUTE)	(SECOND)	(ELAPSED TIME)	
SEA COND.	5			1	0	16.00	4.90
				2	0	20.00	5.00
				3	0	30.00	5.30
SFA DEPTH	1500.00			4	0	40.00	5.50
A. WIND DIRECTION	25.00			5	0	50.00	5.70
				6	1	0.0	6.00
A. WIND VELOCITY	11.00			7	1	20.00	6.50
				8	1	40.00	7.20
ENGINE POWER	M.C.R.			9	2	0.0	8.10
INITIAL SPEED	16.20			10	2	30.00	9.30
				11	3	0.0	10.70
INITIAL COURSE	270.00			12	3	30.00	12.10
				13	4	0.0	13.50
INITIAL RPM	83.00			14	4	30.00	14.70
				15	5	0.0	15.70
DESIGNED RUDDER ANGLE	35.00			16	5	30.00	16.60
				17	6	0.0	17.40
ELAPSED TIME FROM THE ORDER TO DESIGNED RUDDER ANGLE				18	6	30.00	18.10
				19	7	0.0	18.80
				20	7	30.00	19.20
	25.20			21	8	0.0	19.70
MEASURED RUDDER ANGLE	35.00			22	8	30.00	20.00
				23	9	0.0	20.30
DISTANCE FROM PIVOTING POINT TO SHIPS GRAVITY				24	9	30.00	20.60
				25	10	0.0	20.90
	100.00			26	10	30.00	21.20
				27	11	0.0	21.40
LENGTH BETWEEN PERPENDICULARS				28	11	30.00	21.60
				29	12	0.0	21.80
	320.00			30	12	30.00	22.00
				31	13	0.0	22.20
				32	13	30.00	22.30
UNIT FOR CUT PUT	0	METRIC					
INDICATION OF DRAWING	1	DRAW					
DRAWING SCALE	1	A4 SIZE					
INDICATION OF TURNING	0	BOTH					
INDICATION OF RIGHT OR LEFT	1	PORT					
NON-CANADIAN DATA	1	CONSIDER					

旋回力試験

NO	TIME (SEC)	MEASURED SPEED (M/SEC)	CORR. SPEED (M/SEC)	ANGULAR VELOCITY	SHIP'S POSITION (ADVANCE)	SHIP'S POSITION (TRANSFER)	TURNING ANGLE (DEG)
1	5.0	8.180	8.180	0.0	0.0	0.0	0.00
2	5.0	8.183	8.226	0.000923	40.9	0.4	0.16
3	10.0	8.163	8.259	0.002024	82.2	1.0	0.85
4	15.0	8.102	8.238	0.002873	123.5	1.6	1.67
5	20.0	8.060	8.174	0.003669	164.6	1.8	2.72
6	25.0	7.921	8.021	0.004221	205.1	1.6	3.93
7	30.0	7.547	7.766	0.004637	244.7	0.8	5.26
8	35.0	7.406	7.620	0.004706	283.2	-0.9	6.40
9	40.0	7.273	7.514	0.005091	321.0	-3.2	8.06
10	45.0	7.147	7.424	0.005862	358.4	-6.0	9.74
11	50.0	7.018	7.373	0.007512	395.4	-9.3	11.89
12	55.0	6.845	7.386	0.011424	432.6	-12.3	15.17
13	60.0	6.667	7.372	0.014919	470.1	-16.1	19.44
14	65.0	6.520	7.261	0.015680	506.9	-22.3	23.93
15	70.0	6.404	7.260	0.018265	543.5	-30.4	29.16
16	75.0	6.285	6.924	0.019523	577.4	-43.0	33.04
17	80.0	6.154	6.775	0.013140	609.2	-57.2	36.80
18	85.0	5.958	6.613	0.013908	639.4	-73.0	40.53
19	90.0	5.821	6.430	0.012876	667.9	-90.2	44.72
20	95.0	5.648	6.250	0.012744	694.4	-108.6	47.87
21	100.0	5.479	6.076	0.012612	719.2	-128.0	51.48
22	105.0	5.323	5.923	0.012480	742.1	-148.3	55.06
23	110.0	5.194	5.778	0.012348	763.3	-169.4	58.60
24	115.0	5.063	5.640	0.012216	782.7	-191.2	62.10
25	120.0	4.938	5.510	0.012084	800.4	-213.5	65.56
26	125.0	4.823	5.389	0.011952	816.5	-236.3	68.98
27	130.0	4.712	5.271	0.011820	830.9	-259.5	72.37
28	135.0	4.604	5.157	0.011688	843.7	-283.0	75.72
29	140.0	4.500	5.046	0.011556	854.9	-306.6	79.03
30	145.0	4.399	4.939	0.011424	864.6	-330.3	82.30
31	150.0	4.301	4.835	0.011292	872.8	-354.0	85.53
32	155.0	4.199	4.727	0.011160	879.5	-377.6	88.73
33	160.0	4.101	4.639	0.011028	885.1	-401.0	91.99
34	165.0	4.005	4.535	0.011192	889.2	-424.3	95.20
35	170.0	3.913	4.415	0.010604	891.9	-447.1	98.24
36	175.0	3.824	4.309	0.010256	893.2	-469.5	101.17
37	180.0	3.738	4.213	0.010030	893.5	-491.4	104.05
38	185.0	3.657	4.121	0.009795	892.7	-512.7	106.85
39	190.0	3.581	4.035	0.009592	890.8	-533.6	109.60
40	195.0	3.509	3.959	0.009516	888.1	-554.0	112.33
41	200.0	3.439	3.884	0.009404	884.6	-573.8	115.02
42	205.0	3.371	3.811	0.009292	880.2	-593.1	117.68
43	210.0	3.306	3.741	0.009206	875.1	-611.8	120.32
44	215.0	3.242	3.681	0.009289	869.3	-630.1	122.98
45	220.0	3.180	3.615	0.009187	862.8	-647.7	125.61
46	225.0	3.122	3.552	0.009086	855.7	-664.8	128.22
47	230.0	3.066	3.492	0.008996	847.9	-681.2	130.80
48	235.0	3.013	3.432	0.008955	839.6	-697.0	133.33
49	240.0	2.963	3.375	0.008813	830.8	-717.2	135.83
50	245.0	2.917	3.322	0.008570	821.5	-726.8	138.28
51	250.0	2.874	3.272	0.008430	811.7	-740.7	140.70
52	255.0	2.832	3.223	0.008255	801.4	-753.9	143.06
53	260.0	2.793	3.174	0.008063	790.8	-766.6	145.37
54	265.0	2.756	3.129	0.007812	779.9	-778.5	147.61
55	270.0	2.721	3.086	0.007723	768.6	-789.9	149.82



*** INPUT DATA FOR CRASH STOP ASTERN AND AHEAD TEST ***

----- CRASH STOP ASTERN TEST -----

DATE FEBRUARY 20, 1977

PLACE KURE-1 SHIP YARD

COND. FULL LOADED CONDITION

WEATHER 0

SEA COND. 4

SEA DEPTH 7000.00

R. WIND DIRECTION 120.00

R. WIND VELOCITY 7.00

INITIAL SPEED 16.20

INITIAL COURSE 250.00

INITIAL RPM 84.00

SETTLED SPEED -4.50

SETTLED RPM 25.00

UNIT FOR OUT PUT 0 METRIC

INDICATION OF DRAWING 1 DRAW

DRAWING SCALE 4 A4 SIZE

INDICATION OF TEST 0 CRASH STOP ASTERN TEST

NON CANADIAN DATA 1 CONSIDER

DATA NAME FOR ENGINE PART (MIN.) (SECOND)

AHEAD VALVE SHUT 0 — 5.00

ASTERN VALVE OPEN 0 — 7.00

SHAFT STOP AND START 0 — 14.00

ASTERN RPM SETTLED 4 — 20.00

0 — 0.00

前 後 進 試 験

前後進試験

*** SPEED DATA ***

*** HEAD. ANGLE DATA ***

MEASURED SPACE OF SPEED

40.0

DISTANCE FROM C.L. TO MEAN MEASURED BOARD

27.0

(MINUTE) (SECOND) (ELAPSED TIME)

(MINUTE) (SECOND) (HEAD. ANGLE)

1	0	10.00	4.00
2	0	30.00	5.00
3	1	0.0	5.50
4	1	30.00	7.00
5	2	0.0	8.50
6	2	30.00	10.50
7	3	0.0	16.00
8	3	30.00	19.00
9	4	0.0	23.50
10	4	30.00	28.50
11	5	0.0	32.00
12	5	30.00	37.00
13	6	0.0	47.00
14	6	30.00	-45.00
15	7	0.0	-53.00
16	7	30.00	-41.00
17	8	0.0	-40.00
18	8	30.00	-30.00
19	9	0.0	-35.50
20	9	30.00	-32.00
21	10	0.0	-29.70
22	10	30.00	-26.00
23	11	0.0	-22.00
24	11	30.00	-20.00
25	12	0.0	-16.00
26	12	30.00	-15.70
27	13	0.0	-13.50
28	13	30.00	-10.20
29	14	0.0	-10.00
30	14	30.00	-10.00

1	0	10.00	250.00
2	0	20.00	253.00
3	0	30.00	255.00
4	0	40.00	257.00
5	0	50.00	260.00
6	1	0.0	266.00
7	1	30.00	270.00
8	2	0.0	276.00
9	2	30.00	281.50
10	3	0.0	287.00
11	3	30.00	295.50
12	4	0.0	302.00
13	4	30.00	307.00
14	5	0.0	309.50
15	5	30.00	311.00
16	6	0.0	312.00
17	6	30.00	312.30
18	7	0.0	312.00
19	7	30.00	311.90
20	8	0.0	311.00
21	8	30.00	309.70
22	9	0.0	307.20
23	9	30.00	305.00
24	10	0.0	303.00
25	11	0.0	301.20
26	12	0.0	290.20
27	13	0.0	287.00
28	14	0.0	284.00
29	15	0.0	282.00
30	0	0.0	0.0

--- RESULT OF CRASH STOP ASTERN TEST ---

DATE FEBRUARY 20, 1977
 PLACE KURE-1 SHIP YARD
 LOAD COND FULL LOADED CONDITION
 WATHER D
 SEA COND 4
 SEA DEPTH 7000.0 M
 INITIAL COURSE 150.0 DEG
 WIND 14.0 DEG 7.0 M/SIC

INITIAL SPEED 16.7 KTS
 RPM 84.0

ASTERN STOPPED SPEED -4.5 KTS
 RPM 25.0

SHIP'S STOP 6°-15.6°

*** CALCULATION OF CRASH STOP ASTERN TEST ***

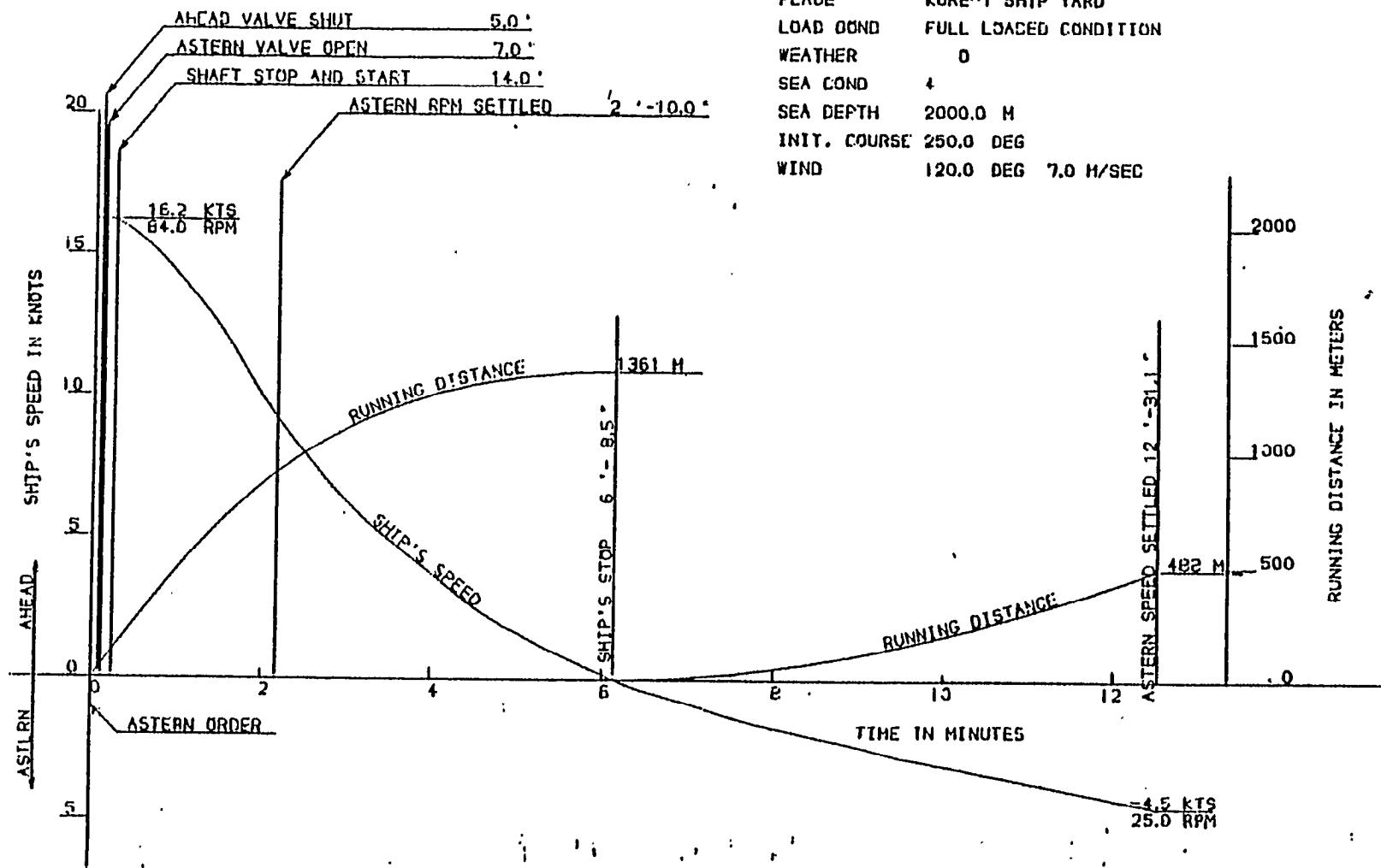
NO	TIME (SEC)	MEASURED SPEED (M/S)	COMP. SPEED (M/S)	ANGULAR VELOCITY (M/S)	SHIP'S POSITION (ADVANCE)	SHIP'S POSITION (TRANSFER)
1	0.0	8.410	8.461	0.0	0.0	0.0
2	5.0	8.400	8.414	0.000564	42.2	-0.1
3	10.0	8.331	8.340	0.000240	84.1	-0.1
4	15.0	8.260	8.252	-0.000053	125.9	-0.1
5	20.0	8.110	8.078	-0.000367	166.6	-0.2
6	25.0	7.959	7.876	-0.000656	217.3	-0.3
7	30.0	7.801	7.556	-0.001478	246.3	-2.1
8	35.0	7.640	7.408	-0.003410	264.5	-5.0
9	40.0	7.493	7.696	-0.003571	323.0	-10.2
10	45.0	7.341	7.501	-0.004455	360.0	-15.2
11	50.0	7.188	7.400	-0.005008	397.0	-21.2
12	55.0	7.032	7.229	-0.005492	433.1	-26.8
13	60.0	6.873	7.111	-0.006016	467.2	-38.0
14	65.0	6.707	7.019	-0.007899	501.1	-48.0
15	70.0	6.571	6.907	-0.008305	524.1	-58.2
16	75.0	6.429	6.523	-0.009016	565.0	-68.4
17	80.0	6.283	6.392	-0.009894	594.0	-76.4
18	85.0	6.147	6.289	-0.010294	624.5	-88.2
19	90.0	5.914	6.166	-0.010543	651.7	-97.9
20	95.0	5.571	6.431	-0.007930	677.7	-107.6
21	100.0	5.343	6.265	-0.007258	702.7	-117.3
22	105.0	5.112	6.090	-0.007222	726.6	-127.1
23	110.0	4.887	5.920	-0.005590	749.6	-137.0
24	115.0	4.658	5.756	-0.003788	771.7	-147.0
25	120.0	4.456	5.598	-0.003986	797.8	-157.0
26	125.0	4.250	5.441	-0.004338	813.0	-167.1
27	130.0	4.041	5.291	-0.004443	832.3	-177.4
28	135.0	3.828	5.138	-0.004358	850.7	-187.7
29	140.0	3.615	4.929	-0.004620	868.4	-198.0
30	145.0	3.406	4.803	-0.004280	885.2	-208.4

前後進試験

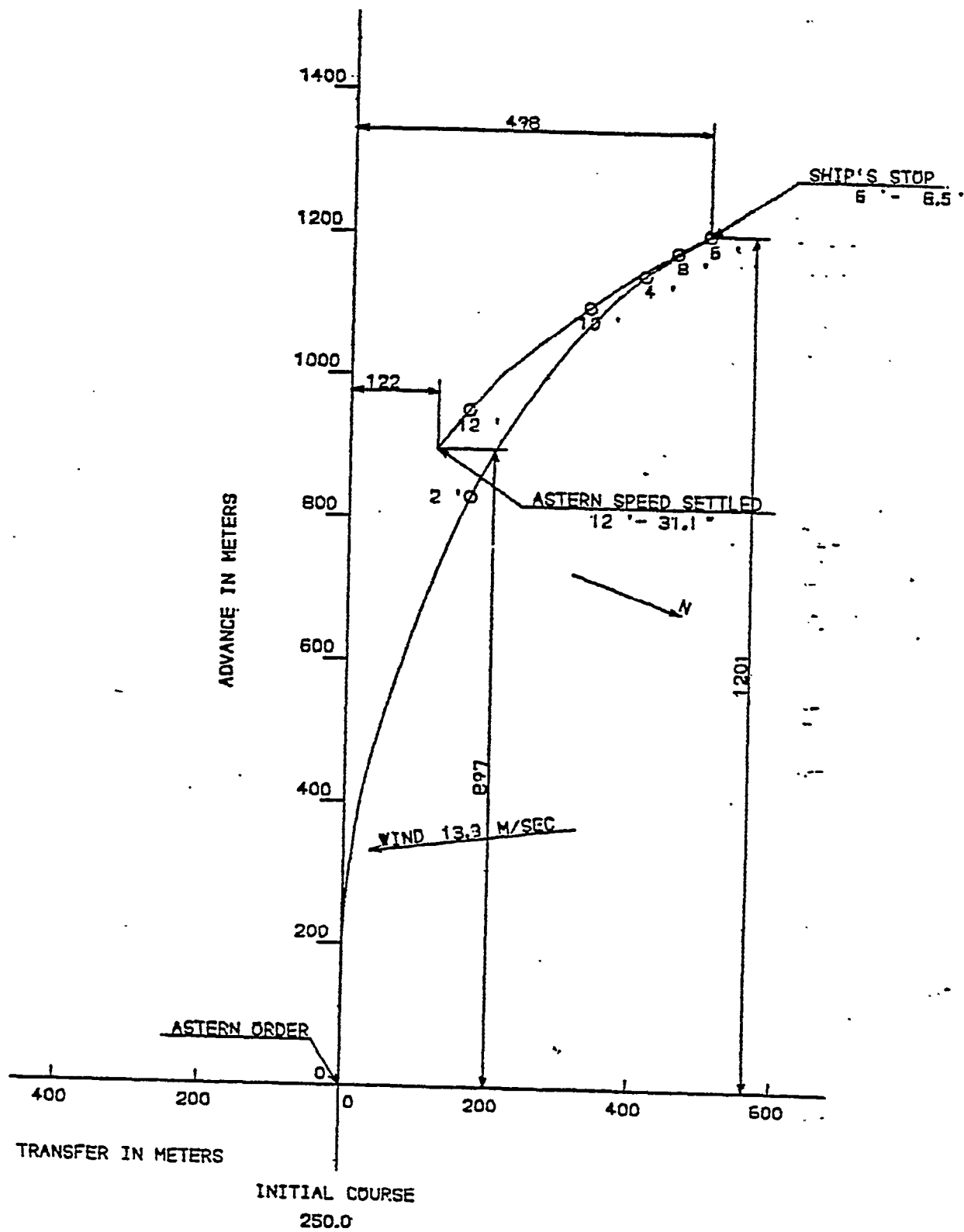
RESULT OF CRASH STOP ASTERN TEST

SPEED, RUNNING DISTANCE AND TIME

DATE FEBRUARY 20, 1977
 PLAGE KURE-1 SHIP YARD
 LOAD COND FULL LOADED CONDITION
 WEATHER 0
 SEA COND 4
 SEA DEPTH 2000.0 M
 INIT. COURSE 250.0 DEG
 WIND 120.0 DEG 7.0 M/SEC



前後進試験
COURSE OF CRASH STOP ASTERN TEST



RESULT OF STOPPING INERTIA TEST

DATE FEBRUARY 17 1977
 PLACE OFF OSHIMA
 LOAD COND BALLAST CONDITION
 WEATHER C
 SFA COND 3
 SEA DEPTH 1700.0 M
 INITIAL COURSE 120.0 DEG
 R. WIND 37.3 DEG 12.0 M/SFG

INITIAL SPEED 16.4 KTS
 RPM 90.0

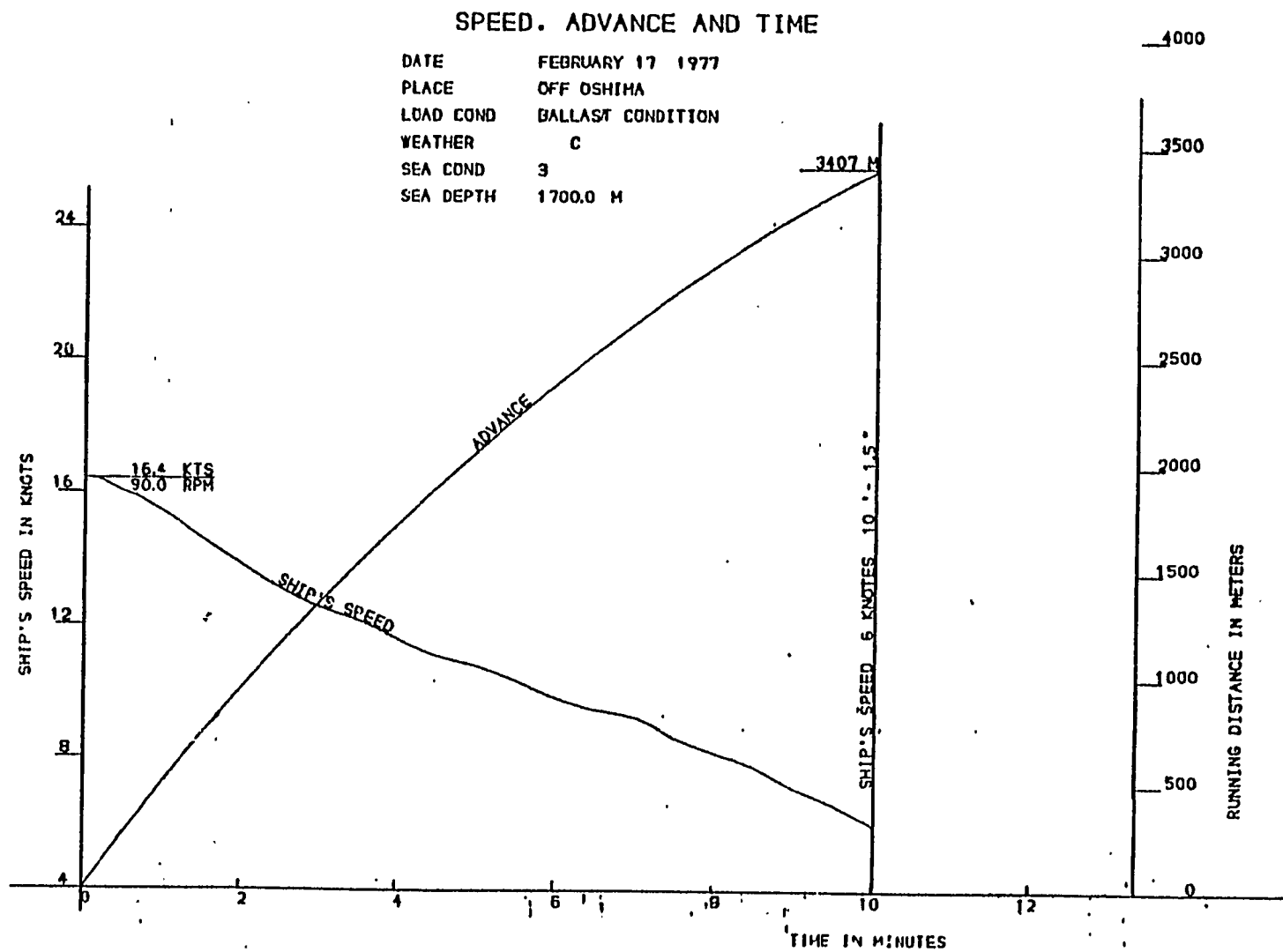
SHIP'S SPEED 6.0 KTS
 ELAPSED TIME 30" - 2.3"

*** CALCULATION OF STOPPING INERTIA TEST ***

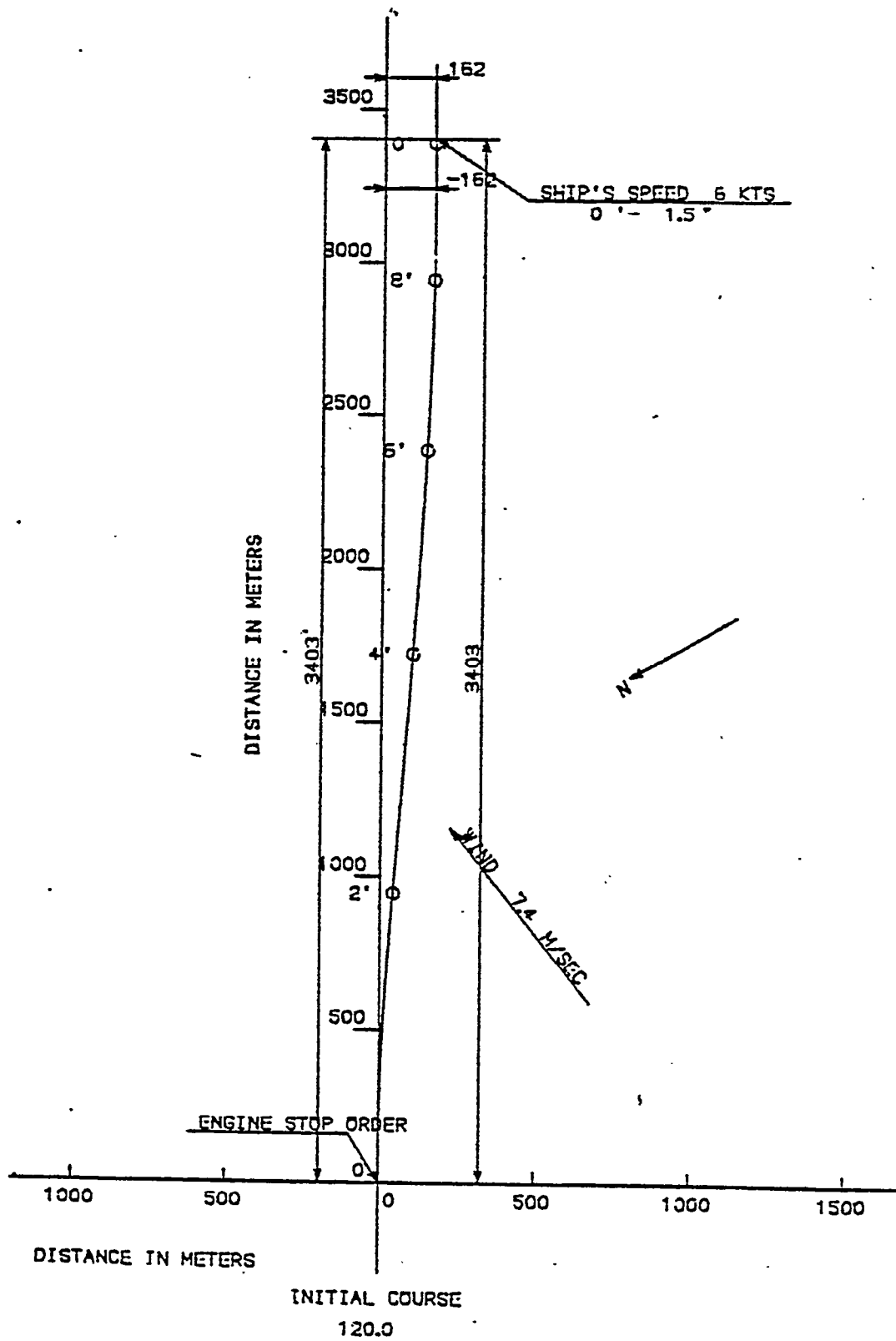
NO	TIME (SEC)	MEASURED SPEED (M/SEC)	CORR. SPEED (M/SEC)	ANGULAR VELOCITY	SHIP'S POSITION (ADVANCE)	SHIP'S POSITION (TRANSEER)
1	0.0	8.304	8.304	0.0	0.0	0.0
2	5.0	8.263	8.154	-0.0004052	41.3	1.1
3	10.0	8.163	8.079	-0.003129	81.9	1.4
4	15.0	8.078	8.010	-0.002207	122.2	1.2
5	20.0	8.000	7.945	-0.001264	162.1	0.6
6	25.0	7.974	7.899	-0.000926	201.8	-0.2
7	30.0	7.843	7.819	-0.000891	241.0	-1.1
8	35.0	7.689	7.666	-0.000851	279.7	-2.3
9	40.0	7.547	7.525	-0.000823	317.7	-3.5
10	45.0	7.477	7.453	-0.000868	355.1	-4.9
11	50.0	7.407	7.384	-0.000883	392.2	-6.4
12	55.0	7.379	7.314	-0.000880	428.9	-8.1
13	60.0	7.273	7.250	-0.000859	465.3	-9.9
14	65.0	7.215	7.194	-0.000764	501.3	-11.9
15	70.0	7.163	7.143	-0.000721	537.1	-14.0
16	75.0	7.117	7.099	-0.000678	572.6	-16.2
17	80.0	7.078	7.061	-0.000635	608.0	-18.5
18	85.0	7.045	7.030	-0.000544	643.1	-20.8
19	90.0	7.018	7.014	-0.000519	678.1	-23.3
20	95.0	6.966	6.966	0.0	713.0	-25.7
21	100.0	6.920	6.920	0.0	747.6	-28.1
22	105.0	6.878	6.878	0.0	782.0	-30.5
23	110.0	6.841	6.841	0.0	816.2	-32.9
24	115.0	6.808	6.808	0.0	850.3	-35.3
25	120.0	6.780	6.780	0.0	884.2	-37.7
26	125.0	6.761	6.761	0.0	917.9	-40.0
27	130.0	6.742	6.742	0.0	951.6	-42.4
28	135.0	6.723	6.723	0.0	985.2	-44.7
29	140.0	6.707	6.707	0.0	1018.7	-47.1
30	145.0	6.689	6.689	0.0	1052.1	-49.4
31	150.0	6.667	6.667	0.0	1085.4	-51.8
32	155.0	6.638	6.638	0.0	1118.6	-54.1
33	160.0	6.605	6.605	0.0	1151.6	-56.4
34	165.0	6.568	6.568	0.0	1184.5	-58.7

前進惰力試験

RESULT OF STOPPING INERTIA TEST



前進惰力試験
COURSE OF STOPPING INERTIA TEST



*** INPUT DATA FOR ZIG-ZAG TEST ***

DATE MARCH 9, 1977
PLACE KURE - 1 OFFICE
COND. BALLAST CONDITION
WEATHER B
SEA COND. 3
SEA DEPTH 1500.00
R. WIND DIRECTION -90.00
R. WIND VELOCITY 20.00
INITIAL COURSE 220.00
INITIAL SPEED 14.00
L B P 94.00

INDICATION OF DATA 0 USING INPUT DATA AS IT IS
INDICATION OF DRAWING 0 NOT DRAW
DRAWING SCALE 0 A0 SIZE

ANGLE VELOCITY DATA

ANGL2 = 0.9833
ANGL4 = -1.2833
ANGL6 = 1.4267

*** RUDDER ANGLE DATA ***

	(MINUTE)	(SECOND)	(RUDDER ANGLE)
1	0	0.0	0.0
2	0	5.80	15.00
3	0	23.00	15.00
4	0	32.80	-15.00
5	0	44.00	-15.00
6	0	53.40	15.00
7	0	141.00	15.00
8	0	152.40	-15.00
9	0	200.00	-15.00

*** SPEED DATA ***

	(MINUTE)	(SECOND)	(KNOT)
1	0	0.0	25.80
2	2	0.0	24.45
3	4	0.0	23.50
4	6	0.0	23.00
5	7	10.00	22.85
6	22	0.0	18.00

*** HEAD. ANGLE DATA ***

	(MINUTE)	(SECOND)	(HEAD. ANGLE)
1	0	0.0	0.0
2	0	41.50	30.00
3	0	100.00	-28.00
4	0	158.30	31.60
5	0	0.0	0.0
6	0	0.0	0.0

2
試
験

- RESULT OF ZIG-ZAG TEST -

DATE MARCH 9, 1977
PLACE KUAE - 1 OFFICE
LOAD COND BALLAST CONDITION
WEATHER B
SEA COND 3
SEA DEPTH 1500.0 M
INITIAL COURSE 220.0 DEG
INITIAL SPEED 14.0 KTS

A. WIND -90.0 DEG 20.0 M/SEC
LENGTH BETWEEN PERPENDICULARS 94.00 M
MANEUVERABILITY

K 4 (1/SEC) 6.14402
K 6 8 (1/SEC) 0.10086
KM (1/SEC) 0.12244
T4 (SEC) 31.933
T68 (SEC) 17.942
TM (SEC) 24.938
DELTA A (DEG) 0.89892

(VS BASE)
K 1.5980
T 1.9107

操縦性指数
(連立方程式による)

Z
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記 号 の 説 明

ABBREVIATION

DI SPT	: displacement with appendage.
DISPT (HID)	: Displacement without appendage.
APPEN	: Appendage displacement.
DIFF	: Displacement difference.
D.CORR.	: Increase of displacement for one CM/inch sagging, in case of hogging this value means decrease of displacement.
T P C	: Ton per one CM immersion.
T P I	: Ton per one inch immersion.
L C G	: Longitudinal center of gravity from midship.
L C B	: Longitudinal center of buoyancy from midship.
L C F	: Longitudinal Center of floatation from midship.
K G	: Vertical center of gravity above base line.
K B	: Vertical center of buoyancy above base line.
T K M	: Transverse metacenter above base line.
L K H	: Longitudinal metacenter above base line.
G H	: Height from center of gravity to transverse metacenter
C O M	: Corrected height from center of gravity to transverse metacenter by free water effects.
G G O	: Increase of center of gravity by free water effects.
A W	: Water plane area.
C W	: Water plane area coefficient.
A H	: Midship sectional area.
C M	: Midship sectional area coefficient.
W.S A	: Wetted surface area.
M T C	: Moment to change trim one CM.
M T I	: Moment to change trim one inch.
I	: Moment of inertia.
I C L	: Moment of inertia around center line.
I N A	: Moment of inertia around neutral axis.
I / D	: Propeller immersion ratio.

APPENDIX G

CADS - PIPING DESIGN SYSTEM

PART V. CADS Piping Design System

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1. CADS in Piping Design System

In piping design system, CADS is used for development of production engineering drawing for the purposes of:

- (1) Modification of piping layout made by module and automated piping design system.
- (2) Input of piping layout prepared by manually drafted sketch.
- (3) Design of new module, and
- (4) Modification of the module.

The data developed by CADS are transferred as a input data of pipe piece calculation program and material control program.

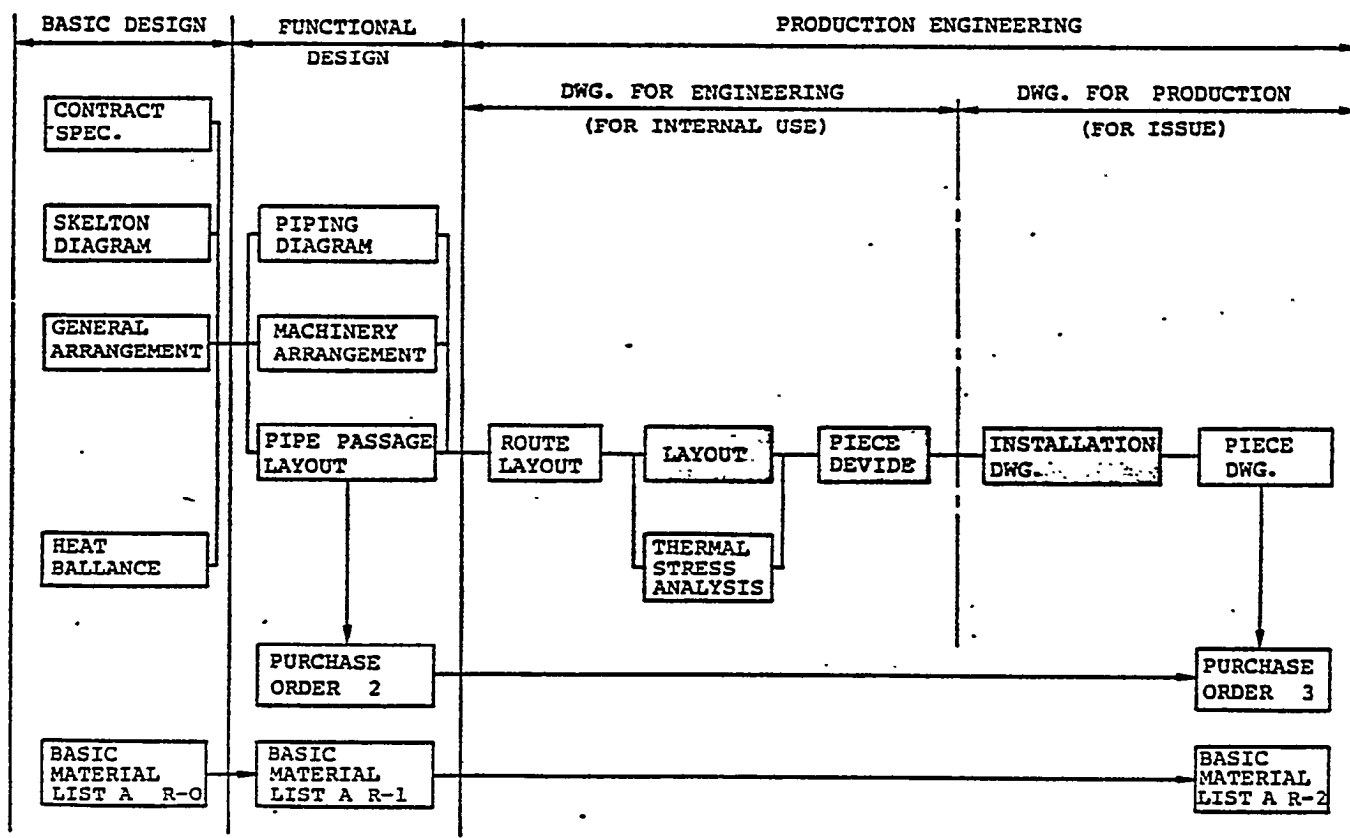


FIG 1.1 PROCESS OF PIPING DESIGN (BY DWG)

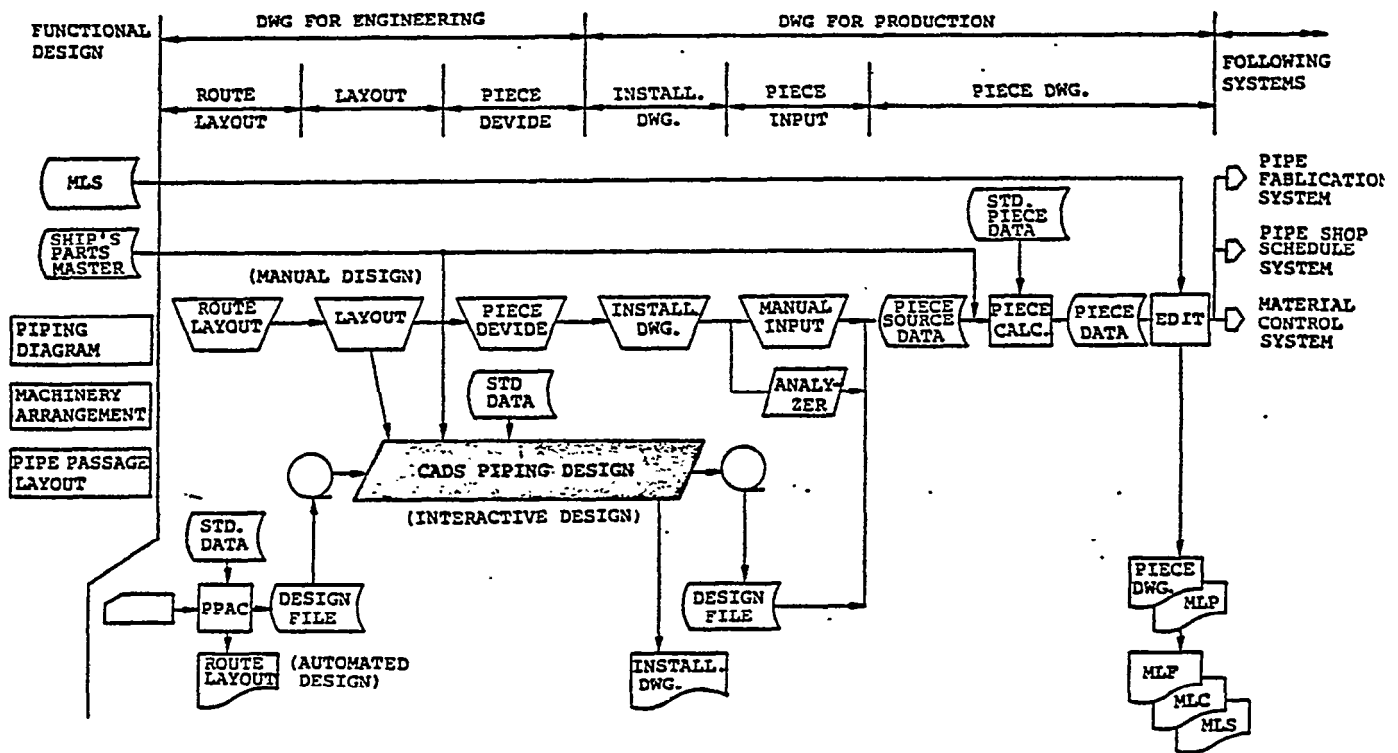


FIG 1.2 PIPING PRODUCTION ENGINEERING SYSTEM (ENG. RM)

2. Functions and Features of CADS Piping Design System

2.1 Functions of the System

- (1) To use background drawings of hull structures and obstacles for piping, which are supplemented by transparent sheets, photographic techniques and additional hand-writing.

Among the background drawings, main hull structures (such as frames, longitudinals, decks) are registered and drawn by the system.

- (2) To obtain tripartite drawings of pipe planning with plan, side and section views.

- (3) To define pipe lines by indicating the start and end points and bent points.

Computer takes the following role by rough manually indicated data.

Running a pipe line in parallel with an axis..

Rounding pipe length

Setting bent piece standardized.

- (4) To check intersection among pipes and others (tanks. hull constructions. etc.). by means of optional sections.
- (5) To calculate the clearance between the designated pair of pipes.

(6) To set pipe fittings on pipe line.

Computer adjust the rough input data with Pen Analyzer to set it on pipe line and to round pipe piece length.

(7) To check the pipe piece dimension based on the fabrication standard.

(8) To design the shape of pipe support.

(9) To set the same shaped pipe lines and pipe supports corresponding to indicated portion that is designed already..

(10) To decide and draw leaders and characters such as pipe piece code, code of pipe supports, title of drawings.

(11) To provide data for pipe piece fabrication system and material control system.

2.2 Features of the System

1) Large Panel:

Optional sections of tripartite with optional scale are easily drawn out on large panel so as to check them in one-glance.

2) Easy Operation:

The designer does not required special knowledge of computer. The designer can operate the system through a few day's training.

3) Minimized Input Data:

(i) Simpel input operation of command and symbol with key-sheet and of X, Y, Z value with defined coordinate, either indication is performed with Pen-Analyzer.

(ii) Command and symbol operation is minimized with "Default" and "Modal" function.

(iii) The computer supplements the attributive data to input data of a few key words by means of the master data based on standardization.

4) Assured Quality of Drawings and Data to relevant System:

When the drawing is finished, every relevant data, such as dimension, fabrication practice, material and installation control, are defined simultaneously. So that the data missing, that is occured frequently in case of manual input, is eliminated.

5). Easy Maintenance:

Data, which have possibility of changing in accordance with ability or restriction of facility and condition of purchasing such as fabrication practice and dimensional table of outfittings, are registered in master file.

Therefore, it is not necessary to change programs to cope with alternation of condition.

Revision of the master file is rather easy than revision of program, *furthermore*, conversational revision measure of master file is established.

3. Design Procedure with CADs

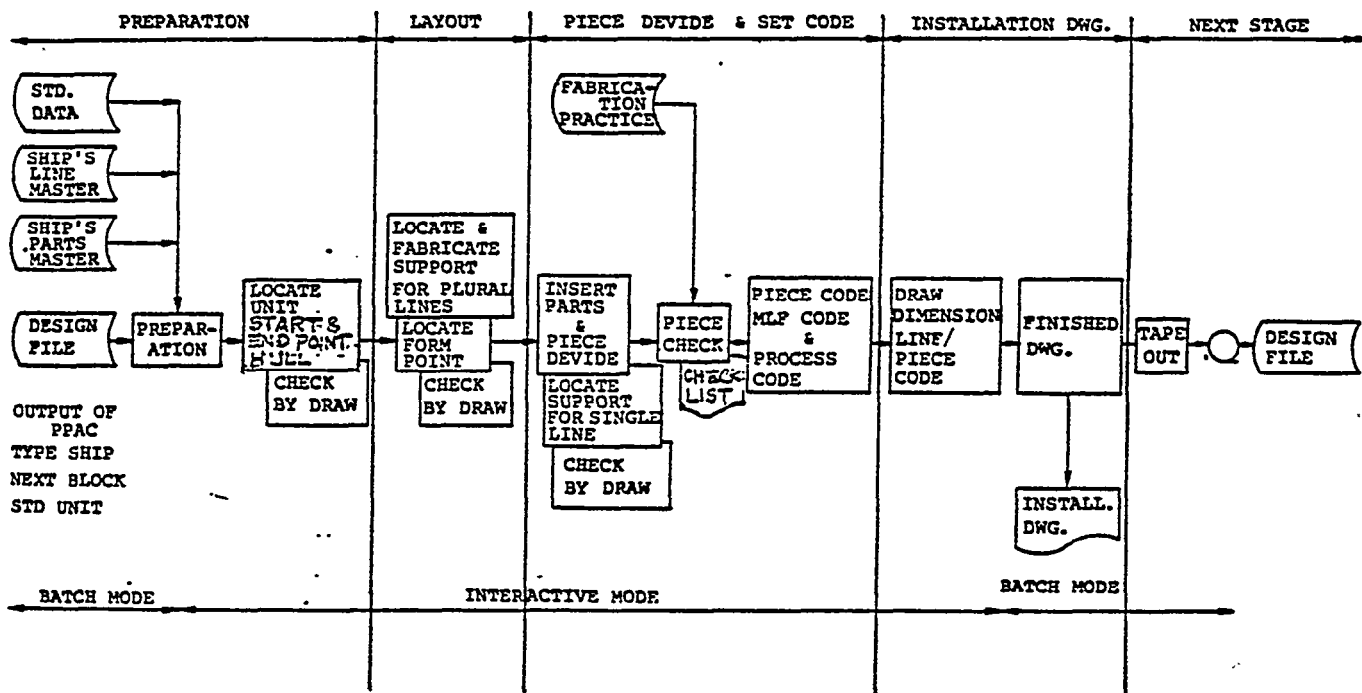


FIG 3.1 . . . OUTLINE PROCESS OF PIPING ENGINEERING WITH CADs

3.1 Step-1 Preparation

Locate Hull Unit & Start and End Point

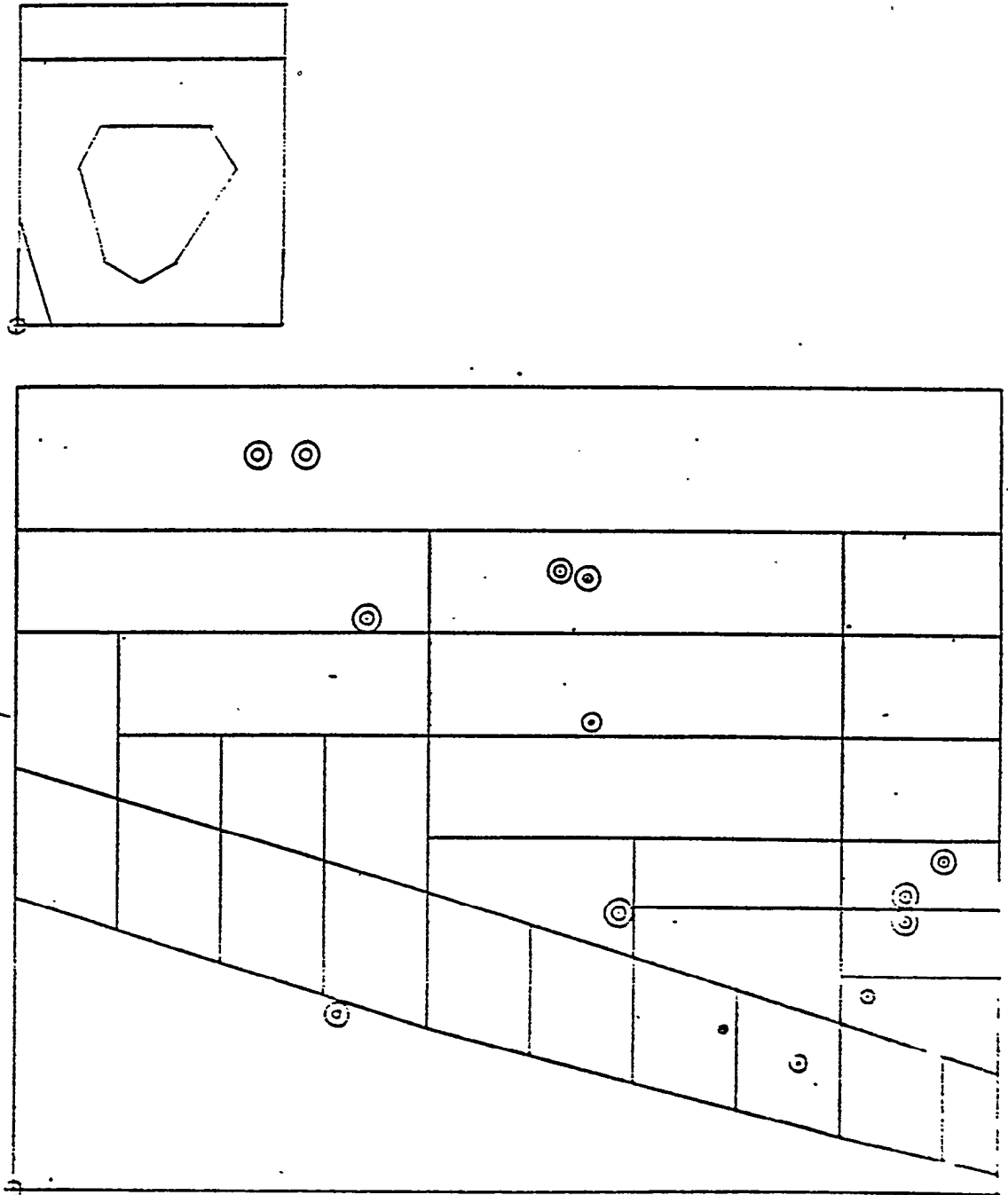


Fig. 3.2

3,2 Step-2 Layout

Locate Form

Locate & Fabricate Support

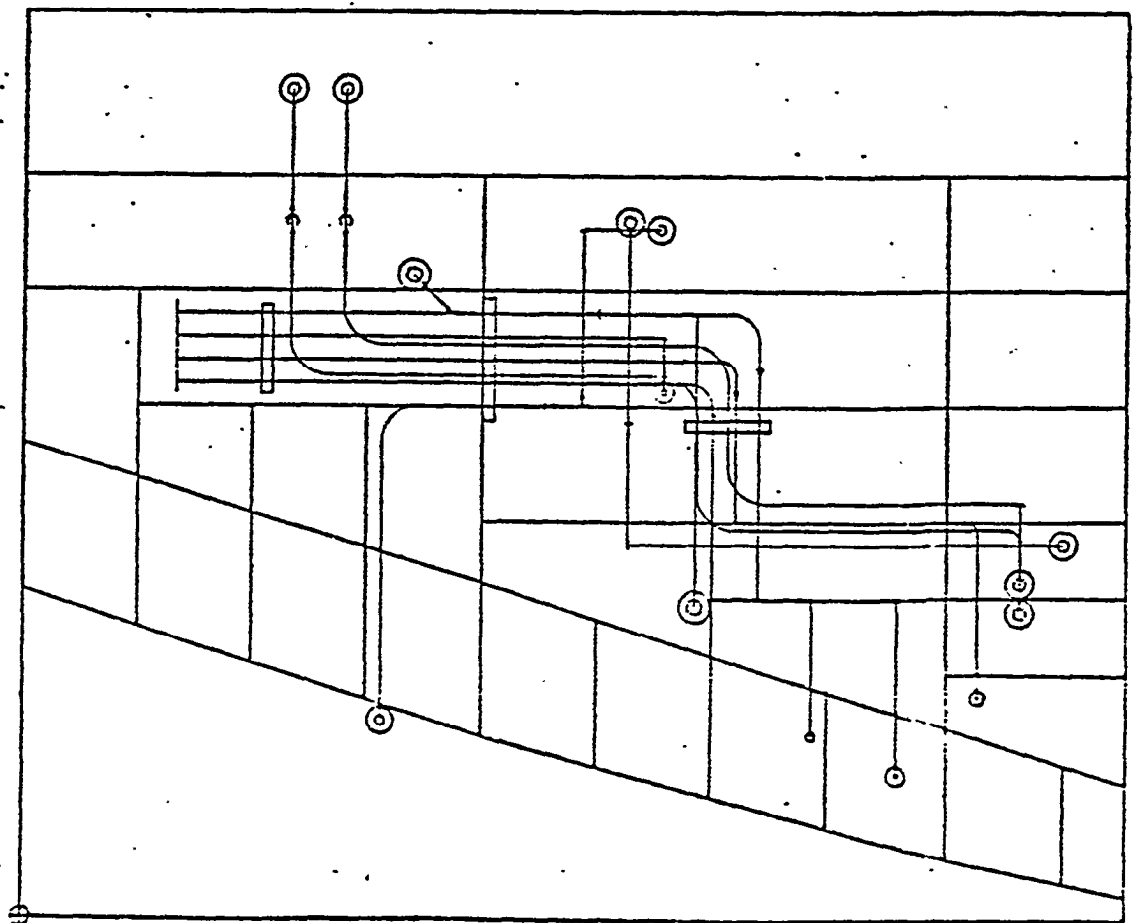
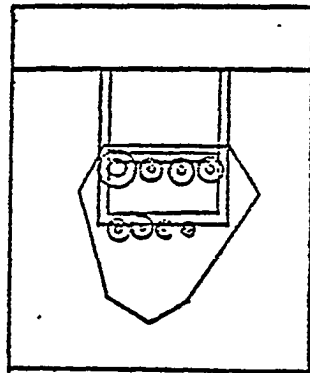


Fig. 3.3

3:3 Step-3 Piece Divide

Insert Parts & Piece Devide

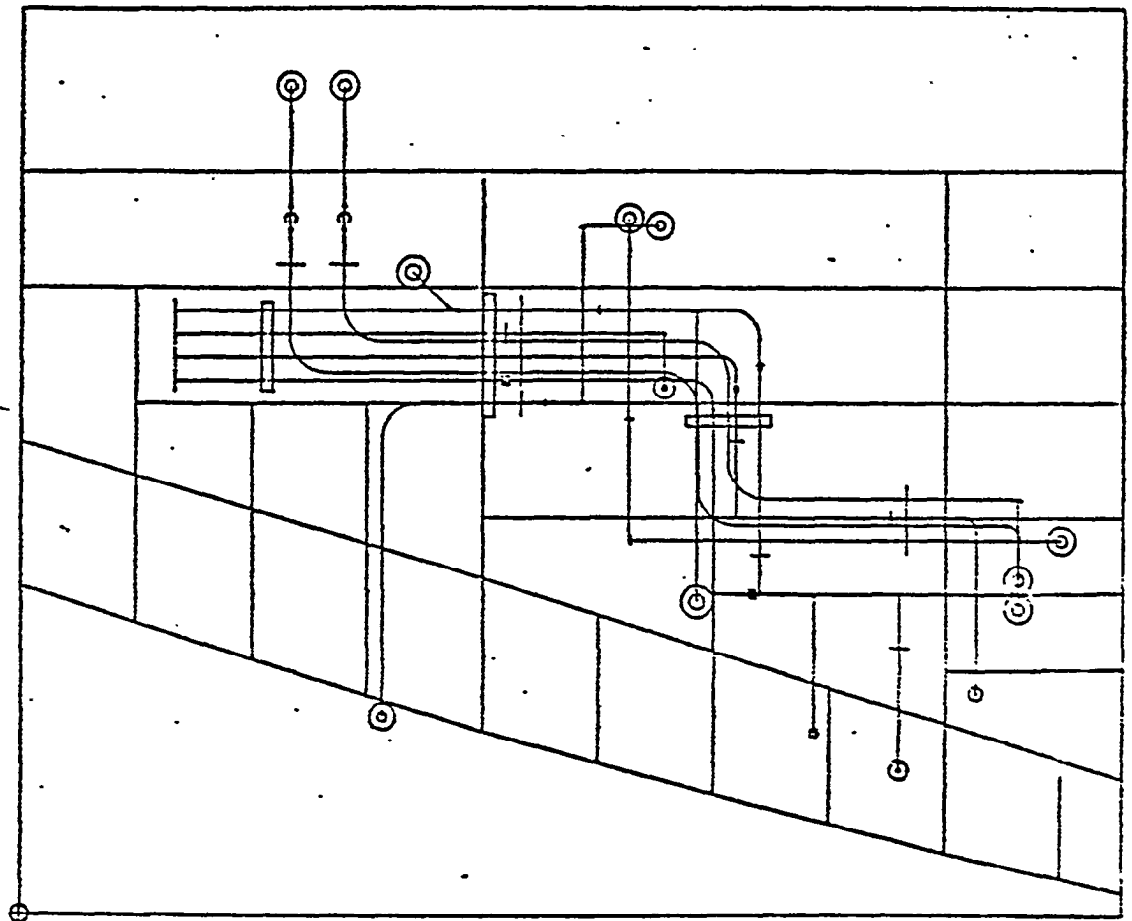
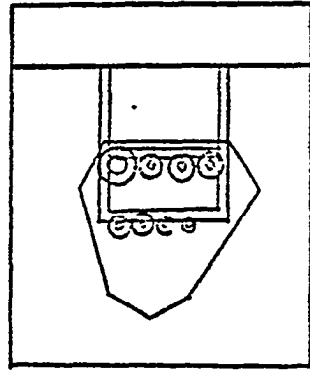


Fig. 3.4

Piece Check

Table 3.1

****PIECE CHECK***

****AS03210**

E042 LESS THAN BASE LENG.
LENGTH= 50 BASE= 305
E042 LESS THAN BASE LENG.
LENGTH= 200 BASE= 300
PIECE CHECK

****AS03210**

E042 LESS THAN EASE LENG.
LENGTH= 50 BASE= 305
E042 LESS THAN BASE LENG.
LENGTH= 200 BASE= 300
PIECE CHECK

****L001151**

E042 LESS THAN BASE LENG.
LENGTH= 100 BASE= 126
PIECE CHECK

****FR01012**

PIECE CHECK

Draw Dimension Line / Piece Code

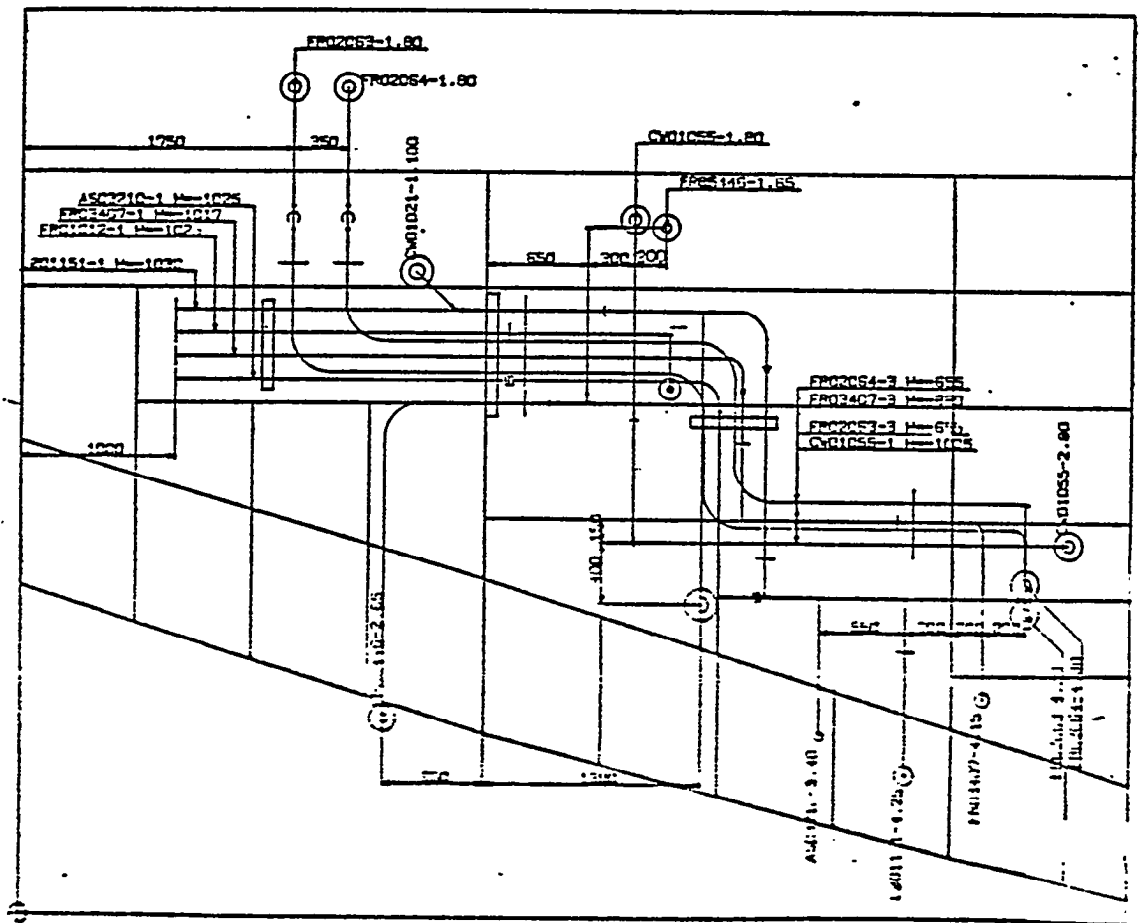


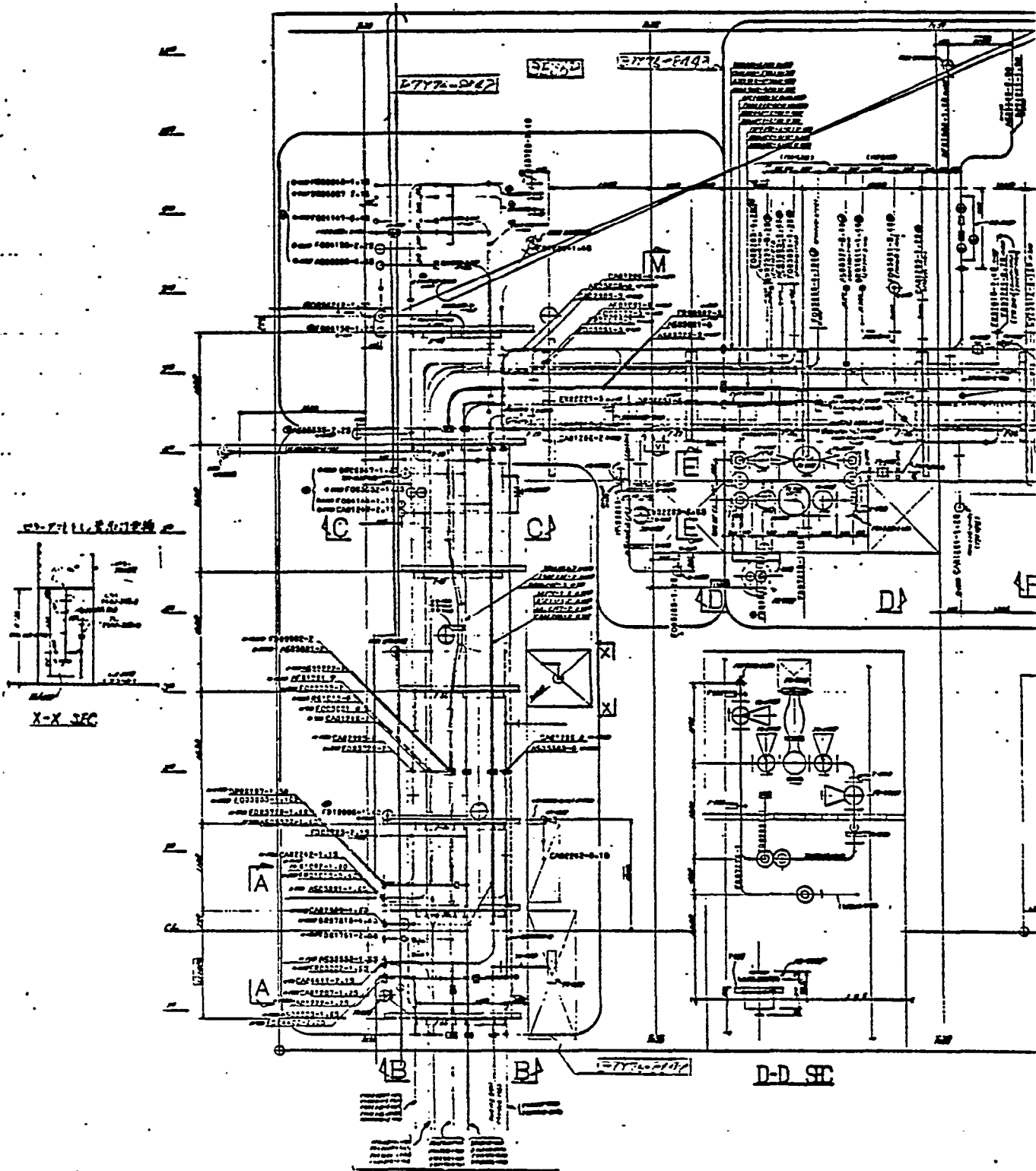
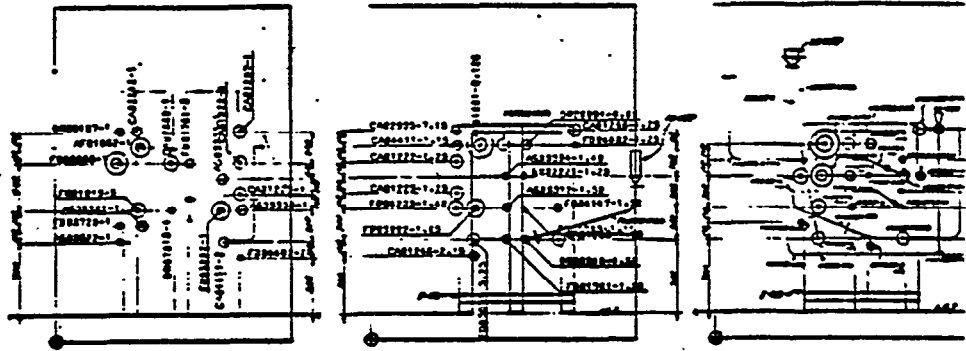
Fig. 3.5

A-A SEC

3-A SEC

C-C SEC

Output Drawing
(Partial)



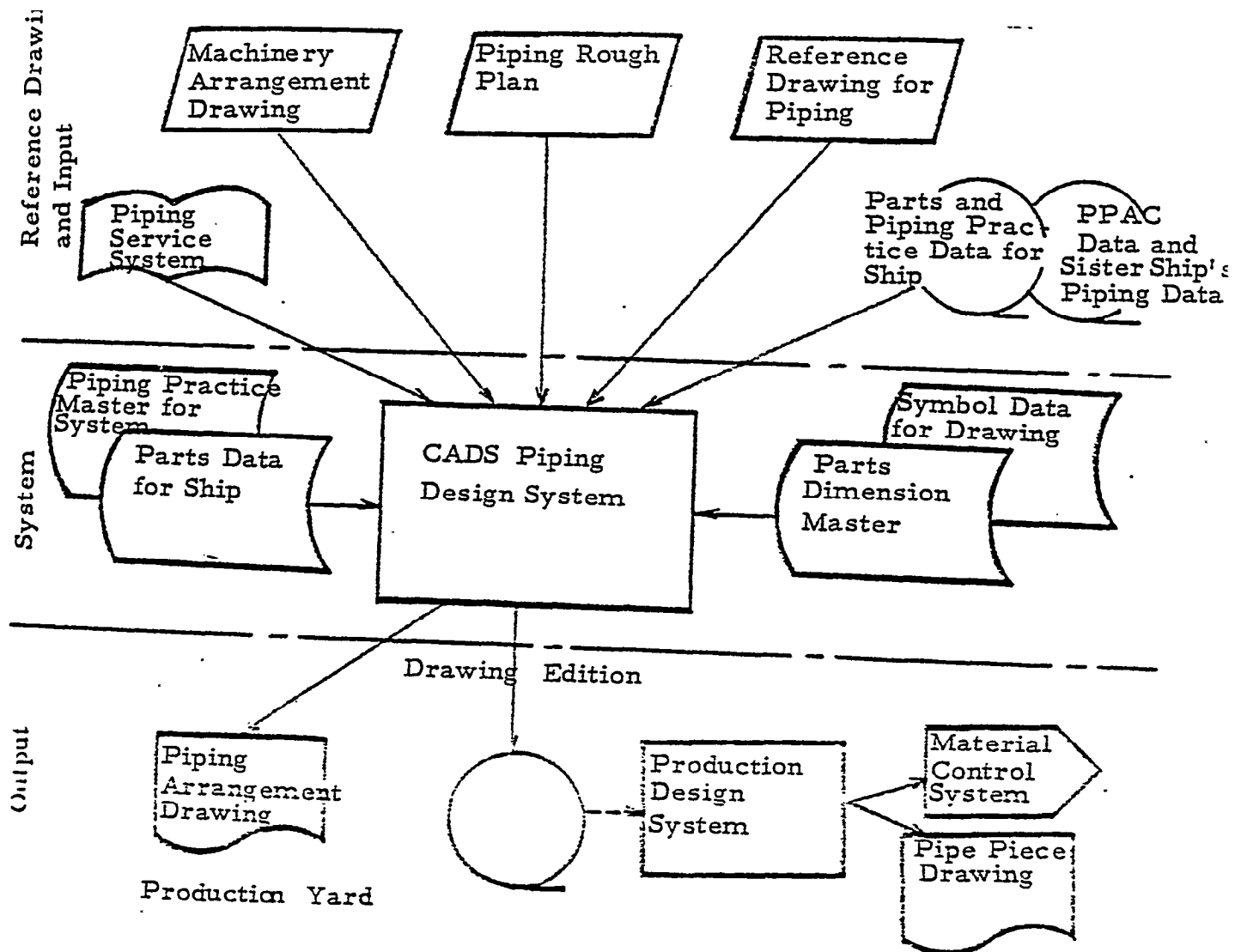


Fig. 5.1 CADS Operation

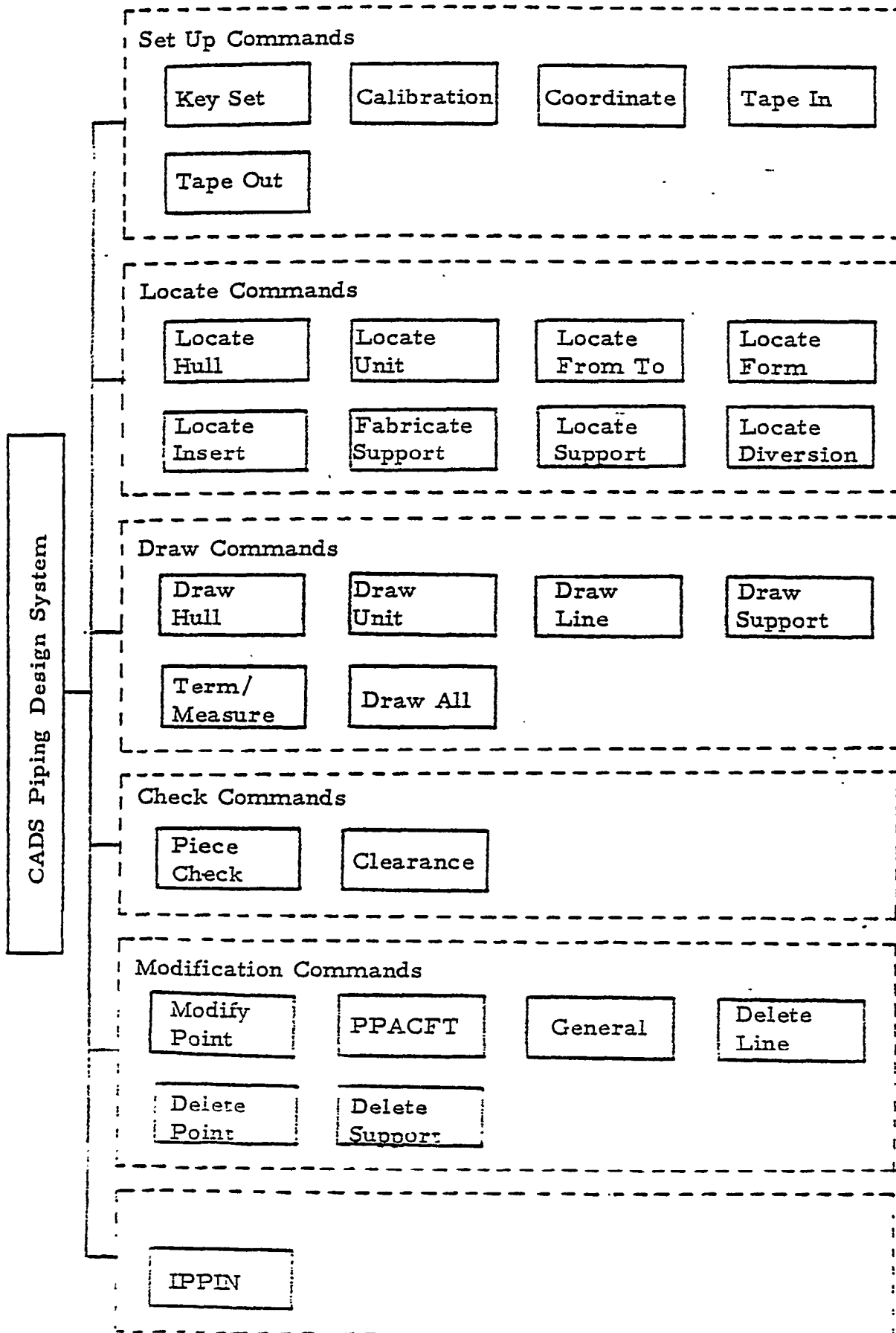


Fig. 5.2

5.2 Function of Commands

5.2.1 Set up Commands Start

- 1) To set initial values in the system.
- 2) To set initial values in data files.
- 3) To input particulars of piping arrangements such as Ship No., Drawing No., Zone, etc.

Coordinate

To define coordinates and their boundaries to be work out on AD table.

Tape In

To read data from the magnet tape and set the data on the file.

Data in the file are pipe data and master data.

Tape Out

To write data on the magnet tape for data transmission to host computer.

Data in the magnet tape are pipe data and master data.

5.2.2 Locate Commands

Locate Unit

- 1) To generate unit data to be stowed in unit standard file.
- 2) To locate unit data derived from unit standard file.
- 3) To alter unit data in deviated points from standard arrangement.

Locate From-To

To input data of systems and to locate pipe endpoints in piping arrangement.

Input data:

- (1) System names
- (2) Pipe end points by coordinates (X. Y. Z.)
- (3) Diameter
- (4) Pipe piece or fitting name
- (5) Others

Locate Form

To locate bedding points on the line of the pipe end points through "Locate From-To" command.

Locate Insert

To set parts on the pipe line determined through "Form Command"

Locate Diversion

To set the new pipe line on the designated position by using the piping data defined previously.

Locate Support

- 1) To set pipe supports on the pipe line
- 2) To determine the position of U-bolt for pipe on the pipe supports.

Fabricate Support

To design pipe support combining basic pattern of support.

Locate Hull

To define hull structure such as frame, longitudinal and deck as a background drawing.

5.2.3 Draw Commands

Draw Hull

To make a hull structure drawing by data given by “Locate Hull” for checking.

Draw Unit

- 1) To draw unit data derived from unit standard file.
- 2) To draw only the end points of the pipe line by data given by “Locate From-To” for checking.

Draw Line

To draw the pipe line by data given by “Locate Form” for checking.

To draw letters and leaders belonging to the pipe.

Draw Support

To draw pipe support by data given by “Plural Support” for checking.

To draw letters and leaders belonging to the pipe support.

Term/Measure

To draw the following marks on the designated positions.

- Pipe Number
- Pipe **Piece** Number
- Pipe Fittings Number
- Pipe Support Number
- Pipe Size

To draw letters and leaders on the designated position.

To draw comments on the designated position.

Draw All

To make a final piping arrangement drawing by input data given in previous stage.

5.2.4 Check Commands

Piece Check

To carry out piece dividing of the line and to check the length between two points in the unit of system.

Items to be checked are shown as follows.

- condition of piece fabrication
- condition of Pipe Piece Program
- direct welding
- length of short pipe, etc.

Clearance

To check the clearance between designated two pipes.

5.2.5 Modification Commands

Modify Point

- (1) To modify entities of fittings.
- (2) To modify all of the coordinates or diameters of the pipe.

PPACFT

- (1) To edit pipe data prepared by PPAC.
- (2) To separate one pipe lines into plural pipe line

General

To delete and modify co-ordinates.

To delete hull structure, letters, leaders and comments.

Delete Line

to delete pipe data for each system or between designated two points on the piping route.

Delete Point

To delete a designated point of the pipe piece.

Delete Support

To delete pipe support data in the unit of system or piece.

5.2.6 Fabrication and Outfitting Data

IPPIN

To prepare data for pipe fabrication such as:

- Pipe piece Number
- MLF No. and/or MLC No.
- unit sign
- Loose sign, etc.

APPENDIX H

IHI REPORT ON COMPUTER-AIDED DESIGN SYSTEM

K2123

TASK 2 ENGINEERING AND DESIGN

SUB-TASK 2.1 COMPUTER-AIDED DESIGN SYSTEMS

1. Examine and Study the SPADES System
2. IHI System
3. Comparison of the Capability between
Levingston's SPADES System and IHI System

March, 1979

Prepared by: Masumi Hatake
 IHI MARINE TECHNOLOGY, INC.

1.0. Examine and Study the SPADES System

The SPADES system of computer -- aided ship design has been examined and studied by IHI to determine if full utilization and benefit is being realized from the use of the system at the Levingston Shipbuilding Company. The study has been proceeded from November, 1978 through February, 1979 at the Engineering Office and the NC Department of Levingston. This report involves "Over View", "SPADES Modules" and "The Usage of the System at Levingston".

1.1. Over View

1) General

The SPADES system can be seen enough to cover almost over all from the design engineering to NC lofting and preparation for production in its function. Its capability shall be evaluated adequate to support many users which build various shapes and sizes of ships. In fact, it has been used by many shipyards in the U.S.A.

Moreover SPADES has enough space and more applicable field to be developed in the future. Newly developed programs, DEMO and SPAC, will make it possible to expand the users operation.

2) The Usage of the SPADES System at Levingston

The Levingston Shipbuilding Company is not using all modules of the SPADES system. Indispensable modules for minimum NC lofting are now in use. From the view . point of usage, SPADES system shall not fully display its worth at Levingston. The main reason shall be in lack of a large drafting machine. FAIRING and ship's hull calculation must be trusted to the Cali and Associates and others. And many difficulties and uneffective matters due to the lack of drafter can be found. If the drafting machine is provided, a useful module of SPADES, DEMO, shall be easily installed to this shipyard. In this concern, more detailed description shall be presented in 1.3.

3) Some Problems Pointed Out by IHI

(3-1) The output for making a material cutting list:

1.1. Over View (Continued)

The output through the system is good enough for full support of NC burning machine. On the other hand, the output for hand marking and hand cutting shall be rather poor. A material cutting list for flat bars, angles, slabs and face plates shall be obliged to be prepared by hand through the results of parts generation.

(3-2) Stiffeners development on a web plate:

Concerning PARTS GENERATION, a web plate and the stiffeners on it, such as brackets, are separately defined. Most of stiffeners on a web have close relationship with it. If they are defined at a time, the output through PARTS GENERATION shall be automatically provided with the useful data such as:

Precisely marked starting and ending point of stiffeners in taking account of stiffeners plate thickness.

Marking the shifting direction of stiffeners plate thickness.

Drawing of stiffeners identification number on a web plate by drafting machine.

In this concern, more detailed study shall be continued later.

(3-3) Installation of the shipyard's standard data:

Some of the designing standard of a shipyard can be easily installed to the system with a few input. The standard of cutout is a good example. However it

1.1 Over View (Continued)

does not seem to be *easy*, at this moment, to install the standard data in the field of production such as a bevel angle for welding, excess at joints and detailed end shape of stiffeners.

Taking a bevel angle for welding between stiffeners and a web plate, as an example, this angle shall be decided by the intersection angle between them. It shall be troublesome work to input the bevel angle by referring the manual of bevel angles as the key data of the intersection angle or referring working drawing. If the process can be treated by the system, it shall be more helpful for the users.

But this problem shall be resolved when the most of shipyards in the U.S.A. establish their own standard. The urgent theme shall be to set up the scheme of the said standard in Livingston.

(3-4) Problem concerning a curved shell unit:

The output for plate assembly from the PIN/JIG module might be inadequate. Dimensions for checking the shape of a curved shell unit, such as girth length at both end seam and end butt and diagonal length of a unit, are necessary as well as positioning data for the corner points of the unit and height dimension. at each pin/jig position.

However this problem has a close relationship with the fabrication method of a curved shell unit. Therefore it shall be prior theme to establish the fabrication method for a curved shell unit from gas cutting, bending, plate assembly and fitting frames and fitting web frames.

In this concern, more detailed description shall be presented in 1.2.

1.2. SPADES Modules

The following modules have been studied by IHI:

FAIRING
HULLCAL*
HULLOAD
PARTGEN
NESTING
PLATDV
ROLL SET TEMPLATE*
FRAME BENDING
PIN/JIG*
DEMO*
SPAC*

Study has been extended to the modules which have not been installed to Levingston. (* Marked Module) Because it seemed to be necessary to evaluate the SPADES system correctly.

Any comments from Levingston shall be most appreciated.

FAIRING

The Levingston Shipyard indirectly uses the FAIRING Program, because a large drafting machine to draw the faired frame lines is not provided. The Cali & Associates, Inc. calculates for Levingston and drawings as output and data to be stored on the SPADES Data Base are sent back to Levingston.

Lines fairing by computer has been one of the most basic matters for every shipyard in the world since a computer was first applied to Naval architecture. Because almost all of primary technology necessary for digitizing are involved in lines fairing. Smoothing, curve fitting, interpolation is a good example. Without these technology, NC (Numerical Control) and development of pieces of ship's hull, such as a curved shell plate, a curved frame and even an internal structure might not have been performed. Moreover from the view points of manhour saving, keeping high accuracy and scarce skilled loft man, lines fairing shall be a most essential theme.

It seems to be very hard to have a perfect fairing program for every kind of ship's hull. The ship's hull form is usually designed to fulfill the ship's purpose and ship's performance, so that the shape is varied very widely. Initial trim, skeg, bulb, notch, sonar dome and appendage are not *easy* to handle. Therefore, lines fairing program should be provided with the function of how to combine the said complex parts to the ordinary surface.

The FAIRING Program of SPADES system has been observed to be well-designed. The principles of analysis and processing are very clear to understand for designers and loft men, and very reasonable. For example, curve fitting method of the program is very similar to

FAIRING (Continued)

the one of fairing by hand. The other outstanding function is to recognize the characteristics of curvature and point; such as straight, knuckle, tangency, a large radius curve and a small radius curve.

The Fairing Program has been serving to not only Levingston but also many other shipyards in the U.S.A., which build many kinds of ships. From this fact, the program is to have adequate flexibility to the variation of ship's hull form.

HULLCAL

The Levingston Shipbuilding Company does not use the HULLCAL program. SHCP (Ship Hull Characteristics Program) developed by the U.S. Navy is now in *use* at Levingston. Therefore, it is not possible to report the usage of the HULLCAL program in practice.

However, a brief comment on the HULLCAL program can be presented through the reference of its user's manual. The following calculations can be performed by the HULLCAL program.

- Curves of Form and Hydrostatics
- . Bonjean Curves of Stability
- . Floodable Length Curves
- . Tank Capacities and Sounding/Ullage Tables
- . Prim calculations
- . Damage Stability
- . Longitudinal Strength
- . End Launching Calculations

Tables of the results are printed out. Drawings by the N/C drafting machine of the results can also be generated as an option.

Levingston has a problem to be solved in launching calculation: Side launching is obliged at Levingston, however, there is no suitable calculation computer program.

In addition, it seems to be useful if information and data necessary for ship's operation and test trials before ship's delivery, such as, Turning Test and Crash Stop Astern/Ahead Test, are performed.

HULLLOAD

The HULLLOAD program is a module to generate descriptions of hull structures and related design data by utilizing the hull definition and frame contours, generated and stored by the FAIRING program or obtained as data in other forms.

These descriptions are permanently stored on the SPADES Data Base, which can be retrieved by other SPADES modules.

The following structures and hull geometry can be generated and stored by the HULLLOAD program.

Additional Frames and Canted Frames
at an angle to the centerplane

- . Breasthooks
- . Decks of any shape, defined by sheer and camber contours
- . Deck Longitudinal and Seams
- . Shell Longitudinals and Sight Edges
- . Longitudinal Bulkheads
- . Cut-Out Requirements
- . Bulkhead Stiffeners and Seams

The HULLLOAD program is provided with sufficient, capability to generate hull structures and hull geometry necessary for succeeding design works. The high availability of the program can be supposed from the feature of generating CANTED FRAMES and BREASTHOOKS which requests an interpolating technique of high grade. Input data of the program is not so much and re-input due to design change is also easily performed.

PARTGEN (Parts Generation)

PART GENERATION is a program primarily designed to allow the lofting of all flat plate parts needed in the hull of ship. A limited amount of developed parts such as cambered deck can also be generated.

The output of the program consists of one or more of the following:

- . Storage of the individual part or burning tape into data base
- . Nesting information for use with the nesting program
- . Paper tape for the drafting machine
- . Calculation list for making a material cutting list by hand

PARTGEN program shall be considered good enough in its function which should satisfy the needs from NC lofting. The adequate function to define element surfaces of parts; such as points, straight lines, circles and curves; and to define contours, holes, cut-outs and stiffener's location are provided. In addition, the function to retrieve the description of ship's hull previously loaded and the function to calculate geometrical matters used for defining parts and for making a material cutting list.

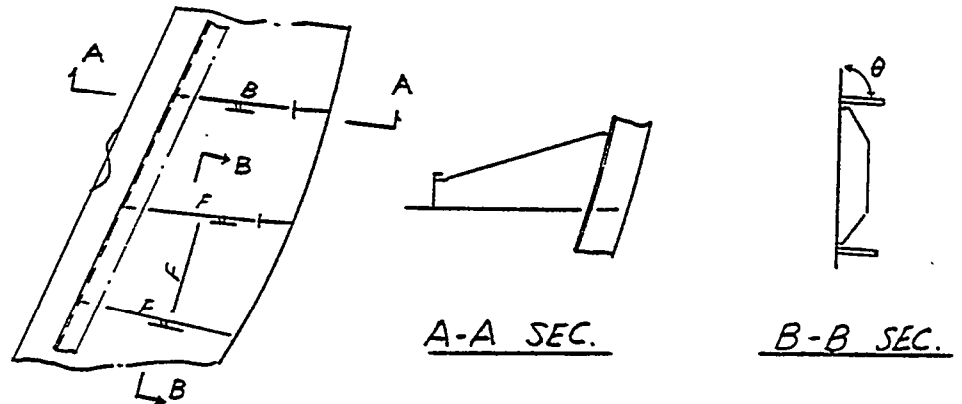
However, the following can be pointed out by IHI for future betterment.

1) Defination of Stiffeners on a Web:

A web plate and the stiffeners on it such as brackets are separately defined by this program even if most of stiffeners on a web have close relationship with it. The stiffeners also correlate each other.

PARTGEN (Parts Generation) (Continued)

This may be very clear by the following figures:



If they can be described at a time, following merits shall be expected.

- . Input for parts generation of stiffeners can be saved.
- . Output for all parts of the sub-unit can be generated at a time.
- . Marking line for stiffeners can be precisely drawn in taking account of plate thickness.
- . The shifting direction of stiffener's plate thickness can be drawn automatically.

Stiffener's identification number (piece mark) on a web plate can be automatically drawn by a drafter.

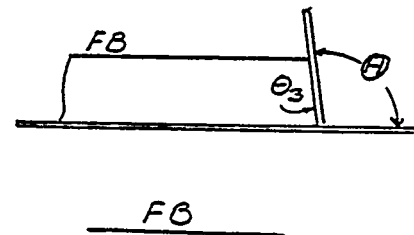
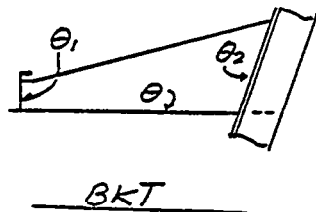
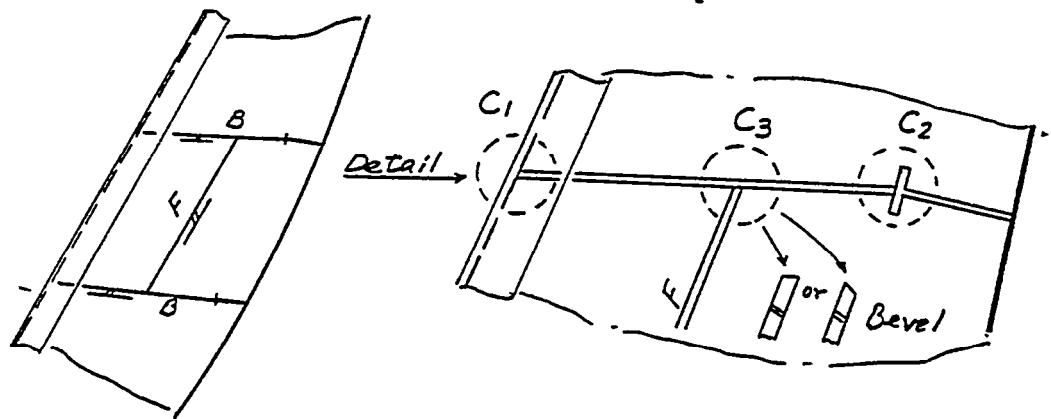
2) Output for a Material Cutting List

Necessary information and data are generated by PARTGEN and printed out to make a material cutting list for flat bars, T-bars and face plates. Comparing with the function for full support of NC burning machine, this output seems to be rather poor. If some features for automatically drawing a material cutting list are added, the output shall become a finished material cutting list.

PARTGEN (Parts Generation) (Continued)3) Installation Shipyard's Standard

Some of the designing standard, such as shape of bracket, end cut of frame and cutout are easily installed by the system. (HULLOAD and PARTGEN) However, it does not seem to be easy at this moment to install the production standard, such as a bevel angle for welding and excess at joint.

Taking a bevel angle for welding at a bracket on a web, as an example, this angle shall be decided by the intersection angle with the correlating structures. Refer to the following figures.



PARTGEN (Parts Generation) (Continued)

Bevel angles θ , θ_1 , θ_2 and θ_3 shall be decided from θ and from the intersection angles at C_1 , C_2 and C_3 respectively. Though these intersection angles can be calculated and printed out by PARTGEN, the actual bevel angles (θ , θ_1 , θ_2 , θ_3) will have to be decided by user. In addition, it seems to be important to remind that the precise length and the precise location of the stiffeners can be finalized through this process.

If these standards or schemes are established and treated by the system, users can be released from this troublesome works.

NESTING

The NESTING Program defines location (in the plate) and alteration of pieces, center punching, inner hole and outer contour. Finally the program generates a paper tape for a NC burning machine. This program is provided with almost all necessary functions, such as Piercing, Common cut, Automatic center punching sequence and Bridging, except Bevel cutting.

For bevel cutting, a programmer codes in NC tape to stop the machine at both start and end point of a surface with bevel. Then a machine operator sets the bevel angle of the cutting torch by hand. This work seems to be inconvenient for operators because they might have no information on the direction where the machine goes ahead. It shall be recommendable to have automatic cutting of bevel, however, it may be complicated to be provided with the function of automatic bevel cutting which can be of great help for saving time and precise cutting.

In this concern, more detailed description shall be presented in another report "Numerical Control Steel Fabrication".

PLATDV

The PLATDV program is a module to develop *three* dimensional surface into flat plate, commonly used for shell plate development, for cold roll process.

The methods used in the program are triangulation and girth length. There can be seen some problems in accuracy at the surface with large curvature as described in the user's manual. Though it is not very clear that the said inaccuracy is caused by the developing method itself or by cold roll process, there may be problems in the both.

Concerning the developing method itself, the following shall be considered to be the cause of inaccuracy:

- 1) The girth length is calculated from the arc length of the circular arc to be defined with three space points. In case of "S-curved" surface and sparse arrangement of space points, the girth length of the circle shall differ from the *true* length.
- 2) Error shall be accumulated during repetition of development from the starting part to the final part of plate by the triangulation method. This tendency shall become conspicuous as the length of plate is longer and as the curvature is larger.
- 3) Function to correct the error during cold roll process is not provided. Generally the plate is known to be stretched by cold roll. This margin should be considered.

As described at 'FAIRING', SPADES provides a good interpolation algorithm. If this algorithm is fully applied to approximate and interpolate the curved surface, the result shall be much amended.

ROLL SET TEMPLATE (Manufacturing Aids)

For lack of a large drafting machine, the ROLL SET TEMPLATE program is not now in use at Levingston. So that the templates are obliged to be made manually by loft men.

A brief comment on the ROLL SET TEMPLATE program can be presented through hearing from Levingston's personnel who used to utilize the program.

A number of templates at frames including two extremes can be provided by the program. In *case* that the plate to be bent has a double curvature or a tight curvature lengthwise, other templates at longitudinal frames and/or water lines shall be prepared by hand referring output lists through the other programs of Manufacturing Aids.

It seems to be troublesome a little for loft men to judge the curvature of plate and to handle those programs. It may be more applicable if the ROLL SET TEMPLATE program handle the said conditions by itself.

FRAME BENDING

The FRAME BENDING Program generates the information required for bending longitudinal and transverse frame and produce templates for the end cuts of the beams. The output can be in one or more of several different forms:

- Full size/reduced scale templates or drawings of the true curvature or the inverse curvature.
- . Tabulated offsets of the inverse or true curvature at specified increments along the chord of the beam.
- . Full size templates for the end cuts of the beam.

Using these output, the following works can be performed:

- . Marking full size templates by hand.
- . Preparation for conjunction with a frame bending machine.
- . Checking after bending by a previously marked inverse curve.

Concerning this subject, it might be meaningful to note that bending performed by the FRAME BENDING is limited to two-dimensional curvature. On the other hand, IHI system allows to bend three-dimensional curvature (space curvature or twisted curvature). The difference might come from the one of bending practice and design practice between U.S. shipyard and Japanese shipyard.

PINJIG

The PINJIG Program has never been used by Livingston, because assembly on pin/jig has not been applied. Through the study by the users manual, following problems could be found.

Positioning data for the corner points of the unit and height dimension at each pin/jig position shall be fulfilled with output through the PINJIG Program. However, more information shall be required for assembly such as:

- . Girth length at both end seams and end butt.
- . Diagonal length of a unit to check the shape of a unit.
- . Fitting angle of internal structures (such as web frames, girders and longitudinal/transverse frames) to shell plate.

This information may be calculated by the program "Manufacturing Aids". It shall be recommendable that the system is provided with the function to totalize the output from the PINJIG Program and the output of the said additional data which may be calculated by the modules of Manufacturing Aids.

DEMO (Engineering Detailing Module)

1) The Levingston Shipbuilding Company has not yet installed 'DEMO', which was a newly developed module to utilize the time and effort spent during the detail design phase for numerical description of the ship structure. Therefore, it is not possible to report the usage of 'DEMO' in practice.

However, it seems to be necessary to report on the new module DEMO. Because DEMO is one of the representative modules to evaluate the functions of the SPADES system, especially to evaluate its- future development.

A study by the preliminary description of DEMO module has been done and a few comments are presented as below.

2) The characteristics and purpose of the DEMO modules are as follows:

a) Visual checking of the previous loaded data base increases and the data base becomes more comprehensive, verification of loaded data becomes more and more difficult. By checking the data loaded on the data base with drawings performed through this module, the possibility of errors downstream during part generation can be greatly reduced.

b) An efficient tool for detailing:

All through members affecting other surfaces must be handled by 'HULLOAD'. On the other hand, local details will be-defined by 'DEMO'. Details

DEMO (Engineering Detailing Module) (Continued)

are defined as follows:

. Stiffeners:

Symbolic Name
Contour Definition
Shape Code Number
Orientation (near side or far side)

. Seams:

Symbolic Name
Contour Definition
Welding Detail (bevel and gap)
Thickness on both sides

. Holes:

Symbolic Name
Contour Definition
Thickness, Width and Offset of Face Bar

. Brackets:

Symbolic Name
Contour Definition or Standard
Detail Identification
Thickness
Width and Thickness of Flange

. Inner Lines:

Contour Definition
Width and Thickness of Face Bar

c) Saving manhour input for part programming:

Using the function of parts separation of part generation to the detailed designed structures by DEMO, manhour input for part programming will be greatly reduced.

Programming capabilities and language *are* designed as close to 'PARTGEN' *as possible*, and all 'PARTGEN' tools, such as Math, Contours, Symbolic Calls, Loops and Reps will be available.

DEMO (Engineering Detailing Module) (Continued)

- d) As a result of design work performed by 'DEMO' associated with 'HULLLOAD', structural drawings can be completed with the exception of lettering and dimensioning.
- 3) IHICS (Integrated Hull Information Control System) of IHI involves the close function of 'DEMO' and 'HULLLOAD'. There can be found close similarity on the purpose and aim between the SPADES system and IHI system, even if detailed approaching methods are different from each other.
- 4) Before installation of 'DEMO' for Levingston, some of the preparation should be requested.

a) A large drafting machine should be necessary.

One of the main purposes of 'DEMO' is on verifying drawings. In order to make 'DEMO' useful, a large drafting machine will have to be used.

b) Preparation on Levingston's design standard:

In order to use 'DEMO' in full worth, design standards will have to be reviewed though some of them have been established.

Design standards are as follows:

- . Symbolic Name of Stiffeners, Seams, Holes and Brackets.
- . Contour (shape) of Stiffeners and Brackets.
- . Welding
- . End Connections of Stiffeners (lap, snipes, knuckles)
- . Drawing standard

These standards should be arranged for easy application to 'DEMO'.

DEMO (Engineering Detailing Module) (Continued)

5) Future scope of 'DEMO':

It seems to be meaningful to try thinking of the future scope of 'DEMO'. As mentioned in 'Over View' of this paper, the SPADES system has enough space to be developed in the future.

'DEMO' and 'SPAC' (Ship Production and Control Module) shall be nucleus for the future development of the SPADES System. From the viewpoint of computer technology, there can be found interesting matters around the said modules. Technology of cathode ray display is one of them.

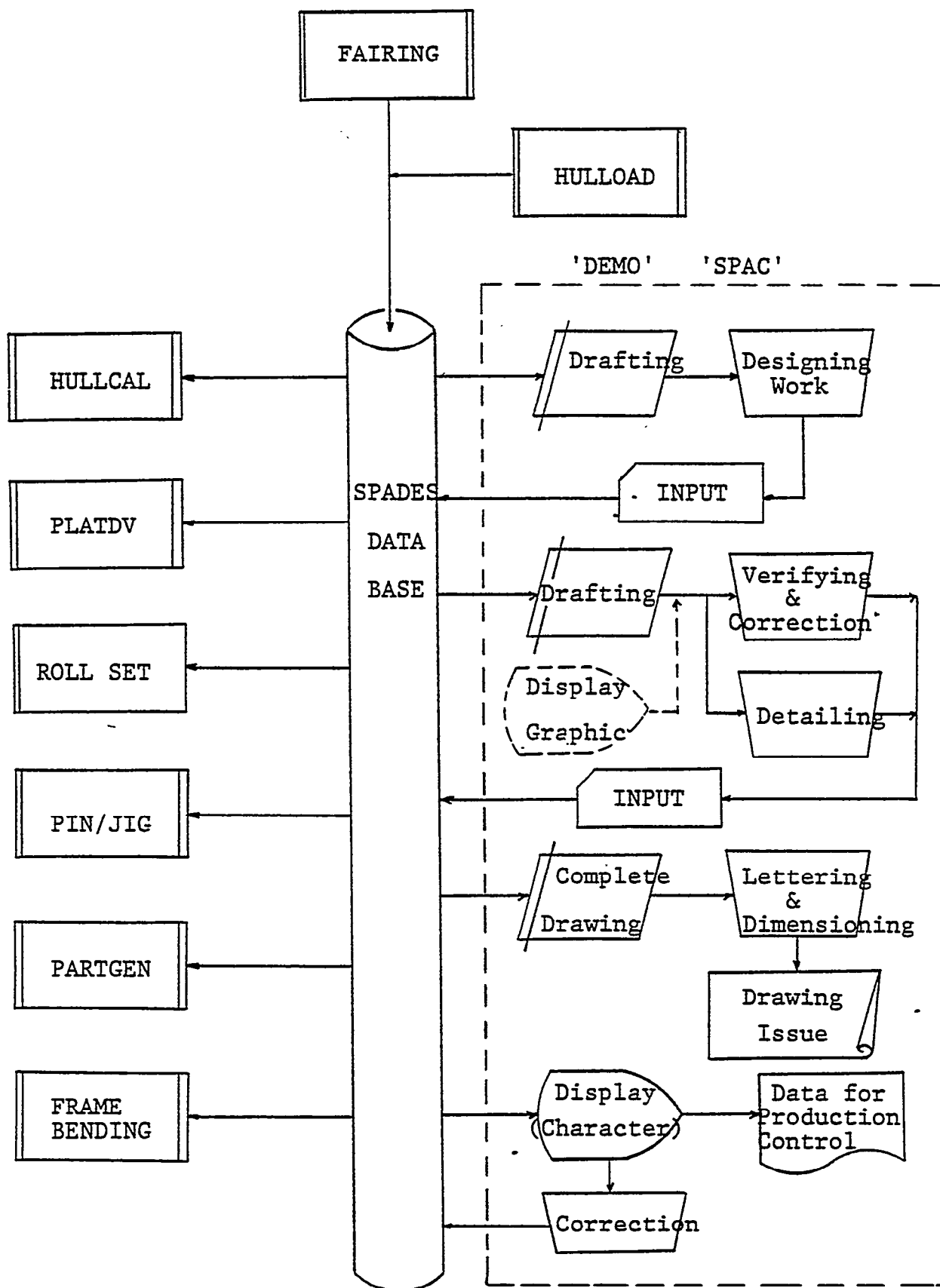
Quick verification of data on the Data Base, detailing by 'DEMO' and correction can be easily performed by a character display or a graphic display. After checking the data, drawings shall be completed by a large drafting machine. This process shall be of great help for reducing the turnaround time. A sample work flow on this matter is displayed as follows:

It does not seem difficult to attach these features to the SPADES System. However, the development will have to proceed in taking account of the cost to be required for users.

Though the future scope of 'DEMO' can be expanded to the said advanced computer technology, the recommended future scope at Livingston shall be to install 'DEMO'. associated with a large drafting machine and without the cathode ray tube technology.

DEMO (Engineering Detailing Module) (Continued)A Sample Work Flow with Advanced 'DEMO' and 'SPAC'

(Future Scope)



SPAC (Ship Production and Control Module)

The Livingston Shipbuilding Company has not yet installed 'SPAC' which *was* a newly developed module to utilize the data needed to generate the required reports for production. Therefore, it is not possible to report the usage of 'SPAC' in practice.

By preliminary description of 'SPAC', the following functions shall be provided to 'SPAC' as listed below.

- Unit weight of pieces and weight and centers of gravity of assemblies and sub-assemblies.

- Length and nesting within standard lengths of shapes of the various individual shaped pieces.

- Cross reference between assemblies due to the nesting into a plate of pieces belonging to different assemblies.

- Processing time for N/C burning tapes and flame planer sketches.

- Bulk material allocation for pieces produced through shearing or 'one-to-one' optical burning.

- Revision control is maintained by the system for all the issued reports generated, and many others.

IHI System involves such kinds of modules in use

as:

- Piece list issuing program for sub-assembly, assembly and erection.

- Piece mark, number of pieces, weight, shape of piece (including material dimension) are involved.

SPAC (Ship Production and Control Module) (Continued)

Material control program and others.

Through IHI's experience, the function of 'SPAC' as a necessity is easily understood, especially the function of piece list issue required at Levingston. However, these matters shall request for user shipyards to make more clear their method for administration of their organization from engineering through production. Therefore, it might be prior matter to establish clearly their production process and material flow to install 'SPAC'.

1.3. The Usage of the SPADES System at Levingston

1) The modules of the SPADES System to be used at Levingston are shown in the following table:

MODULE \ ITEM	USAGE	REMARKS
HULLCAL	Unused	SHCP (Ship Hull Characteristics Program) developed by U.S. Navy is now in use.
FAIRING	Used Indirectly	For lack of a drafting machine, Cali & Associates Inc. calculates for Levingston.
HULLLOAD	Used	Checking by a small plotter
PARTGEN	Used	Ditto
NESTING	Used	Ditto
PLATDV	Used	Ditto
ROLL SET	Unused	Making templates by loftmen
FRAME BENDING	Used Partially	Bending list only to be calculated
PINJIG	Unused	Plate assembly on PINJIG is not performed.
DEMO	Unused	Not yet installed
SPAC	Unused	Not yet installed

1.3. The Usage of the SPADES System at Levingston (Continued)

As shown above, only five modules of the SPADES System are now in use and another one is partially used. As for HULLCAL module and module, concerning fabricating a curved shell unit, there can be seen clear problems as follows. For the others, a totalized study shall be required. In this concern, a detailed study and recommendation shall be presented later.

1.3. The Usage of the SPADES System at Levingston (Continued)

2) For HULLCAL module, following problems have been pointed out by the user engineer at Levingston. Therefore SHCP (Ship Hull Characteristics Program) developed by U.S. Navy is now in use instead of 'HULLCAL' of SPADES.

(2-1) Problems pointed out at Levingston:

- . The program of Damage Stability Calculations cannot be sunk below the Margin Line in damage at 0 heel. The Margin Line cannot be made above the uppermost deck in the present version at Levingston.
- . Documentation does not always agree with the User's Manual.

(2-2) Additional problem at Levingston:

- . Side Launching is obliged at Levingston, however, there is no suitable launching calculation program neither in SPADES nor SHCP.

(2-3) Information and data necessary for ship's operation and test trials before ship's delivery:

- . It seems to be useful if the said information, such as Turning Test and Crash Stop Astern/Ahead Test are performed by

3) PLATDV, ROLL SET, FRAME BENDING, PINJIG:

These are the modules for fabricating a curved shell unit. PLATDV is only in full use and FRAME BENDING is partially used. The others are not in use. The usage of these modules seems to be unbalanced. Lack of a large drafting machine shall be the cause. However, it might be possible to make a template for bending a curved plate or a curved frame through the output of 'ROLL SET' or 'FRAME BENDING'.

PLATDV, ROLL SET, FRAME BENDING, PINJIG (Continued)

As far 'PINJIG', fabrication method for a curved shell unit is the primary theme. Levingston has not decided to adopt the assembling method of 'PINJIG'. One of the biggest differences in constructing technology between Levingston and IHI lies in this method. This theme shall be studied through the Technical Transfer Program.

4) Total View on the Problems Facing at Present and in Future

The urgent themes to be studied at Levingston are as follows:

- . Working drawings to be issued as fast as possible with a suitable advance for study on fabrication method by production people.
- . Easy and quick follow-up to design change caused by the Owner's opinion, claims from the classification society and convenience of production method.
- . Manpower saving both at the Engineering office and Lofting.
- . Error caused by mis-input to the SPADES modules to be minimized for the smooth operation of the system and for preventing the production process from confusion due to errors.
- . Consideration for scarcity of skilled loftmen.

The following are supposed to be concrete problems and difficulties to realize the said themes.

4) Total view on the problems facing at present and in future. (Continued)

(4-1) LINES FAIRING must be trusted in Cali & Associates, INC., so that TAT (Turn Around Time) of it gets longer and money is lost. FAIRING IS the most fundamental for quick start of every designing work. If the work can be performed by Levingston itself, the faired lines shall be brought more quickly in low cost.

(4-2) Visual checking is not so easy. Results of 'HULLLOAD', 'PARTGEN' and 'NESTING' are obliged to be checked with small scaled drawings. This might cause some errors and inaccuracy.

(4-3) Duplicated works can be seen between the Engineering office and Mold Lofting.

Most of manhours are spent for making working drawings at the hull section of the Engineering office. The working drawing might be beautiful enough to express the ship's structure. The most detailed dimensions and all necessary information are involved in the drawings. Piece mark system, plate thickness shifting direction of stiffeners, cutouts, end cut of stiffeners and welding information are described. They are drawn by hand, as if drawn by a drafting machine.

On the other hand, input for 'HULLLOAD' is simultaneously prepared at the Engineering office for the succeeding jobs. Then the input will have to be verified by drawing with a small plotter for only visual checking.

4) Total view on the problems facing at present and in future. (Continued)

If the input for 'HULLLOAD' precedes and drawings are drawn by a drafting machine with a suitable scale., the drawings can be utilized as the base drawings from which more detailed design can be performed as well as checking drawing for input.

In addition, in N/C lofting at present, lettering and dimensioning will have to be obliged to be performed by hand referring the working drawings. This duplicated work is being performed in a small scaled drawing.

(4-4) Manual lofting in full scale still remains at pretty range.

In order to make a template for bending, a full scaled line is being drawn. This work can be performed by the computer system and by the sealed' lines. From the viewpoint of scarcity of skilled loftsmen, this kind of work might be replaced by the computer system as much as possible.

5) Some recommendations from IHI for the better usage of the SPADES system at Levingston:

Through IHI's study on the SPADES system used at Levingston, concrete problems described in the previous paragraph remain. What is needed at Levingston at this moment to solve the said problems shall be to make full use of the SPADES system. For each module of the SPADES system, IHI's recommendations have already been described in 1.2. The following are the additional recommendations from IHI.

5) Some recommendations from IHI for the better usage of the SPADES system at Livingston (Continued)

(5-1) To install a N/C Directed Drafting Machine for the Engineering and the Loft:

A small plotter has been provided for the loft. However, it cannot satisfy the need from Engineering and Lofting as aforementioned at 1.3-4. By utilizing a N/C Drafting machine, these problems can be fairly proved.

The requested drafting machine shall have a 70" x 150' effective drafting area and its cost is estimated to be \$100,000-\$150,000. Installation of a N/C Drafting machine makes it easy to install 'DEMO', which shall contribute to the betterment described already, such as:

- . Fast issue of working drawing
- . Easy and quick follow-up to design change
- . Exclusion of duplicated works
- . Manpower saving

(5-2) To confirm data flow from the Engineering office, including lofting through production:

In order to realize the said urgent theme, the actual data flow extended from Engineering Office through Production field, which is now getting clear, shall be expected to be confirmed. This confirmation and selection of IHI's recommendation described in this paper (1.2, 1.3) are requested to be proceeded simultaneously.

2.0. IHI System

The Computer-Aided Hull Design System of IHI covers almost over all of hull design field from the initial design, detailed design through production engineering.

IHI system consists of six (6) independent main systems, which support their particular functions. Some of them are designed to communicate with the other systems through their data base to keep a coincidence of common data between them and to save input. Main systems are as follows:

ZPLATE, ZVIBRA

Structural Analysis

SPECS

Ship's Hull Calculation

Operational Information Calculation

FAIRING

Lines Fairing

SHELL

Shell Plate Development

Template for Bending

Assembly Unit Marking on PIN/JIG

Supporting Jig Height Dimension

LODACS

Longitudinal/Transverse Frame Development

Template for Bending

IHICS

Ship's Hull Description

Section Design

Parts Generation

NC Lofting (NC Drawing, NC Burning Machine)

Parts List Issue

Data Communication by Display Terminal

2.0 IHI System (Continued)

Since many of documents concerning this subject have been already submitted to Livingston, only special characteristics of the said systems shall be presented here. The following are the documents to have been submitted.

(Through our Memo Ref. No. FPC-073 dated February 23, 1979)

1. Brief Explanation of IHICS
2. IHICS - Actual Input/Output Examples
3. Summary of IHI SHELL
4. LODACS - Ship Frame Data Processing System
5. SPECS - Ship's Preliminary and Exact Calculation System
6. SPECS - Actual Output Example

(Through our Memo Ref. No, FPC-046 dated January 18, 1979)

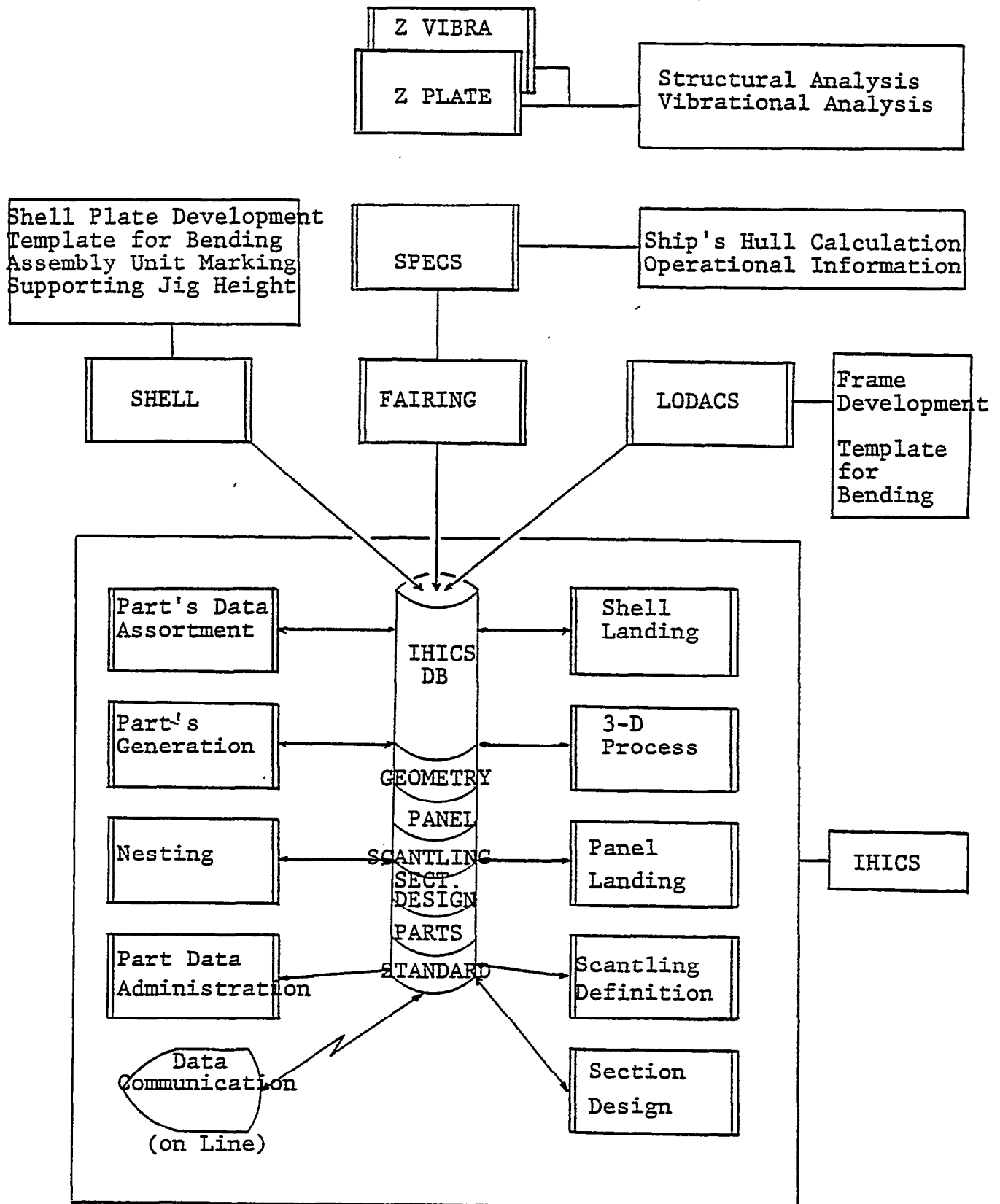
7. The User's Manual 'Z-Plate' Output Sample.

(Through our Memo Ref. No. FPC-029 dated December 20, 1978)

8. General Purpose Program of Plane Stress Analysis by Finite Element Method and Its Application (ZPLATE)
9. Matrix Method of Vibration Analysis of Framed Structure and Its Application

Relationship between the said systems and functions is presented in the following figure.

Shell Plate Development
Template for Bending
Assembly Unit Marking
Supporting Jig Height



2.1 Characteristics of Each System of IHI

Only special characteristics are described here. Other details are presented in the aforementioned documents. It is coherent in all systems that plenty of drawings can be generated through the systems and that designing know-how through IHI's long experience is concentrated in the systems.

2.1 Characteristics of Each System of IHI (Continued)

ZPLATE, ZVIBRA

ZPLATE is a program for analysis of elastic plate structures under plane stress conditions, and especially a program for three dimensional structure constructed with plates or orthotropic plates will be distinctively useful for analysis of ship hull structure. There exists many good programs covering this field in the world. However, labor to make input data for the given problem is generally too large to use in practice.

ZPLATE solved this problem by adopting a substructure method with the function of automatic mesh generation and with periodic identical pattern. In addition, this program includes also a check device of input data and adjustment of calculated results by using a high speed plotter and a graphic display.

ZVIBPA has been prepared for analysis of vibrational responses in elastic range of three-dimensional framed structures under sinusoidal forced vibration. Because the effects of shear rigidity and rotatory inertia are taken into consideration, this method is particularly effective in the analysis of structures such as the ship hull structures where the effects of those factors cannot be ignored. For vibrational analysis method of framed structures, a method in general use obtains natural frequencies in free vibration by replacing the structure to be analyzed with a structure made up of a multiple mass and spring system. However, in framed structures where shearing deformation and rotatory inertia are taken into consideration, it is extremely difficult to obtain natural values by the use of the above method;

In ZVIBRA, an assumption of the framed structures to be a conglomerate of beams, which have infinite degree of freedom, has been taken and then their stiffness matrices were obtained using such matrices, their vibrational responses were calculated, and as a result their vibrational modes and amplitudes were obtained.

2.1 Characteristics of Each System of IHI (Continued)SPECS

SPECS has been applied to detailed design in ship's hull preliminary calculation on Hull Form and its capacity. In addition, necessary information and data at ship's operation and at test trials before its delivery are also calculated. Almost all of the sub-programs of the system generate drawings and curves as well as tabular prints. The actual output examples can be referred to in "Actual Output Example of Ship's Preliminary and Exact Calculation System."

2.1 Characteristics of Each System of IHI (Continued)FAIRING

IHI FAIRING program performs Lines Fairing by adopting a newly developed interpolating method called 'N-Curve'. 'N-Curve', of which term stands on 'Natural Curve', can express straight line, true circle (arc) and a compound straight line with a knuckle point as well as 'natural curve'.

2.1 Characteristics of Each System of IHI (Continued)IHICS (Integrated Hull Information Control System)

IHICS is a series of program packages associated with the Data Base. IHICS serves for mainly describing ship's hull structure, section design, parts generation, NC lofting, NC burning machine and parts list issue. The special characteristics are as follows:

1) To be based on Data Base concept:

By excluding duplicate data, incoincidence of data is prevented and the space of the memory on Disk is much saved.

For easy maintenance of the systems and data, programs and data are independent from each other.

IMS (Information Management System) of IBM, Inc. has been adopted.

- 2) To generate sectional drawings at any location and at any phase of designing.
- 3) To generate a part program by the system itself (as well as manual coding).
- 4) To generate parts list for any stage of production (fabrication, sub-assembly, assembly and erection) at an early time.
- 5)- Parts generation with full information necessary for production (fitting angle, plate thickness shifting direction, bevel angle, piece mark and additional material).
- 6) Automatical reference of design standard and production standard:

Shape standard - cut out, scallop, bracket, stiffener end cut.

. Standard how to select/apply standards.

. Bevel and gap for welding.

IHICS (Integrated Hull Information Control System) (Cont.)

- 7) Register and revise of standard data.
- 8) Material cutting drawings (not lists) with full information necessary for marking.
- 9) Detailed working drawings for sub-assembly and assembly.
- 10) Consideration on design change (Refer to the attached paper).
- 11) Online capability -
Many online terminals are supported under the control of IMS/DB.DC.
- 12) Connection to Graphic Display.

Listed above are only a summary of the characteristics of IHICS. The more detailed description and actual output examples are presented in the submitted documents.

2.1 Characteristics of Each System of IHI (Continued)SHELL

The SHELL system constitutes an integrated and computerized data processing system which provides various highly accurated information pertaining to all the processes in production of a curved shell unit. The SHELL system covers shell plate development, making template for bending, unit marking on supporting jigs and jig height calculation. In addition, these calculations are performed under the common base which user planners can input the most suitable condition from the viewpoint of accuracy and workability in the production process. The standardization of production technologies and analysis of application know-how in the SHELL system has been established by mobilizing of the engineering power in IHI's five shipyards.

Special Characteristics of SHELL:

- 1) Shell system is a composite system for the geometrical calculation and data calculation and a data processing system relevant to the production of a curved shell unit.
- 2) Shell system displays a far higher level on accuracy as compared with the conventional system. The new ideas and method to be adopted for this matter are as follows:

- . In order to make calculating algorithm simple as well as in order to keep the high accuracy of the output, the lines are drawn by the concurrence of points approximated by a certain supplementary straight lines.

- . The optional cut-plane method is fully adopted. This is a method to develop a curved shell plate in the view that the characteristics of its curvature are displayed best.

- . The desired plate is cut out of a larger expanded plan including the surrounding area of the plate.

- . In order to ensure the accuracy at plate bending time, the templates are set up at the right angle against the mean level of the curved plate.

(Refer to Fig. 1 - Fig. 3 in the 'SHELL Manual')

- 3) A remarkable improvement on workability and accuracy in the assembly stage can be expected. Because the various working

SHELL (Continued)

practice in the shop is taken into consideration from the first step of the system execution.

- . In order to keep the accuracy of angles between adjoining seam and butt at plate assembly, the intersection of datum planes in the supporting jig lines and shell plate are marked on each plate. In addition, the datum plane are orthogonal to the platform surface.
- . Instructions can be given in connection with the position for setting plate, position of stopper and the height of supporting jigs.
- . The dimensions of unit, diagonal dimensions and the rate of curvature on seams and butts are calculated and displayed for checking at plate assembly time.
- . The availability of automatic welding on the unit can be checked.
- . Single panel assembly can be also available.
(Refer to Fig. 4 - Fig. 5 in the 'SHELL Manual'),

- 4) Maintainability of data and system.
- 5) Easy recording of feed-back data.

More detailed description is presented in the submitted document.

2.1 Characteristics of Each System of IHI (Continued)LODACS (A Ship Frame Data Processing System)

The LODACS system covers frame development, frame bending and marking-cutting by hand or by NC burning machine. The LODACS system generates precise shape at both end of frame, inverse curve for bending, location of drain holes and template for bending. These data are drawn by a drafting machine, a plotter and dotto printer as well as printed out.

The LODACS supports three-dimensional bending as well as two-dimensional bending. The need of this function comes from fabricating method on bending.

More detailed description is presented in the submitted document.

ATTACHMENT

1. CONSIDERATIONS ON DESIGN CHANGE IN HULL PART

(IHICS: Integrated Hull Information Control System:)
Ref. FPC-073 dated February 23, 1979

Some considerations on design change are involved in the system design strategy of IHICS system which was developed by IHI to perform hull design. The system has been utilizing full in worth.

Design change is considered to be caused mainly by the Owner's opinion and claims from the classification societies. It is very important to remember that designing work for detailing has not been allowed to keep until approval by the said agency is given to the prepared drawings. Therefore, the influences of design change have to be minimized on the designing procedure.

Another consideration to be taken in IHICS is flexibility to the design change due to the change of production method such as welding.

From the viewpoint of computer software, flexibility to this kind of change is fundamentally the same as design change occurring during the period of the actual ship's design.

Some actual examples of the subject to be taken in IHICS are as follows:

- 1) Relative expression on hull structure by defining language called 'LINE'. 'LINE' is designed to describe objective figures in relative expression as far as possible so as to minimize corrections caused by alteration of design.

This concept is coherent in all sub-systems.

(Refer **to** "3) An example of 'LINE' description")

- a) These descriptions will not have to be changed, 'even if the data on longitudinals such as offsets, material dimension and cutout are changed.

ATTACHMENT

These descriptions are executed by the system on both phase of designing and part generation.

- b) Generation of physical data of every part can be postponed up to the execution of parts generation.

The shape of the cutout at every longitudinal frame shall be generated after all inputs are given to the system.

- 2) Independence of design standard data from the computer program.

Design standard data can be registered on the standard data base on the responsibility of designers. Registration and updating can be easily performed by the system.

The following are involved in the standard data base:

- . Shape standard: Cutout, Hole opening, Scallops, Bracket, End shape of stiffeners
- . Standard how to select/apply stands
- . Fabrication standard: Excess, bevels and gaps

3. An example of 'LINE' descriptions

(An example for corner part of transv. section)

```
T      F60
      TL=F60----GEOMETRY DB REFERENCE
      PA=PA-UD,ML--- PANEL DB REFERENCE
      P11=OUT(SL,UD,1) ---DESIGN DB REFERENCE
      SL=PA1,P11
      S11=PR-SL,L=2000,D
      LONG=SL,L40,L59      GEOMETRY, SCANTLING
      LONG=UD,L20,L21      DB REFERENCE
```

Notations

```

C1=TD-S11,T1,-S2
P1=CP-C1
P2=SL0T-PC2,UD-L20
S5=PT-P2,PT-P1
P3=INT(S5-C1),U
P4=ON-C1,FROM-P3,GL=150,D
P5=UD-L20,TOP

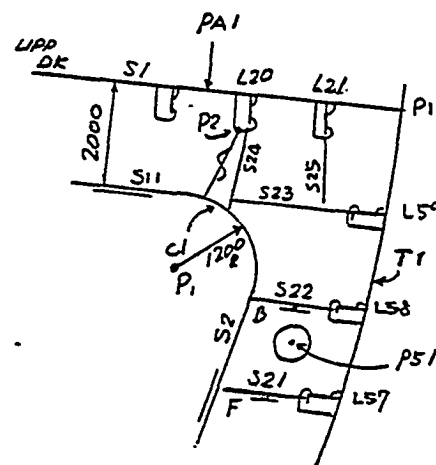
```

Genetic

```

AL=P100,S11,CL,S2,----- COMPLEX SURFACE
S24=PT-P4,PT-P5,SCS=UD-L20,ECS=AL
S21=SL-L57,SCS=SL-L57,ECS=AL
S25=UD-L21;SCS=UD-L21;ECS=S23

```



```
C  -----, T1, MSL(SL, L40, L59), T1, MSC(100), PA1,      CONTOURING
      MSL(UD, L21, L21), PA1, MBS(S5, UD, L20, P3, 21), C1  DEFINITION
      -----
      &
```

```
H      MH(l,P51,150)                - - - - OPENING
                                         DEFINITION
```

```

X  S21=F, FIT=A, PD=D, MRK=U, TYP=FC|S|, NAM=F|5
X  S22=B, FIT=A, PD=D, MRK=U, TYP=BC|S|S|, NAM=B|6
-----
PARTS EXPANSION
(STIFFENER)

```

END OF PART PROGRAM

3.0 Comparison of the Capability Between Levingston's SPADES System and the IHI System

Comparison of the capability between Levingston's SPADES system and the IHI system is briefly presented in this paragraph, since deep study and detailed description has been reported in preceding paragraphs of this paper.

In addition, assessment of the interface problems and the adaptability of the IHI system software to the SPADES system is briefly tried for reference.

3.1 Comparison of the system component between the two (2) systems.

The following is a component figure of the both systems.
The underlined is not used by Levingston.

APPLICATION	SPADES	IHI SYSTEM
Structural Analysis	Unknown	Z-PLATE
Vibrational Analysis	SPADES Unknown	Z-VIBRA
Ship's Hull Calculation	<u>HULLCAL*</u> (Unused)	SPECS
Ship's Operational Information	Unknown	SPECS
Fairing	FAIRING	FAIRLAND IHICS
Ship's Hull Description	HULLOAD	Basic Data Creation Subsystem
Section Design	<u>DEMO*</u> (Unused)	Section Design Subsystem
Part Generation	PARTGEN	LINE System
Nesting	NESTING	Nesting Program
Part's Data Assortment	<u>SPAC*</u> (Unused)	Production Engineering Subsystem
SHELL	PLATDV	SHELL
Plate Development	Unused { <u>ROLL SET*</u>	
Bending Template	PIN/JIG*	
Jig Height		
Unit Marking	Manufacturing Aid	
Frame		
Frame Development	FRAME BENDING (2-Dimensional)	LODACS (3-Dimensional)

3.1. Comparison of the System Component between the Two (2) Systems (Continued)

As shown in the aforementioned component figure of the SPADES system and IHI system, full configuration of the SPADES system covers much the same area as IHI system, except structural analysis and vibrational analysis through SPADES now in use at Levingston, is a part.

In conclusion, capability of SPADES is considered to be almost equal to IHI system. If the betterment for the problems described in 1.1-3) and 1.2 is taken into consideration, and if recommendations by IHI presented in 1.3-5) is studied, the SPADES system shall become full in worth.

3.2. Adaptability of the IHI System Software to the SPADES System

A short study on adaptability of the IHI system software to the SPADES system has been done for reference.

1) As far as the computer hardware configuration, there is no special problem for the subject, because the IHI system can be operated on IBM System/370 or IBM 3031 processor.

2) As far as the computer software configuration, there is no special problem for the subject except IHICS. IHICS requests to install the IMS of IBM Inc. (Information Management System)

3) ZPLATE, ZVIBRA, SPECS

There is no problem to adapt to the SPADES system. These have (their own data file and do not request any interface.

4) SHELL, LODACS

This system might request some interface for their data base unless a new data handler from the SPADES Data Base is attached to these systems.

5) FAIRING

This system might request some post-processor form its data file to the SPADES Data Base unless the results are re-input to the SPADES Data Base from the offset book as the output.

6) IHICS

It shall not be recommendable to adapt to the SPADES system, because almost all the modules were coded by IBM PL/1 based on IMS and too big to adapt.

However, algorithm of the system and design philosophy shall be considered to be convenient for reference.

Epilog:

This report *was* made by IHI through the investigation and the discussion with Levingston's personnel. IHI hopes that Levingston continues a study on the subject matter for the future betterment along the recommendations from IHI described in this paper.

APPENDIX I

IHI REPORT ON NUMERICAL CONTROL STEEL FABRICATION

K2123

TASK 2

ENGINEERING AND DESIGN

SUB-TASK 2.2

NUMERICAL CONTROL STEEL FABRICATION

March, 1979

- Prepared by: IHI MARINE TECHNOLOGY, INC.

M. HATAKE

NUMERICAL CONTROL STEEL FABRICATION

The N/C system now in use at Levingston for steel fabrication has been studied by IHI *in* order to quantify its utilization as compared to its potential capabilities. The study has been in process from November, 1979 through March, 1979, *as* a part of the extended computer-aided hull design system.

In this paper, a brief description on the *usage* of the N/C system at Levingston shall be presented since the more detailed description on the function of the system itself can be found in the attached paper. Then a brief study on the characteristics of the usage of the N/C system at Levingston shall be described comparing with the IHI system. Finally, some recommendations from IHI shall be presented,

Attached Papers:

- 1 . Specification summary for N/C 3000 and N/C 3300 SERIES FUME CUTTERS by C-R-O Engineering Co., Inc.

Detailed functions of the same machine *as* Levingston's are described.

2. IHI High-speed N/C Marking. *System,-*

This machine was developed by IHI to perform high-speed (about 60' per minute) line marking.

3. IHI Multi-torch N/C Cutting Machine.

This machine was developed by IHI to perform gas cutting by three torches simultaneously and to perform line marking by two torches simultaneously. This machine was provided with

Attached Papers: (continued)

mini-computer in order to perform checking the interference of each torch, speed control, co-ordinate transformation and many others.

1.0 The Usage of the N/C System at Levingston

C-R-O Double Model N/C 3000 flame cutter is now in use at Levingston. It is controlled by Kongsberg CNC 500 with the DNC (Direct Numerical Control) software. The machine is provided with almost all necessary functions to perform the N/C steel fabrication at Levingston such as:

Two sets of the master torch associated with two slave torches for each master torch.

Bevel torch for bevel cutting of (K, V, Y, X).

Center-punched marking equipment.

Automatic pierce rate control.

Automatic start-cut control.

Rotating triple-torch suspension.

Height sensing control.

Water spray system for preventing heat torsion.

Torch ignitor.

Others

The machine has been utilized to fabricate almost all hull pieces, which are cut out of raw plates, except square-shaped small pieces to be fabricated by shearing. After its installation at Levingston in April, 1975, this machine has covered Levingston's needs with its capability since the work volume of steel fabrication at Levingston was not too extensive. (The past record was 500-metric tons per month.)

1.0 The Usage of the N/C System at Levingston (continued)

However, since it is estimated that the work volume of Levingston's steel fabrication shall be increased to 1500-metric tons per month through the construction of the bulkers, the work load of the N/C machine is expected to become extremely heavy to fabricate the pieces aforementioned. Therefore, some considerations such as; leveling of the work load, rearrangement of supporting area of objective pieces and installation of an additional machine, shall be requested at this moment. In addition, an alternate method of N/C burning machine to compensate the work load in the time of "machine-down" and "repairing" shall be recommended to be studied. In respect to this concern, a little deeper consideration-shall be presented later.

2.0 Characteristics of the Usage of the N/C System at Levingston

In this chapter, a brief study on the characteristics of the usage of the N/C system at Levingston shall be described comparing the Levingston system with the IHI system.

2.1 Objective Hull Pieces for the N/C Machine

A comparison of the subject title between Levingston and IHI-AI0I Shipyard which constructed the "Future-32" bulkers can be seen in Table 1. The Levingston N/C machine has been utilized to fabricate most of the hull pieces. On the other hand, a quarter of all plates of a "Future-32" was fabricated by the N/C machine in IHI-AI0I Shipyard. In regard to this concern, more detailed descriptions will follow as shown below:

- 1) Difference of the work volume between Levingston and IHI-AI0I Shipyard.

The past record of steel fabrication at Levingston equipped with one (1) N/C machine was 500-M.T. (metric tons) per month. IHI-AI0I Shipyard equipped with three (3) machines keeps 6000 - 8000 M.T. per month.

- 2) Difference of the philosophy on steel fabrication.

(2-1) Levingston stands on the viewpoint that N/C burning is the best way from its high precision and from its capability of burning (2) to (3) plates at a time.

(2-2) IHI stands on the following viewpoint:

Though a N/C burning machine is best for high precision and it has a capability of burning (2) to (3) plates at a time, preparatory work for this such as, nesting operation by this system takes man-hours; nesting of twenty (20)

2.1 Objective Hull Pieces for the N/C Machine (continued)

pieces into a raw plate shall take 1.5 - 2 hours, for example: In addition, the layout for a N/C machine needs a wide space in the shop, Therefore, the use of the N/C burning machine had best be limited to the pieces requiring high precision and the repetitively cut plate from the same N/C tape. In fact, IHI's N/C machines are being utilized for the main structures at cargo hold such as, web plates, floor plates and girders and for the curved shell plates.

2.3 Plate Assembly

For a flat plate unit such as main deck, both Livingston and IHI adopt the preceding plate-assembling method. However, the sequence of it is much different from each other.

At Livingston, marking on each plate is completed by a N/C machine before layout of plates and welding, On the contrary, at IHI each plate is neatly cut by a flame planer and welding of plates follows, Finally, marking on a unit (not plate) is performed before putting the internal structure such as sub-assembled webs on it.

3) Difference of Mold Lofting and Marking Equipment.

IHI has been performing "1/10 scaled mold lofting" except a few full-scaled loftings which are scaled up from 1/10 output to full scale and converting from output prints by the computer system to steel tape templates for, unit working. A large and highly precise drafting-machine and an Electro Photo Marking System made it possible, "1/10 scaled mold lofting" - at IHI.

2.1 Objective Hull Pieces for the N/C Machine (continued)

An Electro Photo Marking System (called shortly (EPM) was developed more than 10-years ago by marriage of Electronics and Optics. It can work a raw plate in eight (8) minutes. It's principle is the same as the one used by photographers. In EPM System, a film is a raw plate on which powders (called photoner) charged static electricity are scattered, and the object is to be taken in photo and is a nested original pattern in 1/10 scale. The original pattern is expanded by a very precise lense into 1/1 scale. The precision of the printed pattern is good enough for the hull pieces.

On the other hand, neither a large drafting machine nor a precise marking equipment piece-is provided at Levingston. In addition, skilled loftsmen are scarce. From these stated reasons, the N/C burning machine is supposed to be very important and very vital at Levingston.

4) Re-arrangement of supporting area of objective pieces for the N/C machine.

The work load of the N/C machine at Levingston shall become more increased through the construction of the bulkers as described in the previous chapters. Moreover, a consideration for "machine-down" of the most vital machine shall be urgent; so that Levignston started thinking of shifting a flat plate (square shaped) from the N/C machine to the flame planer and/or hand cutting. It shall be recommended.

Table 1

OBJECTIVE HULL PIECES FOR N/C MACHINE

Objective Pieces \ Company	LEVINGSTON	IHI-AIOI SHIPYARD (F-32)
WEB PLATE (HOLD)	N/C BURNING	N/C BURNING <u>117 PLT</u>
FLOOR PLATE (HOLD)		
MAIN GIRDER		
WEB PLATE (OTHERS) FLOOR PLATE (OTHERS) GIRDER (OTHERS) BKT		N/C DRAWING ↓ ERECTO MARKING ↓ HAND CUTTING <u>622 PLT*</u>
CURVED SHELL		N/C BURNING <u>240 PLT</u>
FLAT SHELL FLAT DECK FLAT WALL FLAT BULKHEAD		FLAME PLANER <u>606 PLT</u>
FLAT BAR FACE PLATE	MATERIAL CUTTING LIST ↓ HAND MARKING ↓ HAND CUTTING	N/C DRAWING ERECTO MARKING * Includ HAND CUTTING Above
FLAT SHAPE		MATERIAL CUTTING LIST P HAND MARKING 1900 HAND CUTTING
CURVED SHAPE		
COLLAR PLATE, ETC.	SHEARING OR N/C BURNING OR HAND CUTTING	MAGNET TRACER OR PHOTO TRACER

I) Numbers of IHI's columns are the actual plate numbers of "Future-32" constructed at IHI AIOI Shipyard.

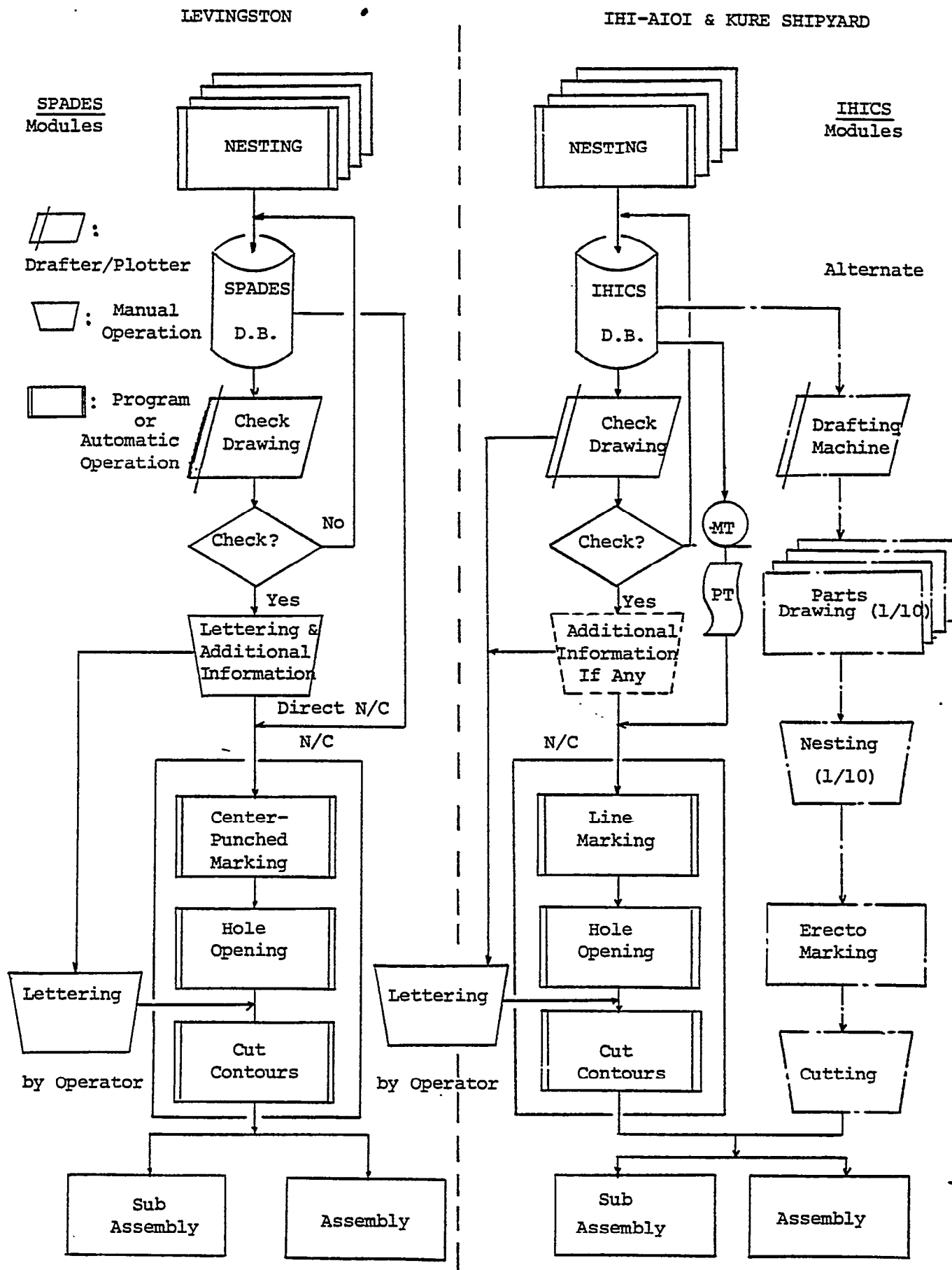
2.2 Process Flow of N/C Works (At Present)

A comparison of process flow of N/C works between Levingston and IHI-AI0I Shipyard can be seen in Figure 1. This figure displays a very simple flow from the computer system to the production through the N/C burning machine. The flow controlled by SPADES and by IHICS (these are computer-aided hull design systems which have been described in another report "Computer-aided Hull Design System"), is almost the same except for the alternate method of IHI.

In this flow, a few differences between Levingston and IHI can be found. They are: the control method of N/C (direct N.C at Levingston and off-line control at IHI) and the marking method (center-punched-marking at Levingston and line-marking at IHI). These are described in the next chapter.

Drawings for checking purposes at Levingston shall be improved if a large drafting machine is provided. In this respect, more detailed study has been completed in another report, "Computer-aided Hull Design System".

COMPARISON FLOW OF N/C WORKS (AT PRESENT)



2.3 The Function Of the N/C Burning Machine

A comparison of the function of the N/C burning machines between Levingston and IHI can be seen in Table 2.

Levingston has one C-R-O N/C 3000 System. The five (5) shipyards of IHI have five kinds of N/C burning machines to suit their fabrication methods and a kind of N/C marking machine. IHI has eleven (11) N/C burning machines and three (3) N/C marking machines in total. In IHI-AI0I Shipyard, three (3) N/C burning machines have been provided.

Only a few differences can be seen in the function of the N/C burning machine between Levingston and IHI. A brief explanation on this subject is described as follows.

1) Control Method of N/C

Levingston's control method of N/C is DNC (Direct Numerical Control), DNC is the system which the host computer controls directly the N/C machine, so that no punched paper tape is necessary. And DNC system shall be more suitable for Levingston, because the host computer is at Ashland Co., in Kentucky, very far away from Orange, Texas. Therefore it seems to be impractical to get N/C tapes from Kentucky.

IHI's control method is all off-line control. IHI also planned to adopt DNC system, however, it did not occur due to the cost of both initiation and running time. Since IHI has five (5) computer centers near the shipyards, paper tapes or magnetic tapes for N/C are easily provided.

2.3 The Function of the N/C Burning Machine (continued)

2) Bevel Cutting

At Levingston, bevel cutting is performed by the following sequence:

- Programmer defines a surface with bevel cut by the NESTING Program.
- N/C machine stops at both ends of the surface with bevel cut.
- N/C machine operator sets and reset the bevel degree and location.
- Machine restarts.

IHI system has several standardized bevel angles such as 15° , 25° , and 35° . The selection of bevel angle and Ignition/Extinguish are automatically performed by the system without stopping the machine.

If the bevel angle can be standardized at Levingston (even not, the bevel angles other than standard are supposed to be quite a few), the automatic bevel cutting shall be performed by additional feature to the post-processing program for the machine.

TABLE 2

COMPARISON TABLE OF N/C BURNING MACHINE BETWEEN LSCO & IHI

COMPANY		LEVINGSTON	IHI							
ITEM	FUNCTION	ALL ROUND	ALL ROUND	SIMPLE	MARKING	ALL ROUND	ALL ROUND	MULTI-TORCH		
INSTALLATION DATE		April, '75	Oct., '71	Sept., '72	April, '75	1974	Aug., '71	Sept., '74		
MAKER	Burning Machine	CRO N/C 3000	Koike, Japan	Tanaka, Japan	Tanaka, Japan	Tanaka, Japan	Tanaka, Japan	Koike, Japan		
	Controller	Kongsberg CNC 500	Toshiba T-1500C	Toshiba T-1300G	IHI MK-240N	Toshiba T-1500	Toshiba T-1500	Toshiba T-40		
CAPACITY	BURNING MACHINE	Effective Rail Span	29'-7"	31'-2"	18'-2"	16'-3"	39'-0"	58'-6"	16'-9"	
		EFFECTIVE Rail Length	111'-0"	56'-3"	74'-8"	74'-8"	97'-6"	73'-2"	58'-6"	
		Weight		10 MT	2 MT	0.7 MT	8 MT	13 MT	1.5 MT *3	
		Gas Pressure Used	O ₂ : 120 PSI Natural Gas: 15 PSI	O ₂ : 9kg/cm ² LPG: 65kg/cm ²	—————	—————	—————	—————	—————	
		SPEED	Cutting	2-50 IPM/15-250IPM	0.4-60 IPM	2-51 IPM	—————	0.4-118IPM	—————	—————
			Marking	20.83'/Min.	39'/Min.	19.5'/Min.	58.5'/Min.	39'/Min.	—————	—————
			Rapid Transverse	20.83'/Min.	39'/Min.	19.5'/Min.	58.5'/Min.	39'/Min.	—————	—————
			Marking Precision		± 1/64"	—————	± 1.5/64"	± 1/64"	—————	—————
		Gas Used	Natural Gas	LPG	—————	—————	—————	—————	—————	
		TORCH BLOCK	Torch Station	6(2 Master, 4 Slave)	4	3	1	2	3	3
	Bevel		I.K.V.X.Y	I.K.V.X.Y	I	—————	I	I.V.Y	I	
	Nozzle Tip		Oxweld Made	IHI Made	Koike 106PD	Tanaka	Tanaka 3155A	Tanaka-Curtain	Tanaka-Curtain	
	Height Sensing		Fluidic	Fluidic	Fluidic	—————	Fluidic	Roller	Roller	
	Rotating Torch		Equipped	Equipped	—————	—————	—————	Equipped	Equipped	
	Ignition		Automatic	Automatic	Manual	Automatic	Automatic	Automatic	Manual	
	Extinguish		Automatic	Automatic	—————	—————	—————	—————	—————	
	Piercing		Automatic	Automatic	—————	—————	—————	—————	—————	
	Marking	Center-punched	Plastic Burned	Zinc Burned	—————	—————	—————	Plastic Burned		
Driving Motor	D.C. Servo	D.C. Servo	—————	—————	—————	—————	—————			
CONTROLLER	Control Axis	X.Y.θ	X.YI-2,θI-2	X.Y	X.Y	X.Y	X.Y.θ	X.Y.θ		
	Minimum Dimension Input	1/64"	0.1/64"	—————	—————	—————	—————	—————		
	Maximum Dimension Input	120'	1230'	—————	—————	—————	123'	1230'		
	Tape Format	ESSI	EIA-8U	—————	—————	—————	—————	—————		
	Interpolation	Linear and Circular	Linear & Cir.	—————	—————	—————	—————	—————		
	Kerr Compensation	Dial Set	Dial Set	—————	—————	Dial Set	—————	—————		
	Reversing	Direct on Path Program Rev.	Dir. on Path Prog. Rev.	—————	—————	—————	—————	—————		
	Aux. Function		36	28	32	33	51	27		
PAST RECORD	CUTTING SPEED	3/8" T 5/8"	51 IPM	24 IPM	—————	30 IPM	28 IPM	24 IPM		
		5/8" T 3/4"	Variable	47 IPM	20 IPM	—————	26 IPM	26 IPM	22 IPM	
		3/4" T 7/8"		31 IPM	16 IPM	—————	22 IPM	24 IPM	20 IPM	
		7/8" T		31 IPM	15 IPM	—————	20 IPM	20 IPM	18 IPM	
	Consideration for Torsion	Water Cooling Cutting Seq., Bridging	Cutting Seq. Wtr. Cooling	—————	—————	—————	—————	Cutting Seq. Bridging		
	Troubles Up-to-date									
ADMINISTRATION	MAINTENANCE	Daily	Operator	—————	—————	—————	—————	—————		
		Periodical	2 Times/Yr.	Maker	—————	—————	—————	—————		
		Repairing	Maker IHI Specialist	—————	—————	—————	—————			
	Operator	Number	2	2	2	4	4	1		
Experience		2-3 Years	3.5 Yrs.	1.5 Yrs.	1.5 Yrs.	3 Yrs.	1.5 Yrs.			
Max. Plate No. to be Cut Simultaneously		4 PL(12'-0"×50'-0")	2 PL(12'×34")	1 PL(15'×75")	1 PL(15'×75")	2 PL(115'×98")	3 PL(16'×46")	1 PL(12'×9")		
REMARKS		DNC	Tokyo - 1 Chita - 1 AIOI - 1	Chita - 1	Chita - 1 Yokohama - 2	Chita - 2 AIOI - 2	Kure - 2	Kure - 2		

3. Some Recommendations on the Usage of the N/C Burning Machine from IHI

In this paragraph, some recommendations on the subject are presented. In addition, IHI's line marking method and its adaptability to the Levingston present system since it seems to be preferable from the viewpoint of workability by sub-assembly and assembly.

3.1 Standardization of Bevel Angle for the Automatical Bevel Cutting

Though this subject is concerned with not only the N/C system, standardization of bevel angle has the possibility for automatical cutting of bevel surface, Since automatical setting of optional bevel degree is very difficult, it is true that the angle has to be set by hand, However, if this standardization has been completed, pretty part of bevel surface can be cut automatically by adding a feature for that to the postprocessing program which is connected to the output from the SPADES system.

Even if the said additional feature is not possible, necessary time for setting bevel angle shall be much saved by standardization of bevel angle,

3.2 Re-Arrangement of Supporting Area 'of Objective Pieces for the N/C Machine and a Consideration for "Machine-down"

Since the work load of N/C machine at Levingston is expected to be increased as described in Chapter 1 of this paper, re-arrangement of the subject shall be urgent.

3.2 Re-Arrangement of Supporting Area of Objective Pieces
for the N/C Machine and a Consideration for "Machine-down"
(continued)

From the viewpoint of the workmanship at Levingston it is recommendable to cut hull pieces by N/C machine as far as possible. However, in case of over work load at N/C machine, it is recommendable that a flat plate such as main deck plate is shifted from the N/C machine to the flame planer. In addition, the scaled mold lofting (1/10 or 1/12) is recommendable to be established with the aid of a large drafting machine; because making templates in full scale from the scaled drawing (1/10 or 1/12) is possible when "machine-down" of N/C continues for awhile. In this concern, more detailed description has been presented in another report "Computer-aided Hull Design System.

4.0 Line Marking Method of IHI System (For Reference)

Levingston's N/C system adopts center-punched marking system. This system can work (punch) points with several variations of intervals between them. From the viewpoint of workability at sub-assembly and assembly, this marking system shall not be so easy for production people to fit pieces on the marked (dotted) line. In fact, production people are seen marking a continuous straight line by stretching a thread. In this concern, it seems to be interesting to introduce IHI's line marking method for reference.

There exists two (2) kinds of line marking methods in IHI's system. One is to burn zinc powder by a working torch to a steel plate. Another-is to burn plastic powder. The clear continuous lines' (1/16" in boldness) can be marked with a speed of about 40' per minute. Comparing with the center-punched marking, it-might have a demerit to be faded away during the fabrication process. However, no particular consideration is requested at IHI. More detailed information on this marking system -is presented in the following table.

LINE MARKING DEVICE IN IHI SYSTEM

	ZINC POWDER	PLASTIC POWDER
Price of One Device (Price in Japan)	400,000 Yen (\$2,000)	800,000 Yen (\$4,000)
Running Cost	<u>Powder</u> 3 Yen per 3'-3" of Marking <u>Nozzle Tip (per one)</u> 25,000 Yen (\$125)	<u>Powder</u> 3 Yen per 3'-3" of Marking <u>Nozzle Tip (per one)</u> 25,000 Yen (\$125)
Maintainability	Easy	Very Complex

Adaptability to Levingston's System

Some additional work shall be requested for adoption of the equipment to the present Levingston machine as follows:

- 1) Fuel gas, oxygen, Water and air must be supplied for the working torch.
- 2) Postprocessing program must have a signal of marking ON/OFF. This function is supposed to be satisfactory in the present program.

EPILOG:

This report was made through the investigation and discussions with Levingston's personnel by IHI. IHI hopes that Levingston continues a study on the subject matter for the future betterment along with the recommendations described in this paper from IHI.

APPENDIX J

LSCO STUDY AND COMPARISON OF SPADES VS. IHI SYSTEM

LEVINGSTON SHIPBUILDING COMPANY

Technology Transfer Program

TASK 2 Engineering and Design

Sub Task 2.1 Computer-Aided Design Systems

STUDY AND COMPARISON OF SPADES VS. IHI SYSTEM

E. E. MAYER

4/25/79

INTRODUCTION

In an overall comparison of the SPADES system and the IHI system for computer-aided design, the SPADES system comes in second only due to the quantity of programs that compose the entire IHI N/C system.

Considering production aids, the SPADES system is equal to the IHI system, and because of ease in user coding, the SPADES N/C production oriented system is considered the better of the two.

Definitions :

S.P.A.D.E.S. - Ship Production and Design Engineering Systems

I.H.I.C.S. - Integrated Hull Information Control Systems

Appendices:

Appendix 1 - Spade System Ship Production & Control Module
Cali & Associates Inc.

Appendix 2 - Spades System - Engineering Detailing Module
Cali & Associates Inc.

COMPARISON ANALYSIS

Comparison Table

	APPLICATION	SPADES	IHICS
1)	Hull definition and data base creation	*Lines fairing *Hulload *Demo	*Lines fairing *Shell landing *3-D process *Section design sub-system
2)	Production L o f t i n g	*Parts generation *Parts separation *Plate development *Nesting	Production Engineering sub-system consisting of: *"Line" system for nesting w/manual and interactive graphics by "cards". *Part generation
3)	Ships produc- tion and con- trol programs	*SPAC (Ship Production and Control)	*Part data base administrative program *Piece data assortment program
4)	Production and Lofting assis- tance programs	Mfg. aids module for: *Frame bend offsets *2 dimensional pin heights *Girth length table *Rol 1 set templates *Meld loft offsets	"LODACS" system for: *3 dimensional frame bending (offset info only for twist- *Mold loft offsets (from data creation sub-system) *Part data base administrative program and shell program produce templates for shell plate bending and pin jig heights

	APPLICATION	SPADES	IHICS
5)	Design engineering and hull calculation programs	Hull calls for: *Bonjean curves *Hydrostatics *Longitudnal strength *Tank capacity and sound- ing and ullage *Trim calculations *Damage stability *End launching	Specs for: *Bonjean Curves *Hydrostaties *Longitudinal strength *Tank capacities w/sounding and ullage *Trim calculations *Damage stability *Launching calculations *Grain heeling moment *Sea trial data
6)	Programs that IHICS has that SPADES does not have are "z VIBRA" for vibrational analysis and "Z PLATE" for structural analysis. These, or similar, programs are available to LSCo from their sources.		

Explanation Of Comparison Table

- (1) The Hull Definition modules compare equally since the end product or output comparisons bear close resemblance. Both FAIRING modules have excellent splines and produce very fair lines. However, the SPADES system utilizes more control line output for assistance in development of other modules. Also, skewed planes may be generated for cant framing and additional frames may be loaded for shell master butts.

The HULLOAD program is the SPADES module that defines shell landings of stiffeners, seams, decks, longitudinal bulkheads. HULLOAD also defines stiffeners and seams on decks, flats, and longitudinal bulkheads.

IHI generates this information with its I.H.I.C.S. shell and panel landing modules, which along with the line module, comprise the data base. Without actual coding examples of the IHI system, a true detailed comparison is not possible. However, based on other available examples, coding the SPADES system is less difficult than coding the IHI system.

DEMO (Detail Engineering Module) and IHI's I.H.I.C.S. production engineering system (Integrated Hull Information Control System) both provide for the loading of structural details into the data base. The SPADES DEMO module (see enclosure) is a powerful tool which enhances the HULLOAD program and allows for structure definition loading in all planes including transverse and skewed. DEMO also places the emphasis of part definition within the engineering group and consequently allows part generation personnel to concentrate on parts separation.

The DEMO module can also provide drawings that are suitable for issue with hand finishing done by a drafter. The IHI system is capable of performing an equal task, but an accurate definition of how, when, and which module performs this function is not explicit in the description material IHI has provided.

- (2) The PRODUCTION and LOFTING N/C modules, when compared based on available I.H.I.C.S. input information, shows the SPADES production module to have an easier input format and to be almost equal in output information. (See appendices No. 1 and No. 2)

Parts generation, plate development and other similar modules compare as to the assistance offered to production. However, the IHI group utilizes more output information than the LSCo group needs at present.

The nesting modules offer no real comparison, as the SPADES system is totally interfaced with the data base and the IHI system uses a manual input of parts information to generate marking and burning tapes. Both systems have an interactive graphics capability in the nesting cycle.

- 3) The ships production and control modules are difficult to compare, as the IHI N/C system performs such tasks under different modules. However, the overall output far exceeds what Levingston or SPADES can generate. IHI adheres to the policy that Production Control and Planning system utilizes every means necessary to achieve and maintain total control. From the data submitted, it is concluded that data input is mainly performed manually using output information found in the data base.

IHI produces a cutting list, parts list, and piece drawing for every item on a ship whether processed by numerical control or manually .

The SPADES SPAC module (Ships Production and Control) has not been used nearly as extensively as the corresponding IHI modules. SPAC is a new module in use at this time only at National Steel and Shipbuilding Company and by Cali and Associates. The SPADES SPAC system utilizes the full data base for reporting and its limitations are set only by user option. This module provides a large growth potential.

- 4) In the area of Production and Lofting assistance, the IHI and SPADES systems are almost completely equal. Each offers the roll set templates, frame bending, pin jig heights, girth length tables, and mold loft offset tables necessary in N/C shipbuilding.

The SPADES system module manufacturing aids interfaces the data base from which it pulls the output information requested, IHI use different sub-systems to gather required information and not all of them actually access the data base for data generation. In fact, the three-dimensional frame bending module, called LODACS, uses offset information from Fairland and other modules for input into the LODACS module which is a stand-alone module. The output information generated by LODACS for frame bending and end cuts is of exceptional quality.

- 5) The Design Engineering and Hull calculation programs of the IHI system is superior to the SPADES system in breadth and completeness, especially as applied by IHI. SPADES Hullcal does have the advantage of direct access to the data base, which simplifies coding . The IHI SPECS (Ships Preliminary and Exact Calculations System) requires manual preparation of input as it is a stand-alone module.

The SPADES output format is now out-dated and the Levingston Design Department has chosen to use SHGP (Ship Hull Characteristics Program). However, with a soon to be implemented Fortran subroutine, the Hullcal output should be more acceptable to regulatory bodies requirements and needs. IHI SPECS is a complete hull calculation system even including calculation of ship sea trial criteria.

- 6) IHI's structural analysis and vibrational analysis programs Z Plate and Z Vibra, are stand-alone modules similar to several programs used by Levingston but produced by other companies. The programs are not comparable to a SPADES module as SPADES is not intended to be involved with Design Engineering analysis.

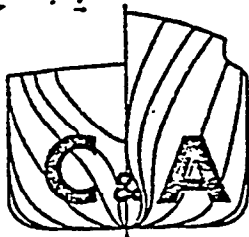
CONCLUSIONS

In summary, the IHI N/C system and the SPADES N/C system are both very good. The IHI system is fully utilized to the best advantage of the IHI shipbuilding complex while the SPADES N/C system utilization at Levingston is limited by a lack of implementation and facilities.

The comparison of those N/C modules that actually duplicate the old style lofting and template making methods would actually give SPADES the advantage as the input coding of SPADES is much easier. Also, SPADES fully utilizes the data base set up with the Fairing and Hullload modules.

Implementation of the IHI system at Levingston is not necessary because the SPADES system currently utilized is more than adequate for present and future needs. All SPADES modules access the data base for ease in generating input data.

Overall, both systems serve the intended functions. IHI utilizes Computer-aided Design and N/C to their maximum capabilities which is one reason they are one of the world's foremost shipbuilders.



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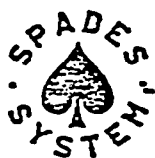
APPENDIX 1

S P A D E S S Y S T E M

SHIP PRODUCTION & CONTROL MODULE

(Preliminary Description)

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Development and Marketing of the 'SPADES' and 'SLAM' N/C Systems



INTRODUCTION

The use of extensive modular construction in shipbuilding, combined with the increased use of Numerical Control, has greatly improved in the last decade the efficiency of the industry.

In order to properly utilize these techniques, it was immediately apparent, however, that more and better planning was necessary.

The planning effort, per se, is neither too difficult nor too costly. The collection and updating of the data needed to generate the required reports is both difficult and costly, in order to obtain a reasonable degree of accuracy,

The 'ship Production and Control (SPAC) Module' of the 'SPADES' System is designed to achieve in this area the following goals:

1. Reduce man-hours for data collection.
2. Improve the accuracy and timeliness of the reports.
3. Reduce ship construction costs by reducing errors and misinformation in the shops,

The 'SPACE' Module covers at the present only the hull construction. It is intended-t, in parallel with the development of modules to handle the design and production of other ships' systems, the 'SPAC' Module will be expanded accordingly.

DESIGN CRITERIA OF THE 'SPAC' MODULE

Since the 'SPAC' Module properly falls in the category of management in **formation** systems, the basic criteria applicable to this type of system must be respected as follows:

1. The module must allow the collection of independent data at the origination source and make it immediately available to all interested shipyard functions.

As an example, for instance, assembly boundaries and schedule starts can be inputted directly to the system and the 'master erection schedule' report generated immediately after for dissemination.

2. All applicable data generated by other modules of 'SPADES' must be collected and used by the 'SPAC' Module without any user intervention,

This feature is the main justification for the development of the module, and the following is a partial list of examples:

- .Allocation to the proper assembly and sub-assembly of all pieces generated through use of 'PARTGEN', 'PARTSEP' 'PLATDV' or 'MANF AID (frame bending).

- *Processing time for N/C burning tapes and flame planer sketches.

- .Unit weight of individual pieces and weight and centers of gravity of assemblies and sub-assemblies.

- *Length and nesting within standard lengths of shapes of the various individual shape pieces.

- Cross reference between assemblies due to the nesting into a plate of pieces belonging to different assemblies.

- .Bulk material allocation for pieces produced through shearing or 'one-to-one' optical burning.

3. Revision control is maintained by the system for all the issued reports generated.

A summary report can also be generated, showing at any one point in time the current valid revisions of all the issued reports.

4. Any change of the independent data or other data used by the system must generate an exception report indicating which of the reports are affected by the change, so that the user can initiate the proper request.

For example, if planning changes require different boundaries for any one assembly, the module must automatically update the allocation of all pieces effected by the change of boundaries, and give a report indicating which reports must be requested for re-issue.

5. Exception reports can be generated to indicate to the user at any point in time which pieces for any **one** particular drawing have not as yet been defined, or any material deficiencies.
6. The system must allow the introduction of data at levels other than the optimum, to override or enrich the **data** base, in order to be able to generate complete reports at anytime.

The Appendix contains the basic data flow for the module, a brief description of the input needed, and some examples of the reports generated by the system. The examples of the reports are simulated in this preliminary description, and they will be changed as the development of the module proceeds.

CONCLUSION

The purpose of this preliminary description is to disseminate among all potential users the features and the capabilities of the module **as** they are conceived by Cali & Associates,. **Inc.**

It is hoped that a review by the shipyards will provide us with the very much needed input and comments for incorporation during the development. Specific comments regarding the size and format of the data used by each shipyard **as** it is applicable to this module will be very helpful in avoiding future incompatibilities and/or restrictions.

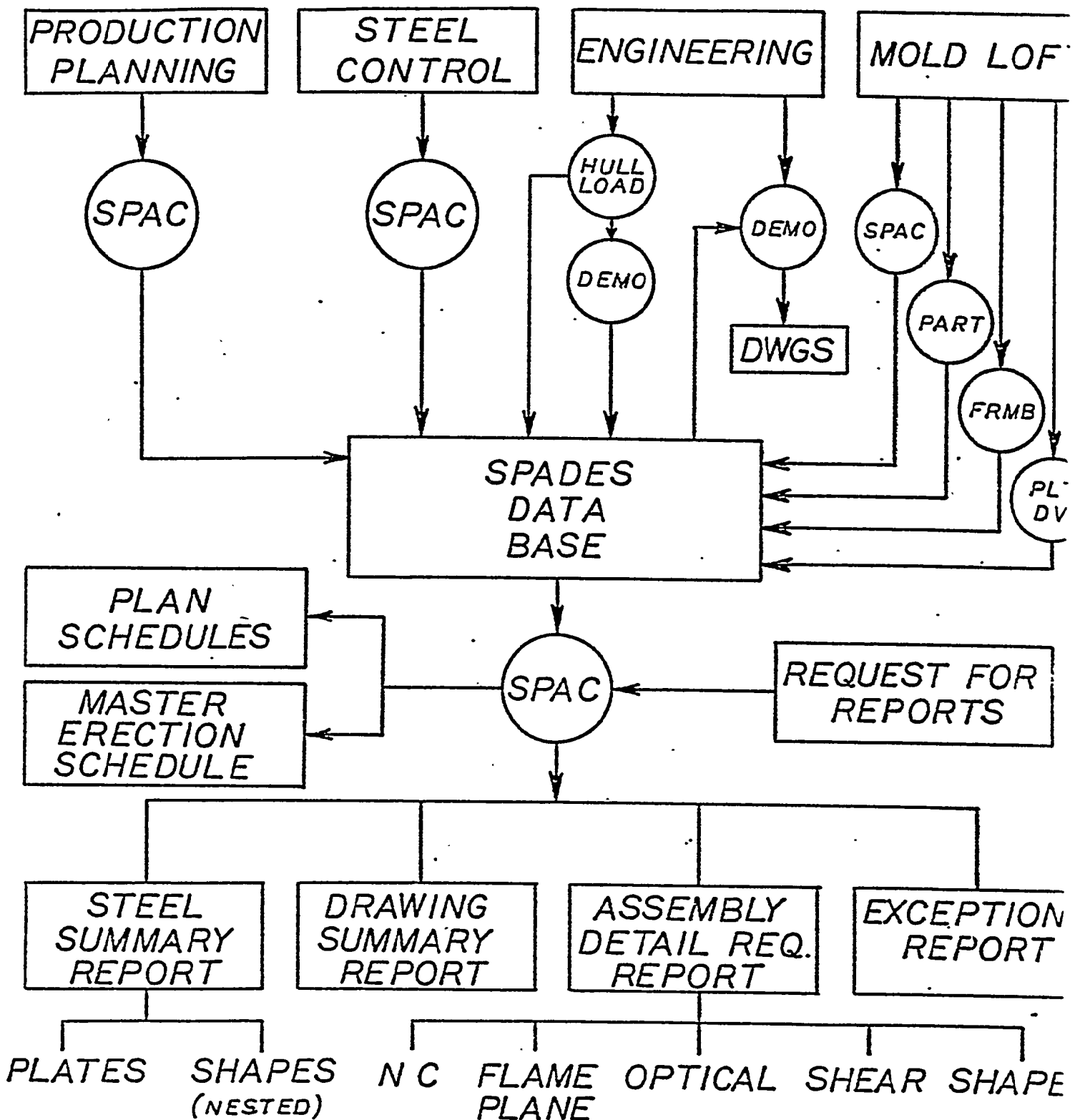
S P A D E S S Y S T E M

SHIP PRODUCTION & CONTROL MODULE

APPENDIX

SPADES SYSTEM

DATA FLOW FOR SHIP PRODUCTION AND CONTROL MODL



TYPES OF INPUT & RESPONSIBILITY FOR
THEIR PREPARATION BY SHIP YARD FUNCTION

1. Production Planning

- a) Limiting boundaries of planned assemblies (units) and sub-assembly breakdown, if any. The system will always assume that ship's surface, such as deck, webs or shell will constitute a sub-assembly,
- b) Planned start date for processing each assembly.

2. Steel Control

- a) Final steel bill. This is intended to mean the steel take-off bill as modified for utilization of stock and/or standardization of plate size, The various items in the various steel bills will carry a unique stock number compatible with the shipyard system.
- b) Storage location of various items in the steel bill will be given to the system upon receipt of the steel.

3. Engineering

- a) Loading of the data base. Through the detail engineering module, the data baseloading capabilities will be expanded, allowing at the same **time the easy** generation of detail drawings, As part of this activity, engineering will also update, as needed, database libraries of standards (brackets, chocks, etc.), shapes, characteristics, and **associated** cut-outs.
- b) Drawing list and associated range of pc. mks. used in each drawing. This will allow the system to generate exception reports calling attention to pieces not generated at any one point in time;

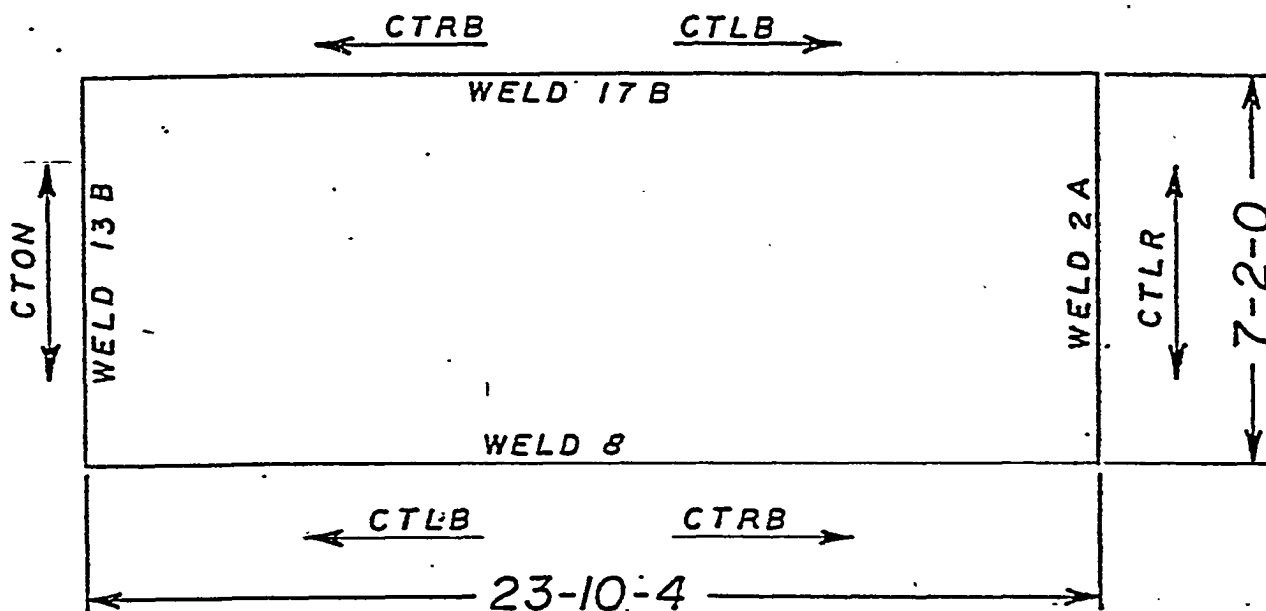
4. Mold Loft

- a) Through the use of 'PARTGEN', 'PARTSEP' and 'PLATDV', the loft will enable the system to allocate the pieces thusly generated to the various assemblies and sub-assemblies. Provision will be made for identifying drawings, pc. mk. and beveling detail, and also **applicability** of a part to another **area** of the ship.

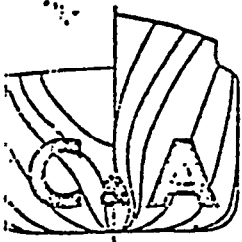
- b) Through the use of 'MANF AID' (frame bending), all shapes, whether straight or curved, will be identified and allocated to the proper assembly, The Frame Bending Program will be modified to easily do that for all flat surfaces.
- c) Through the use of the Ship Production and Control (SPAC) Module, the loft will input to the System all the miscellaneous pieces not otherwise identified.

SHIPYARD NAME
EXACTOGRAPH SKETCH

SHIP _____ HULL NO. _____
JOB ORDER NO. _____
ASSEMBLY _____
SUB ASSEMBLY _____
DWG. NO. _____ PC. NO. _____ DET NO. _____
P L A T E S I Z E _____ QTY REQD. _____
PLATE STOCK NO. _____



TAPE NO. 301376-307-1 EXACTOGRAPH



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. APPENDIX 2

S P A - D E S S Y S T E M

ENGINEERING DETAILING MODULE

(Preliminary Description)
(DEMO)

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Development and Marketing of the 'SPADES' and 'SLAM' N/C Systems



OBJECTIVES

The main purpose of this module is utilize the time and effort spent during the detail design phase for numerical description of the ship structure. During this phase, all structural details are defined, and if these definitions can be recorded **on** the database, interpretation of the drawing and the possibility of errors downstreams during part generation can be greatly reduced, Greatly expanded database loading capabilities will provide information over and above the geometrical part generation requirements which can be used by the planning and control module or other ship's systems.

As the volume of information. the database increases and the base becomes more comprehensive verification of loaded data becomes more and more difficult. 'The quickest way of verificationi by drawing. Therefore, a simple and easyway of accessing the data base with a few commasds is needed to automatically output all loaded data of a particular surface in to a composite drawing,

If this drawing capability is achieved; only a few options are needed to **extract** partial drawings for all kinds of purposes. Structural drawings can be complete, with the exception of lettering and dimensioning. Background drawings for **ar**-rangements and composites can be produced with just a few commands.

PREREQUISITES

In order to make this module an efficient tool for detailing, the loading capabilities of the data base will be expanded. The 'H'JLLOAD' Module will be capable of loading traces and details in transverse, plan and elevation views. Additional information on all surfaces will include:

- a) Stiffeners and their end connections
- b) Seams and plate thickness associated
- c) Brackets and **chocks**
- d) All access holes, including face bars
- e) Inside contours, as defined by web frames.

All through members affecting other surfaces must be handled by 'HUILOAD'
Local details will be defined by 'DEMO'.

OPERATING PROCEDURE

Although the module's primary task is to aid in loading the data base, direct loading capability is not conceived. The actual loading of the **data** base is reserved for the group of people responsible for loading the data base through 'HULLLOAD'. This is to preserve the integrity of the data base by concentrating the responsibility onto one person, or one group of people. However, to avoid having the 'HULLLOAD' people recode all the definitions Module 'HULLLOAD' will have the capability of executing the same input deck, ignoring irrelevant commands, but executing and loading the detail specifications,

The application of the module within the ship design effort is seen as follows:

1. Fairing and loading of the major structure through 'HULLLOAD'
2. **Extract** a drawing of the surface containing outlines and through **members** through 'DEMO'.
3. Load repetitive patterns of stiffeners and seams through 'HULLLOAD'.
4. Extract a new drawing through 'DEMO' containing all loaded details.
5. With 'DEMO', add and modify details of stiffeners, seams, holes and-brackets, resulting in:
 - new drawing, complete with the exception of lettering and dimensioning
 - An input deck defining the details executable by 'HULLLOAD'
 - An entry in a data base record which contains all input decks -- that are generated by 'DEMO' and must be executed by 'HULLLOAD'
6. When the design is completed, control is transferred to 'HULLLOAD' The input deck is executed, loading the details. The entry of the final step above is deleted.
7. Revisions:
 - a) If the drawing is not released as yet, the revision may be added to the 'DEMO' input deck executing '5' and '6'
 - b) if the drawing is released and lettering and dimensioning has been added, revisions **are** effected through 'HULLLOAD' only,
8. After the structural details have been loaded, drawings for other disciplines such as arrangements and composites may be called.

INFORMATION DEFINED BY 'DEMO'

Only local details are defined through 'DEMO'. Details are defined as follows :

1. Stiffeners: Symbolic name s ABC P/S
 Contour definition
 Shape code number
 Orientation (near side or far side)
 End connections (lap, snipes, **knuckles**).
2. Seams: Symbolic name J ABC P/S
 Contour definition
 Welding detail (bevel and gap)
 Thickness on both sides.
3. Holes : Symbolic name H 123 P/S
 Contour definition
 Thickness, width and offset of face bar..
4. Brackets: Symbolic name B 123 P/S
 Contour definition or standard detail identification
 Thickness
 Width and thickness of flange.
5. Inner Lines: Accessible only as a contour
 Identified by 'INNLL'
 Contour definition
 Width and thickness of face bar.

PL. MKS (SEE PLANNING)

PROGRAM CAPABILITIES

Options with automatic drawing of data base contents:

- 4) Scales
- b) Windowing
- c) with or without shapes ('T' 'L' etc.)
- d) With **or** without cut-outs and **snipes**
- e) With or without stiffeners and seams on the surface
- f) Include background frame or deck
- g) Pen selection for turret machines
- h) Line selections of different types of dashed lines.

2. Automatically included as drawing standard:

- a) A standard grid surrounding the entire drawing
- b) Center line and/or base line, if part of the drawing.

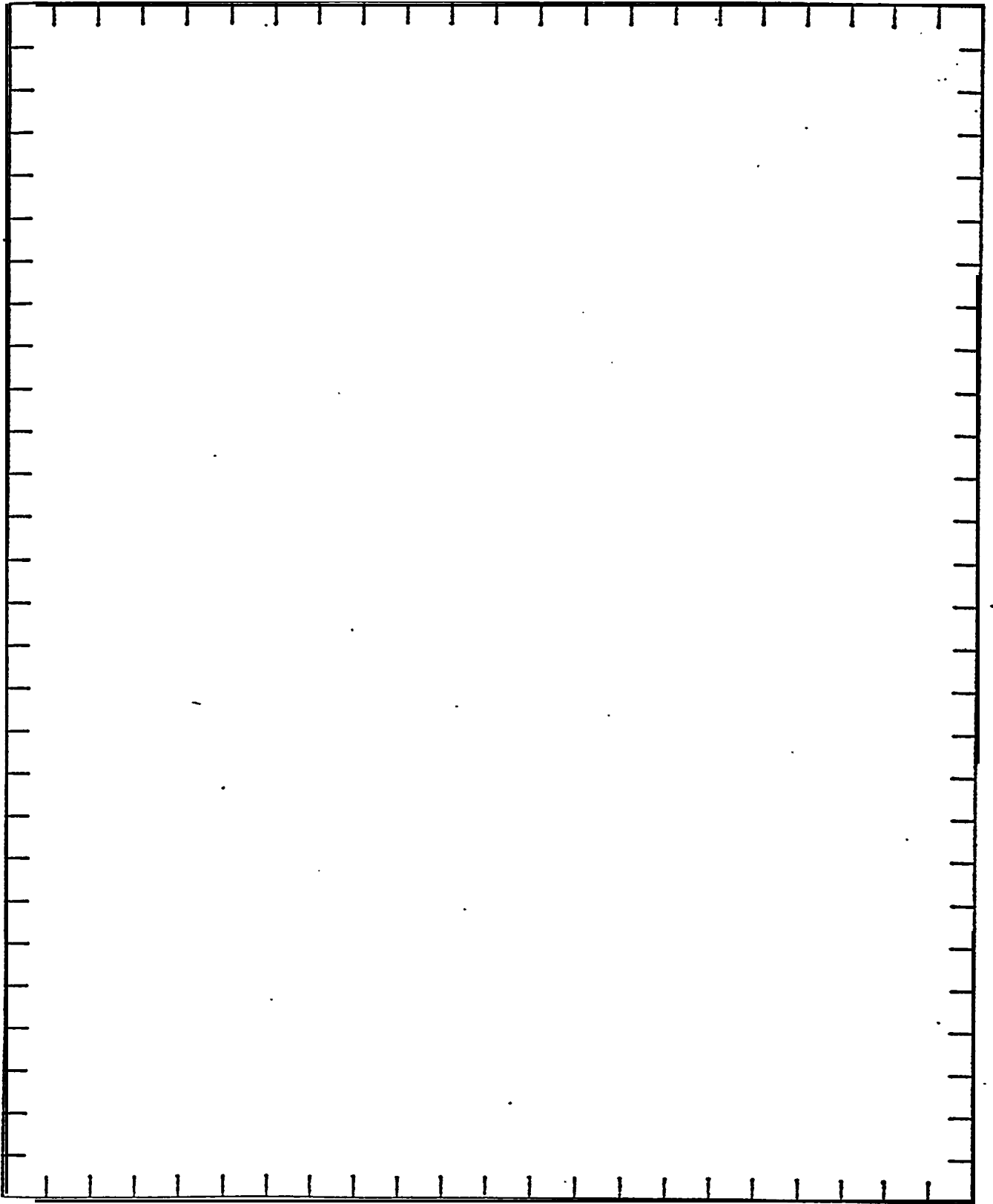
3. Programming capabilities and language 'as close to 'PARTGEN' as possible, so that people programming 'PARTGEN' and 'DEMO' are interchangeable. All 'PARTGEN' tools such as Math, Contours, Symbolic Calls, Loops and Reps will be available.

4. Added Commands for detail definition:

- a) S T I F
- b) S E A M
- c) H O L D
- d) B R K T
- e) I N N L

5. Looping capability:

programming of similar surfaces by modification to typical surface such that only changes have to be redefined.



Standard Grid for All Drawings

TAPE NO. 200002

EXAMPLES

1. Floors 46 through 53 are similar, with the exception of the location of the holes. The sample input deck draws two floors as typical configurations and loads all other floors by continuously modifying the location of the holes-
2. Bulkhead 31 is preloaded by 'HULLLOAD' with most of the vertical stiffeners.

Stiffeners T9, T10 and T11 are modified by 'DEMO'. Access door and seams are added.
3. Web frames 49 through 52 involved quite extensive calculations and developments showing the method of programming details.

***** EXAMPLE 1 : INPUT DECK TO DRAW CONTENTS OF THE DATA BASE
WEB FRAMES 46, 50, 52

*JOB	LNG DEMO	N	9001	12900100
INPS		N	9001	12900100
TRSV		FWD	F 46. F 50. F 52.	12900100
OPTN	SCAL	CUTS	V 48.	12900100
INPE				12900100

***** EXAMPLE 1 : INPUT DECK DEFINING AND LOADING DETAILS FOR
FLOORS FRAMES 46 THROUGH FRAME 52

*JOB	LNG DEMO	N	9002	129002000
INPS		N	9002	129002000

COMMAND DEFH -- DEFINING STANDARD HOLES

DEFH	30	15	7 8	1	129002000
	30	18	9	2	129002001
	12	6	3	3	129002001
TRSV	FWD	F 46.	F 50.	F 52.	129002002
ADDP	D TT	L 15	2	1	129002002
	M	P ORG		2	129002003

COMMAND LIMIT - DEFINING LIMITS OF DRAWING

LIMIT	P	2	P	1	129002003
OPTN	SCAL	CUTS	V 32.		129002004

START DEFINING DETAILS ON FRAME 46

ADDP	L L1	S 1	1	3	129002004
	P	3	-2	4	129002005
	M	L L1	1 3	-1 6	5
	M	S CVK	1 3	1 3	6
	D TT	S CVK	-1 3	1 3	7
	D TT	L L1	-1 3	-1 6	8
	L L1	S 2	1		10
	P	10	-2	9	129002007
CNTR					129002008
CORN	P	3			129002008
	P	4			129002008

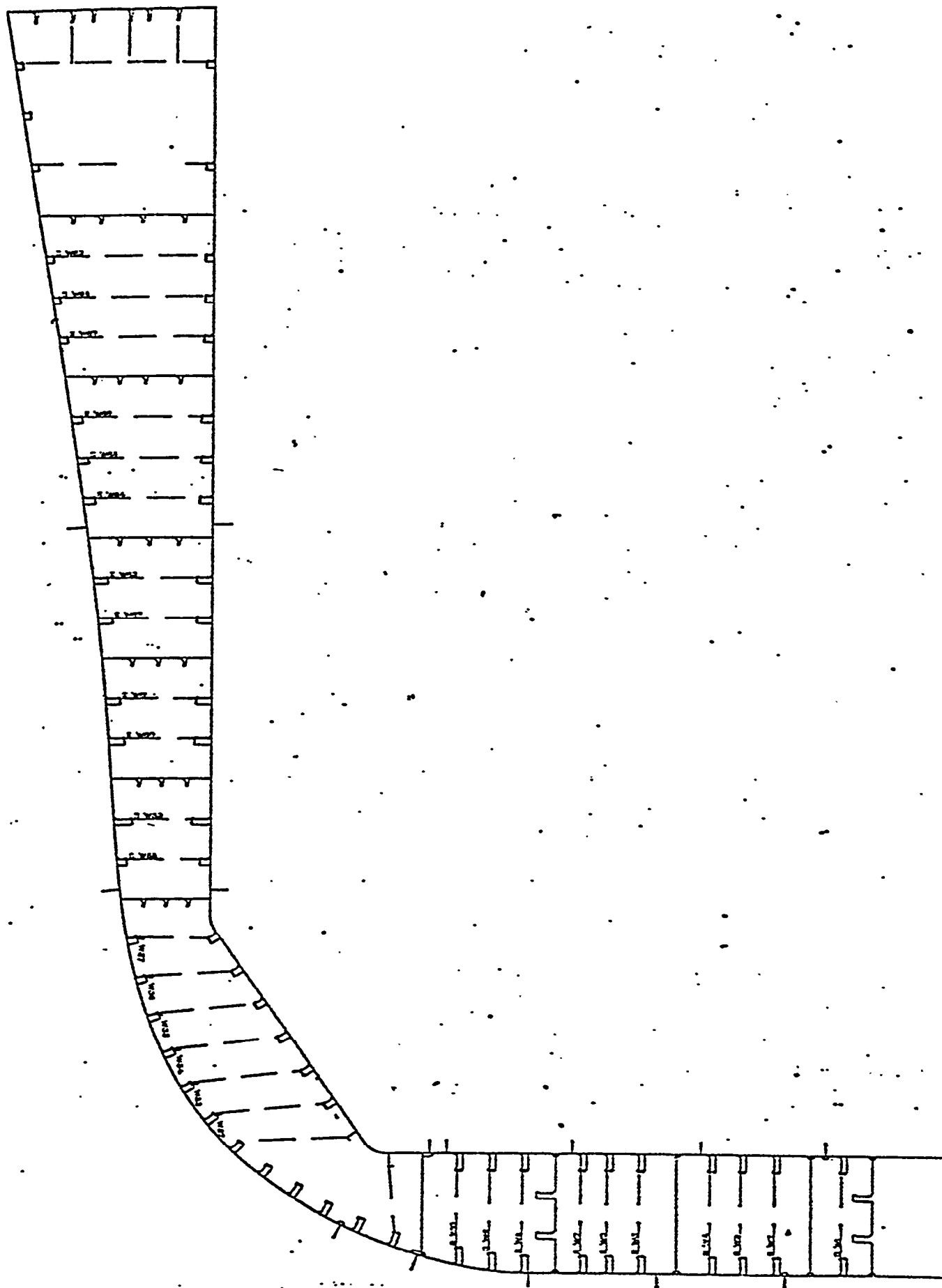
	P	5		9		12900200
	P	6		9		12900201
	P	7		9		12900201
	P	8		9		12900201
	P	9				12900201
	P	10				12900201
CTRE	HOLD		1	H	1	12900201
MIDN		M				12900201
SPLT			L L7	S	4 11	12900201
			S 14	S	6 12	12900201
HOLD		221	Y	11	H 3	2 12900201
		315	Y	12	H 4	2 12900201

LOAD DETAILS ON FRAME 46

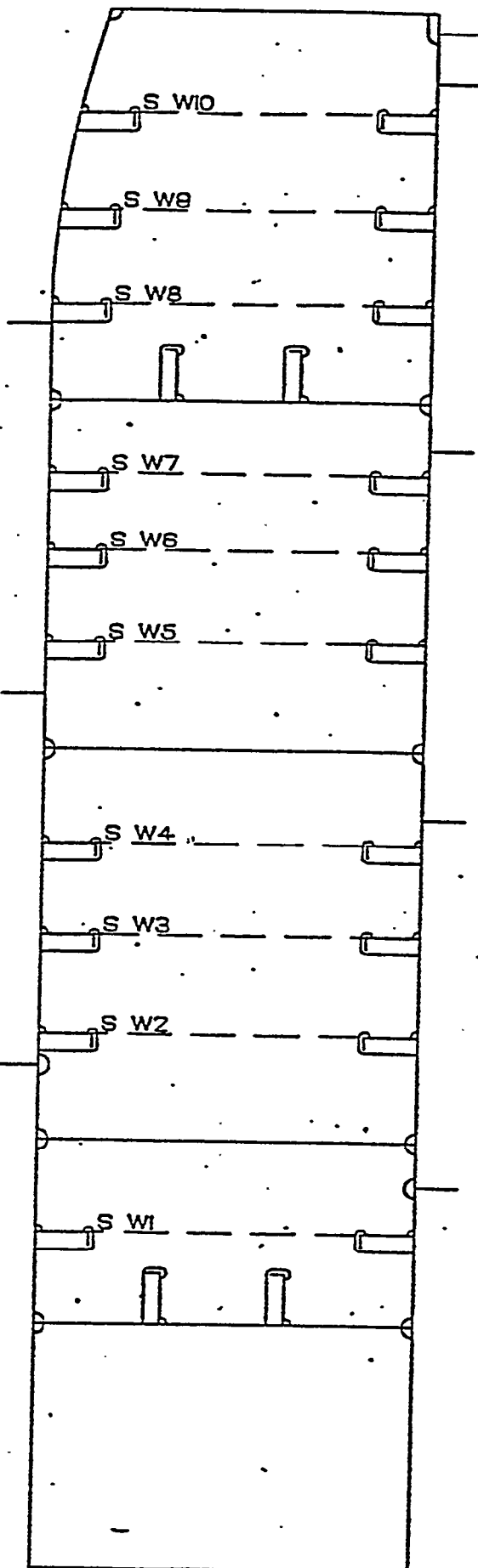
LOAD		F 46.				12900201

DEFINE DETAILS ON FRAME 47 THAT ARE DIFFERENT FROM FRAME 46

SPLT			L L7	S	5 11	12900201
			S 13	S	8 12	12900201
HOLD		221	Y	11	H 3	2 12900201
		221	Y	12	H 4	2 12900201
LOAD			F 47.			12900201
SPLT			S 11	S	8 12	12900201
HOLD		221	Y	12	H 4	2 12900201
LOAD			F 48.			12900201
SPLT			L L3	S	2 13	12900201
			L L11	S	8 12	12900201
HOLD		221	Y	13	H 2	1 12900201
		221	Y	12	H 4	2 12900201
LOAD			F 49.			12900202
SPLT			S 6	S	5 11	12900202
			L L11	S	9 12	12900202
			S 13	S	12 14	12900202
HOLD		221	Y	11	H 3	2 12900202
		221	Y	12	H 4	2 12900202
		315	Y	14	H 5	2 12900202
LOAD			F 50.			12900202
ADDP			S 12		9 6 15	12900202
HOLD		9	Y	13	H 6	3 12900202
		P	15 P	15	H 7	3 12900202
LOAD			F 51.			12900202
SPLT			S 10	S	9 12	12900202
HOLD		221	Y	12	H 4	2 12900202
		3 0 9	3211 8	H	5 2	12900202
LOAD			F 52.			12900202
DLET				H	6	12900202
				H	7	12900202
HOLD		3 0 9	34 9 4	H	5 2	12900202
LOAD			F 53.			12900202
INPE						12900202

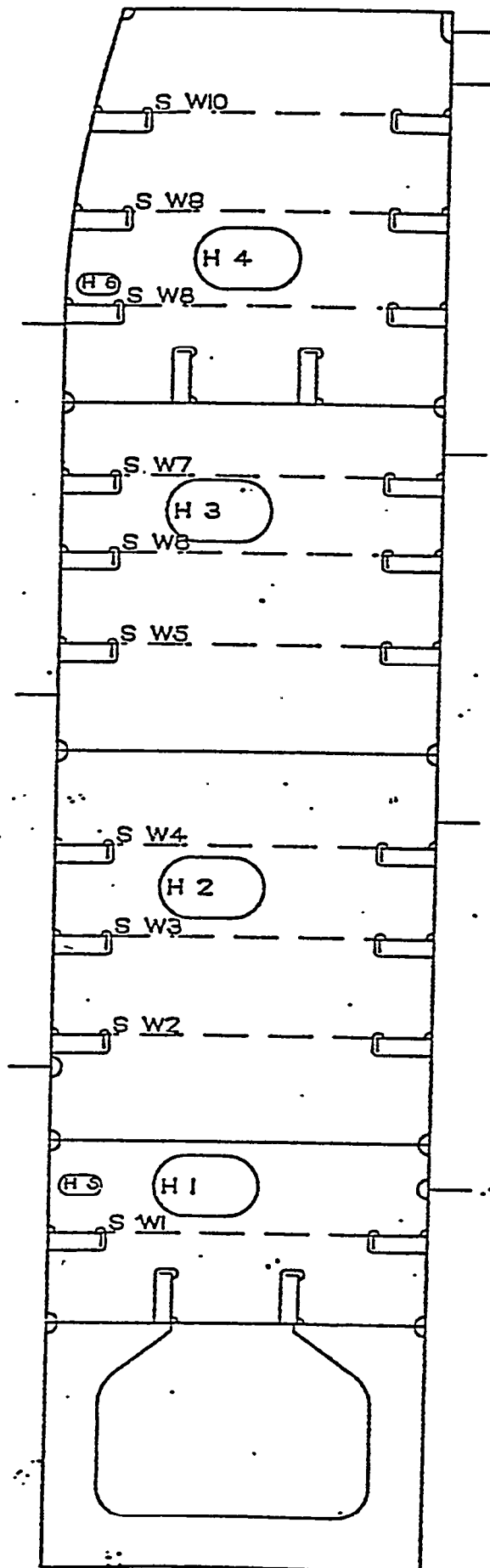


Example 1: Webframe 52
Drawing after 'HULLLOAD' only



Example 1: Floor 52
Drawing after 'HULLLOAD' only

Example 1: Floor 52
Drawing after detailing by 'DEMO'.



***** EXAMPLE 2 : INPUT DECK FOR DETAILING OF BULKHEAD 31

*JOB LNG DEMO N 9010 12901000
INPS N 9010 12901000

AUTOMATIC DRAWING FROM THE DATA BASE

TRSV FWD F 31. 12901000
OPTN SCALNTEE 48. 12901000

START DETAIL DEFINITIONS

CNTR CALC 12901000
SHEL P+ M 12901000
SLPE2 Y 2436 10 1 12901000
SLPE2 Y 1823 11 1 12901000
CTRE NOCT 12901000
CNTR CALC 12901000
DECK P+ D MDK 12901000
SLPE2 Y 1821 21 1 12901000
2 Y 2026 22 1 12901000
2 Y 2436 20 1 12901000
CTRE NOCT 12901000
ADDP D 46F P ORG 13 12901000
D 28F P ORG 14 12901000
D 2ND P ORG 1 2436 1 12901000
P 1 -1313 31 12901000
P 1 1313 32 12901000
P 31 52021 33 12901000
P 32 52021 34 12901000
P 1 11 9 2 5 2 12901000

ACCESS DOOR

CNTR 12901001
CORN P 32 12901001
P 34 13 8 12901001
P 33 13 8 12901001
P 31 12901001
CTRE HOLD 6 5 H D1 12901001

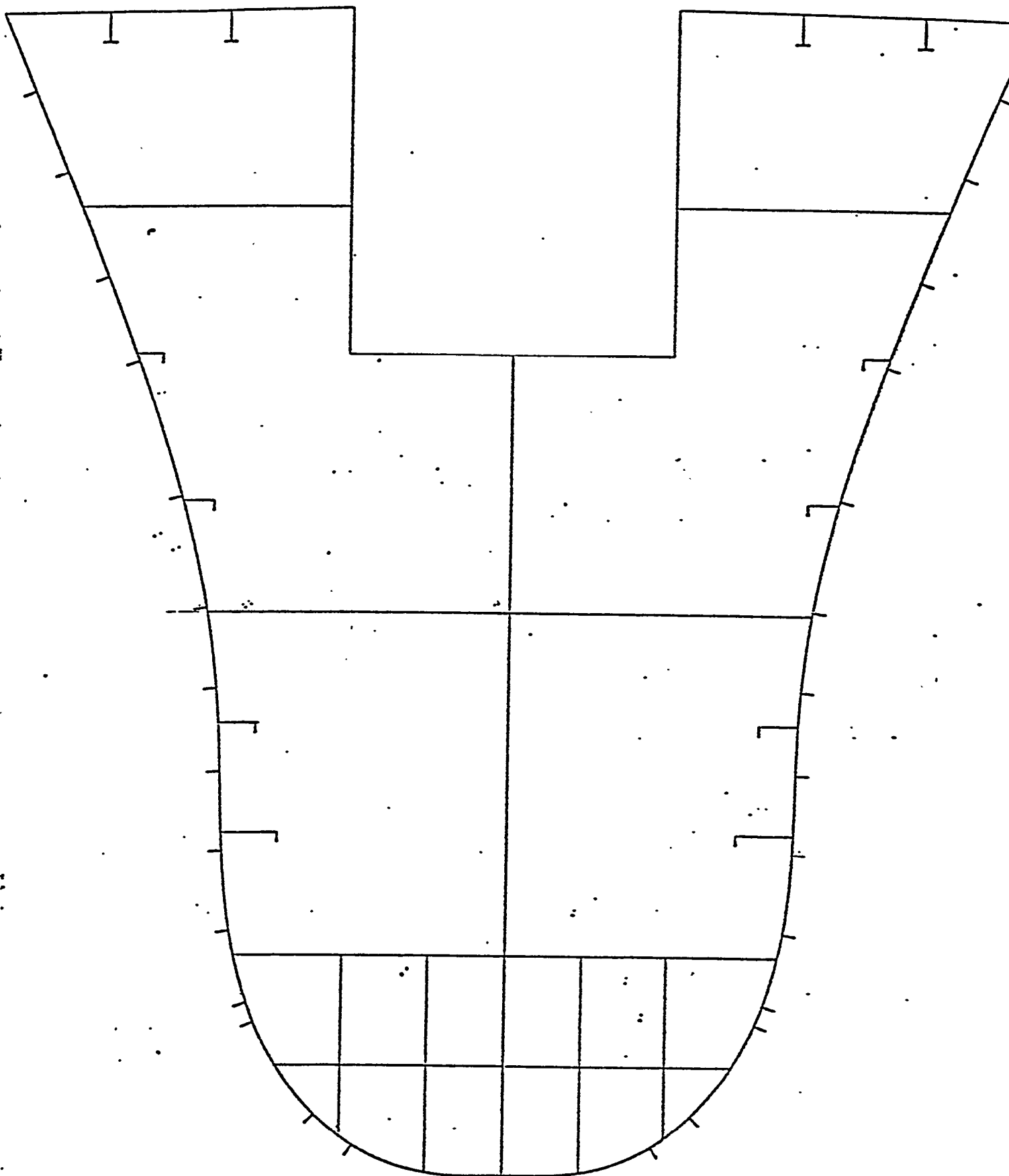
MODIFY STIFFENERS

PNCH3 P 20 P 2 12901001
STIF 502 LAPCSNPE ST22 P 12901001
PNCH3 P 1 P 10 12901001
STIF 503 SNPESNPE ST12 P 12901001
PNCH3 X 20-Y 20 X 10-Y 10 12901001
STIF 503 LAPCSNPE ST12 S 12901001
CNTR 12901001
MANU P 22 12901001
LINE X 13 2026 12901001

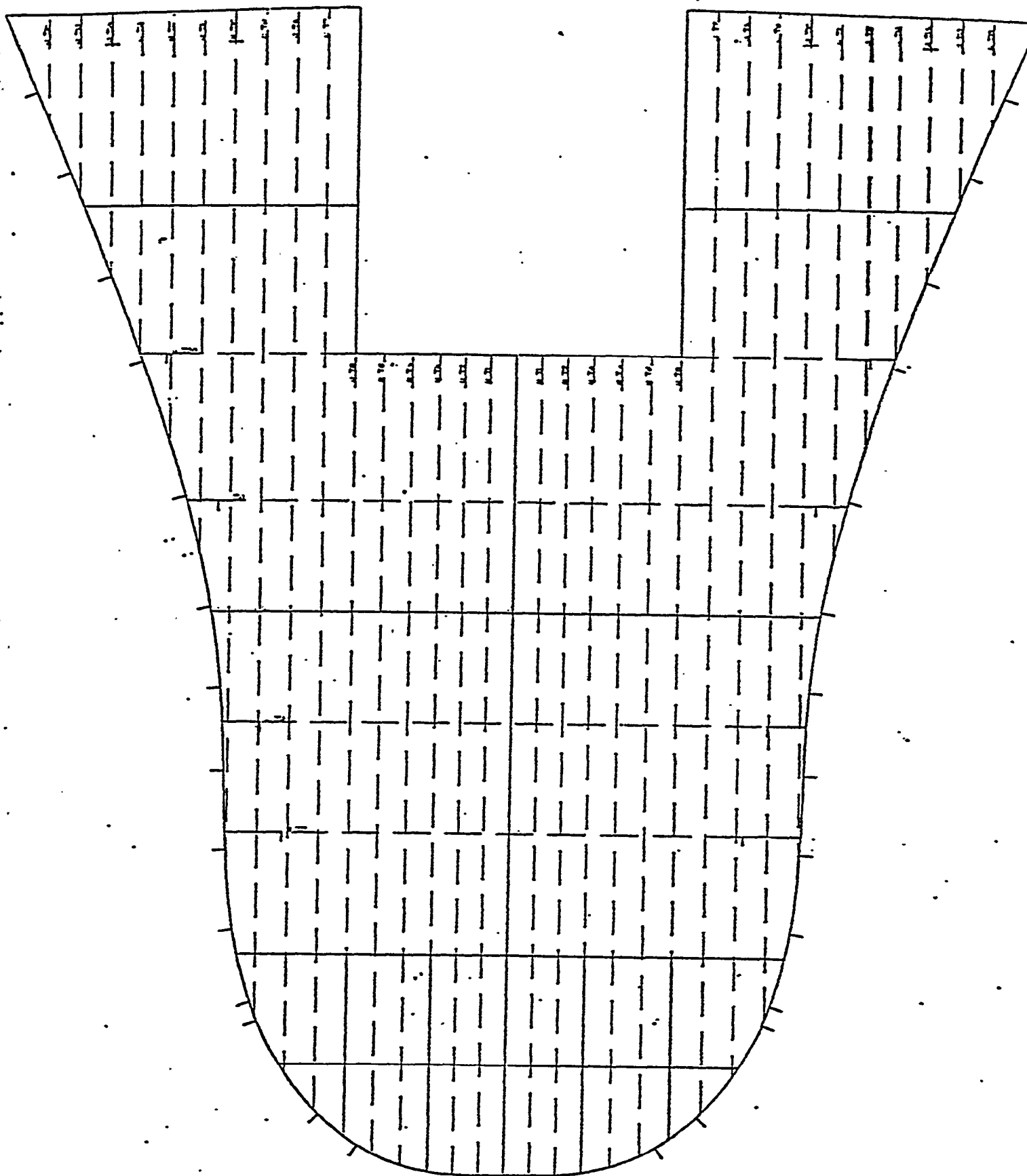
	X	14	1823			1290100160
	P	11				1290100164
TRE	STIFLAPCSNPE				ST10	1290100166
NTR						1290100172
ANU	P	21				1290100176
INE	X	13	1821			1290100180
	X	14	18 8			1290100184
TRE	STIFLAPCSNPE				S 10	1290100188

ADD SEAMS						

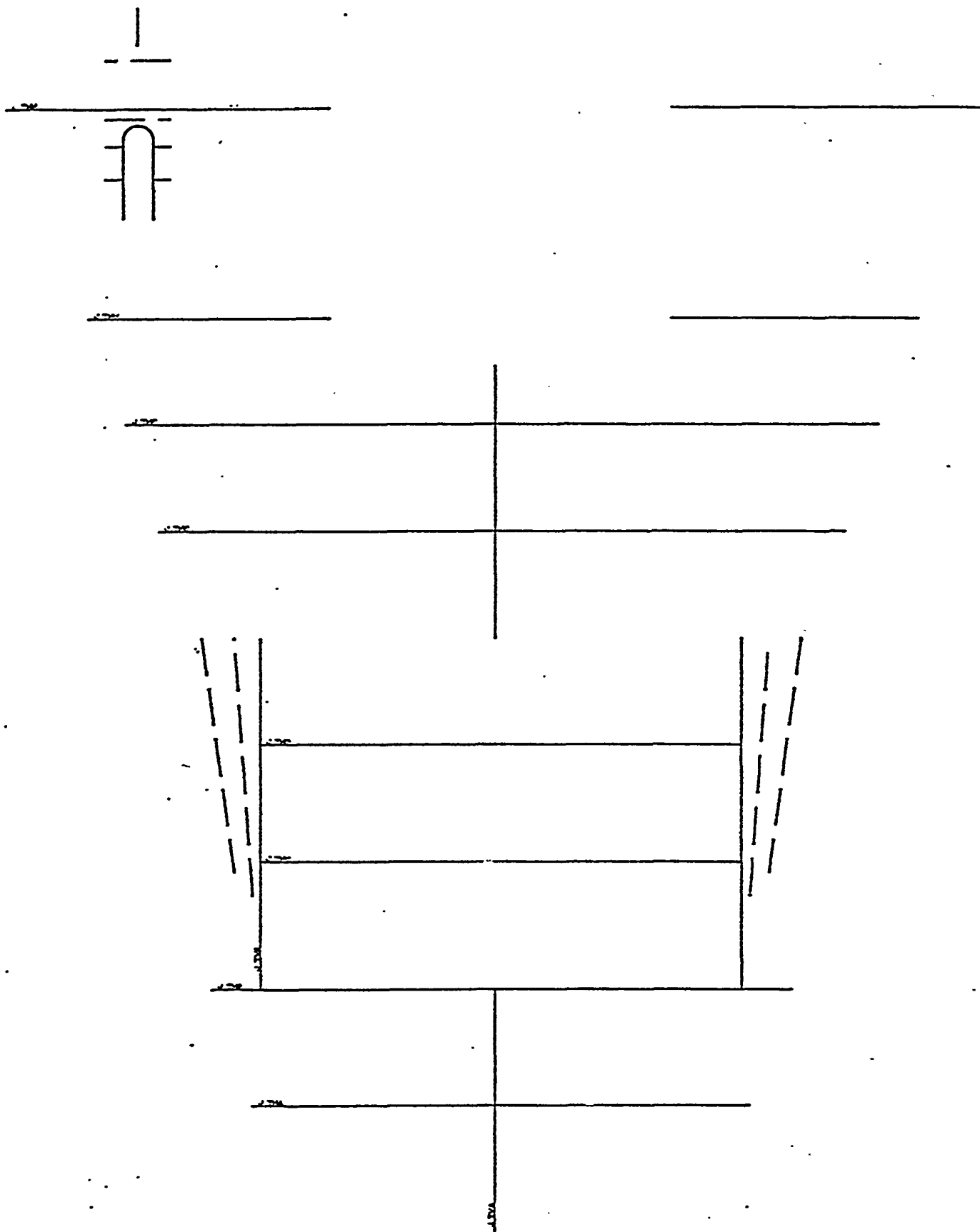
DDP		911				51 1290100200
	P	51				52 1290100204
	P	52		911		53 1290100208
	P	53		9		54 1290100212
	P	54		8 2		55 1290100216
	P	55		8 3		56 1290100220
	P	56		8 3		57 1290100224
	P	57		8 3		58 1290100228
	P	58		8 3		59 1290100232
	P	59		8		60 1290100236
NTR						1290100240
HEL	P+	M				1290100244
OOP	N	1 N	61 N	70		1290100248
TNO	L	1				1290100252
LPE2	XX	* -10				* 1290100256
NOL	N	1				1290100260
TRE	NOCT					1290100264
EAM	P	51		P	61	1290100268
	J HA		11		11	1290100272
EAM	P	52		P	62	1290100276
	J HB		11		10	1290100280
EAM	P	53		X	63 1711	1290100284
	J HC		10		10	1290100288
EAM	P	54		X	64 1711	1290100292
	J HD		10		9	1290100300
EAM	P	56		P	66	1290100304
	J HE		17		8	1290100308
EAM	P	57		P	67	1290100312
	J HF		8		7	1290100316
EAM	X	58	12 8	P	68	1290100320
	T HG		7		6	1290100324
EAM	X	60	12 8	P	70	1290100328
	T HH		5		5	1290100332
DDP	D 67F		P ORG		6 71	1290100336
EAM	P	71		X	55 6	1290100340
	J VB	P	8		8	1290100344
EAM	X	52	6	0	6	1290100348
	J VA	P	11		11	1290100352
EAM	X	55	1711	X	52 1711	1290100356
	T VC		10		10	1290100360
NPE						1290100364



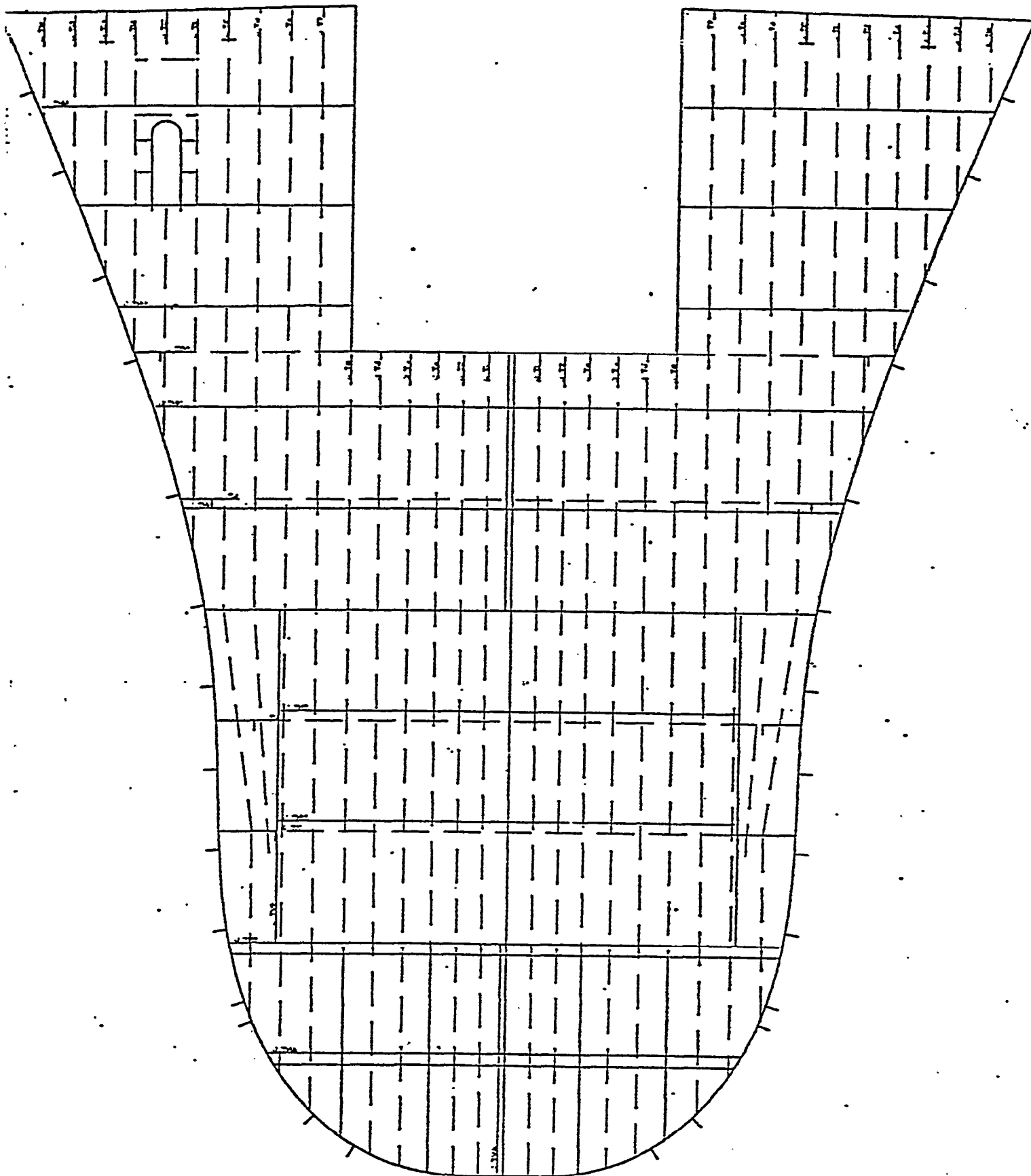
EXAMPLE 2: Bulkhead 31
Drawing of major structure after 'HULLLOAD'



Example 2: Bulkhead 31
Drawing of loaded details after 'HTLLOAD'



Example 2: Bulkhead 31
Details programmed in 'DEMO'



Example 2: Bulkhead 31
Final drawing after detailing by 'DEMO'

***** EXAMPLE 3.: INPUT DECK FOR DETAILING OF WEBFRAMES 52 THROUGH 50

```

*****
*JOB LNG DEMO      N      9003      12900301
INPS              N      9003      12900301
-----
      AUTOMATIC DRAWING FROM THE DATA BASE
-----
IRSV      FWD      F 52.      F 50.      12900301
LIMIT      M      S 14      D MDK      P END      12900301
OPTN      SCAL      CUTS      V 48.      12900301
-----
      START DETAILING
      COMMAND LAPC - DEFINING STANDARD END CONNECTIONS
-----
DEFH      23      15      1      12900301
LAPC      3      1 8      1 8      12900301
-----
      DEFINE SEAMS
-----
ADDP      D 28F      P END      -4      1      12900301
          D 67F      P END      -8      2      12900301
          D 2ND      P END      -6      3      12900301
          D 2ND      P END      8 0 9      3      4      12900301

CNTR      CALC      P+
SHEL
SLPE2      Y D TT      P END      520 12900301
2      XX      1      5 1 12900301
2      XX      2      5 2 12900301
2      XX      3      5 3 12900301
2      XX      4      5 4 12900301

LINK      NEW
LBHD      P+      L LB6
SLPE2      XX      1      511 12900301
2      XX      2      512 12900301
2      XX      3      513 12900301
2      XX      4      514 12900302

CTRE      NOCT
SEAM      P      1      P      11      12900302
          J WK      10      P      12      12900302
          P      2      P      12      12900302
          J WL      9      P      13      12900302
          P      3      P      13      12900302
          J WM      9      P      14      12900302
          P      4      P      14      12900302
          J WN      9      P      14      12900302
          M      SS 23      L LB6      SS 18      12900302
          J WJ      1      10      12900302

```

DEFINE HOLES

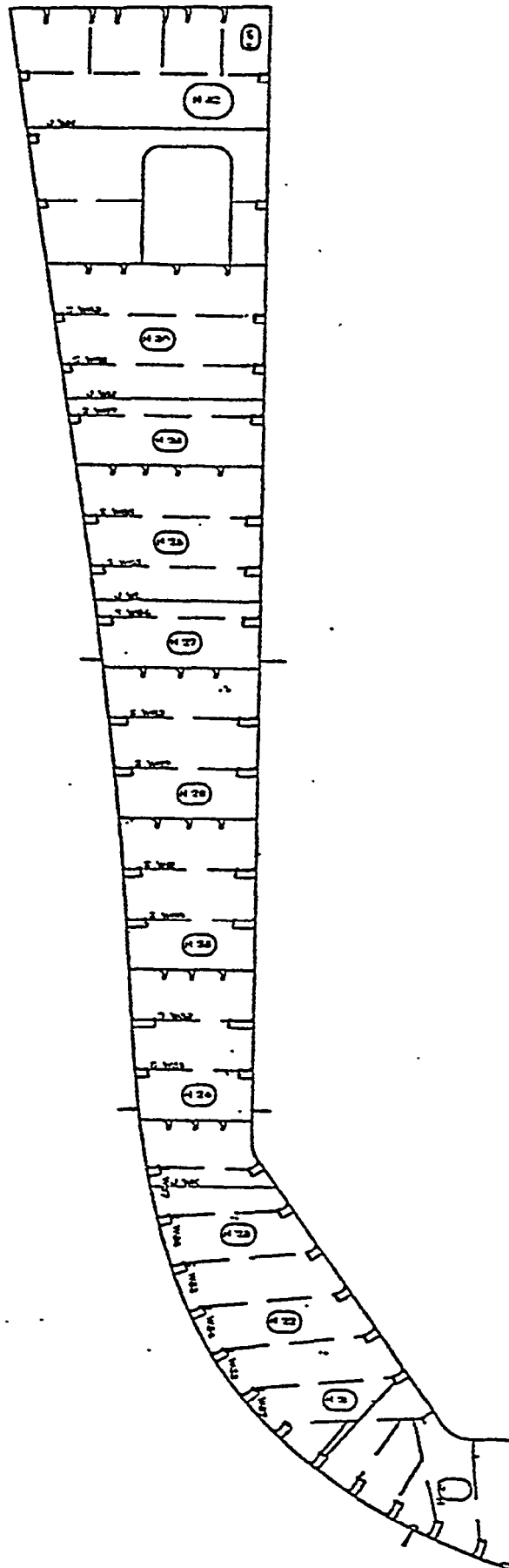
ADDP	P	20		3 6		20	12900302
HOLD	P	20		A 0.	H 20	1	12900302
MIDN	L LB6						12900302
SPLT	IS 17			M	IS 24	18	12900302
	IS 18			M	IS 25	19	12900302
	P	18		P		21	12900302
	IS U			M	IS 26	18	12900302
	IS 20			M	IS 27	19	12900302
	P	18		P		22	12900302
	IS 21			M	IS 28	18	12900302
	IS 29			M	IS 29	19	12900302
	P	18		P		23	12900302
	D 28F			M	D 28F	18	12900303
	IS 32			M	IS 32	19	12900303
	P	18		P		24	12900303
	D 37F			M	D 37F	18	12900303
	IS 35			M	IS 35	19	12900303
	P	18		P		25	12900303
	D 46F			M	D 46F	18	12900303
	IS 38			M	IS 38	19	12900303
	P	18		P		26	12900303
	D 55F			M	D 55F	18	12900303
	IS 41			M	IS 41	19	12900303
	P	18		P		27	12900303
	IS 42			M	IS 42	18	12900303
	IS 43			M	IS 43	19	12900303
	P	18		P		28	12900303
	S 67F			M	D 67F	18	12900303
	IS 45			M	IS 45	19	12900303
	P	18		P		29	12900303
	IS 46			M	IS JL	18	12900303
	IS 47			M	IS 47	19	12900303
	P	18		P		30	12900303
LOOP	N	1 N	21 N				12900303
PTNO	L	1					12900303
HOLD	P *			A 90.	HLOOP 1	1	12900303
ENDL	N	1					12900304
ADDP	L LB6		S 50	2 1	3 4 8	32	12900304
HOLD	P	32		A 909	H 32		12900304
		33	24				12900304
		6	12				12900304
ADDP	D MDK		L LB6	-22	13	33	12900304
HOLD	P	33			H 33		12900304
		18	12				12900304
ADDP	L LB6		D 2ND		11015	40	12900304
	P	40			5 18	44	12900304
	P	40		7 9		41	12900304

CNTR	P	44		7	9		43	12900304
CORN	P	40						12900304
	P	41			12	9		12900304
	P	42			12	9		12900304
	P	43						12900304
CTRE	HOLD	6		9			H 31	12900304

DEFINE STIFFENERS								

ADDP	M		IS 24				49	12900304
VECT	L LB6		IS 17	P	49		6 50	12900304
LINT	P	50		P	49			12900304
	M		IS 22	A*			51	12900304
	M		IS 20	P	50			12900304
	M		IS 21	A*			52	12900304
	P	49		P	50			12900305
	M		IS 23	A*			53	12900305
PNCH3	M		IS 20	P	50			12900305
STIF 501NSIDLAPCSNPE					1 8	S 101		12900305
PNCH3	M		IS 21	P	52			12900305
STIF 501NSIDLAPDSNPE					1 8	S 102		12900305
PNCH3	M		IS 22	P	51			12900305
STIF 501NSIDLAPCSNPE					1 8	S 103		12900305
PNCH3	M		IS 23	P	53			12900305
STIF 501NSIDLAPCSNPE					1 8	S 104		12900305
LINT	L LB6		S 51	M		S 51		12900305
	D MDK		S 23	A*			60	12900305
	L LB6		S 51	M		S 51		12900305
	D MDK		S 23B	A*			61	12900305
	L LB6		S 51	M		S 51		12900305
	D MDK		S 24A	A*			62	12900305
	L LB6		S 51	M		S 51		12900305
	D MDK		S 25	A*			63	12900305
LAPC		2	S		7			12900305
PNCH2	D MDK		IS 23	P	60			12900305
STIF 502NSIDLAPCSNPE					7	S W73		12900305
PNCH3	D MDK		IS 23B	P	61			12900305
STIF 502NSIDLAPCSNPE					7	S W74		12900305
PNCH3	D MDK		IS 24A	P	62			12900305
STIF 502NSIDLAPCSNPE					7	S W75		12900306
PNCH3	D MDK		IS 25	P	62			12900306
STIF 502NSIDLAPCSNPE					7	S W 76		12900306
ADDP	L LB6		S 49			11015	64	12900306
	M		S 49				65	12900306
PNCH3	L LB6		IS 49	P	64			12900306
STIF 503MSIDLAPCSNPE					7	S 105		12900306
PNCH3	M		IS 49	X	65	Y	44	12900306
STIF 503NSIDLAPCSNPE					7	S W70		12900306

LOAD FRAME 52							
LOAD		F 52				129003063	
REDEFINE STIFFENERS FOR FRAME 51 AND 50							
HOLD	P	29		A 90.	H 29	1	129003064
	P	30		A 90.	H 30	1	129003064
LINT	L LB6	S 51		M	S 51		129003064
	D MDK	IS 23A		A*		66	129003065
	L LB6	S 51		M	S 51		129003065
	D MDK	IS 24B		A*		67	129003066
	L LB6	S 51		M	S 51		129003066
	D MDK	IS 24		DD 2ND	S 2B	68	129003066
	L LB6	S 50		M	S 50		129003067
	D MDK	IS 24		D 2ND	S 2B	69	129003067
	L LB6	S 49		M	S 49		129003068
	D MDK	IS 24		D 2ND	S 2B	70	129003068
	D 2ND	IS 2A		D 67F	S 2A		129003068
	L LB6	S 47		M	S 47	71	129003069
	D 2ND	IS 2A		D 67F	F 2A		129003070
	L LB6	S 46		M	S 46	72	129003070
	D 2ND	IS 2A		D 67F	S 2A		129003070
	L LB6	S 45		M	S 45	73	129003071
PNCH3	D MDK	IS 23A		P 66			129003071
STIF 502NSIDLAPCSNPE					7 S W77		129003072
PNCH3	D MDK	IS 24B		P 67			129003072
STIF 502NSIDLAPCSNPE					7 S W78		129003072
PNCH3	D MDK	IS 24		P 68			129003073
STIF 502NSIDLAPCSNPE					7 S W79		129003073
ONCH3	P	68		P 69			129003074
STIF 502NSIDSNPESNPE				7	7 S W80		129003074
ONCH3	P	69		P 70			129003074
STIF 502NSIDSNPESNPE				7	7 S W81		129003075
PNCH	P	70		D 2ND	S 2B		129003075
STIF 502NSIDSNPESNPE				7	7 S W82		129003076
PNCH3	D 2ND	IS 2A		P 71			129003076
STIF 502NSIDLAPCSNPE					7 S W83		129003076
PNCH3	P	71		P 72			129003077
STIF 502NSIDSNPESNPE				7	7 S W84		129003077
PNCH3	P	72		P 73			129003078
STIF 502NSIDSNPESNPE				7	7 S W85		129003078
PNCH3	P	73		D 67F	S 2A		129003078
STIF 502NSID SNPESNPE				7	7 S W86		129003079
LOAD FRAMES 51 AND 50							
LOAD		F 51.		F 50.		1.	
INPE						129003080	
						129003080	



Example 3 : Window of Webframe 52
after detailing by 'DEMO'

APPENDIX 1

HULLLOAD INPUT REQUIRED TO LOAD
STIFFENERS 'TO DATA BASE

***** EXAMPLE 1 : INPUT DECK TO DEFINE AND LOAD
VERTICAL STIFFENERS ON BULKHEAD 31.

```

-----
*JOB LNG HULDDISK      N      3001                                17300100
INPS      16TH      N      3001                                17300100
TRAC TBHD      T 31.                                17300100
TOLR      100      100                                17300100
STIF NAME      S T1      S T2      S T3      S T4      17300100
      S T5      S T6      S T7      S T8      17300100
      S T9      S T10      S T11      S T12      17300100
      S T13      S T14      S T15      S T16      17300100
      S T17      S T18      S T19      S T20      17300100
REFR      L CLB      Y P ORG                                17300100
CNCT2EQSP      M      Y      20500      D 67F      17300100
REPT      M      Y S 1      D 67F      17300100
CNCT2      M      Y S 7      D 67F      17300100
      2EQSP      M      Y      -20500      C 67F      17300100
REFR      M      Y S 7      17300100
CNCT2EQSP      M      Y      20500      D MDK      17300100
REPT      M      D MDK      Y S 10      17300100
      M      D MDK      Y S 14      17300100
      D MDK      Y P END      17300100
INPE                                17300199
-----

```

***** EXAMPLE 2 : INPUT DECK TO DEFINE AND LOAD
 VERTICAL STIFFENERS ON TRANSVERSE FLOORS
 AT FRAMES 46 THROUGH 52.

```

*JOB LNG HULDDISK      N      3002      173002000
INPS      16TH      N      3002      173002000
LOOP      N      1 N  460000 N  520000 N  10000      173002000
TRAC TBHD      T R      1      173002000
STIF NAME      S W1      S W2      S W3      S W4      173002000
      S W5      S W6      S W7      S W8      173002000
      S W9      S W10      173002000
CNCT      M      S 2      D TT      S 2      173002000
:REPT      M      S 14      D TT      S 14      173002000
ENDL      N      1      173002000
INPE      173002990
  
```

***** EXAMPLE 3 : INPUT DECK TO DEFINE AND LOAD
STIFFENERS ON WEBFRAMES 46, 50 AND 52.

```

*JOB LNG HULDDISK      N      3003      173003999
INPS      16TH      N      3003      173003000
LOOP      N      1 N 460000 N 520000 N 20000 173003000
IFEO      L      1 N 480000 N      99 173003000
TRAC TBHD      T R      1 173003000
STIF NAME'      S W50      S W51      S W52      S W53 173003000
      S W54      S W55      S W56      S W57 173003000
      S W58      S W59      S W60      S W61 173003000
      S W62      S W63      S W64      S W65 173003000
      S W66      S W67      S W68      S W69 173003000
      S W70      S W71      S W72      S W73 173003000
CNCT      M      S 19      D TT      S 16 173003000
      L LB6      S 17      M      S 24 173003000
REPT      L LB6      S 51      M      S 51 173003000
NTRY      N      99 173003000
ENOL      N      1 173003000
INPE      173003999

```

EXAMPLE OF PART CODING
AFTER USE OF DETAIL ENGINEERING MODULE

1 2 3 4 5 6 7
123456789012345678901234567890123456789012345678901234567890123456789012345678901234567

INPUT UPDATING DATE 17/10/75 TIME 18/31/54 RUN NO. 2
JOB LNG PRG. PART INPUT ID. 6515 REV. NO. 4 PAGE

INPS	N.	6515	375	10651501
RMKS	EXAMPLE OF PART			10651501
	CODING AFTER			10651501
	USE OF DETAIL			10651501
	ENGINEERING MOD			10651501
TRSV	F 52.			10651501
DPWG	11-03-03			10651501
STRT	M	L L15		10651501
LINE2	8-6		1	10651501
PART				10651501
OUTP				10651501
CNTR	DOWNOUTP			10651501
DECK	P+ D TT			10651501
LINK	RND	- 24		10651501
LEND	P+ L LB6			10651501
LINK	INT			10651501
DECK	P+ D MDK			10651501
LINK	INT			10651501
SHEL	P- M			10651501
CTRE				10651501
MIDN	D-TT			10651501
DECT	SPL L L15			10651502
MIDN	L LB6			10651502
RNGE	P-GRG	END		10651502
RATH2	X P END	3		10651502
MIDN	D MDK			10651502
RNGE	S-23	P-END		10651502
RATH2	Y P END	3		10651502
MIDN	M			10651502
RNGE	D MDK	J D		10651502
DECT	SPL L L15			10651502
LINE	P	1		10651502
MIDN	M			10651502
LOOP2	DN	1 D 28F	D 2ND	10651502
CNTR	CUTSCNLY			10651502
DECK	P+ DLOOP-1			10651502
CTRF				10651502
MIDN	DLOOP 1			10651502
RNGE	L-LF6	P-END		10651502
CUTE				10651502
ENCL	N	1		10651502
DEHL				10651502
DEMK				10651502
ENDP	PSEF1/PE			10651502
DELT	M	S-14	M	D MDK
MOVE2		O Y	99	
PAPT	DET.6-A POC.104			
POEF	R-J WJ			
PCID	PC.194*	M	S 15	A O.
ENDP	STOPTAPE	1 0		2 0
MOVE2		3-0		
PAPT	DET.6-A PC.183			

1		2		3		4		5		6		7			
1234567890123456789012345678901234567890123456789012345678901234567		1234567890123456789012345678901234567890123456789012345678901234567		1234567890123456789012345678901234567890123456789012345678901234567		1234567890123456789012345678901234567890123456789012345678901234567		1234567890123456789012345678901234567890123456789012345678901234567		1234567890123456789012345678901234567890123456789012345678901234567		1234567890123456789012345678901234567890123456789012345678901234567			
INPUT UPDATING				DATE 12/10/75				TIME 10/21/54				RUN NO. 2			
JOB LNG		PROG. PART		INPUT ID. 6515				REV. NO. 4				PAGE			
PDEF	PCID	PC.182#	J WJ	M	IS 21	J VK	A -90	2	0	10651503					
ENDP	STORTAPE				10					10651503					
MOVE2					3	0					10651503				
PART DET.6-A PC.182										10651503					
PDEF	PCID	PC.182#	R J WK	M	IS 30	D 28F	A -90.	2	0	10651503					
ENDP	STORTAPE				12					10651503					
MOVE2					3	0					10651503				
PART DET.6-A PC.179										10651503					
PDEF	PCID	PC.179#	R D 28F	M	IS 33	D 37F	A -90.	2	0	10651504					
ENDP	STORTAPE				13					10651504					
MOVE2					3	0					10651504				
PART DET.6-A PC.172										10651504					
PDEF	PCID	PC.172#	R D 37F	M	IS 36	D 46F	A -90.	2	0	10651504					
ENDP	STORTAPE				0					10651504					
MOVE2					3	0					10651504				
PART DET.6-A PC.171										10651504					
PDEF	PCID	PC.171#	R D 46F	M	IS 39	D 55F	A -90	2	0	10651504					
ENDP	STORTAPE				9					10651504					
MOVE2					3	0					10651504				
PART DET.6-A PC.281										10651504					
PDEF	PCID	PC.281#	R D 55F	M	IS 41	J WL	A -90.	2	0	10651504					
ENDP	STORTAPE				9					10651504					
MOVE2					3	0					10651505				
PART DET.6-A PC.166										10651505					
PDEF	PCID	PC.166#	R J WL	M	IS 43	D 67F	A -90.	2	0	10651505					
ENDP	STORTAPE				9					10651505					
MOVE2					3	0					10651505				
PART DET.6-A PC.164										10651505					
PDEF	PCID	PC.164#	R D 67F	M	IS 45	J WM	A -90.	2	0	10651505					
ENDP	STORTAPE				0					10651505					
MOVE2					3	0					10651505				
PART DET.6-A PC.163										10651505					
PDEF	PCID	PC.163#	R J WM	M	IS 47	D 2ND	A -90.	2	0	10651505					
ENDP	STORTAPE				9					10651505					
MOVE2					3	0					10651505				
PART DET.6-A PC.150										10651505					
PDEF	PCID	PC.150#	R D 2ND	M	IS 40	J WM	A -90.	2	0	10651506					
ENDP	STORTAPE				0					10651506					
MOVE2					3	0					10651506				
PART DET.6-A PC.155										10651506					
PDEF	PCID	PC.155#	R J WM	M	IS 40	J WM	A -90.	2	0	10651506					
ADDP					D MDK	L LR6	-22 0	+13 0	90	10651506					

APPENDIX K

LSCO FINAL REPORT - SUB-TASK 2.1 COMPUTER-AIDED DESIGN SYSTEMS

FINAL REPORT--SUB-TASK 2.1
COMPUTER AIDED DESIGN SYSTEMS

CONTENTS

- I. SUMMARY
- II. COMPARISON ANALYSIS CONCLUSIONS
- III. IHI PRODUCTION IMPROVEMENT SUGGESTIONS
- IV. CHANGE ANALYSIS CONCLUSIONS
- V. RECOMMENDATIONS
- VI. REFERENCES

Sub-Task 2.1 Final Report Computer-Aided Design

I. Summary

Sub-task 2.1 began in November 1978 with a meeting of IHI and Levingston representatives. This first meeting was held primarily to determine the method of approach which would provide accurate descriptions of both systems from which detailed comparisons could be made. From such comparisons, deficiencies in the Levingston system could be isolated and recommendations for change could be developed.

Thus, IHI began its investigation of the Levingston system which continued through February of 1979. The result of this investigation was detailed report prepared by Masumi Hatake of IHI. This report consists of three sections: 1. Examine and Study the SPADES System; 2. IHI System; and 3. Comparison of the Capabilities between Levingston's SPADES System and IHI System. Each section is described as follows:

The purpose of Section 1 was to determine if full utilization and benefit is being realized from the use of the system by Levingston. All available SPADES modules were studied (even though some have not been installed for use at Levingston). (Appendix 1, P. 1.3-1).

Section 2, the IHI System, adequately describes the characteristics and functions of each IHI system (module). (Appendix 1, p. 2.1-1 through 2.1-9). The relationships between the systems is shown in a flow chart. (Appendix 1; p-2-0-3).

Section 3, which compares the capabilities of the IHI system and the SPADES system, concludes that the capabilities of the two are almost equal. (Appendix 1, p.3.1.2). In addition analysis is provided on the adaptability of the IHI software to the SPADES system. (Appendix 1, p.3.1.2-1).

A meeting was held for the presentation of the report and to allow for explanations and discussions. (Technical memorandum-Appendix 12).

I. Continued

In conjunction with the above report, IHI also delivered to Livingston descriptions of the IHI computer design modules. The descriptions were used in the establishment of a detailed comparison table. This table is the basis for Livingston's report entitled "Study and Comparison of SPADES vs. IHI System". (Appendix 2). The comparison table was established according to the specific application of each module. The report consists mainly of a detailed explanation of the comparison table followed by conclusions.

A detailed deficiency analysis and trade-off study was not prepared due to the fact that IHI and Livingston both concluded that the SPADES system is adequate for Livingston's present and future needs. A memorandum to that effect was prepared and is attached as Appendix 3.

II. Comparison Analysis Conclusions

(RE: Appendix 2)

In general, the IHI N/C system and the SPADES N/C system are both very good. Whereas, IHI utilizes its system to its maximum capabilities, Levingston's use of SPADES is not so comprehensive due to lack of implementation and facilities. For example, the absence of an N/C drafting machine is partly the reason for not performing lines fairing in-plant, and for not installing the new DEMO-module of SPADES. The functions of HULLCAL, another SPADES module not in use at Levingston, are duplicated through the use of SHCP which is obtained from another source. HULLCAL directly references the data base but needs some improvements in capabilities, whereas SHCP requires a manual loading of data but adequately performs the necessary functions.

In each case, there is some justification for non-use of certain SPADES modules. Benefits of the additional machine capabilities from the installation of an N/C drafting machine may very well be offset by costly additional personnel requirements. Contracting lines fairing from outside sources may be less expensive than performing the same work in-plant, and definitely draws from the experience of the contractor in fairing many different hull types and shapes.

SPADES may have the advantage over the IHI system when comparing the modules that actually duplicate the old style lofting and template making methods due to easier input coding and full utilization of the data base set up with the Fairing and Hullload modules. (All SPADES modules access the data base, whereas some of the IHI modules are stand-alone systems.)

Implementation of the IHI system at Levingston is not necessary- The SPADES system currently available to Levingston is more than adequate for present and future needs.

The capability of SPADES is considered to be almost equal to the IHI system. Full configuration of the SPADES system covers much the same area as the IHI system, except for structural analysis and vibrational analysis (which are obtained by Levingston from other sources).

III. Production Improvement Suggestions - IHI

IHI strongly recommends that Livingston make full use of the SPADES system. (p.1.3-6, Appendix). Specifically, it is recommended that Fairing can be performed in-plant as opposed to the present practice of contracting this work, thus creating a time delay. Fairing the hull in-plant would enable a faster start on all design work. (p.1.3-5, Appenix 1).

In order to directly utilize the Fairing module, (as well as some other modules not currently used), IHI recommends the installation of a large drafting machine. (p.1.3-7, Appendix 1). This will also help eliminate duplicated work between the Mold Loft and Engineering. (p.1.3-5, Appendix 1). The drawings from the drafting machine can be used as the base drawings from which more detailed design can be performed as well as checking the drawing for input. (p.1.3-6, Appendix 1)

The DEMO module of SPADES is also facilitated through the installation of an N/C drafting machine. (p. 1.3-7, Appendix 1). According to the IHI report DEMO will provide the following:

- *Fast issue of working drawings
- *Easy and quick follow-up to design change
- *Exclusion of duplicated work
- *Manpower savings

As part of Sub-task 2.2, a justification analysis will examine these opinions in detail as to their validity.

VI. Change Analysis Conclusions

It was finally concluded by IHI and Levingston that SPADES offers enough depth, flexibility and future growth potential so that no changes involving the IHI system will be necessary. For this reason a brief explanation of this conclusion was submitted in the form of a memorandum in lieu of a formal change analysis document. (See Appendix 3.)

Some recommendations have been received to install additional N/C hardware. In relation to IHI's recommendations, this activity is directly related to Sub-task 2.2-Numerical Control Steel Fabrication. Upon actual installation of recommended equipment, expansion of Levingston's use of SPADES is to be expected. Monitoring and reporting of the installation of such hardware will be reported in the sub-task 2.2 Final Report. As Levingston's use of SPADES increases, reports to that effect can be submitted in addendum to the sub-task 2.1 final report.

V• Recommendations By IHI

IHI recommends, through Mr. Hatake's report, that Levingston should attempt to make full use of the SPADES system. (p.1.3-6 Appendix 1).

By installing a large N/C directed drafting machine, it would become possible to install two very helpful SPADES modules, Fairing and DEMO. Fairing is now done by Cali and Associates which creates additional expense and time delays. (p.1.3-5, Appendix 1). DEMO would contribute significantly to 1.) fast issue of working drawings, 2.) easy and quick follow-up to design change, 3.) exclusion of duplicated work (p.1.3-5, Appendix A) and 4.) manpower savings (in Engineering office p.1.3-6, Appendix A). (p.1.3-7, Appendix A).

As stated in Section III of this report, the benefits of the above recommendations will be weighed as part of sub-task 2.2.

VI. References (Appendices)

1. Study Of SPADES and LSCo Utilization - IHI
2. Study and Comparison of SPADES vs. IHI System - LSCo
3. Memorandum: Deficiency Analysis and Trade-Off Studies - LSCo
4. Brief Explanation of IHICS
5. IHICS - Input/Output Examples
6. SPECS
7. SPECS - Actual OUtput Example
8. Plate Users Manual and Output Sample
9. SHELL
10. LODACS
11. SPAC
12. Technical Memorandum: Meeting--1HI 2.1 Final Report (IHI)

APPENDIX L

LSCO FINAL REPORT - SUB-TASK 2.2 NUMERICAL CONTROL STEEL FABRICATION

FINAL REPORT--SUB-TASK 2-2
NUMERICAL CONTROL STEEL FABRICATION

CONTENTS

- I. SUMMARY
- II. COMPARISON ANALYSIS CONCLUSIONS
- III. IHI PRODUCTION IMPROVEMENT SUGGESTIONS
- IV. CHANGE ANALYSIS CONCLUSIONS
- V. RECOMMENDATIONS
- VI. REFERENCES

SUB-TASK 2.2 FINAL REPORT

1. SUMMARY

Work began on Sub-task 2.2 of the Technology Transfer Program in November 1978 when Levingston and IHI representatives met to discuss scope, approach and methods. As in Sub-task 2.1, the first step was to study and describe the IHI and Levingston system in order to quantify the present use of current system as compared to its potential capabilities. IHI's M. Hatake began a thorough study and investigation of the Levingston N/C system. At the same time, a documentation of the IHI N/C system was prepared. In March of 1979, IHI delivered a detailed report of their findings concerning Levingston's N/C system as well as a general description of the IHI N/C system. As the information was presented, items of comparison and contrast were identified.

A meeting was held for the formal presentation of this IHI report and to facilitate a question and answer session. Representatives of the Mold Loft and Engineering were afforded the opportunity to get a clear explanation of any item in the report they considered unclear or erroneous.

Levingston began a complete study and comparison of the two systems. The result of this report was a general comparison of the philosophies of N/C steel fabrication. A brief description of equipment used and the flow of events involved beginning with contract signing through actual fabrication was to be the basis of the resulting report. Consideration of IHI recommendations also became a major part of the task.

Deficiencies, or areas in need of improvements in methods, facilities or equipment, were identified in Levingston's deficiency analysis and trade-off studies report. Only the items considered by Levingston to be deficient may be so because of restrictions not prevalent in the IHI yards. However, for the most part IHI's recommendations were followed up with justification analyses which helped in the decision making of whether or not to implement change recommendations.

2.2 FINAL REPORT

II. COMPARISON ANALYSIS CONCLUSIONS

A. Philosophies on N/C Steel Fabrication

Two different philosophies of N/C steel fabrication have developed at IHI and Levingston. These differences are perhaps rooted in differing conditions which affect the shipyards. The abundance of skilled manpower, the close relationships between yards and sub-contractors, industry-wide standards and highly developed facilities, among other reasons, have all contributed to the present policies and methods utilized by IHI. At Levingston, in many cases, conditions are opposite of those at IHI. In turn, these conditions have had impact on Levingston's methods and policies regarding N/C steel fabrication.

In Japan, IHI is able to recruit mold loft and layout personnel from an abundant market of job seekers. They can also be relatively certain that once hired and trained, these employees 'Will remain at IHI until retirement, except in unusual circumstances.

At Levingston, and in the U.S. shipbuilding complex as a whole, there is a shortage of skilled lofting and layout personnel.

It follows that IHI's philosophy of N/C utilization for steel fabrication may be different than at Levingston, and it is. IHI tends to process through N/C only that steel which requires high precision and repetition of shape such as web frames, inner-bottom floors and curved shell plates. Flat, straight pieces are processed through the Panel Shop by a flame planer. Levingston, on the other hand, processes as much steel as possible through its N/C system, including flat and straight pieces.

At Levingston, plate marking for shape, structure locations, etc. is performed as much as possible by the N/C burning machine which is equipped with centerpunch marking heads. The necessary material marks and instructions are added manually after burning. Such marking is usually done before the plate is moved, but other pieces are burned simultaneously on other areas of the burning table.

On the other hand, IHI is equipped to perform a variety of N/C plate marking methods including zinc or plastic powder to form continuous line marks, manual marking of structure locations using steel tapes prepared from N/C generated data, and electro-photo marking .

At IHI-Aioi, a total of 25% of all plates for each Future 32 vessel was fabricated by the N/C equipment. By contrast, at Levingston almost all plates for a vessel are produced by N/C equipment.

II. COMPARISON ANALYSIS CONCLUSIONS, CONTINUED.

B. Equipment And Personnel

Levingston-Orange

*Punch marking on same machine
 *13 Loft personnel
 *1500 to 1800 tons/month

One (1) Burning Machine
 *Direct Control

*SPADES

IHI-Aioi

*Line marking-zinc powder burning
 *50 Loft personnel
 *6000 to 8000 tons/month

Three (3) Burning Machines
 Tape Control

*IHI System

C. Levingston Deficiencies Identified By IHI.

1. No alternate method of automatic burning for times when N/C burning machine is out of service.
2. No panel shops for rapid fabrication and assembly of flat and curved panels , complete with stiffeners, using a flame planer.
3. No numerically controlled drafting system for visual checking of data base for hull parts, template making for fabrication and bending, producing drawings for use with optical tracer type burning director and possible applications for producing working drawings for Engineering .

D. Results of Deficiencies Identification

1. As an alternative to cutting flat straight panels on the N/C burning machine, an optical 1:1 burner director has been installed to direct automatic burning machine when direct numerical control system is not in operation.
2. Work has begun or setting up a panel shop with a flame planer for flat panel fabrication.
3. A system change analysis was conducted with the result being a recommendation to implement the installation of a complete N/C drafting system in the mold loft.

III. IHI PRODUCTION IMPROVEMENT SUGGESTIONS

Since the volume of Levingston's steel fabrication is expected to increase due to the construction of the 36,000 D.W.T. dry bulk carriers, IHI has offered some suggestions such as leveling of the work load, rearrangement of shops and supporting work areas, etc.

Related to sub-task 2.2, IHI recommends consideration of an alternate method of automatic burning (to compensate for times when the present N/C burner is broken down) and installation of a large N/C drafting machine in the mold loft to facilitate a scaled plan system of lofting for template making, plate validation before burning, etc.

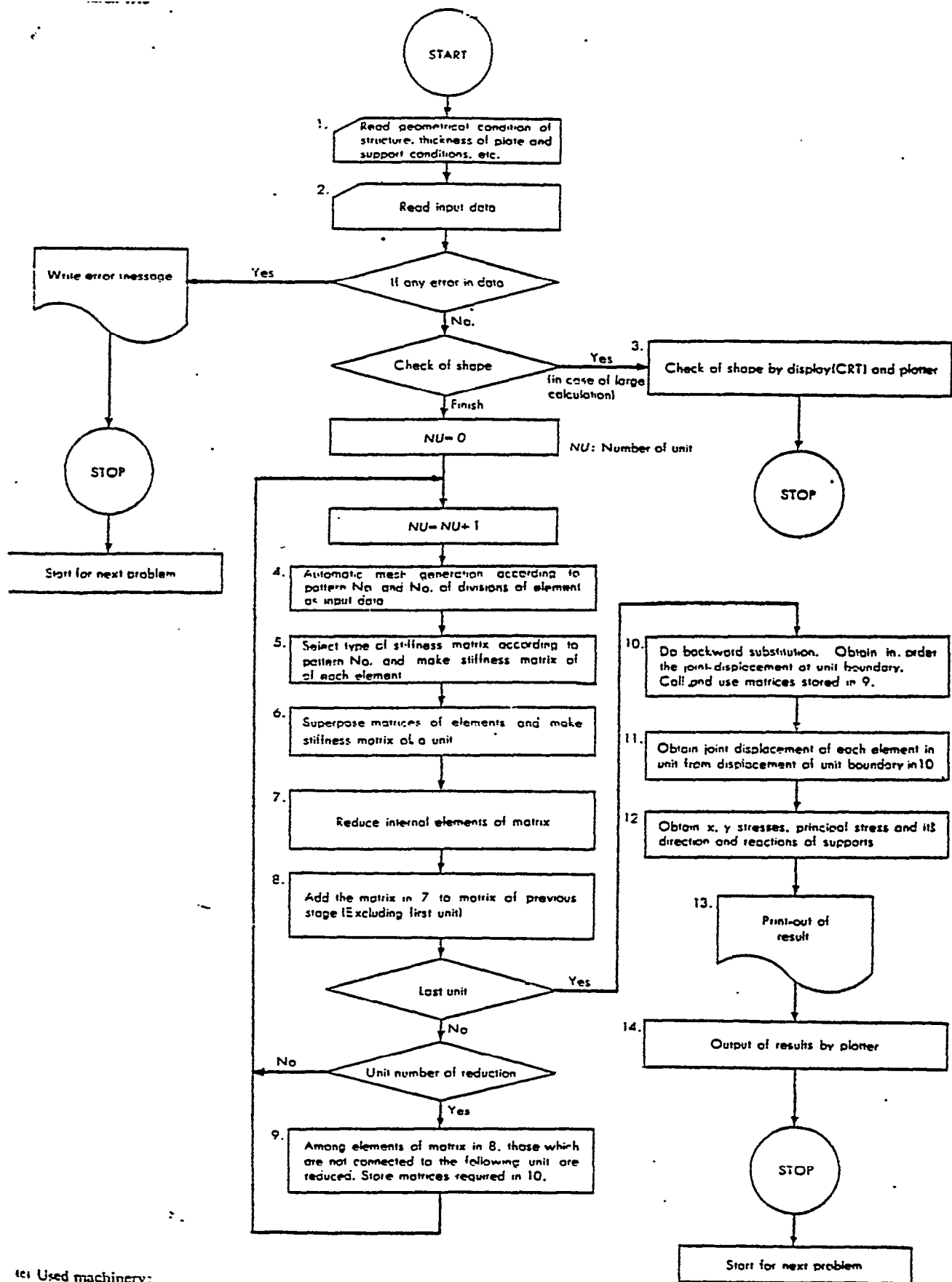
An alternate burning method of automatic burning has been installed as a result of IHI's suggestion. It is in the form of an optical 1:1 burner director. Thus, the main activity of this study is in the area of installing the N/C drafter in the mold loft.

IV. CHANGE ANALYSIS CONCLUSIONS

In almost all of IHI's reports concerning Levingston's N/C steel fabrication, it has been suggested that a major deficiency in the mold lofting and Engineering systems is the absence of a scaled body plan system utilizing an N/C drafting machine. As a result, the attached system change analysis (reference 5) was conducted. Supporting investigative and statistical data was received from IHI (reference 6) and from Levingston's Industrial Engineering Department (reference 3). This data is the basis for determining the results of changing to an N/C drafting system in the mold loft.

In general, it is concluded that the mold loft could successfully utilize a large table N/C drafting machine with the necessary related hardware for interface with the present system. The cost vs. estimated benefit study indicates paybacks in several areas including highly accurate data bank verification, part validation before burning, template making, and providing drawings for use with Levingston's optical tracer burning director.

It may be further concluded that a monetary cost payback due to high accuracy and saved lofting manhours is the obvious benefit of using such a system. But another benefit will accrue in the form of taking more time away from the total amount of time between contract signing and delivery date. These are the kinds of savings that can benefit Levingston now as well as making the U.S.A. ship-building market more attractive in the near future on a worldwide basis.



Used machinery:
 Computer: UNIVAC-1108
 Plotters: CALCOMP
 Display: ADAGE

Fig. 1 Flow chart of ZPLATE program

method item (2) is distinctively useful for structures with periodic identical patterns like ship hull structures. As to item (3), the program must be balanced with items (1) and (2) for saving labour of users. Otherwise, it is not meaningful no matter how refined the program is.

In item (5), an error message can be printed out and a check of structural geometrical data is to be done by plotter or graphic display. For item (6), automatic drawing of calculated results is done by plotter or graphic display. It is also devised to print out Calculated results in most convenient form. For item (7), it is not possible in the present stage to calculate the inverse of a stiffness matrix within the core memory of even a super large computer although it depends on the faculty of the computer. Therefore, some memory devices such as magnetic tape, disc or drum are required. Of course, it is truly useful in this case to use a super large computer with large core memory, but such a large computer is usually open to various jobs by time sharing system. This is because it is not economical to provide a large core memory only for a single small job. Therefore, we must make use of some external memory device effectively although a certain core memory is still needed.

If item (7) is solved, items (3) and (4) can be automatically worked out. If items (1) to (7) are all satisfied, it will be a very refined general purpose program finite element method.

3. Method of analysis

ZPLATE is made to analyze by finite element method the elastic stress of plate structures subjected to static loads. Plate structures are composed of thin plates in the same plan; or of a three-dimensional combination of plates. The plate as an element of structures does not have stiffness against out-of-plane deformation but retains only in-plane stiffness. Therefore, stresses are assumed to be in the plane stress equilibrium. However, the program can also analyze a plate with line members (created as truss elements because of no flexible stiffness). The input data are overall structural formulation, dimensions of members, material modulus, structural conditions of locations of supports and loads (including forced displacement) and the outputs are displacement and stress of each element and reactions of supports.

The structure to be analyzed is first divided into a remain number of units. Each unit is a group of several or several tens of elements and is functional as an element in a wide sense. Each input is associated with units and joints which are vertices of units. The unit has two types of geometry and is selected such that any structure can be easily idealized. The unit plays an important role in saving labour in preparing input data. We use "unit division method"⁽¹⁾ to solve simultaneous equations. However, the unit of the unit division has a slightly different meaning from the unit defined here, as will be described later (section 3.1).

3.1 Composition of program

The flow chart of the program is shown in Fig. 1 (The processes 1 to 14 are a set of subprograms specified into units of functional characteristics of operation). For the substructure method, the main program shown in Fig. 1 will be used as a subroutine as described later.

In fig. 1, the discrimination "Unit number of reduction" between processes 8 and 9 indicates that reduction is to be performed when the reduced elements of the matrix in process 9 become large by superposing several units (process 8). In other words, the reduction is not applied to each unit. This is the reason why, in the unit division method, we call one unit for these groups of units put together.

3.2 Stiffness matrix of element

Out of various stiffness matrices in plane stress problems, the following expressions can be used at present

(1) Line element

Geometric function

$$u = \alpha_1 + \alpha_2 x \dots \dots \dots (1)$$

(2) Triangular element (uniform stress)

Geometric functions

$$\begin{aligned} u &= \alpha_1 + \alpha_2 x + \alpha_3 y \\ v &= \alpha_4 + \alpha_5 x + \alpha_6 y \end{aligned} \dots \dots \dots (2)$$

(3) Rectangular element⁽²⁾

Geometric functions

$$\begin{aligned} u &= \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 xy \\ v &= \alpha_5 + \alpha_6 x + \alpha_7 y + \alpha_8 xy \end{aligned} \dots \dots \dots (3)$$

(4) Arbitraray quadrilateral and triangular element by Hybrid Method⁽³⁾

Assuming linear displacement along each side of the element, stresses can be put in the forms;

$$\begin{aligned} \sigma_x &= \beta_1 + \beta_2 y + \beta_3 y^2 + \beta_4 x^2 + \dots \dots \dots \\ \sigma_y &= \beta_5 + \beta_6 x + \beta_7 y + \beta_8 x^2 + \beta_9 y^2 + \dots \dots \dots \\ \tau_{xy} &= \beta_{10} - \beta_{11} x - \beta_{12} y - 2\beta_{13} xy + \dots \dots \dots \end{aligned} \dots (4)$$

Equation (4) satisfies the equilibrium equations of stresses of the element as can be seen from the forms (4). Employed in the program are two types which include the terms up to β_5 and β_7 respectively.

Since each term of eqs. (1) to (4) satisfies the compatibility conditions for the adjacent elements due to the linear displacement along the sides of elements, mixed use of these elements is possible.

Fig. 2 shows a comparison of stresses by his method and by beam theory applied to a beam with upper and lower face plates and with fixed end conditions. The line element (1) is used for the face plates. As is clear in the figure, stresses of the rectangular element with β_5 by the hybrid method are closest to those of the beam theory and in fact almost identical.

This is because the stress distribution is almost identical if the terms up to β_5 are used. therefore, although we cannot conclude which is the best element. an accurate result might be expected for structures like frames of a ship hull if quadrilateral elements up to β_5 of the hybrid method are used even if the division of elements is coarse

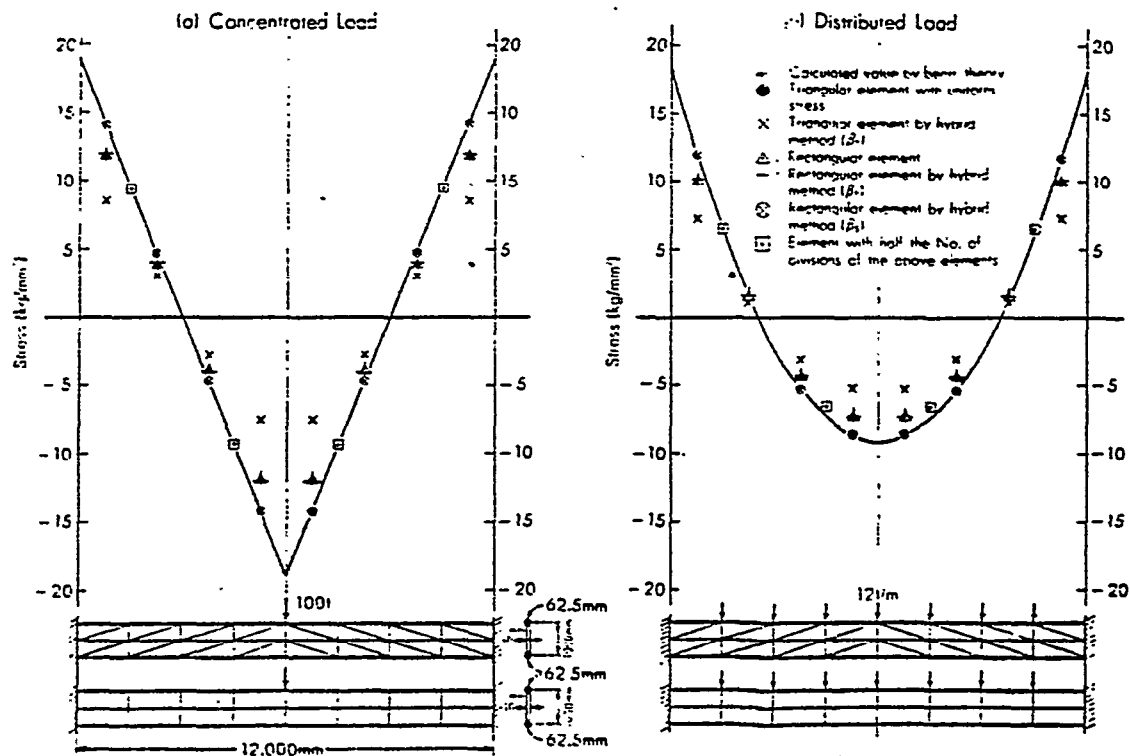
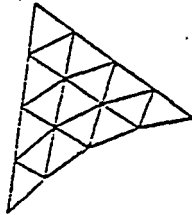
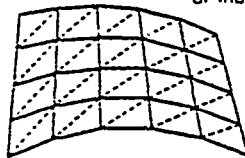


Fig. 2 Comparison between beam theory and P.E.M. with various elements

1- Triangular pattern



2- Quadrilateral pattern (dotted line: in the case of triangular element)



3- Quadrilateral pattern (used for the purpose of varying the No. of divisions)

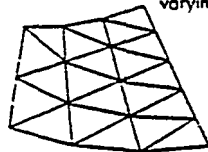


Fig. 3 Method of automatic mesh generation

general the rectangular element (3) seems to be greater than the rectangular element of (4). Also the rectangular element (2) and (4) give almost identical with However the latter is more useful for the stress shown of parts with stress concentration where vary distinctively since the stress distribution element can be obtained by this element.

When this program is used for structural analysis, first divide it into rectangular elements wherever it is possible. Then arbitrary quadrilateral elements are used for the parts where rectangular elements cannot be applied. Finally use triangular elements for only the part where other elements are not possible. Since automatic mesh generation within units is possible in this program, stiffness matrix or stress matrix of an element can be constructed in a single processing if the unit is rectangular. Since the same process is applied to other elements too the computer time will be shortened.

3.3 Automatic mesh generation

The fundamental patterns of units are of two types, arbitrary triangle and arbitrary quadrilateral as shown in Fig. 3, where one side of the triangle and the opposing two sides of the quadrilateral can be replaced with a circular arc. Each side is divided with equi-distance by using the number of divisions assigned in input data, and make elements as shown in the figure. The number of divisions of all sides of a triangle and of opposing two sides of a quadrilateral must be the same. Furthermore, since the number of divisions of the -boundary line between adjacent units must be the same, the determination of number of divisions is restrained. To solve this, a mesh generation patterns as in (c) of Fig. 3 is introduced.

The method of division is not only effective in the difference of labour between preparing input data of each element and preparing input data of each unit, but also convenient since it allows us to make fine mesh

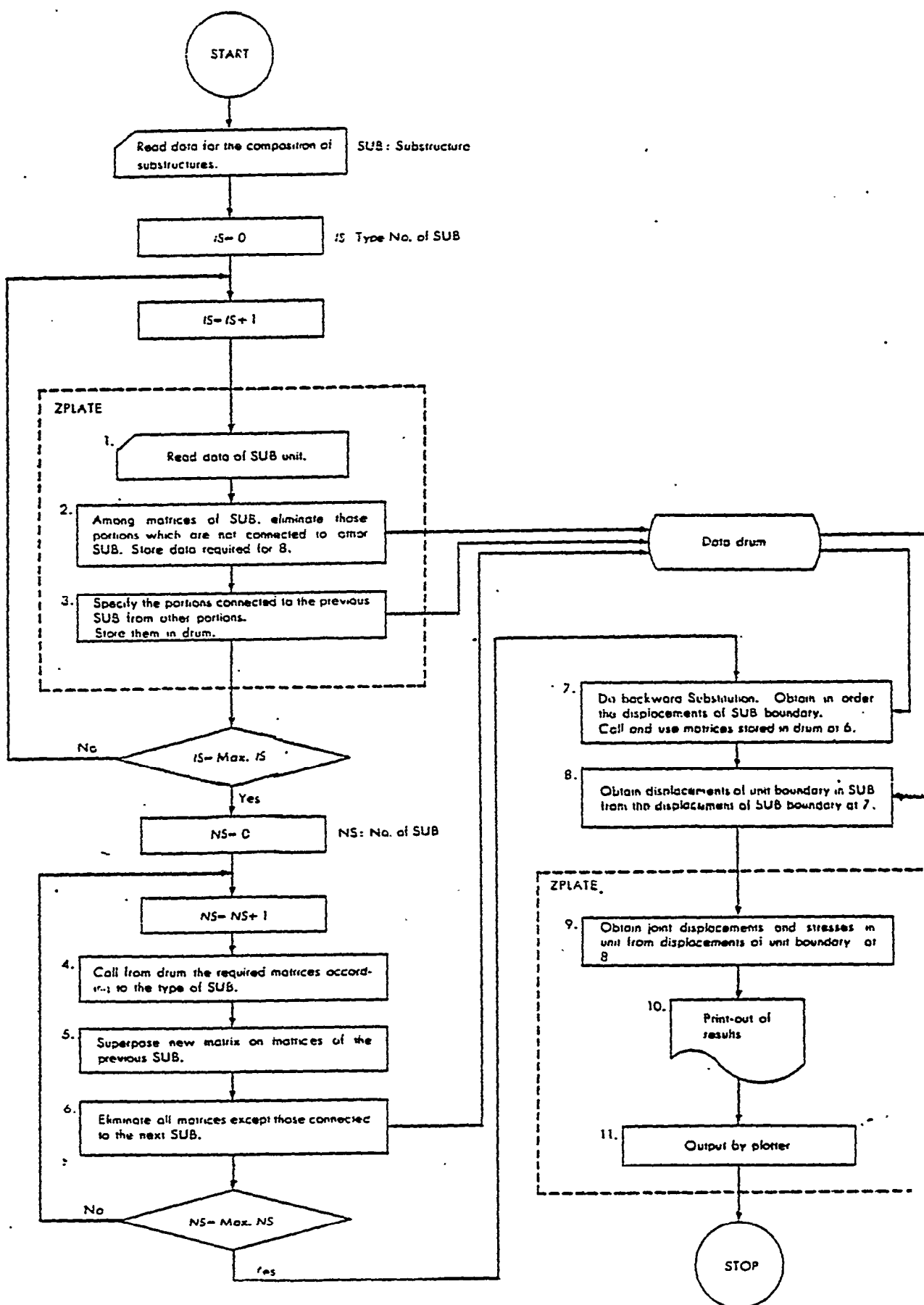


Fig. 4 Flow chart of program by substructure method

where stresses vary rapidly and to make coarse mesh wherever we have no significant change of stresses in a similar manner to the current mesh generation when structure is idealized.

The shape of circular arc is assigned by given coordinates of an arbitrary point on a radius or circular arc. The latter method is convenient for preparing input by approximation of an arbitrary curve as a circular arc. It can be considered that this method retains the adaptability of shape since any shape can be expressed by combination of these fundamental patterns.

3.4 input and output

In order to prepare input data accurately within a short time, the automatic mesh generation of elements is carried out from the viewpoint of reducing the total number of data. However more important is the faculty of the mechanism of error check. Note that the input error does not simply mean the consumptions of computer time but means bringing about the risk of using erroneous results without noticing. As in Fig. 1, data are examined for grammatical error or contradiction of geometry and mesh generation through the error check process of the program and the error messages are printed out. Data corrected in this way proceed to the next page where coordinates of joints and arrangement of **and arc examined** by graphic display. The examples in Figs. 6 and 10 are photocopies of graphic display. The program is made in such a way that a view of structures from any angle is produced on the screen of the display **device by simple operation** of rotating the dial, and even some complicated structures can be examined relatively only for error of coordinates. Since the plotter draws various mesh generations (Fig. 7 and others), the shape of divided elements can be affirmed at the same time as geographical error check.

As output the displacements and stresses are printed out for each unit and displacement of joints and stresses of elements within a unit are arranged such that they correspond to the arrangement of actual joints and elements. Therefore reading of calculated results is very easy. Outputs by plotter include figures of mesh generation % and displacements of joints (Fig. 7) and of principal distribution (Figs. 7 and 12) in which maximum absolute principal stresses are shown by numbers and the directions by arrow signs.

3.5 Treatment of large scale calculation

One of the problems for a program with large capacity how to handle large matrices. One advantage of INVAC-110S computer is the ability to use a high speed magnetic drum. The random access of this magnetic drum is easy due to the treatment program and the stress time is in the order of one tenth of that of a disk.

advantage is made use of as an extension of the core memory. The limitation of band width is a barrier to the treatment of a large matrix in the unit division method. In this program that limitation is avoided by using a drum. This will be explained in the following

paragraphs.

The process 9 of the flow chart in Fig. 1 is given as follows:

$$P = K \cdot D \dots\dots\dots(5)$$

P = Load matrix

K = Stiffness matrix

D = Displacement matrix

This equation is divided into two parts; one is the part of joints connected to the front unit (Subscript-A) and the other is the part of joints to the back unit (Subscript-B) as follows:

$$\begin{bmatrix} P_A \\ P_B \end{bmatrix} = \begin{bmatrix} K_A & K_{AB} \\ K_{BA} & K_B \end{bmatrix} \cdot \begin{bmatrix} D_A \\ D_B \end{bmatrix} \dots\dots\dots(6)$$

Eliminating D_A from eq. (6)

$$P_R = K_R \cdot D_B \dots\dots\dots(7)$$

In eq. (7),

$$K_R = K_B - K_{BA} \cdot K_A^{-1} \cdot K_{AB} \dots\dots\dots(8)$$

$$P_R = P_B - K_{BA} \cdot K_A^{-1} \cdot P_A \dots\dots\dots(9)$$

K_A is controlled within a certain size as described in section 3.1 to calculate accurately the inverse matrix in the core. The elements associated with the subscript B vary depending upon the case or each stage of calculation. Thus, this is divided equally as follows:

$$K_R = \begin{bmatrix} K_{R,11} & K_{R,12} & K_{R,13} & \dots \\ K_{R,21} & K_{R,22} & K_{R,23} & \dots \\ K_{R,31} & K_{R,32} & K_{R,33} & \dots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix} \dots\dots\dots(10)$$

$$K_{AB} = (K_{AB,1} K_{AB,2} K_{AB,3} \dots) \dots\dots\dots(11)$$

$$K_R' = (P_{R,1} P_{R,2} P_{R,3} \dots) \dots\dots\dots(12)$$

An area sufficient for the treatment of one matrix thus obtained is reserved in the core and each matrix is memorized in the drum. Note that since $K_{BA} = K_{AB}'$, $K_{B,ij} = K_{B,ij}'$, these are not memorized. Since eqs. (7) and (8) are put in the forms

$$K_{R,ij} = K_{B,ij} - K_{BA,j} \cdot K_A^{-1} \cdot K_{AB,i} \quad (i = 1, 2, 3 \dots j = 1, 2, 3 \dots) \dots\dots(13)$$

$$P_{R,i} = P_{B,i} - K_{BA,i} \cdot K_A^{-1} \cdot P_A \quad (i = 1, 2, 3 \dots) \dots\dots(14)$$

the calculation proceeds by calling one at a time the matrices with subscripts i and j and the results are again stored in the drum. The process 10 repeats the following calculation.

$$D_A = K_A^{-1} \cdot P_A - \sum_{i=1}^n K_A^{-1} \cdot K_{AB,i} D_{R,i} \dots\dots\dots(15)$$

Following the above procedure any size of matrix can be treated if the capacity of the magnetic drum (external memory device) is sufficient. In practice, however, it is wise to make effective use of magnetic drum since any drum capacity is limited. Consequently the required number of words must be figured out before the calculation and a process is assigned to put data in the drum without any blank. Especially K_{AB} and K_A^{-1} in the introduction process elimination require large

capacity of memory. As to K_{AB} only non-zero element is memorized since many elements of K_{AB} are zero. Also, since K_A^{-1} is symmetric, only the upper half of the elements are memorized. As a result, even the largest matrix in the examples of application could be less than the drum capacity of 1,000,000 words. By the way, the core capacity is 65K words at present.

3.6 Substructure method

As described in the foregoing section, the computer time in the analysis of ship hull structures with periodic identical pattern can be largely reduced by common use of data and stiffness matrices by taking into consideration the periodic characteristics. In this case, the identical pattern is called substructure. Actual structures are composed of several types of substructures and in many cases they repeat periodically. The flow chart of the program by the substructure method is illustrated in Fig. 4, where the parts designated by ZPLATE imply using the *necessary* part of the program of Fig. 1. The other parts of the processes are also the same as those of the previous section in the basic consideration.

Regarding the substructure method, consider the problem of idealization of structures. As to ship hull structures, saving labour in preparation of data can be furthered by standardization of the frame patterns dependent upon the ship hull such as on tankers or ore carriers. In the example of a bulk carrier described later, the substructures are constructed quite arbitrarily. In this case, the time needed to prepare the input data increases, but it does not require a certain type of ship

hull structure and can be applied to any other structure. If they can be respectively called specific and general purpose programs, then the natural order is to first develop the general purpose and then extend it to the specific purpose. However, it is noted that the larger the increase in efficiency of the specific purpose, the more restrained is the idealization of structures. Important to designers are the idealization of structures and the interpretation of results by finite element method. In the case of finite element method, it is required to introduce some approximations based on various assumptions although the idealization is comparatively easy. It seems that these problems should be determined by taking into consideration the characteristics of each structure. At the same time, it is instructive for designers to reevaluate the structural composition through the idealization process. In the future, the specification is expected to progress during the stage where the finite element method is introduced to the design process. However, at present which is still the transient stage, it seems necessary to make full use of the general purpose program.

4. Applications

As applications of the ZPLATE program, the results of three-dimensional stress analysis of a bulk carrier and longitudinal stress analysis of a destroyer are presented below.

4.1 Three-dimensional stress analysis of hull: carrier

The test hull is a bulk carrier of 44,500 DWT with the following principal dimensions.

$$L \times B \times D \times d = 190 \times 30 \times 16 \times 11.55 \text{ m}$$

The models used for the calculations are two types with 1.5 and 2.5 holds respectively (corresponding to 3 and 5 holds if the symmetric property is considered). As to the 1.5 hold, two types of coarse mesh and fine mesh, or a total of three types, are analyzed (Fig. 7). Alternate loading at full draft is employed. The sizes of the three types in the analysis are shown in Table 1.

4.1.1 Assumption of calculation and preparation of input data

For the preparation of input data, the substructure method described above is employed. Fig. 6 shows copies of the shapes of substructures checked by graphic display. For instance, two types of substructure ((a) and (b) of Fig. 6) are prepared and then are orderly connected into the structure shown in (c) of the same figure. The analysis was carried out on the final structure. The figure shows the profile of the units where the elements are further divided into fine mesh. The details of the mesh of each part of the structure are shown in (a) and (b) of Fig. 7.

Although each member is treated as a plate, the face plates of the transverse rings and the bulkhead stiffeners are assumed to be line elements and the plate with longitudinal beams is treated as an orthotropic plate with increased thickness. The adjustment of size is made

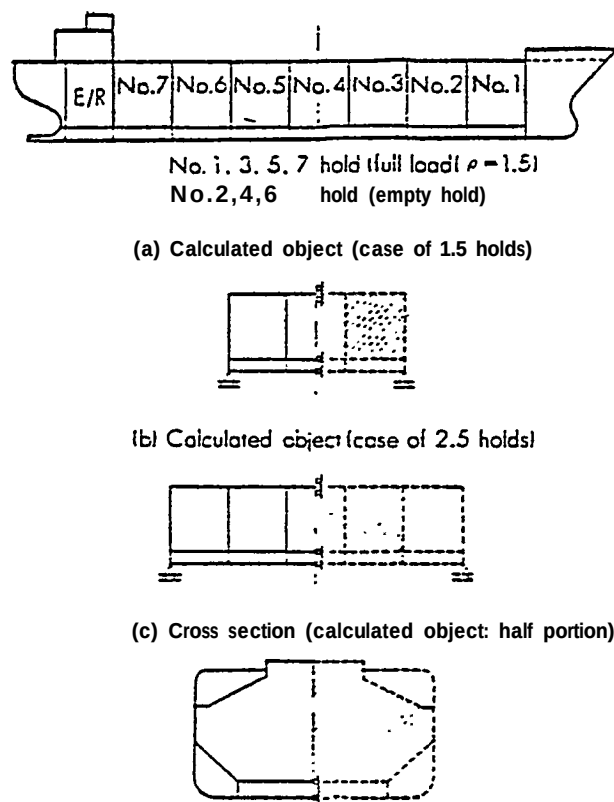


Fig. 5 Loading and bound conditions of bulk carrier

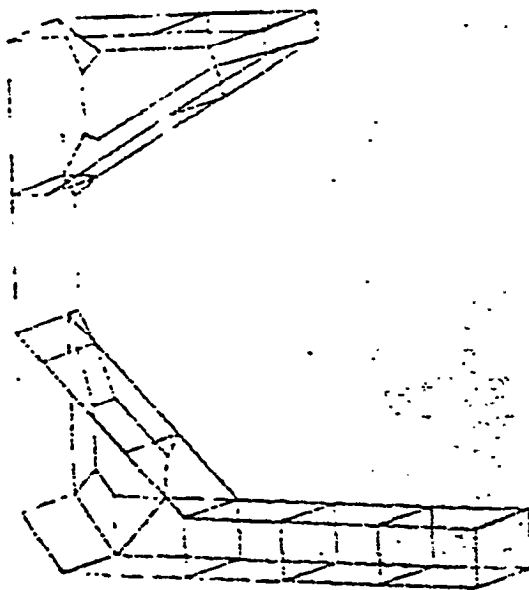


Fig. 6 (a) Idealization of bulk carrier (substructure of transverse ring)

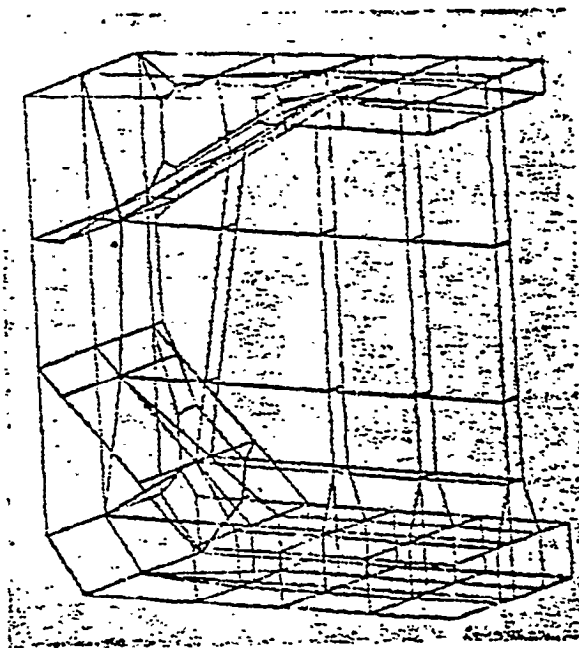


Fig. 6 (b) Idealization of bulk carrier (substructure of bulkhead)

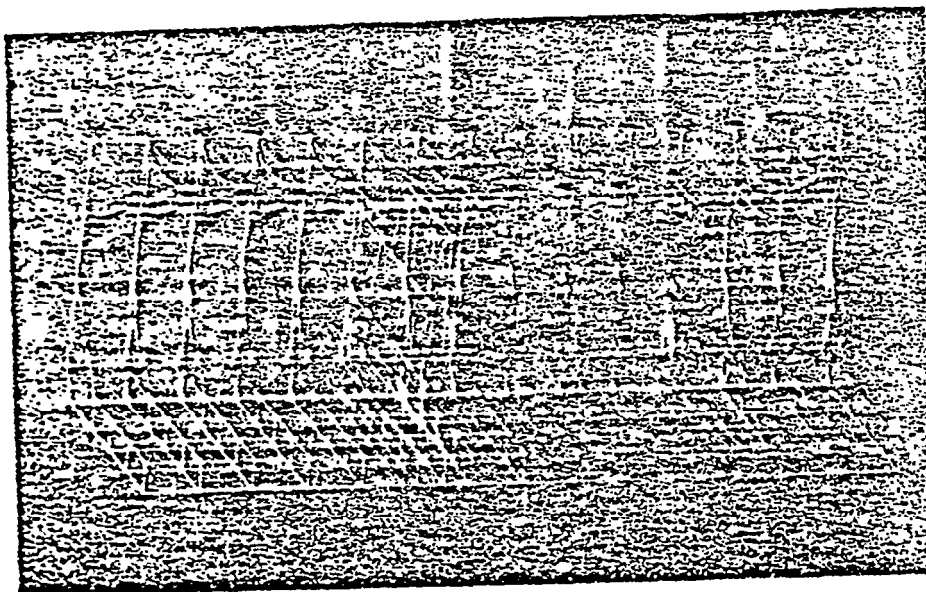
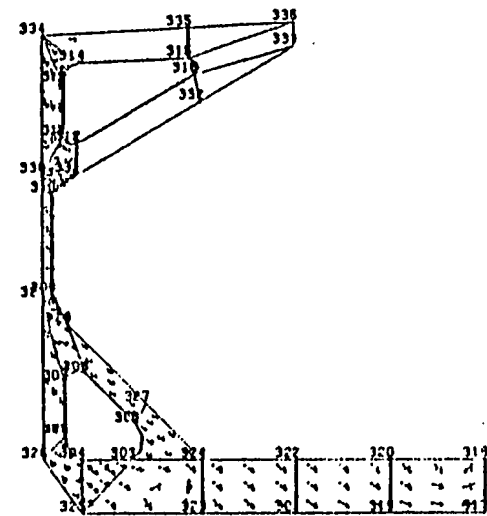
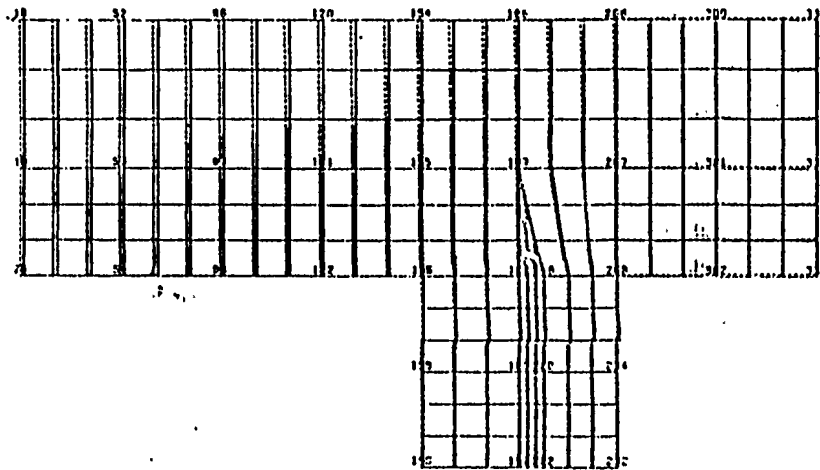


Fig. 6 (c) Idealization of bulk carrier (total structure)

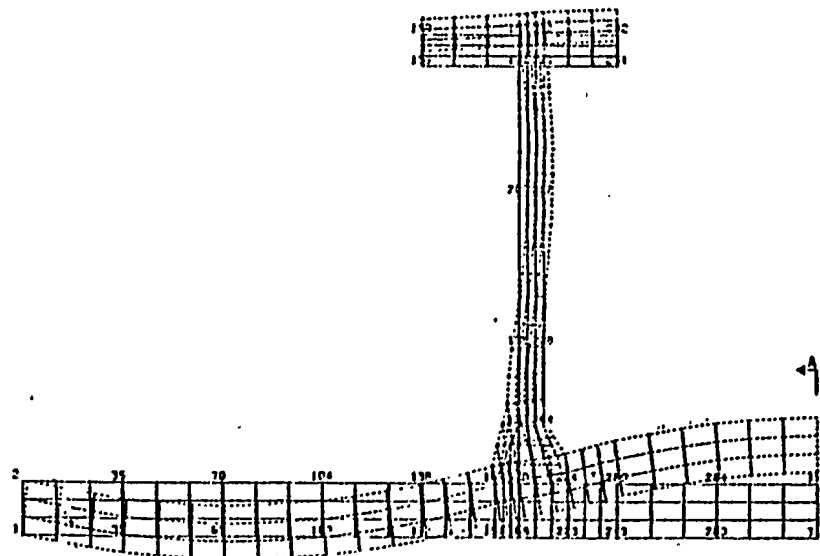
Table 1 Size of calculation of bulk carrier

Items	Mesh generation	No. of unit	No. of element	No. of joint	Degrees of freedom
Calculation score					
1.5 hold	Coarse mesh	444	1,776	1,511	4,347
"	Fine mesh	"	3,996	3,534	10,323
2.5 hold	Coarse mesh	798	3,192	2,640	7,680

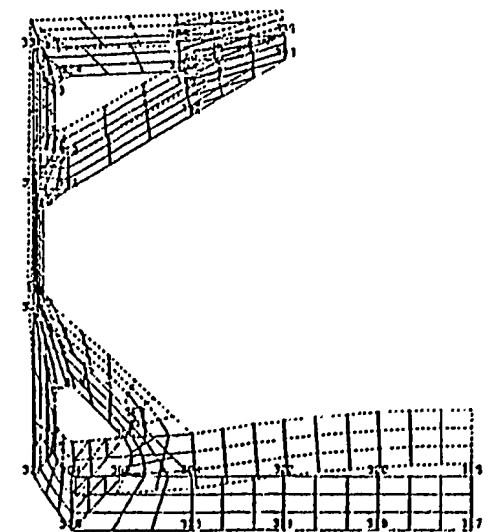
UPPER DECK PLAN

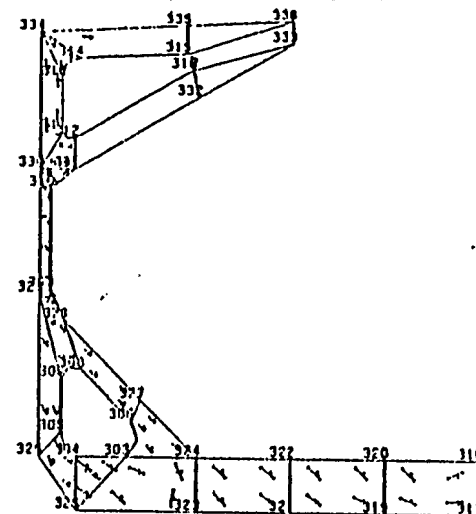
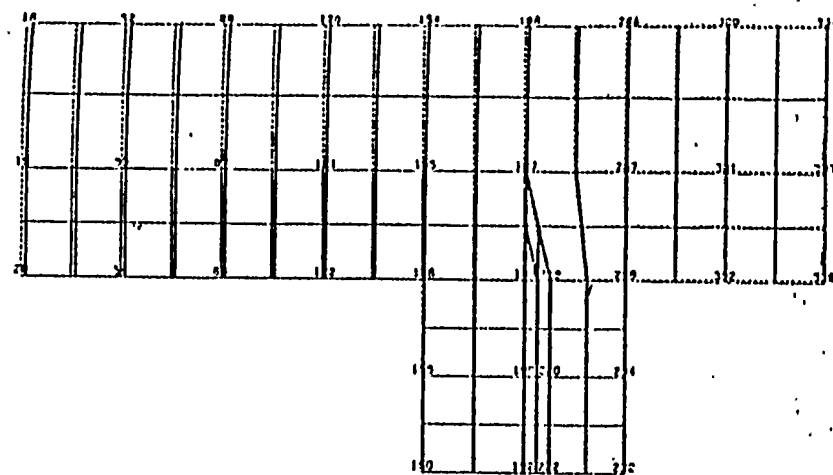


CENTER LINE SECTION

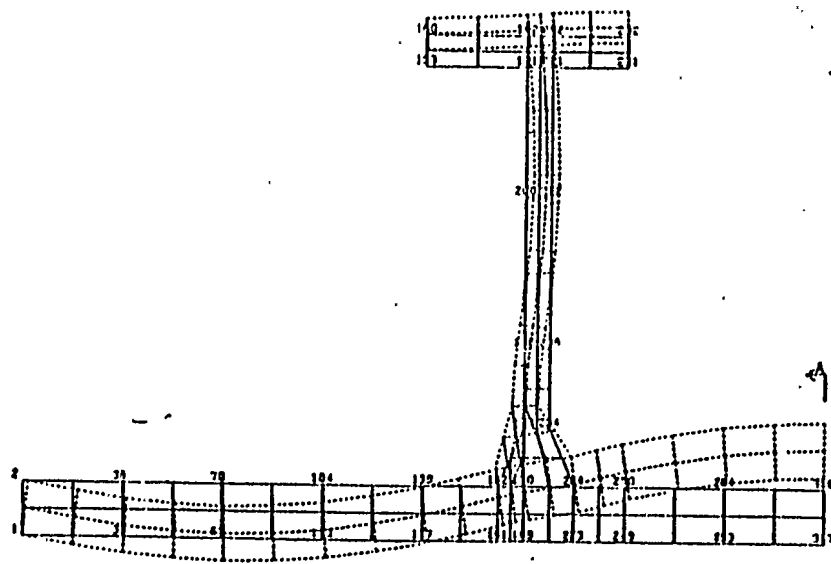


TRANS. RING (A-A SEC.)





CENTER LINE SECTION



TRANS. RING
(A-A SEC.)

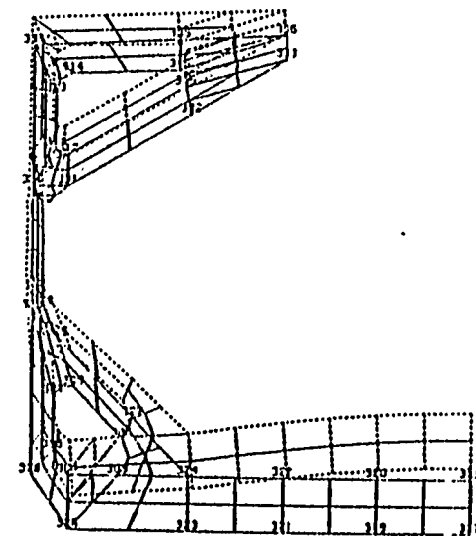


Fig. 7 (b) Results of calculation (coarse mesh)

assuming transverse rings as one unified ring and four frames as a unit. The objectives of the analysis are first to make a rough estimation of displacement of each part such as double bottom floor and hopper and then, with the results, to recalculate stresses of the transverse rings or the frames as the local stress analysis. The idealization is responsible to the above objectives.

In this analysis, we used mostly quadrilateral elements by the hybrid method, together with partial triangular elements of uniform stress. Most of the input data are common to the analysis of the three types. It took about five days for one person to prepare the data.

4.1.2 Results of calculation

Described in the following are the way of mesh generation and the effect of adjacent holds on the three-dimensional stress analysis of a bulk carrier.

Fig. 8 shows a comparison of stresses at the section of No. 4 hold center for two cases of coarse and fine mesh of 1.5 hold models. As seen in the figure, almost no difference can be recognized but the stresses at the transverse ring and frame are slightly different. However, this is mainly due to the idealization described in the section "Assumption of Calculation". In order to evaluate the local stresses, the "zooming method" may be applied in which the part in question is taken out into small mesh. Therefore, the error of this order may be negligible in reality. The displacement is not different at all for the two cases as seen in Fig. 7.

Fig. 9 shows a comparison of stresses at the same section of No. 4 hold center for the two cases of 1.5 and 2.5 hold models, to examine the effect of the adjacent holds. Again, no difference can be seen. The end conditions of each case are both simple supports at the front of the bulkhead. For the alternate loading, the assumption does not affect the adjacent hold. Since the effect of longitudinal stresses of the front and rear holds is not taken into consideration, the stresses of longitudinal members are quite different. However, it does not affect stresses on the cross section as seen in the results.

The following conclusions are drawn from the analysis.

1. The effect of the end boundary condition of the hold adjacent to the inspection hold is comparatively small
2. Even the coarse mesh of this example gives very good results as far as the hybrid mesh is used.

A bulk carrier has a complicated structure compared with a tanker and there are many unknown problems as to the effect of the shape of hopper tank and the type of hull, etc., on the overall strength. Therefore it is not permissible to draw, from the example, conclusions on the general analytical method. It is necessary to establish the three-dimensional stress analysis of finite element method by further studying bulk carriers of various types and boundary conditions.

4.2 Example of stress analyses of ship hull with long deck house

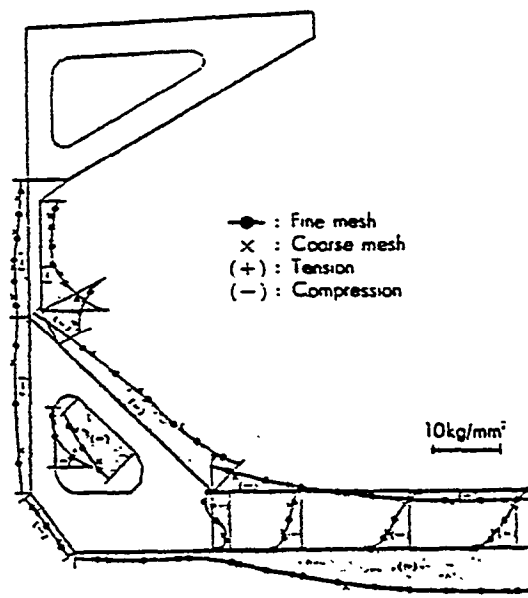


Fig. 8 Comparison of stress at section of No. 4 hold center between the mesh and coarse mesh of 1.5 hold models

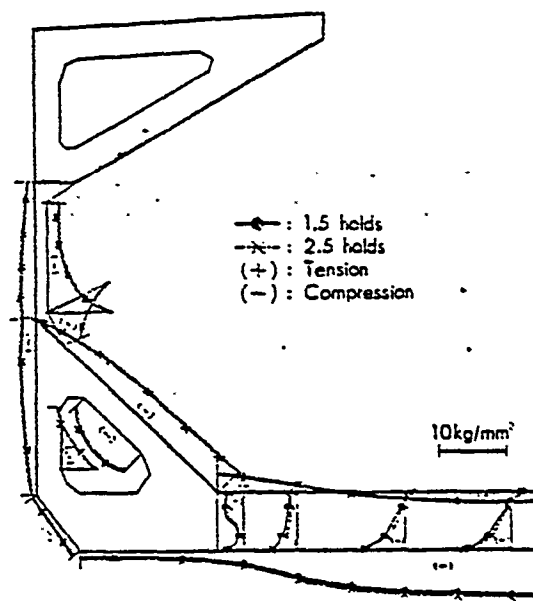


Fig. 9 Comparison of stress at section of No. 4 hold center between 1.5 hold model and 2.5 hold model

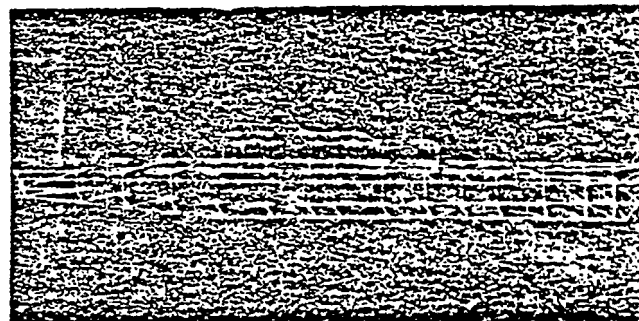


Fig. 10 idealization of destroyer

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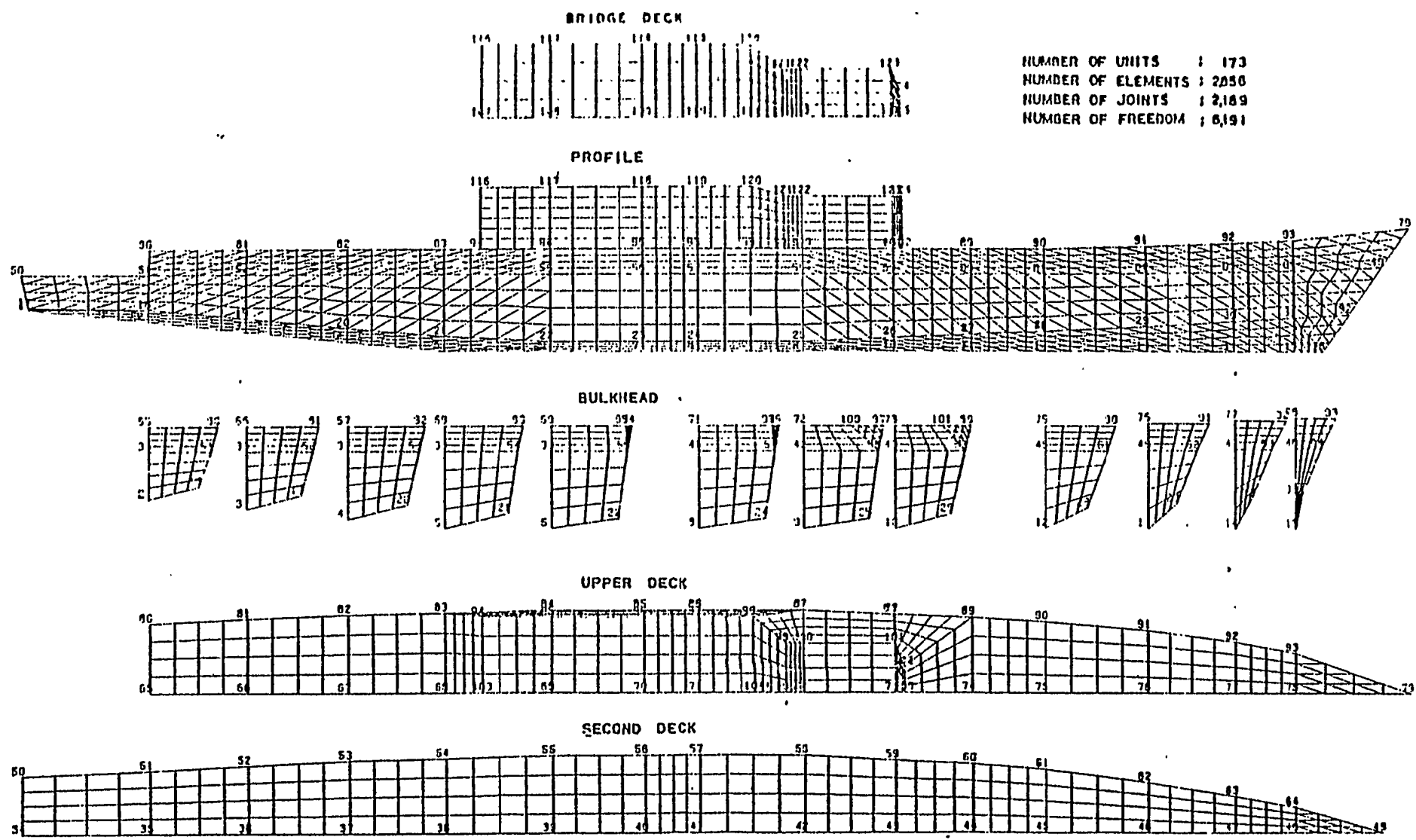
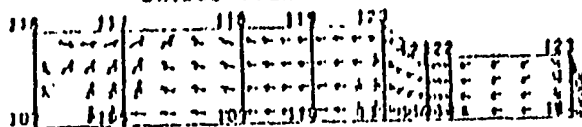
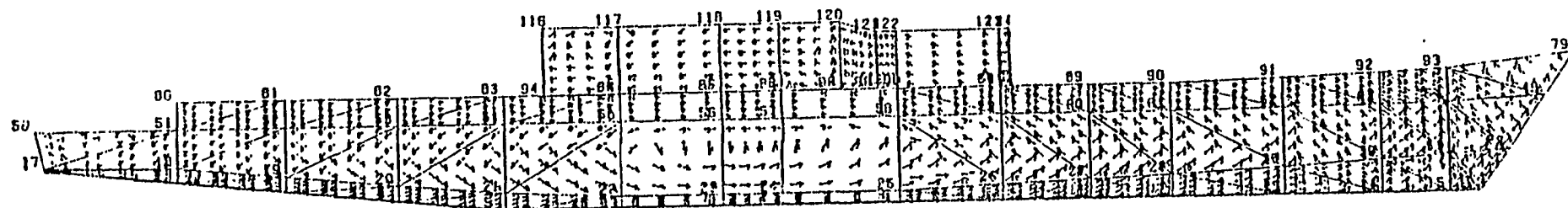


Fig. 11 Mesh layout

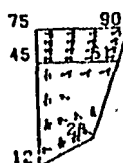
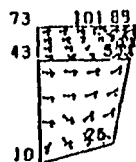
BRIDGE DECK



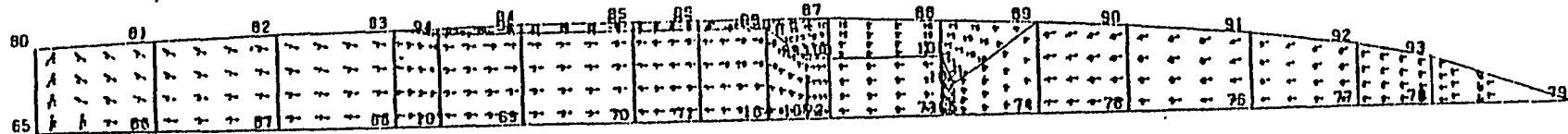
PROFILE



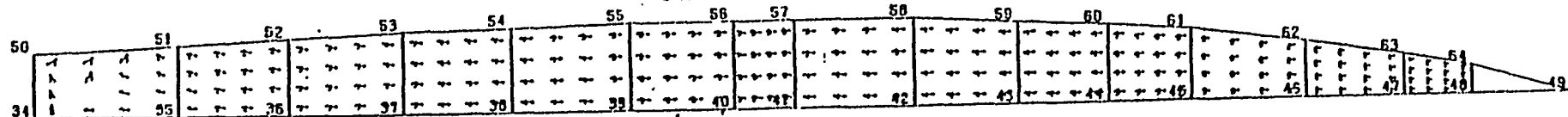
BULKHEAD



UPPER DECK



SECOND DECK



(Note) Arrow: Direction of principal stress
 ←→ : Tension side
 >— : Compression side

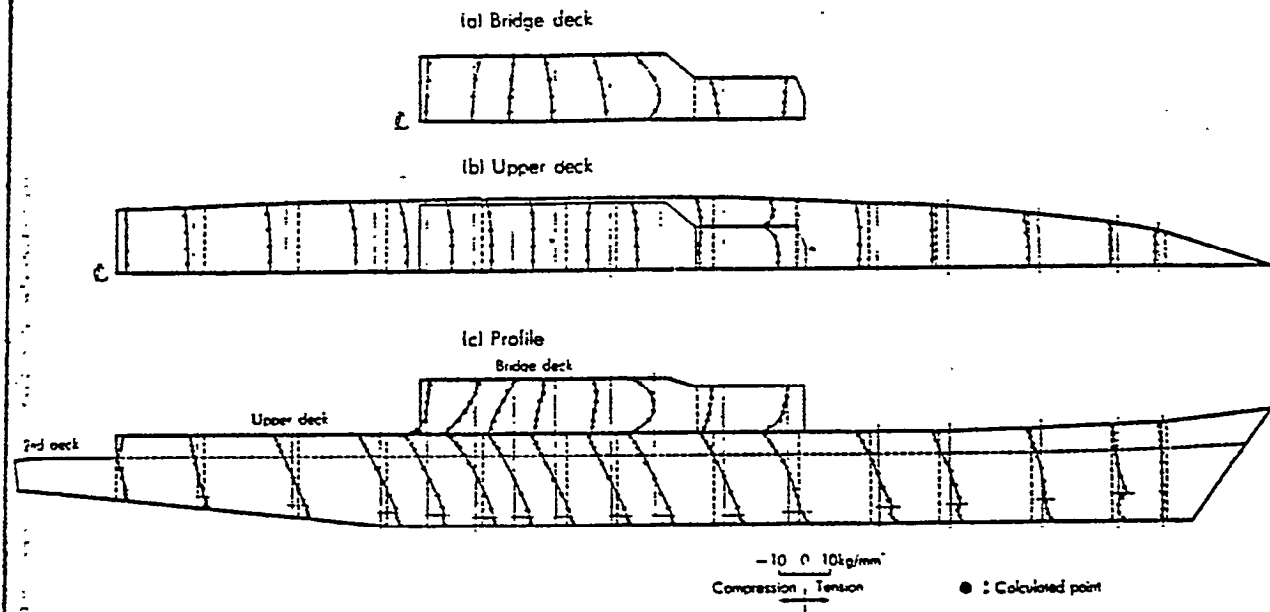


Fig. 13 Distribution of longitudinal stress of hull structure (hogging condition)

Longitudinal stresses of a ship hull are currently derived by assuming the hull as a beam with both ends free. Because of shear lag, the results may be different from the actual stress distribution if the hull with a long deck house is simply treated as a beam of varying section. Although methods of analysis (4), (5), (6) are studied on the interaction of deck and ship hull, they cannot be applied directly to ship hull structures because of the simplified idealization of deck house and ship hull. However, idealization close to the real structures is possible by the finite element method⁽⁷⁾. Presented in this section is the analysis on a destroyer with a long deck house. Since the effect of the deck house is great on the longitudinal stresses of the ship hull structure in this case, stress concentration is produced at the ends of the deck house and quite large stresses can be seen. Therefore, it is necessary to reinforce the part or to provide movable joints to the deck house.

4.2.1 Assumption of calculation

In this analysis, only a single side of the structure can be considered since both the structure and loading conditions are *symmetric* with respect to both sides. As in Fig. 10, the ship hull is divided into a structure composed of flat plates so that the idealization is as close to the actual structure as possible. Treating these plates as units, and applying the automatic mesh generation to the units, the mesh layout shown in Fig. 11 is obtained.

The longitudinal members attached to the side shell deck, deck plate and side wall of the deck house are assumed as orthotropic plates. The stiffeners of the transverse bulkheads are also treated as orthotropic plates and the in-plane

stiffness is taken into account.

3. As to loading, the load in the vertical direction of the ship hull is applied and distributed upon the lower end of the side shell under hogging condition. Where the crest of the wave of one twentieth the ship length locates at the midship.
4. As boundary conditions, the *lower* end of side shell is supported vertically at both ends. One of the ends is also supported longitudinally. Since the actual reactions at the two points are close to zero, we can examine the loading conditions. Furthermore taking the symmetry of the structure and loading into consideration, we assumed that the plate is supported in the transverse direction at the center line of the ship hull and is free in the vertical direction.
5. Used in the analysis are quadrilateral element for the hybrid method and triangular element for the uniform stress.

4.2.2 Results of calculation

Fig. 12 shows the distribution of principal stresses of each part of the ship hull structure. Fig. 23 shows the distribution of longitudinal stresses of the ship hull structure. As can be seen in Fig. 13, the deck house affects very much the longitudinal stresses of the ship hull and the distribution is quite complicated since the side wall of the deck house and the deck plate are not on the same plane. For analysis of the stress concentration at the ends of deck plate, the mesh layout of this example is too coarse to obtain accurate results. Accordingly, the zooming method may be applicable in this case. The study is not given in this paper. However, we can see some stress concentration at the ends of the deck house even in the given mesh layout.

5. Conclusions

A general purpose computer program designated ZPLATE was described for the plane **stress analysis** of plane and three-dimensional structures through finite element method. As applications, the three dimensional stress analysis of a bulk carrier and the longitudinal stress analysis of a destroyer with a long deck house were presented. In the development of the program, we intended to obtain a program with large capacity which is sufficient for practical use and whose scale is balanced with the faculty of saving labour in preparation of input data and in analysis of calculated results. In this paper, examples with 4,000 to more than 10,000 degrees of freedom in calculation are presented. However, this program can solve these examples within a few days. We believe therefore that our initial objectives have been attained satisfactorily. The future problem is to extend the program to those which include analysis of out-of-plane bending, buckling, vibration and elastoplasticity.

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APPENDIX P

Z VIBRA - MATRIX-METHOD OF VIBRATIONAL
ANALYSIS OF FRAMED STRUCTURES, AND ITS
APPLICATION

Matrix Method of Vibrational Analysis of framed Structures and its Application

Isao Neki*

Recently, with the matrix method, analysis of elastic, plastic, vibrational or buckling problems of framed structures widely diffused in the various field of structural design, plus analysis of complex three-dimensional frames structures are becoming daily routine work. A computer program designated ZVIBRA, for vibrational analysis of three-dimensional framed structures, has been developed, using the stiffness matrix method of the author. The present paper outlines the ZVIBRA program with some examples of its application. The program aims at analysis of elastic, vibrational responses of sinusoidal forced-loaded frames, including the influence of shear rigidity and rotatory inertia, which should be particularly useful for analysing ship hull structures.

1. Introduction

In recent years, with the matrix method, analysis of elastic, plastic, vibrational or buckling problems of framed structures which are broadly diffused in the various fields has come into wide use, and-by the use of this method the analysis of complex three-dimensional framed structures are becoming daily routine work. The author has developed a computer program ZVIBRA, for vibrational analysis of three-dimensional framed structures, using the stiffness matrix method. Therefore its outline and examples of its application will be presented here with an intention to place it at the service of the interested public.

ZVIBRA has been prepared for analysis of vibrational responses in elastic range of three-dimensional framed structures under sinusoidal forced vibration. Because the effects of shear rigidity and rotatory inertia are taken into consideration, this **method** is particularly effective in the analysis of structures such as the ship hull structures where the effects of those factors cannot be ignored.

For vibrational analysis method of framed structures, a method in general use obtains natural frequencies in free vibration by replacing the structure to be analysed with a structure made up of multiple masses and spring system. However in framed structures where shearing deformation and rotatory inertia are taken into consideration, it is extremely difficult to obtain natural values by the use of the above method. Moreover, in replacing the structure with that of a multiple masses and spring system, adequate precision can not be obtained unless the members are approximated by as many masses and spring as possible. In consideration of the above fat-

tors, the author has assumed the framed structures to be a conglomerate of beams, which have infinite degree of freedom, and then their stiffness matrices were obtained. Using such matrices, their vibrational responses were calculated and as a result their vibrational modes and amplitudes were obtained. Accordingly, since the natural frequencies can not be obtained under this method, vibrational responses corresponding to the number of vibrations at the necessary number of points were obtained, then by reviewing the increase or decrease of vibrational amplitudes as well as the phase change of vibrational modes, the natural values can be obtained.

2. Solving method

2.1 Application and assumptions

The application and assumptions used in this program are outlined as follows:

1. The objective is the vibrational analysis of framed structures in elastic range under varying loads (including forced displacements) of sinusoidal form with a constant amplitude. The framed structures defined here are structures consisting of joints and straight members between joints, with uniform cross sectional areas. The members are assumed as ideal links, neglecting the thickness, and the joints are assumed as ideal points. Therefore, the structures consisting of plates, curved beams, and tapered beams have to be analysed as structures consisting of **respectively** equivalent beams by using proper approximation method, following the above assumptions.

2. The ends of the members of the framed structures can be pins, rollers, spring-supported, built-in connections, rigid attachments or free-ends. For loading conditions, the concentrated loads applied on joints

and the forced displacements at joints will be considered.

3. For vibrational mass, the dead weight of beams, the added mass uniformly distributed over the beams and the concentrated mass at joints will be, considered.

4. Damping factor of structures is not considered. Therefore, the amplitudes near the resonance point will become considerably larger than the actual values. However, at points 10% apart from the resonance frequency, it is safe to think that the amplitudes in the ordinary structures will be quite close to the actual values, even if damping factor is not considered.

5. The results of analysis calculated will be: The displacements and angular deflections at all joints, the displacements and angular deflections at quarter points of each member, stresses at ends each member, support reactions, etc. When necessary, vibrational mode curves of each structure can be plotted by the use of a plotter.

6. As for the analysis method, the stiffness matrix method derived from the displacement method is used, and by analysis of vibrational responses (but not taking into account of damping factor) the vibrational modes at the desired vibrational frequency are examined, and also by calculating at several levels of vibrational frequency the resonance frequency can be found.

2.2 Stiffness matrix for vibration of beams having uniform cross section

Stiffness matrix of beams having uniform cross section is obtained, when sinusoidal forced load is applied at each end, where bending, shearing, torsion, elongation and rotatory inertia are taken into account. The symbols used in the equations will have the following meaning:

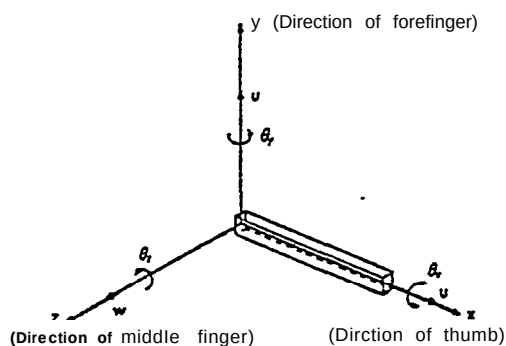


Fig. 1 Right handed coordinate system adapted in present study

X: Coordinate in the direction along the length of beam.

Y, Z: Coordinates perpendicular to the beam, in accordance with the right handed coordinate system (See in Fig. 1)

U: Displacement in x direction

T: Displacement in y direction

w: Displacement in : direction

v_B : Displacement only due to bending in y direction

w_B : Displacement only due to bending in : direction

θ_x : Angle of rotation around x axis

θ_y : Angle of rotation around y axis

θ_z : Angle of rotation around z axis

GJ : Torsional stiffness of beam

EI_y : Bending stiffness of beam around y axis

EI_z : Bending stiffness of beam around z axis

A_x : Cross sectional area of beam

GA_y : Shearing stiffness of beam in y direction

GA_z : Shearing stiffness of beam in z direction

μ : Weight of beam per unit length

I_{mx} : Rotatory inertia of beam per unit length around x axis

Rotatory-inertia of beam per unit length around y axis

Rotatory inertia of beam per unit length around z axis

l: Total length

w: Forced circular frequency

F_x : Axial force in x axis direction

F_y : Shearing force in y axis direction

F_z : Shearing force in z axis direction

M_x : Torsional moment around x axis

M_y : Bending moment around y axis

M_z : Bending moment around z axis

m: Mass of concentrated material paint at joint.

J_x : Rotatory inertia of concentrated mass at joint around x axis

J_y : Rotatory inertia of concentrated mass at joint around y axis

J_z : Rotatory inertia of concentrated mass at joint around z axis

xG: Distance from joint to Center of Gravity of concentrated mass in x axis direction

yG: Distance from joint to Center of Gravity Of concentrated mass in y axis direction

zG: Distance from joint to Center of Gravity of concentrated mass in z axis direction

k_x : Spring constant of support joint in x axis direction

k_y : Spring constant of support joint in y axis direction

k_z : Spring constant of support joint in z axis direction

k_{mx} : Torsional spring constant of support joint around x axis

k_{my} : Torsional spring constant of support joint around y axis

k_z : Torsional spring constant of support joint around z axis

(1) Longitudinal vibration of beam.

Let

$$EA_x \frac{\partial^2 u}{\partial z^2} - \frac{\mu}{g} \frac{\partial^2 u}{\partial t^2} = 0 \dots\dots\dots (1)$$

$$u = u_0(x) \sin \omega t \quad \dots\dots\dots (2)$$

and substitute equation (2) into (I)

$$-\frac{d^2 u_0}{dx^2} - \sigma^2 u_0 = 0 \quad \dots\dots\dots (3)$$

where, $\sigma^2 = \omega^2 \mu / EA_x g$

Therefore, the solution of equation (3) can be given by the next equation

$$u_0(x) = A_1 \cos \alpha x - A_2 \sin \alpha x \quad \dots\dots\dots (4)$$

A1, A2: constant of integration.

(2) Lateral vibration of beam

The lateral vibration of beam having uniform cross section, where bending, shearing and rotatory inertia are taken into account, can be expressed as follows, according to the well known equation" of Timoshenko Firstly, the lateral vibration in y direction can be expressed by the next equation

$$\frac{\partial^4 v}{\partial x^4} - \left(\frac{b_x}{p_x} + \frac{a}{q_x} \right) \frac{\partial^4 v}{\partial x^2 \partial t^2} + \left(\frac{a}{p_x} \frac{\partial^2 v}{\partial x^2} + \frac{b_x}{q_x} \frac{\partial^2 v}{\partial t^2} \right) = 0 \quad \dots\dots\dots (5)$$

Here, since

$$a = \frac{I_x}{g}, \quad b_x = \frac{I_{xy}}{g}, \quad p_x = EI_x, \quad q_x = GA_x,$$

let $v = v_0(x) \sin \omega t \quad \dots\dots\dots (6)$

and substitute in equation (5)

$$\frac{d^4 v_0}{dx^4} + 2k_{1y} \frac{d^2 v_0}{dx^2} + k_{2y} v_0 = 0 \quad \dots\dots\dots (7)$$

where;

$$2k_{1y} = \left(\frac{b_y}{p_x} + \frac{a}{q_y} \right) \cdot \omega^2 \quad \dots\dots\dots (8)$$

$$k_{2y} = \frac{a}{p_x} \left(-\omega^2 + \frac{b_x}{q_y} \omega^4 \right) \quad \dots\dots\dots (9)$$

Hence, equation (7) can be expressed by the next equation

$$v_0(x) = C_1 \cosh m_1 x + C_2 \cos \sinh m_1 x + C_3 \cos m_2 x + C_4 \sin m_2 x \quad \dots\dots\dots (10)$$

C_1, C_2, C_3, C_4 : constant of integration

$$m_1 = \sqrt{\sqrt{k_{1y}^2 - k_{2y}} - k_{1y}}$$

$$m_2 = \sqrt{\sqrt{k_{1y}^2 - k_{2y}} + k_{1y}}$$

In the similar manner, the lateral vibration in z direction to be obtained as below.

$$w = w_0(x) \sin \omega t \quad \dots\dots\dots (11)$$

$$w_0(x) = D_1 \cosh n_1 x + D_2 \sinh n_1 x + D_3 + D_4 \cos n_2 x \sin n_2 x \quad \dots\dots\dots (12)$$

D_1, D_2, D_3, D_4 : constant of integration

$$n_1 = \sqrt{\sqrt{k_{1z}^2 - k_{2z}} - k_{1z}},$$

$$n_2 = \sqrt{\sqrt{k_{1z}^2 - k_{2z}} + k_{1z}}$$

$$2k_{1z} = \left(\frac{b_z}{p_z} + \frac{a}{q_z} \right) \cdot \omega^2$$

$$k_{2z} = \frac{a}{p_z} \left(-\omega^2 + \frac{b_z}{q_z} \omega^4 \right)$$

$$b_z = \frac{I_{xy}}{g}, \quad p_z = EI_z, \quad q_z = GA_z$$

(3) Torsional vibration of beam

let

$$GJ \frac{\partial^4 \theta_z}{\partial x^4} - \frac{J_{xz}}{g} \frac{\partial^4 \theta_z}{\partial t^2} = 0 \quad \dots\dots\dots (13)$$

$$\theta_y = \theta_{z0}(x) \sin \omega t \quad \dots\dots\dots (14)$$

and substitute (14) into equation (13)

$$\frac{d^4 \theta_{z0}}{dx^4} - \tilde{p}^2 \theta_{z0} = 0 \quad \dots\dots\dots (15)$$

where; $\tilde{p}^2 = \omega^2 J_{xz} / GJg$

Therefore the solution of equation (15) can be given by the next equation

$$\theta_{z0}(x) = B_1 \cos \beta x + B_2 \sin \beta x \quad \dots\dots\dots (16)$$

B_1, B_2 : Constant of integration

(4) Stiffness matrix

Stiffness matrix is obtained by using equations (4), (10), (12), (16).

Firstly, let

$$\left. \begin{aligned} F_x &= F_{x0}(x) \sin \omega t & M_x &= M_{x0}(x) \sin \omega t \\ F_y &= F_{y0}(x) \sin \omega t & M_y &= M_{y0}(x) \sin \omega t \\ F_z &= F_{z0}(x) \sin \omega t & M_z &= M_{z0}(x) \sin \omega t \end{aligned} \right\} \quad \dots\dots\dots (17)$$

Here, considering that

$$\left. \begin{aligned} \theta_y &= -\frac{dw_B}{dx}, \quad M_y = EL_y \frac{d^2 w_B}{dx^2}, \\ F_y &= -GA_y \frac{d^2 (v - v_B)}{dx^2} \\ \theta_z &= \frac{dv_B}{dx}, \quad M_z = -EL_z \frac{d^2 v_B}{dx^2}, \\ F_z &= -GA_z \frac{d^2 (w - w_B)}{dx^2} \end{aligned} \right\} \quad \dots\dots\dots (18)$$

where the related equations^{[3]J⁴¹}, obtained by using compatibility conditions of the displacement and equilibrium of forces, are expressed in matrix form, it will become as follows:

$$\begin{aligned}
 \begin{bmatrix} u_0 \\ v_0 \\ w_0 \\ \theta_{x0} \\ \theta_{y0} \\ \theta_{z0} \\ F_{x0} \\ F_{y0} \\ F_{z0} \\ M_{x0} \\ M_{y0} \\ M_{z0} \end{bmatrix} &= \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\left(1+\frac{ap_y}{q_s}\omega^2\right)\frac{1}{C_s} & 0 & 0 & 0 & -\frac{p_y}{q_s C_s} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \left(1+\frac{ap_s}{q_s}\omega^2\right)\frac{1}{C_y} & 0 & \frac{p_s}{q_s C_y} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -GA_x & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \left(\frac{ap_s}{q_y}+b_s\right)\frac{\omega^2}{C_y} & 0 & \frac{p_s}{C_y} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \left(\frac{ap_y}{q_s}+c_s\right)\frac{\omega^2}{C_s} & 0 & 0 & 0 & \frac{p_y}{C_s} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -GJ & 0 & 0 \\ 0 & 0 & \frac{ap_y}{q_s}\omega^2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & p_y & 0 \\ 0 & -\frac{ap_s}{q_y}\omega^2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -p_s \end{bmatrix} \begin{bmatrix} u_0 \\ v_0 \\ w_0 \\ \theta_{x0} \\ \frac{dw_0}{dx} \\ \frac{dv_0}{dx} \\ \frac{du_0}{dx} \\ \frac{d^2v_0}{dx^2} \\ \frac{d^2w_0}{dx^2} \\ \frac{d\theta_{x0}}{dx^2} \\ \frac{d^2w_0}{dx^2} \\ \frac{d^2v_0}{dx^2} \end{bmatrix} \quad \text{---(19)}
 \end{aligned}$$

$$\text{where } C_y = \left(1 - \frac{b_y}{q_y}\omega^2\right), \quad C_s = \left(1 - \frac{b_s}{q_s}\omega^2\right)$$

The equation (19) shall be rewritten in the form of next equation

$$\begin{bmatrix} D(x) \\ F(x) \end{bmatrix} = B \begin{bmatrix} H_1(x) \\ H_2(x) \end{bmatrix} \quad \text{---(20)}$$

Where $D(x)$, $H_1(x)$ are from the top to the 6th row, and $F(x)$, $H_2(x)$ are the last 6 rows. Then, by using equations (4), (10), (12), (16), the next equation can be obtained.

Equation (21) will be expressed as in the next equation

$$\begin{bmatrix} H_1(x) \\ H_2(x) \end{bmatrix} = L(x) \cdot C \quad \text{---(22)}$$

By substituting equation (22) into equation (20), the following can be obtained:

$$\begin{bmatrix} D(x) \\ F(x) \end{bmatrix} = B \cdot L(x) \cdot C \quad \text{---(23)}$$

$$\begin{aligned}
 \begin{bmatrix} u_0 \\ v_0 \\ w_0 \\ \theta_{x0} \\ \frac{dw_0}{dx} \\ \frac{dv_0}{dx} \\ \frac{du_0}{dx} \\ \frac{d^2v_0}{dx^2} \\ \frac{d^2w_0}{dx^2} \\ \frac{d\theta_{x0}}{dx} \\ \frac{d^2v_0}{dx^2} \\ \frac{d^2w_0}{dx^2} \end{bmatrix} &= \begin{bmatrix} \cos \alpha x & 0 & 0 & 0 & 0 & 0 & \sin \alpha x & 0 & 0 & 0 & 0 & 0 \\ 0 & \cosh m_1 x & 0 & 0 & 0 & \sin m_1 x & 0 & \sin m_2 x & 0 & 0 & 0 & \cos m_2 x \\ 0 & 0 & \cosh n_1 x & 0 & \sinh n_1 x & 0 & 0 & 0 & \sin n_2 x & 0 & \cos n_2 x & 0 \\ 0 & 0 & 0 & \cos \beta x & 0 & 0 & 0 & 0 & 0 & \sin \beta x & 0 & 0 \\ 0 & 0 & n_1 \sinh n_1 x & 0 & n_1 \cosh n_1 x & 0 & 0 & 0 & n_2 \cos n_2 x & 0 & -n_2 \sin n_2 x & 0 \\ 0 & m_1 \sinh m_1 x & 0 & 0 & 0 & m_1 \cosh m_1 x & 0 & m_2 \cos m_2 x & 0 & 0 & 0 & -m_2 \sin m_2 x \\ -\alpha \sin \alpha x & 0 & 0 & 0 & 0 & 0 & \alpha \cos \alpha x & 0 & 0 & 0 & 0 & 0 \\ 0 & m_1^2 \sinh m_1 x & 0 & 0 & 0 & m_1^2 \cosh m_1 x & 0 & -m_2^2 \cos m_2 x & 0 & 0 & 0 & m_2^2 \sin m_2 x \\ 0 & 0 & n_1^2 \sinh n_1 x & 0 & n_1^2 \cosh n_1 x & 0 & 0 & 0 & -n_2^2 \cos n_2 x & 0 & n_2^2 \sin n_2 x & 0 \\ 0 & 0 & 0 & -\beta \sin \beta x & 0 & 0 & 0 & 0 & 0 & \beta \cos \beta x & 0 & 0 \\ 0 & 0 & n_1^2 \cosh n_1 x & 0 & n_1^2 \sinh n_1 x & 0 & 0 & 0 & -n_2^2 \sin n_2 x & 0 & -n_2^2 \cos n_2 x & 0 \\ 0 & m_1^2 \cosh m_1 x & 0 & 0 & 0 & m_1^2 \sinh m_1 x & 0 & -m_2^2 \sin m_2 x & 0 & 0 & 0 & -m_2^2 \cos m_2 x \end{bmatrix} \begin{bmatrix} A_1 \\ C_1 \\ D_1 \\ B_1 \\ D_2 \\ C_2 \\ A_2 \\ C_4 \\ D_4 \\ B_2 \\ D_3 \\ C_3 \end{bmatrix} \quad \text{---(21)}
 \end{aligned}$$

Therefore

$$C = (B \cdot L(x))^{-1} \begin{bmatrix} D(x) \\ F(x) \end{bmatrix} \dots\dots\dots(24)$$

By using equations (23), (24), the following can be obtained:

$$\begin{bmatrix} D(l) \\ F(l) \end{bmatrix} = B \cdot L(l) \cdot C = B \cdot L(l) (B \cdot L(0))^{-1} \begin{bmatrix} D(0) \\ F(0) \end{bmatrix} \\ = \begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix} \begin{bmatrix} D(0) \\ F(0) \end{bmatrix} \dots\dots\dots(25)$$

Where the above takes the form of

$$\begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix} B \cdot L(l) (B \cdot L(0))^{-1} \dots\dots\dots(26)$$

then, M_{12} , M_{21} , M_{11} , M_{22} are each a matrix of 6×6 .
From equation (25),

$$D(l) = M_{11} \cdot D(0) + M_{12} \cdot F(0) \dots\dots\dots(27)$$

$$F(l) = M_{21} \cdot D(0) + M_{22} \cdot F(0) \dots\dots\dots(28)$$

By using equations (27), (28) and applying the symmetry of stiffness matrix, the following equation can be obtained:

$$\begin{bmatrix} F(0) \\ F(l) \end{bmatrix} = \begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \end{bmatrix} \begin{bmatrix} D(0) \\ D(l) \end{bmatrix} = K \begin{bmatrix} D(0) \\ D(l) \end{bmatrix} \dots\dots\dots(29)$$

where

$$\begin{aligned} K_{12} &= (M_{12} M_{22}^{-1})^{-1} \\ K_{12} &= K_{21} = M_{22}^{-1} K_{22} \\ K_{11} &= M_{22}^{-1} (K_{21} - M_{21}) \end{aligned} \dots\dots\dots(30)$$

K in equation (29) is the stiffness matrix for vibration of beam having uniform cross section. Furthermore, when there is a concentrated mass m at the starting point or ending point of beam, the following matrix should be added to K_{11} or K_{22} .

$$\begin{bmatrix} -m\omega^2 & & & & \\ 0 & -m\omega^2 & & & \\ 0 & 0 & -m\omega^2 & & \\ 0 & m\omega^2 z_G & -m\omega^2 y_G & -J_x \omega^2 & \\ -m\omega^2 z_G & 0 & m\omega^2 x_G & 0 & -J_y \omega^2 \\ m\omega^2 y_G & -m\omega^2 x_G & 0 & 0 & 0 & -J_z \omega^2 \end{bmatrix} \dots\dots\dots(31)$$

Moreover, when the joint is spring supported, k_n , k_{n-1} , k_{n+1} , k_{n-2} , k_{n+2} , etc. should be added to the terms in diagonal line of the matrix for that joint.

2.3 Solution of vibrational stiffness equation

Using the equation (29) derived in the preceding section, the stiffness matrix for each member will be prepared. These matrices and external loads are placed in absolute coordinates, by carrying out transformation of coordinates. Then the stiffness matrix for the entire structure will be prepared by adding the matrices of all joints. When the inversed matrix of this stiffness matrix

for the entire structure is obtained and when it is multiplied by the external loads, the vibrational displacement and vibrational modes for each joint in that structure, in the case of circular frequency ω , can be obtained. By changing this ω little by little and repeating the above calculations, it is possible to obtain the resonance curve of that structure. In the actual computational programs, calculations for several vibrational frequencies are carried out simultaneously.

Because the stiffness matrix of the entire structure, in the case of three-dimensional framed structures, will become a matrix, of a size 6 times the number of general joints, it is not possible to directly calculate this inversed matrix, from the standpoint of computer capacity, when a structure contains very many joints. Therefore, the author has adopted the unit splitting method, which is generally used. The author, however, invented a method which will eliminate the need of splitting the structure into several units by the user himself, which is very troublesome work and is considered as shortcomings of unit splitting method. Since the details of this system had already been presented⁽¹²⁾, its explanation will be omitted here. Furthermore, assumptions concerning the relation between the structural member coordinate system and the absolute coordinate system, and the releases at joints and at ends of members are the same as the above reference⁽¹²⁾.

3. Program

The program was prepared in accordance with the contents as explained above. The points which were specially considered in the preparation of this program are as follows:

1. The sectional properties and dead weight of each member will be automatically calculated by the input of its dimensions and specific gravity.
2. The vibrational modes can be drawn by the plotter, thereby the results of analytical work can be quickly and appropriately grasped by appealing to vision.
3. Attempts have been made to minimize the user's efforts by providing the error messages at each check point, thereby permitting early detection of erroneous data.
4. Considerations have been made to permit computational capacity of structures having large number of joints and members. At present, the maximum computational capacity is as follows:

Number of joints: 800

Number of members: 1,600

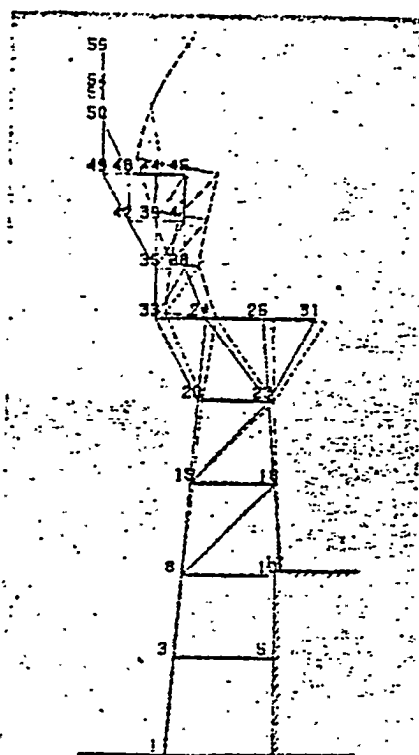
Number of loading conditions: 16

the computer employed in this system is UNIVAC-1108, and the plotter is CALCOMP.

4. Example of applications

4.1 Example of vibrational analysis of radar mast

An example of analysis of radar mast in an escort ship, as shown in Fig. 2, will be introduced here. This

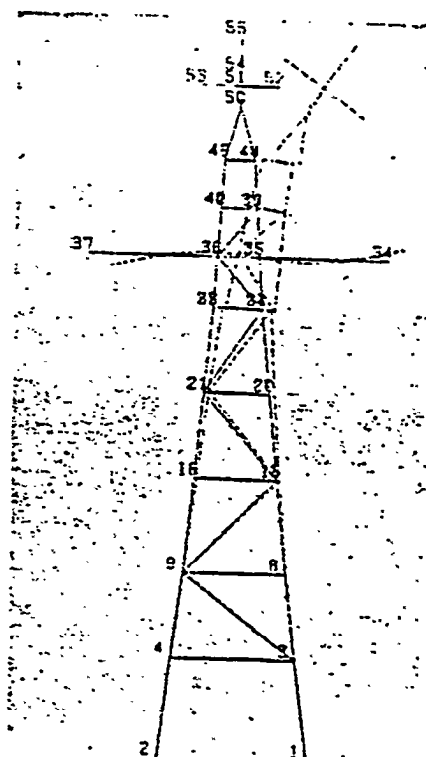


LOADING 1 FIG. 1

MODE CURVE (DY)

SCALE $\frac{1}{100}$ 358.0 CPM

Fig. 2-(a) Vibration mode of radar mast (first order in longitudinal direction)

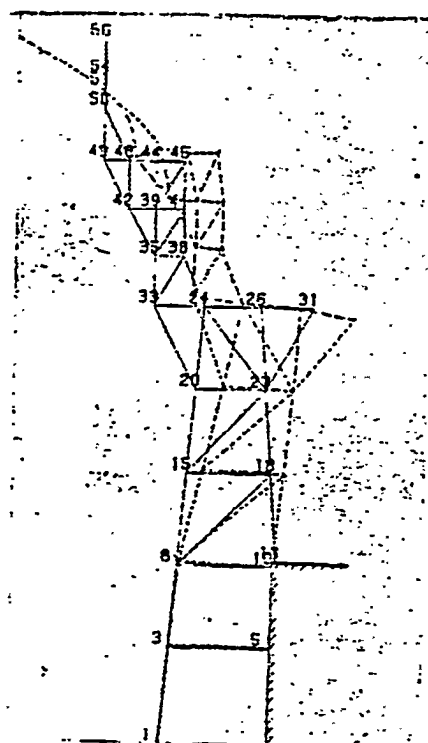


LOADING 1 FIG. 3

MODE CURVE (DY)

SCALE $\frac{1}{100}$ 323.0 CPM

Fig. 2-(c) Vibration mode of radar mast (first order in port and starboard direction)

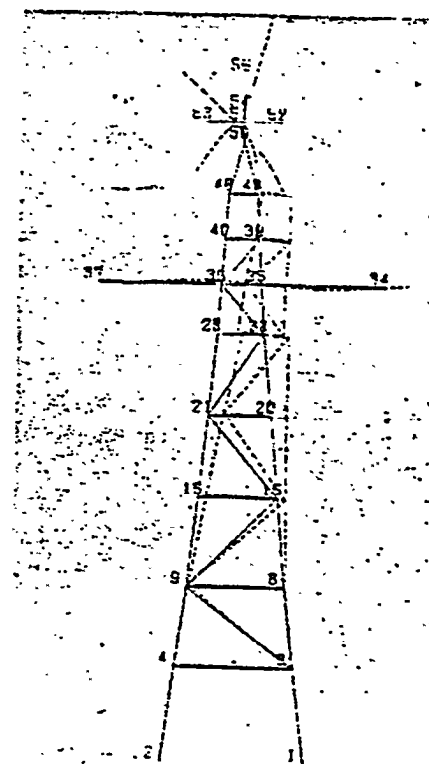


LOADING 1 FIG. 2

MODE CURVE (DY)

SCALE $\frac{1}{100}$ 672.0 CPM

Fig. 2-(b) Vibration mode of radar mast (second order in longitudinal direction)

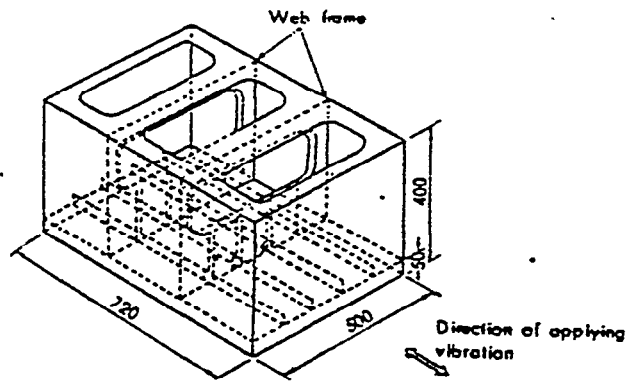


LOADING 1 FIG. 4

MODE CURVE (DY)

SCALE $\frac{1}{100}$ 630.0 CPM

Fig. 2-(d) Vibration mode of radar mast (second order in port and starboard direction)



(note Material: Acryl
Elastic modulus: 460 kg/cm²)

Fig. 3 Model of experiment (mm)

radar mast is a three-dimensional framed structure made up of steel pipes. The radar and other equipment are attached to 14 joints **near** the top of the mast, and they are considered to constitute a concentrated masses.

The dead weight of steel pipes, which constitute the framed structure will be computed as distributed mass in the program by inputting pipe diameter, thickness and specific gravity, and the distributed mass will be applied to each member. Moreover, **since** the dimensions of each member are given the sectional properties of each member will be automatically computed in the Program. In addition, the coordinate values and boundary conditions of each joint will be input. As for the hud. forced displacements, consisting of sinusoidal waves of same amplitude, were applied to 10 support joints: at the base of radar, in the directions along the length of **ship** as well as toward port and starboard.

The 'computational results of vibrational modes are Drawn by the plotter as shown in Fig. 2 The resonance Points in port and starboard directions were 320 cpm

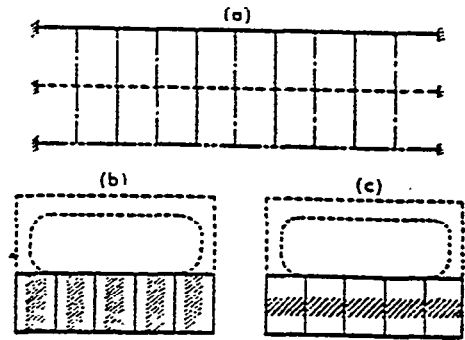


Fig. 4 Process of modification to web frame structure

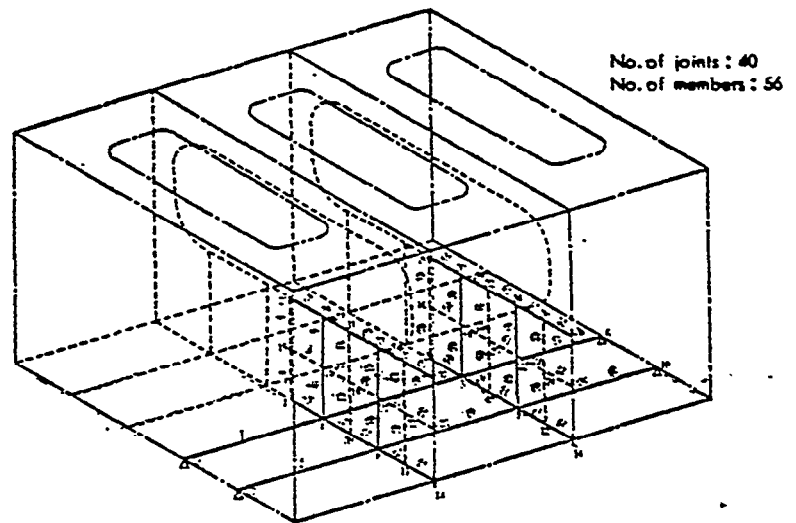


Fig. 5 Frame structure of tank for calculation

for first order and 630 cpm for second order. and in longitudinal direction 365 cpm for first order and 672 cpm for second order. Moreover, because the weight distribution of this mast is not symmetrical longitudinally, a **small** amount of torsion will be generated in lateral vibrations.

4.2 Example of vibrational analysis of web frame in tank

Recently, with the increase in ship size, there are sometimes damages of web frames in tank near the stem, due to vibrational forces. In order to investigate the behavior of vibration on web frames in tank, a model test was done by the technical research laboratory of our company. A comparison between the test results and the analytical results by this program ZVIBRA has been made.

(I) Model test

A test model shown in Fig. 3 consists of tank, made of acrylic resin, in which 2 web frames were installed. The model was mounted on the vibrator base, then vibration was applied on to **the model** in longitudinal direction (perpendicular to surface of web frame), and

vibrational responses and vibration modes were measured for the cases of with and without water in the tank.

Measurements were made in the following manner, namely. 8 accelerating type pick-ups (weight: 1.5 g) were attached to the web frames, and pick-up was fixed onto the vibrator base. By changing the vibrational frequency both acceleration and phase were measured for each vibrational frequency. The positions where the pick-ups were attached are shown in Fig. 6.

(2) Computation by this program

Because this program is applicable only to framed structures, it is necessary to modify the type of structure where it is close to a plate, as in the case of web frame, into a model of frame-type structure. According to test results (Fig. 6), it is clear that the panel itself between stiffeners also vibrates considerably. Therefore, the conventional method of solving the web frame stiffness problems, in assuming the web frame to be substituted by a grillage structure made up of stiffeners with appropriate effective width, as generally used, is not useful. Therefore, the panel between stiffeners was also assumed to constitute a part of the grillages, and the fixing condition of web frame ends was also taken into consideration. Then computations were carried out with the assumptions as below:

1. The portion shown by the dotted lines in Fig. 4-(b) will be ignored, and it is assumed that the web frame is made up of panels and stiffeners shown by solid lines only.
2. The panel between stiffeners is assumed to constitute a part of grid, thereby the web frame is assumed to be a grillage structure in Fig. 4-(a). Further, lines in Fig. 4-(a) show the following items:

Heavy continuous line:

Stiffness and weight will be determined by assuming a member made up of a vertical stiffener plus an effective width equal to a half of the panel between stiffeners.

Alternate long and short dash line:

The shaded portion in Fig. 4-(b), namely, stiffness and weight will be computed by taking up the central half of the panel between stiffeners.

Dotted line:

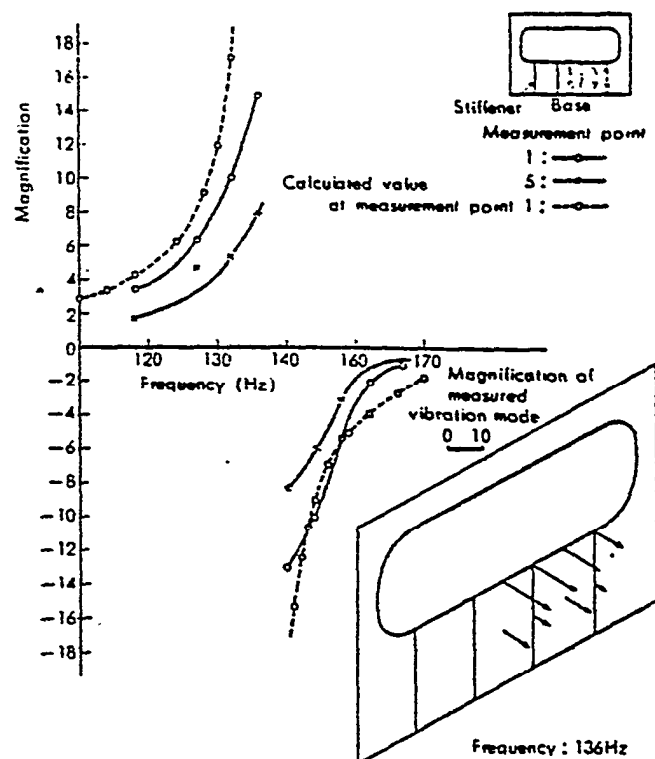
An area having a width equal to 1/2 of panel in horizontal direction is taken up in the middle of panel (shaded portion in Fig. 4-(c)), and it is assumed that there is a member which has stiffness equivalent to the above dimensions but has no weight.

Light continuous line:

The face plate only on upper edge, and its stiffness and weight will be determined.

Alternate long and two short dashes line:

The lower plate of web frame and 1/2 of tank bottom plate are assumed to contribute to the stiffness and only the latter item will be accounted for weight.



(Note) $\text{Magnification} = \frac{\text{Measured acceleration}}{\text{Acceleration on vibrator base}}$
(Negative sign if in inverse phase)

Fig. 6 Resonance curves and vibration mode of web frame in air

3. Both left and right ends of the grillage shown in Fig. 4-(a) are supposed to be rigidly fixed to both walls of sufficiently rigid model tank.
4. The lower end of web frame which is assumed to be of grillage structure is rigidly fixed to the tank bottom stiffeners at the bottom of vertical stiffeners, and the stiffness and weight of the tank bottom stiffeners is computed by including the entire effective width of the panel.
5. The entire model is handled as a framed structure shown in Fig. 5. In this case since the model is symmetrical about the center of tank, only a half of the above model will be considered and at the center only a half of the stiffness and weight of a member is taken, and its rotatory displacement was assumed to be zero.

As for the loads used in computation, an attempt was made to produce the same conditions as in the case of test by applying forced displacements of sinusoidal type onto joints 3, 6, 7, 10, 13, 14, 25, 26, 37, 38, in Fig. 5.

(3) Comparison of test and computational results

Frequency response curves and vibration modes of the model tested in air are shown in Fig. 6, and the frequency response curve was plotted from the computations at measurement point-i. Further, in Fig. 7 a comparison is made of measured and computed

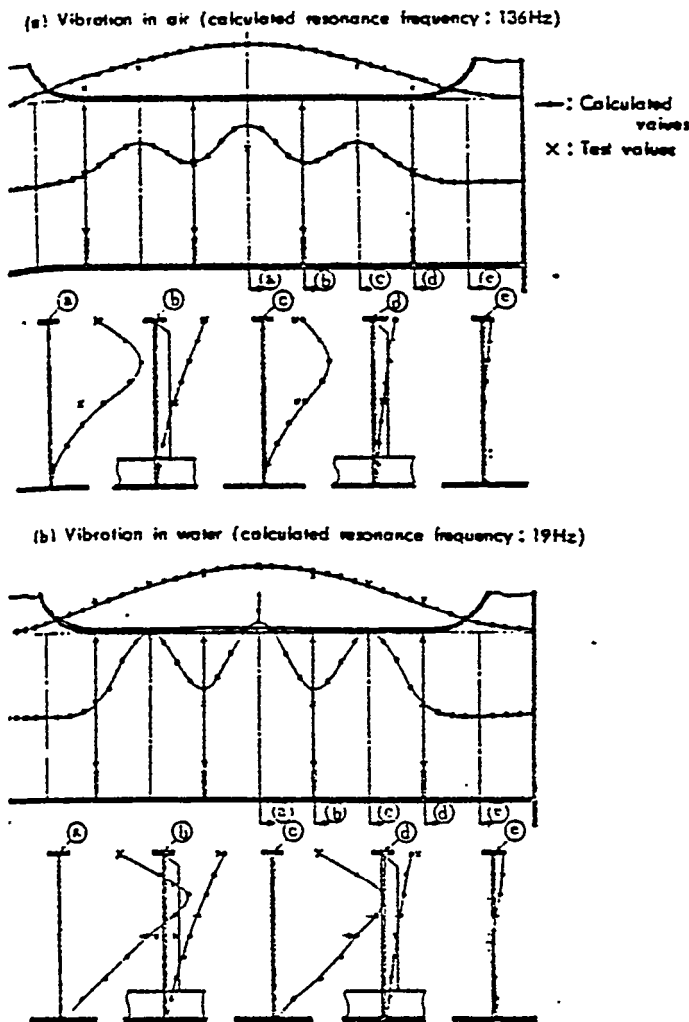


Fig. 7 Measured and computed vibration mode of web frame

vibration modes. **both in air and in water.** However, in the case of computation of vibrations in **water**, the virtual mass of water was estimated from the frequency of both in air and in water according to tests, and those values were used in the computation.

As can be seen from Fig. 6, the calculated value of resonance frequency is 136Hz which agrees fairly well with the test value. However, the magnification of vibrations shown to be of large value near the resonance point, because damping factor is not taken into **account**, and the calculated **values** approach to the test values as the frequency moves away from the resonance point. In Fig. 7, when the test and computative values are taken equal at measurement point-1, a comparison of the two values at other points is shown. As can be seen from the above, the form of vibration mode agrees fairly well with test results, and the mode from computation clearly shows that the panel between stiffeners is in coupled vibration. Examples of output mode by the plotter in drawing the vibration mode curves are shown in Fig. 8.

4.3 Example of analysis of coupled vibration between hull and bottom

As one method of analyzing the vibration of hull, the hull **can** be considered as a beam with varying cross section, and it has been ascertained that computation based on the above assumption produces adequately precise results, if the degree of vibration is rather low. However it is known that⁽³⁾ in high degree vibration having more than 4 nodes or so, unless the coupled vibration with local vibrations arising from bottom, etc. is not taken into account, it is difficult to carry out accurate analysis.

As an example of analysis of coupled vibration between hull and bottom (double bottom), the case of Ship A (a bulk carrier) will be explained below:

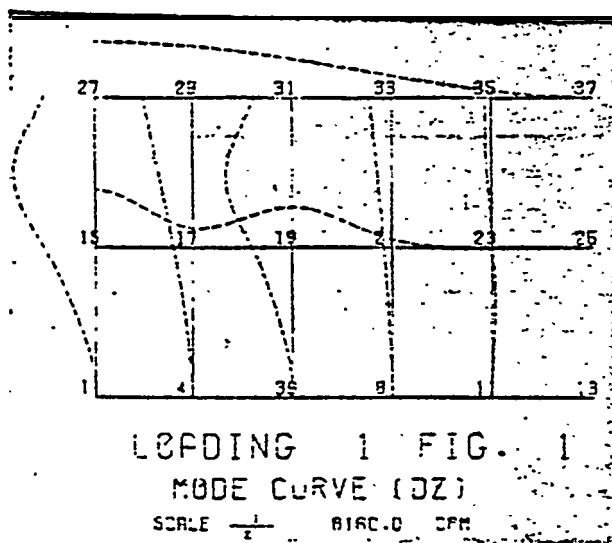


Fig.8(a) Output from CALCOMP plotter of vibration mode curve of web frame in air (1)

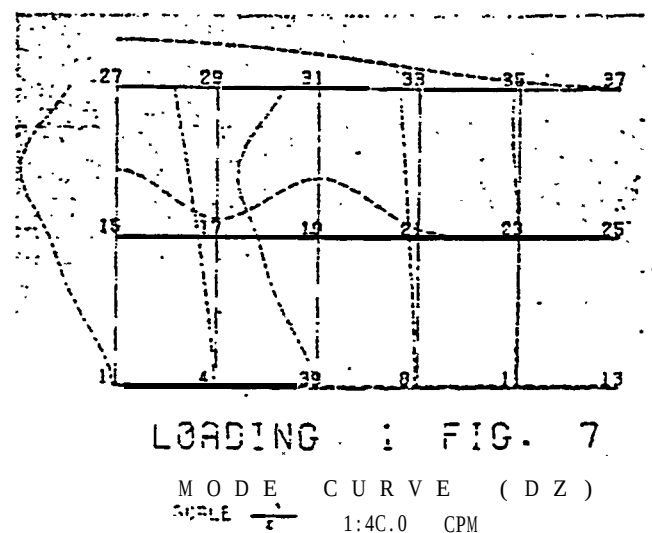


Fig. 8-(b) Output from CALCOMP plotter of vibration mode curve of web frame in air (2)

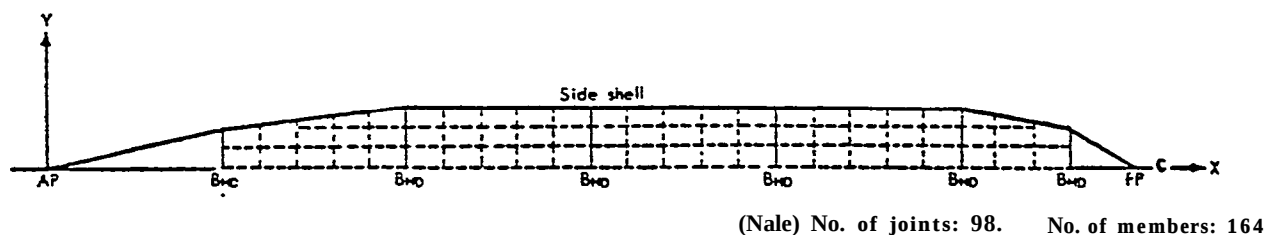


Fig. 9 Modification to plane grid of side shell, transverse bulk had and double bottom

(1) Computative assumption

In **carrying** out the analysis the following assumptions have been made:

1. The hull will be approximated by a plane grid as shown in Fig. 9. **Since the hull** is a symmetrical structure at port and starbord. of the hull need be considered. Namely, by letting the vertical displacements of all joints on the centerline of ship as well as the rotatory displacements around Y axis free. and also by letting other components displacements constrained, the results would be the same as if both sides were computed. As for the means of approximating the structure by plane grids. the double bottom structure is shown by a plane grid with dotted lines. and both side structure and transverse bulkheads by a grid with continuous lines.
2. The stiffness of each structure was-taken as below:
Double bottom:

The double bottom was split into 4 transverse girders and 3 longitudinal girders, then their stiffness was computed. The torsional stiffness was computed by using a value assuming that the double bottom is made of plates with anisotropic plate.

Side shell:

One half of the longitudinal stiffness of ship {moment of inertia and the effective shearing area used in the so-called longitudinal strength of ship) was used. For the torsional stiffness of double bottom, the torsional stiffness of hopper, which is connected with the double bottom floor was used.

Transverse bulkhead:

The bending stiffness was taken to be very large, and computing the shearing stiffness the cross sectional area of bulkhead plate was used.

3. The distribution of hull weight has been allocated as below:

Double bottom:

The dud weight of double bottom and the ballast within double bottom **were uniformly distributed** to transverse **girders**.

Side shell:

Both hull weight and ballast other than those of the double bottom were distributed, according

to the respective distribution in longitudinal direction. so that the resultant distribution in o member would be uniform.

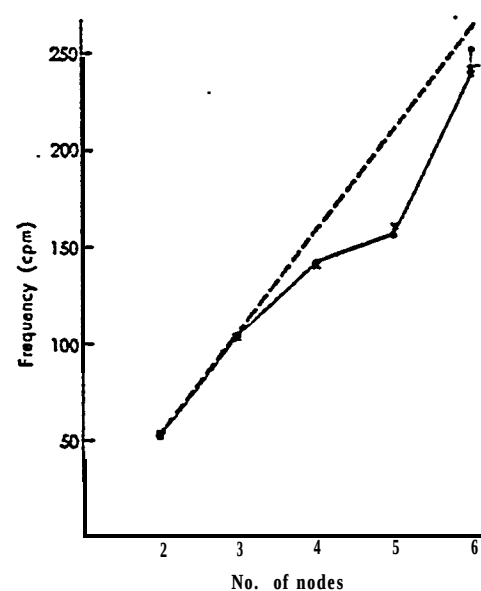
Transverse bulkhead:

The dead weight of transverse bulkhead is to included in the side shell.

4. Virtual mass of the water, as obtained using t method of Lewis⁽⁶⁾ was distributed to the ion tudinal girders of double bottom, and where the is no longitudinal girder. it was distributed to t side shell.

Table : Comparison between calculated and measured natural frequencies of ship-A

Node	2	3	4	5	6
Category					
measured values	53	103	140	160	(252)
Calculated values	52	104	141	156	(239/251)



(Note) - - -: calculated values

x : Measured

-----: calculated values uunder assumption that hull is abeam with varying cross section.

Fig. 10 Natural frequency versus number of nodes c ship-A

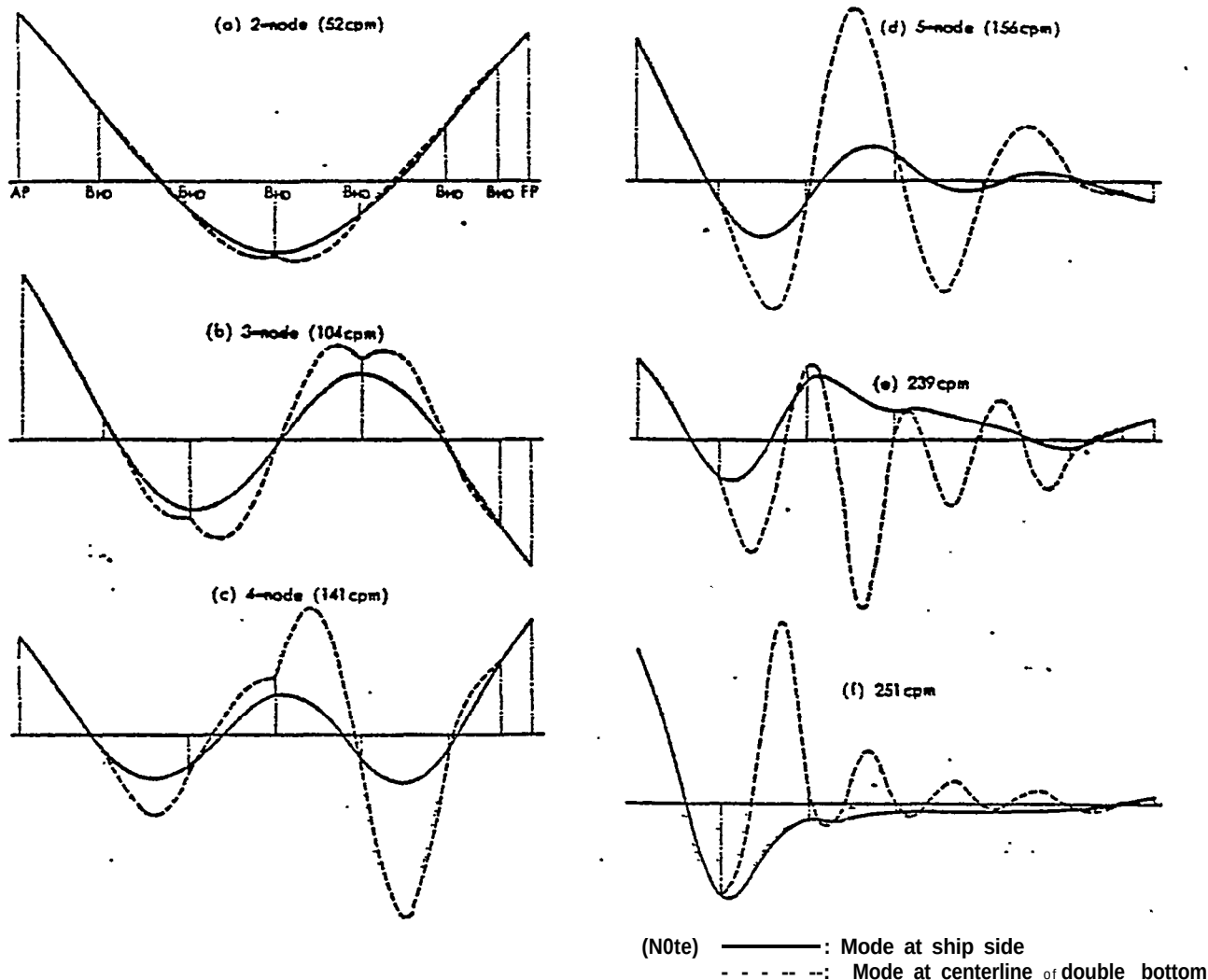


Fig. 11 Calculated mode curves of ship-A

5. As for the load, vertical forces of sinusoidal form were applied onto joint at **stern** end.

(2) Results of analysis and comparison with actual measurement results

Under the above assumptions, the vertical hull vibration of Ship A was computed. Table I contains the comparison between calculated and measured values of natural frequencies, and Fig. 10 shows the comparison between calculated and measured results of natural frequency curves. The dotted line in the above figure represents the calculated values, when the hull is assumed of a beam having varying cross section. Moreover, the frequency with 6 nodes in the above table is actually not of a mode with 6 nodes, and because only the stern is vibrating, its frequency is equivalent to 6 nodes but not of 6 nodes in strict sense.

As can be seen from Fig. 10, the values obtained from calculations agree very well with measured values, when calculations were made by assuming a beam with varying cross section, as a matter of course the coupling effects between hull and double bottom can not be accounted

for, and because the resonance frequency varies linearly as the number of nodes increases, the calculated results will differ considerably from the measured values starting from around the 4th node.

Vibration modes of side shell and centerline of double bottom at the resonance point, according to the calculation of this system is shown in Fig. II. It can be seen that the vibration of double bottom increases starting from around the 4th node. Moreover, the fact that at resonance points of 239 cpm and 251 cpm the nodes on side shell disappear and only the stern portion vibrates will provide a good explanation on the actual cases where stern vibrations frequently occur in higher degree vibrations.

5. Conclusions

With the stiffness matrix method, a general **purpose** program ZVIBRA for vibrational analysis of three-dimensional and two-dimensional framed structures has been prepared. Its outline and several examples of its application have been presented, showing that

there have been good agreements between theory and test results. As a target for future studies, it is necessary to continue research which takes into account of the damping factor of vibration.

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V. RECOMMENDATIONS

The current upgrading of facilities and equipment related to Numerical Control Steel Fabrication, Sub-task 2.2 of the T.T.P., has produced a system which is capable of increasing the tons per month of fabricated steel. The related N/C software package, SPADES, currently provides more data than the system is utilizing. It is the common opinion of IHI and key Livingston Production and Engineering personnel that an N/C system of scaled body plan mold lofting be implemented through the installation of a numerically controlled drafting machine in the mold loft.

Please see Reference 1 which documents the rationale for this decision.

VI. REFERENCES

1. Study of LSCo N/C System and Description of IHI N/C System-IHI
2. Comparison Analysis: LSCo vs. IHI N/C Systems-Levingston
3. Memo: RW Taylor to Clyde LaRue; April 24, 1979; N/C Drafting Machine
4. Study of SPADES and LSCo Utilization-IHI
5. System Change Analysis
6. Memo: K. Honda to Bob. Peterson, June 20, 1979; Merits for Installation of N/C Drafter Machine.

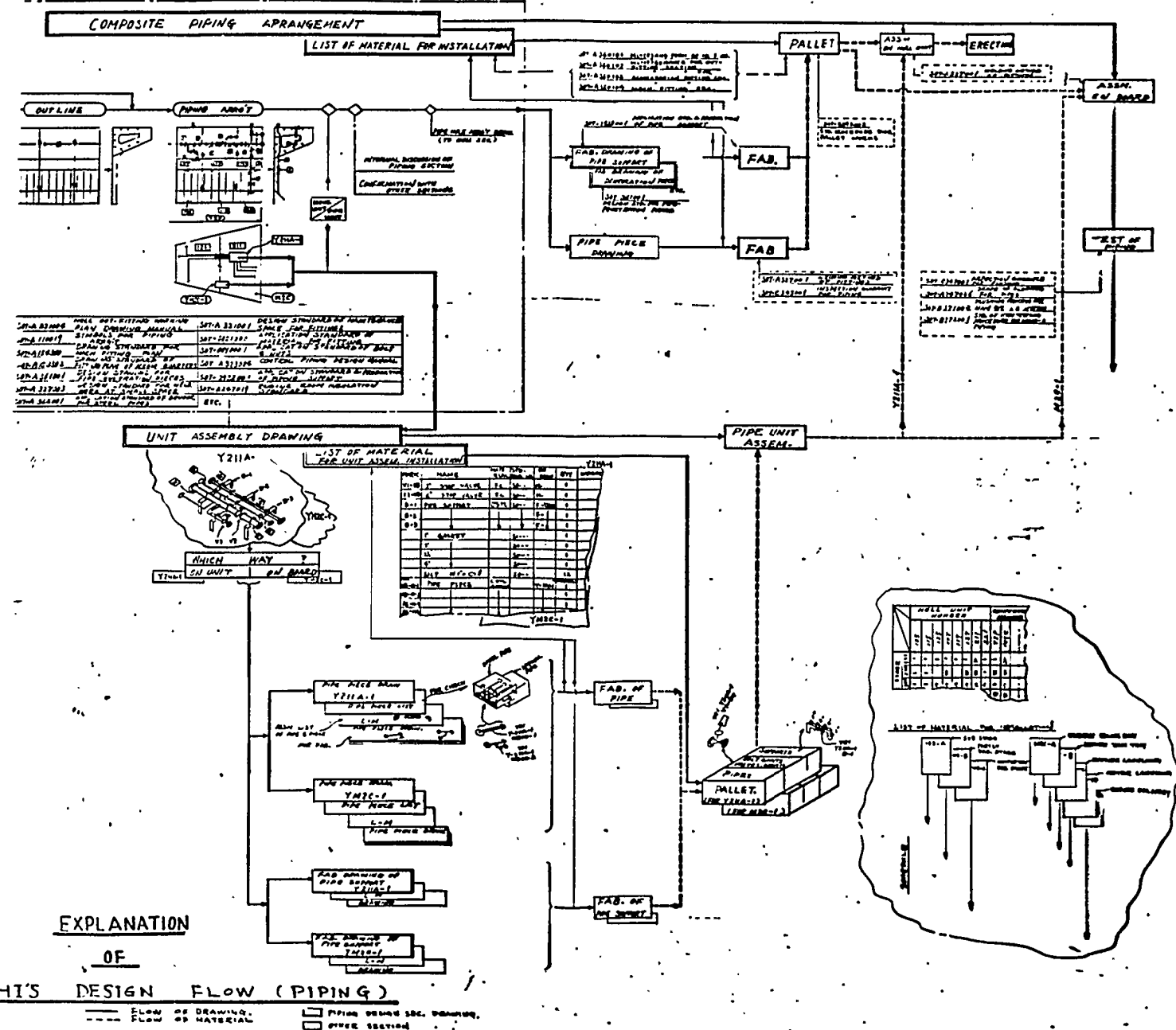
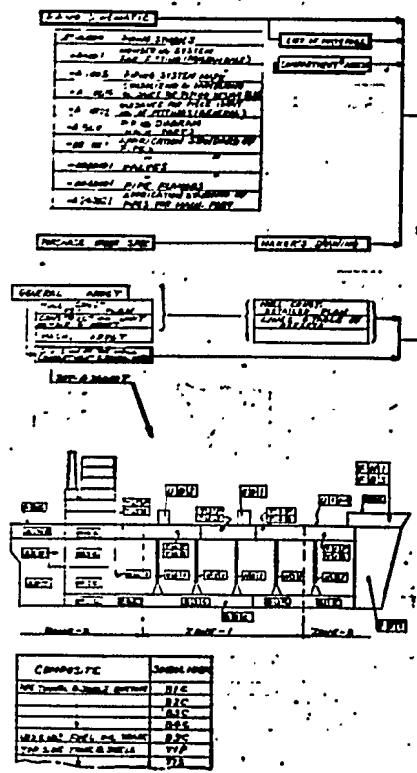
APPENDIX M

IHI WORKING FLOW AND SCHEME FOR HULL STRUCTURE DESIGN

APPENDIX N

EXPLANATION OF IHI'S DESIGN FLOW (PIPING)

1. FABRICATION OF FITTING
2. FABRICATION OF PIPE
3. FABRICATION OF VALVE
4. FABRICATION OF FLANGE
5. FABRICATION OF ELBOW
6. FABRICATION OF TEE
7. FABRICATION OF CROSS
8. FABRICATION OF REDUCER
9. FABRICATION OF CAP
10. FABRICATION OF PLUG
11. FABRICATION OF GASKET
12. FABRICATION OF BOLT
13. FABRICATION OF NUT
14. FABRICATION OF WASHER
15. FABRICATION OF LOCKWASHER
16. FABRICATION OF RIVET
17. FABRICATION OF SCREW
18. FABRICATION OF PIN
19. FABRICATION OF NAIL
20. FABRICATION OF WIRE
21. FABRICATION OF CABLE
22. FABRICATION OF ROPE
23. FABRICATION OF BELT
24. FABRICATION OF CHAIN
25. FABRICATION OF HOIST
26. FABRICATION OF CRANE
27. FABRICATION OF LIFT
28. FABRICATION OF PUMP
29. FABRICATION OF MOTOR
30. FABRICATION OF GENERATOR
31. FABRICATION OF TRANSFORMER
32. FABRICATION OF SWITCH
33. FABRICATION OF RELAY
34. FABRICATION OF FUSE
35. FABRICATION OF CIRCUIT BREAKER
36. FABRICATION OF CONTACTOR
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100. FABRICATION OF THERMISTOR



EXPLANATION

OF

THIS DESIGN FLOW (PIPING)

--- FLOW OF DRAWING

--- FLOW OF MATERIAL

□ PIPING ON BOARD SEC. DRAWING

□ PIPE SECTION