

# USNS HAYES (T-AGOR 16) U.S. Navy Oceanographic Research Ship

A. T. McCLINTON

*Systems Engineering Staff  
Acoustics Division*

April 7, 1972



**NAVAL RESEARCH LABORATORY**  
**Washington, D.C.**

## CONTENTS

Abstract .....	ii
Problem Status .....	ii
Authorization .....	ii
INTRODUCTION .....	1
SHIP CHARACTERISTICS .....	1
GENERAL ARRANGEMENTS .....	3
SHIP FACILITIES .....	4
Communication System .....	5
Navigation System .....	5
Telephone Systems .....	6
PROJECT EQUIPMENT .....	7
Scientific Handling Gear .....	7
Scientific Communication Equipment .....	9
Scientific Navigation Equipment .....	9
Scientific Bathymetric System .....	10
DR. HARVEY CORNELIUS HAYES .....	11

## ABSTRACT

The USNS *Hayes* (T-AGOR 16), a new acoustic and oceanographic research vessel utilizing a catamaran hull, represents the most advanced design and engineering concepts in the fleet of U.S. oceanographic research vessels. The most distinctive features of the *Hayes* in comparison to AGORs of conventional monohull construction are the large laboratory and open deck area for scientific and project equipment, the large inboard area (center well) for lowering and raising large and/or heavy objects and the greater degree of stability and the centralized machinery control. The T-AGOR 16 was most appropriately named after one of the great scientists of the U.S., Harvey C. Hayes. Dr. Hayes made many contributions to the successful exploitation of sound as a practical method for exploration in the ocean and the detection of underwater objects.

## PROBLEM STATUS

This is a final report on one phase of the problem; work on the other phases is continuing.

## AUTHORIZATION

NRL Problem K03-44  
Project RF 05-552-402

Manuscript submitted November 17, 1971.

**USNS HAYES (T-AGOR 16)**  
**U.S. NAVY OCEANOGRAPHIC RESEARCH SHIP**

**INTRODUCTION**

The USNS *Hayes* (T-AGOR 16), a new acoustic and oceanographic research vessel utilizing a catamaran hull, represents the most advanced design and engineering concepts in the fleet of U.S. oceanographic research vessels. The most distinctive features of the *Hayes* in comparison to AGORs of conventional monohull construction are the large laboratory and open deck area for scientific and project equipment, the large inboard area (center well) for lowering and raising large and/or heavy objects, the greater degree of stability, and the centralized machinery control. The T-AGOR 16 was most appropriately named after one of the great men of the U.S., Harvey C. Hayes. Dr. Hayes made many contributions to the successful exploitation of sound as a practical method for exploration in the ocean and the detection of underwater objects.

The preliminary design of the *Hayes* was completed by M. Rosenblatt & Son, Inc. under the direction of the Naval Ship Engineering Center. The guidance plans, contract drawings, and specifications were completed on Mar. 22, 1968 by Rosenblatt, and a contract for ship construction was awarded Dec. 10, 1968 to the Todd Shipyard Corporation, Seattle, Washington, for \$13,950,000. Delivery was made in July 1971. The construction contract was administered by the project Manager, Oceanographic and Instrumentation Ship Acquisition Office, PMS-391. The Oceanographer of the Navy, who sponsored the *Hayes*, assigned the ship to the Military Sealift Command for operational control and to the Naval Research Laboratory (NRL) for technical direction and funding control as the principal user laboratory.

**SHIP CHARACTERISTICS**

The principal characteristics of the ship are as follows:

a. Hull

	<u>Feet</u>	<u>Inches</u>	<u>Tons</u>
Length design W.L.	220	0	
Length overall	246	5	
Length between perpendiculars	220	0	
Beam, maximum	75	0	
Beam, each hull	24	0	
Distance between hulls	27	0	
Depth at side to main deck amidships (above base line)	34	0	
Draft above bottom of keel at full load	19	2	

	<u>Feet</u>	<u>Inches</u>	<u>Tons</u>
Draft above lowest projection			
below keel at full load	21	8.5	
Height of main mast above			
DWL	104	0	
Height of Twinmast above			
DWL	104	0	
DWL	18	6	
Displacement, full load			3180
Potable water, full load			31
Diesel oil			368
Lubricating oil			10

## b. Machinery

Number of propulsion shafts			2
Design full power ahead, main propulsion, BHP			5400
Auxiliary propulsion, BHP			330
Design full power ahead, shaft rpm			139
Endurance (13.5 knots), miles			6000
Speed, sustained knots (at 80% power and			
100% torque)			15
Creep speed knots (auxiliary propulsion)			2-4

## c. Electrical

Ship's service diesel generators, 3, each rated 450 V, 3 phase, 60 Hz, 350 kW  
 Scientific diesel generators, 2, each rated 450 V, 3 phase, 60 Hz, 75 kW  
 Emergency diesel generator, 1, rated 450 V, 3 phase, 60 Hz, 75 kW

d. Habitability: Living, messing, sanitary, and recreation facilities are provided for the following personnel:

Officers (11)

1 Master  
 1 1st Officer  
 1 2nd Officer  
 1 3rd Officer  
 1 Radio Officer  
 1 Chief Engineer  
 1 1st Assistant Engineer  
 1 2nd Assistant Engineer  
 1 3rd Assistant Engineer  
 1 Purser  
 1 Chief Steward

Crew (34)

- 1 Deck Engineer-Machinist
- 1 Chief Electrician
- 1 Chief Cook
- 1 Yeoman-Storekeeper
- 6 Able Seamen
- 3 Ordinary Seamen
- 2 Engine-Utilitymen
- 6 Oilers
- 2 Wipers
- 1 Cook-Baker
- 1 2nd Cook
- 4 Messmen
- 5 Utilitymen

The ship will also furnish quarters for 1 Chief Scientist and 24 Scientists. There are five emergency berths.

**GENERAL ARRANGEMENTS**

The general configuration of the *Hayes* is shown in the several views, Figs. 1a, 1b, and 1c, taken during the preliminary acceptance trials on July 7, 1971. The general arrangement provides a forward and after centerbody construction, ample deck space for U-frames and cranes to suspend objects overboard, scientific deck machinery in enclosed areas, adequate masts for antenna locations, and twin screws for maneuverability. The U-frames, cranes, and other scientific handling gear were not provided as part of the shipbuilder's contract. These will be installed later.

The forward and after centerbody structures, Fig. 2, are compatible with an arrangement which represents a major improvement over earlier ships. The after superstructure houses the scientific laboratories, research control center, computer and data processing spaces, calibration and instrument test facilities, scientific refrigeration equipment, and the scientists' radio facility. Large stowage areas for scientific equipment are located in the two hulls directly below. The forward superstructure houses the ship control and living spaces. This arrangement separates completely the scientific spaces from the machinery and living spaces.

The center well is expected to become a significant and worthwhile feature of this ship in the NRL program. Past experiences of NRL with the USS *Hunting*, a converted LST, the USNS *Mizar*, a converted cargo ship, and the USNS *Mission Capistrano* have all shown the advantages of wells located near the center of pitch and roll for suspending arrays and for towing operations. Although the "well" on the *Hayes* is open fore and aft, it will provide a significant advantage to over-the-side work.

In addition to the large center well, three 30-in.-diameter wells are provided for general-purpose work involving smaller instrumentation. One of these wells is located in the port hull ahead of the forward centerbody structure, and the other two are located approximately midships, one in each hull. Because of their relative locations they can be used for an underwater tracking system.

The features described above may be seen in detail on the general arrangement drawings presented in Figs. 3a through 3k. The locations of the instrumentation wells are shown on Fig. 4.

## SHIP FACILITIES

The *Hayes* is not only a unique oceanographic vessel because of hull configuration and the large ratio of designated scientific space to total ship space, but also is unique in ship propulsion and maneuverability, the degree of automation of ship operation, and ship facilities. Automation of ship operation is provided through the ship control console (at four control stations) and at the central machinery control. The latter is provided in the Engineering Operating Station (EOS) which contains switchboards for the ship's service and scientific generators and for electric power distribution, essential lighting load center, the main control console, an alarm and data logger, bell logger, and numerous other machinery and valve remote controls, alarms, system status displays, and indicators. The EOS is designed for one licensed watch stander and completely unmanned machinery spaces. Two views of the control console in the EOS are shown in Figs. 5a and 5b. It is located on the main deck, astride the cross-structure in the aftermost space of the forward deckhouse. On the main control console, equipment is provided for remote selection, starting, speed control, and stopping of the propulsion engines. Provision is made for remote transfer of tankage among the other engineering functions that are also included, and for remote starting, paralleling, and stopping of diesel generators.

The machinery control system provides for remote control of the propulsion machinery for ship speed and direction from the ship control consoles in the pilot house, both bridge wings, and the auxiliary ship control station starboard hull aft. A view of the control station in the bridge is shown in Fig. 6. For ship speed, these controls and a similar control on the main console in the EOS are single level, programmed for automatic matching of propeller pitch and rpm relationships. This automatic control is supplemented by remotely operated manual controls on the EOS main console for the separate control of propeller pitch and/or rpm.

The monitoring and display of machinery plant management information is accomplished in a General Electric Data Center which is contiguous with the EOS main control console. The most important operating data are displayed continuously; for example, propeller rpm and pitch, diesel cooling water and combined cylinder exhaust temperatures, etc. Individual engine cylinder temperatures, line shaft bearing temperatures, boiler feed salinity, and boiler service tank level typify the data available by dialing the desired quantity.

There are two machinery plants, one in each hull, each of which contains an EMD-20-645E5, 2700-BHP main propulsion diesel and a GM 67-1, 165-BHP auxiliary propulsion diesel, driving a LIPS reversible pitch propeller through a reduction gear. A disconnect clutch is provided between each engine and the reduction gear, interlocked to preclude simultaneous engagement of the main and auxiliary engines. The main propulsion design will provide a 15-knot sustained speed and 6000 mi. at 13.5 knots endurance speed. Usage of the auxiliary propulsion engines is for a 2- to 4-knot creep speed only. In addition to the usual auxiliaries, the plant provides 450-V, 3-phase, 60-Hz electric power from three 350-kW ship's service, two 75-kW scientific diesel generators, and one 75-kW emergency generator. Interconnection of these generators and distribution to the load centers is illustrated on the power system one-line diagram of Figs. 7a and 7b.

Brief summaries of characteristics of the ship communication, navigation, and telephone systems are presented in the following sections.

### Communication System

1. Marine Radio — MRU 29A/30A: This is the ship's main and reserve transmitter and receiver system for radio telegraph (A-1, A-2); the frequency range is 400 to 535 kHz at 500 W on main transmission power and at 40 W on emergency power. This system provides for an automatic alarm and an automatic alarm signal keyer as well as control facilities for the direction finder and is expected to provide communications under all conditions.
2. RF Communications — RF 201M: This is a single-sideband radiotelephone in the 2- to 24-MHz marine service band. Transmit power rating is 150 W. The unit is capable of upper sideband, fully suppressed carrier (A3J) and compatible AM (A3H) transmission-reception. It has the capability for 30 crystal-controlled channels.
3. Collins MR201 Marine Radiotelephone, FM 156- to 162-MHz international vhf marine band: This provides simplex or duplex FM communications on 31 channels in maritime vhf band. Output power is 20 W.
4. Mackay 4004A Direction Finder: This system utilizes a fixed-loop sense antenna and a separate superheterodyne receiver indicator with a built-in goniometer. Relative bearing and true bearing scales are available. Tuning is manual over the frequency range of 200 to 525 kHz.
5. Gifft GFR-2 Facsimile Recorder: Provides the permanent recording system for weather charts and other navigational data as broadcast. It features automatic start/stop, and automatic and manual phasing. It will receive AF shift modulation from 1500 to 2300 Hz and also AM modulated signals and direct-coupled video from other demodulators.

### Navigation System

1. Sperry Mk 23 Model C3 Gyrocompass: The most significant characteristics of the gyrocompass are a heading accuracy  $\pm 0.75^\circ$ , drift rate  $\pm 0.25^\circ$  per hour, and  $45^\circ$  roll and pitch clearance. Provision is included for automatic latitude and speed correction, and for 1- and 36-speed synchro output (400 Hz).
2. Radiomarine Corp CRM-N2C-30 Radar, 10 cm, 3000 MHz, S band: The radar display is a 16-in. CR indicator, with range scales from 1/2 to 40 naut mi. Range accuracy is within 2% of range scale and resolution is 20 yd on shorter range scales. Peak transmit power is 30 kW.
3. Sperry Model 1 Loran A/C: This unit receives either Loran A signals or Loran C signals. It provides visual matching for Loran A and C and electronics (meter) matching for Loran C. Readout is by time delay dials. Loran A range is 600 to 900 mi in the day-time and 1200 mi at night but with decreased accuracy. Loran C provides longer range in coverage areas (up to 3000 mi under ideal conditions).

4. Chesapeake Instrumentation Corporation UL-100 Electromagnetic Log: This system, consisting of indicator transmitter and a rodmeter (sensor) provides indicated speed from  $-9$  to  $+30$  knots. Ship speed is displayed to  $\pm 0.1$ -knot resolution. The distance traveled is obtained from an integrator using a crystal-controlled oscillator as a time base. Distance is displayed in increments of 0.01 naut mi. Expected speed accuracy is  $\pm 0.1$  knot below 10 knots and 1% above 10 knots, and distance range accuracy is 1% of distance traveled. Remote readouts are provided in the research control center, electronics laboratory, main recording laboratory and on the bridge.

5. Bendix type F/60 Windspeed Indicator: The anemometer mounted on the ship's main mast will provide measurement of windspeed to 60 knots with  $\pm 1$ -knot accuracy and from 60 to 100 knots with  $\pm 2.5$ -knot accuracy. Direction accuracy above 5 knots is  $\pm 2^\circ$ . Remote indicators are provided in the research control center, electronics laboratory, main recording laboratory, on the bridge, and in the engineers operation station.

6. Raytheon DE 714/7 Fathometer: The transducer is mounted in the sonar dome starboard hull. This is a 25-kHz barium titanate unit with approximately a  $30^\circ$  beam. The system range scales cover depths to 780 fathoms in six increments.

7. Sperry Course Recorder: This device uses a step-by-step motor and chart paper feed roller that is clock controlled. The recorder writes an accurate continuous record of course on strip chart using the electrical signal from the master gyrocompass. A visual indicator readout is provided also.

### Telephone Systems

An automatic dial telephone system and a sound-powered telephone system are provided for interior communication. The dial telephone system (Hose McCann) provides a means of communication between stations in the ship, and between the ship and shore systems, on a fully selective basis under the direct control of the calling stations. Selection of the called line station is effected through a central automatic switchboard. Provisions are made for executive cut-in, conference feature, and selective high-power intercommunication facilities.

Telephone facilities are provided at the computer room, scientific radio room, all laboratories, electronics shops, IC and gyro room, quarterdeck (port and starboard), personnel dayrooms, engineering operating station, scientist's office and library, gravity meter room, ship's radio room, pilot house, chief scientist's stateroom and office, one other scientist's stateroom, master's office, officers' and scientists' lounge, scientists' and officers' messroom, and research control center. An executive cut-in feature is provided in the pilot house, EOS, main recording laboratory, and chief scientist's stateroom and office. Provisions are made for extension capability via phone jacks to the telephones at the research control center, main recording laboratory, and electronics laboratory. A weatherproof jack is provided in the van area and in the forward-anchor winch-control console.

Direct shore lines are provided at dockside to the master's stateroom and office, chief scientist's stateroom and office, chief engineer's stateroom and office, and quarterdeck (port and starboard).

Selective high-power intercommunication facilities include local transistorized power amplifier-speaker units at selected locations as an optional receiver and linked together with other stations in a conference system. Telephone sets with selective high-power intercommunication facilities are provided at all winch-control stations and winch rooms, crane cab 01 level, crane cab 02 level, main recording laboratory, mechanical engineering shop, electronics laboratory, and stern U-frame area. In addition, six local loudspeaker amplifiers are provided with a nominal 2-W output at the speaker for use at the option of the operator for the following stations: research control center, main recording laboratory, electronics laboratory, and wet laboratory.

The scientific radio room station can provide remote radio facilities via phone patch on the dial telephone system.

The sound-powered telephone system provides for the essential ship communication and includes ship operation circuits, engineers' circuits, damage control circuits, radio and signal circuits, and dumbwaiter circuit. The latter provides communication between the demolition charge magazine on the first platform and the ready service room on the main deck.

## PROJECT EQUIPMENT

The spaces and deck areas on the *Hayes* reserved for project purposes have been assigned for specific functional uses such as electrical, mechanical, biology, chemistry, data processing, communications, machinery, and storage. A review of the compartment arrangement drawings presented in Fig. 3 will reveal the relative location, size, and general arrangement within these designated areas. To allow for the greatest flexibility these spaces are provided with certain standard pieces of equipment, power, and interlab communication; and decks are fitted with tie-downs to secure transient equipment. There are several types of systems which are required as a part of most scientific experiments, and these are being supplied as permanent onboard project equipment. The general characteristics of these systems are described in the paragraphs to follow.

### Scientific Handling Gear

The scientific handling gear consists of five major winch systems, four U-frames, two cranes, a deep-sea anchor system, and several smaller winch systems. (The procurement of these items of equipment was separate from the shipbuilding contract, and they are scheduled for delivery and installation in calendar year 1972.) A summary of the principal characteristics of each major component is as follows:

1. Deep-sea winch system, forward. Traction Unit: Line pull 15,000 lb at 270 ft/min to 50,000 lb at 80 ft/min, 3000 lb maximum back tension, 36-in.-diameter drums, grooved for cable sizes up to 1-1/4 in.

Dual Drum Stowage Unit: Two barrels each 24-in. in diameter by 76 in. long, flange 75 in. in diameter. Level wind 1/4 to 1-1/4-in.-diameter cable. Continuity device for electric cable. Line pull 3000 lb maximum.

2. Deep-sea winch system, aft. Traction Unit: Line pull 15,000 lb at 270 ft/min to 50,000 lb at 80 ft/min, 3000 lb maximum back tension, 36-in.-diameter drums, grooved for cable sizes up to 1-1/4 in.

Dual Drum Stowage Unit: Two barrels, each 24 in. in diameter by 76-in. long, flange 75-in. in diameter. Level wind 1/4 to 1-1/4-in.-diameter cable. Continuity device for electric cable. Line pull 3000 lb maximum.

Single Drum Stowage Unit: One barrel 24 in. in diameter by 76 in. long, flange 75 in. in diameter. Level wind 1/4 to 1-1/4-in.-diameter cable. Continuity device for electric cable. 3000 lb maximum tension.

3. Intermediate winch system, one each forward, midship and aft. Dual Drum Units: Line pull 5000 lb at 500 ft/min to 20,000 lb at 125 ft/min. Two barrels, each 18-in. in diameter by 36 in. long, flange 54 in. Level wind 1/4 to 1-1/4-in.-diameter cable. Continuity device for electric cable.

4. Deep-sea anchor windlass, forward, Windlass: Pay out under control 1000-lb anchor and 860 fathoms of 3/4-in. stud link chain at speeds up to 17 fathoms per min and hoist the same at speeds up to 8.5 fathoms per min.

Chain: 3/4-in.-diameter, steel, high-strength stud link, 67,960-lb breaking strength, in lengths of 1 to 60 ft, 10 to 500 ft and 1 to 160 ft.

5. U-Frames. Bow: Will support 50,000-lb line pull while in outer stop and will transit with 15,000-lb line pull. Transit time stop to stop is 3 min.

Stern: Will support 50,000-lb line pull while in outer stop and will transit with 15,000-lb line pull. Transit time stop to stop 30 sec. Width 10 ft at base, 8 ft at top, height 16 ft, outboard reach 6 ft.

Starboard, Forward, and Midships: Will support 20,000-lb line pull while in outer stop and will transit with 10,000-lb line pull. Transit time stop to stop 30 sec. Width 10 ft at base, 8 ft at top, height 16 ft, outboard reach 6 ft.

Platforms installed at the stern and starboard U-frames can be rotated outboard to a horizontal position, providing easier access to overboard lines.

6. Cranes, one each midships and stern. Lift is 50,000 lb at 15 ft radius to 8000 lb at 60 ft radius. Boom can support 50,000 lb with outer end set in a support. Angular rotation is 370° and topping range is 70°.

The midshipscrane boom is provided with a rest giving a capability to support a 50,000-lb load over a sheave suspended from the boom. This serves the opening in the midships' cross structure. The clear opening without doors is 14.5 ft by 36 ft and with doors in place and open is 14.5 ft by 32 ft. The doors can support a load of 360 lb per square foot.

The stern crane is provided a rest midships from which the crane can support a 50,000-lb load over a sheave suspended from the boom.

The traction unit or intermediate winch on the 02 level serves either of these cranes. In addition the cranes each have the normal winch and control arrangement, and can serve the decks and hatches in the area aft of frame 52.

7. Line metering: Instrumentation to monitor line tension speed and quantity out will be provided for each of the five winch units.

The locations of these systems and the fairleading arrangements from each winch system to U-frame or crane are illustrated on Figs. 8a and 8b. The principal location for deep-sea anchoring will be forward, using the deep-sea anchor windlass and the deep-sea winch system. Stern anchoring will be possible using the crane or U-frame and deep-sea winch system.

Provision is made for interconnecting the winch rooms, deck areas, bridge, and aft mast platform with the laboratory areas. Installed cables include shielded twisted pair, coaxial lines, and closed-circuit TV cable.

Sliprings will be provided on all winch drums to permit both power transmission to transducers and the reception of low-level signals from undersea sensors.

### Scientific Communication Equipment

Communication equipment is provided specifically for scientific purposes including data transmission as well as voice, separately or concurrently. Primary equipment consists of two identical high-frequency transmitter systems (RF Communications, RF 130) individually made up as follows:

RF 131 — Dual-channel synthesized exciter tunable in 100-Hz increments.

Modes: USB, LSB, ISB, AME, CW, RATT

RF 110 — RF amplifier, 1-kW PEP output

RF 112 — Power supply

RF 601 — Automatic antenna coupler and control system

Complementing these transmitters are two high-stability, fully digitized receivers covering the 2- to 30-MHz range (RF 505). Short-range communication is provided by a 30- to 40-MHz FM transceiver (Motorola Type LG). In addition, one UG-169 Teletype System will be provided in conjunction with (RF 2069) FSK terminal equipment.

A standard underwater telephone (Ametek ATM-504A) is provided with control in the research control center. This unit is intended for voice communication and cw operation between ship and submersibles. The expected range is up to 20,000 yd. The system can be expanded to transmit and receive data, and function as a transponder, ranging interrogator, pinger, and echo sounder. Transducers are provided for both 360° horizontal and vertical coverage and are mounted in the sonar dome, starboard hull.

### Scientific Navigation Equipment

Navigation equipment provided for scientific experiments is located in the research control center and consists of a Loran C receiver, a satellite navigation system, an X-band radar, and a dead-reckoning tracer. The satellite navigation system has an integral computer.

**Decca 629 True Motion:** The radar is a 3-cm-wavelength, high-resolution device configured to provide a relative or true motion plot. Tracking speed accuracy is better than  $\pm 5\%$  of indicated speed from log, and tracking course accuracy is to be better than  $\pm 2^\circ$  of indicated course. Inputs from the ship's gyrocompass and electromagnetic (EM) log are supplied for the true motion plot. The system provides a range discrimination of 10 yd on a 0.5-naut-mi range scale and has an accuracy of  $\pm 1\%$  of range scale or  $\pm 50$  yd, whichever is greater. The maximum range scale is 50 naut mi. An accessory to the radar permits manual scanning or automatic sector scanning of  $5^\circ$ ,  $10^\circ$ , or  $15^\circ$  sectors. This feature increases the target scan rate, and thus will be useful in buoy or other small-target tracking.

**Dead Reckoning Analyzer Indicator (DRAI), Mk 9 Model 4, and Dead Reckoning Tracer, Mk 6 Model 4B,** accept gyrocompass and underwater log inputs to provide a track of ship movement. Precision navigation over the bottom or tracking of underwater vehicles and bodies is to be accommodated by use of the three instrument wells, two in the port hull and one in the starboard hull (see Fig. 4). These three instrument wells are provided for future installation of hydrophones to be used in a three-dimensional tracking system. These can be used for navigation relative to bottom-mounted transponder and beacons or in tracking underwater devices carrying a sound source. The output from each or all of these navigation equipment(s) can be supplied to an onboard computer to develop precise up-to-date ship position coordinates or to provide ship control data.

**Loran A/C (Decca type ADL 21(M))** features automatic tracking on mode C visual digital readout, and output for computer processing.

A Satellite Navigation System with integral computer (Magnavox 706C) provides visual readings directly in latitude and longitude. Provision for hard copy printout is an option.

### **Scientific Bathymetric System**

The bathymetric equipment consists of a narrow-beam bathymetric system, a bottom-subbottom profiling system, and two precision depth recorders. The transducers for these systems are mounted in the sonar housing starboard hull at approximately frames 30 to 35. A summary of the salient features of this equipment is as follows:

1. **EDO-313 Narrow-Beam Bathymetric System:** Transducer — 16 kHz (Edo 202),  $6.5^\circ$  beam width, 34-in. face diameter, source level approximately 130 dB, receiving sensitivity approximately  $-84$  dB. Platform is mechanically stabilized for roll and pitch. Electronics will consist of a 2-kW transceiver, a digital signal conversion unit and display, and a system control.

2. **Bottom-Subbottom Profiling System:** Transducer — 3.5 kHz (Edo 240H),  $30^\circ$  beamwidth, 35-in. diameter, receiving sensitivity approximately  $-84$  dB. Electronics — 2-kW transceiver, 8-kW amplifier, and system control (Edo 248B).

Provision is made to install or remove transducers from inside the ship by pressurizing the sonar transducer room and a separate escape passage.

**DR. HARVEY CORNELIUS HAYES**

Dr. Hayes

Harvey Cornelius Hayes was born in North Fenton, New York, near Binghamton, on November 2, 1877, the son of William Henry and Edith Marion Hayes. His formal education was completed at Harvard University, where he received degrees of A.B. in 1907, A.M. in 1908, and Ph.D. in 1911. He was an assistant in physics from 1908 to 1911, and an instructor at Harvard from 1911 to 1913. In 1913 he went to Swarthmore College as a professor of physics and remained there for five years. His fields of contribution other than sound were principally cooling curves, magnetic susceptibility of water, rate flowmeters, sap flow, sap pressure, and oil prospecting.

During World War I Dr. Hayes, in association with other outstanding physicists, attacked the problem of detecting and locating enemy submarines. His effort was devoted to developing a listening device suitable for detecting, locating, and tracking. At the end of World War I, Dr.

Hayes remained with the Navy to continue work on the problem of detection and location of submarines. The sonic depth finder was a product of this period, and the MV hydrophone, using the same principle of beam steering as German World War II equipment, was completed.

In April 1923 he came to the new Naval Research Laboratory as Superintendent of the Sound Division where he initiated research on active sonar. Success in development of active sonar did not reduce Dr. Hayes' appreciation of passive detection. After 1928, further research on passive detection led to the development of a listening hydrophone using Rochelle salt as the active transducing element. This type permitted operation over a broad frequency band. By 1932, the combination of listening and echo-ranging equipment was available to the Navy. The optimum utilization was passive detection and active attack.

The next logical step forward was to use Rochelle salt transducers for transmission as well as reception. Research determined the conditions and restrictions under which the Rochelle salt crystals would deliver acoustic power, and a decided gain was achieved in replacing quartz by Rochelle salt transducers. The so-called QB equipment developed at NRL on the eve of World War II was one of two standard equipments. This provided both passive and active operation and incorporated "unicontrol" for tuning both transmitter and receiver with a single knob.

At the start of World War II, Dr. Hayes devoted a portion of his time to two tactical problems. One problem led to the techniques for using the variable QB beamwidth to advantage for both search and attack. He also analyzed the mediocre success of antisubmarine warfare in terms of the detection and attack factors. At that time the attack factor offered the better chance of immediate improvement. He therefore calculated escape areas and studied attack courses.

Late in World War II, Dr. Hayes undertook the development of attack equipment utilizing many techniques, both mechanical and electronic, developed by NRL during the war. This formed the basis of experimental fleet equipment.

Dr. Hayes led the Sound Division of NRL into the development of improved sonar domes and dome material, improved transducer designs, and techniques of localizing the target beyond the resolution of the sonar beam. Harbor defense sonar and mine location sonar were important developments. It was he who first recognized the potentiality of the helicopter and blimp in ASW, and the Sound Division developed the first sonar equipment for these vehicles.

Throughout the history of the Sound Division under Dr. Hayes, a substantial and continuing contribution was made in studies of ocean characteristics. Before 1940, the Laboratory had measured temperature changes with depth and had analyzed their importance in the refraction of sound. It had gone beyond this by correlating these conditions with the past history of cloudiness, wind velocity, sea state, and air temperature. It had delved into the calculation of sound velocity as a function of temperature, pressure, and salinity and had constructed sound ray diagrams for various ocean conditions. Dr. Hayes had cruised around the world mapping the ocean bottom. During and shortly after the war, additional work was carried out on surface and bottom reflections. Wave theory was applied to the propagation of low-frequency sound in shallow channels and experimental corroboration was obtained.

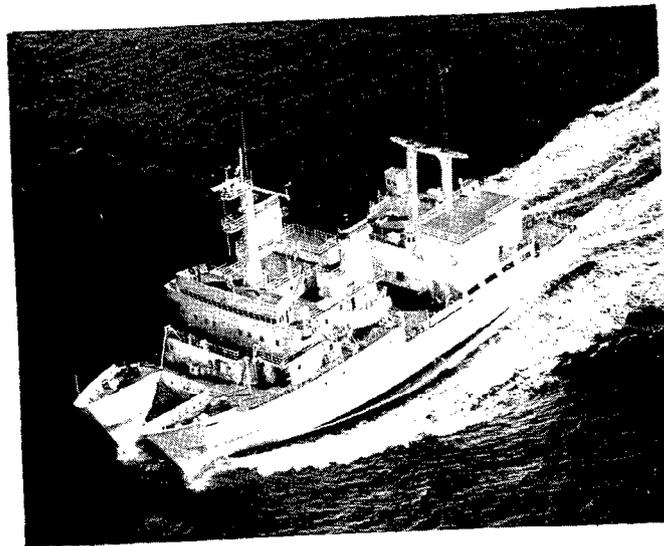
Dr. Hayes had been a Fellow in the American Physical Society, and a member of the Washington Academy of Science, the Geophysical Union, the Philosophical Society of Washington, and the Cosmos Club. He was a member of Phi Beta Kappa. Also, he was a recipient of the Levy gold medal and of the John Scott medal, both from the Franklin Institute, and the Cullom geographical medal from the American Geographical Society.

One of the greatest tributes to the contributions of Dr. Hayes and his colleagues was contained in a recovered order by Karl Doenitz, Grand Admiral of the German Navy, which is quoted in part:

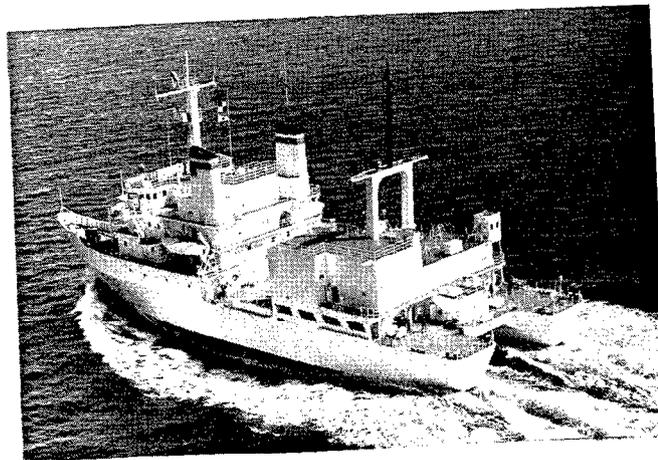
“For some months past, the enemy has rendered the U-boat ineffective. He has achieved this objective, not through superior tactics or strategy, but through his superiority in the field of science; this finds its expression in the modern battle weapon — detection. By this means he has torn our sole offensive weapon in the war against the Anglo-Saxons from our hands.”

In 1945, Secretary of the Navy, James Forrestal, bestowed on Dr. Hayes the highest civilian award, the Distinguished Civilian Service Award, for his outstanding service to the United States Navy.

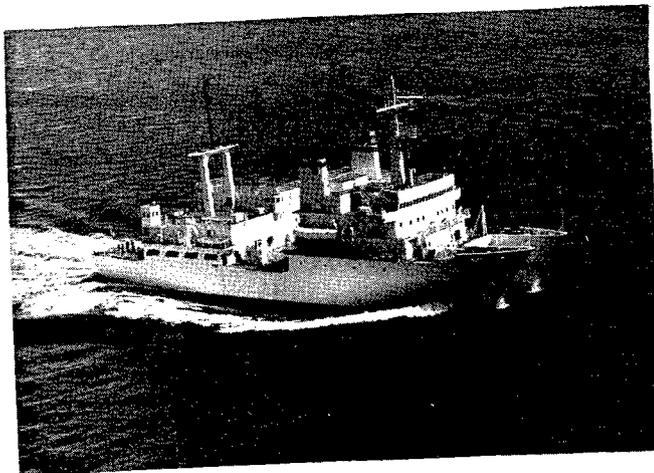
Dr. Hayes died on July 9, 1968.



(a)



(b)



(c)

Fig. 1 - USNS *Hayes* (T-AGOR 16)

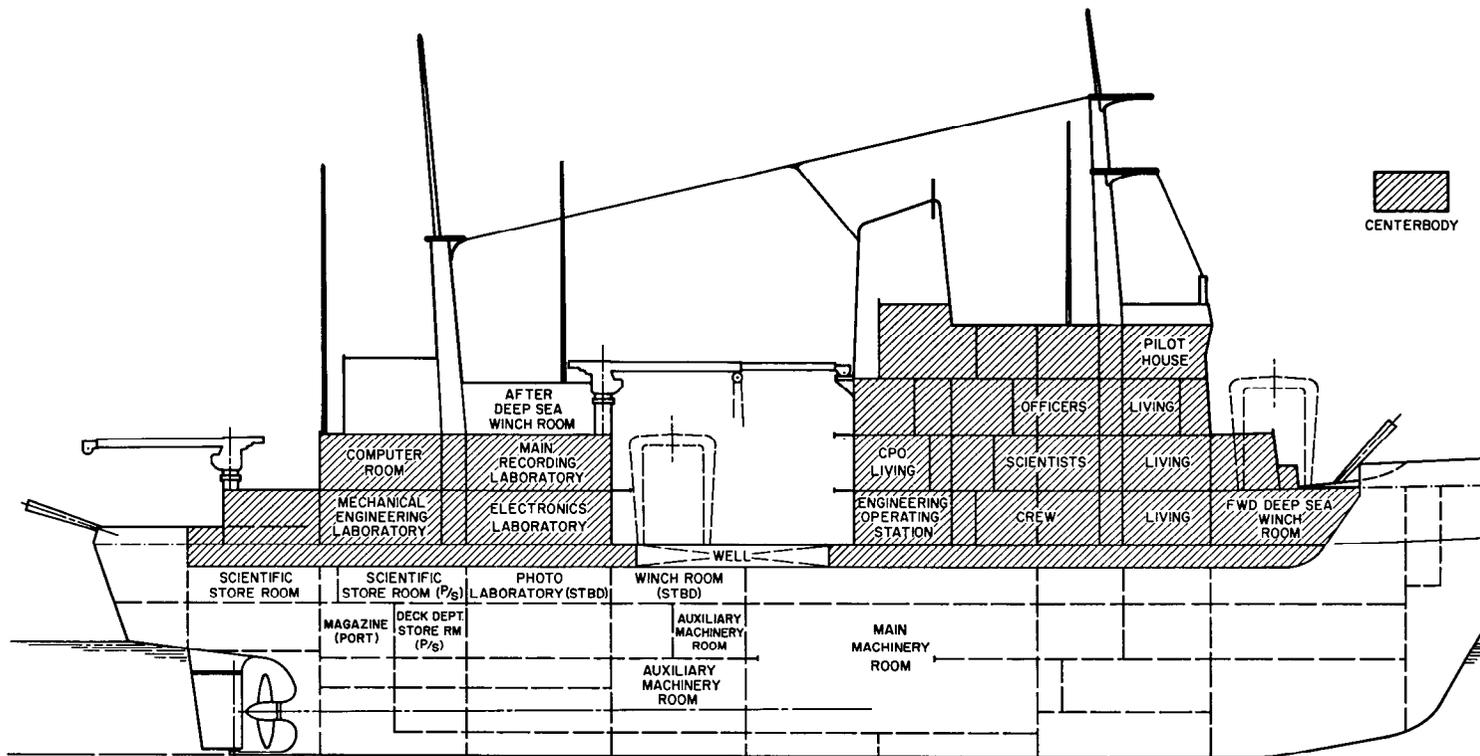
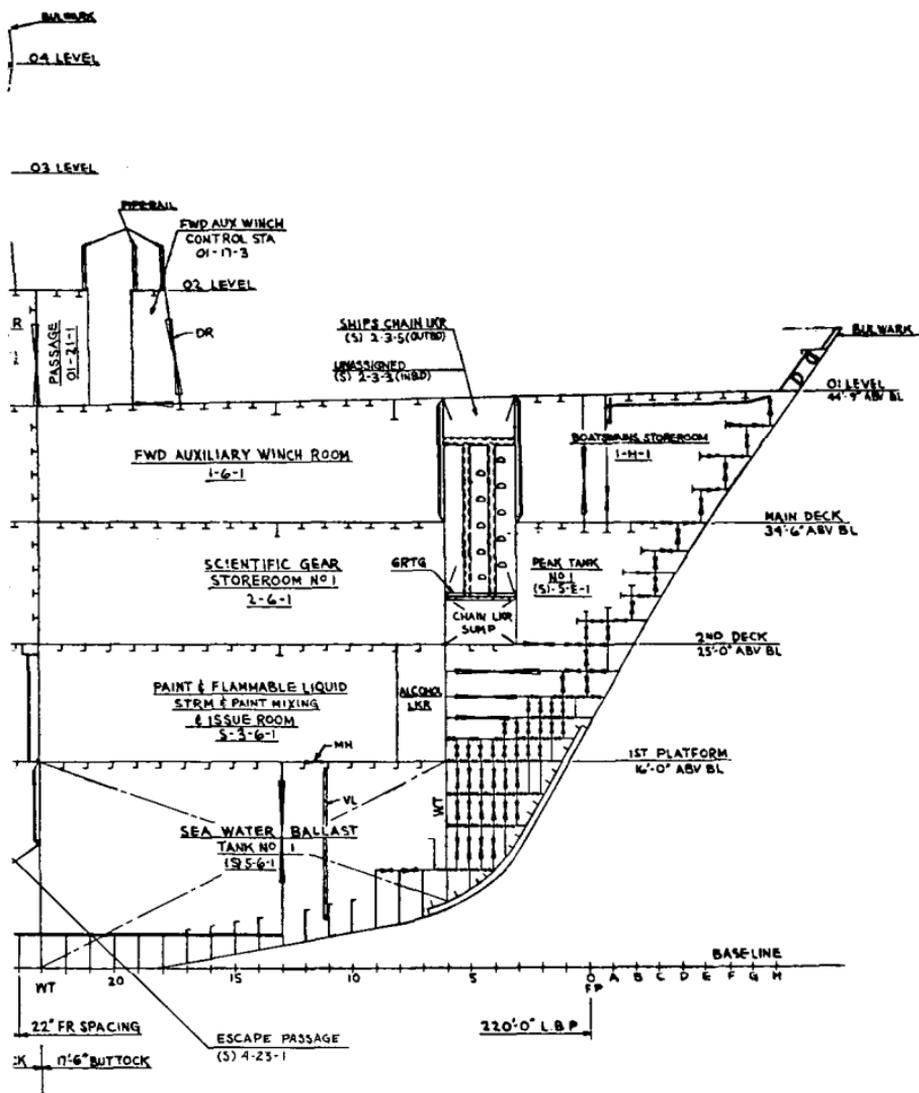
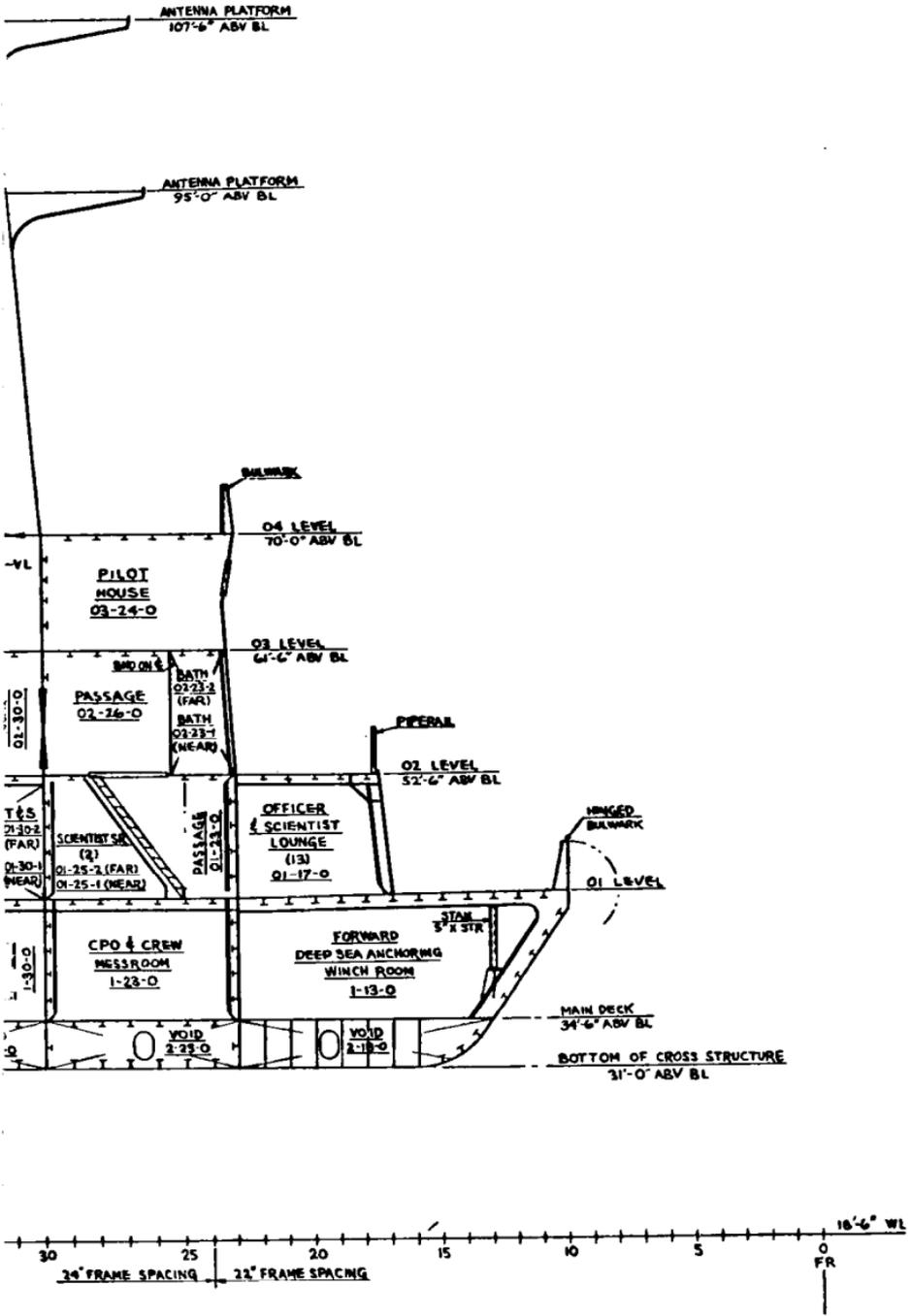


Fig. 2 — General arrangement of scientific and ship facilities









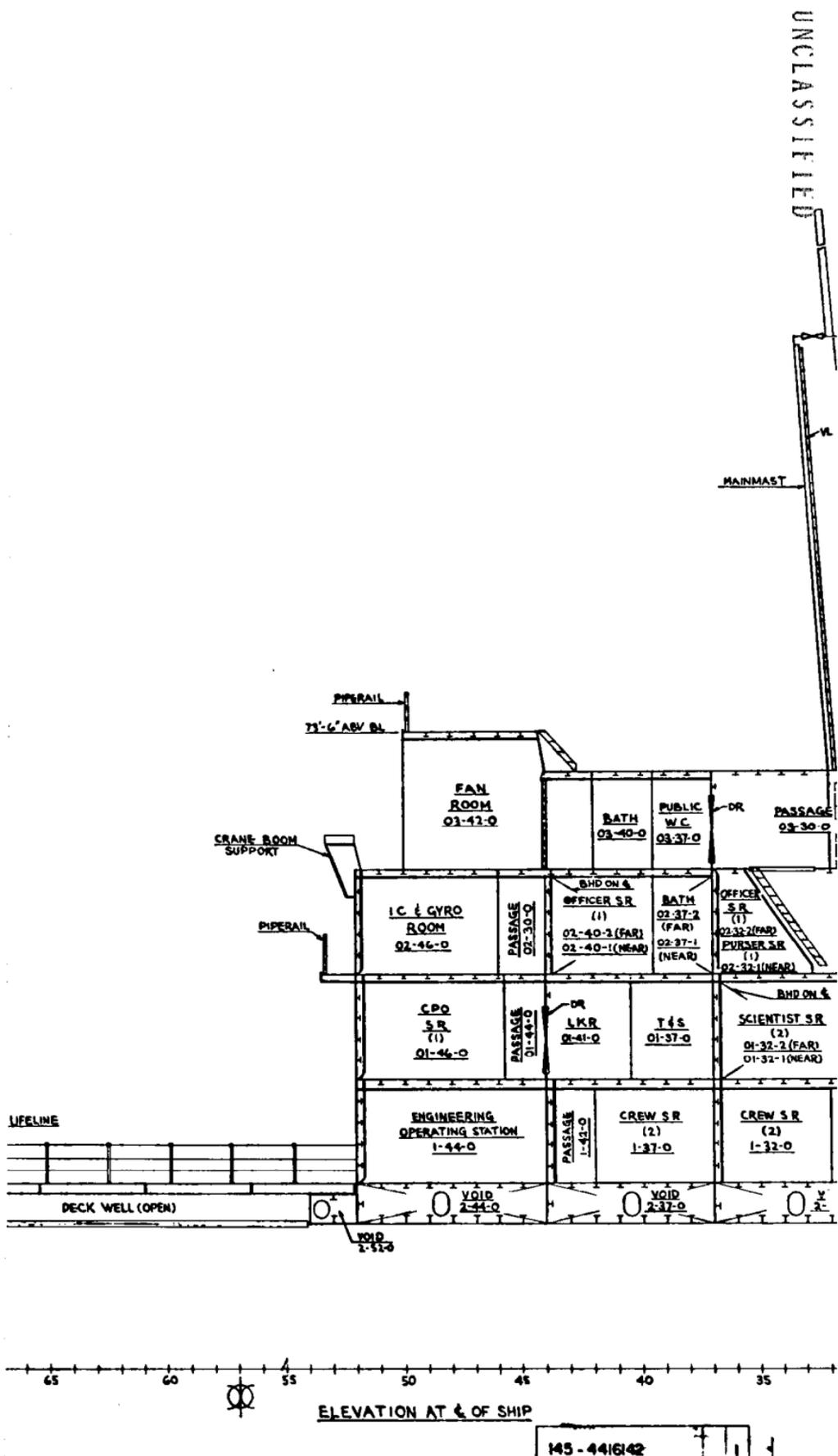
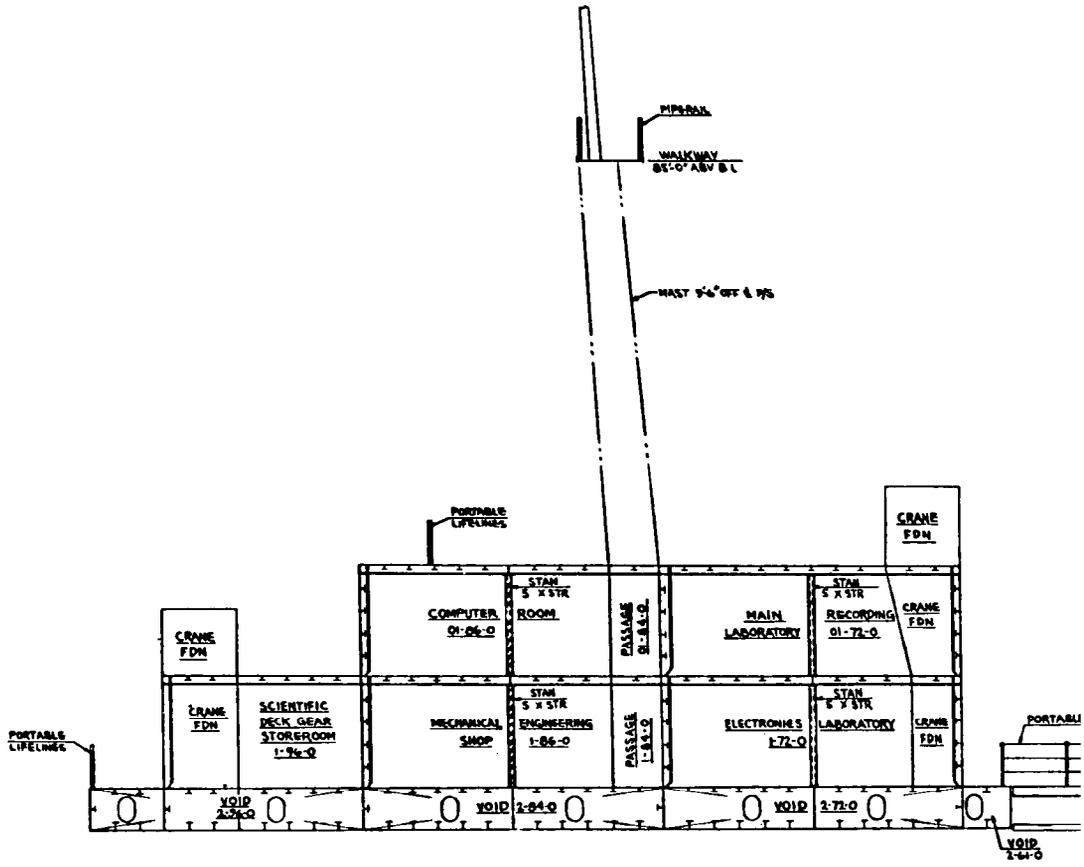
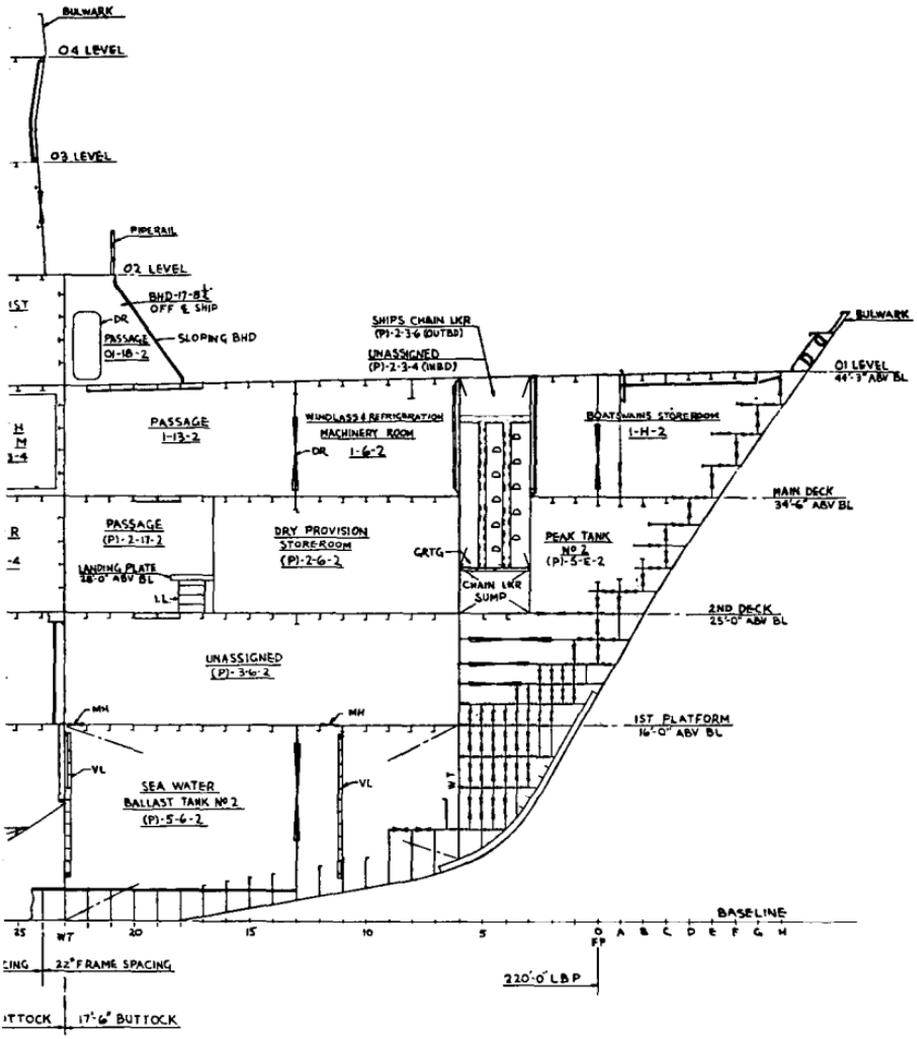


Fig. 3b — Elevation, inboard





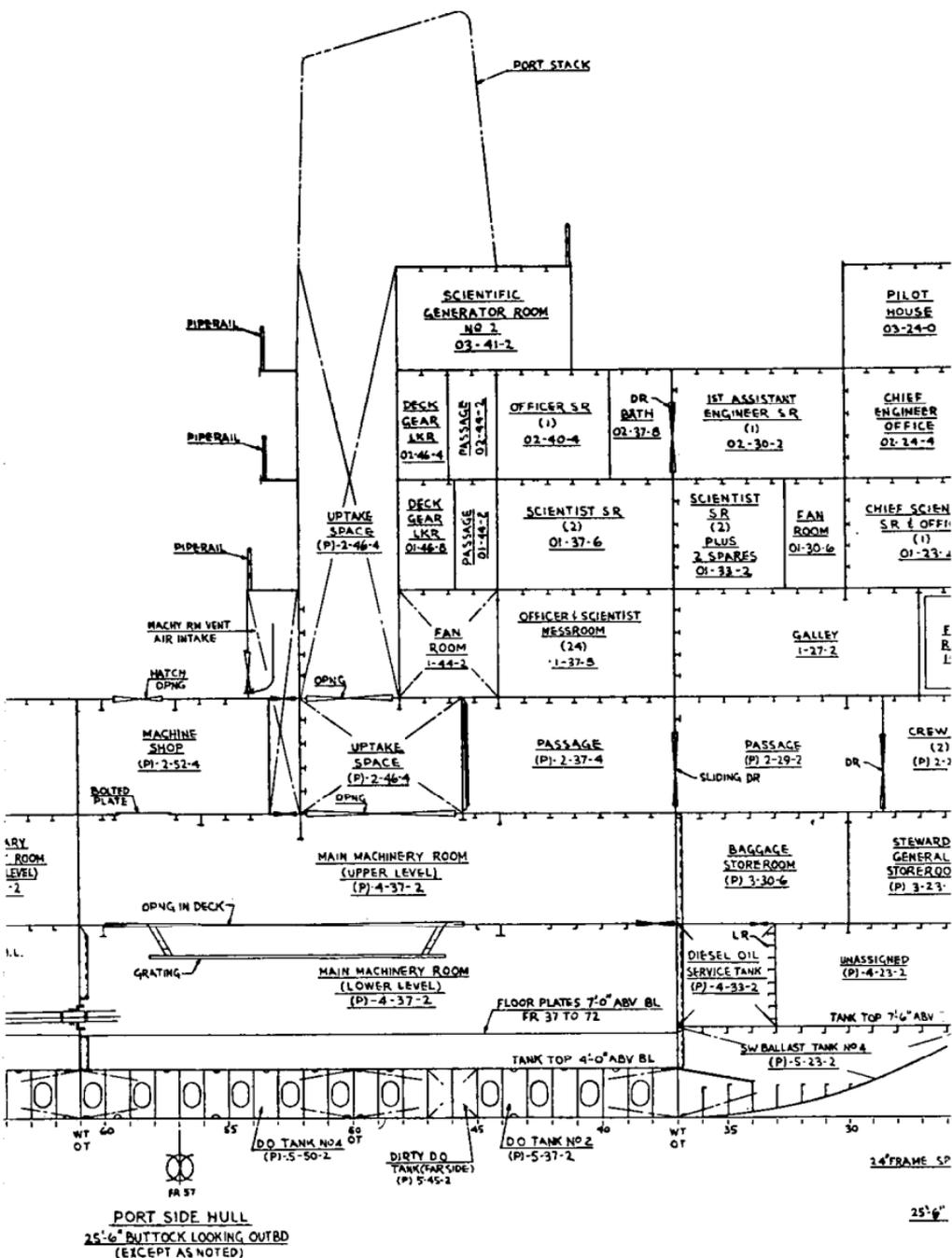
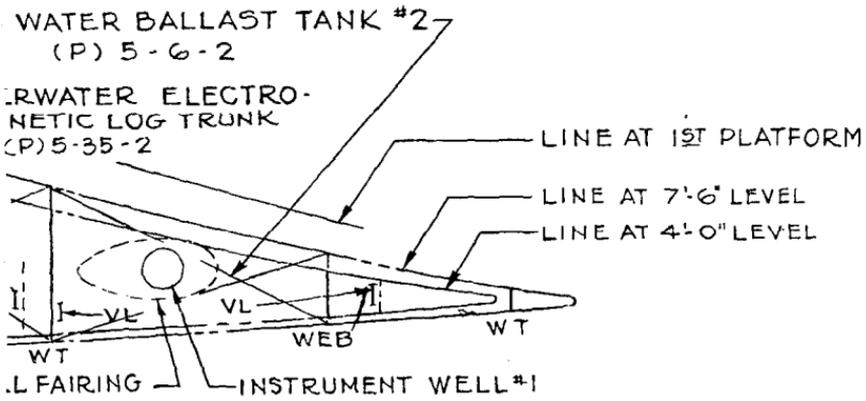
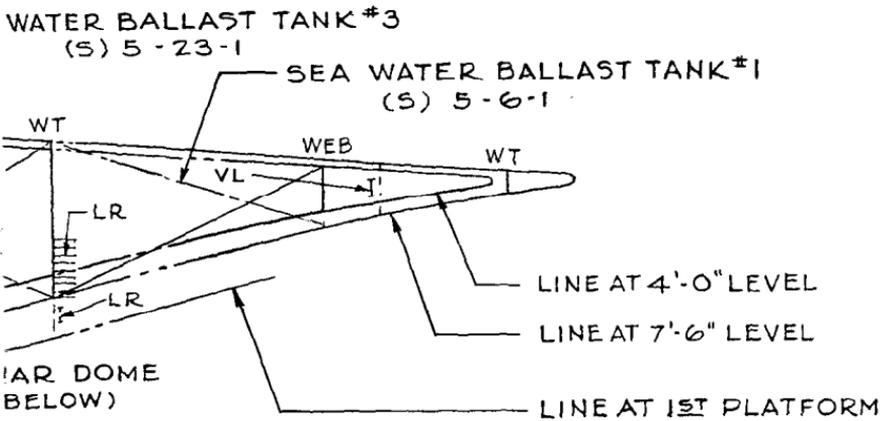
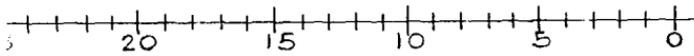


Fig. 3c — Elevation, port hull





LAST TANK #4



INK

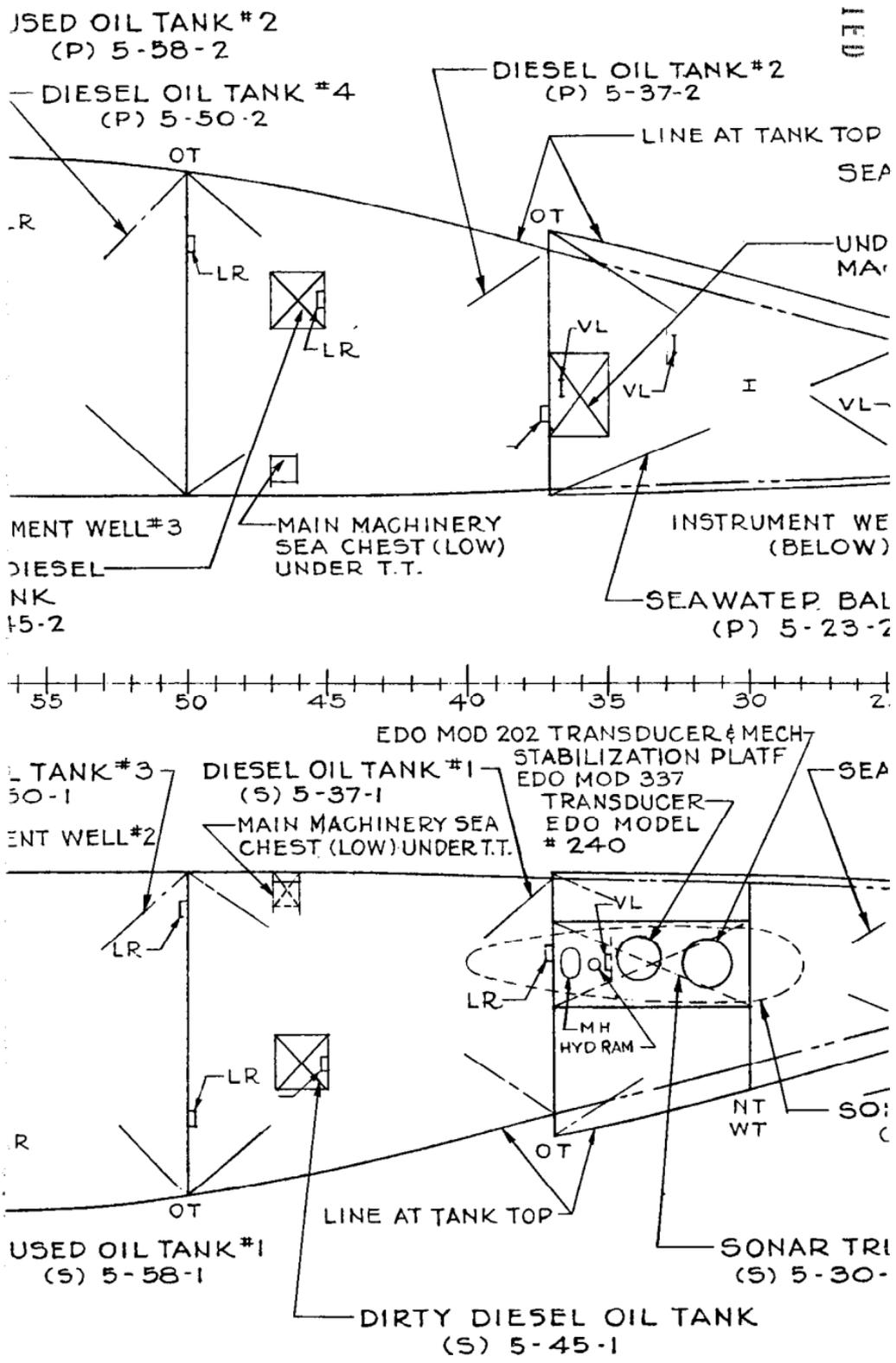
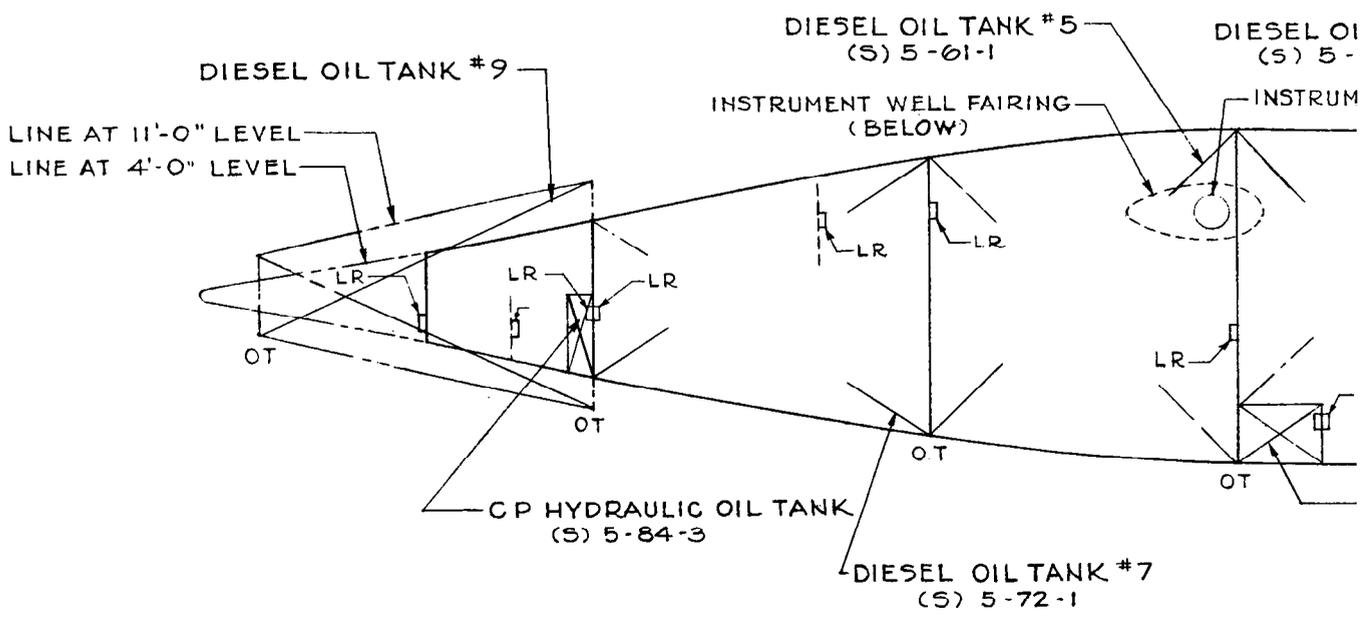
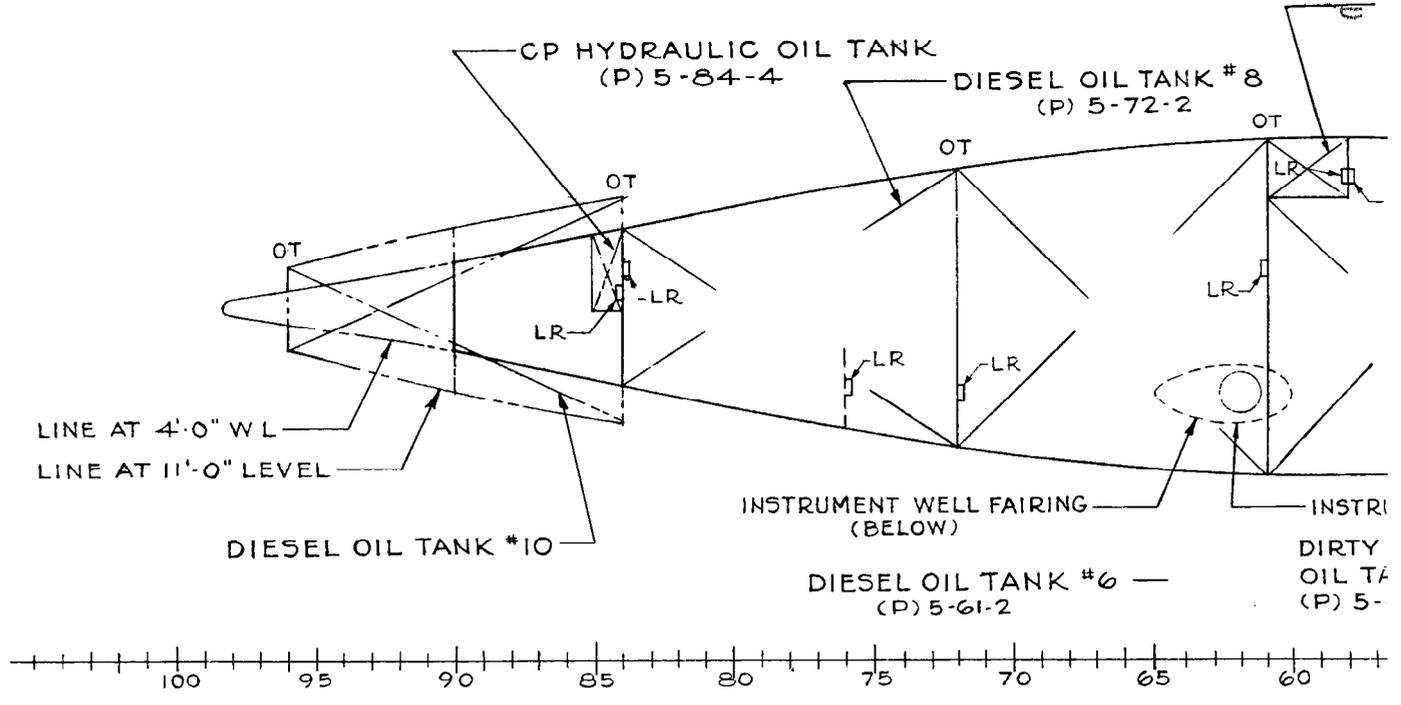


Fig. 3d - Plan view, inner bottom

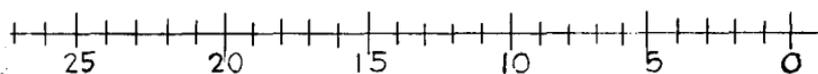
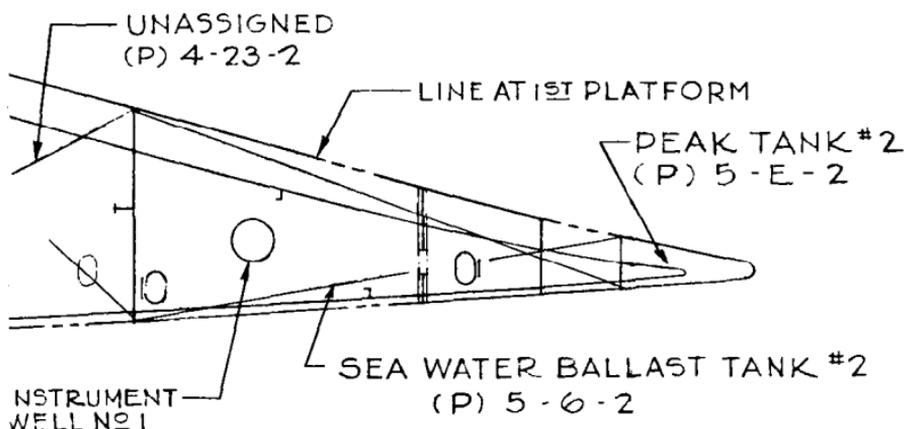
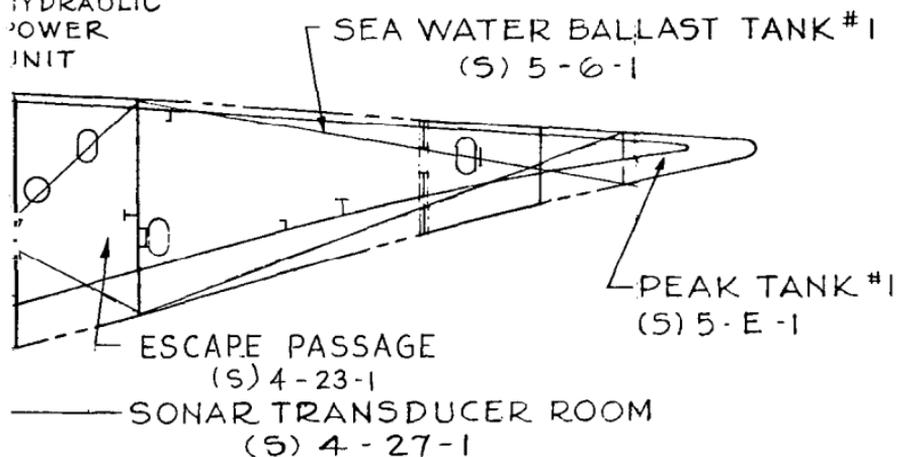


## LEGEND

1. Main Propulsion Diesel Engine
2. Auxiliary Propulsion Diesel Engine
3. Ship Service Diesel Generator
4. Fire Pump
5. Distilling Plant
6. Potable Water Pressure Tank

## EL OIL SERVICE TANK #3

(P) 4-33-2

HYDRAULIC  
POWER  
UNIT

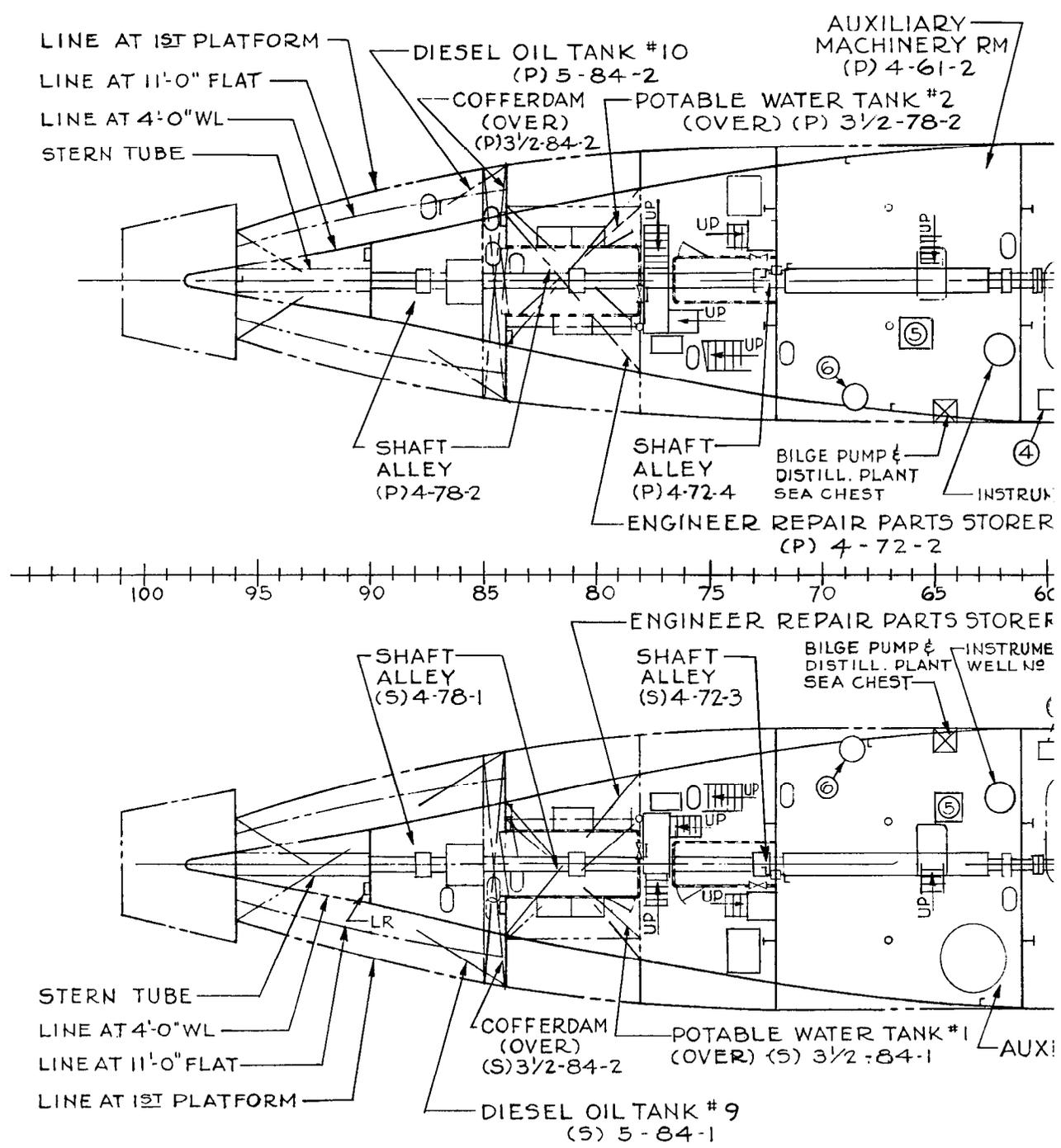
## EL OIL SERVICE TANK #2

(S) 4-33-1

## ICE TANK #1

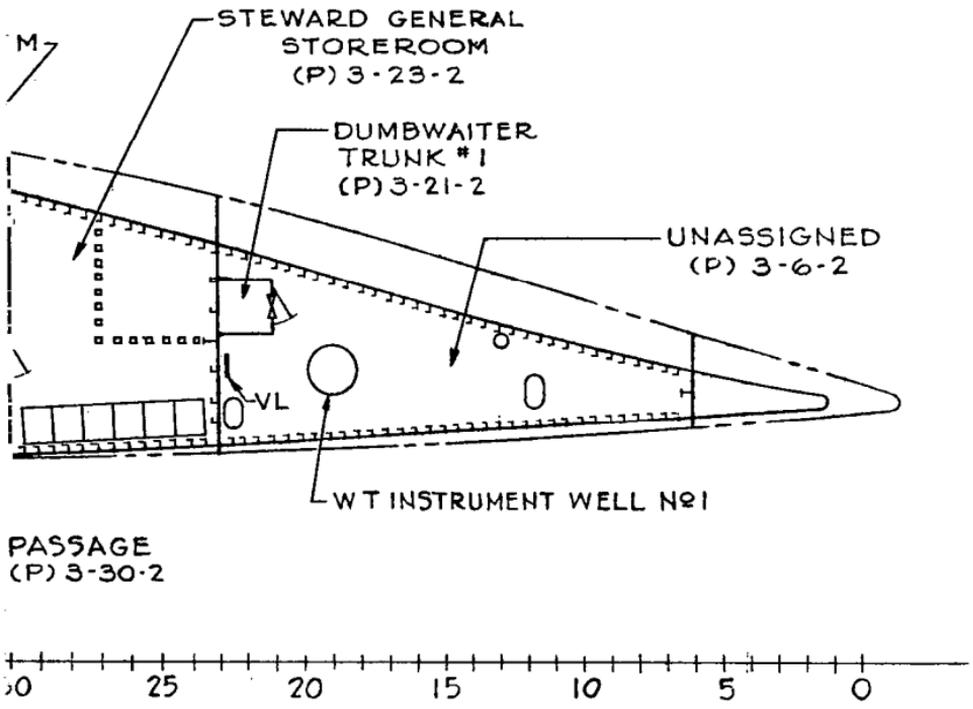
-3



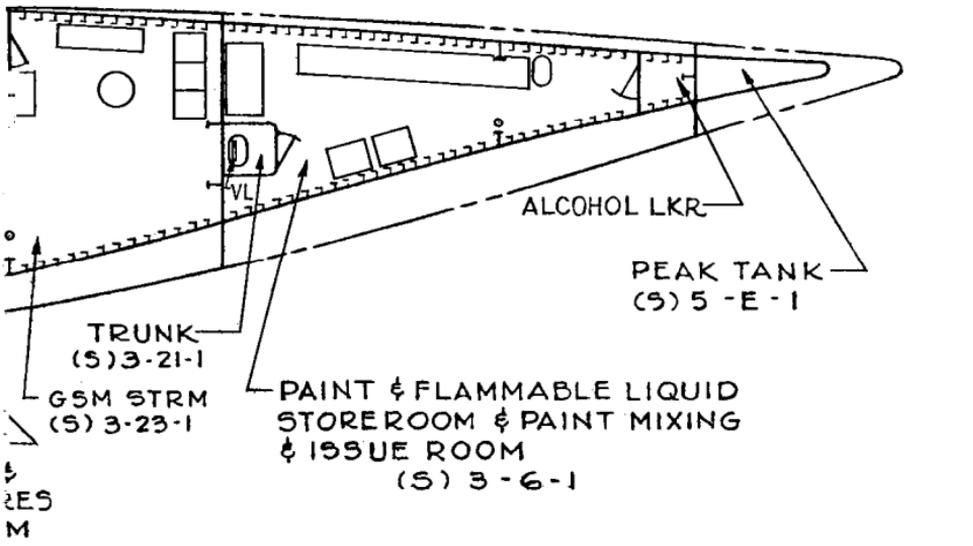


6. Vacuum Priming System
7. Ship Service Air Compressor
8. High Pressure Air Compressor
9. Dual Hydraulic Power Unit

pressor  
enser  
iver  
er



- PASSAGE (S) 3-30-3
- PASSAGE (S) 3-30-1



**LEGEND**

- 1. Oil Fuel Boiler
- 2. Air Conditioning Plant Compressor
- 3. Air Conditioning Plant Condenser
- 4. Air Conditioning Plant Receiver
- 5. Air Conditioning Plant Chiller

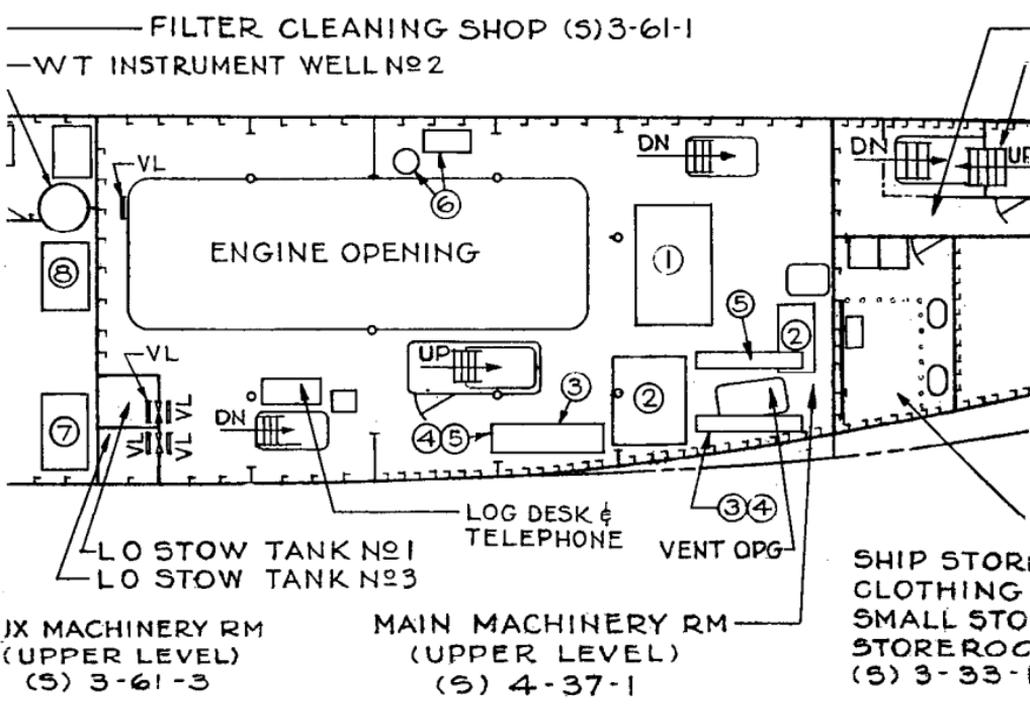
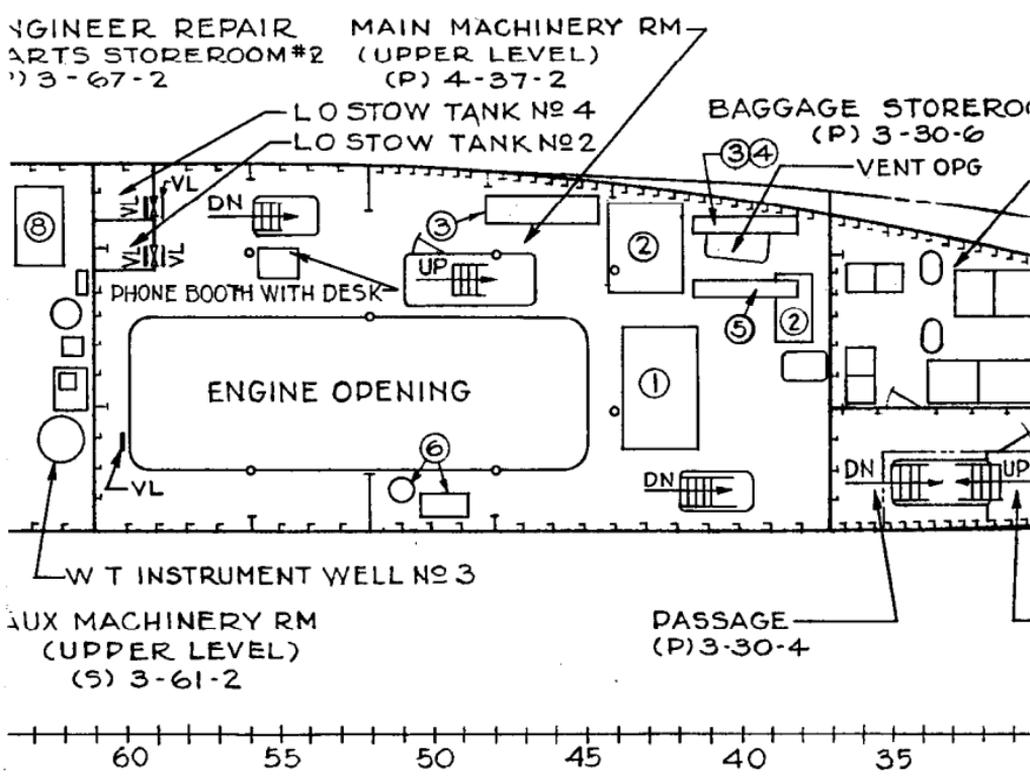
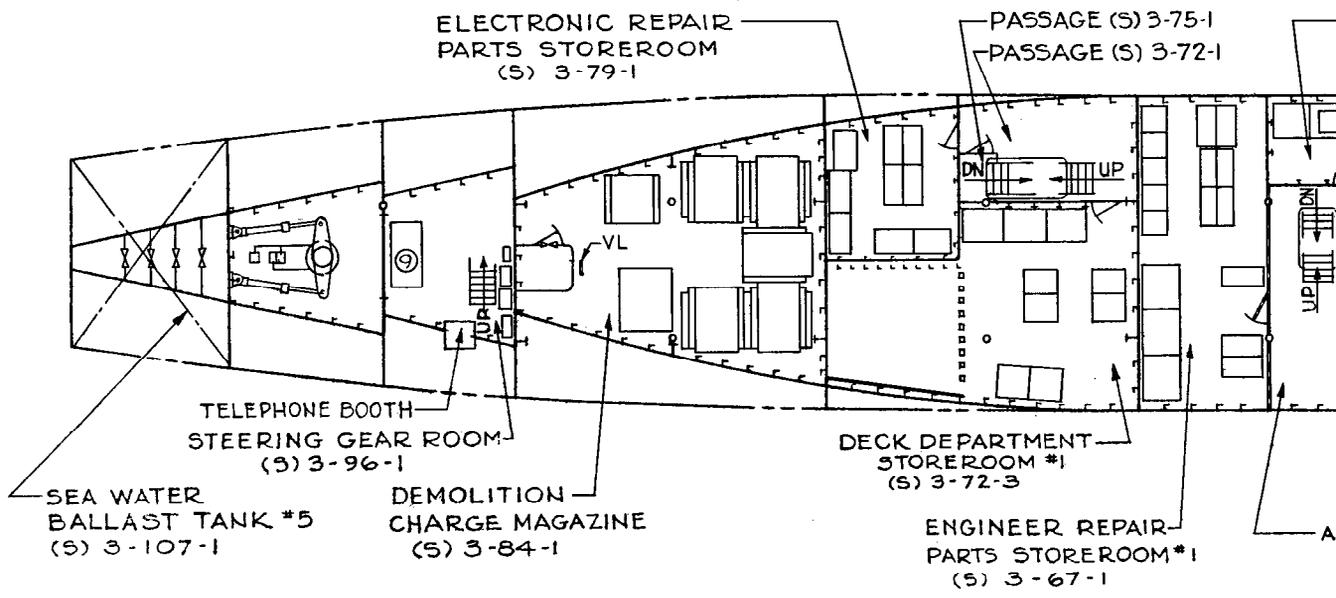
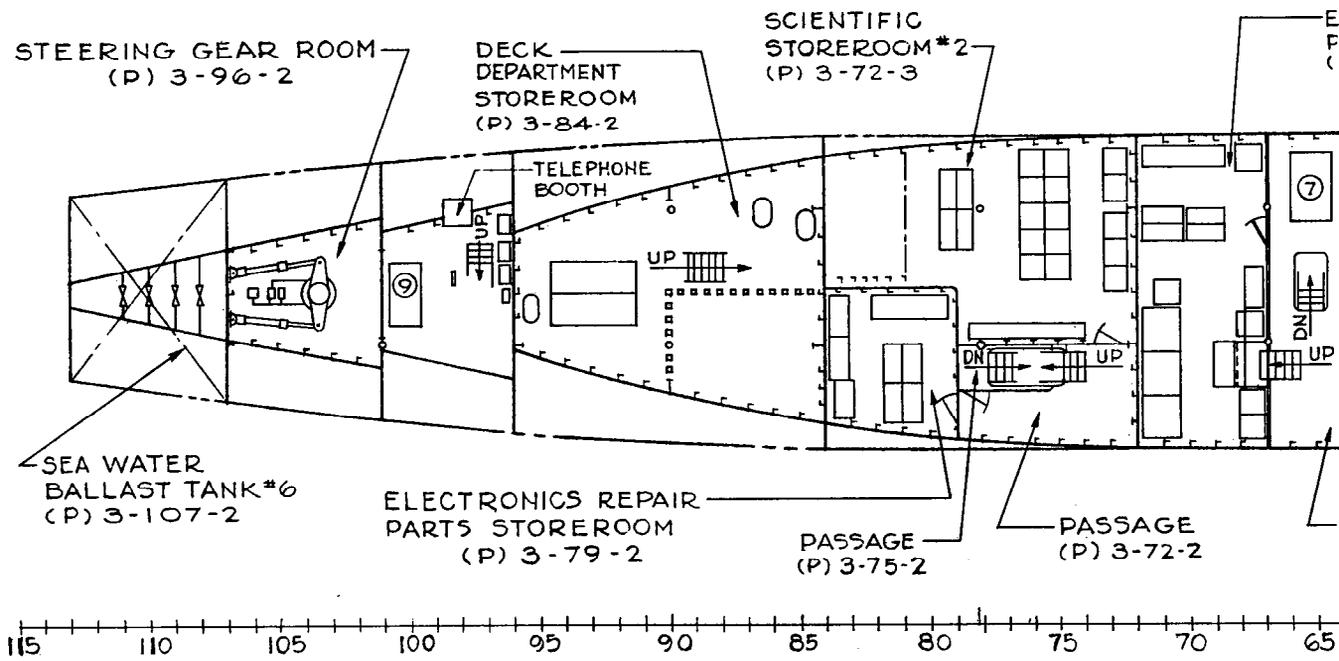
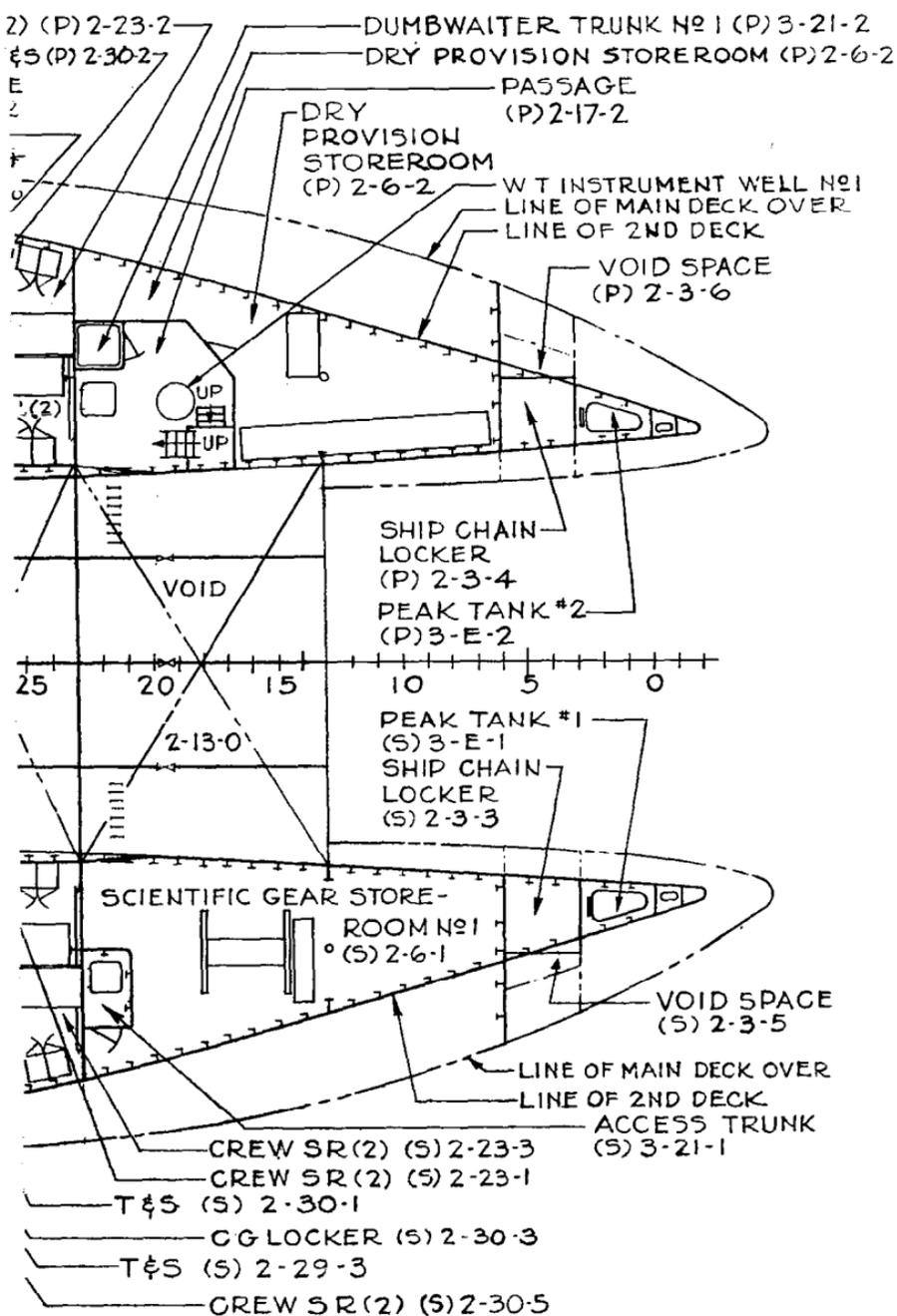


Fig. 3f - Plan view, first platform





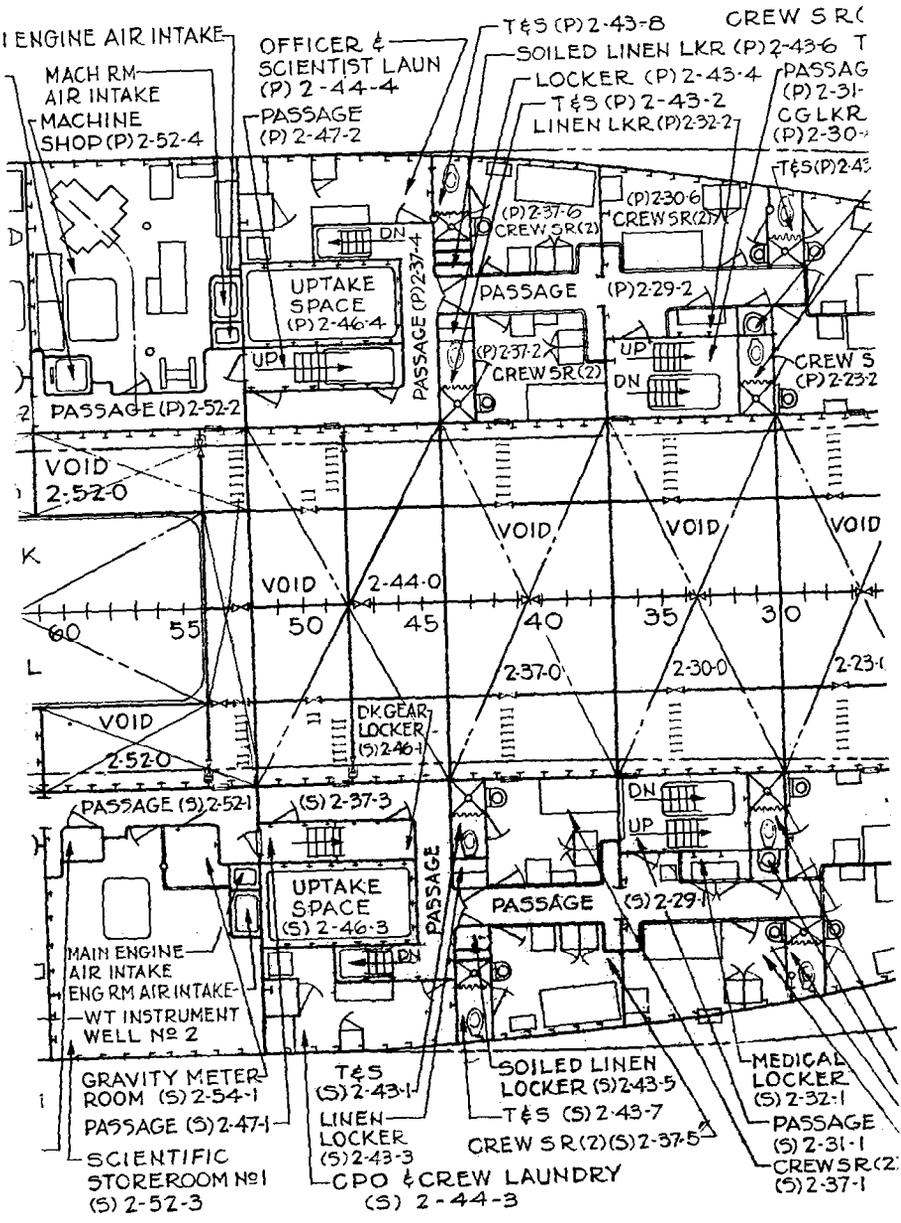
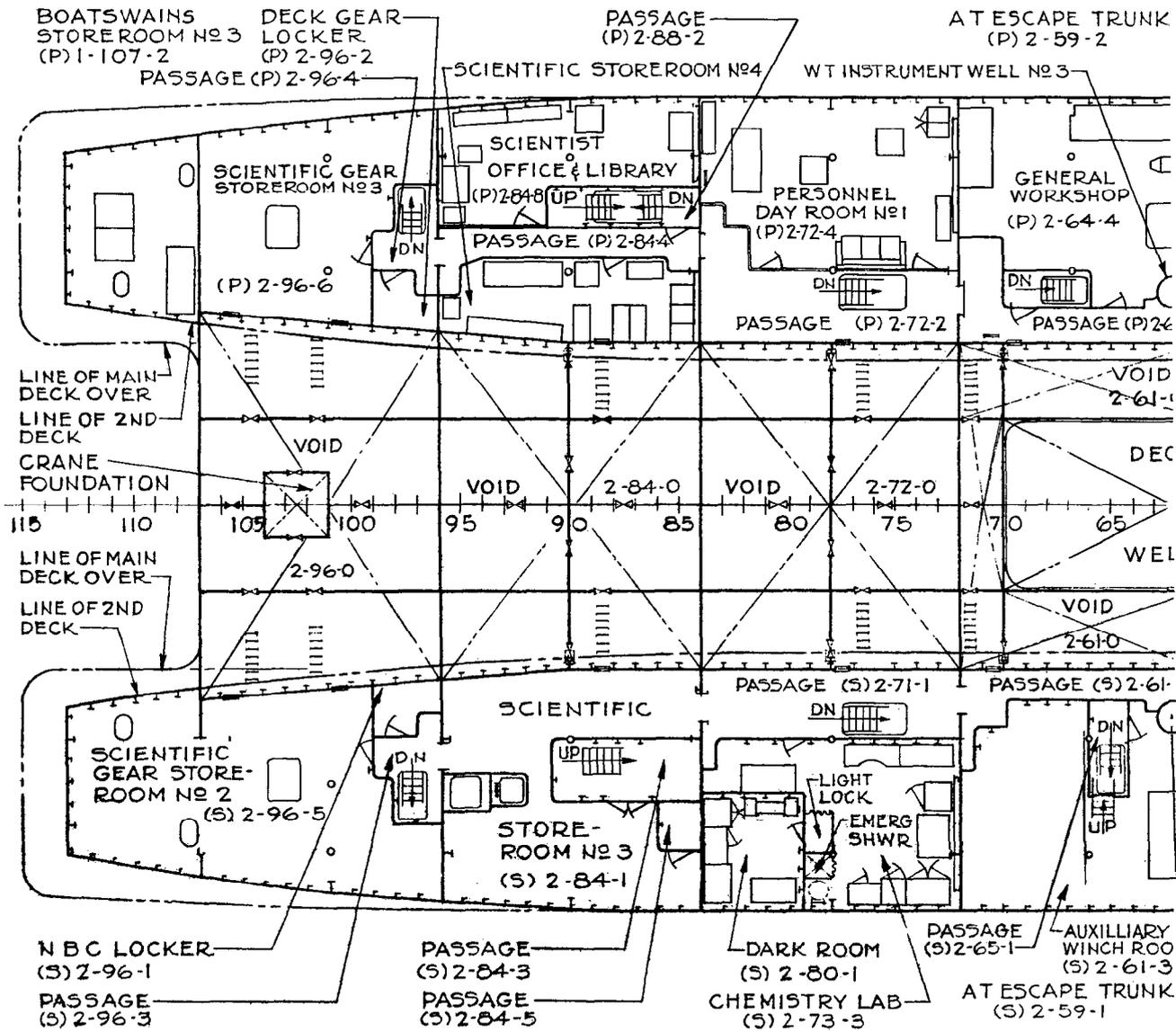
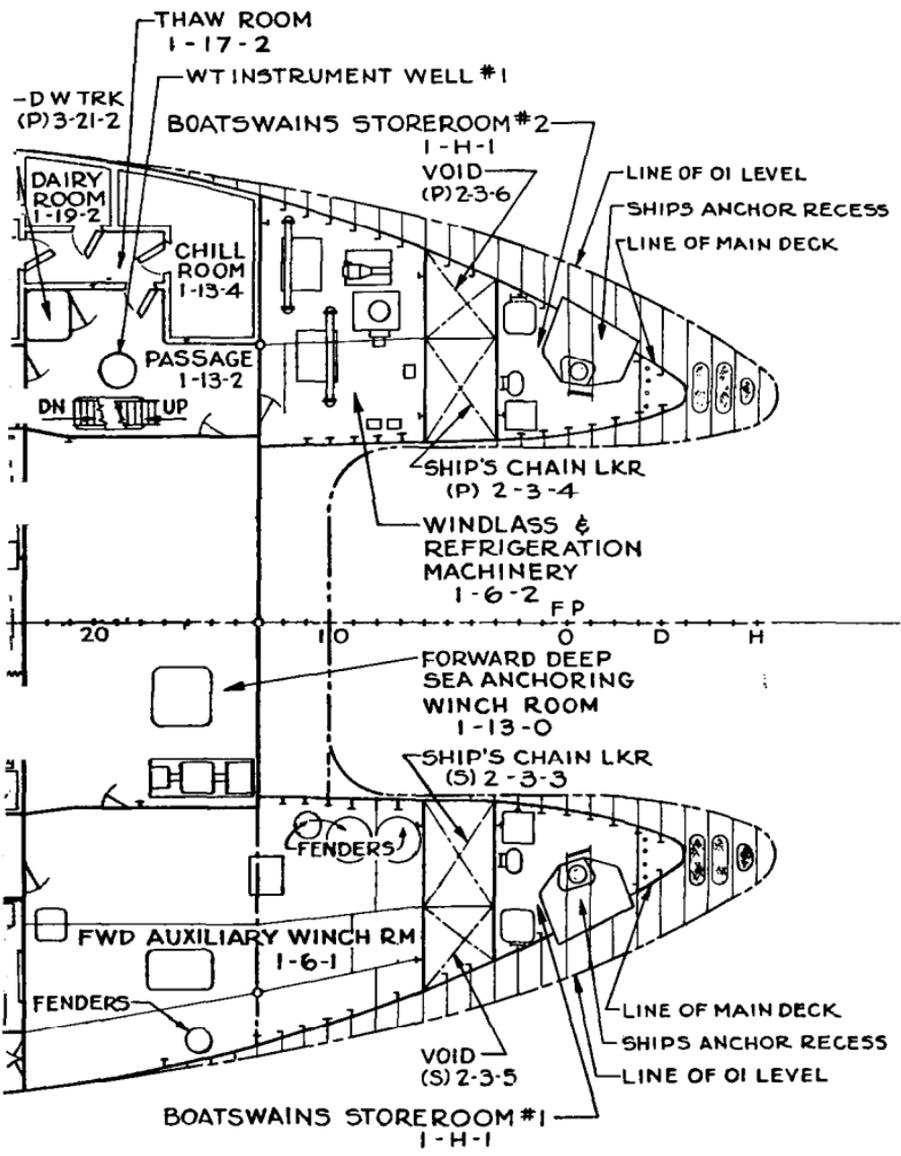


Fig. 3g — Plan view, second deck





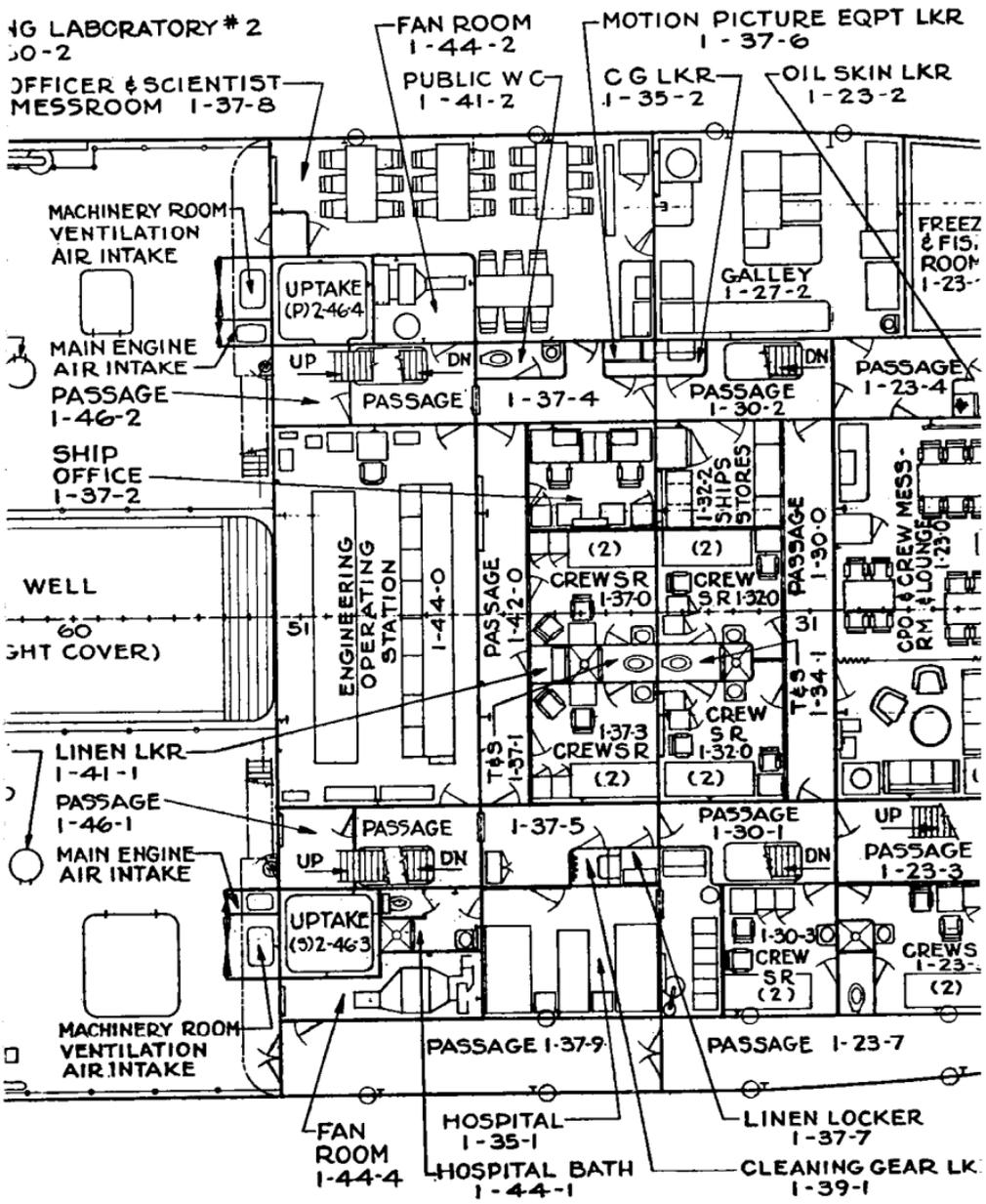


Fig. 3h — Plan view, main deck

# USNS HAYES (T-AGOR 16) U.S. Navy Oceanographic Research Ship

A. T. McCLINTON

*Systems Engineering Staff  
Acoustics Division*

April 7, 1972



**NAVAL RESEARCH LABORATORY**  
**Washington, D.C.**

## CONTENTS

Abstract .....	ii
Problem Status .....	ii
Authorization .....	ii
INTRODUCTION .....	1
SHIP CHARACTERISTICS .....	1
GENERAL ARRANGEMENTS .....	3
SHIP FACILITIES .....	4
Communication System .....	5
Navigation System .....	5
Telephone Systems .....	6
PROJECT EQUIPMENT .....	7
Scientific Handling Gear .....	7
Scientific Communication Equipment .....	9
Scientific Navigation Equipment .....	9
Scientific Bathymetric System .....	10
DR. HARVEY CORNELIUS HAYES .....	11

## ABSTRACT

The USNS *Hayes* (T-AGOR 16), a new acoustic and oceanographic research vessel utilizing a catamaran hull, represents the most advanced design and engineering concepts in the fleet of U.S. oceanographic research vessels. The most distinctive features of the *Hayes* in comparison to AGORs of conventional monohull construction are the large laboratory and open deck area for scientific and project equipment, the large inboard area (center well) for lowering and raising large and/or heavy objects and the greater degree of stability and the centralized machinery control. The T-AGOR 16 was most appropriately named after one of the great scientists of the U.S., Harvey C. Hayes. Dr. Hayes made many contributions to the successful exploitation of sound as a practical method for exploration in the ocean and the detection of underwater objects.

## PROBLEM STATUS

This is a final report on one phase of the problem; work on the other phases is continuing.

## AUTHORIZATION

NRL Problem K03-44  
Project RF 05-552-402

Manuscript submitted November 17, 1971.

**USNS HAYES (T-AGOR 16)**  
**U.S. NAVY OCEANOGRAPHIC RESEARCH SHIP**

## INTRODUCTION

The USNS *Hayes* (T-AGOR 16), a new acoustic and oceanographic research vessel utilizing a catamaran hull, represents the most advanced design and engineering concepts in the fleet of U.S. oceanographic research vessels. The most distinctive features of the *Hayes* in comparison to AGORs of conventional monohull construction are the large laboratory and open deck area for scientific and project equipment, the large inboard area (center well) for lowering and raising large and/or heavy objects, the greater degree of stability, and the centralized machinery control. The T-AGOR 16 was most appropriately named after one of the great men of the U.S., Harvey C. Hayes. Dr. Hayes made many contributions to the successful exploitation of sound as a practical method for exploration in the ocean and the detection of underwater objects.

The preliminary design of the *Hayes* was completed by M. Rosenblatt & Son, Inc. under the direction of the Naval Ship Engineering Center. The guidance plans, contract drawings, and specifications were completed on Mar. 22, 1968 by Rosenblatt, and a contract for ship construction was awarded Dec. 10, 1968 to the Todd Shipyard Corporation, Seattle, Washington, for \$13,950,000. Delivery was made in July 1971. The construction contract was administered by the project Manager, Oceanographic and Instrumentation Ship Acquisition Office, PMS-391. The Oceanographer of the Navy, who sponsored the *Hayes*, assigned the ship to the Military Sealift Command for operational control and to the Naval Research Laboratory (NRL) for technical direction and funding control as the principal user laboratory.

## SHIP CHARACTERISTICS

The principal characteristics of the ship are as follows:

a. Hull

	<u>Feet</u>	<u>Inches</u>	<u>Tons</u>
Length design W.L.	220	0	
Length overall	246	5	
Length between perpendiculars	220	0	
Beam, maximum	75	0	
Beam, each hull	24	0	
Distance between hulls	27	0	
Depth at side to main deck amidships (above base line)	34	0	
Draft above bottom of keel at full load	19	2	

	<u>Feet</u>	<u>Inches</u>	<u>Tons</u>
Draft above lowest projection			
below keel at full load	21	8.5	
Height of main mast above			
DWL	104	0	
Height of Twinmast above			
DWL	104	0	
DWL	18	6	
Displacement, full load			3180
Potable water, full load			31
Diesel oil			368
Lubricating oil			10

## b. Machinery

Number of propulsion shafts			2
Design full power ahead, main propulsion, BHP			5400
Auxiliary propulsion, BHP			330
Design full power ahead, shaft rpm			139
Endurance (13.5 knots), miles			6000
Speed, sustained knots (at 80% power and			
100% torque)			15
Creep speed knots (auxiliary propulsion)			2-4

## c. Electrical

Ship's service diesel generators, 3, each rated 450 V, 3 phase, 60 Hz, 350 kW

Scientific diesel generators, 2, each rated 450 V, 3 phase, 60 Hz, 75 kW

Emergency diesel generator, 1, rated 450 V, 3 phase, 60 Hz, 75 kW

d. Habitability: Living, messing, sanitary, and recreation facilities are provided for the following personnel:

Officers (11)

1 Master  
1 1st Officer  
1 2nd Officer  
1 3rd Officer  
1 Radio Officer  
1 Chief Engineer  
1 1st Assistant Engineer  
1 2nd Assistant Engineer  
1 3rd Assistant Engineer  
1 Purser  
1 Chief Steward

Crew (34)

1 Deck Engineer-Machinist  
1 Chief Electrician  
1 Chief Cook  
1 Yeoman-Storekeeper  
6 Able Seamen  
3 Ordinary Seamen  
2 Engine-Utilitymen  
6 Oilers  
2 Wipers  
1 Cook-Baker  
1 2nd Cook  
4 Messmen  
5 Utilitymen

The ship will also furnish quarters for 1 Chief Scientist and 24 Scientists. There are five emergency berths.

**GENERAL ARRANGEMENTS**

The general configuration of the *Hayes* is shown in the several views, Figs. 1a, 1b, and 1c, taken during the preliminary acceptance trials on July 7, 1971. The general arrangement provides a forward and after centerbody construction, ample deck space for U-frames and cranes to suspend objects overboard, scientific deck machinery in enclosed areas, adequate masts for antenna locations, and twin screws for maneuverability. The U-frames, cranes, and other scientific handling gear were not provided as part of the shipbuilder's contract. These will be installed later.

The forward and after centerbody structures, Fig. 2, are compatible with an arrangement which represents a major improvement over earlier ships. The after superstructure houses the scientific laboratories, research control center, computer and data processing spaces, calibration and instrument test facilities, scientific refrigeration equipment, and the scientists' radio facility. Large stowage areas for scientific equipment are located in the two hulls directly below. The forward superstructure houses the ship control and living spaces. This arrangement separates completely the scientific spaces from the machinery and living spaces.

The center well is expected to become a significant and worthwhile feature of this ship in the NRL program. Past experiences of NRL with the USS *Hunting*, a converted LST, the USNS *Mizar*, a converted cargo ship, and the USNS *Mission Capistrano* have all shown the advantages of wells located near the center of pitch and roll for suspending arrays and for towing operations. Although the "well" on the *Hayes* is open fore and aft, it will provide a significant advantage to over-the-side work.

In addition to the large center well, three 30-in.-diameter wells are provided for general-purpose work involving smaller instrumentation. One of these wells is located in the port hull ahead of the forward centerbody structure, and the other two are located approximately midships, one in each hull. Because of their relative locations they can be used for an underwater tracking system.

The features described above may be seen in detail on the general arrangement drawings presented in Figs. 3a through 3k. The locations of the instrumentation wells are shown on Fig. 4.

## SHIP FACILITIES

The *Hayes* is not only a unique oceanographic vessel because of hull configuration and the large ratio of designated scientific space to total ship space, but also is unique in ship propulsion and maneuverability, the degree of automation of ship operation, and ship facilities. Automation of ship operation is provided through the ship control console (at four control stations) and at the central machinery control. The latter is provided in the Engineering Operating Station (EOS) which contains switchboards for the ship's service and scientific generators and for electric power distribution, essential lighting load center, the main control console, an alarm and data logger, bell logger, and numerous other machinery and valve remote controls, alarms, system status displays, and indicators. The EOS is designed for one licensed watch stander and completely unmanned machinery spaces. Two views of the control console in the EOS are shown in Figs. 5a and 5b. It is located on the main deck, astride the cross-structure in the aftermost space of the forward deckhouse. On the main control console, equipment is provided for remote selection, starting, speed control, and stopping of the propulsion engines. Provision is made for remote transfer of tankage among the other engineering functions that are also included, and for remote starting, paralleling, and stopping of diesel generators.

The machinery control system provides for remote control of the propulsion machinery for ship speed and direction from the ship control consoles in the pilot house, both bridge wings, and the auxiliary ship control station starboard hull aft. A view of the control station in the bridge is shown in Fig. 6. For ship speed, these controls and a similar control on the main console in the EOS are single level, programmed for automatic matching of propeller pitch and rpm relationships. This automatic control is supplemented by remotely operated manual controls on the EOS main console for the separate control of propeller pitch and/or rpm.

The monitoring and display of machinery plant management information is accomplished in a General Electric Data Center which is contiguous with the EOS main control console. The most important operating data are displayed continuously; for example, propeller rpm and pitch, diesel cooling water and combined cylinder exhaust temperatures, etc. Individual engine cylinder temperatures, line shaft bearing temperatures, boiler feed salinity, and boiler service tank level typify the data available by dialing the desired quantity.

There are two machinery plants, one in each hull, each of which contains an EMD-20-645E5, 2700-BHP main propulsion diesel and a GM 67-1, 165-BHP auxiliary propulsion diesel, driving a LIPS reversible pitch propeller through a reduction gear. A disconnect clutch is provided between each engine and the reduction gear, interlocked to preclude simultaneous engagement of the main and auxiliary engines. The main propulsion design will provide a 15-knot sustained speed and 6000 mi. at 13.5 knots endurance speed. Usage of the auxiliary propulsion engines is for a 2- to 4-knot creep speed only. In addition to the usual auxiliaries, the plant provides 450-V, 3-phase, 60-Hz electric power from three 350-kW ship's service, two 75-kW scientific diesel generators, and one 75-kW emergency generator. Interconnection of these generators and distribution to the load centers is illustrated on the power system one-line diagram of Figs. 7a and 7b.

Brief summaries of characteristics of the ship communication, navigation, and telephone systems are presented in the following sections.

### Communication System

1. Marine Radio — MRU 29A/30A: This is the ship's main and reserve transmitter and receiver system for radio telegraph (A-1, A-2); the frequency range is 400 to 535 kHz at 500 W on main transmission power and at 40 W on emergency power. This system provides for an automatic alarm and an automatic alarm signal keyer as well as control facilities for the direction finder and is expected to provide communications under all conditions.
2. RF Communications — RF 201M: This is a single-sideband radiotelephone in the 2- to 24-MHz marine service band. Transmit power rating is 150 W. The unit is capable of upper sideband, fully suppressed carrier (A3J) and compatible AM (A3H) transmission-reception. It has the capability for 30 crystal-controlled channels.
3. Collins MR201 Marine Radiotelephone, FM 156- to 162-MHz international vhf marine band: This provides simplex or duplex FM communications on 31 channels in maritime vhf band. Output power is 20 W.
4. Mackay 4004A Direction Finder: This system utilizes a fixed-loop sense antenna and a separate superheterodyne receiver indicator with a built-in goniometer. Relative bearing and true bearing scales are available. Tuning is manual over the frequency range of 200 to 525 kHz.
5. Giffit GFR-2 Facsimile Recorder: Provides the permanent recording system for weather charts and other navigational data as broadcast. It features automatic start/stop, and automatic and manual phasing. It will receive AF shift modulation from 1500 to 2300 Hz and also AM modulated signals and direct-coupled video from other demodulators.

### Navigation System

1. Sperry Mk 23 Model C3 Gyrocompass: The most significant characteristics of the gyrocompass are a heading accuracy  $\pm 0.75^\circ$ , drift rate  $\pm 0.25^\circ$  per hour, and  $45^\circ$  roll and pitch clearance. Provision is included for automatic latitude and speed correction, and for 1- and 36-speed synchro output (400 Hz).
2. Radiomarine Corp CRM-N2C-30 Radar, 10 cm, 3000 MHz, S band: The radar display is a 16-in. CR indicator, with range scales from 1/2 to 40 naut mi. Range accuracy is within 2% of range scale and resolution is 20 yd on shorter range scales. Peak transmit power is 30 kW.
3. Sperry Model 1 Loran A/C: This unit receives either Loran A signals or Loran C signals. It provides visual matching for Loran A and C and electronics (meter) matching for Loran C. Readout is by time delay dials. Loran A range is 600 to 900 mi in the day-time and 1200 mi at night but with decreased accuracy. Loran C provides longer range in coverage areas (up to 3000 mi under ideal conditions).

4. Chesapeake Instrumentation Corporation UL-100 Electromagnetic Log: This system, consisting of indicator transmitter and a rodmeter (sensor) provides indicated speed from  $-9$  to  $+30$  knots. Ship speed is displayed to  $\pm 0.1$ -knot resolution. The distance traveled is obtained from an integrator using a crystal-controlled oscillator as a time base. Distance is displayed in increments of 0.01 naut mi. Expected speed accuracy is  $\pm 0.1$  knot below 10 knots and 1% above 10 knots, and distance range accuracy is 1% of distance traveled. Remote readouts are provided in the research control center, electronics laboratory, main recording laboratory and on the bridge.

5. Bendix type F/60 Windspeed Indicator: The anemometer mounted on the ship's main mast will provide measurement of windspeed to 60 knots with  $\pm 1$ -knot accuracy and from 60 to 100 knots with  $\pm 2.5$ -knot accuracy. Direction accuracy above 5 knots is  $\pm 2^\circ$ . Remote indicators are provided in the research control center, electronics laboratory, main recording laboratory, on the bridge, and in the engineers operation station.

6. Raytheon DE 714/7 Fathometer: The transducer is mounted in the sonar dome starboard hull. This is a 25-kHz barium titanate unit with approximately a  $30^\circ$  beam. The system range scales cover depths to 780 fathoms in six increments.

7. Sperry Course Recorder: This device uses a step-by-step motor and chart paper feed roller that is clock controlled. The recorder writes an accurate continuous record of course on strip chart using the electrical signal from the master gyrocompass. A visual indicator readout is provided also.

## Telephone Systems

An automatic dial telephone system and a sound-powered telephone system are provided for interior communication. The dial telephone system (Hose McCann) provides a means of communication between stations in the ship, and between the ship and shore systems, on a fully selective basis under the direct control of the calling stations. Selection of the called line station is effected through a central automatic switchboard. Provisions are made for executive cut-in, conference feature, and selective high-power intercommunication facilities.

Telephone facilities are provided at the computer room, scientific radio room, all laboratories, electronics shops, IC and gyro room, quarterdeck (port and starboard), personnel dayrooms, engineering operating station, scientist's office and library, gravity meter room, ship's radio room, pilot house, chief scientist's stateroom and office, one other scientist's stateroom, master's office, officers' and scientists' lounge, scientists' and officers' messroom, and research control center. An executive cut-in feature is provided in the pilot house, EOS, main recording laboratory, and chief scientist's stateroom and office. Provisions are made for extension capability via phone jacks to the telephones at the research control center, main recording laboratory, and electronics laboratory. A weatherproof jack is provided in the van area and in the forward-anchor winch-control console.

Direct shore lines are provided at dockside to the master's stateroom and office, chief scientist's stateroom and office, chief engineer's stateroom and office, and quarterdeck (port and starboard).

Selective high-power intercommunication facilities include local transistorized power amplifier-speaker units at selected locations as an optional receiver and linked together with other stations in a conference system. Telephone sets with selective high-power intercommunication facilities are provided at all winch-control stations and winch rooms, crane cab 01 level, crane cab 02 level, main recording laboratory, mechanical engineering shop, electronics laboratory, and stern U-frame area. In addition, six local loudspeaker amplifiers are provided with a nominal 2-W output at the speaker for use at the option of the operator for the following stations: research control center, main recording laboratory, electronics laboratory, and wet laboratory.

The scientific radio room station can provide remote radio facilities via phone patch on the dial telephone system.

The sound-powered telephone system provides for the essential ship communication and includes ship operation circuits, engineers' circuits, damage control circuits, radio and signal circuits, and dumbwaiter circuit. The latter provides communication between the demolition charge magazine on the first platform and the ready service room on the main deck.

## PROJECT EQUIPMENT

The spaces and deck areas on the *Hayes* reserved for project purposes have been assigned for specific functional uses such as electrical, mechanical, biology, chemistry, data processing, communications, machinery, and storage. A review of the compartment arrangement drawings presented in Fig. 3 will reveal the relative location, size, and general arrangement within these designated areas. To allow for the greatest flexibility these spaces are provided with certain standard pieces of equipment, power, and interlab communication; and decks are fitted with tie-downs to secure transient equipment. There are several types of systems which are required as a part of most scientific experiments, and these are being supplied as permanent onboard project equipment. The general characteristics of these systems are described in the paragraphs to follow.

### Scientific Handling Gear

The scientific handling gear consists of five major winch systems, four U-frames, two cranes, a deep-sea anchor system, and several smaller winch systems. (The procurement of these items of equipment was separate from the shipbuilding contract, and they are scheduled for delivery and installation in calendar year 1972.) A summary of the principal characteristics of each major component is as follows:

1. Deep-sea winch system, forward. Traction Unit: Line pull 15,000 lb at 270 ft/min to 50,000 lb at 80 ft/min, 3000 lb maximum back tension, 36-in.-diameter drums, grooved for cable sizes up to 1-1/4 in.

Dual Drum Stowage Unit: Two barrels each 24-in. in diameter by 76 in. long, flange 75 in. in diameter. Level wind 1/4 to 1-1/4-in.-diameter cable. Continuity device for electric cable. Line pull 3000 lb maximum.

2. Deep-sea winch system, aft. Traction Unit: Line pull 15,000 lb at 270 ft/min to 50,000 lb at 80 ft/min, 3000 lb maximum back tension, 36-in.-diameter drums, grooved for cable sizes up to 1-1/4 in.

Dual Drum Stowage Unit: Two barrels, each 24 in. in diameter by 76-in. long, flange 75-in. in diameter. Level wind 1/4 to 1-1/4-in.-diameter cable. Continuity device for electric cable. Line pull 3000 lb maximum.

Single Drum Stowage Unit: One barrel 24 in. in diameter by 76 in. long, flange 75 in. in diameter. Level wind 1/4 to 1-1/4-in.-diameter cable. Continuity device for electric cable. 3000 lb maximum tension.

3. Intermediate winch system, one each forward, midship and aft. Dual Drum Units: Line pull 5000 lb at 500 ft/min to 20,000 lb at 125 ft/min. Two barrels, each 18-in. in diameter by 36 in. long, flange 54 in. Level wind 1/4 to 1-1/4-in.-diameter cable. Continuity device for electric cable.

4. Deep-sea anchor windlass, forward, Windlass: Pay out under control 1000-lb anchor and 860 fathoms of 3/4-in. stud link chain at speeds up to 17 fathoms per min and hoist the same at speeds up to 8.5 fathoms per min.

Chain: 3/4-in.-diameter, steel, high-strength stud link, 67,960-lb breaking strength, in lengths of 1 to 60 ft, 10 to 500 ft and 1 to 160 ft.

5. U-Frames. Bow: Will support 50,000-lb line pull while in outer stop and will transit with 15,000-lb line pull. Transit time stop to stop is 3 min.

Stern: Will support 50,000-lb line pull while in outer stop and will transit with 15,000-lb line pull. Transit time stop to stop 30 sec. Width 10 ft at base, 8 ft at top, height 16 ft, outboard reach 6 ft.

Starboard, Forward, and Midships: Will support 20,000-lb line pull while in outer stop and will transit with 10,000-lb line pull. Transit time stop to stop 30 sec. Width 10 ft at base, 8 ft at top, height 16 ft, outboard reach 6 ft.

Platforms installed at the stern and starboard U-frames can be rotated outboard to a horizontal position, providing easier access to overboard lines.

6. Cranes, one each midships and stern. Lift is 50,000 lb at 15 ft radius to 8000 lb at 60 ft radius. Boom can support 50,000 lb with outer end set in a support. Angular rotation is 370° and topping range is 70°.

The midshipscrane boom is provided with a rest giving a capability to support a 50,000-lb load over a sheave suspended from the boom. This serves the opening in the midships' cross structure. The clear opening without doors is 14.5 ft by 36 ft and with doors in place and open is 14.5 ft by 32 ft. The doors can support a load of 360 lb per square foot.

The stern crane is provided a rest midships from which the crane can support a 50,000-lb load over a sheave suspended from the boom.

The traction unit or intermediate winch on the 02 level serves either of these cranes. In addition the cranes each have the normal winch and control arrangement, and can serve the decks and hatches in the area aft of frame 52.

7. Line metering: Instrumentation to monitor line tension speed and quantity out will be provided for each of the five winch units.

The locations of these systems and the fairleading arrangements from each winch system to U-frame or crane are illustrated on Figs. 8a and 8b. The principal location for deep-sea anchoring will be forward, using the deep-sea anchor windlass and the deep-sea winch system. Stern anchoring will be possible using the crane or U-frame and deep-sea winch system.

Provision is made for interconnecting the winch rooms, deck areas, bridge, and aft mast platform with the laboratory areas. Installed cables include shielded twisted pair, coaxial lines, and closed-circuit TV cable.

Sliprings will be provided on all winch drums to permit both power transmission to transducers and the reception of low-level signals from undersea sensors.

### Scientific Communication Equipment

Communication equipment is provided specifically for scientific purposes including data transmission as well as voice, separately or concurrently. Primary equipment consists of two identical high-frequency transmitter systems (RF Communications, RF 130) individually made up as follows:

RF 131 — Dual-channel synthesized exciter tunable in 100-Hz increments.

Modes: USB, LSB, ISB, AME, CW, RATT

RF 110 — RF amplifier, 1-kW PEP output

RF 112 — Power supply

RF 601 — Automatic antenna coupler and control system

Complementing these transmitters are two high-stability, fully digitized receivers covering the 2- to 30-MHz range (RF 505). Short-range communication is provided by a 30- to 40-MHz FM transceiver (Motorola Type LG). In addition, one UG-169 Teletype System will be provided in conjunction with (RF 2069) FSK terminal equipment.

A standard underwater telephone (Ametek ATM-504A) is provided with control in the research control center. This unit is intended for voice communication and cw operation between ship and submersibles. The expected range is up to 20,000 yd. The system can be expanded to transmit and receive data, and function as a transponder, ranging interrogator, pinger, and echo sounder. Transducers are provided for both 360° horizontal and vertical coverage and are mounted in the sonar dome, starboard hull.

### Scientific Navigation Equipment

Navigation equipment provided for scientific experiments is located in the research control center and consists of a Loran C receiver, a satellite navigation system, an X-band radar, and a dead-reckoning tracer. The satellite navigation system has an integral computer.

**Decca 629 True Motion:** The radar is a 3-cm-wavelength, high-resolution device configured to provide a relative or true motion plot. Tracking speed accuracy is better than  $\pm 5\%$  of indicated speed from log, and tracking course accuracy is to be better than  $\pm 2^\circ$  of indicated course. Inputs from the ship's gyrocompass and electromagnetic (EM) log are supplied for the true motion plot. The system provides a range discrimination of 10 yd on a 0.5-naut-mi range scale and has an accuracy of  $\pm 1\%$  of range scale or  $\pm 50$  yd, whichever is greater. The maximum range scale is 50 naut mi. An accessory to the radar permits manual scanning or automatic sector scanning of  $5^\circ$ ,  $10^\circ$ , or  $15^\circ$  sectors. This feature increases the target scan rate, and thus will be useful in buoy or other small-target tracking.

**Dead Reckoning Analyzer Indicator (DRAI), Mk 9 Model 4, and Dead Reckoning Tracer, Mk 6 Model 4B,** accept gyrocompass and underwater log inputs to provide a track of ship movement. Precision navigation over the bottom or tracking of underwater vehicles and bodies is to be accommodated by use of the three instrument wells, two in the port hull and one in the starboard hull (see Fig. 4). These three instrument wells are provided for future installation of hydrophones to be used in a three-dimensional tracking system. These can be used for navigation relative to bottom-mounted transponder and beacons or in tracking underwater devices carrying a sound source. The output from each or all of these navigation equipment(s) can be supplied to an onboard computer to develop precise up-to-date ship position coordinates or to provide ship control data.

**Loran A/C (Decca type ADL 21(M))** features automatic tracking on mode C visual digital readout, and output for computer processing.

A Satellite Navigation System with integral computer (Magnavox 706C) provides visual readings directly in latitude and longitude. Provision for hard copy printout is an option.

### **Scientific Bathymetric System**

The bathymetric equipment consists of a narrow-beam bathymetric system, a bottom-subbottom profiling system, and two precision depth recorders. The transducers for these systems are mounted in the sonar housing starboard hull at approximately frames 30 to 35. A summary of the salient features of this equipment is as follows:

1. **EDO-313 Narrow-Beam Bathymetric System:** Transducer — 16 kHz (Edo 202),  $6.5^\circ$  beam width, 34-in. face diameter, source level approximately 130 dB, receiving sensitivity approximately  $-84$  dB. Platform is mechanically stabilized for roll and pitch. Electronics will consist of a 2-kW transceiver, a digital signal conversion unit and display, and a system control.

2. **Bottom-Subbottom Profiling System:** Transducer — 3.5 kHz (Edo 240H),  $30^\circ$  beamwidth, 35-in. diameter, receiving sensitivity approximately  $-84$  dB. Electronics — 2-kW transceiver, 8-kW amplifier, and system control (Edo 248B).

Provision is made to install or remove transducers from inside the ship by pressurizing the sonar transducer room and a separate escape passage.

**DR. HARVEY CORNELIUS HAYES**

Dr. Hayes

Harvey Cornelius Hayes was born in North Fenton, New York, near Binghamton, on November 2, 1877, the son of William Henry and Edith Marion Hayes. His formal education was completed at Harvard University, where he received degrees of A.B. in 1907, A.M. in 1908, and Ph.D. in 1911. He was an assistant in physics from 1908 to 1911, and an instructor at Harvard from 1911 to 1913. In 1913 he went to Swarthmore College as a professor of physics and remained there for five years. His fields of contribution other than sound were principally cooling curves, magnetic susceptibility of water, rate flowmeters, sap flow, sap pressure, and oil prospecting.

During World War I Dr. Hayes, in association with other outstanding physicists, attacked the problem of detecting and locating enemy submarines. His effort was devoted to developing a listening device suitable for detecting, locating, and tracking. At the end of World War I, Dr.

Hayes remained with the Navy to continue work on the problem of detection and location of submarines. The sonic depth finder was a product of this period, and the MV hydrophone, using the same principle of beam steering as German World War II equipment, was completed.

In April 1923 he came to the new Naval Research Laboratory as Superintendent of the Sound Division where he initiated research on active sonar. Success in development of active sonar did not reduce Dr. Hayes' appreciation of passive detection. After 1928, further research on passive detection led to the development of a listening hydrophone using Rochelle salt as the active transducing element. This type permitted operation over a broad frequency band. By 1932, the combination of listening and echo-ranging equipment was available to the Navy. The optimum utilization was passive detection and active attack.

The next logical step forward was to use Rochelle salt transducers for transmission as well as reception. Research determined the conditions and restrictions under which the Rochelle salt crystals would deliver acoustic power, and a decided gain was achieved in replacing quartz by Rochelle salt transducers. The so-called QB equipment developed at NRL on the eve of World War II was one of two standard equipments. This provided both passive and active operation and incorporated "unicontrol" for tuning both transmitter and receiver with a single knob.

At the start of World War II, Dr. Hayes devoted a portion of his time to two tactical problems. One problem led to the techniques for using the variable QB beamwidth to advantage for both search and attack. He also analyzed the mediocre success of antisubmarine warfare in terms of the detection and attack factors. At that time the attack factor offered the better chance of immediate improvement. He therefore calculated escape areas and studied attack courses.

Late in World War II, Dr. Hayes undertook the development of attack equipment utilizing many techniques, both mechanical and electronic, developed by NRL during the war. This formed the basis of experimental fleet equipment.

Dr. Hayes led the Sound Division of NRL into the development of improved sonar domes and dome material, improved transducer designs, and techniques of localizing the target beyond the resolution of the sonar beam. Harbor defense sonar and mine location sonar were important developments. It was he who first recognized the potentiality of the helicopter and blimp in ASW, and the Sound Division developed the first sonar equipment for these vehicles.

Throughout the history of the Sound Division under Dr. Hayes, a substantial and continuing contribution was made in studies of ocean characteristics. Before 1940, the Laboratory had measured temperature changes with depth and had analyzed their importance in the refraction of sound. It had gone beyond this by correlating these conditions with the past history of cloudiness, wind velocity, sea state, and air temperature. It had delved into the calculation of sound velocity as a function of temperature, pressure, and salinity and had constructed sound ray diagrams for various ocean conditions. Dr. Hayes had cruised around the world mapping the ocean bottom. During and shortly after the war, additional work was carried out on surface and bottom reflections. Wave theory was applied to the propagation of low-frequency sound in shallow channels and experimental corroboration was obtained.

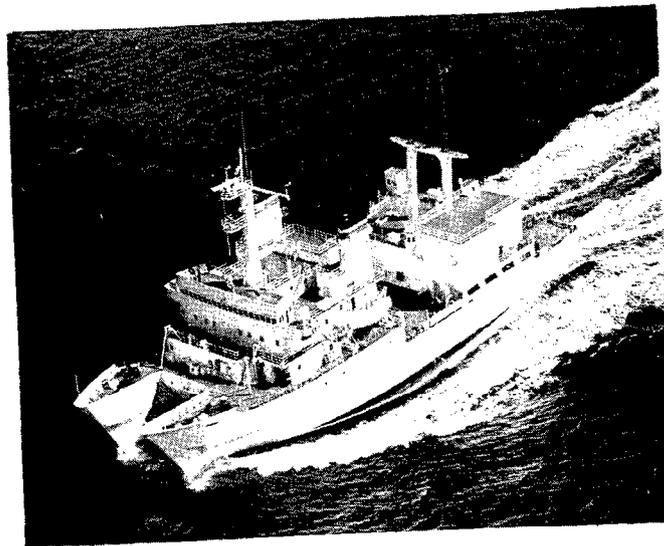
Dr. Hayes had been a Fellow in the American Physical Society, and a member of the Washington Academy of Science, the Geophysical Union, the Philosophical Society of Washington, and the Cosmos Club. He was a member of Phi Beta Kappa. Also, he was a recipient of the Levy gold medal and of the John Scott medal, both from the Franklin Institute, and the Cullom geographical medal from the American Geographical Society.

One of the greatest tributes to the contributions of Dr. Hayes and his colleagues was contained in a recovered order by Karl Doenitz, Grand Admiral of the German Navy, which is quoted in part:

“For some months past, the enemy has rendered the U-boat ineffective. He has achieved this objective, not through superior tactics or strategy, but through his superiority in the field of science; this finds its expression in the modern battle weapon — detection. By this means he has torn our sole offensive weapon in the war against the Anglo-Saxons from our hands.”

In 1945, Secretary of the Navy, James Forrestal, bestowed on Dr. Hayes the highest civilian award, the Distinguished Civilian Service Award, for his outstanding service to the United States Navy.

Dr. Hayes died on July 9, 1968.



(a)



(b)



(c)

Fig. 1 - USNS *Hayes* (T-AGOR 16)

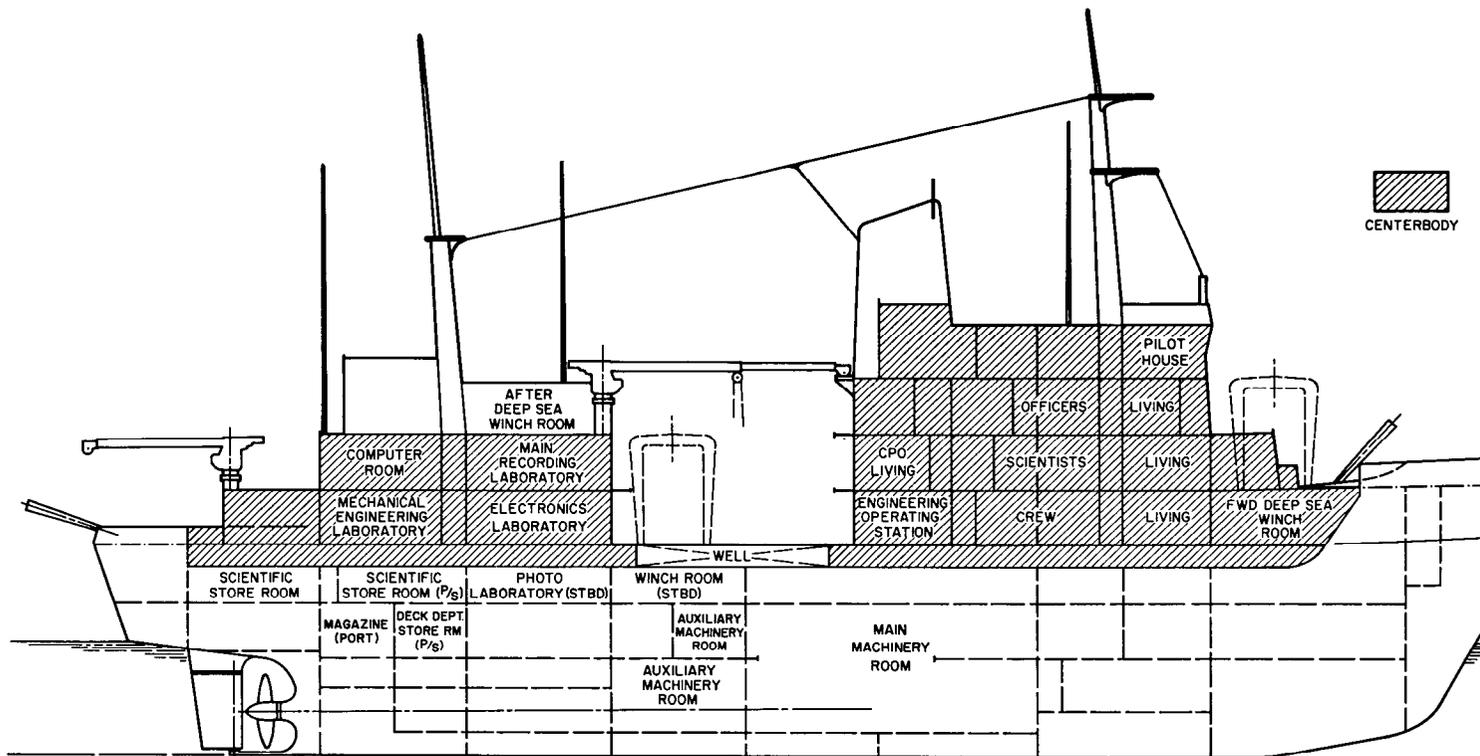
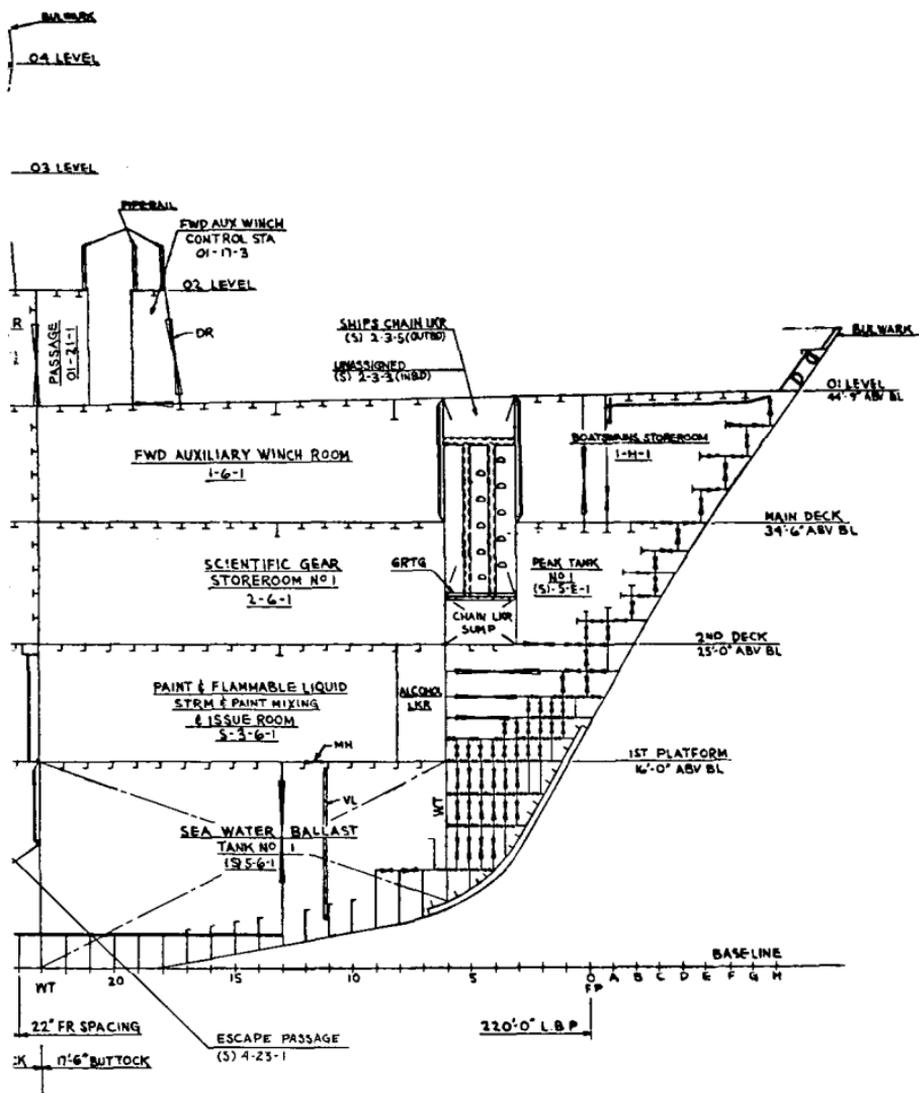


Fig. 2 — General arrangement of scientific and ship facilities



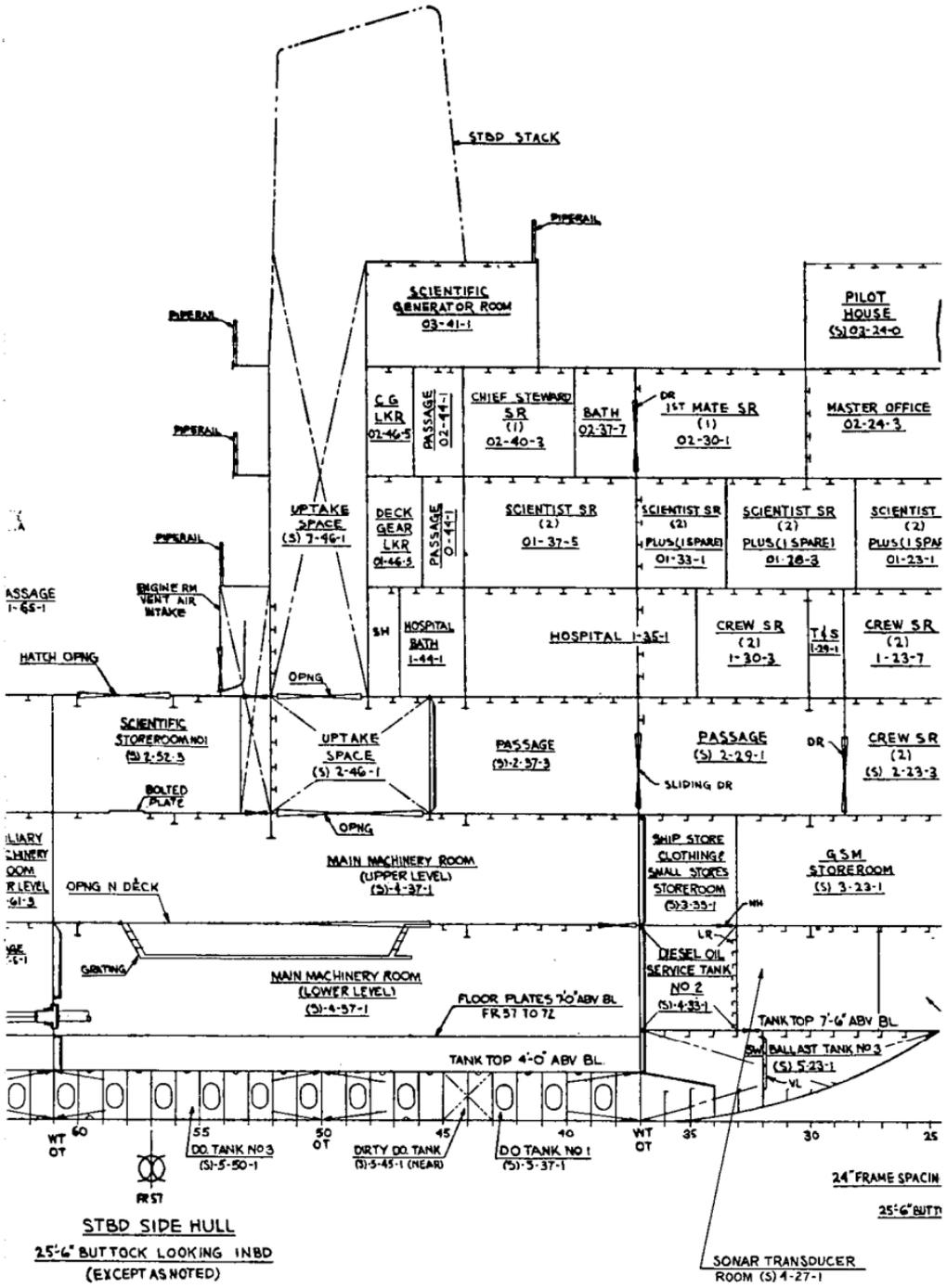
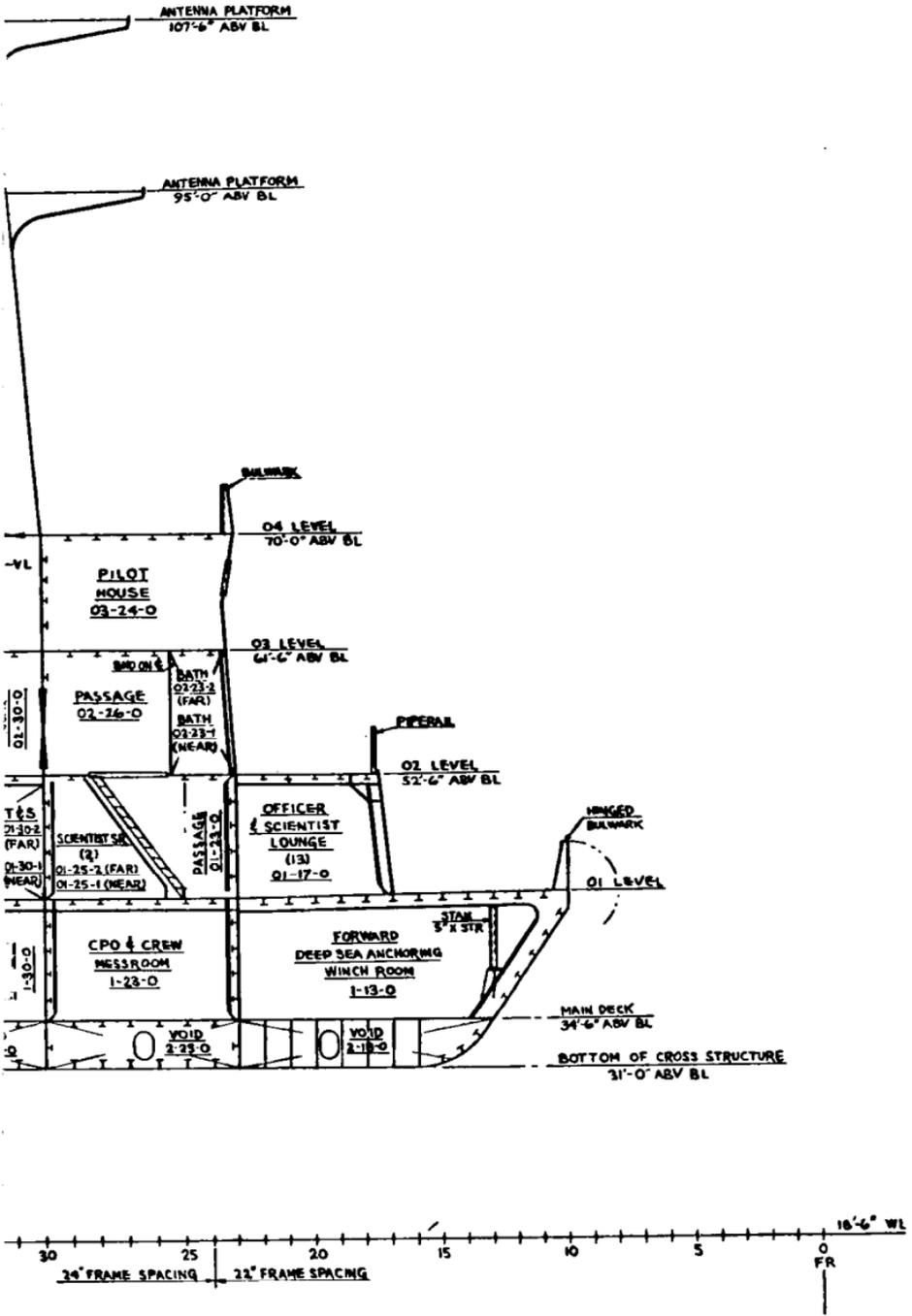


Fig. 3a — Elevation, starboard hull





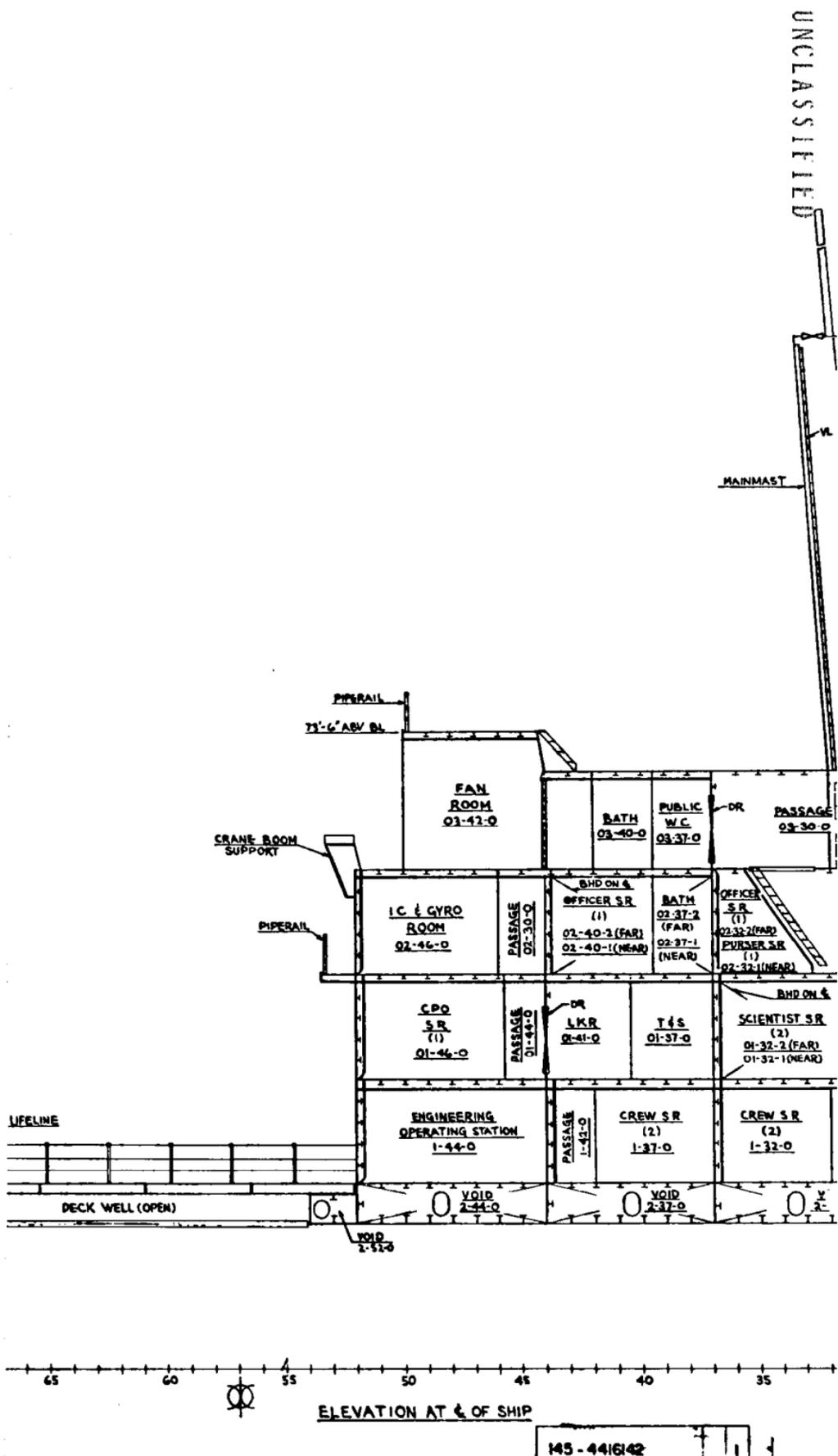
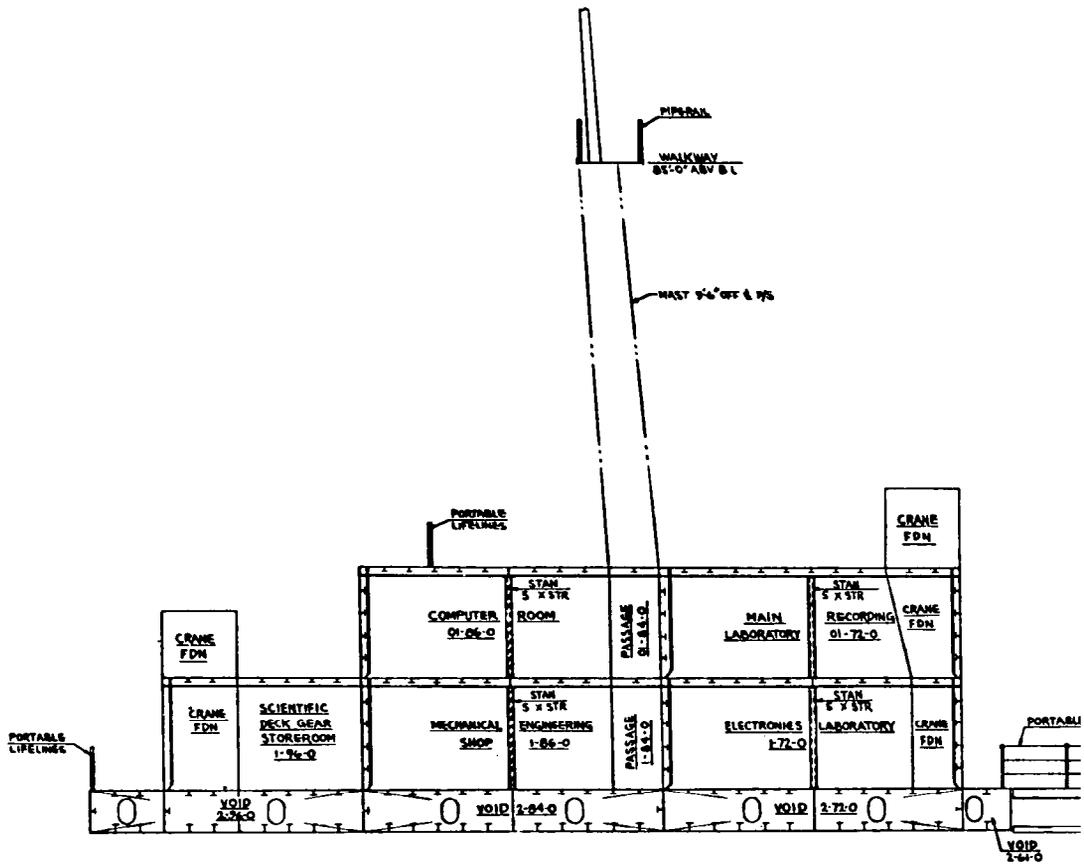


Fig. 3b — Elevation, inboard





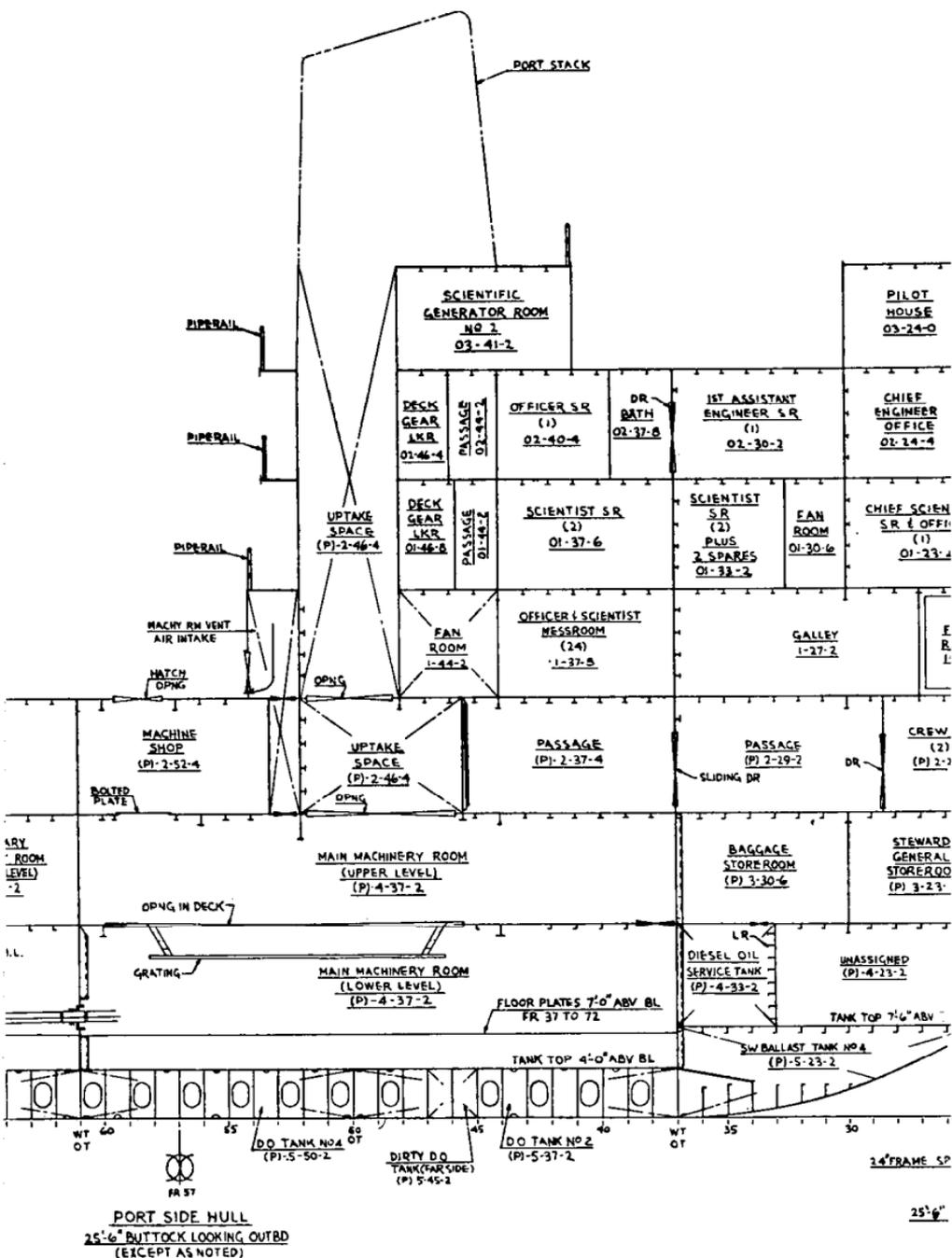
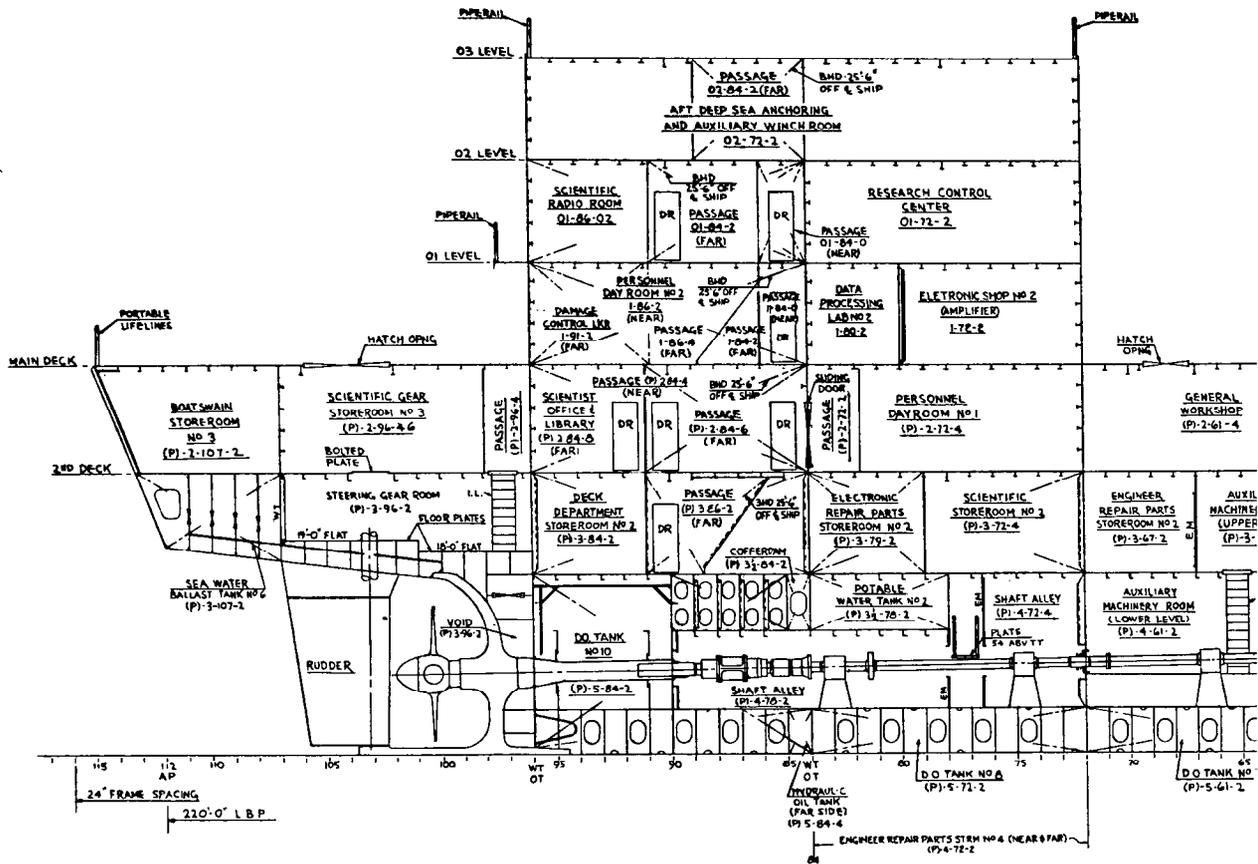
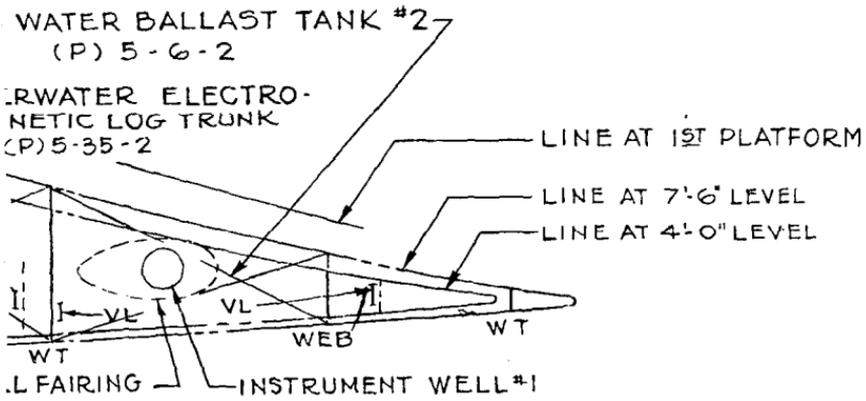
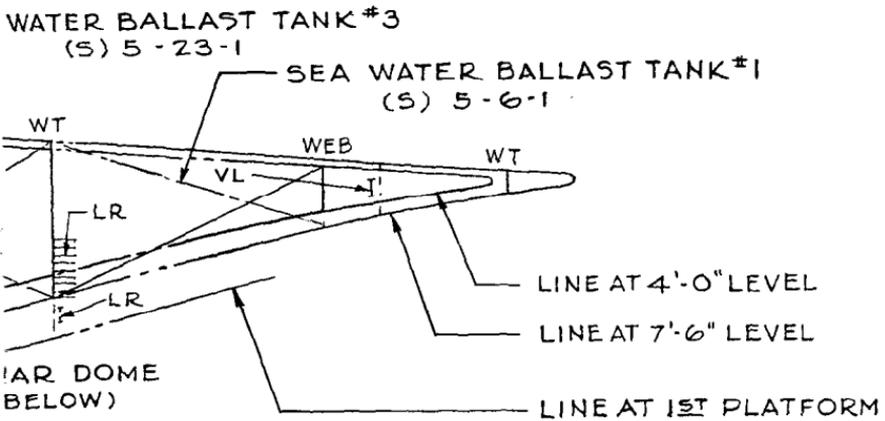
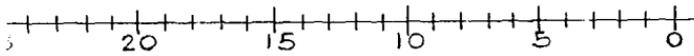


Fig. 3c — Elevation, port hull





LAST TANK #4



INK