NRL Report 7759

Relative Capabilities of USNS Hayes and USNS Mizar for Meeting NRL Shipboard Requirements

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Ship Engineering Committee
Oceanology Department

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

The Ship Engineering Committee conducted a study in which present and future at-sea operations and experiments performed in the Oceanology Area were examined with respect to their special requirements for ship facilities. Results of the study substantiate the premise that the *Hayes* design was based on the requirements of acoustics-type operations, while *Mizar* was configured to perform the search and recovery operations. More recently, other facilities have been added to *Mizar* to accommodate the requirements for the ocean sciences experiments. With few exceptions, however, both ships are well prepared to meet the requirements of all

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phases of the oceanographic research program undertaken by NRL. The most notable differences in the characteristics and capabilities of the two ships are fully discussed, and results of the study are presented in tabular form where possible, in an effort to provide a more convenient and comprehensive summary of pertinent information.

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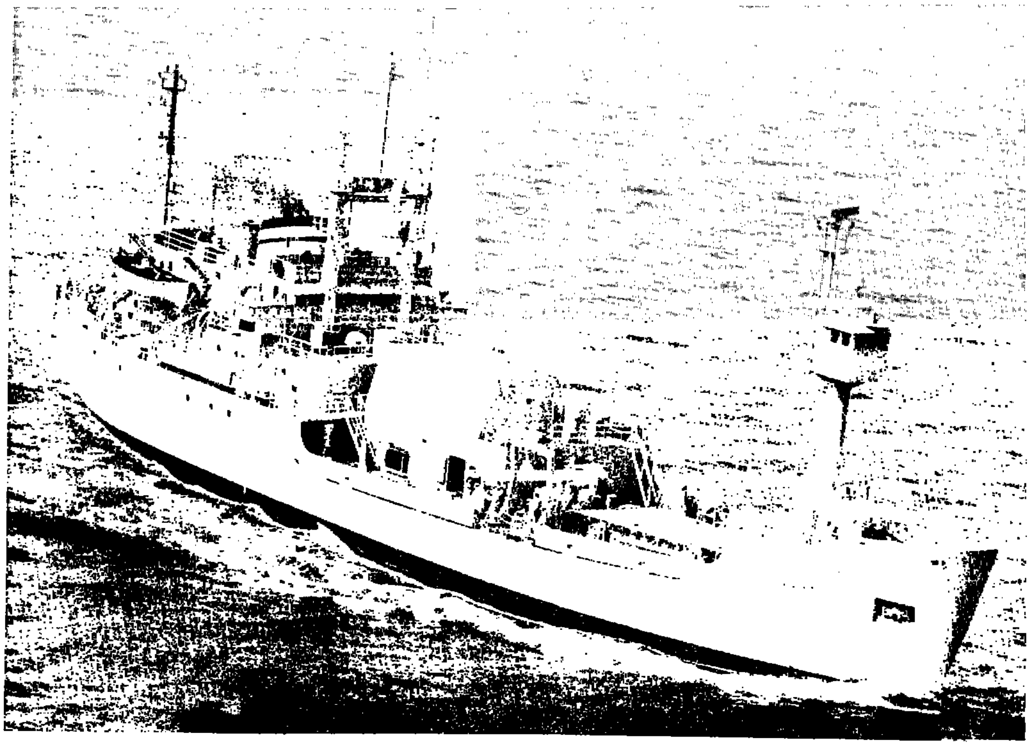

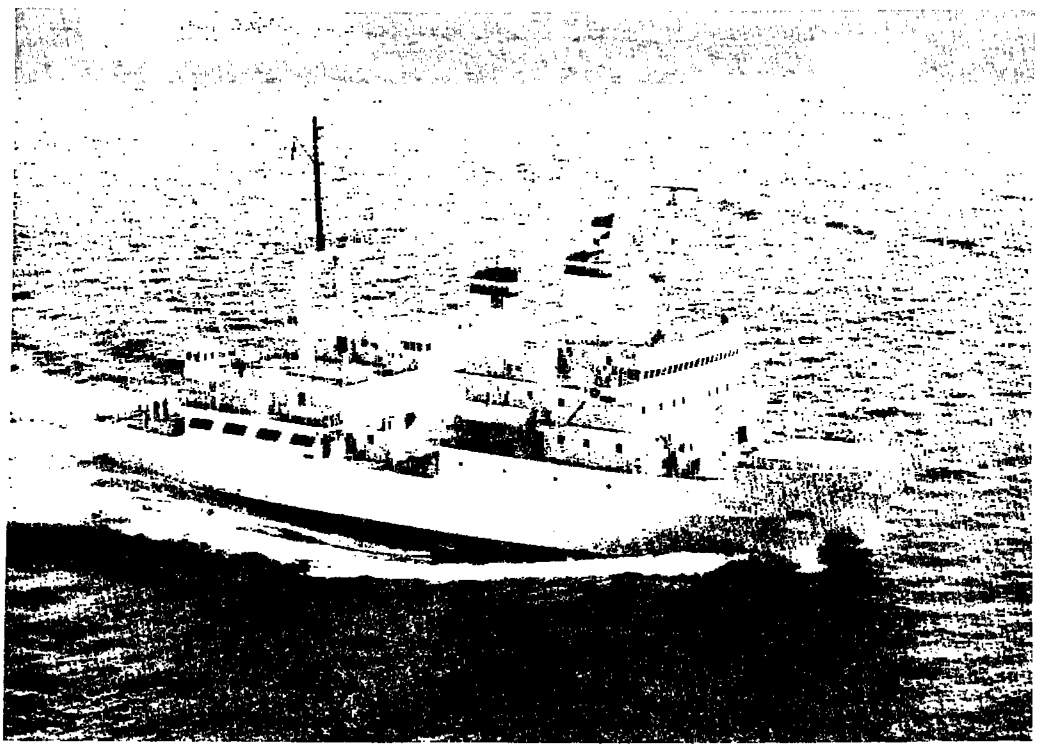

NRL—Sponsored Research Ships
USNS MIZAR (T-AGOR 11) and USNS HAYES (T-AGOR 16)

RELATIVE CAPABILITIES OF USNS HAYES AND USNS MIZAR FOR MEETING NRL SHIPBOARD REQUIREMENTS

INTRODUCTION

During the past 5 years, the Naval Research Laboratory (NRL) has conducted an extensive and diversified oceanographic research program requiring the simultaneous employment of at least two research ships. The ships currently sponsored and technically controlled by NRL are USNS *Mizar* (T-AGOR 11), a converted polar supply ship, and USNS *Hayes* (T-AGOR 16), a new research catamaran. The at-sea effort of NRL has included underwater photography, acoustics, bathymetry, magnetics, surveys, buoy handling, biological and chemical research, and search and retrieval of sunken vessels. Most of these operations are conducted in connection with research problems and consequently are supported by research funds. The daily rates paid for operation and maintenance of *Mizar* and *Hayes* during fiscal 1974 were $4600 and $4900, respectively. It is anticipated that these rates will increase substantially in fiscal 1975. Because of recent budget cuts and ever-increasing operation and maintenance costs, several oceanographic organizations have been forced to deactivate their ships.

In an effort to assemble more information on NRL ship requirements and capabilities, the Associate Director of Research for Oceanology has organized two ad hoc committees to study and assist in the determination of the most feasible course of action to be taken in the event further budget cuts necessitate relinquishment of *Hayes* or *Mizar*. The Ship Planning Committee has provided the Ship Engineering Committee with a list of "Continuing Shipboard Experiments," which include special shipboard requirements for the performance of these experiments, and a list of "Ship Attributes," consisting of such physical features as photographic laboratory, machine shop, and navigation facility. Using these inputs, the Ship Engineering Committee conducted a study and prepared this report, which is addressed to the various operational requirements of the seagoing scientists and the inherent capabilities of the two ships.

PHYSICAL CHARACTERISTICS OF *HAYES* AND *MIZAR*

Hayes and *Mizar* are quite dissimilar in appearance and certain physical characteristics, but the two ships complement each other in providing research facilities, because the inherent capabilities and attributes not available on one vessel in general are available on the other; so that almost every NRL shipboard operation can be performed by at least one of the ships without any degree of modification (Fig. 1).

Note: Manuscript submitted April 26, 1974.

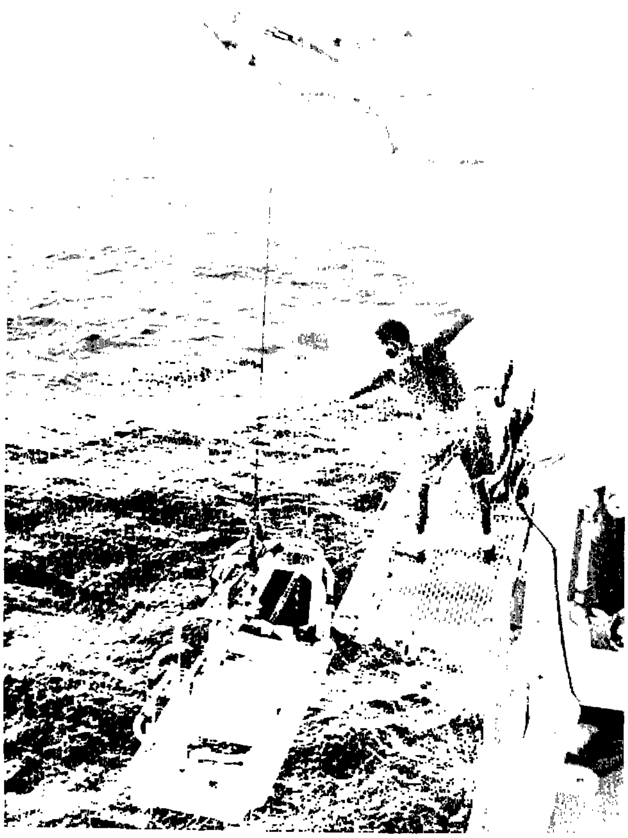

Fig. 1—A typical side-launching operation from USNS *Hayes* in which a test sled is being lowered by the midship equipment-handling deck machinery.

The physical characteristics of *Hayes* and *Mizar* are compared in Table 1.

Table 1
Physical Characteristics of Research Vessels *Hayes* and *Mizar*

Characteristics	USNS *Hayes*	USNS *Mizar*
Length, overall (ft)	246	266
Beam (ft)	75	51-1/2
Draft (ft)	21-2/3	20
Displacement (tons)	3180	3000
Pitch period (s)	6.4, at full scale with foil	11.5
Roll period (s)	8.5	9.0
Cruising speed (knots)	15	12
Creep speed (knots)	2 to 4 (auxiliary propulsion)	0.5 (minimum)
Cruising range (n.mi.)	6400	20,000
Endurance, at 10 knots (days)	20 (at 15 knots)	25 (at 12 knots)
Endurance, at 10 knots	27	35

Table 1 (Continued)
Physical Characteristics of Research Vessels *Hayes* and *Mizar*

Characteristics	USNS *Hayes*	USNS *Mizar*
Fresh-water processing rate (gal/day)	8000 (2 evaporators; each of 4000 gal. capacity)	4000 (2 evaporators; each of 2000 gal. capacity)
Fresh-water storage (gal.)	7500	34,460
Fuel oil capacity (tons)	368	680
Fuel oil consumption rate (bbl/day)	98	80-84
Port service requirements:		
Electrical power	440 V, 60 Hz, 3 phase, 800 A	440 V, 60 Hz, 3 phase, 400 A
Water (tons/day)	15	15
Steam (lb, saturated)	100 (2-in. line)	100 (2-in. line)
Other services	Telephone service Garbage collection	Telephone service Garbage collection
Ship's complement	11 officers, 34 crewmen	11 officers, 30 crewmen
Scientific personnel capacity	25 men and/or women	19 men and/or women
Propulsion equipment	Port and starboard diesel engines (main), 2700 hp each; 5400-hp total	Port and starboard diesel engines, 1600 hp each; 3200-hp total
	Port and starboard diesel engines (auxiliary) 165-hp each; 330-hp total	Port and starboard electric propulsion motors, 2700 hp total, 150 rpm max.
	2 variable-pitch propellers	2 solid 4-blade propellers
Steerage equipment	Twin rudders at 45-ft separation	Single rudder
Power equipment	3 ship's service diesel generators: 350 kW, 450 V, 3 phase, 50 Hz	2 ship's service diesel generators: 300 kW, 450 V, 3 phase, 60 Hz
	2 scientific diesel generators: 75 kW, 450 V, 3 phase, 60 Hz	1 ship's service diesel generator: 100 kW, 450 V, 3 phase, 60 Hz
Scientific handling equipment:		
Deep-sea winches	2 of 250 hp each	1 of 75 hp
Intermediate winches	3 of 125 hp each	2 of 25 hp each
Light-duty winches	1 BT winch of 5 hp 1 SMC winch of 5 hp 1 VERSUS winch of 15 hp	1 BT winch of 5 hp 1 SMC winch of 5 hp 1 T-MK 6 winch of 5 hp 1 Wellhouse winch of 3 hp

Table 1 (Continued)
Physical Characteristics of Research Vessels *Hayes* and *Mizar*

Characteristics	USNS *Hayes*	USNS *Mizar*
Deck cranes	1 midship and 1 stern: 25-ton lift at 15-ft radius and 4-ton lift at 60-ft radius	1 starboard: 5-ton lift at 15-ft radius and 3-ton lift at 25-ft radius
U-frame davits	1 bow: 25-ton static load and 7-1/2-ton transit capacity 3 starboard: 10-ton static load and 5-ton transit capacity 1 portside stern: 10-ton static load and 3-ton transit capacity	1 starboard: 10-ton static load and 3-ton transit capacity
Other davits	No other davits	1 stern-mounted Welin davit of 1-3/4-ton static capacity
Self-loading capability	Port and starboard	Starboard only
Hydrophone wells	3 of 30-in. dia., from ship's keel to main deck	3 of 12-in. dia., from ship's keel to second deck
Underwater tracking system	Not available	Acoustic array system
Scientific bathymetric system	16-kHz bathymetric system with 6.5° beamwidth and precision fathometer recorder 3.5-kHz profiling system with 30° beamwidth and precision fathometer recorder	12-kHz profiling system with precision depth recorder and precision graphic recorder
Scientific communication equipment	2 high-frequency transmitters 2 high-stability receivers 1 short-range transceiver 1 Teletype system 1 standard underwater telephone	2 single-sideband transceivers with linear amplifiers 1 FM 2-way radio set 1 general-purpose receiver 1 standard underwater telephone
Intercommunication system	Automatic dial telephone system	5-station intercom service (scientific only)
Scientific navigation equipment	1 loran C receiver 1 satellite navigation system 1 X-band radar system 1 dead-reckoning tracer	1 loran C receiver 1 satellite navigation system
Photographic laboratory facilities	Darkroom in chemistry laboratory	Photographic laboratory with processal film developer and darkroom

Table 1 (Continued)
Physical Characteristics of Research Vessels *Hayes* and *Mizar*

Characteristics	USNS *Hayes*	USNS *Mizar*
Storage compartment for explosives	20-ton magazine	Portable storage available
Laboratory work space (ft^2)	3000	2100
Mechanical and electronic workshops (ft^2)	900	670
Open deck work space (ft^2)	5000	3400
Scientific storage space (ft^2)	3000	2760
Work boat availability	16-ft Boston Whaler with outboard motor	16-ft Avon inflatable boat with outboard motor
Elevator (scientific use)	Not available	25-ft^2 3000 lb. capacity; Service available at 4 deck levels

The *Mizar* center well is a 23-ft-long by 10-ft-wide water-tight installation extending from the ship's keel to the main deck (Figs. 2 and 3). The well, which is enclosed by a deck house, is equipped with a hydraulically actuated cover at the main deck level and a carriage that traverses on vertical rails to guide equipment packages into and out of the water (Fig. 4). This arrangement provides a safe, convenient, reliable mode of operation close to the ship's center of pitch and roll; and, if necessary, equipment can be handled covertly. The *Hayes* center well, on the other hand, is simply a 32-ft-long by 16-ft-wide opening that extends from the main deck down to the tunnel separating the two hulls. The opening is provided with a folding hatch cover at the main deck level, but because the well does not reach the air–sea interface, an equipment-handling carriage arrangement is not applicable. At present this well can be used to launch and retrieve equipment while the ship is hove to, but to use it in a towing operation would require some modification.

The *Hayes* scientific handling gear consists of two 250-hp deep-sea winch systems, three 125-hp intermediate winches, five U-frame davits, two deck cranes, a deep-sea anchor windlass, and several smaller winch systems (Figs. 5 to 8). In addition to handling heavy equipment quickly and efficiently in deep water, this machinery also provides *Hayes* with the capability to bottom anchor by the bow or stern in water as deep as 25,000 ft for either a one- or two-point moor with 3/4-in. wire rope. *Mizar* is not equipped with handling gear of this caliber. The winch suite of *Mizar* consists of one 75-hp deep-sea winch, two 25-hp intermediate winches, one deck crane, and several smaller machines in the 5- to 15-hp class (Figs. 9 to 12). The *Mizar* deep-sea winch is equipped with three control stations, however, one of which is located in the Display and Control Laboratory (Fig. 13). Winch control from the laboratory is a highly desirable feature in search and/or survey operations.

Mizar has been provided with three tubular hydrophone wells that are 12 in. in diameter and extend from the second deck level down through the hull (Fig. 14).

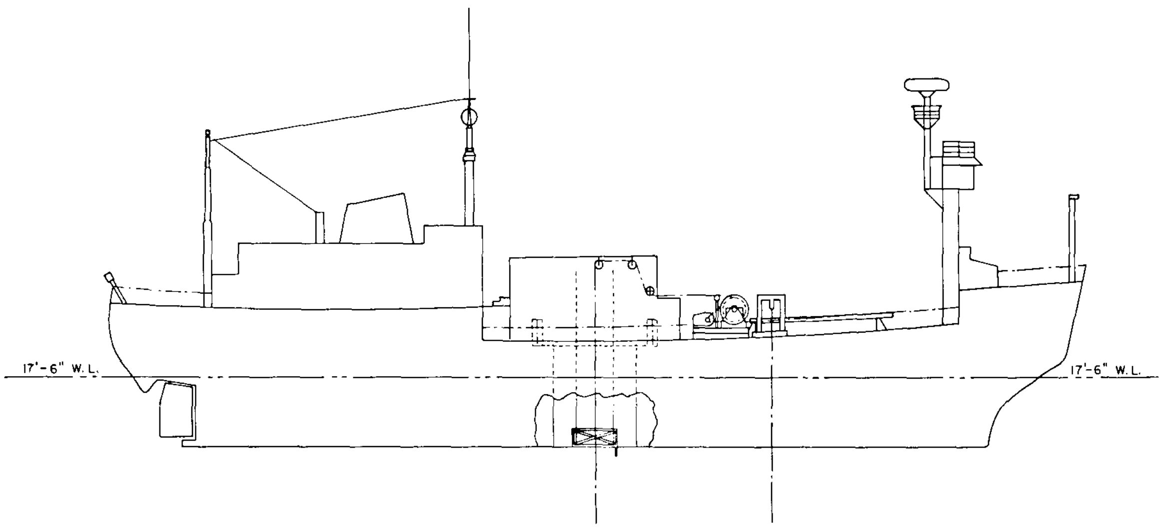

Fig. 2—Profile drawing of USNS *Mizar*, showing a cutaway view of the center well and carriage

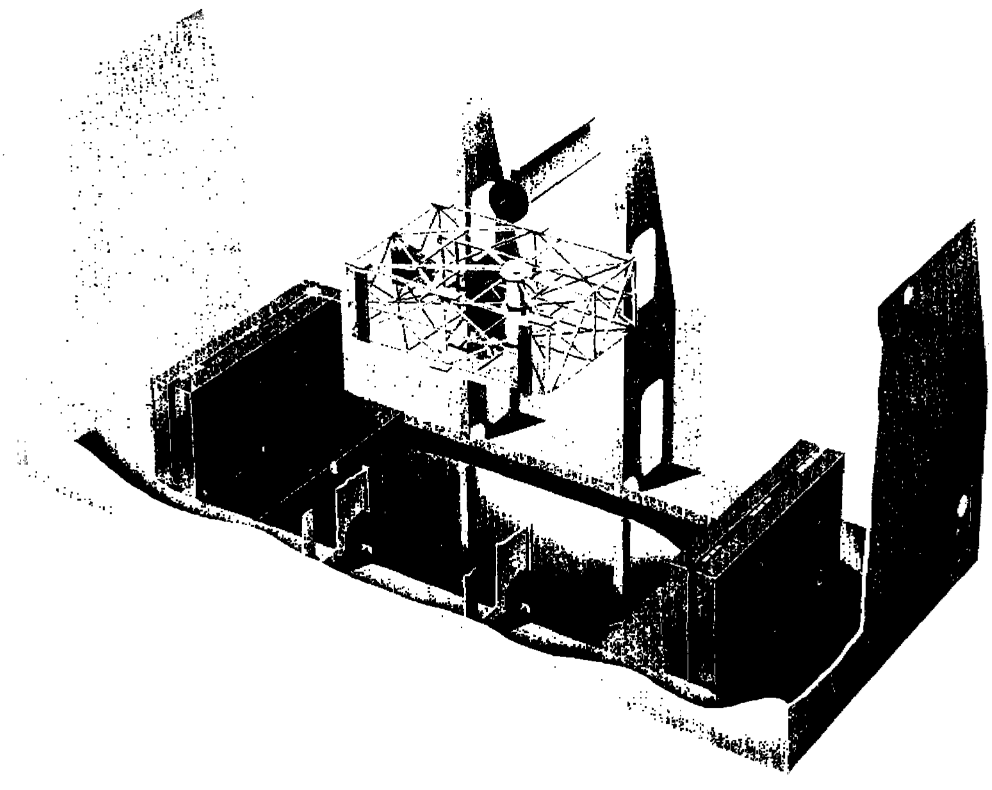

Fig. 3—Cutaway drawing of USNS *Mizar*'s well house, showing carriage in stowed position and center well hatch cover opened

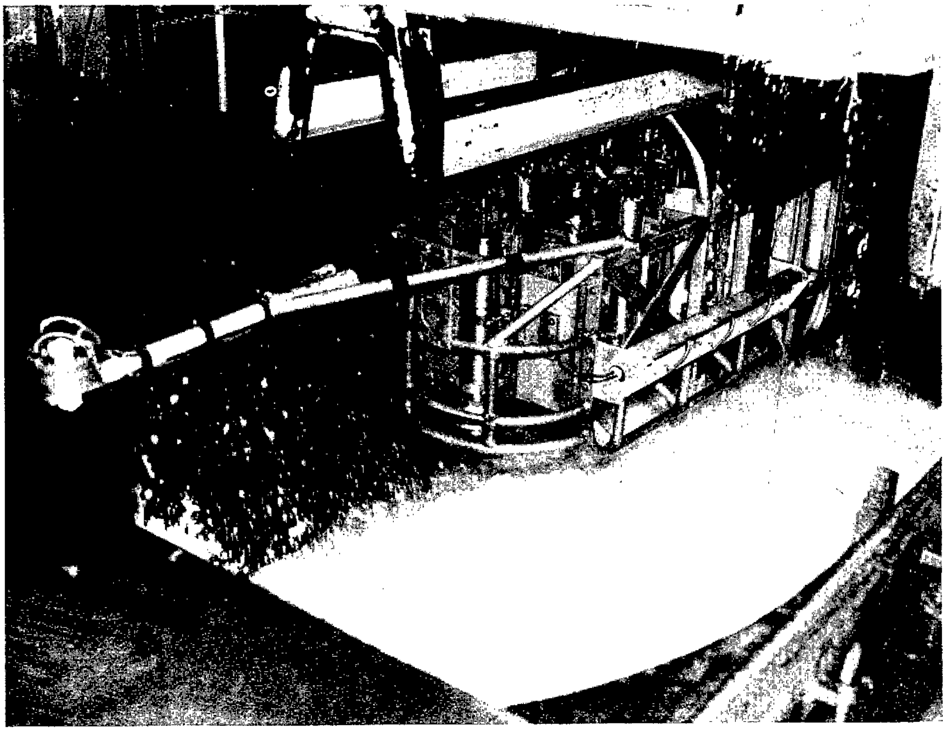

Fig. 4—Deep-sea search and survey vehicle being guided by carriage down through center well during launching operation from USNS *Mizar.*

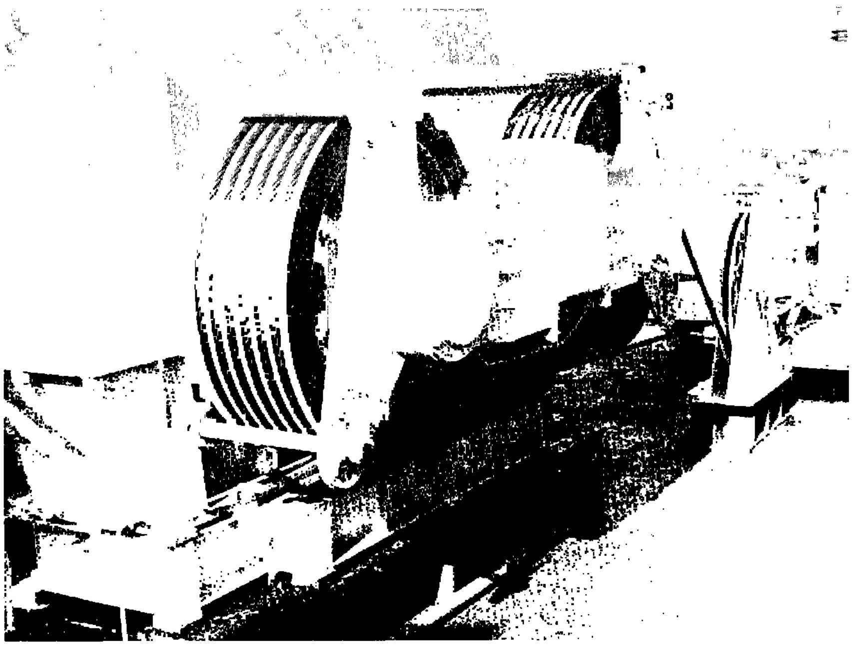

Fig. 5—Traction unit of the aft deep-sea winch system aboard USNS *Hayes*

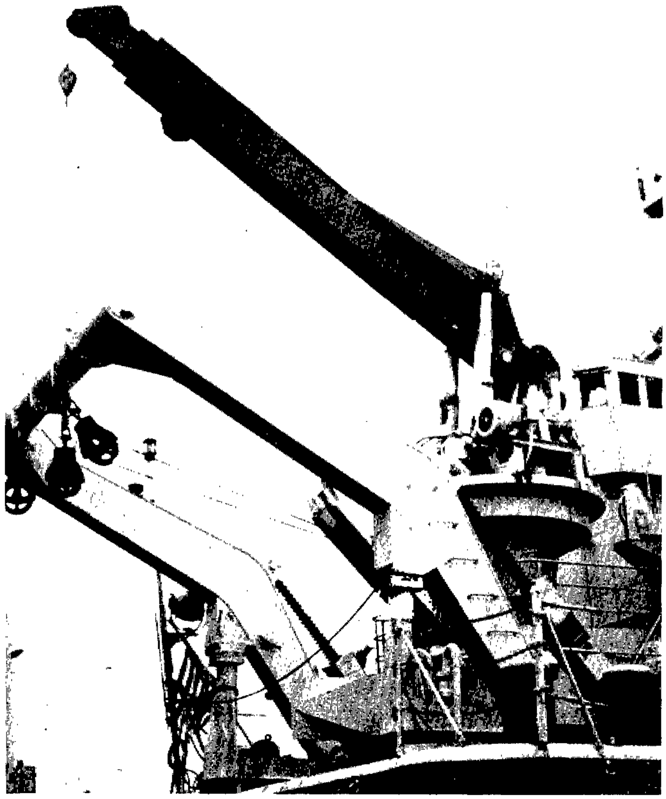

Fig. 6—Stern crane and stern starboard U-frame davit aboard USNS *Hayes*

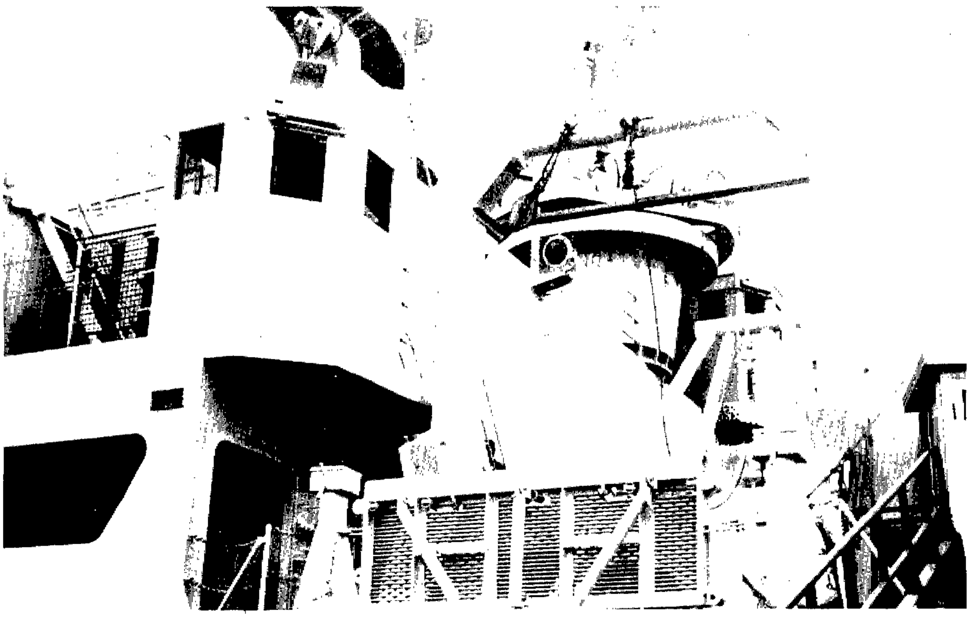

Fig. 7—USNS *Hayes'* midship equipment-handling facilities consist of crane, intermediate winch, U-frame davit, platform (shown in retracted position), and operator's control station.

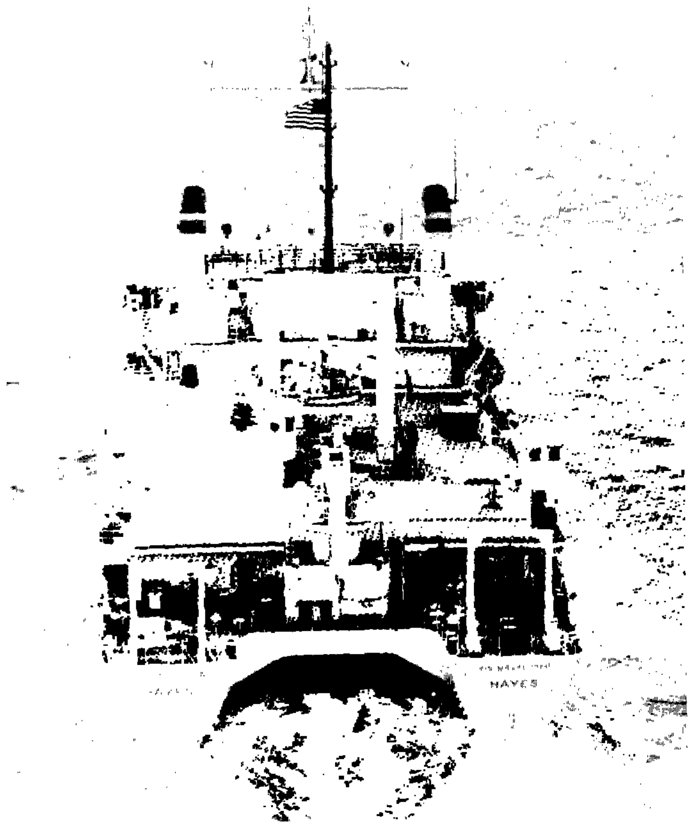

Fig. 8—Stern view of USNS *Hayes* showing cranes located on ship's centerline and U-frame davits installed on both hulls

Two of the wells are located on the portside of the ship, approximately 70 ft apart; the third well is located on the starboard side, approximately 50 ft away from each of the portside wells. The wells support the hydrophone components of the underwater tracking system (Fig. 15). The hydrophones are housed by standard Navy domes that protrude 34 in. beneath the ship's hull (Fig. 16). *Hayes* has three 30-in. diameter hydrophone wells that are similarly arranged and can also be used for an underwater tracking system. Provision has also been made on *Hayes* to install or remove transducers from inside the ship by pressurizing a sonar transducer room and separate escape passage.

Mizar's draft, including the domes, is 20 ft, compared to 21 ft, 8 in. for *Hayes.* This 20-in. difference is sufficient to enable *Mizar* to navigate the Potomac River and berth at the convenient home port of Alexandria, Virginia. *Hayes* uses berthing space at Cheatham, Virginia, which is 155 mi. from NRL.

Hayes can operate as an acoustically quiet ship. Specially mounted generators located high in the ship's superstructure radiate their sound more into an airborne path than into the ship's steelwork. The generators supply minimum hotel, navigation, and scientific requirements, with the quiet ship duration being governed by food spoilage.

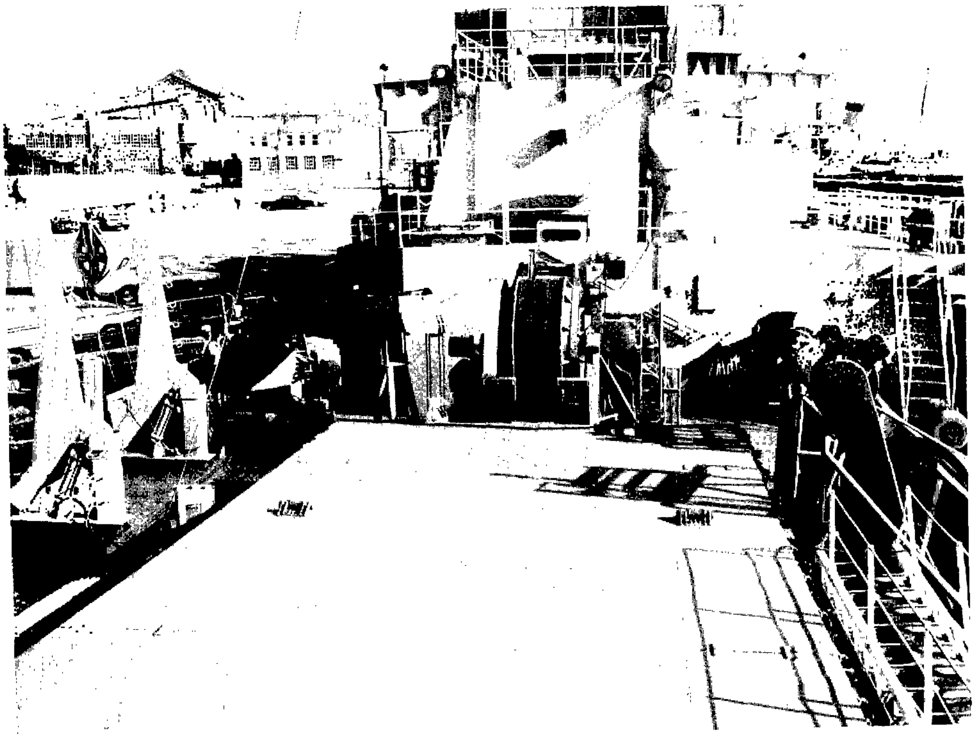

Fig. 9—View looking aft from USNS *Mizar*'s cargo hatch showing starboard U-frame davit, deck crane, deep-sea winch and two intermediate (RAP) winches

Mizar, being a converted polar-region supply ship, has a reinforced hull. This feature allows *Mizar* to operate safely in the Arctic and Antarctic regions.

NRL REQUIREMENTS AND SHIP'S CAPABILITIES

Mizar and *Hayes* serve as general-purpose, seagoing research ships for NRL, and as such they are assigned to carry scientists and instruments to sea for the purpose of conducting oceanographic research. This research consists of the study of sea-surface behavior; current structure of the ocean; oceanic temperatures; marine meteorology; environmental effects on instruments and techniques; earth's gravity and magnetic fields; bottom topography; sediments and structure; heat flow through the ocean floor; sound transmission and velocities; ambient noise; biological activity and specimen; nuclear components; and water samples for salinities, phosphates, oxygen, and nitrates. This section compares the special shipboard requirements of the three seagoing divisions in the Oceanology Department at NRL with the present capabilities of *Hayes* and *Mizar.*

Acoustics Division

Acoustics Division is concerned with measurements and other data reflecting changes in oceanic properties to support research projects associated with undersea surveillance, acoustic warfare, sonar systems, and underwater sound propagation. (See Table 2.)

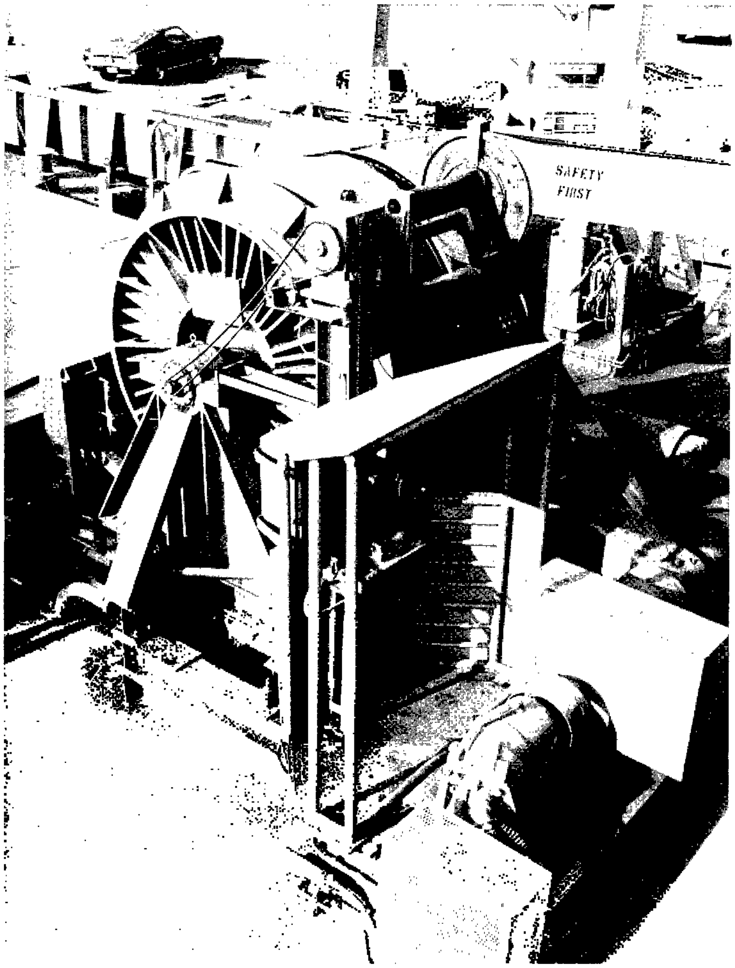

Fig. 10—Port-side view of USNS *Mizar's* deep-sea winch which hoists and lowers scientific equipment through the center well

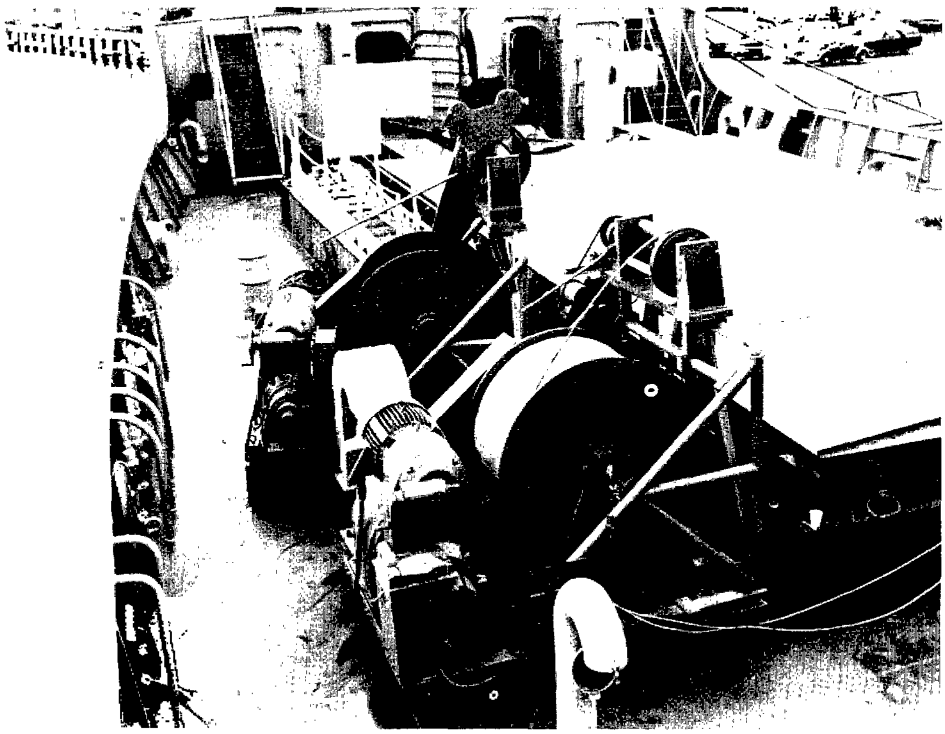

Fig. 11—Two intermediate (RAP) winches, located on portside of USNS *Mizar*, pay out cable athwartships through starboard U-frame davit

Table 2
Summary of Acoustics Division Requirements and Ship Capabilities

Operations or Experiments	Special Requirements	Present Capabilities	
		Hayes	*Mizar*
Array deployment tows	Ability to launch or retrieve acoustic array on armored electrical cable over bow	Yes	No
	Ability to launch or retrieve acoustic array on armored electrical cable through center well	No	Yes
	Ability to launch or retrieve acoustic array on armored electrical cable over the side	Yes	Yes
	Ability to launch or retrieve acoustic array on armored electrical cable over the stern	Yes	Yes
	Provision for 3 accurately located instrumentation mounting points for portable instrumentation to provide for under-way monitoring, tracking, or beacon sites	Yes	Yes
	Operable acoustic ray tracking system for relative positioning and tracking of underwater equipment	No	Yes
	Crane boom extension of 60 ft to assist in launch or retrieval and deck handling of large arrays or array segments	Yes	No
	Ability to load and spot on deck, port or starboard, without shore crane assistance, array segments or transducers weighing 5 tons	Yes	No
Source tows	Ability to tow simultaneously two 3-ton units at 1000 ft depth at 10 knots	Yes	Yes
	Ability to tow simultaneously four 5-ton units	Yes	No
	Ability to provide sliprings and multiwinch capability	Yes	Yes
	Ability to handle and stow 3/4-in. electromechanical cables in 36,000-ft lengths	Yes	No
	Power amplifier capability to simultaneously provide 20 kW to 4 separate towed transducers	Yes	No
	Ability to provide interconnecting cabling from any launch or winch location to the electronic recording instrumentation	Yes	Yes
	Ability to provide space, tiedown facilities, and one-point grounding for 80 instrumentation racks	Yes	No
	Remote monitors for shaft RPM, propeller pitch rudder angle, pit log, gyro compass, and wind speed and direction in all recording laboratories	Yes	No
	Ability to provide 150 kW of 60-Hz power, regulated for frequency and voltage to ±1% and transient free	Yes	Yes
Buoy deployment	Ability to covertly launch buoys	No	Yes
	Ability to deploy buoys weighing more than 12,000 lb	Yes	No
	Small boat accurate X-band radar to locate and retrieve low-riding buoys	Yes	Yes
Quiet ship operation	Special power source for quiet ship operations	Yes	No
Bottom anchoring	Bow and stern anchoring capability in 25,000 ft of water	Yes	No
	Ability to launch or retrieve transducers and arrays through center well	No	Yes
	Ability to 3-point moor in shallow water and to recover 3 moors without assistance	Yes	No
Bathymetry	Hull-mounted bottom profiling system(s)	Yes	Yes
	Ability to provide usable bathymetry record that does not lose the bottom for the duration of a 10-knot tow	Yes	Yes

Table 2
Summary of Acoustics Division Requirements and Ship Capabilities

Operations or Experiments	Special Requirements	Present Capabilities	
		Hayes	*Mizar*
Transducer testing	Ability to handle transducers weighing up to 15,000 lb	Yes	Yes
	Ability to power attend instrumentation and transducers on the sea floor	Yes	Yes
Instrument calibration	Shipboard instrument calibration facility	Yes	No

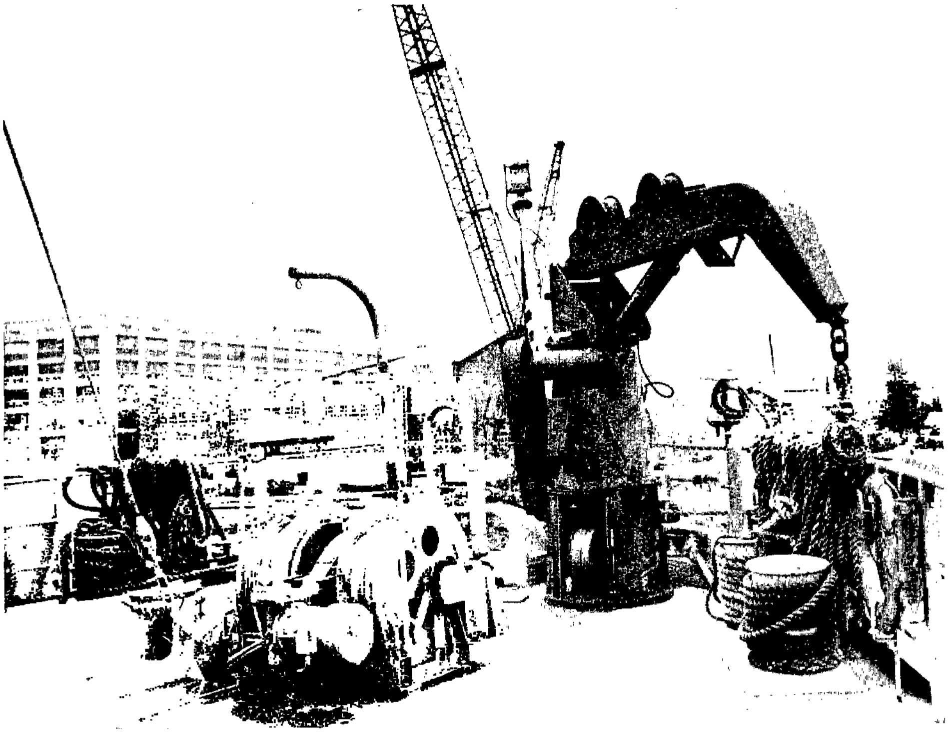

Fig. 12—Streaming winch (T-Mk 6) and Welin davit, located on stern of USNS *Mizar*

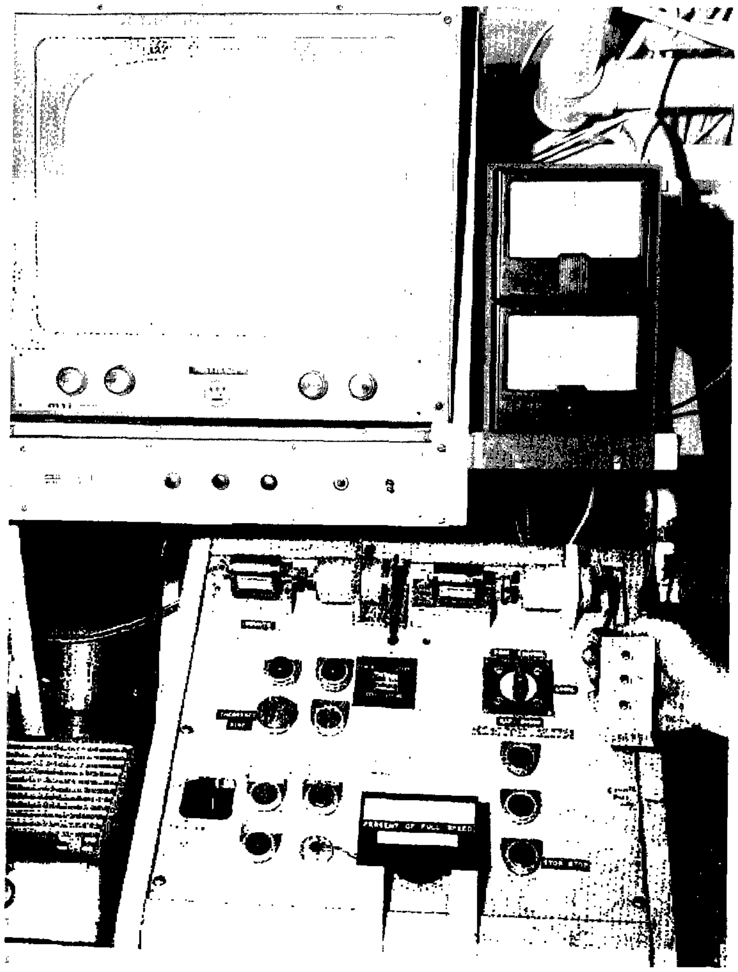

Fig. 13—Deep-sea winch control station located in Display and Control Laboratory of USNS *Mizar*

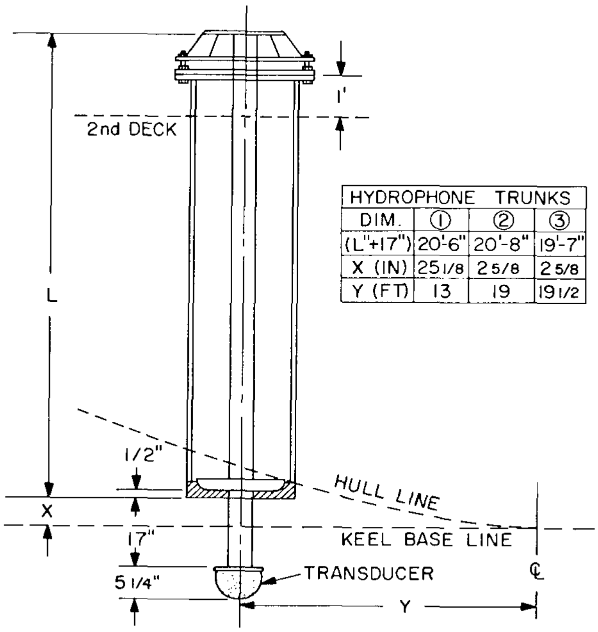

Fig. 14—Drawing of typical hydrophone well installation on USNS *Mizar.* Table includes *L, X,* and *Y* dimensions associated with the drawing.

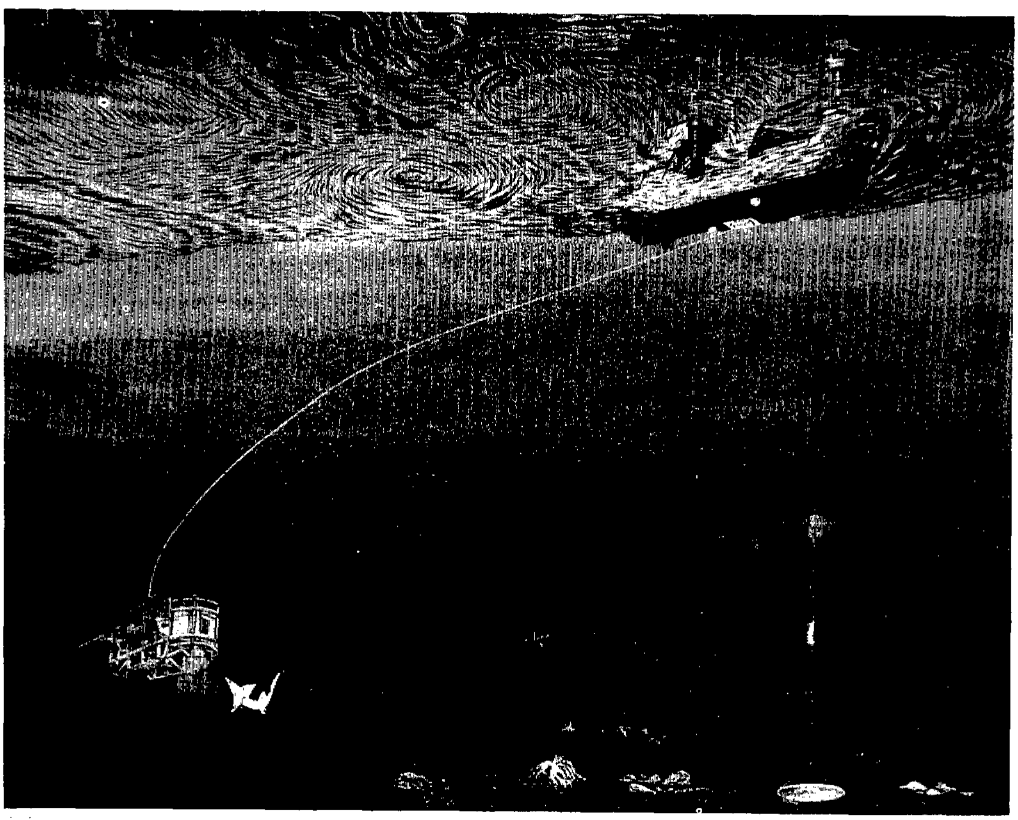

Fig. 15—Artist's conception of deep-sea search vehicle being towed by USNS *Mizar* and monitored by her three-hydrophone underwater tracking system

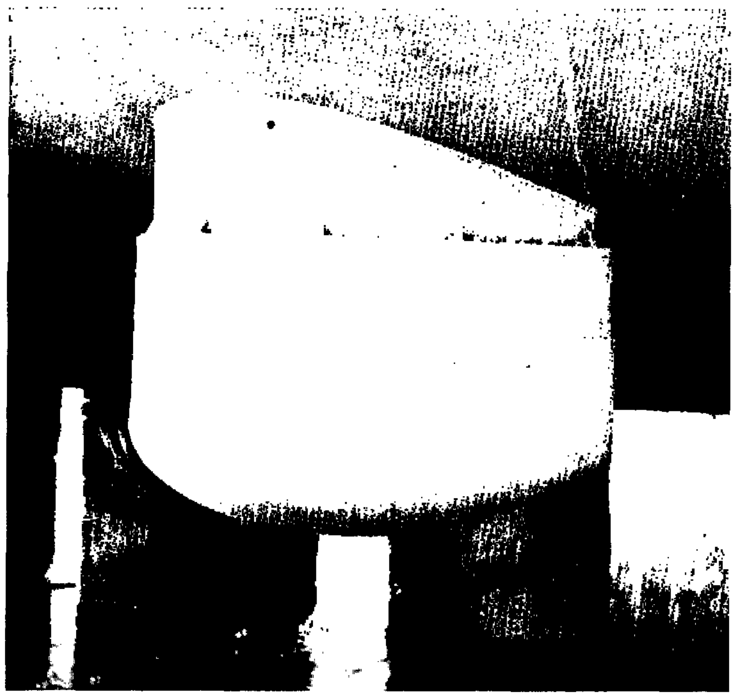

Fig. 16—Typical sonar dome installation providing protection for one of the three USNS *Mizar* underwater tracking system hydrophones

Array Deployment and Tows—The capability of deploying towed arrays is determined by the array length, element spacing, element size, stowage drum size, open deck requirement for hand flaking, and whether the elements are in line or attached at the deck edge. An array that can be manhandled over the side and attached to the end of an armored electric cable can be launched and retrieved by both *Hayes* and *Mizar*. *Mizar* can launch an array the size of its well opening (21 by 8 ft) and provide a line pull of 12,000 lb including the carriage weight when the array and carriage are in air, or an 8000-lb array weight. *Mizar* can also tow the array at slow speed because the tow point is at keel depth. As presently configured, *Hayes* does not have a keel-depth tow point. Plans were drawn by the architect (Rosenblatt) for the provision of a structure to launch large arrays through the well. The plan specifications were to launch, tow, retrieve, and stow an array of 200,000 lb in the well area with a tow point at the waterline. The size of the array would be 25 ft long, 8 ft deep, 18 ft high, and the tow speed would be 2 knots with the array at a depth of 1000 ft.

An in-line array of a length requiring winch pull to launch and retrieve would also require sheaves to pass the modules and deck space to install the stowage reel. The *Mizar* center well sheave size and arrangement would require modifications to satisfy the demand. The U-frame launch on *Mizar* would require chafing protection from the bilge keel, or transfer of the tow point to the stern, or a means of keeping the wire away from the hull. *Hayes* has large open deck spaces adjacent to all overboarding areas for stowage drum location. Heavy modules attached to the cable at the deck edge with takeouts in the cable can be handled from either ship. However, the open stern area on *Hayes* affords an accessible area for local staging of the components. The large metacentric height of *Hayes* allows large weights (as much as 100 tons) to be placed anywhere on the structure without affecting the seakeeping ability of the ship.

Source Tows—Towing low-frequency sources at depths to 1000 ft and ship speed to 10 knots requires multiple winches and overboarding capability. Past experiments have required that two sources (one deep and one shallow) be towed at the same time. Both the *Mizar* and *Hayes* have performed the simultaneous two-unit tow; however, a simultaneous tow of four transducers could not be performed on the *Mizar* as presently equipped. Additional winches and over boarding structures would have to be installed. The *Hayes* can tow four separate transducers with the winch and overboarding capability as presently configured. The limiting factors on the *Hayes* would be the 20,000-lb line tension and a 10,000-lb transiting load on two U-frames, 15,000 lb on another, and 6000 lb on the port stern U-frame. In an effort to avoid entanglement of the lines in the water or with the ship's propellers, selection of the tow-point location and separation requires serious consideration.

Buoy Deployment—Both ships can deploy NRL subsurface instrumented buoys. However, *Mizar* has the capability of launching buoys covertly because of the enclosed wellhouse. Both ships can launch surface buoys of reasonable size; however, long spar buoys would be easier to launch and stow on *Hayes* because of the proximity of the cranes to vertical bulkheads of three deck heights. Surface mooring buoys weighing over 6000 lb would have to be towed or cut loose from the deck edge of *Mizar*. *Hayes* would require the same deck edge or tow procedure for surface mooring buoys weighing more than 15,000 lb.

Quiet Ship Operation—Only *Hayes* has quiet operation capability, and this feature has been checked and recorded at the Atlantic Underwater Test and Evaluation Center's range. This capability is provided by specially mounted generators high in the superstructure that radiate their sound more in the airborne path than the steelwork. These generators supply minimum hotel, navigation, and scientific requirements. The limit of quiet ship time is governed by food spoilage.

Bottom Anchoring—Anchoring hydrophones on the bottom requires that the ship be anchored also. *Mizar* does not have an anchoring capability for scientific purposes. *Hayes* can anchor by the bow or stern in water as deep as 25,000 ft for either a one- or two-point moor with 3/4-in. wire rope (Fig. 17). Monitoring bottom-mounted equipment would be governed by the length and strength of an armored electric cable capable of withstanding the anchor tensions. A 28,000-ft triple-armored coaxial cable has been used in the past for anchoring in 15,000 ft of water. *Hayes* can lay her own tri-moor in shallow water and power attend bottom-mounted instrumentation while in the moor. *Hayes* recently laid a tri-moor in the Gulf of Mexico in 450 ft of water with a 1.5-knot current and 20-knot winds and then calibrated a Mark VI source that was placed on the bottom. The estimated swing of the ship in this tri-moor was within a 450-ft-diameter circle. This tri-moor operation required the use of four winches, one crane, and three U-frames.

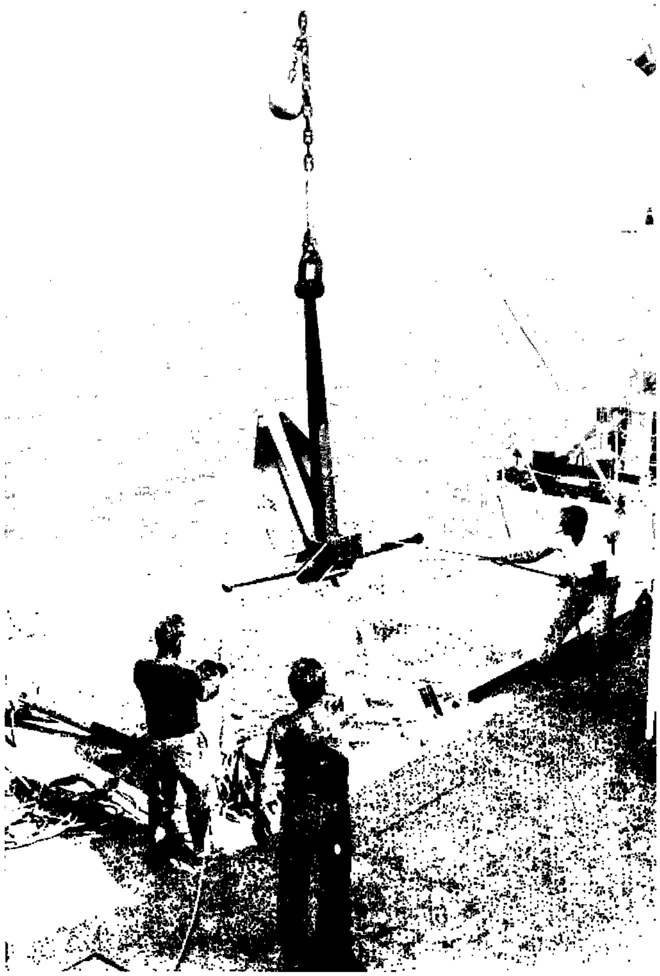

Fig. 17—Anchor being launched during a stern anchoring operation of USNS *Hayes*

Bathymetry—Hayes is well suited for bathymetric operations. The bathymetric equipment consists of a narrow-beam bathymetric system, a bottom or 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.

The *Hayes* EDO-313 narrow-beam bathymetric system has a 16-kHz transducer (EDO 202), 6.5° beamwidth, 34-in. face diameter, source level of approximately 130 dB, and receiving sensitivity of approximately 84 dB. The 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.

The bottom-subbottom profiling system has a 3.5 kHz transducer (EDO 240H), 30° beamwidth, 35-in. diameter, and receiving sensitivity of approximately 84 dB. Its electronics consist of a 2-kW transceiver, an 8-kW amplifier, and a system control (EDO 248B).

Mizar is equipped with one AN/UQN-1B precision fathometer. This 12-kHz instrument is connected to a precision depth recorder (PDR) and a precision graphic recorder (PGR), both of which are located in the Control and Display Laboratory (Fig. 18).

Transducer Testing—*Mizar* is limited to an 8000-lb transducer through the center well and a 6000-lb unit using the U-frame. *Hayes* is limited to a transducer weight of 15,000 lb on either the stern or forward U-frame.

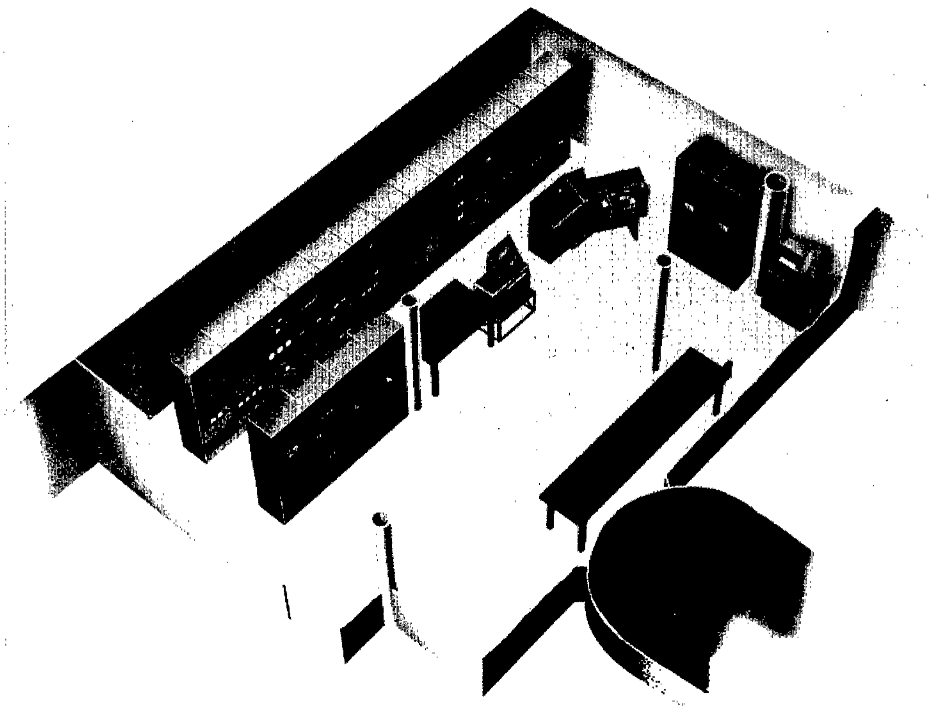

Fig. 18—Drawing of USNS *Mizar's* Control and Display Laboratory, in which readout instruments connected to various sensing devices located throughout the ship and in the sea are monitored by scientific personnel

Both ships have a reserved compartment for power amplifiers. *Mizar* does not have permanent power amplifiers installed. *Hayes* has two 20-kW power amplifiers installed and provisions for two more identical amplifiers that would allow either single or multiple operation.

Instrument Calibration—*Hayes* has a mechanical workshop for calibrating small instruments. A 16-in. projectile is used with a hydrophone calibrator and large dial Heise gages for onboard pressure calibration from 0 to 10,000 psi. The projectile is permanently welded into the ship's structure, and the pressure circuit requires a modification to smooth out pump-up pressure fluctuations to allow vernier-type accuracy. The hydrophone calibrator is a portable fixture that can be installed temporarily on other vessels.

Ocean Sciences Division

The Ocean Sciences Division is concerned with the collection and analysis of data and samples from the sea in an effort to support studies in marine atmospheric physics; marine biology; and chemical, physical, and applied oceanography. (See Table 3).

Table 3
Summary of Ocean Sciences Division Requirements and Ship Capabilities

Operations or Experiments	Special Requirements	Present Capabilities	
		Hayes	*Mizar*
Atomspheric sampling and analysis	Provision of space on ship's forecastle for installation of atmospheric sampling and sensing equipment	Yes	Yes
Biological sampling and analysis	Ability to collect water samples by Rosette sampler and Niskin bottles	Yes	Yes
	Ability to tow plankton nets at 500-m depth	Yes	Yes
	Ability to deploy Tucker trawl to depth of 500 m	Yes	Yes
	Provision of deck and wet laboratory space to handle specimens caught in nets	Yes	Yes
	Ability to launch or retrieve a sampling skiff under calm sea conditions	Yes	Yes
	Scientific navigational facilities to enable ship to return to station within 1 mi	Yes	Yes
Chemical sampling and analysis	Provision of facilities for the handling and stowage of Niskin bottles	Yes	Yes
	Ability to handle 6-ft, 300-lb "fish" at 100 m	Yes	Yes
	Provisions of various gases under pressure in chemistry laboratory	No	Yes
	Clean room for handling oceanographic samples for trace analysis	No	No
	Wet laboratory for handling cores and water samples	Yes	Yes
	Ability to launch or retrieve STD microprofiler	Yes	Yes
Geomagnetic operations	Ability to tow simultaneously deep and surface magnetometers	Yes	Yes
	Shipboard computer facility, complete with computer	No	No
Bottom coring	Ability to extract cores requiring 12,000-lb line pull	Yes	Yes
	Ability to extract cores requiring 50,000-lb line pull	Yes	No
	Ability to bring aboard a 30 ft core in a vertical manner and stow in or out of the weather in its undisturbed vertical position	Yes	Yes
	Refrigerated stowage for cores	Yes	No
Nonacoustic anti-submarine warfare	A specially equipped oceanographic ship is required for research in support of nonacoustic ASW being conducted by the Applied Oceanography Branch of the Ocean Sciences Division. During the past year the USNS *Lynch* has been equipped with special research equipment and used effectively at sea in preliminary research exercises.	No	No

Atmospheric Sampling and Analysis—The principal shipboard requirement for these experiments is work space on the forecastle or other elevated bow location from which the atmosphere may be sampled devoid of exhaust stack gases and other contaminating ship emanations. This operation also requires the use of a shipboard computer, the installation of which may be either permanent or temporary. Because there are no immediate plans for performing this experiment in the Arctic region where *Mizar*'s ice-operating capabilities would be of significance, it appears that both *Mizar* and *Hayes* would be suitable.

Biological Sampling and Analysis—Performance of experiments related to marine biology requires the following shipboard operations:

- Collection of water samples by Rosette sampler and Niskin bottles
- Towing both 0.5-m closing nets and 1-m open plankton nets as deep as 500 m
- Deployment of 6-ft Tucker trawls (opening and closing) to depths of 500 m
- Lowering photometers over the side to 200-m depths under darkened ship conditions
- Lowering salinity-temperature-depth (STD) sensors to 2000-m depths
- Launch of expendable bathythermograph (XBT) probes
- Launch and retrieval of acoustic profile transducers, with associated precision depth readout and recording in the laboratory
- Launch and retrieval of sampling skiff under calm sea conditions

These operations require ample open deck space with suitable davits and intermediate range winches; adequate electronics, chemistry, biology, and wet laboratory spaces; topside stowage of compressed gases with appropriate piping to laboratories located below decks; and scientific navigation equipment capable of directing the ship to within 1 mi of its desired station of operation. Both *Hayes* and *Mizar* are equipped to perform such operations; however, *Hayes* would require the installation of gas lines from the bottle stowage area on the main deck to the chemistry laboratory located on the second deck (Fig. 19).

Chemical Sampling and Analysis—Chemical shipboard experiments are principally concerned with the sampling and analysis of seawater. The following operations are performed by chemical oceanographers:

- Deployment of hydrocasts using Niskin bottles (5 to 30 l)
- Lowering of a 6-ft, 300-lb water-sampling vehicle ("fish") supported by a faired coaxial cable to a depth of 100 m. This vehicle may be deployed over the side or from the stern.
- Pumping of "undisturbed" water samples from protruding inlets in the bows or center wells of the ships to the wet laboratory areas for bottling or immediate analysis
- Future deployment of a deep-towed fish equipped with in-situ sensors
- Future deployment of an untethered fish equipped with electrochemical sensors

These shipboard operations require the use of fast-hauling, intermediate-load winches and suitable davits for deploying sampling equipment; ample wet and chemical laboratory space for handling and analyzing samples; and medium-capacity immersion pumps for pumping seawater to the laboratory areas. Both *Hayes* and *Mizar* are capable of satisfying present requirements, but future operations may require minor modifications to both ships.

A clean room for handling oceanographic samples for trace analysis, improved wet laboratory facilities, and capabilities for supporting and handling an untethered fish are some of the improvements that must be added to both ships to satisfy future operational requirements.

Geomagnetic Operations—Experiments associated with geomagnetics require the capability of the ship to launch and simultaneously tow surface and deep magnetometers, which are usually enclosed in vehicles. Because electrical signals must be transmitted from the submerged instrument through the tow cable to readout, printout, and/or other recording instruments in the laboratory, the winches must be equipped with sliprings. The deep magnetometer may require as much as 10,000 m of coaxial cable; also, a shipboard computer and precise navigation equipment are required. Geomagnetic experiments can be performed from both *Mizar* and *Hayes* when the necessary laboratory instruments are installed for the operation.

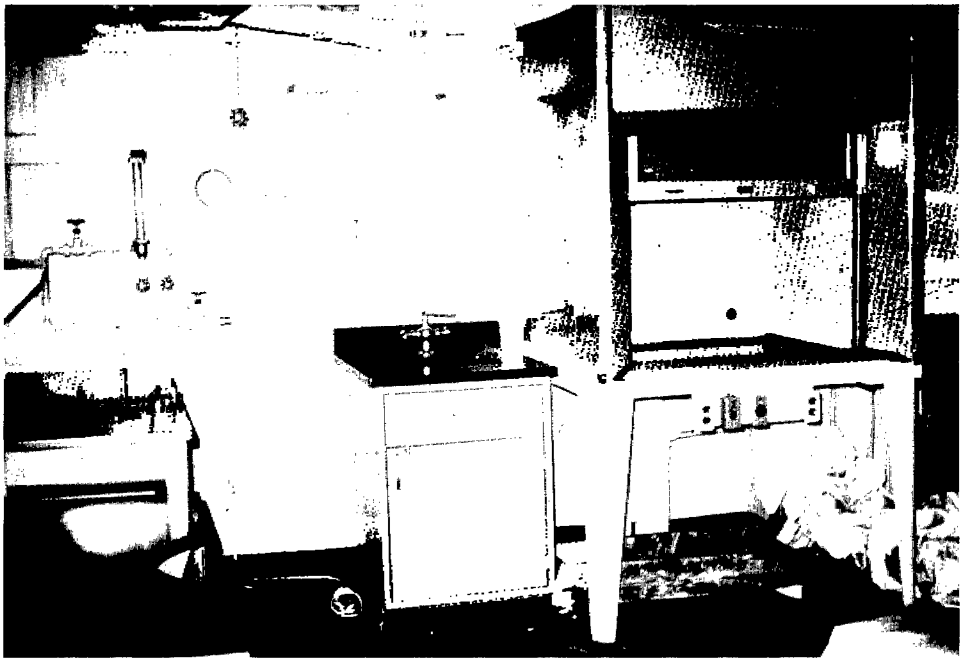

Fig. 19—Chemistry Laboratory located on the second deck, starboard side of USNS *Hayes*

Bottom Coring—Cores are extracted from the ocean bottom by driving steel tubes, usually equipped with plastic liners, into the sediment and then trapping the sample and hauling the coring device on deck for removal and stowage of the core. Both ships have the coring capability. *Hayes* is equipped with vertical stowage brackets at the main deck midships area. There are accommodations for stowage of cores up to 30-ft long in a starboard hull ladder well that has an access hatch to the 02 level weather deck. Cores can also be cut to fit the wet laboratory refrigerators and stowed at any temperature in either a horizontal or vertical arrangement. The two deep-sea winches aboard *Hayes* are capable of extracting cores with line tensions up to 50,000 lb. The maximum available line pull from *Mizar*'s deep-sea winch is 12,000 lb, which is adequate for coring. Both horizontal and vertical stowage space is available; however, no freeze capability is available for scientific purposes.

Nonacoustic Antisubmarine Warfare—A specially equipped oceanographic ship is required for research in support of nonacoustic antisubmarine warfare being conducted by the Applied Oceanography Branch of the Ocean Sciences Division. The ship will be required to make coordinated measurements with the RP-3A aircraft in oceanographic studies at sea. The studies require installation of 20 tons of specially developed research equipment now operated by 14 scientists. The equipment includes a 50-ft-long bow-mounted boom and supporting tower for air–sea interface studies. A stern-mounted U-frame, a special U-frame crossbeam, and cable storage reels are used together with an existing stern towing winch for towing an array of temperature and dye sensors to depths of 1000 ft. The bow and stern sensor systems require 23 racks of instrumentation in the ship's electronics laboratory. The overall equipment installation was made to be semi-portable to facilitate loading and off-loading and to minimize interference with other users of the ship.

Conventional equipment required aboard the oceanographic ship includes the XBT system, a fathometer, a hydrographic winch suitable for salinity-temperature-depth-sound velocity (STDV) casts, a ship's radar system for tracking current drogues, and an electromagnetic log providing ship's speed. A total of 17 kW of 115-v single-phase 60 Hz electrical power is required for the specially installed research equipment. The shipboard communication equipment must include VHF, UHF single-sideband radio and underwater telephone. Loran A and C and satellite navigation systems are required for defining oceanographic stations. Neither *Hayes* nor *Mizar* is presently equipped to perform this operation; however, both ships have suitable laboratory and open deck space to accommodate the addition of such equipment. Shipyard work costing approximately $100,000 would be required to perform this installation.

Ocean Technology Division

The Ocean Technology Division is concerned with the testing of materials and the collection of data to support research and development in ocean engineering. Scientists and engineers of this division perform many diversfied operations at sea, such as environmental tests on materials, deep-sea photography, instrument development, and search and survey operations. Heretofore, this division has worked almost exclusively from *Mizar* and has found her to be an extremely valuable deep-sea search platform. *Mizar* was used to locate and photograph the lost submarines *Thresher*, *Scorpion*, and *Eurydice;* assist in the location and recovery of the lost H-bomb off the coast of Spain; and locate, photograph, and recover the lost submersible *Alvin.* In all of these operations, *Mizar*'s deep-sea winch was employed with the cable reeved through the wellhouse sheave system and down through the center well. Other advantageous features of this ship are the acoustic ray tracking system, scientific communications system, scientific navigation facilities, and laboratory control of the deep-sea winch. *Hayes*, on the other hand, has not been used by the Ocean Technology Division; consequently, the exact extent of her effectiveness in the performance of this division's operation is unknown. However, an extensive study has been conducted by engineers in the Ocean Technology Division in an effort to devise an effective search capability for *Hayes.* (See Table 4.)

Table 4
Summary of Ocean Technology Division Requirements and Ship Capabilities

Operations or Experiments	Special Requirements	Present Capabilities	
		Hayes	*Mizar*
Ocean engineering	Environmentally controlled workshops (electronic and mechanical)	Yes	Yes
	Scientific storage spaces (convenient to workshops)	Yes	Yes
	Ship endurance for 30 days	No	Yes
	Ability to navigate in shallow waterways and berth at shallow draft ports	No	Yes
	Unmanned submersible handling and deployment facilities for 8000 lb in sea state 6	Yes	Yes
	Ability to tow vehicles weighing up to 100 tons at 6 knots	Yes	Yes
	Provision for operation of bottom samplers, corers, trawls, multiple water sampler, expendable bathythermograph, STDV probe and recorder	Yes	Yes
Testing of materials	Ability to lift at least 10,000 lb from 15,000-ft depth	Yes	Yes
	Ability to launch or retrieve equipment in state 5 seas	No	Yes
	Ample open deck space for large sample racks	Yes	Yes
Search and recovery operatons	Electromechanical cable more than 20,000 ft long, electrically equal to RG-8/V, stronger than 30,000 lb	Yes	Yes
	Deep-sea winch having the following characteristics:		
	Line pull of at least 15,000 lb	Yes	Yes
	Speed range from 10 to 250 ft/min	Yes	Yes
	Response at least 1 ft/sec^2		Yes
	Electrical sliprings	Yes	Yes
	Laboratory control of winch	No	Yes
	Ship maneuverability from 0 to 2 knots in sea state 5	Yes	Yes
	Ship navigation accuracy at least ±1000-ft worldwide	Yes	Yes
	Automatic data acquisition equipment	Yes	Yes
	Electronic digital and analog data processing capability	Yes	Yes
	Ability to process more than 10,000 photographs per week (35mm, 70mm, or 127mm negatives)	Yes	Yes
	Printing and enlarging capability (at least 700 8-by-10-in. prints per week and 1500 ft of 35- or 70-mm positive prints, paper and film, per week)	No	Yes
	Provision of 1 gal. of fresh water per minute at 60°F	No	Yes
	Provision of 2 gal. of fresh water per minute at an uncontrolled temperature	No	Yes
	Ability to handle and deploy a 5000-lb instrumented fish	Yes	Yes
	Environmentally controlled laboratory space for 20 instrumentation racks, work benches, plotting table, winch control station, and various fathometers and recorders (at least 800 ft^2 of laboratory space)	Yes	Yes
	Laboratory control of deep-sea winch	No	Yes
	Intercommunication system between spaces as required	Yes	Yes
	Chart-making and data analysis space with chart and drawing duplication facility	Yes	Yes
	Electrical power required in laboratory:		
	25 kW of 60-Hz power, regulated for frequency and voltage to 1% variation	Yes	Yes
	100 kW of 60-Hz power, regulated for frequency and voltage to 5% variation	Yes	Yes

Table 4 (Continued)
Summary of Ocean Technology Division Requirements and Ship Capabilities

Operations or Experiments	Special Requirements	Present Capabilities	
		Hayes	*Mizar*
	Tow point in close proximity to ship's center of pitch and roll (must be positioned so that towed bodies avoid interference with appendages when cable sweeps out a cone of 45° about the vertical axis)	No	Yes
	Scientific radio communication, worldwide	Yes	Yes

Ocean Engineering—Operations addressed to ocean engineering require versatile deck machinery to lay cable, deploy equipment, tend submersibles, and tow unmanned vehicles. These operations also require ample deck space to stage and prepare euipment for launching and adequate laboratory space to monitor and analyze data received. Both *Hayes* and *Mizar* are capable of performing ocean engineering operations. As stated previously, *Hayes* scientific handling equipment is versatile and powerful; her two deep-sea winches have a horsepower rating of 250 and a maximum line pull of 50,000 lb. But the center well is inoperable at present, making vehicle towing difficult because of the inherently high tow point. Both ships can support a submersible that requires towing to and from the operating site; however, *Mizar*'s 6000-lb lifting capability of both crane and U-frame would limit the transporting of submersibles. The *Hayes* stern crane is rated for 12,000-lb lifts at 28-ft boom length; in calm water similar to dockside conditions, the crane can safely launch or retrieve submersibles weighing as must as 26,000 lb in air. Both ships carry scuba equipment and can provide high-pressure air for life support or diver assistance.

Testing of Materials—Materials testing operations generally require deck space for the staging of large sample racks prior to deployment and stowage space following recovery of the test materials from the ocean. Both ships are suitable for these operations. Open deck space is available on *Mizar* in the well house, on the main deck starboard of the wellhouse on the 01 level port side, and on the 01 level stern; in addition to these spaces, the forward hatch cover is also available for staging purposes. *Hayes* has three large open deck staging areas: midships on the main deck, and the stern main deck area port and starboard. An additional open deck space could be provided if the stern slot were bridged with a portable grating that could be served by two U-frames and a crane.

Search and Recovery Operations—The general character of search and recovery operations requires quick, orderly efficient organization and implementation of an operation plan. The search vehicles (fish), equipped with cameras, strobe lights, magnetometers, and sonar systems, are either stowed aboard ship or are kept at NRL in a state of readiness for installation aboard ship. The laboratory instrumentation is constructed in modular subsystems that are installed aboard in such a manner that, when used in conjunction with the search vehicles, a long coaxial submarine cable (at least 20,000 ft), and the ship's facilities, a very effective search system is assembled. The shipboard requirements for search and recovery operations are considerably more extensive than for all the oceanographic operations; consequently, special consideration must be directed to this aspect of the planning. Some of the most important considerations, such as ship motions, slow-speed maneuverability, endurance, winch response, and equipment handling and stowage, are discussed in the following paragraphs.

Ship Motions: Because motions of the instrumented search vehicle are directly related to the pitch, roll, and heave of the towing ship resulting from the transmission of motion by the tow cable, ship motions must not exceed the limits specified for the towed vehicle. The overall effect of ship's motions on towed vehicles depends to a great extent on the location of the cable tow point; i.e., when a tow cable is last in contact with the ship at or near the ship's center of pitch and roll, the amplitude of these motions at the tow point is nil, so the only ship motion transmitted by the cable to the towed vehicle is heave. The heave responses for a towed instrumented vehicle performing in an underwater photographic operation must be limited to an amplitude of 8 ft. A stern-towed vehicle (Fig. 20) is affected by the ship's pitch, roll, and heave; consequently, stern towing cannot be tolerated in search and survey operations. The recommended handling system for these operations uses the center well arrangement, as shown previously in Fig. 4.

Ship Slow-Speed Maneuverability: Search and survey operations employing instrumented towed vehicles require a speed of less than 0.8 knot over the ocean bottom for complete photographic coverage. This operation imposes a requirement of controlled 1-knot ship maneuverability in sea states up to 5. This requirement is of greater significance when operating in deep water than in shallow because of the additional resistance applied by the towing cable. The efficiency of search and survey operations using towed vehicles can be adversely affected by the ship's inability to maintain course and maneuver at slow speeds.

Ship Endurance: Search and survey missions require surface platforms to remain at sea for at least 25 days and to cruise continuously at speeds ranging from 1 to 3 knots. In addition to this, another 3 to 6 days of transit time cruising at the ship's most efficient speed may be required to reach and return from operational areas.

Winch Response: Search and inspection operations require a winch capable of performing at various speeds and having reserve power and acceleration potential available for emergency situations. Emergencies arise when it appears that a towed instrumented vehicle is about to collide with an underwater obstacle, or when the vehicle becomes entangled with a bottom obstacle or the bottom itself.

Remote Control of Winch: In the performance of deep-sea search and survey operations it is necessary to have control of the winch not only at the winch location itself but also from the scientific control center. This requirement is necessary to enable the winch operator to monitor the fathometer and tracking instrumentation and therefore make the required adjustment(s) to properly position the towed vehicle.

Equipment Handling and Stowage: Instrumented vehicles used in deep-sea research operations can vary in weight from 5000 to 8000 lb. Because of these heavy loads, adequate equipment arrangements must be provided for handling and stowage purposes. In addition to the advantages offered by operating towed vehicles through a center well, the wellhouse constructed to cover it provides protection against the elements for both instruments and personnel working during inclement weather at sea. Monorail hoists, light-duty

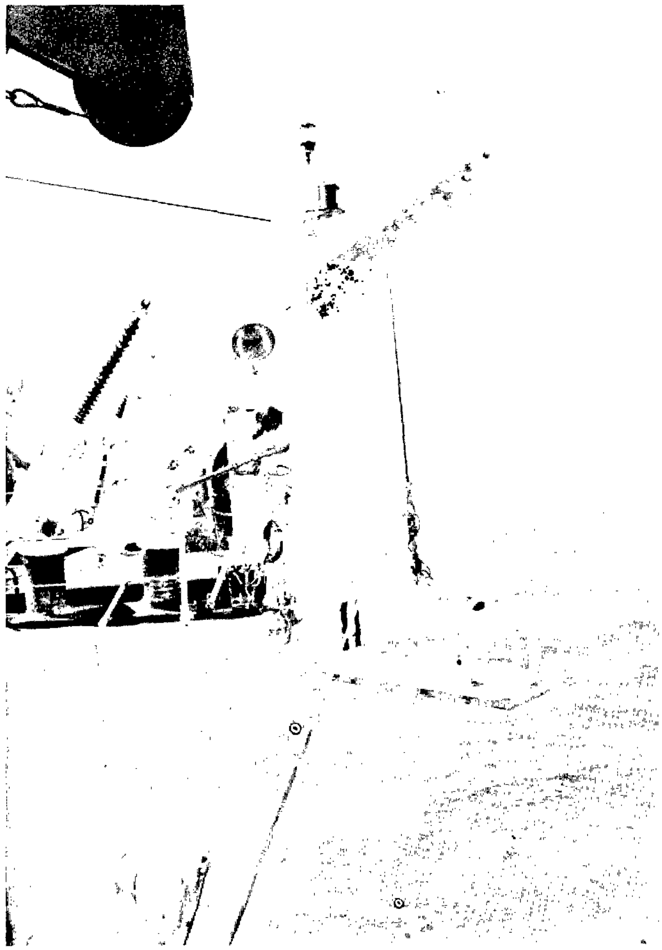

Fig. 20—Test sled being launched from stern of USNS *Hayes*

winches and cranes, and even elevators are highly desirable in the scientific equipment handling area to move heavy vehicles and other equipment.

Study of Hayes — A study was recently conducted on USNS *Hayes* by an engineering committee within the Ocean Technology Division to determine the most feasible means for launching, retrieving, and handling search and survey instrumented vehicles. Figure 21 shows the arrangement of scientific gear-handling equipment aboard *Hayes.* Because both bow and side towing of the instrumented search vehicles were immediately eliminated from consideration, only the stern and center well areas of the ship were discussed. U-frame davits are located on each of the *Hayes* fantails as shown in Fig. 8. Both of these U-frame davits are intended to work with the stern crane as well as the deep-sea and intermediate winches on the 02 level, aft. All of this equipment has the mechanical capacity to handle the instrumented search vehicles; however, control of the vehicles while launching, operating, and retrieving is adversely affected by the transmission of ship motions by a stern U-frame tow point. Another detrimental aspect associated with stern towing from *Hayes* is the proximity of the ship's propellers to the stern U-frame

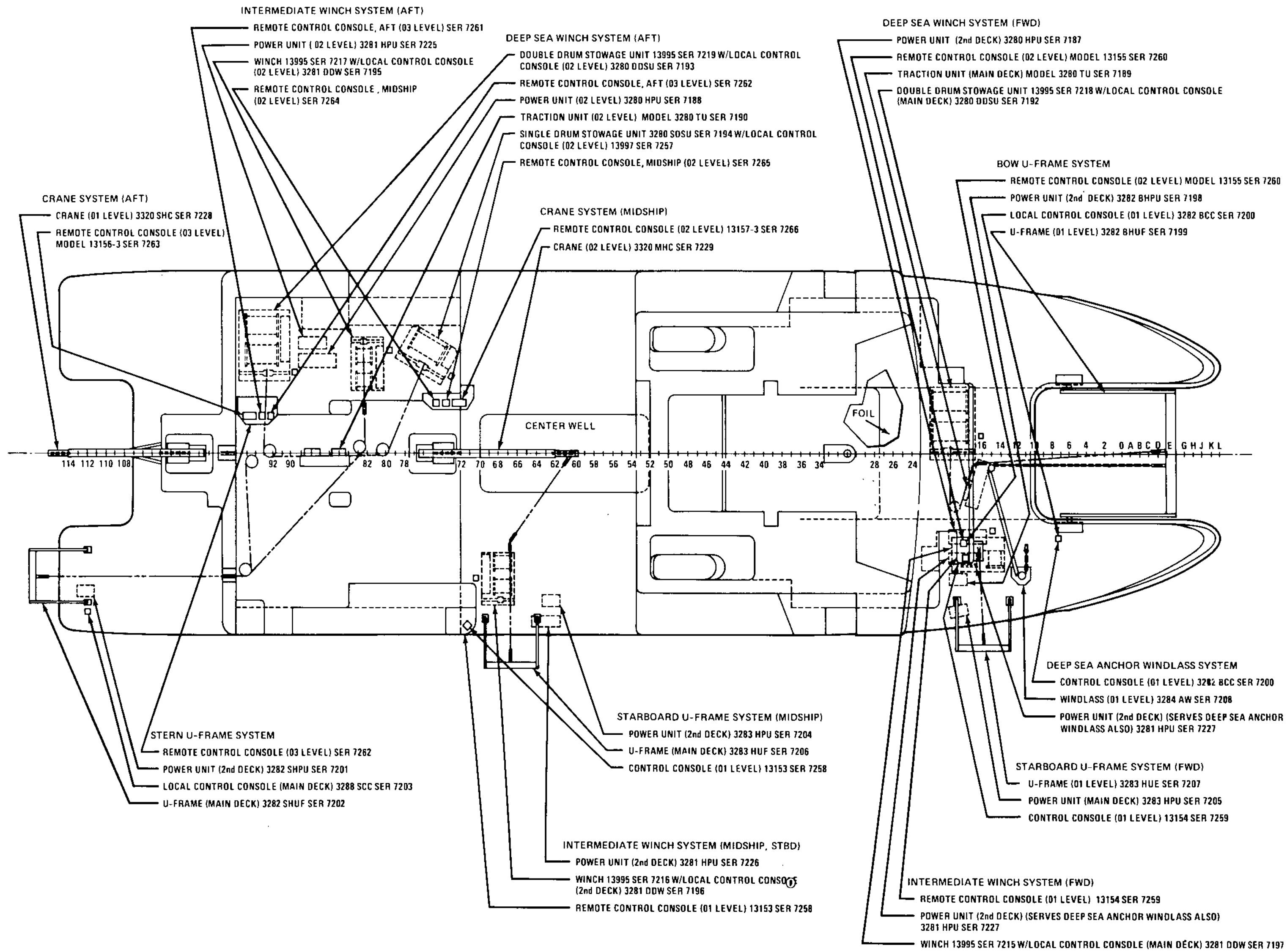

Fig. 21—Arrangement of USNS *Hayes'* scientific gear-handling equipment

davits. During certain search operation maneuvers, the tow cable is required to describe a 90° cone having its apex at the tow point. This cable configuration would definitely interfere with rudder and propeller appendages if operations were attempted from the stern because the maximum permissible towline angle on *Hayes* is 35°.

After careful consideration had been given to all possibilities of towing from existing U-frame davits aboard *Hayes*, it was decided that the requirements for search and survey operations, as listed in Table 4, could be met only by a special towing arrangement at the center well for handling equipment through the cross structure. The center well, which is normally hatched over, can be opened to perform experiments at sea, and cable leads have been provided from the various winches to be used with the midship crane for this purpose. After a thorough consideration of the problem through paper studies, one scheme was selected for more detailed examination by the construction of a model. Figures 22 through 30 illustrate how the scheme would operate in retrieving an instrumented deep-sea search vehicle. Figure 29 shows the vehicle being raised to the ship, but still below keel level. It appears that should the tow cable assume an angle of 45° in any direction, it would not interfere with any part of the ship or its appendages. The tow-point location on the ship's centerline at the trailing edge of the foil was selected to be as low as possible and as close as practical to the ship's center of pitch, roll, and heave. Preliminary calculations indicate that the foil load would be substantially less than its structural design limit. Cable and sea loading under the search conditions produce stresses in the foil less than 1/10 of those allowed in its design. Whereas the original design loading condition was developed assuming full speed cruising in high sea states, the survey condition assumes cable loads comparable to practically zero ship speed and only moderate sea conditions. A feature of the proposed retrieval scheme is the support given both above and below to the instrumented vehicle as it passes through the water interface. Downward support is provided by a preset back-tension line running to the midship intermediate winch via the starboard U-frame. When the vehicle has cleared the ship and is in transit to the ocean bottom, this back-tension cable is firmly anchored and its winch secured. Upon retrieval, tension in the vehicle towing cable is increased to exceed the constant back-tension of 5000 lb, and the vehicle is hoisted through the interface, held from above and below. Directional constraint is provided to the vehicle during launch and retrieval by a cable notch on the forward end of the vehicle. When the instrumented vehicle has been raised to the main deck level, support from below is transferred to the fixed restraining cable anchored near the ship's centerline on the bulkhead at the aft end of the well. Transfer of the vehicle from above the center well to the deck is achieved by using the midship crane. To use this crane, the main towing cable for deep-sea search operations is sheaved over the midspan attachment point to an intermediate winch located on the 02 level aft.

The launch and retrieval system, which has just been described, is not necessarily recommended as the one that should be implemented. It is presented and described here only to indicate the feasibility of developing, at reasonable expense, a scientific equipment launch and retrieval capability for *Hayes* comparable to that presently existing on *Mizar.*

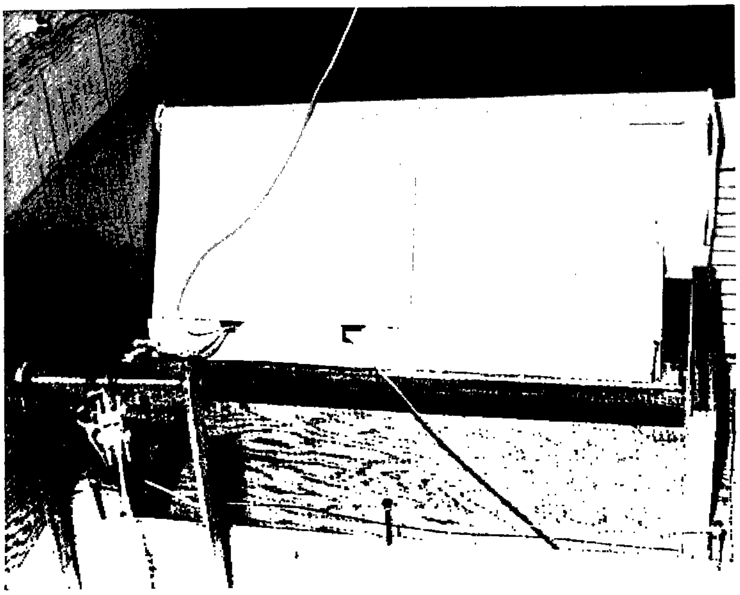

Fig. 22—Model of proposed installation for USNS *Hayes* includes a new scientific equipment enclosure to be located on portside of the existing center well, joining the forward and after superstructure

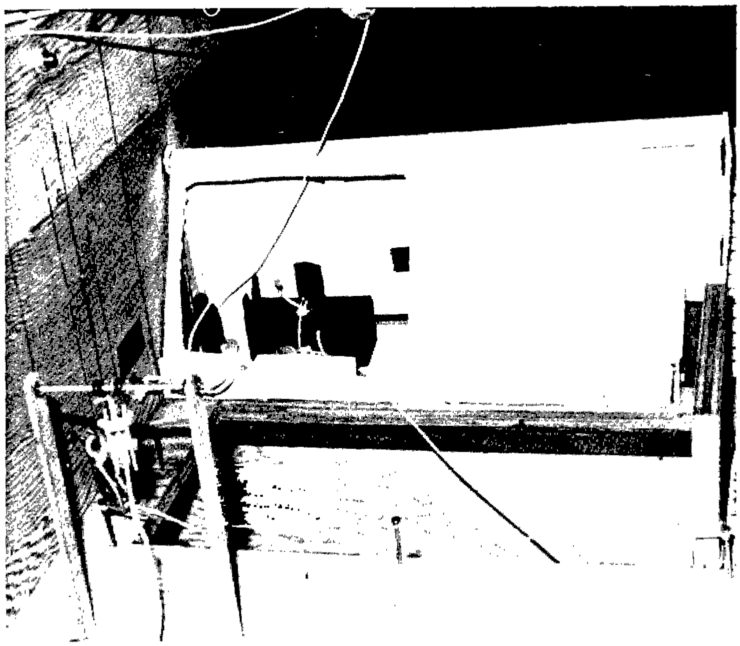

Fig. 23—Model of proposed installation at midship area of USNS *Hayes* including deep-sea search vehicle prior to being launched through center well

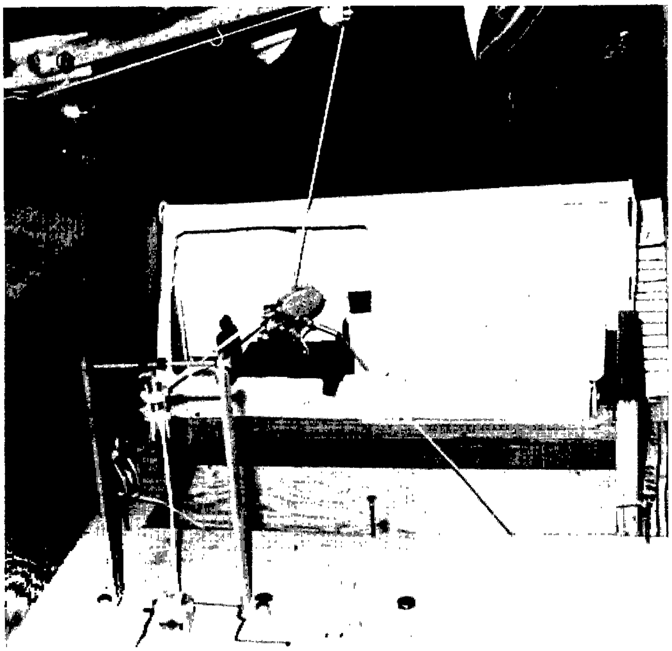

Fig. 24—Model of proposed USNS *Hayes* midship equipment-handling arrangement of cable reeving

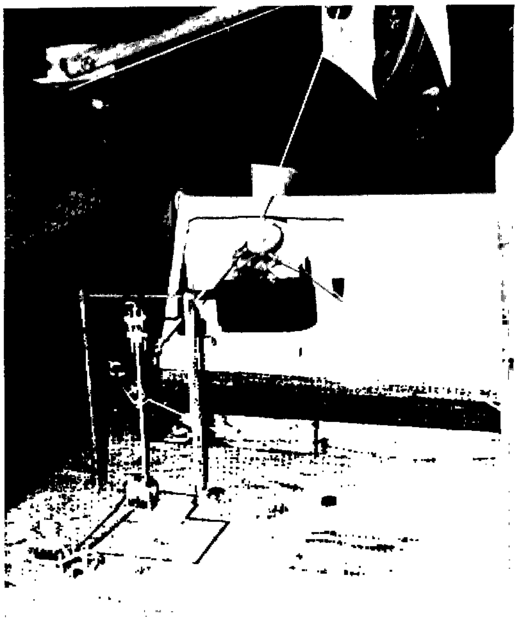

Fig. 25—Model of deep-sea search vehicle being lifted out of proposed midship equipment enclosure by existing midship crane for launching through center well of USNS *Hayes*

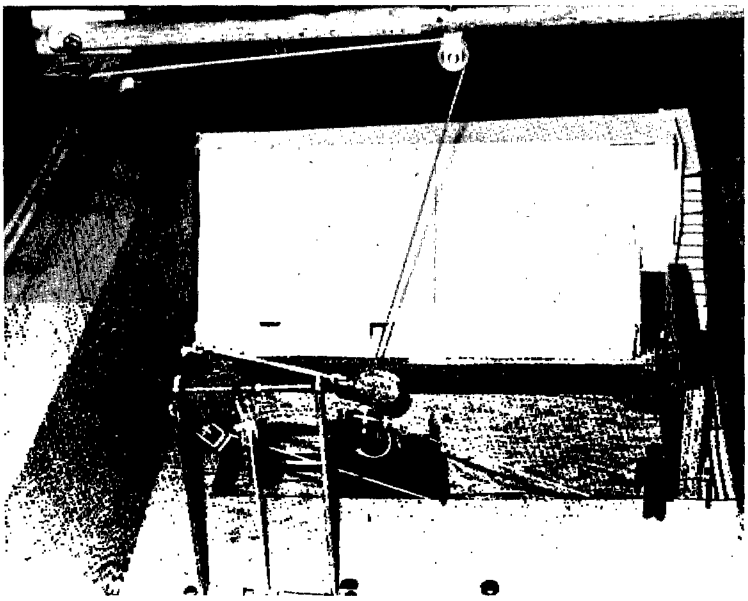

Fig. 26—Model of proposed USNS *Hayes* midship equipment-handling scheme demonstrates launching of deep-sea search vehicle through center well

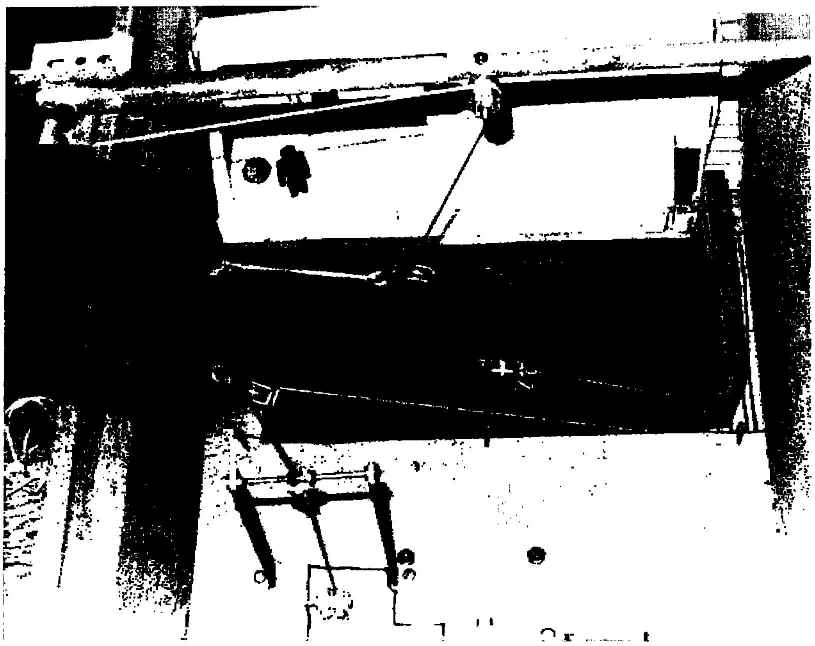

Fig. 27—Model of proposed USNS *Hayes* center well equipment-handling arrangement is shown lowering search vehicle through well toward tow point to be located at cross-structure foil

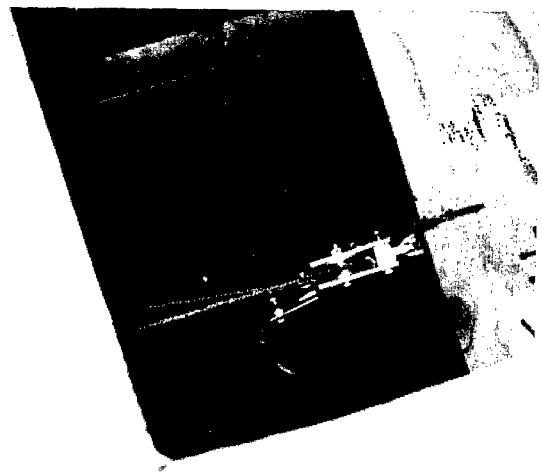

Fig. 28—Model of proposed towing arrangement attached to existing cross-structure foil on USNS *Hayes*

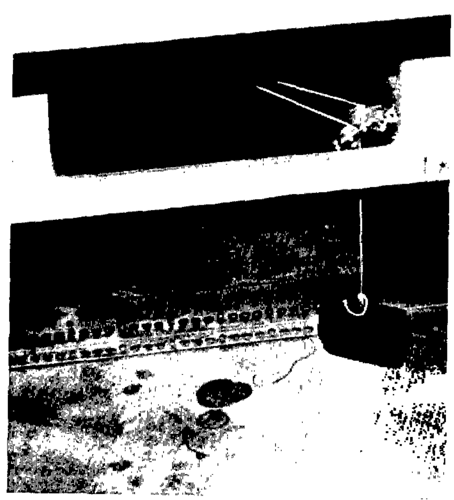

Fig. 29—Side view of model showing proposed launching arrangement for handling the deep-sea search vehicle below the foil-mounted tow point on USNS *Hayes*

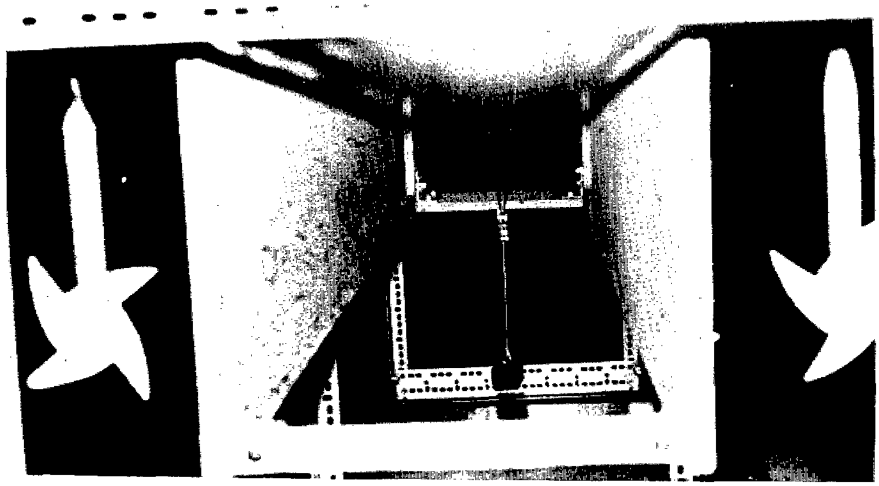

Fig. 30—Stern view of USNS *Hayes* proposed equipment-handling arrangement with model of deep-sea search vehicle being retrieved at cross-structure foil position

CONCLUSION

In this report present and future sea operations and experiments performed in the Oceanology Area of NRL have been examined with consideration being addressed to their special requirements for ship facilities. Results of the study conducted by the Ship Engineering Committee substantiate the premise that the *Hayes* design was based primarily on acoustics-type operations while *Mizar* has been configured to perform basically the search and recovery operations. More recently, other facilities have been installed on *Mizar* to accommodate the requirements for the ocean science experiments. Although *Hayes* and *Mizar* differ in appearance, construction, and scientific capabilities, the two ships together are well equipped to fulfill the requirements of all phases of the oceanographic research program undertaken by NRL.

The most notable differences in the capabilities of the ships are listed below.

- The deep-sea search capability of *Mizar*, because of her unique underwater tracking system, efficient center well launch and retrieval arrangement, and laboratory control of her responsive deep-sea winch

- The ability of *Hayes* to anchor in deep water for the performance of scientific experiments

- The shallower draft of *Mizar*, which allows transit of the Potomac River and other shallow waterways to more convenient ports

- The enclosed installation of the *Hayes* scientific winching equipment, providing preventive maintenance for the machinery

- The endurance advantage of *Mizar* over *Hayes*, allowing *Mizar* to log more working time

- The ability of *Hayes* to operate as a quiet ship during the performance of certain acoustics experiments

- The ability of *Mizar* to transit into the ice regions, permitting the performance of certain important Arctic and Antarctic operations at stations beyond the operating range of many oceanographic research ships

- The improved comfort and modern conveniences in habitability aboard *Hayes*, principally resulting form the 14-year age difference of the two ships

NRL is obligated to maintain its deep-sea search capability; consequently, if *Mizar* were no longer available, it would be necessary to modify *Hayes* to handle and tow the search equipment. Such a scheme is now being studied, and an operable model has been devised and constructed by an ad hoc engineering group within the Ocean Technology Division. It is recommended that a limited search and survey operation be conducted using *Hayes* to uncover any latent problems that may exist before actual operations of this type are attempted. On the other hand, to duplicate *Hayes* capabilities of deep-sea anchoring and quiet ship operation, *Mizar* would require extensive modification. However, it would greatly alleviate ship scheduling problems if major oceanographic operations could be performed from either ship.