JPRS: 2850

17 June 1960

SHIPBUILDING INDUSTRY AND DESIGNING WORK IN COMMUNIST CHINA

Distributed by:

OFFICE OF TECHNICAL SERVICES
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~~Price: $2.50~~

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205 EAST 42nd STREET, SUITE 300
NEW YORK 17, N. Y.

JPRS: 2850

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[The following are full translations of selected articles from Chung-kuo Tsao-ch'uan (China's Shipbuilding), Number 4, 15 October 1959, Shanghai.]

CONTENTS

AN INTRODUCTION TO THE "HO-P'ING NO 49" COASTAL FREIGHTER

[This is a full translation of an article appearing in Chung-kuo Tsao-ch'uan (China's Shipbuilding), No 4, Shanghai, 15 October 1959, pages 18-39.]

SUMMARY

This article is a concise introduction to the design, construction and sea trial of S.S. "Ho-p'ing No 49". Actual data and claculations pertaining to the design and trial run of this vessel are also included for future reference. At the same time, a general introduction to the analysis of principal dimensions of this vessel, features of hull structure and the application of new technique in the power installation and electrical system are also given. The final portions of the article appraises the design, construction and sea trial of this vessel and also provides comments and suggestions for future efforts in further analysis and research on the collected data.

(1) GENERAL INTRODUCTION

"Ho-p'ing No 49" is a single deck, single propeller, steel shell dry cargo vessel. It's main engine is a Misima type coal-burning steam engine. The vessel is designed to carry heavy cargoes such as timber, steel, ore and grain between our large and medium coastal ports. Its design is based on the highest class P½C class of the 1956 Steel Vessel Construction and Classification Manual of the USSR Vessel Registration Bureau. The main engine's economic horsepower is 1000 IHP; rotating speed 100 revolution per minute; service speed 10.8 knots.

The Shanghai Shipyard started the design and construction of this ship in 1958. Under the glowing light of the General Line and total support and correct guidance of the Party, the staff and workers of the shipyard applied standardized procedures in the preparation of calculation and drawings. It took only twenty-six days of designing to finish essential preliminary-starting prints for this ship.

Again, it took only thirty-five days from the shipway assembly of hull structure to the launching which created a new record in China's shipbuilding history. Ninety-five days after starting the shipway assembly of hull structure, the vessel was completed and delivered. The Shanghai Shipyard had victoriously built that ship. Its efficiency and skill matches international shipbuilding standards.

This ship's shell, propulsion and auxiliary machinery, electrical and navigational equipment were all manufactured in our own country. Its quality has been appraised and examined by marine inspection agencies and is considered to be of high standards. This ship's features are high efficiency in handling of cargo and fuel economy. Among domestic sea transports it is classified as an economy vessel.

This vessel has already been on sea duty for over six months on a heavy service schedule. This considerable period of actual sea duty has proved its high performance and its design has met requirements. Following is a concise introduction to this vessel's design, construction and sea trial.

(II) DESIGN

1. Design Requirements:

This vessel was designed and built according to anticipated service requirements. Its deadweight tonnage is 3200 metric tons, cruising distance 1700 nautical miles. The steam engine was adopted as the main engine. Economic horsepower was determined as 1000 IHP; trial speed not lower than 10.5 knots. The welding design of the hull plating was based on the standard P$\frac{1}{4}$C class of the 1956 USSR Sea Vessel Specifications. S.S. "Ho-p'ing No 18" was used as the model ship.

2. **Hull Design:**

(1) The selection of principal dimensions and coefficients:

(a) Calculation and selection of displacement--According to the deadweight coefficient method and admiralty coefficient, the displacement was first estimated between 4800 to 4900 metric tons, with 4850 metric tons [finally] adopted.

(b) Selection of length of ship--Based on tested formulas, it was estimated that this ship's economic length was L=85~88 meters. The length of ship affecting the resistance was analyzed which resulted in the plotting of two curves: Effective Horsepower Curve in Fig 1 and, under constant speed, the Length of Ship Affecting Resistance Curve in Fig 2.

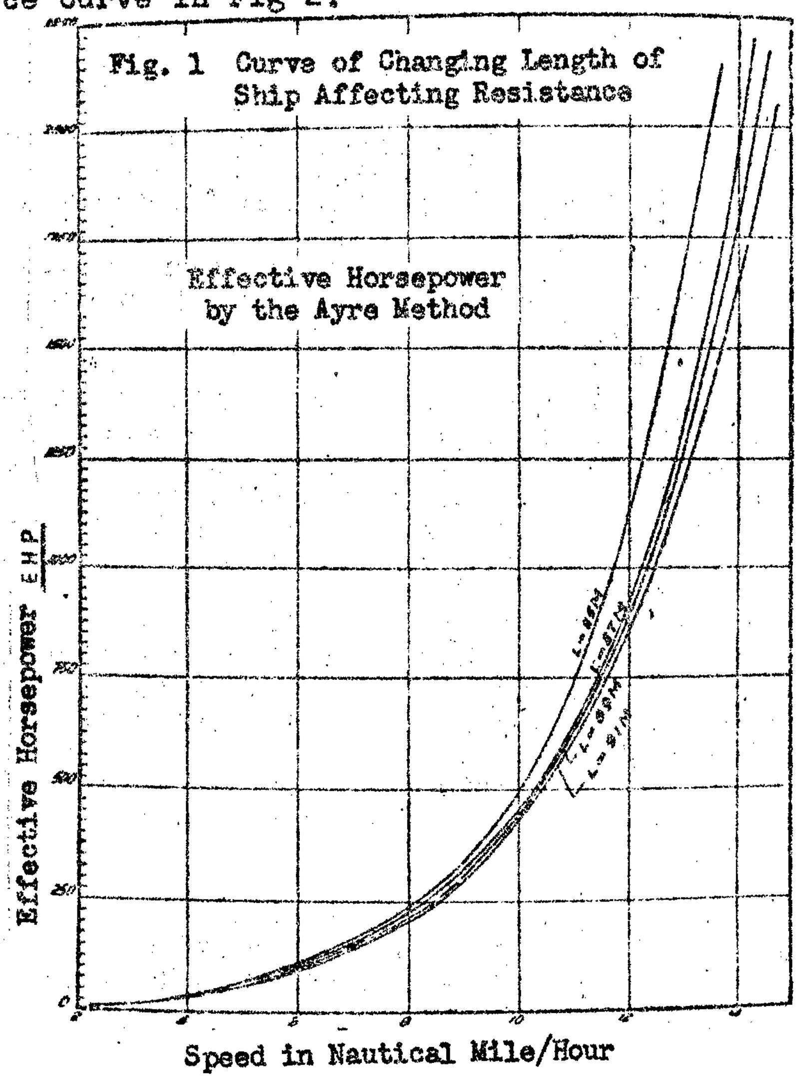


Fig. 1 Curve of Changing Length of Ship Affecting Resistance

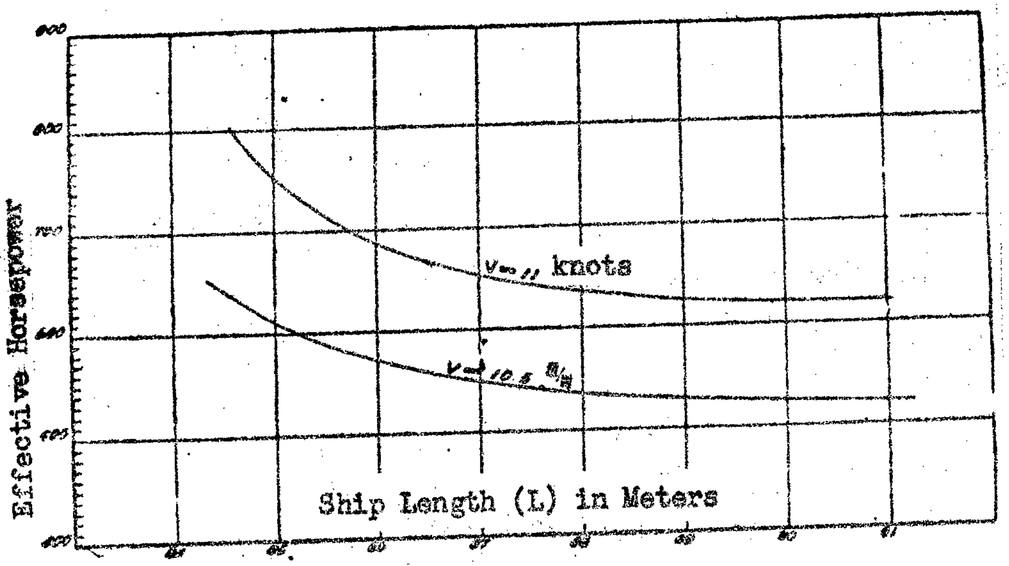


Fig. 2 Curve of Changing Length of Ship Affecting Resistance

Fig 2 shows that the resistance was comparatively low when the length of ship was between 86 to 87 meters. And when the length was over 87 meters, the change in resistance was negligible. The length of ship was therefore chosen at 86.0 meters. Further, when V=10.5 knots, $\frac{V}{\sqrt{L}}$ = 0.625 which is near the curve's bottom and this is fairly reasonable.

(c) Determination of the beam, depth and draft-- According to data on medium and small type sea vessels, the length-beam ratio L/B was mostly between 6.0 and 6.8. The length-beam ratio of the model ship was 6.6. Based on tested formulas it was estimated that B 12.8 to 13.5 meters. This ship's beam was selected as 13 meters.

Generally speaking, when $\frac{V}{\sqrt{L}}$ = 0.63 or thereabouts, the beam-draft ratio B/T=2.2~2.4. The determination of draft should take the depth of various coastal harbours into consideration. According to requirements, this ship's draft should be about the same as the model ship whose draft was T=5.66 meters. Based on calculation, the beam-draft was 2.3 which is between the 2.2 and 2.4 as set forth above.

The depth of ship should be determined according to the freeboard, hold capacity and the values of L/H and H/T. Generally, the limitation on the L/H ratio of modern sea vessels is 14 and H/T=1.05~2.0. Because this vessel was designed mainly for carrying coal, it would fulfill requirements when hold capacity coefficient Therefore, H was taken at 6.5 meters and by calculation the hold capacity coefficient $\hbar$ =1.3 meter^3/ton which also corresponds with the freeboard. Thus, L/H=13.25<14, H/T=1.145 > 1.05 which are all within usual limitations.

(d) The selection of principal coefficients--Based on principal dimensions selected above, this ship's block coefficient δ =0.744. Calculated by tested formula δ =0.73 to 0.77.

Usually for such type of vessel if we take higher midship-section coefficient β and lower prismatic coefficient φ we could get lower resistance. According to the suggestion of Mr "No-chi-te" and Mr "Fan-la-mao-lun", the value of β is near 0.98. We took higher value β=0.983, then $\varphi = \delta/\beta =$ 0.757. At this instance, Ⓟ = 0.535. Mr Baker holds that when Ⓟ = 0.515, the wave-making resistance should be at the minimum. This ship's Ⓟ value was quite near it.

The $\frac{1}{2}$ angle of attack at stems of average low speed ships is 22^o to 24^o. This ship's water-plane section is somewhat wider; ϵ was taken at 24^o.

According to Mr Todd, Mr Ayre and Mr Yamaken's suggestion on the location of center of buoyancy X_ρ of low speed vessels, the best X_ρ =+(0.7 1.7%)L. But based on center of gravity calculations in considering pitching, + 0.673%L is more apt and is not too different from the above figure.

The length of parallel middle body "ϕ", according to tests and design experience, is more suitable at 24 to 30 percent of L. It was set at 27 percent of L, 23.23 meters.

Water-plane coefficient "α", according to Mr Baker and Mr No-chi-te, should be α = 0.829 to 0.84 when this ship's Froude number Fr<0.22. It was taken at 0.833.

(2) Principal dimensions and other data comparing with other vessels:

During the first phase of design work, the data of several domestic and foreign vessels of the same type had been collected and used as reference. Among them, Ho-p'ing No 18 was picked as the model ship. The principal dimensions and coefficients selected for Ho-p'ing No 49 in comparison with those of several other vessels are shown in Table I.

TABLE I Reference Data Table

Name of Vessels / Specifications	Ho-p'ing No 18	500 Metric Ton	Densei Maru
Length, over-all (meter) L	90.52	115.5	90.4
Length, B.P. L (ft.)	278.542	351.5	279.0
Length, B.P. L (meter)	84.9	107	85.0
Beam B (meter)	13.0	16	12.5
Depth H (meter)	6.5	9.5	6.5
Draft, full-load, T(meter)	5.66	6.78	5.622
Displacement Δ (long ton)	4725	8450	-
Displacement Δ (metric ton)	4800	8680	-
Speed V in Nautical mile/hr	10.5	12	10
Maximum Speed Vmax in Nautical mile/hour	11.5	-	13.054
Horsepower x revolution HP x R.P.M. (Max.)	-	2400x115	1300x113
Horsepower x revolution HP x R.P.M. (Economy)	1000x100	-	900x113
Horsepower x revolution HP x R.P.M. (Rated)	-	-	1100x107
Block Coefficient δ	0.7435	0.73	0.732
Midship-section Coefficient β	0.938	0.989	-
Prismatic Coefficient φ	0.752	0.737	-
Water-plane Coefficient α	-	0.816	-
Location of Center of Buoyancy x_f	Fore 0.943%L	Fore 1.784%L	-
Length-beam Ratio L/B	6.53	6.69	6.8
Beam-draft Ratio B/T	2.3	2.36	2.22
Length-depth Ratio L/H	13.08	11.27	13.07
Length-speed Ratio $\frac{V}{\sqrt{L_1}}$ (English system)	(Economic speed) 0.63 (Max.speed) 0.69	0.641	0.6

Nikko Maru	Joshun Maru	Minyo Maru	Wadama Maru	11 Daigen Maru	Ch'ang-wei-lo Wei-chi-ts'ang No 1	Recessed Deck Wei-chi-ts'ang No 2	Ho-p'ing No 49
90.5	-	90.36	88.82	90.4	-	-	93.2
276.0 84.0	278.96 84.99	279.0 85.0	274.0 83.52	279.0 85.5	284.5 86.8	269.0 82	- 86.0
12.2	12.5	12.5	12.2	12.5	13.2	12.8	13.0
6.5	6.5	6.5	6.21	6.5	6.9	6.7	6.5
5.608	5.55	5.676	5.377	5.645	5.85	5.7	5.66
4185 4256.5	4370 4454	4455 4503	4090 4163	4385 4460	5100 5180	4525 4600	4760 4850
10.5	10	10	10	10	12	11.5	10.8
13.626	11.0	12.445	12.71	13.007	-	-	11.62
1350x106	1600	1200x130	1750x118	1100x107	1800x180	1800x250	-
1000x94	1200	1000x115	1200x100	900x100	-	-	1000x10
1200x102	1300	1100x119	1450x110	1000x104	-	-	-
0.721	-	0.729	0.74	0.725	0.75	0.75	0.744
-	-	-	-	-	-	-	0.983
-	-	-	-	-	-	-	0.757
-	-	-	-	-	-	-	0.833
-	-	-	-	-	-	-	Fore 0.673%
6.89	6.8	6.8	6.85	6.8	6.58	6.40	6.615
2.176	2.25	2.2	2.257	2.216	2.28	2.245	2.3
12.82	13.07	13.09	13.47	13.07	12.6	12.24	13.25
0.632	0.60	0.6	0.605	0.6	0.712	0.701	0.643 0.692

Table I Continued......

Name of Vessels Specifications	Ho-p'ing No 18	500 Metric Ton	Densei Maru
Froude Number (Metric system) $\frac{v}{\sqrt{g \cdot L_1}}$	(Economic speed) 0.1872 (Max. speed) 0.2045	0.19	0.178
$L/\Delta^{1/3}$ (English system)	16.62	17.2	-
Admiralty Coefficient $\Delta^{2/3} \times V^3/H.P.$	326.0	(340) 298	-
Parallel Middle Body ϕ	-	17%L	-
½ Angle of Attack ϵ	28°	21°	-
Deadweight d_w (Metric ton)	3200	5890	-
Deadweight Coefficient d_w/Δ	0.6665	0.679	-

Nikko Maru	Joshun Maru	Minyo Maru	Wadama Maru	11 Daigen Maru	Ch'ang-wei-lo Wei-chi-ts'ang No 1	Recessed Deck Wei-chi-ts'ang No 2	Ho-p'i No 4[illegible]
0.188	0.1785	0.1782	0.18	0.1782	0.2115	0.208	0.19[illegible] 0.20[illegible]
17.15	17.05	16.97	17.1	17.05	16.61	16.25	16.8
335	222.5	270.0	213.0	294.0	285	232	355
-	-	-	-	-	-	-	27%L
-	-	-	-	-	-	-	24°
-	-	-	-	-	3600	3400	3465
-	-	-	-	-	0.695	0.738	0.71

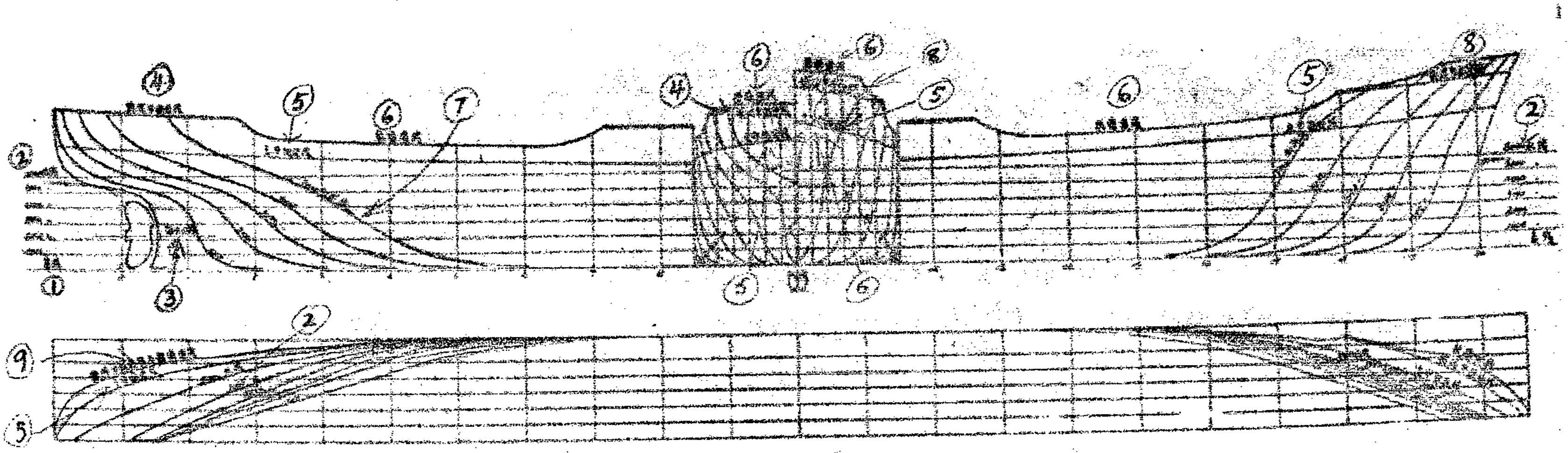


Fig. 4 Lines Plan

1. Base Line
2. Water Line
3. Shaft Axis Line
4. Poop Deck Line
5. Main Deck Line
6. Bulwark Line
7. Longitudinal Cross-Section Line
8. Forecastle Deck Line
9. Poop Deck and Bulwark Line

(3) Lines Plan, Propeller, Horsepower and Speed:

This vessel's stern is regular cruiser stern and the stem is of clipper type bow. Forebody line plan is of V type. The stem line is slightly peaked. Stem sheer was chosen at 2.5 meters, stern sheer 1.5 meters. Based on B=0.983, the maximum-section area Amax=B T B = 72.3 meter^2. The distribution of cross-sectional areas is shown in Table 2 and Section-Area Curve. (Fig 3)

Table 2 Section Area Distribution Table

Station Number	0	1	2	3	4	5
Area(Meter^2)	5.9	12.02	30.10	45.64	58.02	65.60
Percentage (A/Amax)%	8.16	16.65	41.65	63.2	80.4	90.7

	6	7	8	9	10	11	12
Area(Meter^2)	69.90	71.80	72.30	72.3	72.3	72.3	72.3
%(A/A_{max})%	96.60	99.2	100	100	100	100	100

	13	14	15	16	17	18	19	20
Area(Meter^2)	72.3	72.2	70.2	63.6	51.2	34.2	14.7	-
% (A/A_{max})%	100	99.99	97.2	88.1	70.9	47.4	20.31	-

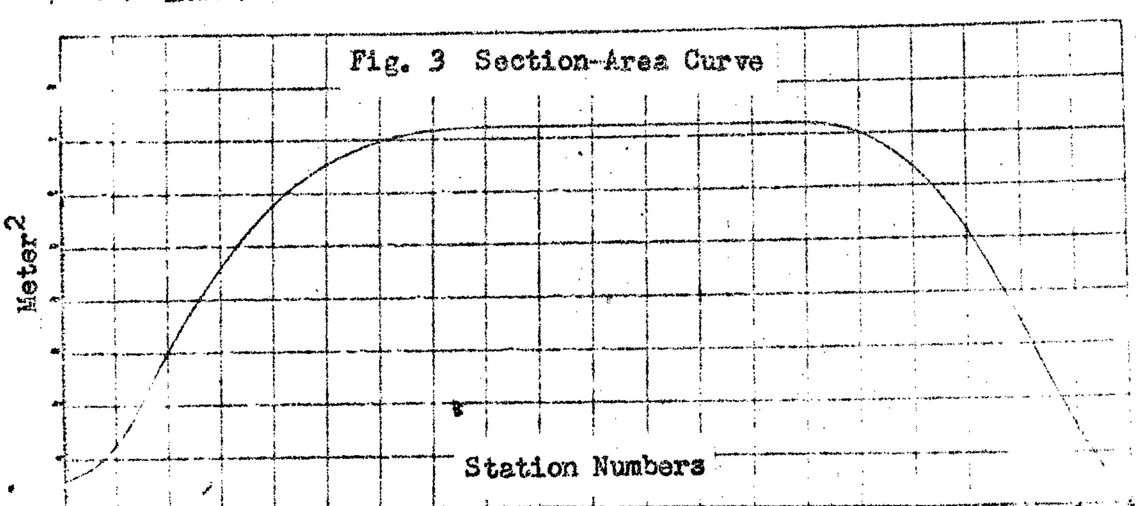


Fig. 3 Section-Area Curve

Effective horsepower from results of model test was ompared with E.H.P. curve calculated by the Ayre Method n Fig 5. Under the designed speed V=10.8 knots, model est data shows its effective horsepower is approximately ! percent larger than that calculated by the Ayre Method.

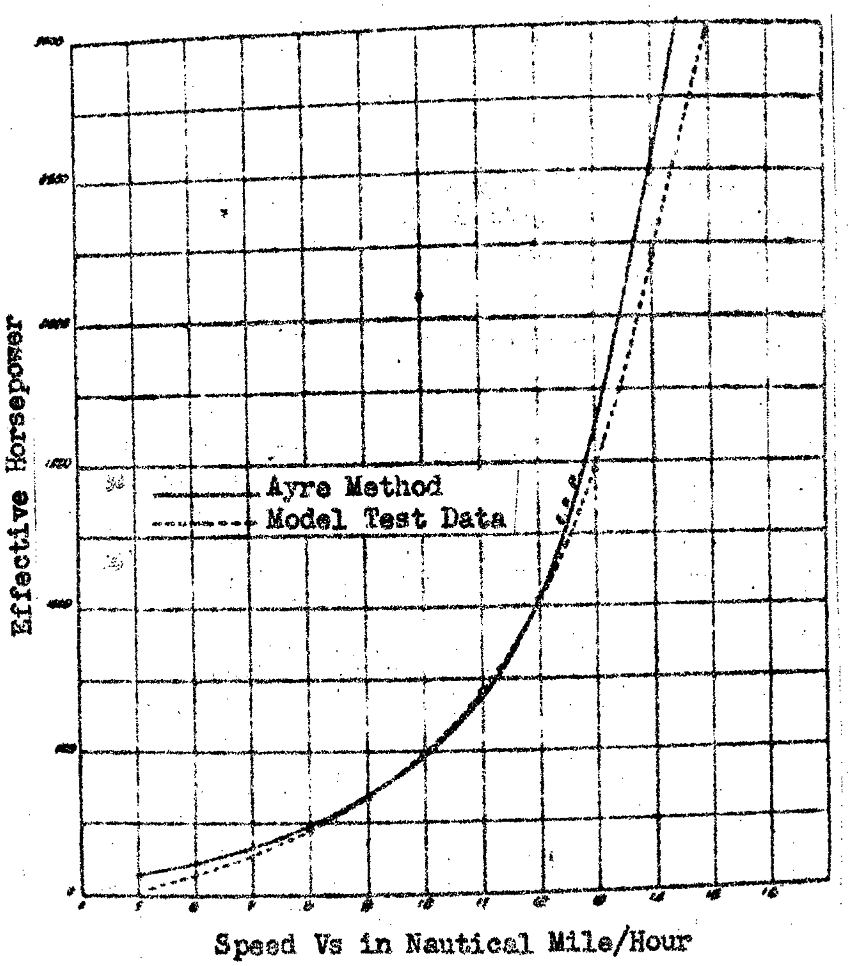


Fig 5 Effective Horsepower Curve

The propeller design was based on B4 - 40 screw design diagram of Dr Laurens Troost. Main engine's horsepower most frequently used was 1000 IHP x 100 revolution/minute. Transmission and mechanical efficiency was taken at 86.4 percent which is equivalent to delivered horsepower 843 HP in the test basin. The wake fraction was set at $\varphi = 0.322$, thrust deduction $t = 0.226$, hull efficiency $\eta_H = 1.14$ and by calculation, curves were plotted showing the relation between Thrust Horsepower (THP) under designed speed and Effective Horsepower (EHP) in Fig 6.

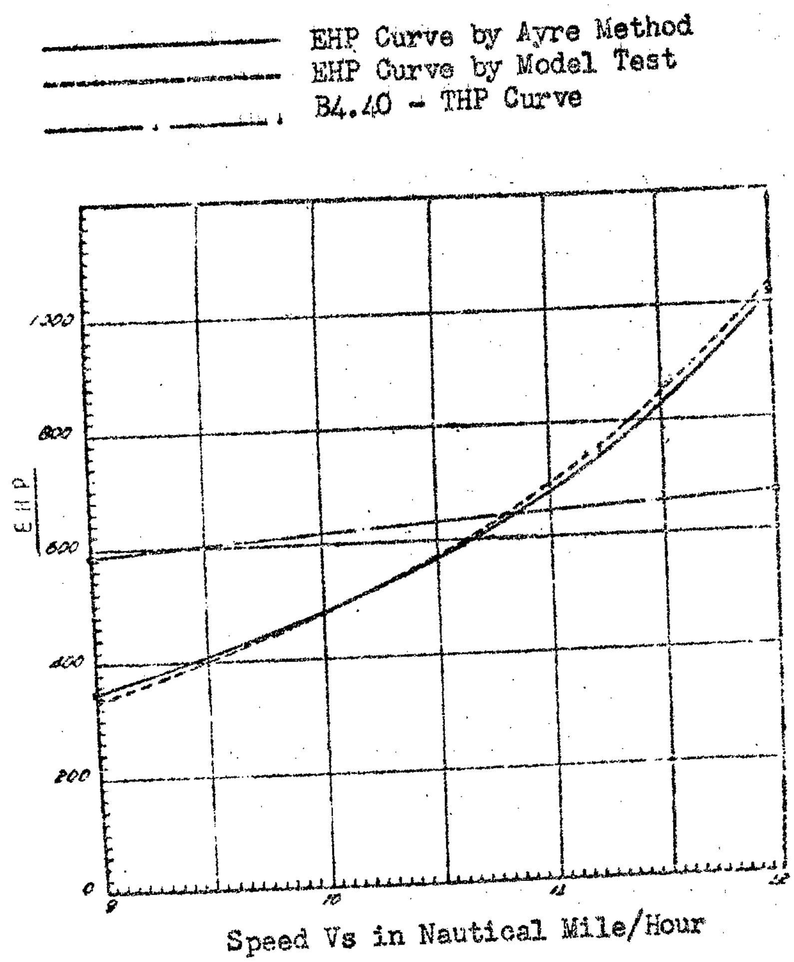


Fig. 6 Thrust Horsepower and Effective Horsepower Curves

From Fig 6 we obtained the speed at intersecting point of THP and EHP curves V = 10.8 knots. With consideration of added resistance, the desi gn of propeller was based on V = 10.5 knots. By claculation, this ship's propeller dimensions are:

Diameter	$D = 4.0$ meter
Pitch	$H_o = 3.16$ meter
Pitch Ratio	$H_o/D = 0.79$
Propeller Efficiency	$\eta_p = 64.1$ percent
Boss-Diameter Ratio	$d_n/D = 0.175$
Number of Blades	$Z = 4$
Shaft Thrust	$S = 143000$ kilogram

(4) Weight, Center of Gravity and Hold Capacity:

Based on center of gravity calculation, the empty weight of this ship should be 1373.59 metric ton. The distance between center of gravity and base line should be 5.326 meter. Longitudinal center of gravity should be located 1.576 meters from amidship in afterbody. After the ship was completed, the heeling test data showed that the weight of the ship itself was 1392.8 metric tons which was 19.21 metric ton heavier than calculated weight. (1.36 percent of total weight). The data also showed that the distance between center of gravity and base line was 5.451 meters which was 0.125 meter larger than calculated distance.

The ship's launching weight was 870 metric ton. Vertical center of gravity $Zg = 4.25$ meter, longitudinal center of gravity $Xg = 0.731$ meter (afterbody).

By calculation, the weight of steel shell was 787.72 metric ton which was 57.3 percent of total weight. The woodwork and equipment weighed 311.43 metric tons which was 22.65 percent of total weight. The engine and auxiliary machinery weighed 274.44 metric tons which was 20.05 percent of total weight.

This ship's cubic volume $C_v = L \cdot B \cdot H = 86 \times 13 \times 6.5 =$ 7260 meter^3, then;

a) Steel shell weight and cubic volume ratio = 0.1081 metric ton/meter^3;

b) Woodwork trim and cubic volume ratio = 0.0426 metric ton/meter^3;

c) Light ship(without cargo) and cubic volume ratio = 0.178 metric ton/meter^3;

d) Machinery weight per horsepower = 0.2744 metric ton/horsepower;

e) Light ship and full displacement ratio = 28.8 percent;

f) Total deadweight and full displacement ratio = 1 - 0.288 = 71.2 percent.

This ship's total cargo hold volume was 4141.8 meter^3 for cargo in bales and 4441.8 meter^3 for cargo in miscellaneous packaging. Coal hold volume was 198 meter^3, auxiliary cargo hold or auxiliary coal hold volume was 208.4 meter^3, and deadweight 3132 metric ton. Therefore, coefficient of hold capacity $\eta = 4141.8/3132 = 1.32$ meter^3/metric ton. Total water tank capacity was 436.9 meter^3; boiler feed water tank capacity was 112.7 meter^3, drinking water tank capacity was 91.50 meter^3.

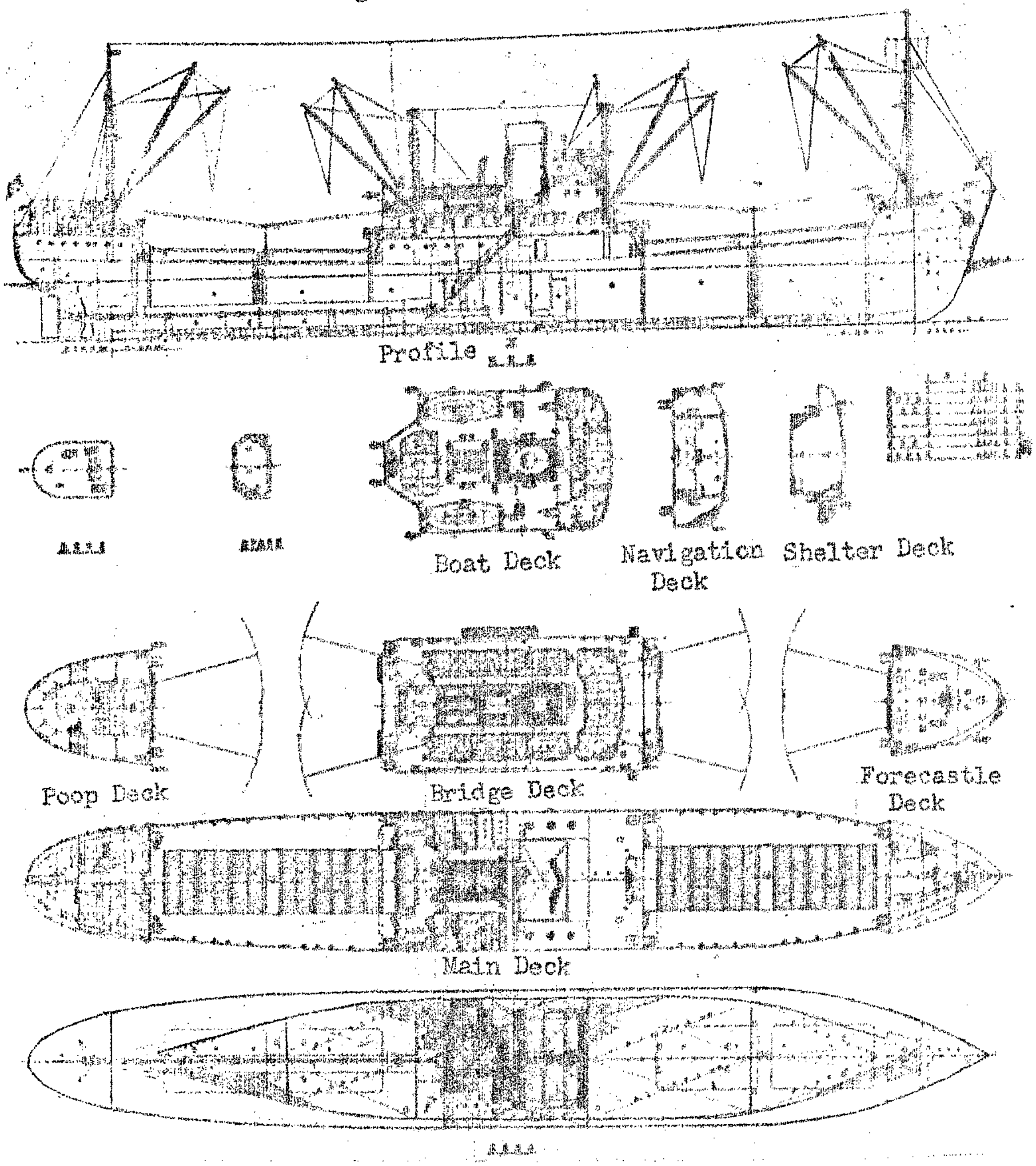
(5) Stability and Various Load Conditions:

The design of this ship's stability was based on requirements of the second class vessel listed under the USSR 1948 Rules (Provisional) Governing the Stability of Ocean Going and Coastal Vessels. By calculation, the height of transverse stability is 0.5 meter minimum and 2.754 meters maximum. The dynamic and statical stabilities all satisfy requirements. Only under full load and half load conditions is the angle of heel of the ship while leaving port $58° < 60°$. The rolling period is estimated between 10 to 14 seconds.

(6) Ship's Plan:

The ship has four water tight bulkheads. Adjacent to the engine room are two large cargo holds which have four cargo hatches (9.75 meter x 6.0 meter). The ship's crew numbers 43 men. High ranking officers occupy single cabins and crew members occupy double or multiple rooms. Besides the crew, there are 10 apprentices and trainees whose living quarters are dispersed at amidship and aftership. On the upper deck, there is a large dining hall which has a seating capacity of two-thirds of the ship's crew at a time. A conference room is located on the midship upper deck. The living conditions of the crew is comparatively good. The general plan of the ship is shown is Fig 7. The areas of crew's living quarters are shown in Table 3.

Fig. 7 General Plan



Principal Dimensions

Length, Overall	93.200 meters
Length, Designed Water Line	88.400 "
Length, Between Perpendiculars	86.000 "
Beam	13.000 "
Depth	6.500 "
Designed Draft	5.660 "
Full Load Displacement	4857 metric tons

Table 3 Areas of Crew's Quarters

Cabin Name	Captain	Political Officer	Chief Engineer	First Officer	Second Officer	Third Officer	First Engineer
Area(meter^2)	13.5	11.0	11.0	10.0	7.5	7.5	8.2

Cabin Name	Second Egineeer	Third Engineer	Radio Operator	Pilot	Boatswain Carpenter	4 Mechanics	2 Seamen 1st Class
Area(meter^2)	7.35	7.35	7.5	6.0	7.5	6.75	5.0

Cabin Name	2 Seamen 2nd Class	2 Cooks	2 Electricians	2 Stewards	Apprent. Trainees
Area (Meter^2)	5.0	5.0	5.0	5.0	5.0

(7) The Design of Hull Structure:

The hull structure of this vessel was designed in accordance with the P¼C class of the USSR 1956 Ocean Going Steel Vessel Construction and Classification Regulation. The steel used was CT4 shipbuilding steel. At the same time, a wave length of 86 meter and wave height $h = \frac{L}{30} + 2 = 4.865$ meter were determined in the calculation and verification of longitudinal strength.

The structure is of transverse type. The space between frames is 650 millimeters. The shell plating is of welded type. The frames and beams are of channel frame and channel beam with I bar cut to two serrated Tee's used as welded frame and welded beam. The interior of the superstructure is constructed with large and small corrugated panels. This kind of structure was done by applying new techniques. The inner wall and cabin furnitures are of fine woodwork and of modern design. The steel used for hull structure weighed 787.7 metric ton. The coefficient of steel weight is 108.1 kilogram/meter^3. All structural parts of the structure are adequately strengthened. The details of the structure is shown in Mid-section Diagram (Fig 8)

Main Dimensions

Length, Overall	93.2 meters
Length, B.P.	86.0 "
Beam	13.0 "
Depth	6.5 "
Load Draft	5.66 "

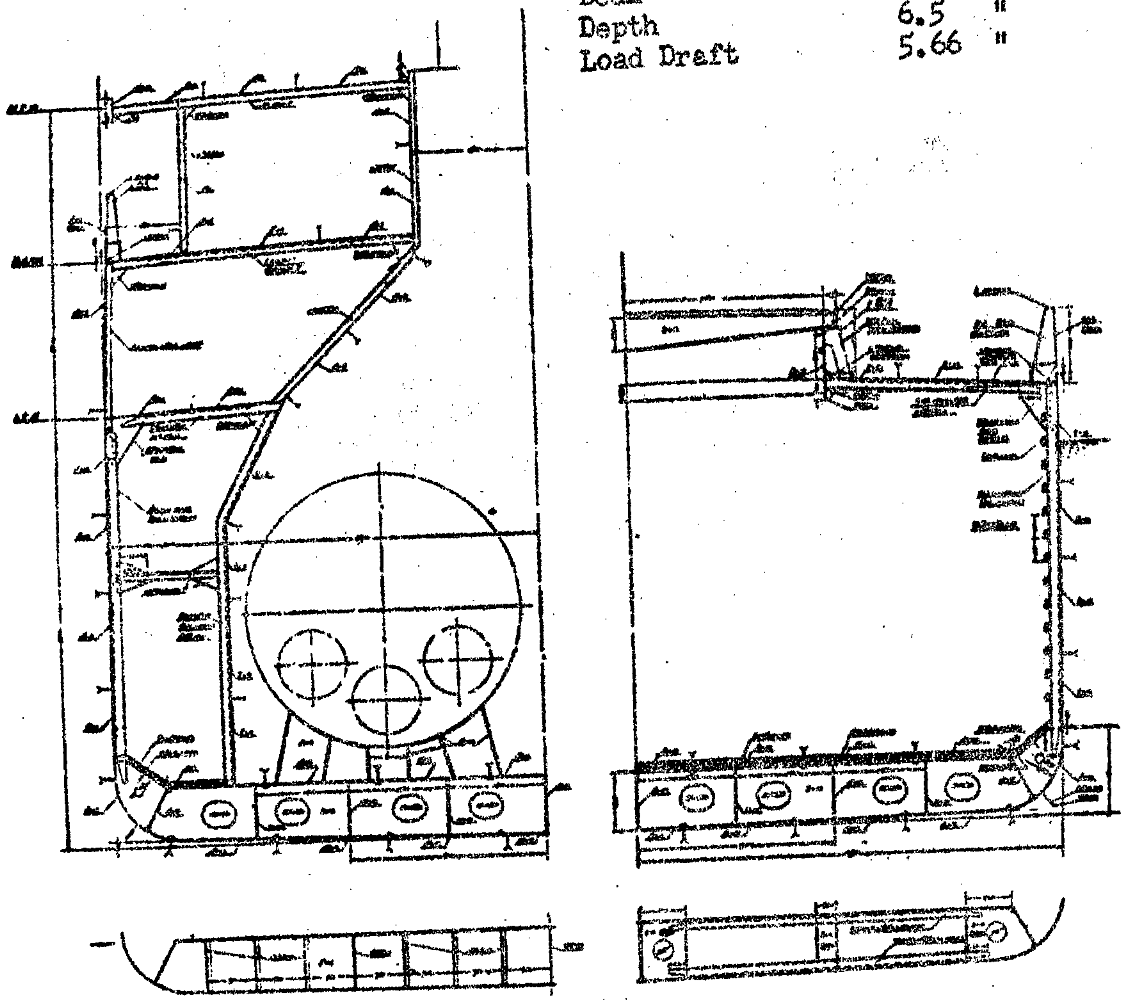


Fig. 8 Mid-Section Diagram

By the midship section modulus calculation, the minimum section coefficient was 12989 meter-centimeter^2, the corresponding standard strength coefficient f = 17600. While international standard f = 13294, it actually is 32.4 percent higher than required. As a result of longitudinal strength calculation, this ship's stress and deflection are shown in Table 4.

Table 4 Table of Stress and Deflection

Full Load Hogging

$Deflection_{max}$ (Ton-meter)	Deck Stress σ_{δ} (kg./cm^2)	Keel Stress σ_A (kg/cm^2)
15280	1104	-757

Full Load Sagging

$Deflection_{max}$ (kg/cm^2)	Deck Stress σ_{δ} (kg/cm^2)	Keel Stress σ_A (kg/cm^2)
-650	-50	34.4

Light Ship Hogging

$Deflection_{max}$ (Ton-Meter)	Deck Stress σ_{δ} (kg/cm^2)	Keel Stress σ_A (kg/cm^2)
5650	377	-209

Light Ship Sagging

$Deflection_{max}$ (Ton-Meter)	Deck Stress σ_{δ} (kg/cm^2)	Keel Stress σ_A (kg/cm^2)
-5810	-388	215

From the above table we can see that the maximum stress is σ_s = 1104 kilogram/centimeter^2 < 0.5σ_T = 1200 kilogram/centimeter^2. Therefore, the longitudinal strength of this ship is quite enough.

(8) Equipment Design:

This ship's equipment number is N_c = 1811 meter^2. It is equipped with two bower anchors, each weighing 2000 kilograms, one sheet anchor which weighs 1500 kilograms, one stream anchor which weighs 600 kilograms, two bower anchor chains of total length of 450 meters. The diameter of the anchor chain is 46 millimeters. The design of deck equipment was based on the elastic force coefficient calculation. The deck is equipped with two king posts, two pairs of hoisting columns, eight 3/5 ton cargo booms, eight units of three ton derricks, two life boats of 42 person capacity each and one life raft of 10 person capacity. The rudder section consists of reaction rudder post and streamlined rudder blade with 8 meter^2 of area. The area ratio is 1.6 percent. Cabins and holds are equipped with mechanical or natural ventilation.

3. Machinery Design:

(1) Selection of Power Plant

According to service requirements, the steam engine was chosen as the power plant. The main engine is a compound double-expansion semi-uniflow steam engine. Its various reference number are: Main engine uses superheat steam with temperature at 310°C, pressure at 14.5 kilogram/centimeter^2. The auxiliary engine in the engine room also uses superheat steam with temperature at 240°C, pressure at 10 kilogram/centimeter^2. Steam for general use is of 3 kilogram/centimeter^2 pressure reduced steam. The water system is a second-class pre-heated circulation system. Principal equipment is as follows:

a) General installation of the engine room equipment-- Engine room is situated between 51st and 65th frame positions. The space between the 51st and 55th frame positions is for the thrust bearing. The proportion of the length of the engine room to the length of the ship is about 6.4 percent. All equipment and machinery in the engine room and boiler room are shown in the Plane Diagram and Profile of Engine Room and Boiler Room (Fig 9a and 9b) Principal specifications are shown in Table 5.

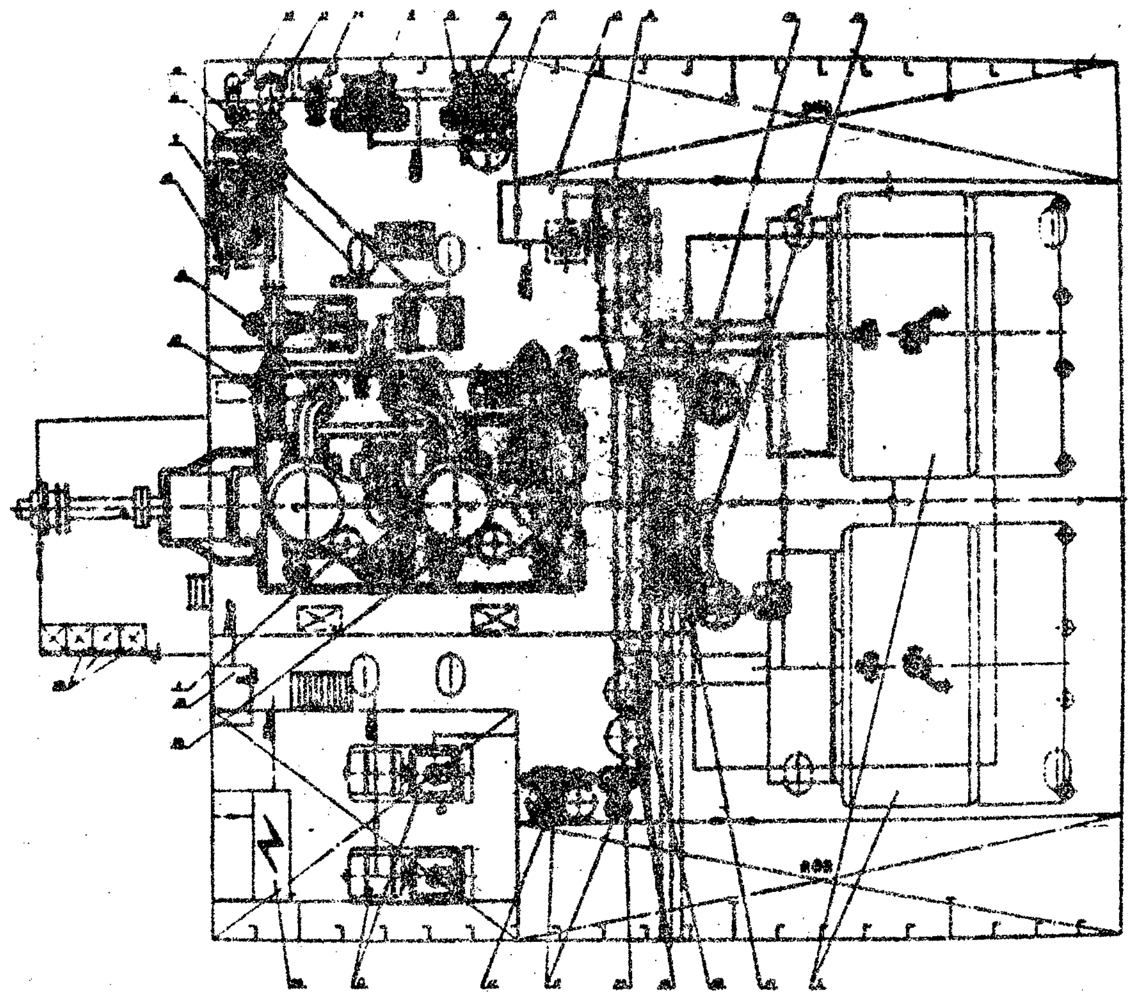


Fig. 9a Plane Diagram of Engine Room and Boiler Room

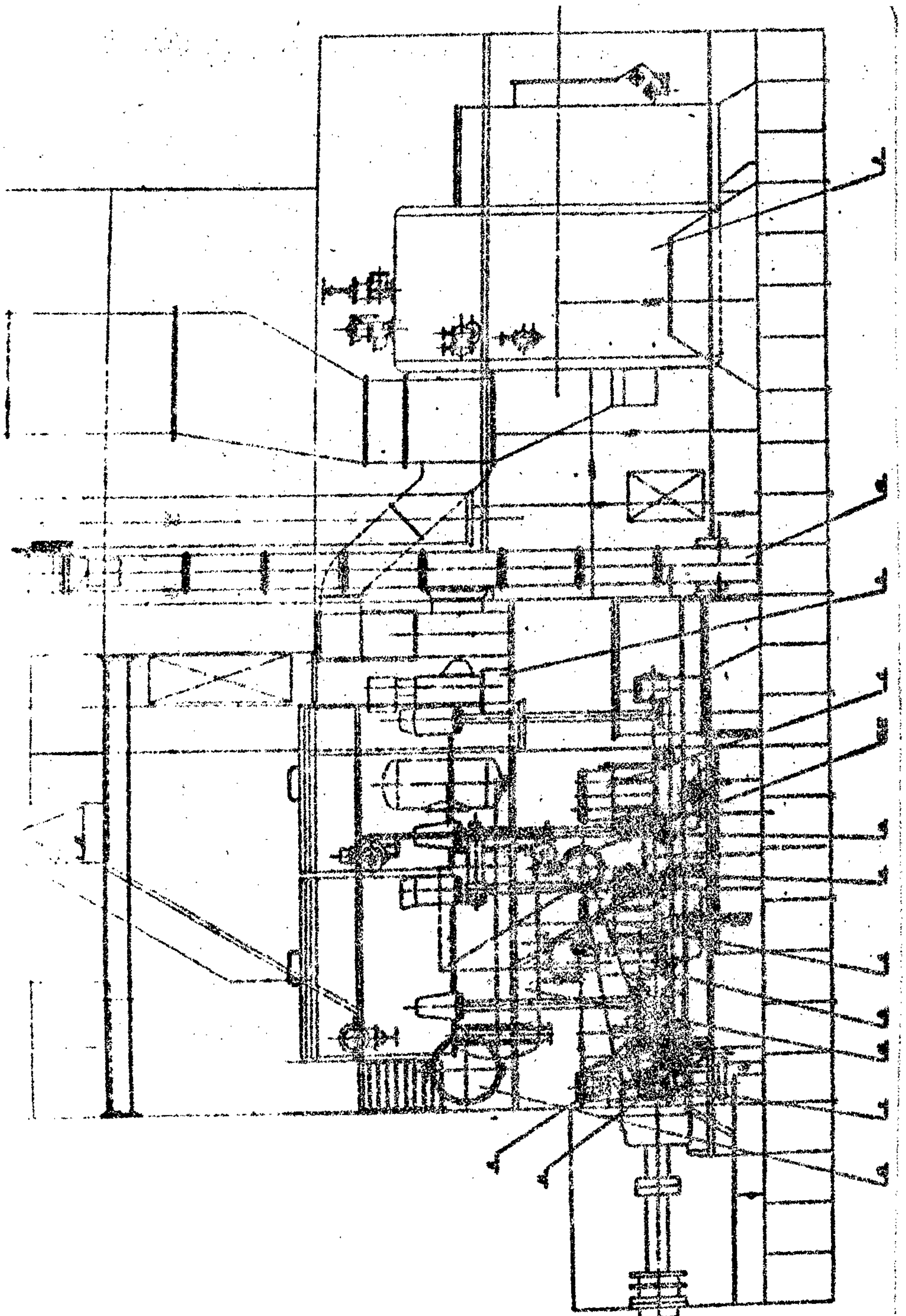


Fig. 9b Profile of Engine Room and Boiler Room

1. Main Engine
2. Boiler
3. Feed Pump
4. Generator, for Lighting
5. General Pump
6. Fire Protection Pump
7. Auxiliary Circulating Pump
8. Main Circulating Pump
9. Boiler Blower
10. Electric Drinking Water Pump
11. Electric Sanitary Water Pump
12. Main Condenser
13. Auxiliary Condenser
14. Hot Well [see Table 5, item 21]
15. Double Type Water Filter
16. Water Heater
17. Drinking Water Pressure Tank
18. Sanitary Water Pressure Tank
19. Funnel Type Ash Handling Machine
20. Motor, Ash Handling Machine
21. Distribution Board
22. Instrument Panel
23. Telltale
24. Recording Stand
25. Service Platform
26. Reverse and Forward Gear
27. Traverse Gear
28. Oil Tank
29. Electric Ash Handling Machine, Spare
30. Lathe
31. Boring Machine
32. Grinding Wheel
33. Main Circulating Pump Water Outlet Valve
34. Auxiliary Circulating Pump Water Outlet Valve
35. Auxiliary Circulating Pump Bilge Inlet Valve.

Table 5 Engine Room Equipment and Machinery

Item	Name	Specification	Quantity
1	Compound Double-expansion semi-uniflow Steam Engine	$2\times\frac{380 \times 820}{820} \times 100$	1 unit
2	Surface Main Condenser	Condense area 120 meter^2	1 set
3	Air Pump, Operated by Main Engine	ϕ420 x380	1 unit
4	Bilge Water Pump, Operated by main Engine	ϕ 75 x 380	2 units
5	Motor, Main Circulating Pump	$\frac{\phi 150}{130} \times 250\sim550$	1 unit
6	Main Circulating Pump	ϕ510, pumping capacity, 300 ~ 350 meter^2/hour	1 unit
7	Steam Generator	$\frac{\phi 455}{385} \times 500$	2 units
8	Generator	20 kw, 115 V, 500 rpm	2 units
9.	Surface Condenser, Auxiliary	Condense area 40 meter^2	1 set
10.	Main Feed Pump, Steam, Warren Type	$\frac{240\times160}{450} \times 18$	2 units
11.	Fire Pump, Steam	$\frac{225 \times 230}{240} \times 30\sim45$, pressure head 60 meter column of water	1 unit
12.	General Pump, Steam (Used concurrently as fire pump)	ditto	1 unit
13.	Auxiliary Circulating Pump (Concurrently as Bilge water Pump)	$\frac{225\times225}{300} \times 30$, pressure head 40 meter column of water	1 unit
14.	Sanitary Water Eddy Pump, Electric	3CHM, pumping capacity 8 meter^3/hour	1 unit
15.	Drinking Water Eddy Pump, Electric	" " "	1 unit
16.	Steam Motor, Boiler Blower	$\frac{\phi 150}{130}$ 250~550	1 unit

Table 5 continued ....

Item	Name	Specification	Quantity
17.	Boiler Blower	Ø800, wind capacity 21500 meter^3/hour, wind pressure 50 millimeter column of water	1 unit
18.	First Class Water Heater, Cylindrical	Heating area 7.8 meter^2, Feed temperature 90°C	1 unit
19.	Second Class Water Heater, Cylindrical	Heating area 7.8 meter^2, Feed temperature 120°C	1 unit
20.	Compound High Pressure Water Filter	Inner diameter Ø65, capacity 10.5 meter^3/hour	2 unit
21.	Low Pressure Water Filter (Hot Well)	1875 x 860 x 1100	1 unit
22.	Reverse and Forward Gear, Steam	$\frac{Ø70}{90}$ x 250~300	1 unit
23.	Traverse Gear	Chain diameter Ø13	1 unit
24.	Distribution Board	2100x530x1880	1 unit
25.	Single Ring Thrust Bearing	Ø285(Shaft diameter)	1 unit
26.	Engine Oil Tank	760 x 330 x 1050	2
27.	Cylinder Oil Tank	360 x 330 x 1050	1
28.	Hot Water Tank	Type A: Ø520 x 1376	1
29.	Sanitary Water Pressure Tank	Type A: Ø510 x 1470	1
30.	Drinking Water Pressure Tank	" " " "	1
31.	Recording Stand	700 x 600 x 1000	1

b) Equipment installation in the Boiler Room--Boile[illegible] situated between the 65th and 76th frames. There are [illegible] holds on both sides of the boiler room. The length of the boiler room to that of the length of ship is about 7.0 percent. The boiler room installation is shown in Fig 9. The principal equipment in the boiler room is shown in Table 6.

Table 6 Principal Equipment in the Boiler Room

Item	Description	Specification	Quantity
1	Combined Cylindrical Boiler	Produce about 4.5 ton/hour, Heating area 164 meter^2	2 units
2	Funnel Type Ash Handling Machine	Power 2.0 Kilowatt Speed 60 meter/minute	1 set
3	Spare Ash Handling Machine, Electrical	Power 1.0 Kilowatt Speed 30 meter/min	1 set

c) The Installation of Deck Machinery--The specifications and quantity of principal deck machinery of this ship is shown in Table 7.

Table 7 Table of Deck Machinery Installation

Item	Description	Specification	Quantity
1	Derrick, Steam	$\frac{200 \times 200}{300}$, 3 ton, cargo hoisting speed 26 meter/min	8 units
2	Anchor Capstan, Steam	$\frac{230 \times 230}{280}$, anchor hoisting speed 12 meter/min	1 unit
3	Steam Steering Gear, Electrically controlled	$\frac{150 \times 150}{125}$	1 unit
4	Boat Hoist	Descending speed 30 meter/min Hoisting speed 0.52 meter/min	2 units
5	F-12 Refrigerator Compressor	$\frac{80 \times 80}{64}$ x 450, energy 2700 calorie/hr, Power 2.8 kilowatt	1 unit

(2) Main Engine:

a) Type and Power--The type of main engine is double-expansion low pressure cylinder semi-uniflow slide-valve compound steam engine. Superheat steam is used. The temperature of steam entering the high pressure cylinder is 310°C, pressure 14.5 kilogram/centimeter^2. Main engine stem high pressure cylinder concurrently operates one air pump and two bilge pumps. When main engine air intake capacity is 40 percent, rotation is 100 revolution per minute; the power is 1000 indicated horsepower. When engine is over-loaded, air intake is at 51 percent, rotation at 110 revolution per minute, the power is 1180 indicated horsepower. After completion of installation and sea trial, it was proved that the main engine satisfied design requirements entirely. Its running condition was smooth and stable.

b) Lubrication System--The rockarm automatic oil injector is used as the lubrication device. Every unit of the main engine has five units of injectors.

c) Specifications--$2 \times \frac{380 \times 820}{820} \times 100$, Rotating direction: clockwise facing the stem.

d) Weight--52 metric tons (excluding thrust bearing).

(3) Boiler:

a) The boiler is a combined cylindrical shape type. It is equipped with air pre-heater, water economizer and steam superheater, and is hand-fired. A strong blower is used for the boiler; the wind pressure is between 40 to 50 millimeters water column.

b) The saturated steam of the boiler passes through a main stop valve to the superheater at the back of boiler. There the steam is heated to 320°C and then is lead through pipes on both sides to supply superheat steam to the main engine. When necessary, mixed steam can also be used to supply the main engine.

c) Specifications (Each unit):

Steam produced ....Approximately 4.5 ton/hr

Work pressure ....15 kilogram/centimeter^2

Superheat steam temperature .... 320°C

Vaporization heating surface........... 164 meter^2

Superheat heating surface .... 21 meter^2

Water economizer heating surface....... 15 meter^2

Air Pre-heater heating surface .... 80 meter^2

Grating surface .... 4.6 meter^2

Boiler inner diameter .... 4082 millimeter

Outer length of boiler .... 2052/3860 millimeter

d) Weight - 52 metric ton (excluding feed water).

(4) The Application of New Technique:

a) The shaft system uses long span intermediate bearings--The model ship has eight intermediate bearings. This ship uses six. The relation between span L and the diameter of the intermediate bearing d is $L= 98.1\sqrt{d}$. The condition of the system was found in good order after trial run. Various bearings maintained their temperature between 43° to 35°C. The temperature of one terminal of the ground shaft near the engine room was 27°C and the other terminal near the stern was 20°C. As the result of the trial run, it was found that the relation between span and intermediate bearing is $125d < L < 200\sqrt{d}$ which is reasonable and can be adopted.

b) Main Engine Piston Ring--The adoption of superheat steam engine piston rings involved problems of wear. For the improvement and elimination of that deficiency; some improvements were made on the butt clearance and the construction of piston ring. For instance, the ring itself was redesigned to a combination of raised and recessed lap. The butt clearance under free conditions was taken at 25 millimeter which is one half smaller than ordinary butt clearance. Therefore, the wear on the piston ring of this ship was greatly reduced.

c) It is equipped with an electrical ash handling machine--Most ships are equipped with a manual ash handling machine. For saving of manual labor and efforts toward automation, this ship uses a one kilowatt electrically operated machine. Its hoisting speed is 30 meters/minute.

d) Funnel Type ash handling machine--The merit of this machine is its comparatively low power but faster ash disposal capability. In one cleaning of the furnace, ash can be disposed of in about twenty minutes. The power of this machine is 2 kilowatts.

4. Design of Electrical System

(1) General:

Little auxiliary electrical machinery is installed in this ship. Estimated by analysis of generator load, it was found that the load of auxiliary electrical machinery is 12 kilowatts and the load of electric lights is about 6 kilowatt during sea run. The total kilowatts needed is 18. On the other hand, during loading and unloading at the pier, the electricity needed is about 8 kilowatts for auxiliary electrical equipment and about 11.5 kilowatts for lighting. The total is 19.5 kilowatts.

Because the demand for electricity is not too great, two generators of 20 kilowatt capacity each were installed in the ship. As to the source of the alternating current 110 V voltage used by the ship, two units of current transformers of 4.5 kilowatt capacity each were installed. One of these two units is used as a spare. But two units can be used alternatively so that there is no cut-off of electricity. To insure that the important sections and areas of the ship are not affected by the cut-off of electrical current, this ship is equipped with an extra 19 x 6 V battery as emergency lighting equipment.

(2) Electrical Equipment:

a) Electricity generating equipment--This ship is equipped with two units of direct current generators, each with a capacity of 20 kilowatt, 115 volt and 500 revolutions per minute. The ship is also equipped with two units of current transformers which are for the purpose of changing direct current to alternating current. Each current transformer has a 4.5 kilowatt capacity, direct current 115 V, 3,000 volt ampere, 115 V alternating current, single phase, 50 cycle, 1500 revolutions per minute.

b) Distribution system--The ship is equipped with a main distribution board (or switch board) which includes: two units of 20 kilowatt 115 V each direct current generator control panel, one unit 115 V line distribution panel and one unit of 2 to 5 kilovolt ampere alternating current control panel.

c) Lighting equipment--The lighting equipment is divided into regular and special lighting. The ship is also equipped with emergency lighting equipment. Dining hall and conference room are all equipped with florescent lamps.

d) Communication equipment and electrical instruments--The communication equipment includes alarm units and three kinds of telephone service; direct line, permanent magnetic type two-way telephone and station to station telephone. Electrical instruments and navigational aids include: propeller rotation speed meter, one set of 755 type electrical fathometer, one set of drag type electric range finder, rudder angle indicator, fire alarm system, telltale and main engine direction error alarm system, etc.

e) Loudspeaker system and radio equipment--The ship is equipped with a loudspeaker system, two units of 110 V, 50 cycle, 78 rpm alternating current gramophone; radio communication equipment includes two transmitters, two sets of receiver and automatic signal senders. It also has a set of life boat transmitters.

f) Electric power equipment--Principal electric power equipment of this ship is shown in Table 8.

Table 8 **Electrical Power Equipment**

Line No.	Equipment No	Name	Specification	Purpose	Location	Control Equipment & Starter Accessories
C1	M16	Electromotor	2.8Kw 220V 16 A 1500 rpm	Sanitary Water Pump	Lead from Main distribution board in the engine room.	4 horsepower electro-magnetic starting controler R_1=3.11Ω R_2=1.54Ω Wound by 1.295mm resistance wire, 110 V resistance coil rewound to 220 V.
	M17	"	2.8Kw 220V 16 A 1500 rpm	Drinking water pump	"	4 horsepower electro-magnetic starting controler R_1-3.11Ω R_2=1.54Ω Wound by 1.295 mm resistance wire, 110 V resistance coil rewinded to 220 V.
C2	M3	"	1.43Kw 220V 8.2 A 2900 rpm	Engine room ventilation	Port boat deck	3 horsepower electro-magnetic startin[illegible] controler R_1=5.95Ω Wound by Ø 1.14 [illegible] resistance wire, 110 V resistance coil rewound to 220 V.
	M4	"	1.43Kw 220V 8.2A 2900rpm	Engine room ventilation	Starboard boat deck	3 horsepower electro-magnetic starting controler
	M8	"	0.47Kw 220V 2.65A 3300rpm	Deck ventilation	Port bridge deck	1 horsepower electro-ma[illegible] controller (direct startin[illegible]).
	M9	"	0.47Kw 220V 2.65A 3300rpm	Deck ventilation	Starboard bridge deck	1 horsepower electro-ma[illegible] controler.
	M10	"	0.47Kw 220V 2.65A 3300rpm	Deck ventilation	Poop deck	1 horsepower electro-[illegible] controler.

- Continued -

Table 8 continued ......

Line No	Equipment No	Name	Specification	Purpose	Location	Control Equipment & Starter Accessories
	M11	Electro Motor	2.8 Kw 220V 16A 1500 rpm	Refrigerator	Refrigerating room	2 - 6Kw refrigerator electro-magnetic starting controler R1=3.11Ω R2=1.54Ω Wound by 1.295 mm resistance wire, 110 V resistance coil rewinded to 220 V.
C3	M12	"	2.2Kw 220V 12.5A 1500rpm	Lathe	Lathe Room	2 - 6Kw refrigerator electro-magnetic starting control, R_1=3.98Ω R_2=2.02Ω Wound by 0.81 mm resistance wire, 110 V resistance coil rewound to 220 V.
	M13	"	0.1Kw 220V 0.57A 3000rpm	Lathe Cooling Pump	Lathe Room	Push-button switch direct starting.
	M14	"	1Kw 220V 5.7A 930rpm	Boring Machine	Lathe Room	1 horsepower electro-magnetic starting controler R_1=9.35Ω Wound by Ø0.9116 mm resistance wire, 110 V resistance coil rewound to 220 V.
	M15	"	0.4Kw 220V 2.2A 1500rpm	Grinding Wheel	Lathe	1 horsepower electro-magnetic controler (direct starting) R_1=9.35Ω Wound by Ø0.9116 mm resistance wire, 110 V resistance coil rewound to 220 V.
C4	M1	"	0.9Kw 220V 5.0A 2900rpm	Boiler Room Ventilation	Port boat deck	1 horsepower electro-magnetic starting controler R_1=9.36Ω Wound by Ø0.9116 mm resistance wire, 110 V rewound to 220V.

- Continued -

Table 8 continued ......

Line No	Equipment No	Name	Specification	Purpose	Location	Control Equipment & Starter Accessories
	M2	Electro-Motor	0.9Kw 220 V 5.0A 2900rpm	Boiler Room Ventilation	Starboard boat deck	1 horsepower electro-magnetic starting controler R_1=9.36Ω Wound by Ø0.9116mm resistance wire, 110 V rewound to 220 V.
	M7	"	1.75Kw 220V 10 A 1450rpm	Ash Handling Machine	Middle of port bridge deck	3 horsepower electro-magnetic starting controler R_1=5.3Ω Wound by Ø1.14mm resistance wire, 110 V resistance coil rewound to 220 V.
C5	M5	"	4.5Kw 220V 26A 1500rpm	No 1 current transformer	Lathe Room	6 horsepower electro-magnetic starting controler R_1=1.93Ω R_2=0.855Ω. Wound by Ø1.45mm resistance wire, 110 V resistance coil rewound to 220 V.
C6	M6	"	4.5Kw 220V 26A 1500rpm	No 2 current transformer	Lathe Room	6 horsepower electro-magnetic starting controler R_1=1.93Ω R_2=0.855Ω. Wound by Ø1.45mm resistance wire, 110 V resistance coil rewound to 220 V.
C7	-	"	-	Tele-communication direct current source	Tele-Communication Room	Knife Switch (30 Ampere).
C8	-	"	-	Navigational Aids direct current source	Main deck rice storage	Knife Switch (30 Ampere).

Notes: Equipped with 1 pressure switch, automatic stopping water pressure 3.5 kg/cm^2; automatic starting water pressure 2.5 3.2 kg/cm^2.

(3) The application of new technique:

The principal new techniques were applied in the electrical field in this ship.*

a) 258-A type electric control for the steam sterring gear--A set of electrical controls was installed with the steam stearing gear, using a self-adjusting stroke motor and electro-magnetic control to operate and control the electric motor of the steam sterring gear steam valve.

b) 58-1A type slide-ring self-adjusting stroke motor electric telltale set--Bridge and engine room each has a telltale set which are electrically controlled.

(III) THE CONSTRUCTION OF HULL

1. Dividing of Sections.

In accordance with the different material specifications and the conditions of hoisting equipment, the ship's body is divided into twenty-three solid sections and seventy-three plane sections. In all, there are ninety-six sections. Among them, the heaviest section is thirty-two metric tons, and the largest section is 13 meter x 6.5 meter x 1.3 meter. The detail of divided sections is shown in Sectional Diagram (Fig 10). The weight and specifications of various sections are shown in Table 9.

*For details of these two new techniques, see Shanghai Shipyard Technical Information and Technical Revolution, Third Edition.

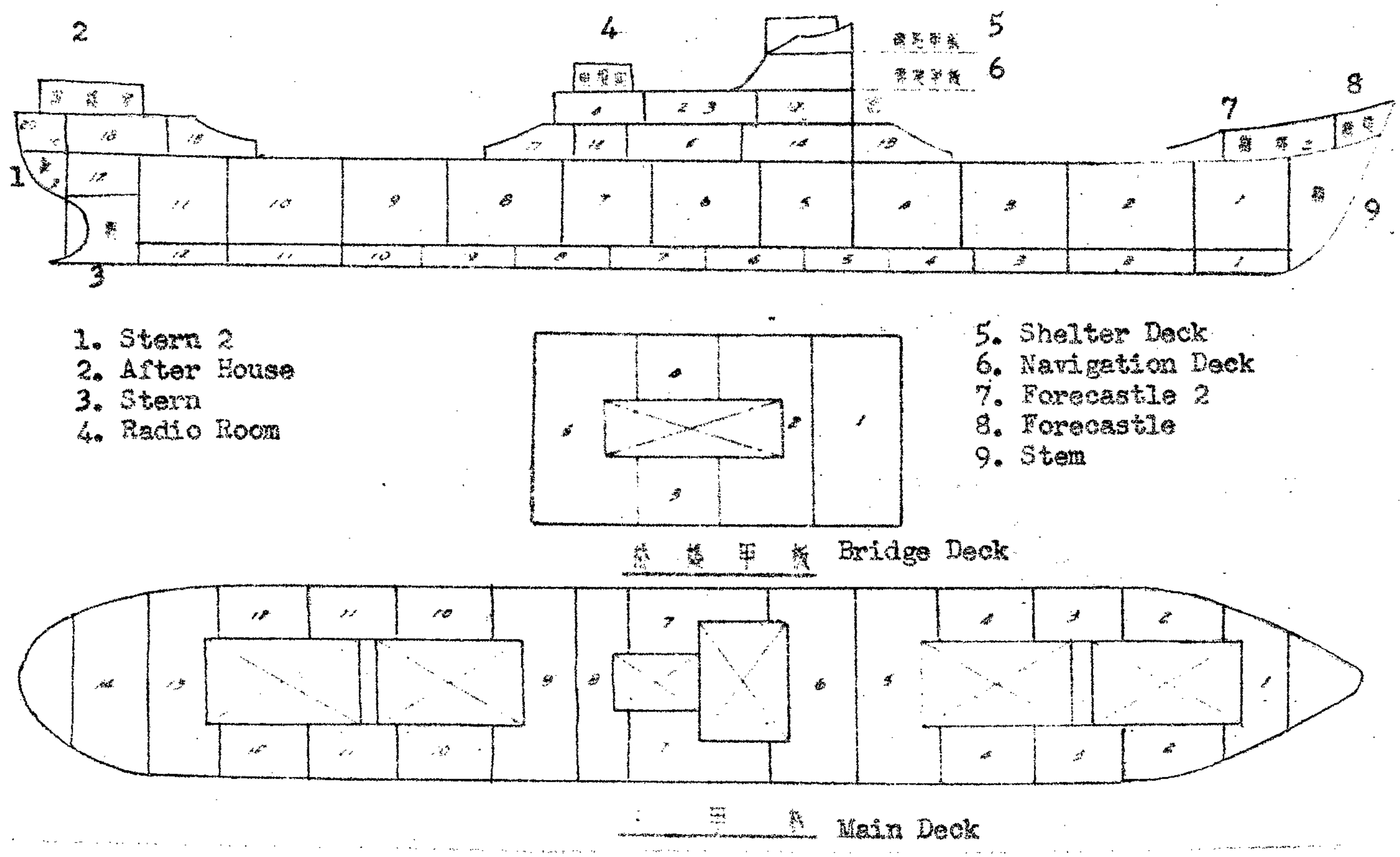


Fig. 10 Sectional Diagram

Table 9 - 1 Bottom Sections (1 - 12 sections)

Number	Type	Frame Position	Specification Width x Length x Height (meter)	Weight of Section(tc
1	Solid	117 - 124	6.4 x 6 x 2	9.5
2	"	104 - 115	10.3 x 3.5 x 1.6	25
3	"	94 - 103	13 x 3.5 x 1.3	28
4	"	85 - 93	13 x 6 x 1.3	26.5
5	"	76 - 84	13 x 6 x 1.3	27.5
6	"	67 - 75	13 x 6 x 1.3	32
7	"	58 - 66	13 x 6 x 1.3	27.5
8	"	49 - 57	13 x 6 x 1.3	25.5
9	"	38 - 48	12.6 x 7 x 1.3	28
10	"	28 -37	11.5 x 6.5 x 1.5	22
11	"	16 - 27	7 x 7.7 x 1.4	19.5
12	"	8 - 15	3.3 x 3.2 x 1.5	17

Table 9 - 2 Stem and Stern Sections (8 sections)

Stem	Solid	125 - stem	7 x 7 x 9.2	23
Fore-castle 1	"	130 - stem	6.8 x 5.2 x 2.2	5
Fore-castle 2	"	115 - 129	11.4 x 9.5 x 2.2	10
Stern 1	"	0 - 7	7 x 5 x 6.2	13
Stern 2	"	Stern - 0	7.4 x 4.3 x 6	6
Poop Deck 1	Plane	3 - 12	11.5 x 6	3.3
Poop Deck 2	"	Stern - 2	9.5 x 6	2.5
After House	Solid	Stern - 8	5.5 x 8 x 2.5	5.5

Table 9 - 3 Side Plating Sections (39 sections)

Number	Type	Frame Position	Dimension Length x Height (Meter)	Weight (ton)	Note
1	Plane	117 - 124	6 x 7.6	6	Port and Starboard
2	"	104 - 116	8 x 7.6	10	"
3	"	93 - 103	7.5 x 6.2	7	"
4	"	81 - 92	6 x 6.2	7.8	"
5	"	72 - 80	6 x 6.2	6	"
6	"	60- 71	6 x 6.2	7.5	"
7	"	51 - 59	6 x 6.2	5.5	"
8	"	39 - 50	8 x 6.2	8	"
9	"	28 - 38	8 x 6.2	6.5	"
10	"	16 - 27	8 x 7.8	8	"
11	"	8 - 15	5.4 x 8	6	"
12	"	0 - 7	5 x 4.5	3.5	"
13	"	81 - 89	5.7 x 2.4	2	"
14	"	71 -80	7.8 x 3.2	3	"
15	"	60 - 70	6 x 2.4	2	"
16	"	52 - 59	5.5 x 2.4	2	"
17	"	42 - 51	6 x 2.4	2	"
18	"	0 - 17	11 x 2.4	3	"
19	"	E - 0	3.6 x 2.4	1	"
20	"	Stern - E	-	-	Dispersed

Table 9 - 4 Main Deck Sections (21 sections)

Number	Type	Frame Position	Dimension Length x Height (Meter)	Weight (ton)	Note
1	Plane	117 - 124	10.5 x 5.5	9	-
2	"	108 - 115	3.3 x 6	3.5	Port and Starboard
3	"	99 - 107	3.5 x 6	3.5	"
4	"	90 - 98	3.5 x 6	3.5	"
5	"	81 - 89	13 x 6	10	-
6	"	7 - 80	13 x 6	9.5	-
7	"	57 - 71	4.6 x 9.8	7	Port and Starboard
8	"	52 - 56	13 x 3.3	5	-
9	"	43 - 51	13 x 6	10	-
10	"	34 - 42	3.5 x 6	3.5	Port and Starboard
11	"	25 - 33	3.5 x 6	3.5	" "
12	"	16 - 24	3.2 x 6	3	" "
13	"	10 - 13	11.2 x 4	5	-
14	"	0 - 9	10 x 6	6	-

Table 9 - 5 Superstructure Sections

Number	Type	Frame Position	Specification, Width x Length x Height (meter)	Weight (ton)	Note
Bridge Deck 1	Plane	77 - 86	13 x 6.5	5	-
Bridge Deck 2	"	68 - 76	13 x 6.5	4.5	-
Bridge Deck 3	"	59 - 67	4.5 x 6	2.5	Starboar
Bridge Deck 4	"	59 - 67	4.5 x 6	2.5	Port
Bridge Deck 5	"	45 - 58	13 x 7.5	8	-
Boat Deck 1	Solid	72 - 81	13 x 6.5	9.5	-
Boat Deck 2	Plane	59 - 71	4.5 x 8.6	4	Starboard
Boat Deck 3	"	59 - 71	4.5 x 8.6	4	Port
Boat Deck 4	Solid	49 - 58	13 x 6 x 2.5	10	-
Navi-gation Deck	"	73 - 81	13 x 5.2 x 3.5	9	-
Radio Room	"	50 - 56	6 x 3.5 x 2.5	4	-
Shelter Deck	"	73 - 80	13 x 4.6 x 3	4.5	-

2. Construction Progress and Construction Period

The progress of all phases of construction of this ship was rapid. Therefore the length of the construction period was greatly reduced. Due to the well planned preparation work and well controlled material supply, from 4 November when shipway assembly was started to 28 November when all water tight tests and shafting alignment were basically completed until launching on 8 December, it took only thirty-five days of shipway period. (Actual working days--33 days.)

At the time of launching, the superstructure, deck house, and principal trim equipment were all installed and erected. After the launching, from the installation of the main engine, boiler, various auxiliary machinery, all types of piping, deck equipment and cabin decoration to the anchoring test and then to the engine trial run, it took only some fifty days. In all, from shipway assembly to completion and delivery, the construction took only ninety-five days.

Because the shipway used to construct Ho-p'ing No 49 was newly built just before the construction started, the overhead cranes which were supposed to be equipped on both sides of the shipway, had not yet been put into production. Therefore, the installation of king posts and the assembly of stem and deck house did meet some difficulties. But, through the technical revolution of the workers and by utilization of two 12-ton cranes, the shortcoming on the limitation of hoisting capacity was overcome.

3. Construction Equipment:

(1) Area used by the platforms:

The total of used area was 1407 meter^2. It was di divided into seven platforms: One 7 x 30 meter, one 7.5 x 30 meter, one 8 x 24 meter, one 10 x 20 meter and three 10 x 16 meter.

(2) Cradle:

16 Side shell cradles, 8 deck plate cradles, 1 stern post cradle, 1 stem post cradle, 1 rudder post cradle. Total 27 cradles.

(3) Hoisting Equipment:

Shipway was newly built before the construction. Other equipment: two 12-ton cranes and one 6-ton crane.

(4) Welding Equipment:

Two automatic welding machine were used. The total number of electric welding machines on the shipway and platforms was approximately 30 units.

4. Quality Inspection.

The welding hull plating underwent X-ray inspection and the dimensions of the hull was carefully measured. They all met the technical requirements of the design. The quality of the ship was verified by the manager and ship inspection organs and was classified as a high class ship. The result of hull dimension measuring is shown in Table 10.

Table 10 - 1. Survey of Principal Dimension of Hull (Unit - millimeter)

Item	Designed Dimension	Dimension Measured	Permissible Error	Actual Error	Error %
Length, Overall	93200	93170	-140	-30	0.032
Length, B.T.	86000	85975	-129	-25	0.03%
Beam	13000	12995	-13	- 5	0.04%
Depth (Up to main deck)	6500	6497	±6	- 3	0.05%
Depth (Up to upper deck)	8800	8794	± 8.8	- 6	0.07%

Table 10 - 2 Keel Line Deflection Measurement

Frame No:	0	6	11	18	27	40	51	56	66	75	83	93	104	115	122	126
Deflection:	27	21	0	-10	-13	-11	-12	-10	-19	21	-11	-10	9	-1	0	0

Note: + for upward, - for downward

Table 10 - 3 Deviation Measurement of Keel

Frame No:	37	48	57	66	75	84	93	103
Deviation:	8	6	5	0	4	8	6	6

Note: Deviation is the difference in height between port and starboard to a point 3.8 meters to the center.

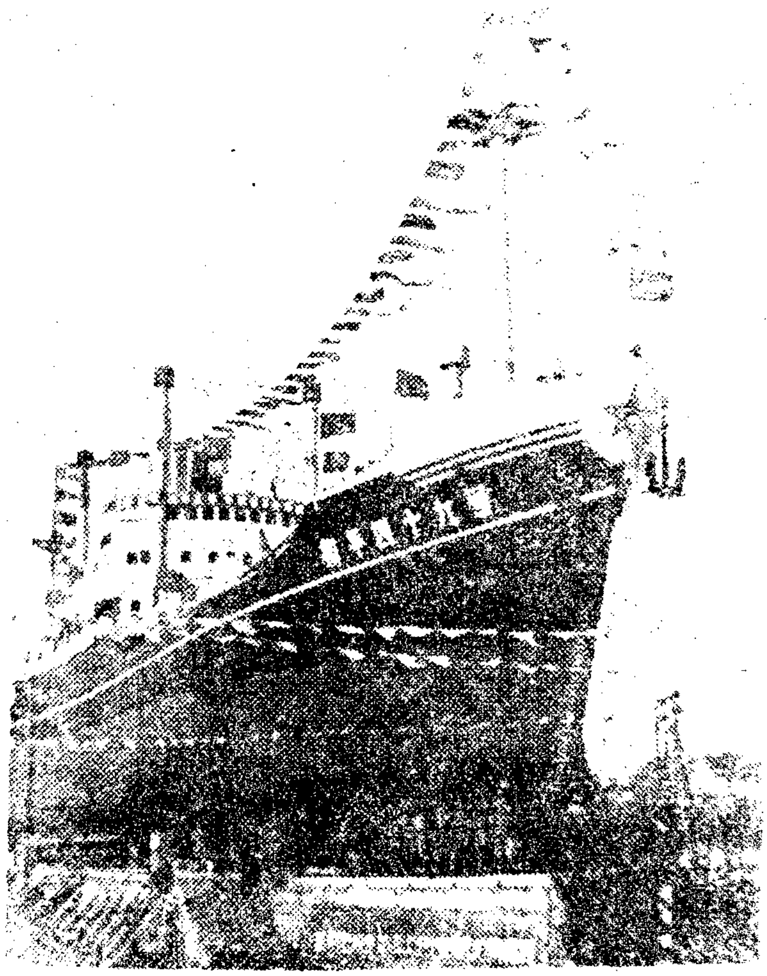


Fig. 11 Scene Before Launching

(IV) SEA TRIAL

After completion, Ho-p'ing No 49 went through two trial runs, one empty and the other with full load. The zero weight trial run was performed outside Wu-sung K'ou. The main engine was tested by continuous run and the speed of the ship was determined. However, due to trouble in the electrically controlled steering gear, other tests did not turn out as well as planned. In the full load trial run, the survey of hull capability was comparatively well performed.

The full load trial run was carried out between 25 February and 9 March 1959 when the ship was returning from Dairen to Shanghai. The principal test items included:

1. Speed Trial
2. Inertia test
3. Turning test
4. Zig-zag course test
5. Course stability test
6. Rudder post torque, hull stress and rolling period test

During trial run, the ship was loaded with ore and timber. Average draft was 4.58 meters, displacement was 3723 metric tons. The trial run was performed under the joint efforts of the Shanghai Shipyard, Marine Science Research Institute and the Shanghai Marine Transportation Bureau. Following is brief introduction to the tests carried out in the sea trial:

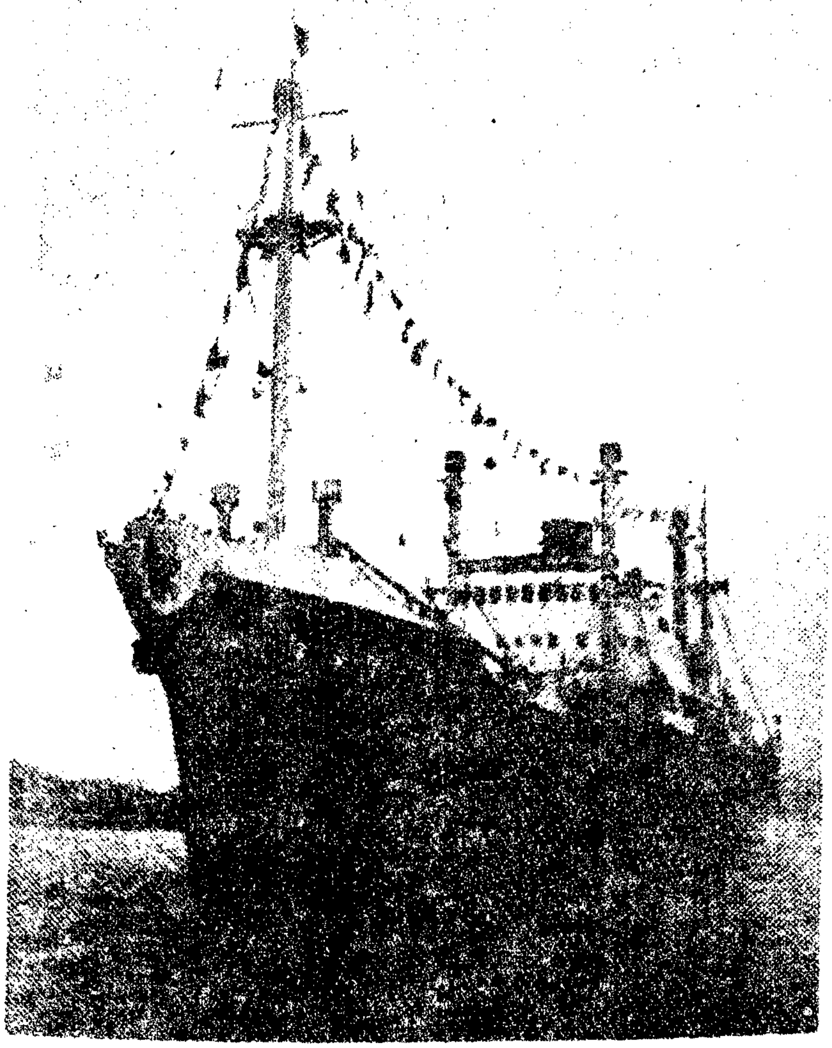


Fig. 12 Leaving Harbour for Sea Trial

1. Speed trial

This test was carried out near the navigation beacon at Hsiao-chiu-tuan outside Wu-sung K'ou. The water depth at the trial location was 13 meters which was 2.84 times the draft of the ship. The distance between the range marks was one nautical mile. Water was calm and smooth. The duration was from low tide to high tide. The atmosphere temperature was from $10\frac{1}{2}$° to 12°C. Water temperature was $9\frac{1}{2}$° C. The courses on the magnetic compass were 312° and 124°. Test was carried out under the main engine's four different speeds: 80, 90, 104 and 110 revolutions per minute. During the trial, the main engine's horsepower was also determined.

Trial results were calculated and Horsepower-Revolution (SHP-N), Horsepower-Speed (IHP-Vs, SHP-Vs), Main Engine Revolution-Speed ($N-V_s$) and Admiralty Constant-Speed (C_A-V_s) Curves were plotted which are shown in Fig 13.

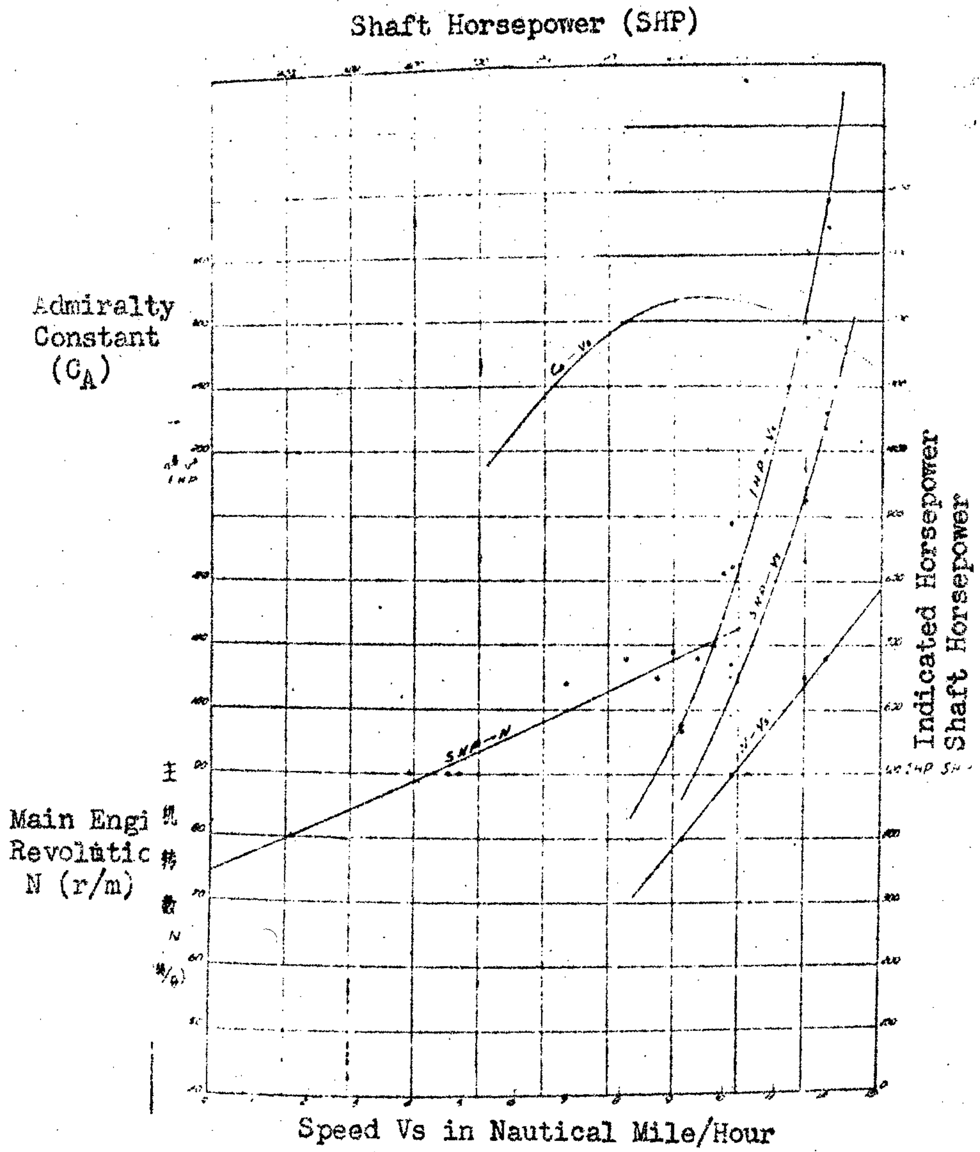


Fig. 13 Speed Trial Curves

2. Inertia Test

This test was carried out near Yuan-yuan-sha and Ya-o-sha outside Wu-sung K'ou. The water depth of the sea lane was fourteen to fifteen meters. Water was calm during the test. The tide was rising. Wind was from the west northwest. The wind registered force 2 on the wind scale. Temperature 13oC. The inertia test was carried out in two phases, full speed ahead to stop engine and full speed ahead to full speed astern. The result of the test was plotted in the Speed-Time Curve and Inertia Distance-Time Curve. During the full speed ahead-stop engine test, ship's speed decreased from 12.1 knots to 4 knots in seven minutes. The ship's inertia distance in the seven minutes was 1350 meters. During the full speed ahead-full speed astern test, the time required for the ship to turn from 11 knots speed ahead to the point where the ship starts astern was three minutes. The inertia distance was 500 meters. The test was carried out by the dropping of wood flakes method.

3. Turning test

The test was carried out near Shan-shan Island outside of Dairen Harbour. The weather was fine, sea surface slightly broken, and water depth 40 meters. Average draft was 4.6 meter, displacement 3834 metric tons. Wind was from the northwest; wind velocity 1.8 meters/second. Main engines r tation was at 80 revolutions/minute, rudder wet surface at $a = 7.02$ meter^2, ship's longitudinal section wet surface $A = 398.6$ meter^2. The ratio $A/a = 55.4$.

The heel during the turning was insignificant. The reading on the heel indicator was less than $\frac{1}{2}^{o}$. The test started from steering course 15^{o} to 34^{o}, turning six times left and right. The result of the test was the plotting of The Trace of Turning Diagram, Turning Angle-Time Curve, etc. From the conclusion, it was found that the longitudinal distance of turning circle was 300~500 meter, the transverse distance was 300~430 meter, advancing distance was 215~325 meter. The ratio of longitudinal distance and length of ship was 3.0~5.8, transverse distance and length of ship was 3.5~5.4. The speed estimated during the turning test was 5 to 5.5 knots. Time required for turning 360^{o} was 5.3 to 8.0 minutes. The test was determined by "hui-chuan-i" [gyrograph?]. Therefore, results are quite accurate.

4. Zigzag Sterring Test

The zigzag course test was carried out in the Yellow Sea. The water depth was 50 meters. The sea had slight waves during the test. Ship's speed was 9.4 knots. Wind from the north. Relative wind velocity 0.8 meter/second. Main engine's rotation at 100 revolution/minute. The steering test was carried out in four separate tests. The operation of the first test was in the following order: Rudder steered to the right 32°, maintained at the position for 10 seconds, rudder steered to the left 32°, maintained at the position for 10 seconds, rudder steered to the center. The second test was identical to the first test. The only exception was that the rudder was steered to the left 32° first. During the third test, the rudder was steered to the right 32° and after the course turned to 32° right, the rudder was steered to the left 32°. When the course turned to 32° left, the rudder was steered to the center. The fourth test was identical to the third. The only exception was that the rudder was steered to the left first.

Result of the test was the plotting of Rudder Angle-Time, and Course Angle-Time Curves. During the first and second tests, time required for the rudder to change from one side to the other and return to the center was 65 to 75 seconds.

5. The Course Stability Test

The test was carried out near the lightship at the estuary of the Yangtze River. Relative wind velocity was 4.09 meters/second. Main engine's rotation at 100 revolution/minute. The method used in the test was maintaining the rudder at the center and the brake was applied. The course then was recorded. The test was carried twice, one under head wind conditions and one under tail wind conditions. After the test, a Course Angle-Time Curve was plotted. It was found that in ten minutes the deflection of the course were: 20° under head wind conditions and 70° under tail wind conditions.

6. Hull Stress, Rudder Post Torque and Rolling Period Test

(1) Hull Stress Test:

The test was carried out under the conditions of rough sea and cargo load of 2805 metric tons. Strain gage was used to measure the stress. The readings registered on the gage were: upper deck stress 366 kilogram/centimeter^2 and main deck stress 166 kilogram/centimeter^2.

(2) Rolling Test:

The rolling test was carried out in the East Sea under the following conditions: weather was sunny, sea was rough, and wind was registered at force 6 in the wind scale. The ship was carrying 2805 tons of sulphide of iron ore and 184 tons of coal. The draft was 5.5 meters, the height of center of gravity $Z_g = 2.46$ meters, initial stability moment $h = 2.84$ meters. It was recorded in the test that the rolling period was 6-6.5 seconds, maximum heeling angle was 25° to 30°. These show that when the cargo of the ship was pure ore, the stability was too good and the rolling period was too short. This test was carried out during the journey between Shanghai and Dairen.

(3) Rudder Post Torque Test:

The determination of rudder post torque was carried during the turning test, zigzag steering test and astern test. The test resulted in the plotting of the Torque and Time Curve. It was determined that during the zigzag course, the maximum torque of the rudder post was 9.47 ton-meter and during the astern, the maximum torque was 9.0 ton-meter. These figures are quite near those calculated by theory.

(V) CONCLUSION

After completion, sea trial and six months of actual sea service, Ho-p'ing No 49's general performance was considered good, fulfilling original design requirements. Here, we would like to spell out some experiences realized during the design and construction of the ship and a few comments concerning the sea trial for future study and application:

1. The principal dimensions and line plan of this ship selected under the designed speed (V=10.8 knot) were reasonable. But the main engine was designed to have latent power. Due to encouragement stimulated by the "Great Leap Forward," the crew of this ship did not use economic horsepower during actual sea run but used larger horsepower.

Therefore, the actual steaming speed was usually kept at 11 to 12 knots. This means that original designed line plan and main engine could not perform under the most economic efficiency. From the admiralty coefficient, we can see that the most economic steaming speed of this ship should be approximately 10 knots.

2. From sea trial we found that the steering performance and navigational performance were normal. But when the cargo was ore, the rolling period was too short. On the stability side, the healing angle was 58° 60° under two load conditions. Therefore, it seems that the dimension of the beam can be slightly increased. This also means that B/T - 2.3 did not measure up to the stability requirements.

3. The layout plan in which two large cargo holds are located forward and after and the loading and unloading are performed at two posts is the feature of lumber carriers. This kind of setup also increases the efficiency of loading and unloading. Its only disadvantage is that cranes are located amidship. During loading and unloading the noise made by the cranes is quite troublesome to the crew members.

4. In the hull structure, the use of channel steel cut to two serrated tee's as welded frame, welded deck beam and stiffener and large and small pressed corrugated panels as interior structure of superstructure are found in good order after actual sea service. These types of structure have great effect on the saving of steel and lowering the weight of the hull. This kind of application should be studied by domestic shipbuilding industry and should be expanded.

5. The main engine of this ship has some latent power. During sea trial, when the main engine's rotation was 110 revolutions/minute the indicated horsepower was 1390 IHP, the speed reached 11.92 knots. According to test results, the ratio of shaft horsepower and indicated horsepower (SHP/IHP) was between 0.72 to 0.82. This shows that the mechanical and transmission efficiencies were slightly too low. This is a question that should be further studied and analyzed.

6. Because the boiler and other navigation instruments developed trouble during the sea trial, the heat treatment test of the power plant, the coal consumption test of the

boiler and the smoke analysis test were not satisfactory. They are being further studied and tested.

7. During the course of design and construction of this ship, the cadres, workers, engineering and technical personnel and supervisory personnel were all mobilized in close cooperation and coordination under the leadership of the party committee. With the encouragement of the General Line and liberated ideology, these men worked vigorously and enthusiastically for the technical revolution and technical improvement. It was this vigour that resulted in the accomplishments of design in twenty-six days, shipway period in thirty-five days and completion in ninety-five days record time.

POSTSCRIPT

The contents of this article is based on Ho-p'ing No 49's design, construction and sea trial data, and materials in Engine Design supplied by Comrade Yung Tz'u-hsien, Electrical Design by Comrade Lo Hsien-chih and Thirty-Five Day Shipway Period for 3000 Ton Sea Vessel by Comrade Chu-Yuan chun. We wish to express our appreciation.

DESIGN OF THE CHIANG-SU-HAO AND THE CHIN-LING-HAO TRAIN FERRIES

[This is a full translation of an article appearing in Chung-kuo Tsao-ch'uan (China's Shipbuil ng), No 4, Shanghai, 15 October 1959, pages 40-60.]

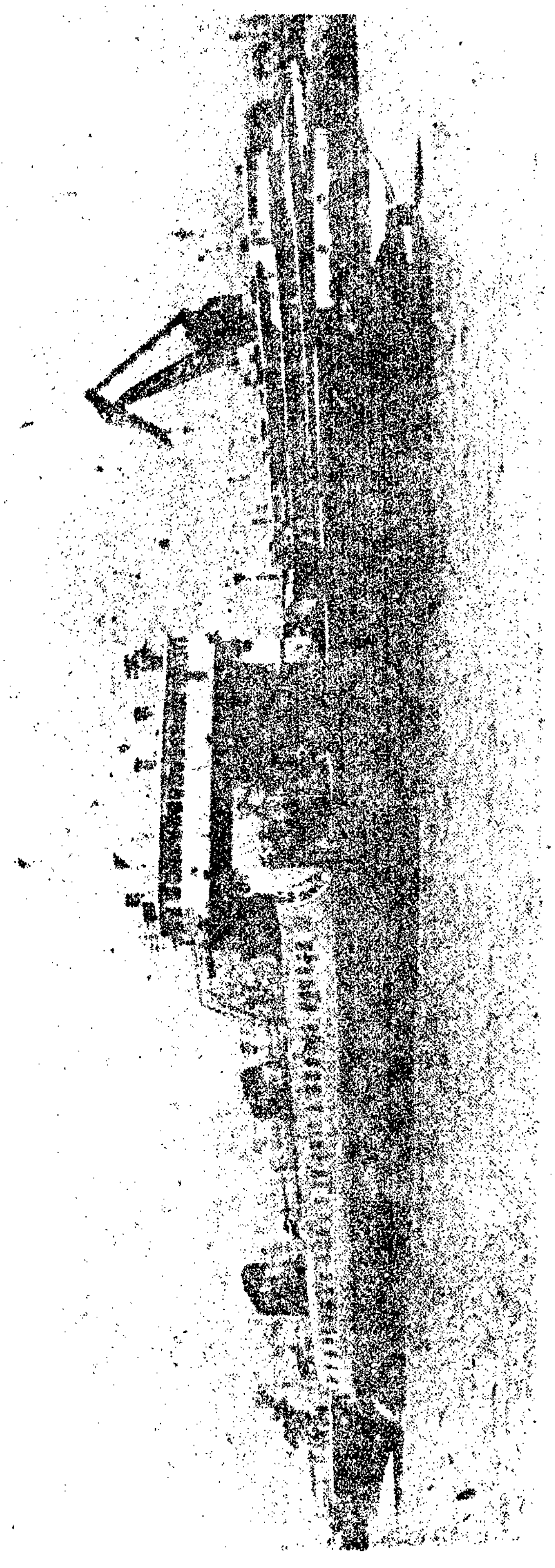
SUMMARY

The Kiangnan Shipyard has completed our country's two largest modern diesel engine train ferries during the first half of 1959. Each ship is 126 meters in length. Each ferry is capable of carrying 18 freight cars of 70 tons each and 9 freight cars of 45 tons each. For the purpose of improving the maneuverability of the ships, the stems are specially equipped with propellers and rudders.

This article is an introduction to the efforts made during the designing stage of these new ships. The design data of three previously built ferries are also gathered as a basis of comparison with the data of the new ships.

The two new ships have been put to sea trial and maneuvering tests after their completion. Based on results of the tests, the performances of stem propellers and stem rudders have received initial appraisal and analysis.

In the final chapter, several opinions and suggestions are raised in regard to the problems existing in the design of these new ships in order to encourage improvements in the future.



(I) FOREWORD

In late 1958, the overall great leap forward of industry and agriculture stimulated the rapid development of communications and transportation enterprises. For the fulfillment of national requirements, the Kiangnan Shipyard of Shanghai designed and constructed two more new train ferries after completion of the S.S. "Shanghai-hao". The staff and workers of the yard, under the glowing light of the Party's General line, worked with the greatest enthusiasm on the construction of these two ships. Due to their tireless efforts and selfless endeavour, the ferries "Chiang-su-hao" and "Chin-ling-hao" were completed in June and August, respectively, of 1959. These two ships have been efficiently put into the service of railroad transportation.

[From here on "new ship" refers to either "Chiang-su-hao" or "Chin-ling-hao". They are of the same type and same design.]

The duty of the new ship is mainly to ferry north and south-bound trains between P'u-k'ou on the north bank of the Yangtze River and Nanking on the south bank. Thus, with the ferry service several railway lines, Huning Line (Shanghai to Nanking), Ningwu Line (Nanking to Wu-hu) and Chinpu Line (Tientsin to P'u-k'ou) are connected. Before these two new ferries entered the ferry service, there were already three other train ferries in service. They are: "Shanghai-hao", "Nanking-hao" and "P'u-k'ou-hao".

"Nanking-hao" and "P'u-k'ou-hao" were constructed during the time of the Japanese aggression. The dimensions of both ships are identical. (See Table 1) Both ships are equipped with steam engines as the main engine but their propulsion systems are altogether different. "Nanking-hao" is of twin-engine stern propulsion but the "P'u-k'ou-hao" is of mono-engine stem and stern propulsion, employing propellers and rudders at both the stem and the stern. Because of the comparatively short distance between Nanking and P'u-k'ou and the current of the Yangtze River, the navigational course between these two ports is somewhat in a "S" pattern. And the time spent in pulling in and pulling out at piers occupies about one half the time required for the full operation of one ferrying trip.

Under these circumstances, the performance of "Pu-k'ou-hao" was superior because it has the stem propulsion system which increases the maneuveribility of the ship and also has greater backing efficiency. Although the horsepower of the P'u-k'ou-hao main engine is only one half that of the Nanking-hao and it's speed is slower, the time Pu-k'ou-hao spends on one trip is still about the same as the Nanking-hao. Due to the advantage of the stem propulsion system, it is also incorporated in the design of the Shanghai-hao.

Table 1 Comparison of Principal Dimensions

Item	Particulars \ Name of Vessel	Chiang-su-hao	Shanghai-hao	Nanking-hao	P'u-k'ou-hao
1	Length, Over-all (Meter	126.55	118.35	105.70	104.70
2	Length of Water Line (Meter)	122.00	118.00	102.25	--
3	Length, B.P. (Meter)	117.20	112.00	100.00	100.00
4	Beam(Meter)	17.2	17.2	17.2	17.2
5	Depth(Meter)	6.5	6.5	6.3	5.3
6	Draft, Full-load (Meter)	3.51	3.63	3.3	3.1
7	Displacement (Ton)	5090	4950	3760	3380
8	Block Coefficient	0.690	0.675	0.663	0.638
9	Midship-section Coefficient	0.972	0.975	0.682	0.968
10	Prismatic Coefficient	0.710	0.693	0.682	0.659
11	Water-plane Coefficient	0.798	0.792	0.808	0.785

Table 1 continued.....

Item	Particulars	Chiang-su-Hao	Shanghai-Hao	Nanking-Hao	P'u-k'ou-Hao
12	L : H	18.03	17.22	15.87	18.87
13	B : H	2.646	2.646	2.730	3.248
14	T : H	0.544	0.558	0.523	0.585
15	Effective Track Length (Meter)	120.534	113.900	-	-
16	Deadweight (Ton)	2878	2416.3	1706	1772
17	Vehicle Carrying Capacity (Ton)	1800	1680	1113	1113
18	Vehicle Carrying Capacity/Full-load Displacement	0.349	0.34	0.296	0.330
19	Deadweight/Full-load Displacement	0.5575	0.4875	0.453	0.525
20	Horsepower	3-600(Diesel Engine)	2-960 (Steam-Fngine)	2-600 (Steam Engine)	600(Stea Engine)
21	Rotation Speed (Revolution/ Minute)	350	200	180	180
22	Speed (Knot)	10.3	10.5	11	9

(Continued)

Item	Particulars (Stem Propeller)	Chiang-su-hao	Shanghai-hao	Nanking-hao	P'u-k'ou-hao
23	Number	1	1	-	1
24	Type	Four-Blade Symmetrical Section	Four-Blade Wing Shape	-	Four-Blade Symmetrical Section
25	Diameter (Meter)	1.890	2.400	-	2.200
26	Pitch	1.359	2.240	-	1.850
27	Disk Area Ratio	0.400	0.512	-	0.745
	(Stern Propeller)				
28	Number	2	2	2	1
29	Type	Three-Blade Wing Shape	Four-Blade Wing Shape	Four-Blade Arch Shape	Four-Blade Symme[illegible] cal Sec
30	Diameter (Meter)	1.960	2.400	2.300	2.200
31	Pitch	1.156	2.110	2.300	1.850
32	Disk Area Ratio	0.388	0.550	0.450	0.745
	(Stem Rudder)				
33	Area A (Meter^2)	7.36	9.60	-	5.733
34	Area Ratio A/LT	0.0177	0.0236	-	0.0185

(Continued)

Item	Particulars (Stern Rudder)	Chiang-su-hao	Shanghai-hao	Nanking-hao	P'u-k'ou-hao
35	Area A (m^2)	9.04	9.60	11.378	5.733
36	Area Ratio A/LT	0.0218	0.236	0.0345	0.0185
37	Weight of Left & Right Balancing Water(Ton)	430	350	200	240
38	Weight of Forward & Astern Balancing Water (Ton)	160	122	172	183
39	Height of Stability Under Full-load h (Meter)	2.87	3.35	4.52	4.86
40	Distance Between Center of Gravity to Base LineZ_g (m)	5.72	5.1	4.97	4.50
41	Z_g/H	0.88	0.785	0.79	0.85

During the initial stage of design, it was first stipulated that Chiang-su-hao and "Chin-ling-hao" was to be the same type as the "Shanghai-hao" with slight changes in the arrangement. But the urgent demands for ferry service resulted in the switching of power plant type from steam engine to that of diesel engine. The reason was that the steam main engine required a longer period of manufacturing which barred early delivery of the ferries. Therefore, after a careful checking on the availability of equipment and material at that time, it was decided that three units of national 6350 type diesel engines would be employed as the main engines. It was also decided to install a stem propulsion system.

Due to the change in power plant installation, the dimensions, arrangement, line plan and structure of the ship were also required to have major changes. In the course of redesigning it was decided that the length of the ship would be lengthened to accomodate more freight cars.

The designing work of these new ships was started in late November of last year and was completed in January 1959. During the course of designing, some improvements had been made based upon the experiences gained from the designing and actual service of "Shanghai-hao."

For further understanding and research on the actual performance of stem main engine and stem rudder, speed tests and maneuvering tests was conducted with the co-operation of the Marine Science Research Institute after the completion of these new ships.

The design specifications and initial analysis on the trial run of the new ship are detailed below.

(II) PRINCIPAL DIMENSION, LINE PLAN AND RESISTANCE

Because of the restrictive conditions of the Nanking train ferry pier, some principal dimensions of the ship such as beam and depth were copied from "Shanghai-hao" without any change. The length of the ship had been lengthened about eight meters longer than "Shanghai-hao" to suit the needs of more vehicle carrying capacity. At the same time, based on the weight calculation, the draft and block coefficient were revised. Principal dimensions finally decided were as follows:

Length, Overall	126.55 meters
Designed Length of Water Line	121.60 meters
Length Between Rudder Posts	117.20 meters
Beam	17.20 meters
Depth	6.50 meters

Draft, Full-load	3.51 meters
Displacement, Full-load	5090 tons
Main Engine Rated Horsepower	3 x 600 horsepower
Designed Speed	10.30 knots
Deadweight	2878 tons
Vehicle Carrying Capacity (18 freight cars of 75 tons each and 9 freight cars of 50 tons each)	1800 tons

The line plan of "Shanghai-hao" was taken as a model for the designing of this ship's line plan. The line plan of the stem remained the same but the design of the stern line plan was based on the requirements of twin-propellers at the stern and in coordination with the line plan of the stem. The feature of this ship's line plan is that the cross-section of the stem and stern are all in V pattern. And to insure that the deck is wide enough for carrying vehicles, the width of the cross-section from designed water line to the deck expanded sharply. (Fig 1)

The principal characteristics of this ship's line plan are as follows:

Block Coefficient	0.690
Midship-section Coefficient	0.972
Prismatic Coefficient	0.710
Water Plane Coefficient	0.798
Position of Longitudinal Center of Buoyancy	0
One-Half Angle of Attack	21°
Parallel Middle Body	30%L

The effective horsepower curve, derived from model test on the line plan, is shown in Fig 2. For the purpose of comparison, the effective horsepower curve of "Shanghai-hao" is also plotted in Fig 2. Also included is the ⓒ value of two model ships calculated at 122 meters ship length. It can be seen obviously in Fig 2 that new ship's resistance is slightly lower than "Shanghai-hao's". Therefore, in the designing of ship's speed about four percent of horsepower could be saved.

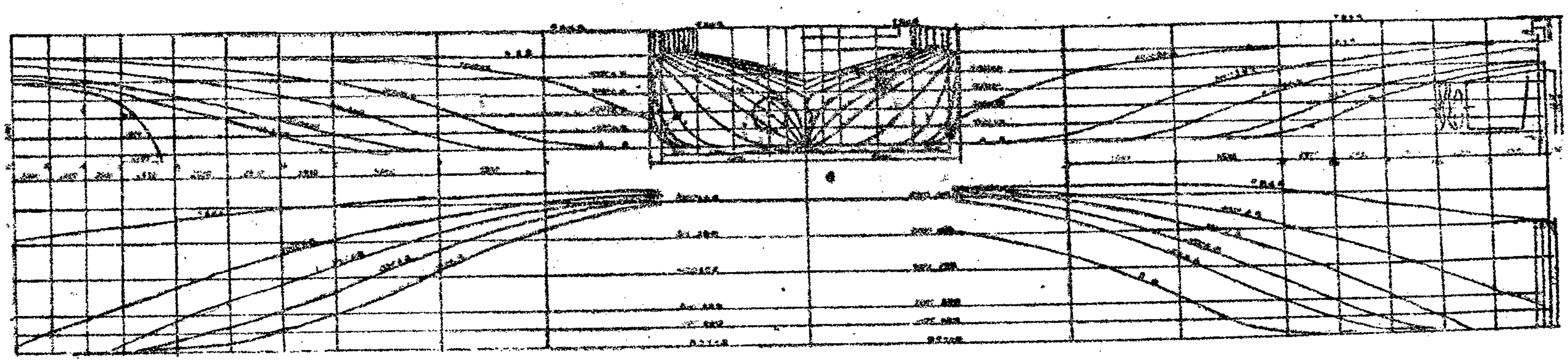


Fig 1 Line Plan

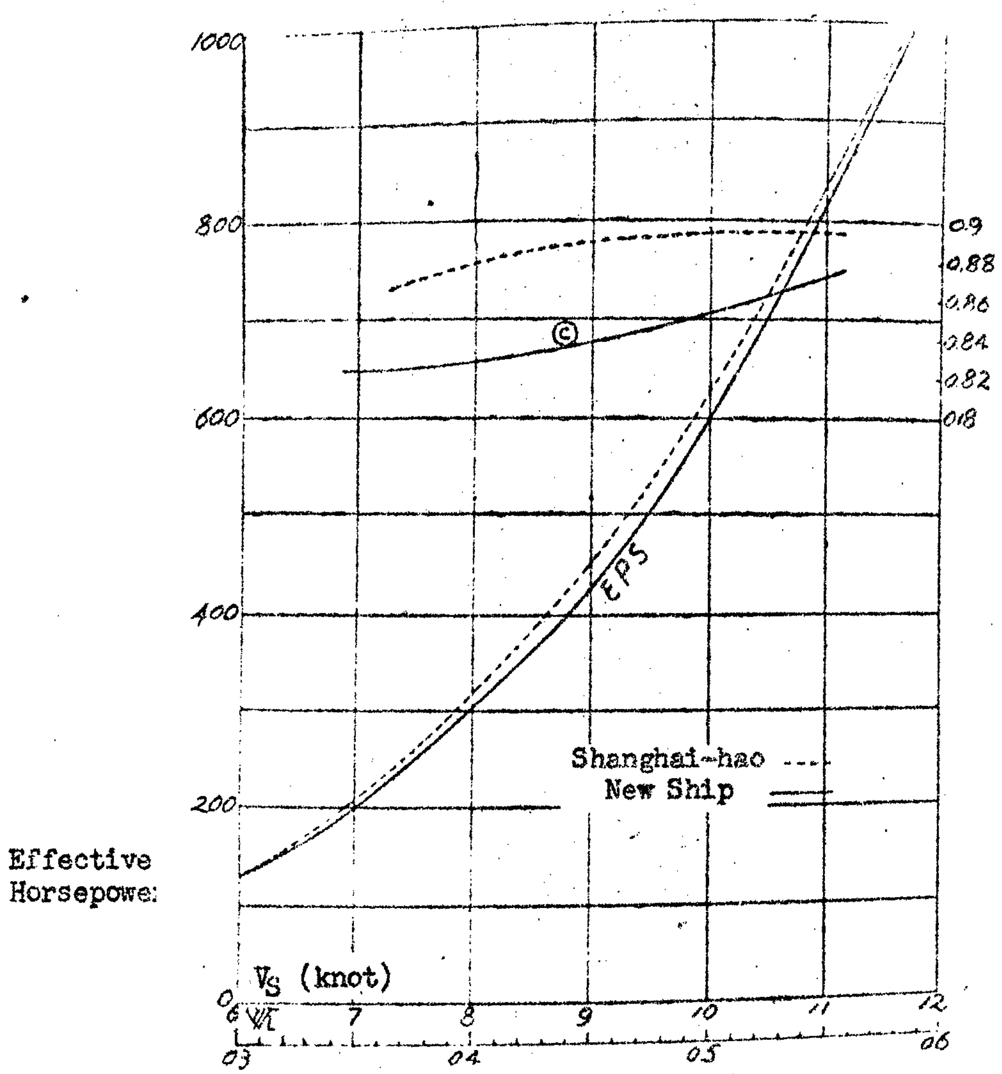


Fig 2 Effective Horsepower Curve

(III) ARRANGEMENT DIAGRAM OF THE SHIP

This is a single deck ship. The main deck is also the vehicle deck on which three railroad tracks are laid. The distance between the centers of two tracks is 3.66 meters. The effective length of each track is 120.534 meters which provides enough space for six freight cars of seventy-five tons each and three freight cars of fifty tons each. On the port and starboard of the main deck at midship, about 40 percent of length of ship, there are two rows of deck houses for the accommodation of ship's crew. To insure safety during the handling of trains and freight cars, the inner wall of the deck house and neighboring track is kept at least 2.5 meters apart. The entrances to the forward and after engine room are also located in the deck house.

The navigation bridge is located atop the fore-deck at quarter length of the ship distance to the stem. According to previous experience in the services of other ferries, this location is considered most suitable. It is a most convenient location from which the ship's pulling in and pulling out at the pier can be easily watched. And it is a good location for directing balancing pumps during the loading and unloading of trains. The navigation bridge is T shaped, with a 66-square-meter area. The rear of the navigation bridge has glassed window so that the stern can be watched when the ship is steaming back astern.

To insure that any freight car and locomotive can be carried on any section of track, the navigation deck and the surface of the track is separated by a distance of 5.15 meters. In other words, the navigation deck forms a bridge above the vehicle deck with a clearance of 5.15 meters. This allows locomotives to pass under the navigation bridge.

Two engine rooms are located in the forward and after body. The forward engine room has one main engine. The stern engine room has two main engines. The arrangement of two engine rooms in this manner is for the purpose of shortening the length of the shaft system.

An auxiliary engine room is located in front of the stern engine room. For the convenience of engine crew movement between auxiliary engine room, forward and after engine rooms without entering and leaving the main deck, electrically controlled doors were installed in the water tight bulkheads between the forward and after engine rooms. The door are opened at all times for engine crew passage, but during emergencies, the doors can be rapidly closed by remote control from the navigation bridge.

Because the engine rooms are arranged at the stem and the stern and while it was impossible to install a smokestack at the forebody, the disposal of the forward main engine's exhaust was a quite difficult problem to solve. In the course of designing, the deck house was lengthened to cover the forward engine room and it's rear housing. This permitted the exhaust pipe to run upward through a part of the deck house to the top of the navigation bridge. This exhaust outlet was so designed that it looked like an air intake. This design saved space and was also good in appearance.

The left and right balancing water tanks are located at port and starboard at the mid-body. The total capacity of these two tanks is 430 tons of water for balancing purposes. With the use of electric balancing water pumps, the quantity of water in the tanks can be adjusted from the navigation bridge. By shifting water from port to starboard or vise versa, the rolling angle of the ship can be controlled during the loading and unloading of vehicles.

Stem and stern balancing water tanks' maximum capacities are 378 tons and 367 tons each. These balancing tanks are for adjusting the longitudinal inclination of the ship and for ballast during flood season for decreasing the freeboard to suit the requirements of the gangway's radient at the pier.

Besides these installations, there are stem and stern steering gear rooms and an empty hold under the main deck. There are a conference room platform and a crew rest room in the empty hold. Also installed in the empty hold are four spare fuel oil tanks with a capacity of 196 tons.

For effective protection of deck plating, the main deck and the top of the deck houses are laid with asphalt.

The arrangement of the ship is shown in Fig 3.

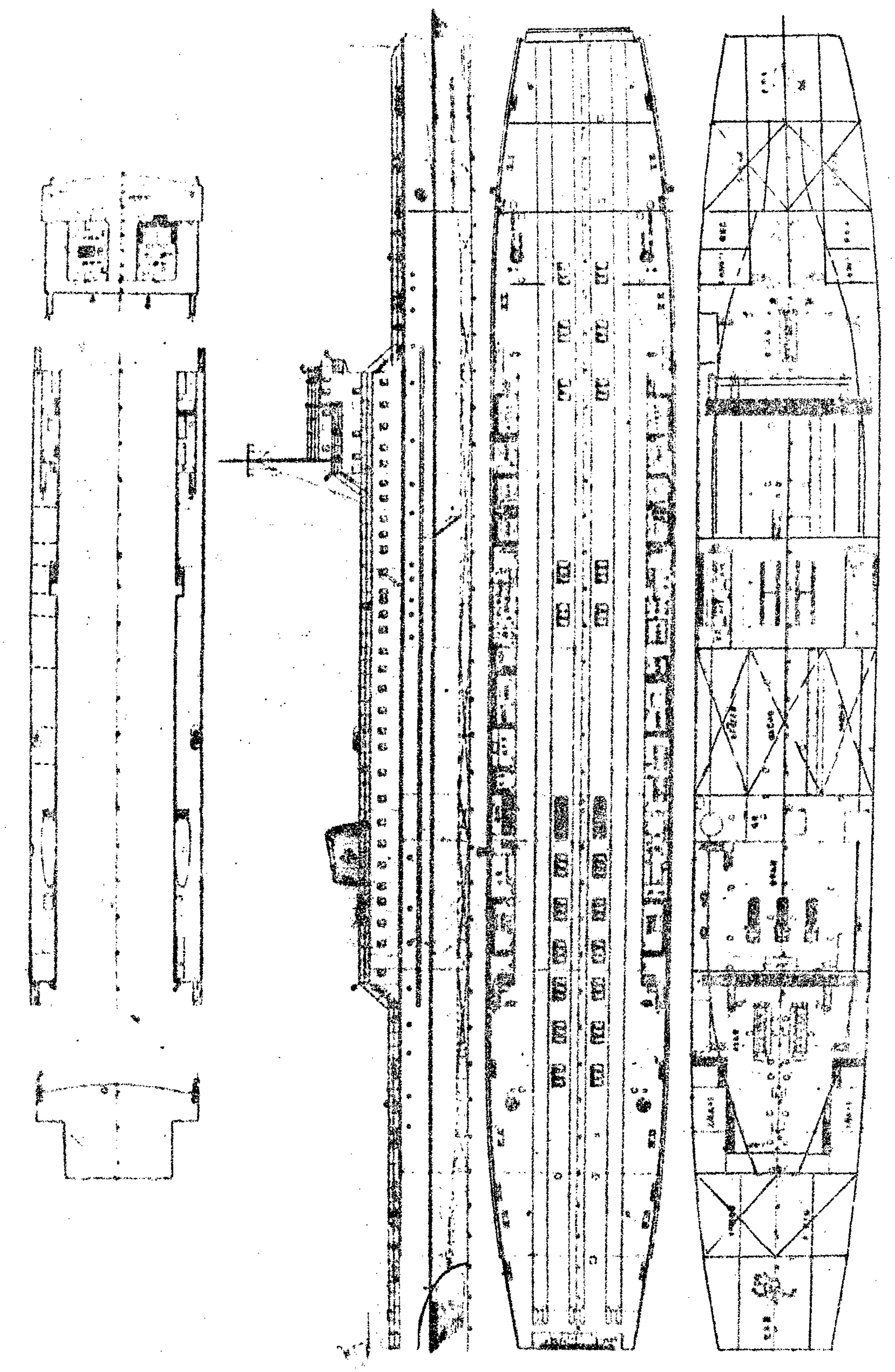


Fig 3 Arrangement of the Ship

(IV) HULL STRUCTURE AND STRENGTH

The shell plating of this ship is welded except for the side plate of the deck and side shell plating which are riveted to the gunwale angle. The hull framing is a mixture of transverse and longitudinal systems. (The deck and bottom frames are of longitudinal system and the rib of transverse structure). To insure the hull structure having enough athwartship strength, a ring shaped web frame consisting of reinforced rib, reinforced transverse beam and web plate is employed every six frame stations (4.20 meters).

In the midship section, the web frame is employed every three frame stations because this part of the ship would receive the heaviest impact in docking operations. And at the stem and stern, the web frame is employed at every frame station because the stem and stern receive great impact during the handling of vehicles.

The selection of a mixtureof longitudinal and transverse framing systems was a new attempt. Older shops like "Nanking-hao" and "P-u-k'ou-hao" are all of transverse framing structure. Searching through available data on foreign built ferries revealed that most of them were also of transverse framing structure. Therefore, "Shanghai-hao" which was built previously was also of transverse framing structure in design. But during the designing of the new ship, we considered that though the transverse strength requirement of a train ferry is higher than that of general types of vessels, if we could insure the strength of tranverse framing and at the same time change the design of deck and bottom structureto longitudinal framing, definite advantages in the improving of longitudinal strength of the ship or more reasonable utilization of steel members could be obtained.

Especially in the deck framing, because railroad tracks are laid on the deck, it was necessary to strengthen longitudinal girder throughout the total length of track under the deck in order to support the vehicle lead. These longitudinal girders provided advantageous conditions to the longitudinal frame strutture of the deck.

After a period of actual service, it is now considered that the adoption of longitudinal and transverse framing systems in the train ferry is suitable.

There are definite features in the structure and strength requirements of the train ferry, especially the principle dimensions of the river ferry and general types of vessels which have higher degrees of differences. Therefore, in the determination of dimensions of structural parts of the new ship there were no definite rules that could be followed. During the course of designing, the previously built ferry "Shanghai-hao" was taken as the basis of design. At the same time the requirements stipulated for vessels for sub-speed navigation zone in the USSR Steel Shell Sea Going Vessel Regulations (Sub-speed navigation zone vessel's principal dimensional ratios are: $L/H = 10$-24, $B/H \leq 3.25$. This ship's $L/H = 18$ and $B/H = 2.65$) and "Norwegian Steel Vessel Construction Rules" were taken as references in making comparison for final determination of dimensions of structural parts of the new ship. (See Fig 4)

Due to improvements in the framing system and adequate adjustment in the dimensions of structural parts, the weight of steel material in this ship's hull is considerably lighter than the three train ferries previously built. Compared to "Shanghai-hao" the coefficient of steel weight of this ship is 9.25 percent lower. (See Table 2)

In the calculation of longitudinal strength of this ship's hull, several unfavorable conditions of loads were taken into consideration. They are:

First Condition: Empty cars 460 tons on the midship section.

Second Condition: Empty cars 460 tons on stem and stern.

Third Condition: Empty cars 460 tons on the midship section with ballast.

Fourth Condition: Flood season ballast with empty cars 460 tons on the midship section.

Fifth Condition: Flood season ballast without empty cars.

Due to lack of substantial data on the wave conditions of the Yangtze River in the Nanking area, we used 24 meters as the wave length and 1.5 meters as the wave height in calculations. The maximum bending moment and the maximum shear coefficient of various loading conditions are listed in Table 6.

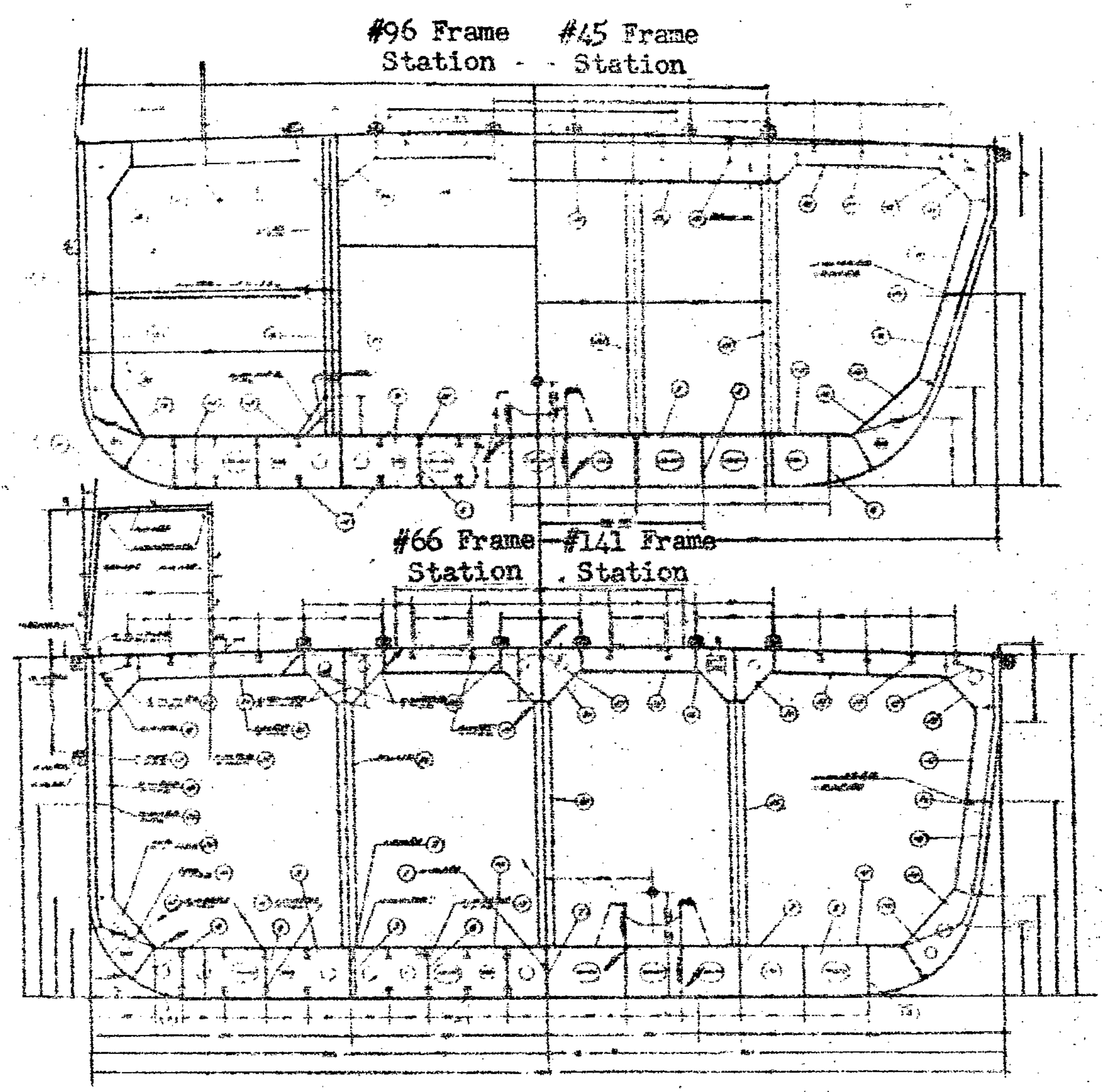


Fig 4 Diagram of Cross-section

Table 2 Comparison of Coefficient of Steel Weight

Name of Ship	Frame System	Method of Structure	Steel Weight of Ship's Body P_k (ton)	Cubic Number L. B. H. (Meter^3)	Coefficient of Weight of Steel P_k L.B.H. (ton meter)
Nanking	Single Bottom, Transverse Structure	Rivet	1300	10840	0.122
P'u-k'ou	Single Bottom, Transverse Structure	Rivet	1060	9120	0.116
Shanghai	Double-Bottom, Transverse Structure	Electric Arc Welding	1348	12500	0.108
New Ship	Double-Bottom, Longitudinal and Transverse Structure	Electric Arc Welding	1285	13100	0.098

Table 3 Distribution of Total Weight

No	Item	Weight (metric ton)	Percentage of Total Weight
1	Total Weight of Hull	1285.15	58.1
2	Woodwork and Furniture	78.6	3.55
3	Equipment and Trim	620.753	28.1
4	Engine Installation	227.330	10.25
	Total Weight of Light Ship	2211.803	100

Table 4 Distribution of Weight

No	Item	Weight (Metric ton)	Percentage of Total Weight
1	Steel Material of Hull and Weld Metal	1096.31	85.312
2	Transverse Bulkheads	57.012	4.434
3	Superstructure	110.928	8.63
4	Smokestack	7.4	0.576
5	Hawse Pipe and Chain Pipe	3.5	0.27
6	Hull Allowance	10	0.778
	Total Steel Weight of Hull	1285.15	100
7	Deck Machinery	32	4.55
8	Ventilation Equipment	14	2.00
9	Electrical Equipment	26	3.70
10	"A" Bracket and Boss Plate	3	0.42
11	Sanitary Equipment and Piping System	12.9	1.84

(Continued....)

Table 4 Continued......

No.	Item	Weight (metric ton)	Percentage of Total Weight
12	Anchor and Anchor Chain	47	6.71
13	Equipment	169.8	24.3
14	Fine Woodwork	18	2.57
10	Rough Woodwork (including tie)	60.6	8.67
11	Paint	15	2.14
12	Cement Tile	23	3.30
13	Asphalt	278.053	39.08
	Total Weight of Equipment, Trim, Woodwork and Furniture	699.353	100
14	Main Engine	75.6	33.3
15	Generator	15.3	6.74
16	Earth Axle and Intermediate Thrust Axle	14	6.17
17	Steam Boiler	8.5	3.75
18	Engine Room Equipment and Piping System	113.9	50.04
	Total Weight of Engine and Boiler Rooms	227.30	100

Table 5 Distribution of Full Displacement

No	Item	Weight (metric ton)	Percentage of Total Weight
1	Weight of Light Ship	2211.803	43.442
2	Fuel Oil	138.60	2.72
3	Fuel Oil, Spare	195.80	3.845
4	Lubrication Oil	18.1	0.355
5	Engine Oil	12.5	0.245
6	Fresh Water	44	0.865
7	Boiler Feed Water	15	0.295
8	Left and Right Balancing Water	430	8.450
9	Forward Balancing Water	80	1.572
10	After Balancing Water	80	1.572
11	Coal	60	1.18
12	Personnel and Baggage	4	0.079
13	Vehicle Carrying Weight	1800	35.38
	GRAND TOTAL	5089.8	100

From Table 6 we can easily see from the numbers that under calculated loading conditions, the hull of the ship is constantly taking the action of positive bending moment (hogging bending moment). Its highest magnitude is 18769 ton-meters.

The condition of stress produced at the deck and bottom plate is shown in Table 7.

Under the same loading conditions (First condition: Full-load, empty cars at midship) the actual working stress of this ship's deck is 16.5 percent higher than that of "Shanghai-hao" . (See Table 8)

The deck houses of this ship are in two rows at the port and starboard sides and are within the limit of 40 percent of ship's length. Their outer side wall and the strake are on a same plane. In order to avoid the deck house being involved in the hull's longitudinal total bending, elastic joints were employed in connections as in "Shanghai-hao". The type of elastic joint in "Shanghai-hao" is shown in Fig 5.

But in the case of "Shanghai-h o", the joint at the top of deck house and the joint of side plating are welded in a right angle. After a period of service, serious cracking occurred at the seams. The crack continues to develop along the elastic joint itself (Fig 6). In order to avoid this phenomenon, an arc shape structure was employed in the design of the new ship. (See Fig. 7)

Table 6

Load Condition	Maximum Shear (ton)	Maximum Bending Moment (ton-meter)	Coefficient of Bending Moment C= L/M
I			
Standard Wave	630	16009	35.2
Hogging	666	18164	31
Sagging	583	13210	42.6
II			
Standard Wave	274	5149	109
Hogging	309	7012	80.3
Sagging	231	3223	175
III			
Standard Wave	621	16540	35.8
Hogging	656	18769	31.6
Sagging	559	13535	43.8
IV			
Standard Wave	585	15740	39
Hogging	626	18211	33.7
V			
Standard Wave	518	13622	49
Hogging	564	16112	41.5

Table 7

Name of Structure	Total Bending Stress (kg/cm^2)	Permissible Stress (kg/cm^2)	Service Coefficient	Total Stress (kg/cm^2)	Permissible Stress (kg/cm^2)	Service Coefficient
Deck	+987	1145	0.861	+1216	1320	0.922
Bottom Plate	-805	1145	0.703	- 779	1980	0.394

Table 8

	Shanghai-hao		
	Deduction Coefficient Unaccounted	Deduction Coefficient Accounted	New Ship
Deck Stress (kg/cm^2)	+765	+820	+955
Bottom Stress (kg/cm^2)	-640	-810	-780

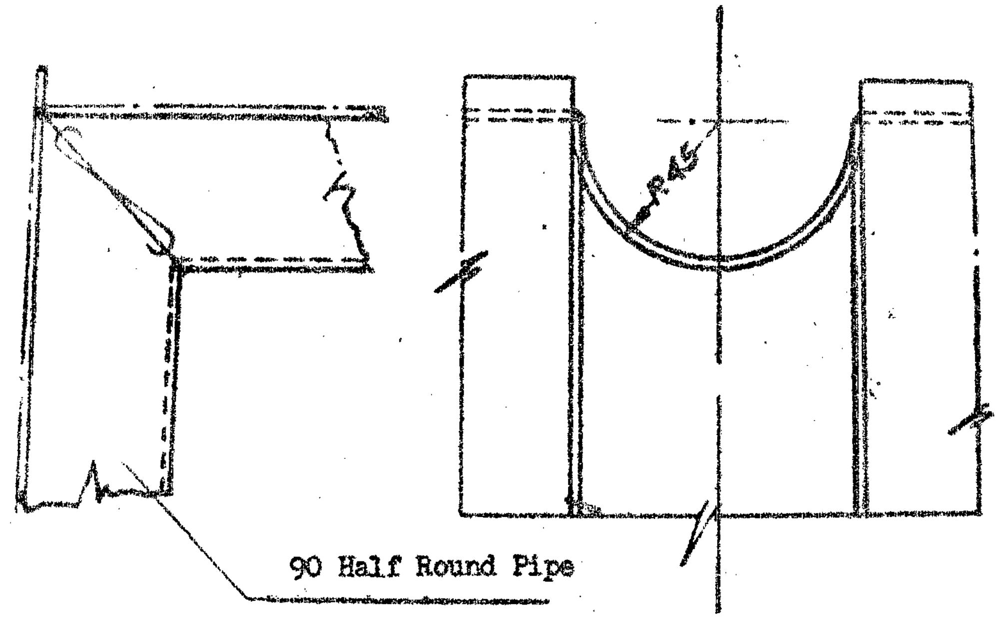


Fig 5 Elastic Joint of Deck House in Shanghai-hao

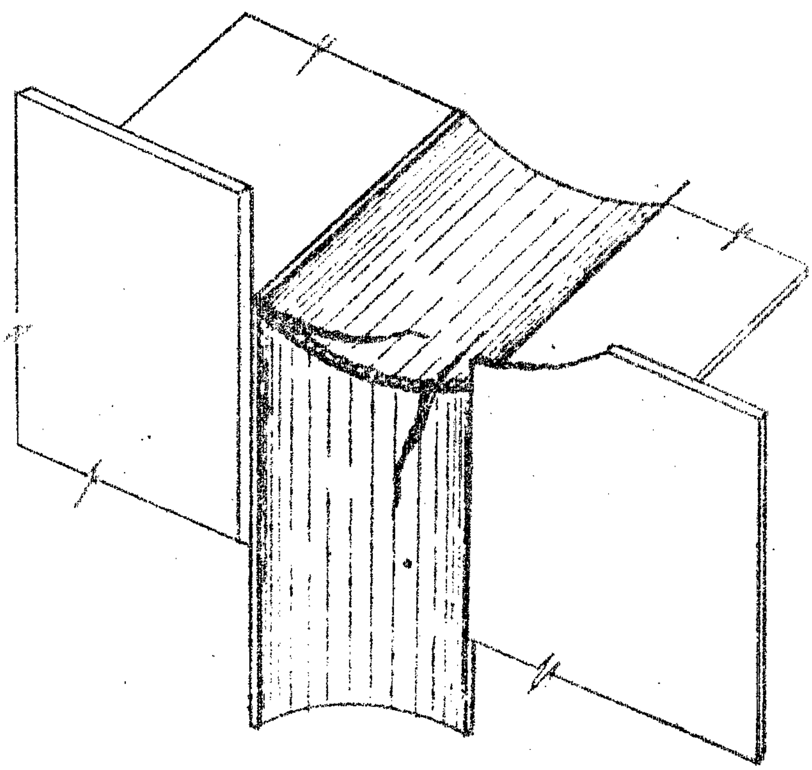


Fig 6 Crack at Elastic Joint of Deck House

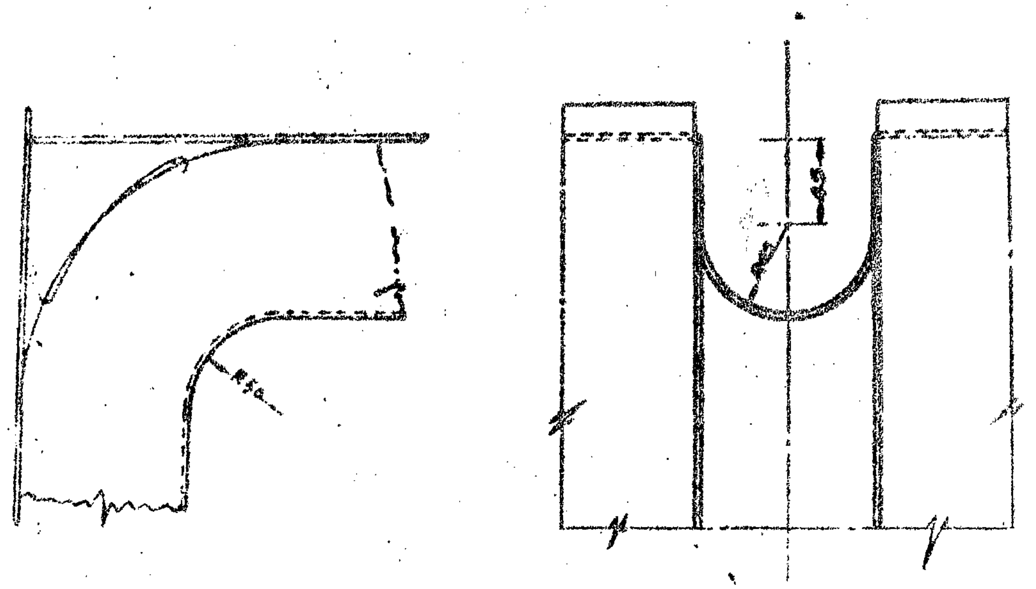


Fig 7 View of Elastic Joint of Deck House of Chiang-su-hao

The structural form of hawse pipe of this ship is shown in Fig 8. Because the cross-section line plan of stem above water line was comparatively flat, the design of hawse pipe was different from those of "P'u-k'ou-hao" and "Shanghai-hao." According to service experience, the hook of anchor would easily be held up when it runs against the side plate at "P'u-k'ou-hao" and "Shanghai-hao" which have regular type of hawse pipe. The anchor regularly does not rest at its normal position after it is hoisted. (See Fig 9)

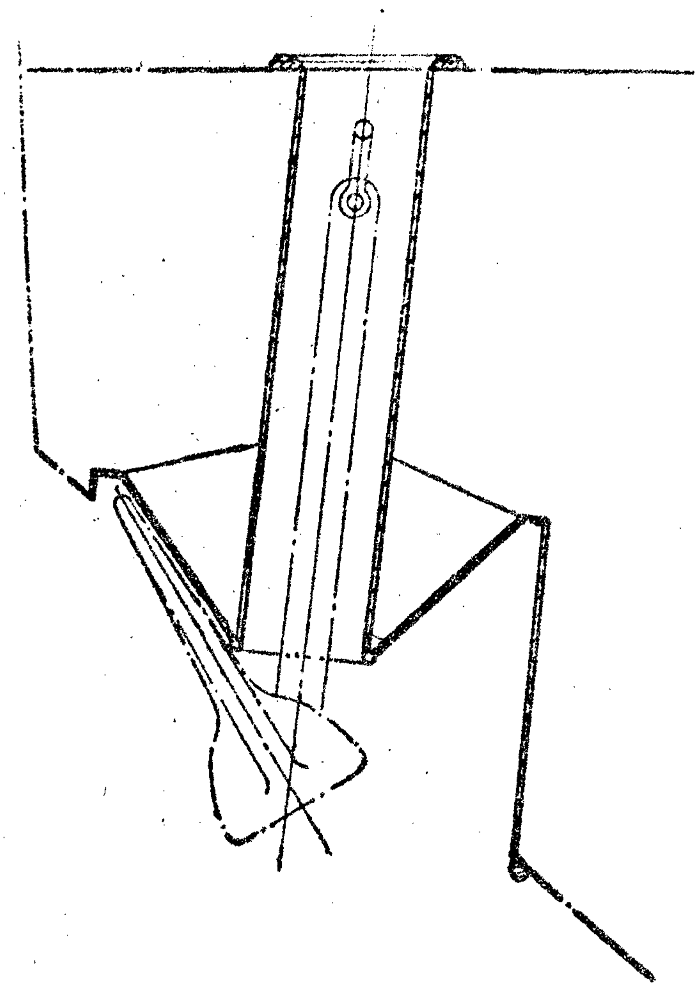


Fig 8 View of Hawse Pipe of Chiang-su-hao

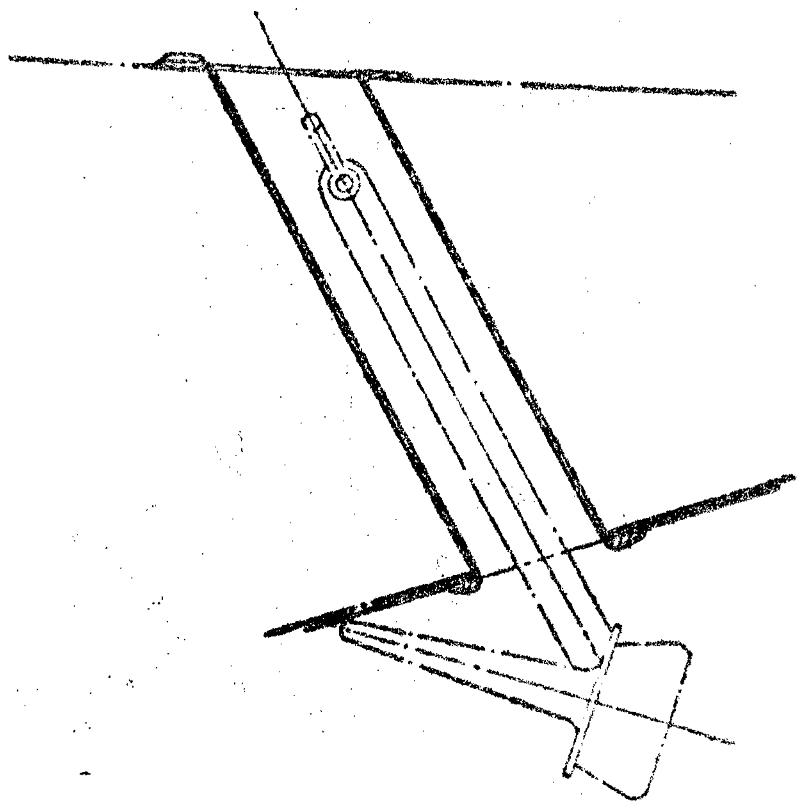


Fig 9 View of Hawse Pipe of Shanghai-hao

The improved structural form of hawse pipe of "Chiang-su-hao" has eliminated the above mentioned deficiency. Under any circumstance, the anchor is readily hoisted and housed in final position.

(V) PROPELLER AND RUDDER

Two stern propellers of this ship are directly rotated by left and right stern main engines. The principal dimensions of the propeller are as follows:

Diameter	1.96 meters
Pitch Ratio	0.59
Disk Area Ratio	0.388
Efficiency	0.584
Type	Troost B_3 type

There is one propeller at the stem which is directly rotated by the stem main engine. For the purpose of improving the efficiency of reverse rotation, in turn increasing the maneuveribility of the ship, the blades and sections of the propeller are in symmetrical forms. (See Fig 10)

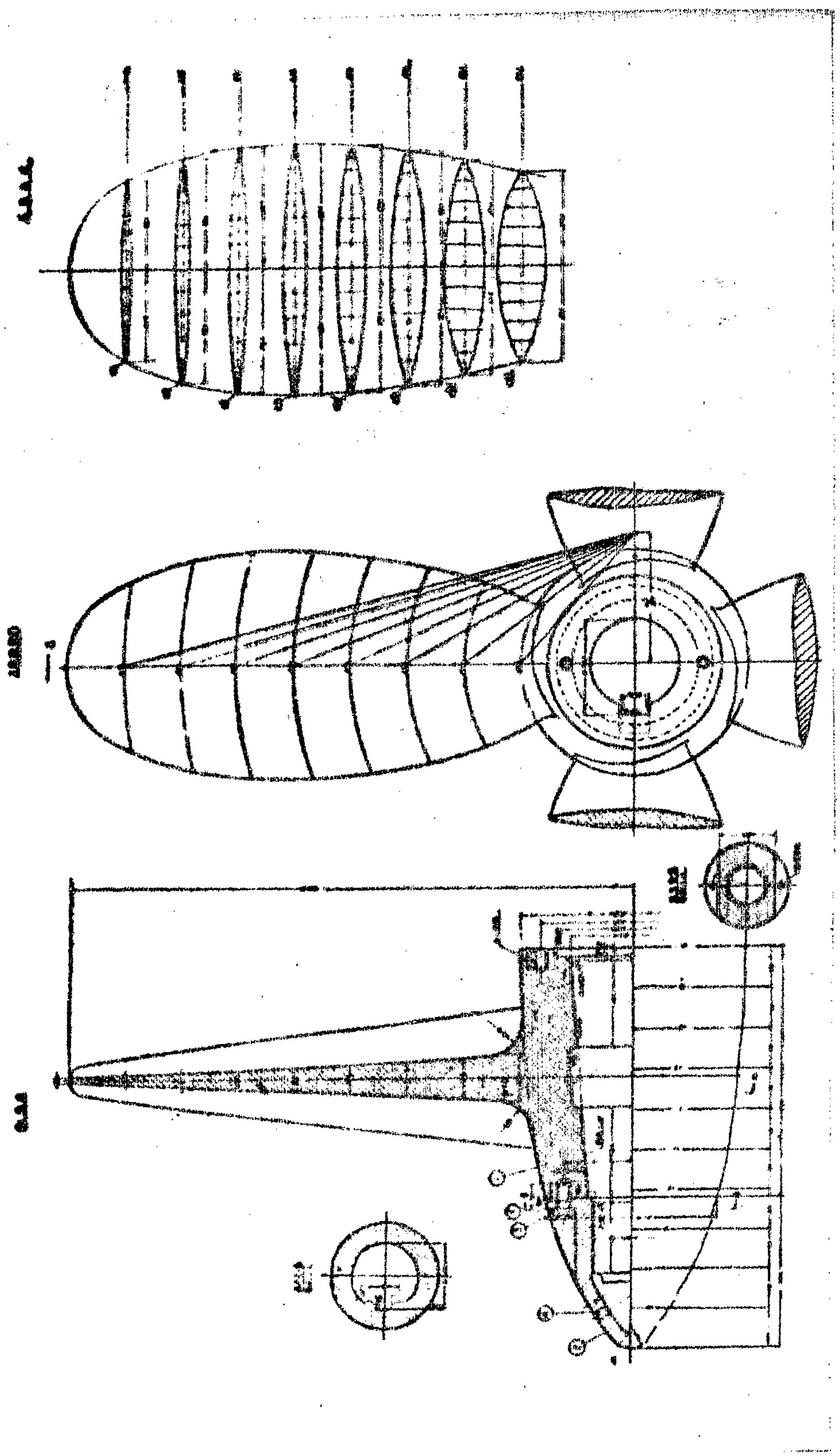


Fig 10 Stem Propeller

The principal dimensions of the stem propeller are as follows:

Diameter	1.89 meters
Pitch Ratio	0.719
Disk Area Ratio	0.40
Efficiency	0.526
Number of Blades	4 blades

Figure 11 is a diagram of characteristics curves of the propeller from the results of a model test against Troost four bladed screw characteristics curves. At designed speed the efficiency decreased about twelve percent.

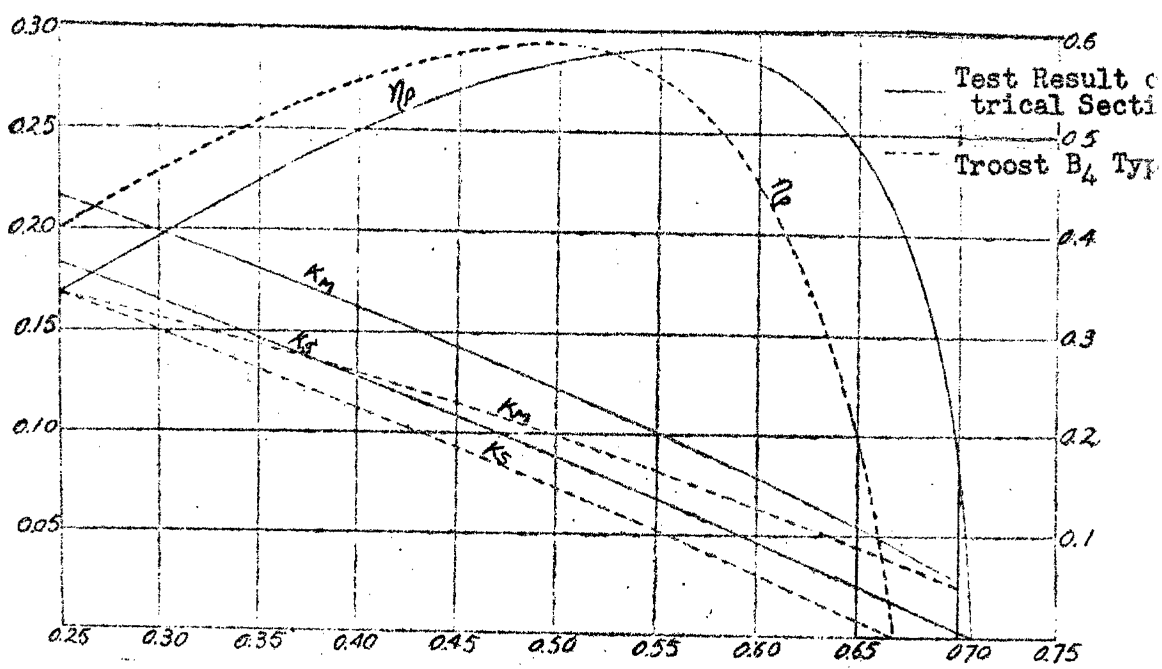


Fig 11 Diagram of Propeller Characteristics Curves

The ship has two rudders which are Wageningen test basin B type balance rudders. They are located directly behind the left and right propeller at the stern. Their relative positions are shown in Fig 12. The stem has one rudder which is the same type as "Shanghai-hao's."

The principal dimensions of stem and stern rudders are as follows:

	Stem Rudder	Stern Rudder
Rudder Area A (square meter)	7.36	4.62 (two)
Average Form Number Ratio	0.85	1.14
Average Thick and Width Ratio	15%	15%
Area Ratio A/L·T	0.0177	0.0104.

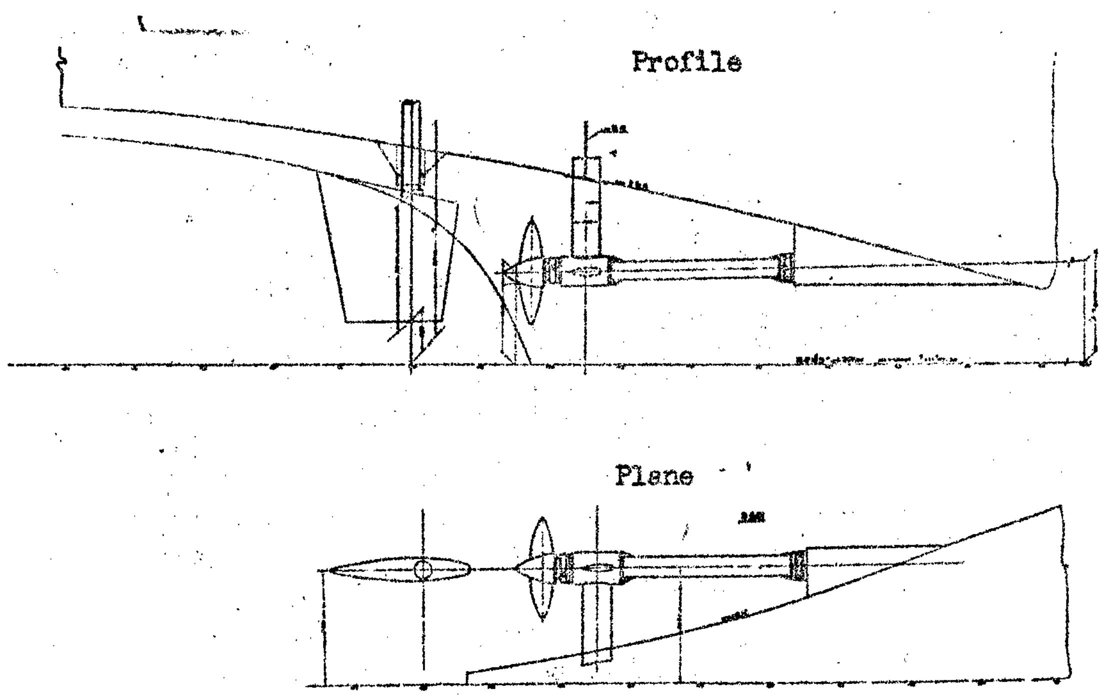


Fig 12 Arrangement of Stern Rudder and "A" Bracket

(VI) INSTALLATION OF THE POWER PLANT

Short-range travel, frequent alternations of back-and-forward movements and abrupt changes in the payload are the features necessarily attached to this ship. Maneuverability of a high degree in the control system is therefore demanded. The incipient design of the railroad bureau called for installation of a steam-driven power plant. However, it was discarded because the need for this ship was becoming urgent and because the manufacture of steam engines required a long time and high cost, whereas both main and auxiliary diesel engines can be selected and put into immediate use from a variety of existing products, thus shortening time in designing and building, and reducing manufacturing cost. All these considerations determined the adoption of the diesel engine power plant.

Taking the then prevailing conditions into view, three units of indigenuous 6350 marine type diesel engines were chosen as the ship's main engine. The diameter of its cylinders is 350 millimeters. The stroke of piston travels 500 millimeters. Rated speed of revolution is 500 revolution/minute, rated power 600 horsepower, and rate of fuel consumption 172 gram/horsepower-hour.

All its auxiliary engines are electric-powered. There are three units of 110 kilowatts 230 volts direct current generators, and an 8 cylinder, 4 stroke diesel engine of national 8160 type was adopted as the prime movers of the three generator units.

Some specific equipment on board, such as the large-type, four-way cross electric cock used in the balancing pumps, and the forward capstan and the capstan astern, all of which operate only during pulling in and pulling out of the ship at the pier and are inoperative during voyages, cause imbalance in the load of the generators, and diminish the utility of equipment. In the course of designing, electric power drives and generators driven by the main engine with a clutch were also considered, but there were disadvantages here too. Further studying is necessary.

(VII) ARRANGEMENT OF THE ENGINE ROOM

There are two engine rooms in this ship, one near the stem and one near the stern. The purpose of this arrangement is to shorten the length of the shaft system and to simplify installation work on the shaft system.

There are two main engines in the after engine room. They are in parallel position and directly drive the thrust shaft, intermediate shaft and propeller shaft. For decreasing the main engine's inertia when the engine is stopped and for shortening operating time during forward-and-back engine, a compressed air automatic braking device was installed on the intermediate shaft. On both sides of the engine room there are a sea water cooling pump for serving the main engine, a spare fresh water cooling pump, a fuel feeding pump, a spare lubrication oil feeding pump, a centrifugal oil purifier, an engine oil cooler, a fresh water cooler, and main engine's oil tanks, etc. Along the front wall of the engine room there are four main engine starting air tanks and two units of auxiliary electrical air compressors. Along the rear wall, there are a electric-powered low pressure air compressor for testing train brakes and low pressure air tanks, etc. On both sides of the engine room near the rear wall, there are also two platforms. A electric motor for electircal winch and transmission gear housing are installed on the platforms.

The forward engine room houses one main engine. On its two sides there are servicing pumps and heat exchangers Near the rear wall, there are also two main engine starting air tanks and auxiliary air compressor. On both sides of the stem engine room wall there are also two platforms each with a transmission gear housing for electrical winch. The arrangement of various auxiliary engines is relatively good.

The auxiliary engine room is located in front of the stern main engine room. The auxiliary engine room houses three diesel generators and the main switchboard. On its port side there are a fire protection pump, ballast pump, bilge pump, etc. On the starboard side there are a electric-powered fresh water pump, sanitary pump, sea and fresh water pump pressure tanks and two large balancing water pumps and a large type four-way cross electric cook.

On the port side in the forward area of the auxiliary engine room there are the auxiliary boiler room and coal hold. The auxiliary boiler room houses a vertical heating boiler and steam pump and other equipment.

The balancing water pump is special equipment for the train ferry. Its main purpose is increasing and decreasing the quantity of water in left and right balancing water tanks, thus controlling the rolling of the ship during the loading and unloading of trains. This ship has two units of balancing waterpumps which are of double-inlet mixed-flow type water pump. The pump has a flow rate of 1800 tons per hour. Its pressure head is 6.3 meters water column, power 45 kilowatts, rotation 620 revolutions per minute. The flow of balancing water is controlled by the rotating direction of two large type four-way cross electric cocks, each with a diameter of Ø 700. The cock is driven by motor and directly controlled from the navigation bridge. When the cock rotates to certain angle, the motor is stopped automatically in order to maintain correct valve position.

The details of arrangement in the engine room is shown in Fig 13. Principal machinery is listed in Table 9.

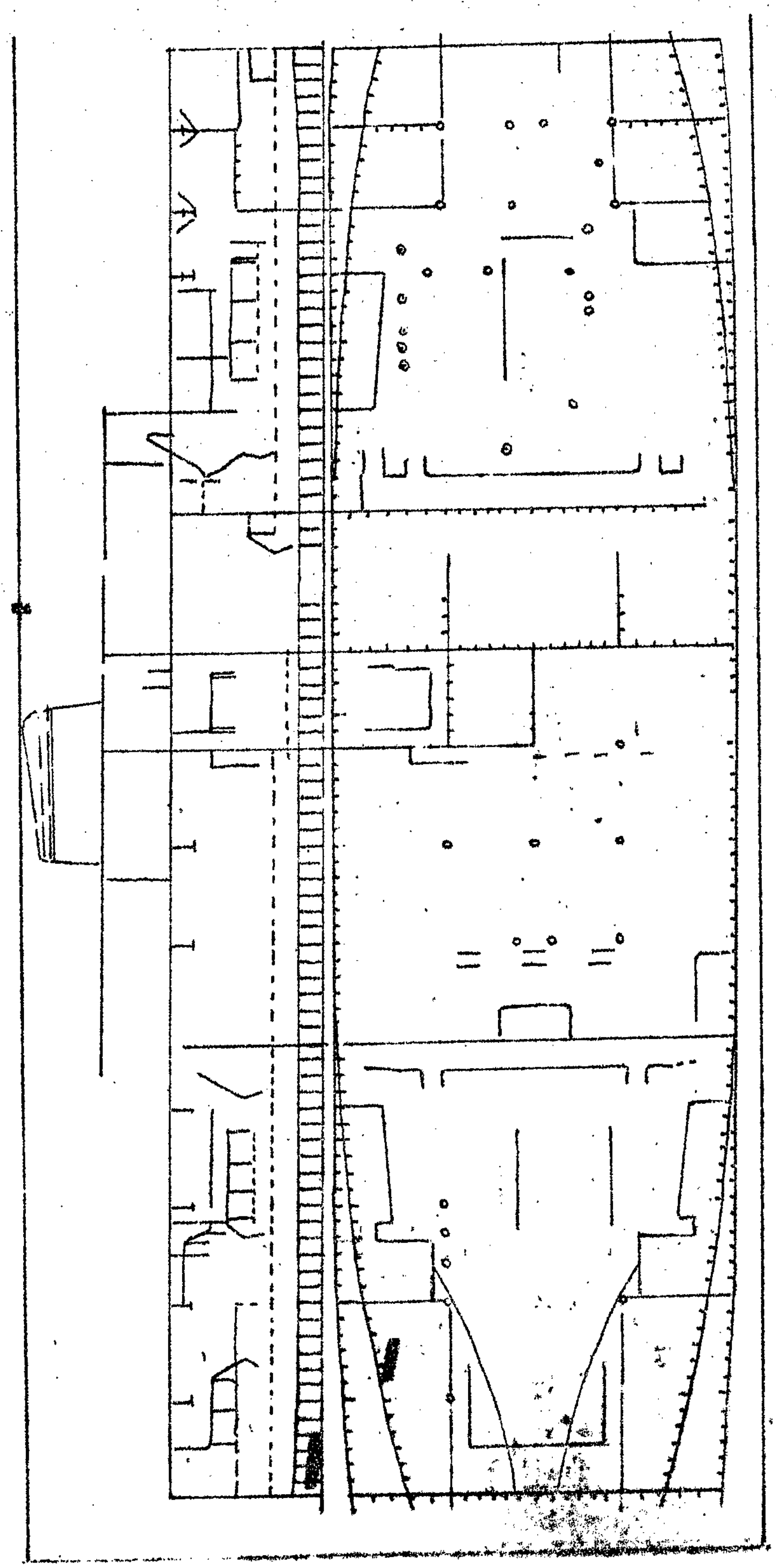


Fig 13 Arrangement of Engine Room

Table 9 - Table of Machinery

Item	Name of Machinery	Purpose	Type and Specifications	Quantity	Remark
1	Forward Main Engine	-	6350 diesel engine, 6 cylinder 4 stroke, 350 rpm, 600 HP	1 unit	-
2	After Main Engine	Propelling	Same as above	2 units	-
3	Generator	Electricity Supply	Direct current 220V, 750 rpm, 110 KW	3 units	2 units in continuous use. 1 spare unit
4	Generator Engine	Prime mover of genrrator	8160 type diesel engine, 4 stroke, 750 rpm, 180 HP	3 units	" "
5	High Pressure Air Compressor	Main Engine Starting	0.34 model vertical type reciprocating type double stage 27 kg/cm^2, 22.4 m^3/hr electric-powered	4 units	2 each in forward and after engine room
6	High Pressure Air Tank	Main Engine Starting	Ø800 x 3000 mm 27 kg/cm^2	6	2 for each main engine

(Continued)

Item	Name of Machinery	Purpose	Type and Specifications	Quantity	Remark
7	Low Pressure Air Compressor	Train inspection	Horizontal type water-cooled single cyclinder double action 600 rpm, 3.2 m^3lhr, 7 kg/cm^2, electric-powered	1 unit	-
8	Low Pressure Air Tank	Train inspection	Ø1200 x 4000 mm 7 kg/cm^2	1	-
9	Turning Gear	Main engine turning	Electric-powered, double stage worm gearing reduction	3 units	1 unit for each main engine
10	Fuel Oil Feed Pump	-	Electric-powered gear pump, 5 m^3/hr, 3 kg/cm^2	2 units	-
11	Lubrication Oil Feed Pump	-	" " "	2 units	-
12	Oil Purifier	Treatment of vitiated lubrication oil	Electric-powered, centrifugal type, 500 liters	1 unit	-
13	Cooler	Cooling main engine circulating water	Straight tube, surface cooling, double-flow, 20m^2 cooling area	3 units	1 for each main engine

(continued)

Item	Name of Machinery	Purpose	Type and Specifications	Quantity	Remark
14	River Water Cooling Pump	For cooler	3X-9A model, centrifugal type, electric-powered, 25 m^3/hr, 26.2 m column of water	3 units	1 for each cooler
15	Fresh Water Cooling Pump	Main engine-driven pump, spare	" " "	2 units	-
16	Balancing Water Pump	Balance Ship	24II-28A model centrifugal type, electric-powered, 620 rpm, 1840 m^3/hr, 6.3 m column of water 45 KW	2 units	--
17	Bilge Pump	Dispose of bilge water	Electric-powered, reciprocating type, 25 m^3/hr, 2.8 KW	1 unit	-
18	Universal Pump	For bilge, ballast and other usages	6X-12 model, 200 m^3/hr, 17.1 m column of water, 1450rpm, 21 KW	1 unit	-
19	Fire Pump	Fire Fighting	2900rpm, 90 m^3/hr, 60 m column of water, 28 KW	1 unit	-

(continued)

Item	Name of Machinery	Purpose	Type and Specifications	Quantity	Remark
20	Transferring(4-way) Cock	Transferring of balancing water	Ø 500 electric-powered	2 units	-
21	Fresh Water Pump	Supply drinking water	ЭCH1/1 model Turbine pump, 5-8 m^3/hr, 3 kg/cm^2, 2850 rpm	1 unit	-
22	Sanitary Water Pump	Supply Sanitary water	" " "	1 unit	-
23	Boiler	Supply hot water & heating	K'ao-k'o-lan vertical type, fire tube boiler 27.8 m^2, 7 atmospheric pressure, 750 kg/hr	1	-
24	Engine Room ventilator	Forward and After engine rooms and generator room ventilation	Axial-flow, electric-powered 16000 m^3/hr, 326 mm column of water, 1500 rpm	4 units	-
25	Conference Room Ventilator	Coference room ventilation	Axial-flow, #3½ 9000m^3/hr, 55 mm column of water 1000 rpm, centrifugal type	1 unit	-
26	Kitchen Ventilator	Kitchen ventilation	Axial-flow, electric-powered, 2500m^3/hr, 10 mm column of water, 1450rpm	1 unit	-

(continued)

Item	Name of Machinery	Purpose	Type and Specifications	Quantity	Remark
27	Current Transformer	-	Imput 220 V direct current, output 115V 50 alternating current, 1.5 KVA	2 units	-
28	Boring Machine	Machine Shop	Electric-powered, 15 mm perforation	1 unit	-
29	Grinding Wheel	"	Electric-powered, 8 inches	1 unit	-
30	Steering Gear	-	10-ton-meter, 8.5KW, Electric-powered, three stages speed reducing	2 units	Stem steering gear for single rudder, stern steering gear for twin-rudder
31	Hand Pump	Kitchen drinking water, lubrication oil and fuel oil hand-operate feeding	Ø $1\frac{1}{2}$"	6	-
32	Capstan	Hoisting of anchor	Ø 53 chain diameter, 12 m/min, 24KW, vertical type electric-powered capstan three stages speed reducing.	2 units	-
33	Winch Machine	-	5 tons 20 m/min, 19KW vertical type electric-powered three stages speed reducing.	2 units	-

(VIII) INSTALLATION OF SHAFT SYSTEM

The shaft system at the stem is the mono-propeller shaft type. The stern shaft system comprises twin-propeller shafts. The tail shaft at the stem section is drawn inside the ship. The tail shaft at the stern section, for having an "A" bracket, is drawn outside the ship.

The crank shaft of every main engine is directly connected to the thrust shaft, intermediate shaft and propeller shaft. The thrust shaft is equipped with Michell thrust bearings. The propeller shaft is supported by the babbit lining on the tail shaft strut. Black oil lubrication is used in the propeller shaft. In the past, wear and oil leaks occurred frequently in the stern tube seal lubricated by oil. This allowed the attack of vitiated water and sand into the shaft jacket and lining and accelerated wearing of lining. Against this background, the design of the new ship has incorporated some improvements in the structure of tail shaft lining. A front and rear dual plastic ring of formaldehyde methylphenol graphite and a copper ring which rotates with the shaft were used to produce plane friction. Springs were employed to press tight the plane of the rings. This eliminated wear and oil leaking in the shaft system.

Furthermore, the jacket of the shaft and shaft are covered with a layer of oil-proof rudder to offer more protection. This type of structure installed in the three previously built ships has been tested in actual service. So far no oil leaking has occurred. However, a longer time is required for further observation and improvement.

(IX) DECK MACHINERY

On the port and starboard of the forward deck near the stem there are two vertical type electrical capstans. These capstans can also be used to wind the warpping rope during pulling in at the pier. The specifications of the capstan are: weight of anchor 2500 kilograms, diameter of anchor chain 53 millimeters, anchor hoisting speed 12 meters/minute, and electric motor power 24 kilowatts. The motor of the capstan and speed reducing transmission device are installed on a platform under the deck . Only the anchor chain wheel and the capstan appear above the deck.

On the port and starboard of the after deck near the stern there are two electric-powered winches. The machine's specifications are : 5 tons of pull, winding speed 20 meters/minute, power of motor 19 kilowatts. The speed reducing transmission part of the winch is also located under the deck same as arrangement of the capstan.

This ship is equipped with two steering gears, one each at the stem and the stern. It is of a worm and spur gear reducing speed type, electric-powered steering gear. Its maximum torque is 10 ton-meter. The time required to turn the rudder from left 32° to right 32° is twenty-six seconds. The power rate of the motor is 8.5 kilowatts. To insure the reliability of navigation, every steering gear is equipped with two electric motors which can be used simultaneously or singly.

(X) ELECTRICAL EQUIPMENT

The new ship's electric power and lighting are all of direct current. Working voltage is 220 volts. Two generators are regularly used and the third is a spare. Generator voltage is 230 volt 110 kilowatts. It is a compound excitation drip-proof generator, using a magnetic field rheostat to regulate voltage to 220 volts. Hand-carry lights and emergency lighting are all of 24 volts. The master switchboard has four panels: three are power generating control panels (with a partial power load distribution device), the other is a distribution panel.

According to analysis tables of power load in the design, the load on the generator is highest during the operation of pulling in, handling of trains and pulling out at the pier. The balancing water pump requires higher current in starting and is frequently started at the same time with the winch and steering gear. This usually touches off the circuit breaker. To insure safe service of the ship, every ship is equipped with a generator overload intermediate protection device. Overloading of the generator will be released through intermediate relays before the air circuit breaker functions. This insures safe electric supply; its worth has been proved after the ferry went into service.

But there still exists some problems. Because the step-back efficiency of the intermediate protection device is low, a manual step-back is required. If a high step-back coefficient electro-magnetic step-back relay is used with protection type time relay, then the above disadvantage would be removed. According to actual observation during operations, when the number of vehicles was not too large and the loading is slow, only one balancing pump is needed. Under this circumstance, one generator is enough to supply the power needed.

For saving manpower and for convenience of control steering gear, balancing water pump, and cock controls are concentrated on one control panel. The service has been satisfactory.

The telegraph on this ship is of the slide-ring contact type direct current telegraph. Ship's electricity is lowered to 48 volts as the source of power. When the ship's generator is not in use the power is supplied by a 6 volts 175 ampere-hour battery series. The interior telegraph is equipped with transmitting contact slide-ring and receiving synchronizing motor which combines to become a synchronized communication system.

The synchronized transmission of direct current telegraph is functioned by the position of mechanical angle in the resultant magnetic field of armature which makes the rotor turn by the magnetic action in the same direction as the electrode resultant magnetic field. In the armature, three windings are connected in a Y-shape with a 120 degree angle each to the other. The calculation of position of resultant magnetic field can be made by equation of the theory of electricity.

$$Q_F = t_g^{-1} \frac{\frac{\sqrt{3}}{2} I_B - \sqrt{3} I_C}{I_A - I_B - I_C}$$

Where A, B, and C represent three windings and also it is presumed that the angle of center line position of "A" winding is 0° resultant magnetic field. It is also presumed that the angle under other conditions is angle relative to the center line of A winding.

In the above equation:

Q_F is the offset angle between resultant magnetic field and cent r line of "A" winding.

I_A is current of "A" winding.

I_B is current of "B" winding.

I_C is current of "C" winding.

From the above we can see the synchronized transmission of the telegraph. The slightest angular displacement of the transmitting rotor causes the associated rotors to seek synchronous position. This action activates the sound relay and the alarm is sounded until trnasmitting and reply positions are synchronized when the alarm stops.

To insure the power source of electric telegraphs, the power inlet is connected with two-way electric source changeable switch for convenience of selection.

A stop buttom is installed under the bridge telegraph (one each, left and right) for interchangeable service.

(XI) TEST RESULTS

"Chiang-su-hao" was launched on 6 February 1959. The record of the launching is shown in Table 10.

"Chin-ling-hao" took a speed test and maneuvering test in August 1959. Results are set forth below:

1. Speed test.

Speed test was carried out in two operating conditions, three-engine ahead and twin stern engine ahead. Each test was carried out under four different rotation speeds of the main engines in determination of the ship's speed and corresponding shaft horsepower of individual main engine.

The shaft horsepower was determined by the "Maihak" of the Marine Science Research Institute and by the "Semen'sford type torsion meter manufactured by the Institute.

The draft conditions of the ship during the test were:

Draft, Stem	2.705 meters
Draft, stern	3.495 meters
Draft, average	3.1 meters
Corresponding displacement	4385 metric tons

Fig 14 shows the speed-shaft horsepower curves of three-engine propulsion and twin stern engines propulsion. From the figure we can see clearly that under the condition of same speed, three-engine propulsion consumes about 20 percent more horsepower than twin-engine propulsion. This is due to the fact that the stem propeller when rotating drives a heavy flow of water toward and against the bow, thus greatly increasing the consumption of the main engine' horsepower.

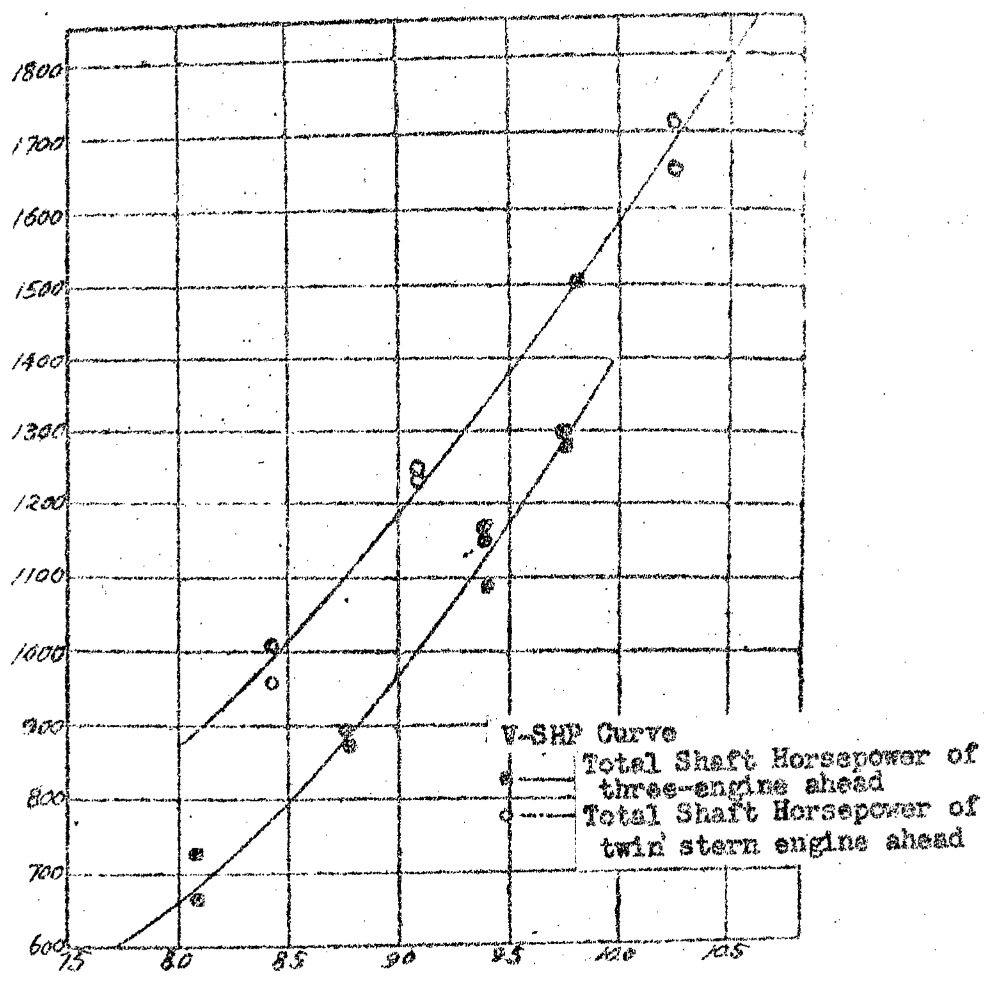


Fig 14 Speed-Shaft Horsepower Curve

Table 10 Record of Launching Of "Chiang-su-hao" Train Ferry

Location of Launching	Our Shipyard's 2nd Shipway	Gradient of the Ship	1/20
Condition of Ballast	653 ton ballast water	Bearing pressure of way end at forward poppet	490 tons
Total Weight of Launching	2209 tons	The bearing pressure intensity at forward poppet	25.93 metric ton/m^2
Slideway	Gradient	1/19	
	Length	173 meters	
	Width	1.050 meters	
	Distance between inner edges	4.8 meters	
Dimension of Slide	2 x 1.050 m x 110.55 m		
Pressure on the Slide	10 ton/meter^2		
Lubricating Condition	Surface of slide poured on with two layers of hard beef tallow 25 m/m, also spread with yellow tallow, and poured over it with grease; surface of slideway poured on with three layers of hard beef tallow 35 m/m, also spread with chopped soap, and poured over it with grease.		
Date of Launching	1300, 6 February 1959	Weather	Rain, rainfall medium
Measurement of Tide	3.8 meters	Range of Slide	140.5 meters

(continued)

Table 10 Continued........

Times During Launching	Range of Slide(m)	10	20	30	40	50	60	70
	Time (sec)	6.5	9.5	12.1	14.3	16.6	18.5	20.7
Launching Speed	Meter/sec	1.59	3.13	3.85	4.55	4.35	5.26	4.55

Range of Slide(m)	80	90	100	On Float
Time (sec)	22.8	24.8	27	33
Launching Speed	4.76	5.00	4.55	-

Draft After Launching Stem 0.8 m, Stern 2.85 m, Amidship 1.77 m

Table 11 Record of Speed Test

No	Propelling Condtion	Speed (knot)	Stern Right Engine Rotation Speed (r/m)	Stern Right Engine Shaft Horse-power	Stern Left Engine Rotation Speed (r/m)	Stern Left Engine Shaft Horse-power
1	Twin Stern Engine Ahead	9.449	319	527	317	562
2			324	541	327	612
3			324	553	321	618
4		8.753	290	392	293	479
5			300	437	293	462
6		8.094	277	341	273	385
7			272	300	260	353
8		9.728	336	614	337	680
9			337	600	335	638
10	Three Engine Ahead	8.416	262	220	266	296
11			264	230	275	376
12		9.084	273	260	285	427
13			271	250	303	487
14		10.252	300	380	307	470
15			315	450	321	570
16		10.484	324	500	330	591
17			320	480	329	640

(continued)

2nd half of Table 11 continued.........

No	Propelling Condition	Stem Main Rotation Speed(r/m)	Engine Shaft Horsepower	Total Shaft Horsepower
1	Twin Stern Engine Ahead	-	-	1089
2		-	-	1153
3		-	-	1171
4		-	-	871
5		-	-	899
6		-	-	726
7		-	-	658
8		-	-	1294
9		-	-	1288
10	Three Engine Ahead	280	435	951
11		277	395	1001
12		320	557	1240
13		304	501	1238
14		330	732	1640
15		330	709	1729
16		330	709	1729
17		324	665	1791

Based on the results from the actual examination of shaft horsepower during the speed test of stem engine, the actual advancing speed derived from the characteristics of open water test of stem propeller is shown in Table 12.

In the table we can see that the stem propeller's av-
erage advancing speed $V_e = 0.537\ V_s$ during three-engine ahead, but the advancing speed taken during the designing of the propeller was $0.75\ V_s$ which was 40 percent too high.

Table 12

Type of Navigation	Recorded Ship Speed V_s (knot)	Recroded Shaft Horsepower SHP	Recorded Turning Speed of Shaft N	Stem Propeller Advancing Speed V_e (knot)	$\frac{V_e}{V_s}$
Stem Engine Ahead	6.27	700	326	4.20	0.670
Three-engine Ahead	9.084	529	300	5.00	0.550
Three-engine Ahead	10.252	715	300	5.50	0.536
Three-engine Ahead	10.484	659	324	5.50	0.525

Fig 15 shows SHP-RPM curves of various main engines during three-engine ahead operation. Because the actual advancing speed is lower, when the stem main engine's turning speed is above 315 revolution/minute, it is operating on an overload condition. And when turning speed is at 330 revolution/minute, the overload reaches about .7 percent.

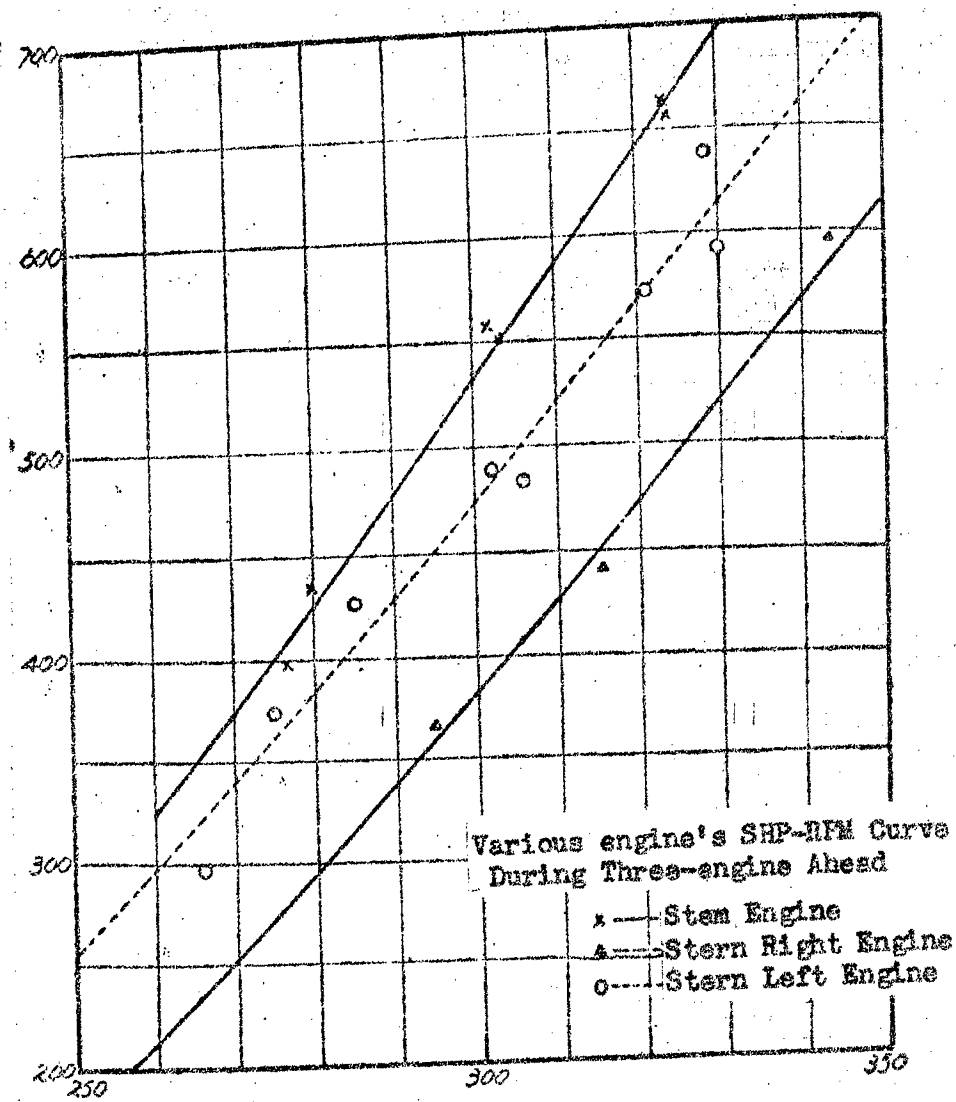


Fig 15 . Shaft Horsepower-Turning Speed Cruves At Three-engine Ahead Operation.

From the SHP-RPM curves (Fig 17) plotted with the results of twin stern engine ahead operation, we can see that there is also an overload when the stern left engine's turning speed is at 320 revolution/minute.

Based on above test results, it is considered that:

(1) During three-engine ahead operation, the stem propeller has little effect on the increasing of speed.

(2) The main purpose of installing stem propulsion system is to improve control during pulling in and pulling out at the pier. Because the ship's speed is low during these operations, if the dimensions of stem propeller were selected based on advancing speed equal to zero, then it could more efficiently bring out the anticipated effect and at the same time eliminate the overload effect of the stem main engine.

(3) Because the design of the stern propeller is based on three-engine ahead operation, therefore, during twin stern engine ahead operation with the stem propeller out of operation the overload phenomenon appears at the stern main engine. If the design of the stern propeller were based on stern engine ahead operation only, then it not only avoids overload but also has the advantageous effect of increasing speed.

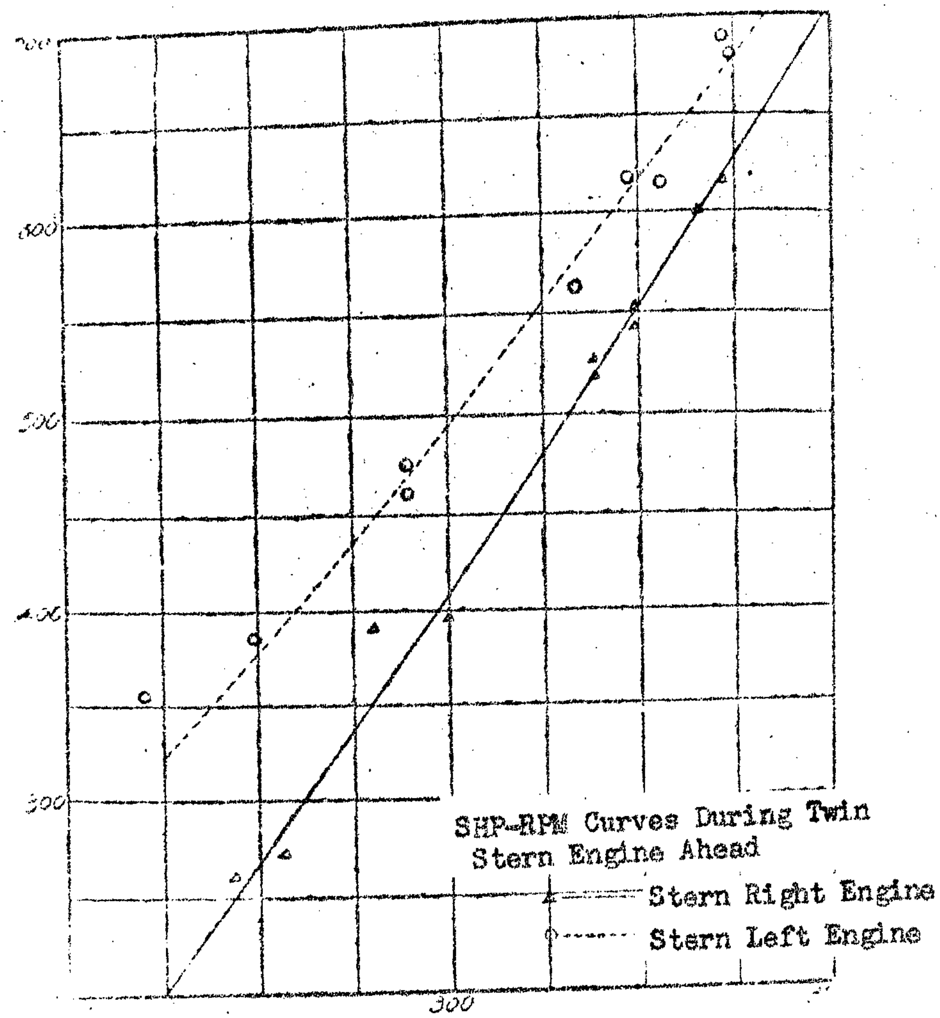


Fig 16 Shaft Horsepower-Turning Speed Curves at
Twin Stern Engine Ahead Operation

2. Maneuvering Test

The method used in the maneuvering test was: In the course of turning, the instantaneous steering courses were recorded at different timings. At the same time the turning speed was determined with viameter. The following equations were used to calculate the coordinates of various instantaneous bearings. Finally, ship's turning track was plotted.

$$x = V \int \cos \theta \cdot dt$$

$$y = V \int \sin \theta \cdot dt$$

Where: V - is the turning speed of the ship;

θ - is instantaneous turning angle;

t - is time of turning.

The ship's draft during maneuvering test was the same as that of speed test. The length of water line was 116.8 meters.

The ratio of area of twin stern rudders to longitudinal mid-section wetting surface was 0.0218. The stem rudder area ratio was 0.0177.

The principal items of test were:

(1) Stern rudders turning during three-engine ahead.

(2) Three-rudder turning during three-engine ahead.

(3) Stern rudders turning during twin stern engine ahead.

(4) Three-rudder turning with stem engine in reverse and stern engines in forward.

Fig 17 shows the positions of rudder angle during three-rudder turning. The records of maneuvering test are shown in Table 13.

Table 13 Records of Maneuvering Test

No	Propulsion and Maneuvering of Rudder	Rudder Angle Stem Left	Rudder Angle Stem Right	Rudder Angle Stern Left	Rudder Angle Stern Right	Speed Before Turning (Knot) V1	Steady Turning Speed (knot) Vo	Steady Turning Diameter (meter) D	D/L	Time Required for Turning 360 Degree
1	Three-engine Twin Stern Rudders Ahead	-	-	-	15°	10.484	6.80	576	4.93	7'-46"
2		-	-	15°	-	"	7.00	604	5.175	8'-55"
3		-	-	-	20°	"	6.04	448	3.84	7'-1"
4		-	-	20°	-	"	6.30	588	5.04	7'-54"
5		-	-	-	25°	"	5.64	428	3.67	6'-56"
6		-	-	25°	-	"	5.92	392	3.36	7'-16"
7		-	-	-	32°	"	5.25	376	3.22	6'-57"
8		-	-	32°	-	"	4.88	344	2.95	7'-8"
9	Three-engine Three-rudder Ahead	-	32°	32°	-	10.484	5.98	364	3.12	7'-21"
10		32°	-	-	32°	"	4.88	388	3.32	8'-10"
11		32°	-	32°	-	"	4.28	320	2.74	6'-56"
12		-	34°	-	35°	"	4.08	320	2.74	7'-5"
13	Twin Stern Engines Twin Stern Rudders Ahead	-	-	15°	-	9.728	5.47	488	4.18	9'-05"
14		-	-	20°	-	9.728	4.85	396	3.39	8'-13"
15		-	-	25°	-	9.728	4.62	364	3.12	7'-42"
16		-	-	32°	-	9.728	3.33	232	1.99	7'-27"
17		-	-	-	32°	9.728	4.16	312	2.67	8'-29"
18	Stem Engine Reverse, Stern Engines Ahead	32°	-	-	32°	9.728	-	196	1.68	8'-12"
19		-	32°	32°	-	9.728	-	217	1.68	7'-29"

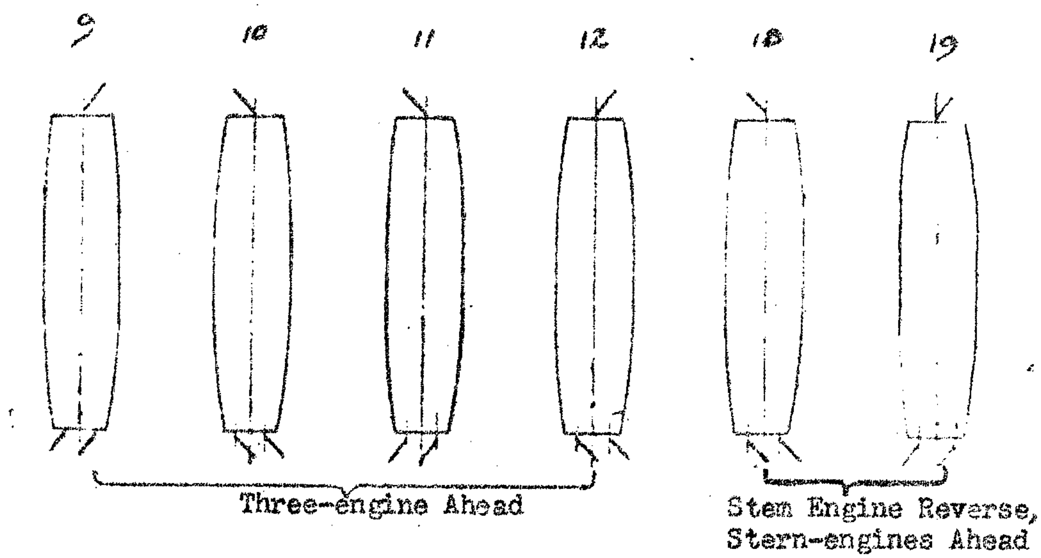


Fig 17 Diagram of Stem and Stern Rudder Angle During Three-engine Turning

Fig 18 shows the track of returning course with maximum rudder angle 32° during various test conditions.

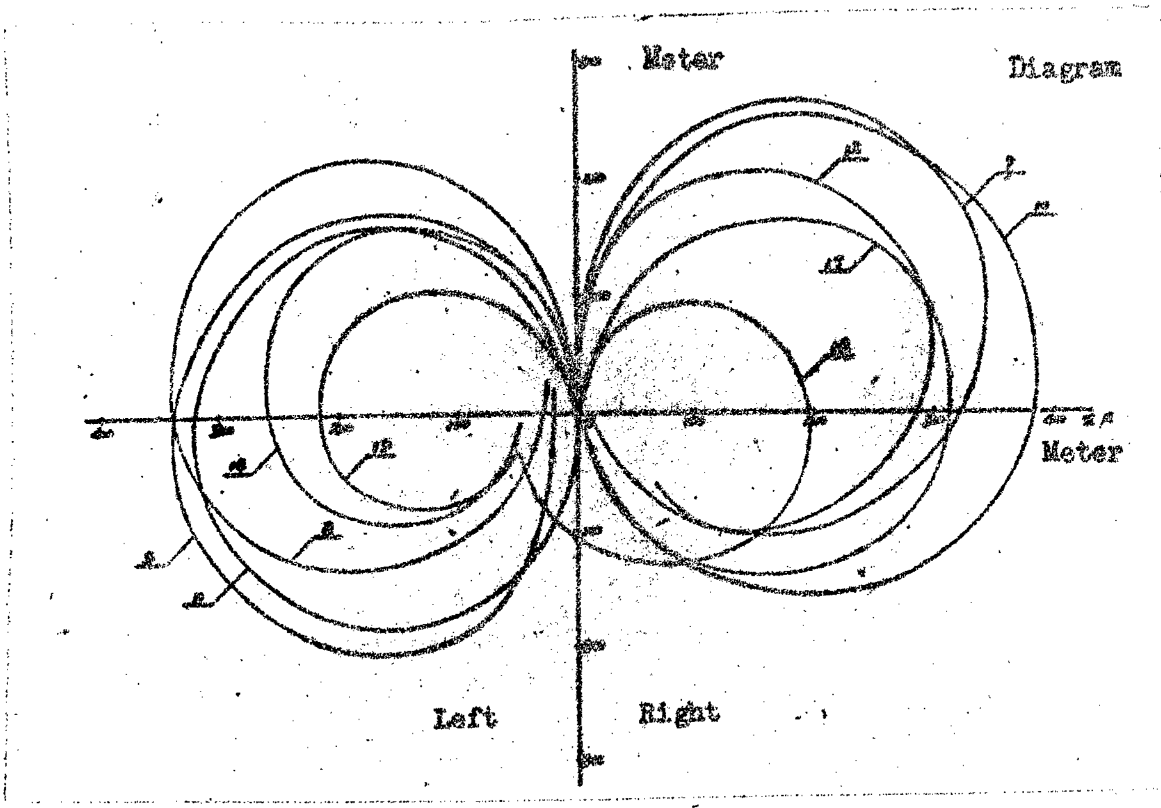
According to test results it can be said that:

(1) when three-rudder operation (18) (19) was used during stern engines forward position and stem engine reverse position, ship's advance and transverse moment were at minimum. Therefore, under this condition the stem rudder has the best effect.

(2) Three-engine three-rudder ahead (11) (12) compared to three-engine twin rudder ahead showed some decrease of turning diameter due to the effect of stem rudder. But the decrease was not too obvious. Under this condition the effect of stem rudder was not too high.

(3) Twin-engine twin stern rudder ahead (16) (17) compared to three-engine twin stern rudders ahead showed

obvious decrease in the turning diameter. This shows that the working of stem propeller during ahead course has bad effect on the control of the ship.



The direction and rudder angle of turning are as follows:

7. Three-engine twin stern rudder, rudder angle 32° right. (continued .....)

8. Three-engine twin stern rudder, rudder angle 32° right.

9. Three-engine three-rudder, rudder angle: stem rudder 32° right, stern rudders 32° left.

10. Three-engine three-rudder, rudder angle: stem rudder 32° left, stern rudders 32° right.

11. Three-engine three-rudder, rudder angle: stem rudder 32° left, stern rudders 32° left.

12. Three-engine three-rudder, rudder angle: stem rudder 34° right, stern rudders 35° right.

16. Twin stern engines twin stern rudders, rudder angle: 32° left.

17. Twin stern engines twin stern rudders, rudder angle: 32° right.

18. Twin stern engines in forward position, stem engine in reverse position, rudder angle: stem rudder 32° left and stern rudders 32° right.

19. Twin stern engines in forward position, stem engine in reverse position, rudder angle: stem rudder 32° right and stern rudders 32° left.

(XII) EXISTING PROBLEMS AND OPINION FOR IMPROVEMENT

1. "Shanghai-hao" was taken as basis for setting the rincipal dimensions of this ship with 8 meters longer in he length of ship as an exception. This was to satisfy he needs of higher vehicle carrying capacity. But more conomic effect can be achieved if more suitable length f ship, speed and higher controlability can be made hrough more study. This is necessary in order to set a etter standard for future work in the design of the same ype of train ferry.

2. Because construction rules and standards of trength were lacking, the construction of these two new erries was based on the requirements for vessels for

sub-speed navigation zone in the "USSR Steel Sea Vessel Construction Regulation" and "Norwegian Steel Sea Vessel Rules" in determining the dimensions of ship's structural parts. And the checking of ship strength was based on sea vessel's standards. Whether these policies are right or not is worth further consideration.

3. The purpose of installing stem propeller was mainly for improving control during pulling in and pulling out at the pier. However, test results showed that the efficiency of the stem propeller was rather low during ahead operation. It even has a bad effect on the control of the ship. It was only during reversing operations that its anticipated effect is shown. In view of the above, if the stem propeller were designed for reverse operation only, then not only could the waste of horsepower be avoided but the controllability of ship cojld also be improved. There are some foreign train ferries in service at present equipped with rotary stem propellers. They have very good controllability and also are economical to operate. These examples are worthwhile to be considered or adopted in the future design of train ferries.

4. The 6350 type diesel engine can be attached with a supercharger of exhaust turbine. The rated power could reach 930 horsepower with the supercharger. During the initial stage of designing the device was first included, but because of the inadequacy of supply and the service department's doublt as to the effect of the device in such a short course, between two river ports, the idea was then abandoned. But according to test results on the operation of the stem engine we think that if the power saved during stand fast of stem main engine in ahead operation could be added to the output of stern main engines, the propeller efficiency and speed would undoubtly be greatly improved. Therefore, if conditions permit, the addition of a supercharger to the stern main engine is worthy of consideration.

5. The selection of dimensions for this ship's rudder post and rate of power of stem steering gear was based on the torque exerted on the stem rudder during ahead operation. But in actual service the stem rudder was not used during ahead operation. And test results also showed low efficiency of stem rudder during ahead operation. Therefore, the selected rate of power of the stem steering gear and dimensions of rudder post exceeded actual needs. In the future the stem rudder design should be improved.

6. The transverse bulkheads of this ship are equipped with five 1000 x 600 electrically controlled water tight doors. The rate of power of electric motor for these doors was 0.60 kilowatts. These doors are opened constantly except in emergency. Therefore, they are seldom used. Considering that this ship is a river ferry, much equipment can be saved if regular mechanically-controlled doors are used instead.

POSTSCRIPT

This ferry was collectively designed by the Technical Department of the Kiangnan Shipyard. Those who participated in the editing and composing of this article also included comrades Ho San-kao, Ku Kuei-lin and Lo Hsiang-yun.

2002

- END -