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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
SAN FRANCISCO, CALIFORNIA

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10 January 1946

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Characteristics of Japanese Naval Vessels, Article 7.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering characteristics of Japanese submarines outlined by Targets S-01 and S-05 of Fascicle S-1 of reference (a), is submitted herewith.

2. The target report was prepared by Comdr. T.H. White, USN, from the pertinent sections of the reports submitted to Commander Submarine Force, Pacific, by Commander Submarine Squadron Twenty and Commander Submarine Squadron Thirteen.

C. G. Grimes

C. G. GRIMES
Captain, USN

31779

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S-01-7

CHARACTERISTICS OF JAPANESE NAVAL VESSELS
ARTICLE 7
SUBMARINES, SUPPLEMENT II

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE S-1, TARGETS S-01 AND S-05

JANUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

SHIP AND RELATED TARGETS

CHARACTERISTICS OF JAPANESE NAVAL VESSELS - ARTICLE 7
SUBMARINES, SUPPLEMENT II

This report describes the various types of Japanese submarines and the noteworthy equipment installed on them. A more detailed description of the I-400 and HA-201 class submarines is given than has been provided in Articles 1 and 6 of the series on the characteristics of naval vessels. Detailed information is provided on the hull and engineering equipment.

TABLE OF CONTENTS

LIST OF ENCLOSURES

(A) List of Documents from Subron 20 Shipped to Washington Document Center.

(B) List of Documents from Subron 13 Shipped to Washington Document Center.

(C) List of Japanese Equipment Delivered to ComSubPac by Subron 13.

(D) List of Japanese Equipment Delivered to ComSubPac by Subron 20.

LIST OF ILLUSTRATIONS

Submarine Bases

I-400, I-14 Class

Midget Submarines with Torpedo Tubes

Midget Submarines - (Designation number less than 1000)

Midget Submarine (Designation number between 1000 and 2000)

Midget Submarine (Designation Numbers Starting at 4000)

Type "D"

O-58

HA-101 Class

I-369 Class

HA-201 Class

Celestial Objects Calculator

Electronic-Propeller Underwater Log

REFERENCES

Location of Targets:

Maizuru Submarine Base.

Yokosuka Naval Base.

Kure Naval Base.

Sasebo Naval Base.

Source of Information:

Preliminary Report on Japanese Submarine Force - Subron 20.

Japanese Submarines and Submarine Material in Western Japan - Subron 13.

(Note: Reference reports have been submitted to ComSubPac with copies to CNO.)

INTRODUCTION

On the advent of the Japanese surrender, Commander Submarine Force, Pacific, sent two units to Japan to exploit submarine targets. One of the units was under the command of Capt. L. S. PARKS, USN, Commander, Submarine Squadron Twenty, and the other was under the command of Capt. S. P. MOSELEY, USN, Commander Submarine Squadron Thirteen.

These units made a comprehensive study of the Japanese Submarine Force and submitted their findings in the from of two separate reports, one from each unit, to Commander Submarine Force, Pacific, with a copy of each to Chief of Naval Operations. The two reports are very complete. They were made immediately after the surrender by experienced submarine personnel in all ratings and with the facilities of submarine tenders to analyze and operate equipment. Further, the actual Japanese officers and crews were available for careful questioning by equally qualified personnel of the U.S. Navy submarine force. The reports include a wealth of technical information which otherwise would not have been obtained.

In order to make the final report of the Naval Technical Mission to Japan as complete as possible, those parts of the above reports which have reference to hull and machinery characteristics and technical information on equipment have been extracted and combined into this one article. It is desired to make due acknowledgement to the two squadrons for the assistance thus rendered in preparing the report of the Mission.

Since the ordnance and electronic equipment has been made the subject of separate reports of the Mission, very little of the excellent material on these subjects found in the two squadron reports has been included in this article.

THE REPORT

Part I - SUBMARINE FACILITIES, YOKOSUKA NAVAL BASE

The Navy Yard at YOKOSUKA, Japan, in addition to being a general repair base and assembly yard for all types of midget submarines, had, as a separate entity, a submarine base. The function of this base differed radically from the type of submarine base set up by the United States Navy.

Its primary function was apparently to house and subsist submarine crews while their submarine was being overhauled after a war patrol. In addition to this, some repairs were made directly at the base. These included all submarine battery work, minor machine work, and miscellaneous small repairs. In general, overhauls and major hull work, including dry docking, was done at the Navy Yard proper. The coordination of responsibility was very vague and seemed to be left to a great extent to the submarine commanding officer. In other words, the submarine officers supervised and controlled their own overhauls and refits. At the time of writing this report the base was about three quarters underground and seemed to be in a transition period during which repair facilities were in some confusion pending complete transfer underground. This being the case, it was impossible to compare the efficiency of the base as a whole with one of our own. In general, however, it may be stated that submarine work was definitely not unified under one command, that transportation of materials from shops to submarines was poor, and that inefficiency was prevalent on the base.

There seemed to be no lack of supplies either for general use or for repairs.

There was no tender present at this base. Interrogation of prisoners revealed that only one submarine tender was left to the Japanese Submarine Force. At the close of the war, tenders, as a whole, were not thought very important or of very high efficiency. This was further proved by the fact that the Japanese had converted several of the tenders into general cargo carriers before the close of the war. They apparently did not set up a mobile system of submarine repair but depended almost wholly on their bases for the maintenance of their submarine force. The following photographs show the type of cave storage and work shop being currently set up when the submarine base was being taken over by our forces.

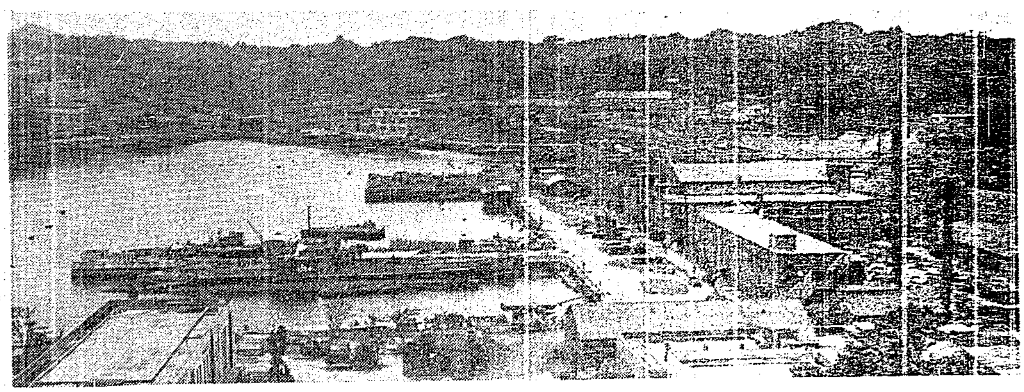


Figure 1
GENERAL VIEW OF SUBMARINE BASE, YOKOSUKA

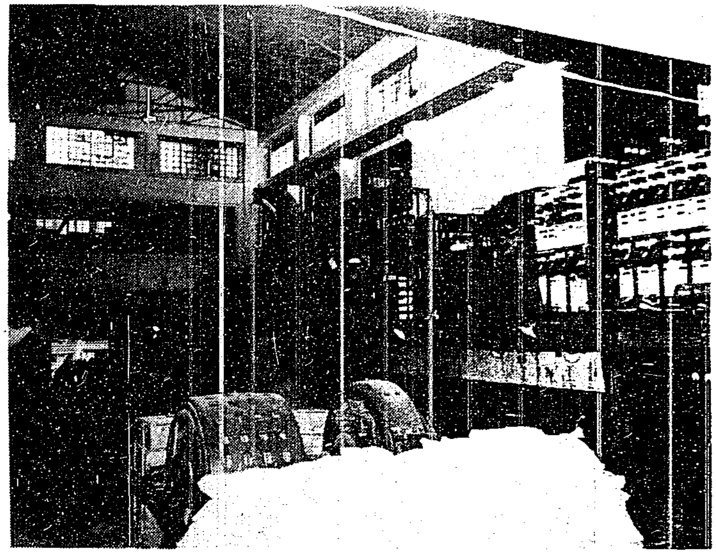


Figure 2
OUTSIDE POWER PLANT

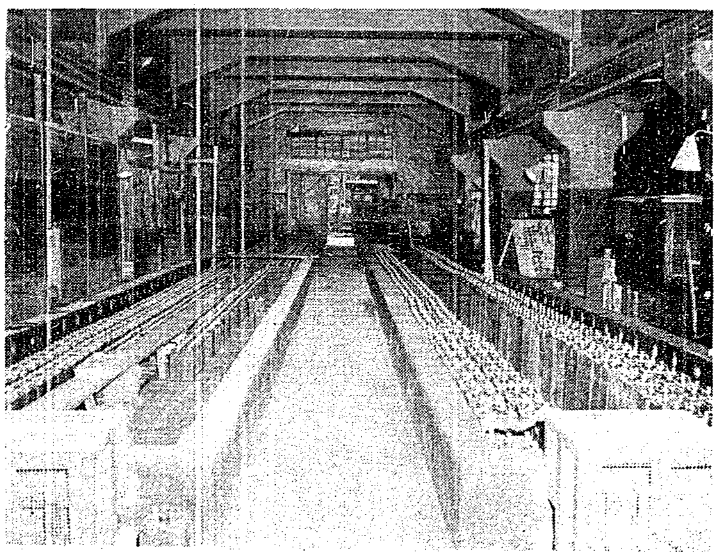


Figure 3
OUTSIDE BATTERY CONSTRUCTION SHOP

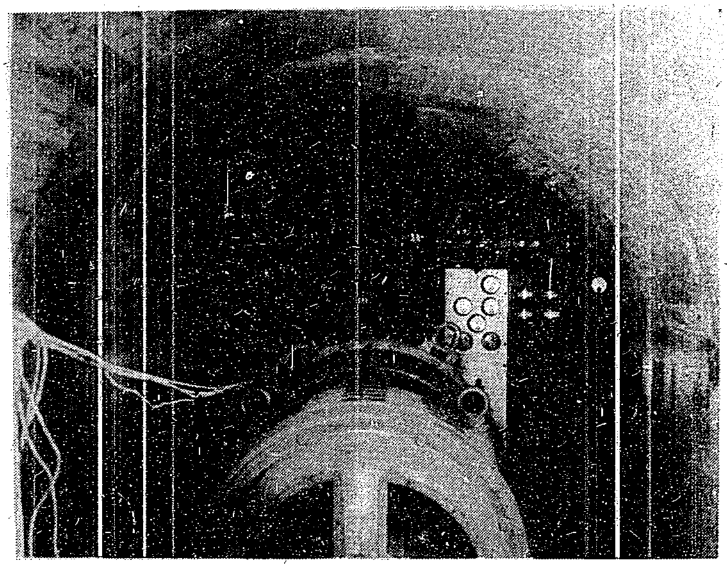


Figure 4
POWER SUPPLY IN CEMENTED CAVE

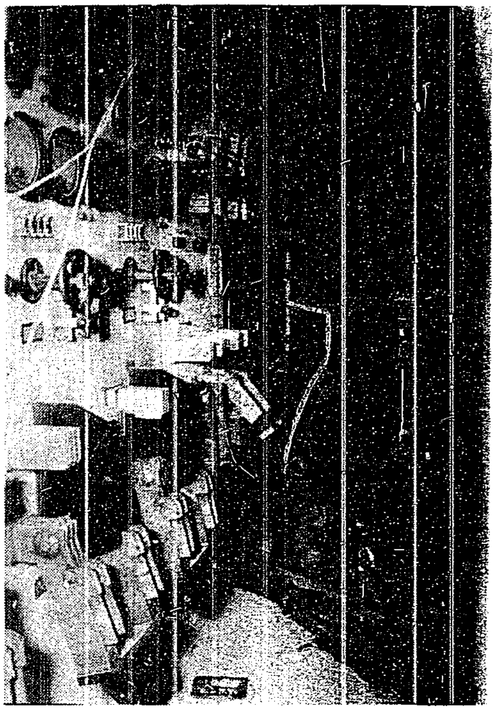


Figure 5
BATTERY CHARGING SWITCHBOARD

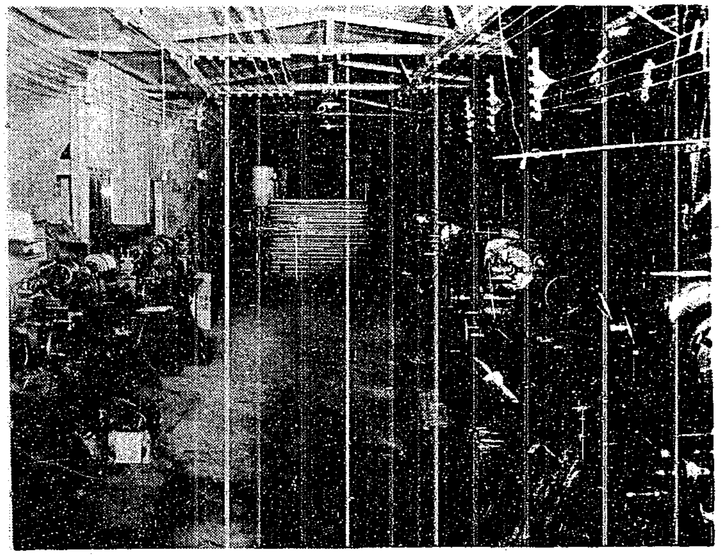


Figure 6
MACHINE SHOP IN ROCK CAVE

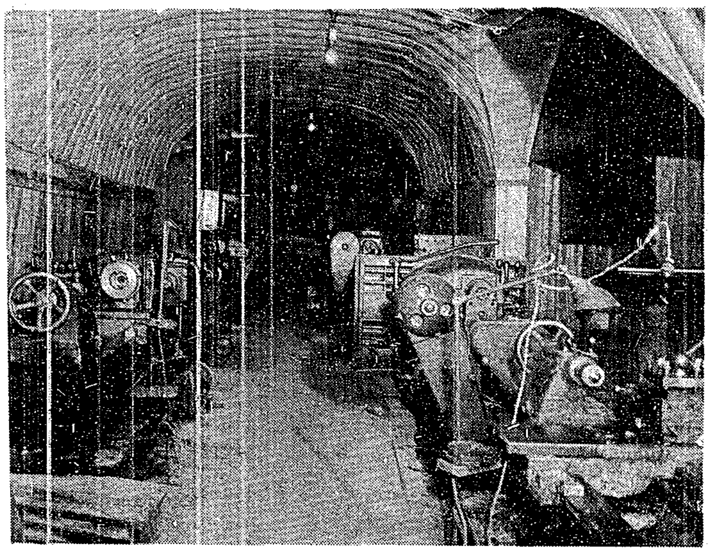


Figure 7
MACHINE SHOP IN ROCK CAVE

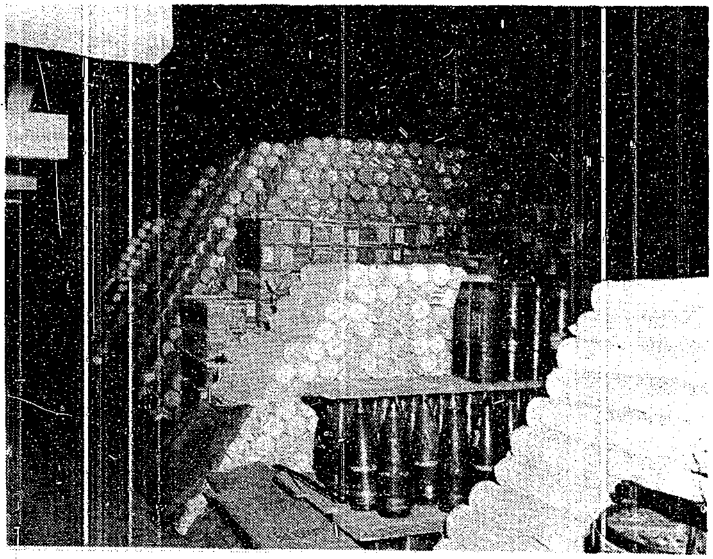


Figure 8
AMMUNITION STOWAGE CAVE

Large caves were used for ammunition and stowage of delicate gear. These caves are of double construction: a concrete structure fabricated inside a rock cave with an air space between for ventilation. Air is fed in from a smaller passage tunneled over the large cave. Note indiscriminate stowage of powder, detonators, and miscellaneous gear.

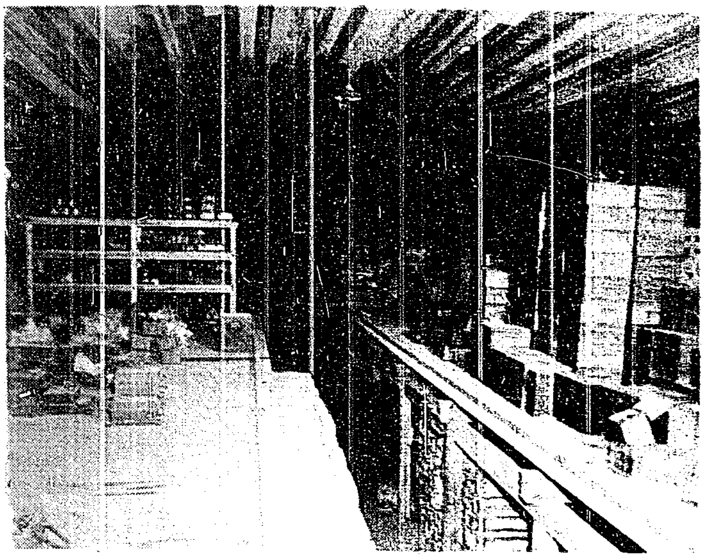


Figure 9
AMMUNITION STOWAGE CAVE

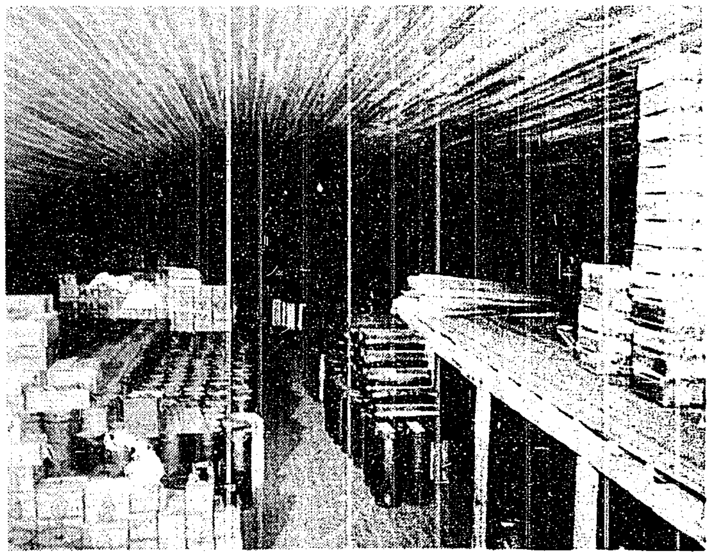


Figure 10
AMMUNITION STOWAGE CAVE
There are about ten behind the Submarine Base.

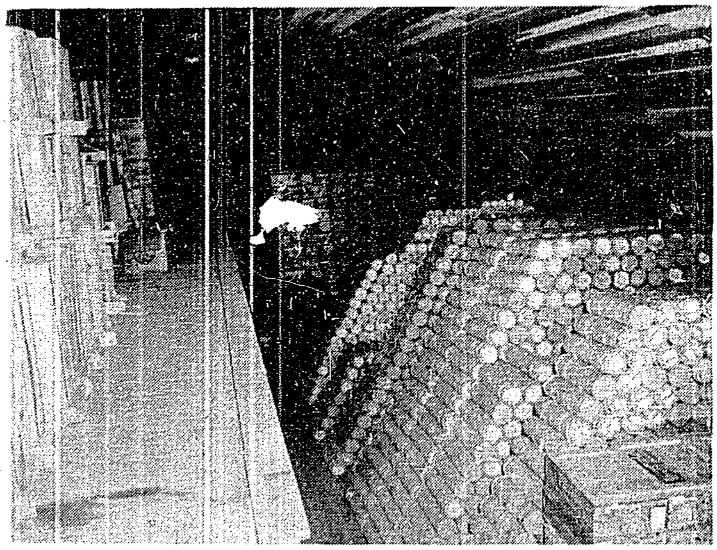


Figure 11
AMMUNITION STOWAGE CAVE

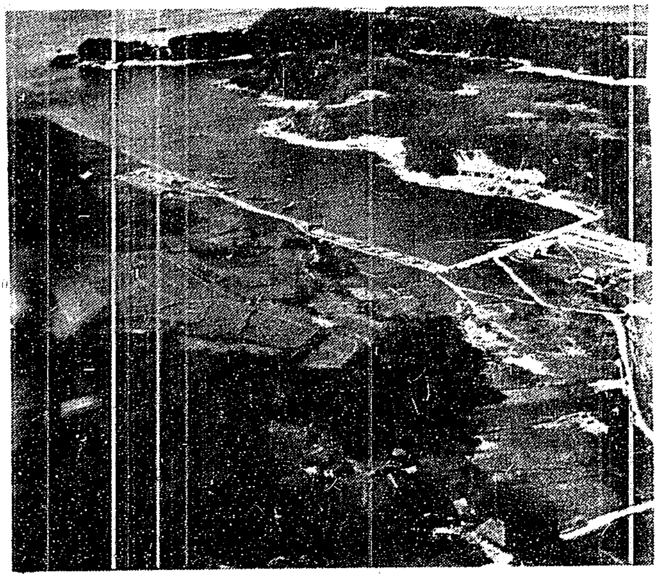


Figure 12
GENERAL VIEW OF MIDGET SUBMARINE BASE, MISAKI, JAPAN

Part II - OPERATING SUBMARINES AND THEIR USES AT THE CLOSE OF THE WAR

The Japanese Submarine Force had apparently been divided into two strategic groups at the close of the war: The first group was composed of long range patrol submarines; the second group was coastal submarines used for defense of specific points in the Empire and for cargo carrying over short distances.

In order to carry out their mission and combine the function of attack and transport, the new I-14 class and the I-400 class were designed as a composite type patrol submarine, whose function was both cargo carrying and attack. They are described in detail because it is believed that they show the latest trends in Japanese submarine design and because inspection of the older type submarines shows no new innovations and nothing which was not known to our intelligence prior to the writing of this report. The I-369 class was designed specifically as a cargo carrier and is described briefly herein.

The Japanese Submarine Force as a whole functioned as an integral part of the fleet, its components operating directly under the Admirals in charge of the several fleets. Unification of material and operating procedures was achieved through the General Staff in TOKYO. Each Fleet Admiral or District had a submarine liaison officer on his staff who advised on the operations of the submarines of that particular unit and maintained liaison with the general staff in TOKYO. This seemed to be an inherent weakness in the command structure, for it subordinated submarine operations to local needs and tactical situations and precluded the use of submarines as a unified strategic force.

Part III - I-400 AND I-14 CLASS SUBMARINES

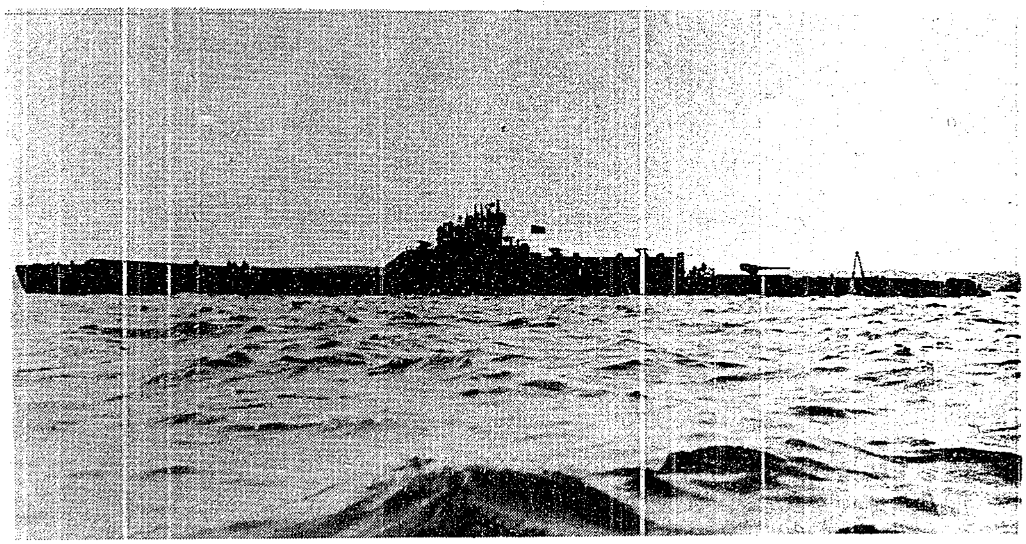


Figure 14
I-401

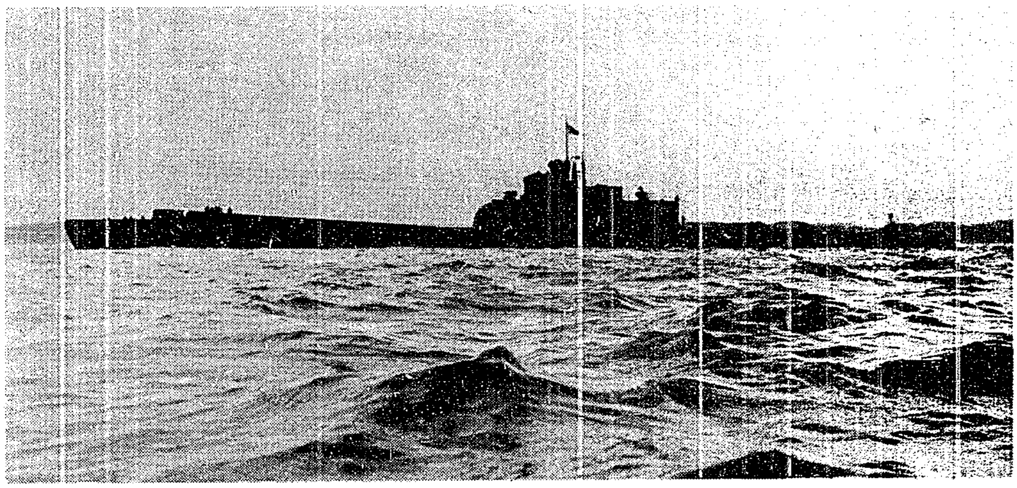


Figure 15
I-14

NRL(M) 38819

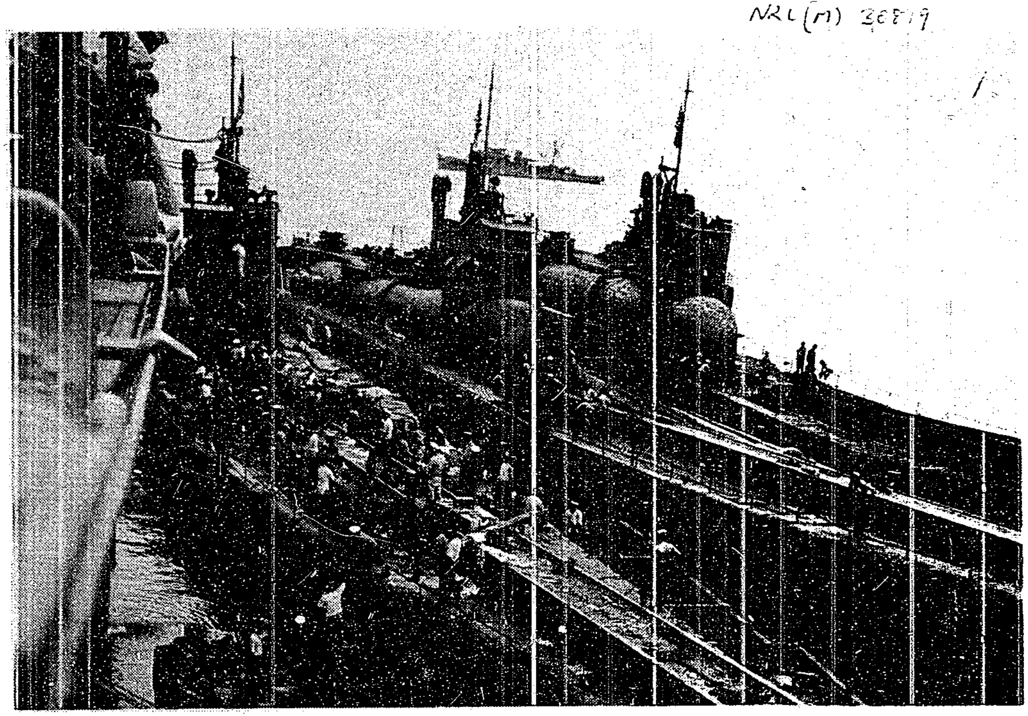


Figure 16
I-400, I-401, I-14 ALONGSIDE TENDER

PHOTO # NH 78650

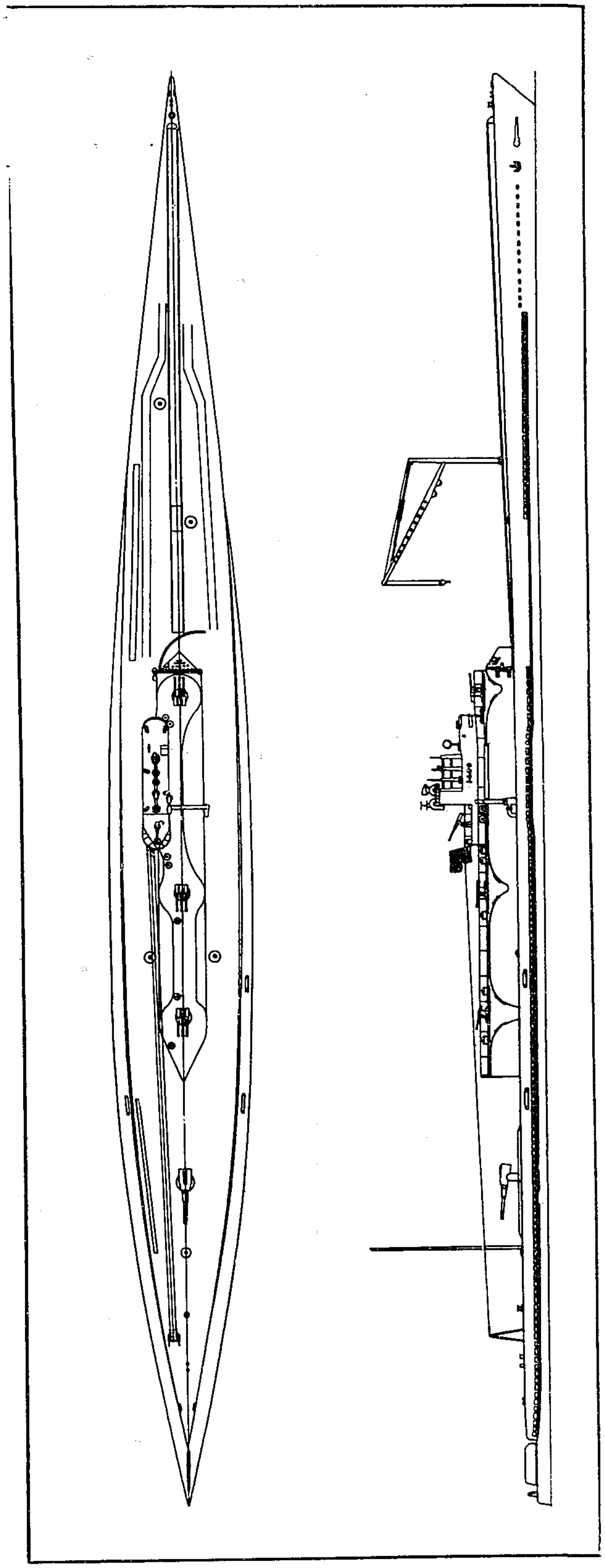


Figure 17
OUTBOARD PROFILE AND DECK PLAN, I-400

A. I-400 Submarines: Hull Construction and Arrangement:

Purpose:

The I-400 class of Japanese submarine is designed primarily for transportation of supplies, fuel, and planes to outlying islands.

General Characteristics:

Length overall (approx)	400 ft
Maximum beam (approx)	40 ft
Distance keel to top of shears (approx)	56 ft
Mean draft (approx)	24 ft 6 in
Displacement, surface (from POW)	5700 long tons
Test depth	100 meters (328 ft)
Pressure hull - thickness	3/4 in to 1 1/16 in
frame spacing	60cm (23.6 in)
Complement	21 officers, 170 enlisted men
Completed (from POW)	February 1945

Propulsion:

Maximum speed, surface*	19 plus knots
Cruising - speed, surface	16 knots
range (approx)	20,000 miles
Speed submerged	5 to 7 knots
Engines	four MAN Type, 2250 S.H.P. each
Generators	two auxiliary diesel, 400 KW each
Main motors	two, 1600 KW each
Propellers	two

*Direct engine reduction drive on surface.

Armament:

Torpedo tubes	eight forward
Deck guns - 145mm (5.7 in)	one aft
25mm - triple mounts	three
single mount	one
Sea planes	four*

*Three in hangar assembled and one disassembled and crated.

Pressure Hull Construction

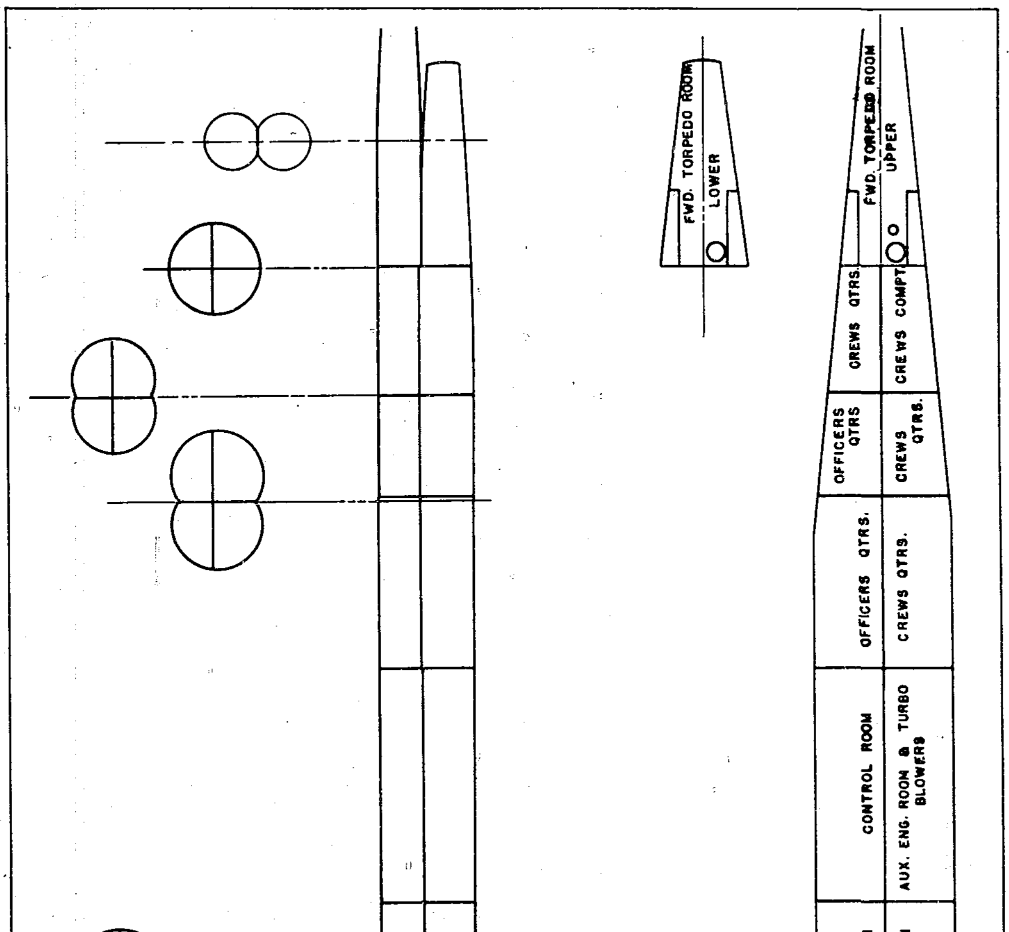
1. Of primary interest is the design of the pressure hull. There are two torpedo rooms forward, one vertically above the other, each containing four tubes. The contour is that of a vertical figure eight with the common side being of structural strength. The forward bulkheads are of 8 ft. 6 in. diameter and are dished outward to a constant radius. The radii of the two lobes of the figure eight increase as the after bulkhead is approached. At the bulkhead the pressure hull is a circle of 19 ft. 6 in. diameter.

A longitudinal centerline structural bulkhead runs from the after bulkhead of the forward torpedo room to the forward bulkhead of the after compartment of the pressure hull.

In the two pairs of compartments aft of the torpedo room, the cross-section varies from a circle at the forward end to a horizontal figure eight at the after end, having the longitudinal bulkhead as a common side. The two intersecting circles are of 9 ft. 6 in. radius maximum and have a common chord of approximately 16 ft. 9 in. at the after end. The cross-section is uniform and of the above dimensions in the next three longitudinal watertight spaces which include the following: Battery compartment, port and starboard, with living quarters above; control room to port and auxiliary room to starboard; main engine rooms, port and starboard.

From the after bulkhead of the engine rooms, the cross-section tapers in the maneuvering room toward the after bulkhead. The cross-section becomes somewhat heart-shaped due to the rise of the after keel. There is a flat inner keel of about three and a half feet total width.

The exact geometric contour of the cross-section in the forward part of the after room has not been determined because of inaccessibility. It appears to be circular in the upper half and tapers toward the keel. The after compartment, which contains crew's quarters, steering gear and operating gear for stern planes, is the longest compartment in the pressure hull, being 61 ft. 3 in. in length. The cross-section fairs almost to a perfect circle at the after end of 8 ft. 6 in. diameter.

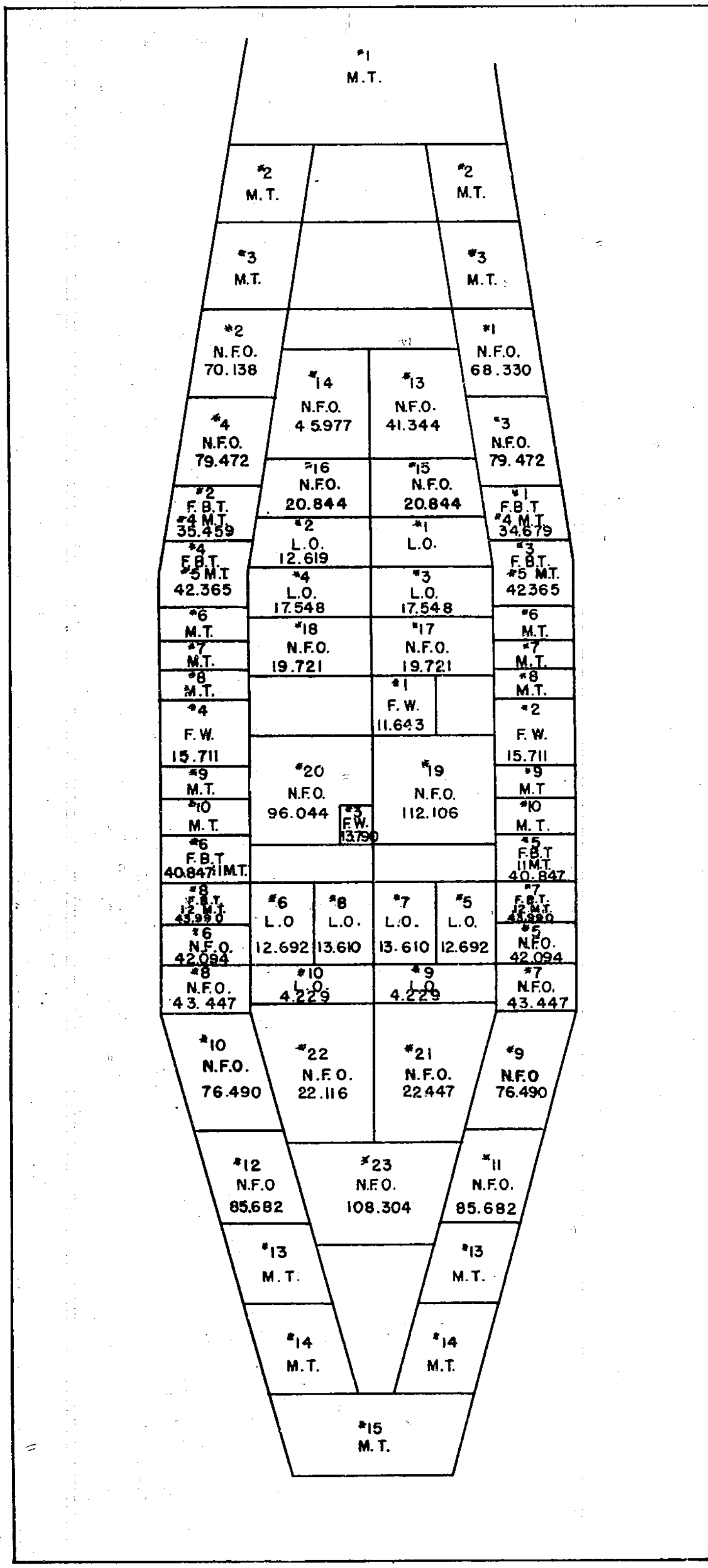


Sketch of Pressure Hull and Compartment Plan, I-400

Figure 18

PHOTO #: NH 78651

PHOTO # NH 78652



Sketch of General Arrangement and Capacity of Tanks, I-400

Figure 19

The pressure hull has a thickness of 1-1/16 in. amidship and from .7 in. to .75 in. at the ends. It is of double-butt strap, riveted construction throughout. The external longitudinal straps are intercostal with the frames. Although the riveting appears to be good in general, there exists tne definite impression of careless construction. The construction in the vicinity of hull openings and fittings appears to be inconsistent. For example, around a hatch trunk in the engineroom a large doubler plate is secured by riveting to replace the pressure hull plating cut out for the trunk opening. In other places the external pressure hull frames are greatly increased in size adjacent to a hull opening, the fitting for which appears to supply sufficient strength to compensate for pressure hull removed. The other extreme is shown in both enginerooms. The hull opening for the exhaust line from each inboard engine was cut on the same circumference as that of the outboard engine. A change in design moved the inboard exhaust valves and hull openings approximately two feet aft. The method of closing the holes first cut was to install a lapped external plate with a single circle of rivets in one arc. Another example exists in the after compartment, port side, where a 3 in. fitting through the hull had been removed. Closure was effected externally with a lapped plate and external fillet weld only. Also pressure hull bulbous frames are joined by a lap riveted joint, reversing the direction of the lower flange.

The pressure hull frame spacing is 60 centimeters or about 23.6 inches. The spacing is not too consistent, varying plus or minus a half inch from that figure. The frames are of the bulbous angle type 3 1/2 in. by 9 in. size. About every six frames is a 3 3/4 in. by 9 1/4 in. bar frame. The framing is another example of a general characteristic of failure to utilize the strength of the structural steel per unit weight to the full.

2. The hangar will house four airplanes. There are two long pressure proof stowages of about 5 1/2 feet in diameter, port and starboard to hold pontoons and/or wings. The hangar is 11 ft. 9 1/2 in. diameter with a length of 102 ft. 3 in. and is approximately 15 in. to starboard of the centerline. Frame spacing is an average of 60cm but the variation is greater than on the pressure hull. Internal frames are T-bar with 3/4 in. by 3 1/4 in. flange and 2 1/2 in. web. The wrapper plate and frames are welded construction throughout. The internal framing is interrupted in the lower arc by the track for airplane launching carriage. Over this portion, there are external frames which are in turn secured at the pressure hull at about every fourth frame. The hangar door is a weldment and hung on a riveted vertical hinge to starboard. It can be opened hydraulically through a piston and bell-crank arrangement or manually from the deck by means of a rack and spur gear. Watertightness is obtained by means of a 2 in. wide rubber gasket inserted in the door. A gagging device is installed on the port side.

3. The conning tower is of 8 ft. internal diameter with a cylindrical length of 20 ft. 3 in. The two end-bells are of approximately 8 ft. radius. The centerline of the conning tower is approximately 6 ft. 10 in. to port of the centerline of the ship.

4. There are seven hatches leading into the pressure hull of 25 1/2 in. I.D.

a. Aft port side of fwd. torpedo room.
b. Fwd. end of second compartment to starboard (crew's quarters).
c. From conning tower.
d. From hangar to starboard auxiliary room (opposite control room). (19 3/4 in. diameter).
e. Starboard engineroom.
f. Port engineroom.
g. After room.

5. There are four doors of 31 1/2 in. diameter in the longitudinal bulkhead; namely, in the third compartment from forward, between the control room and the auxiliary room, between the two enginerooms, and between the port and starboard maneuvering room.

General Arrangement

1. Topside

a. The bow planes completely house in the superstructure and overlap each other in the rigged-in position. The planes are rigged out by rotation about a vertical axis through approximately 140 degrees. The electric rigging motor in the overhead of the torpedo room rotates the planes through gears and shafting which runs through a duct in the upper part of #1 M.B.T. Rigging requires about twenty seconds. Power for tilting is furnished by an electric motor in the torpedo room overhead driving an A-end hydraulic pump. The B-end hydraulic pump has a worm gear on the rotating shaft which in turn extends through the pressure hull at a sharp angle and is connected to the tilting bell crank between the two bow planes. The planes will tilt 30 degrees rise and 35 degrees dive. When the planes are tilted the rigging axis of the planes also tilts. The relative motion in the rigging shafting is accommodated by means of a universal and a slip joint. There is hand power operation for tilting from the control room by means of a clutch arrangement in the forward room. The bow planes appear to be comparatively small for this size of submarine.

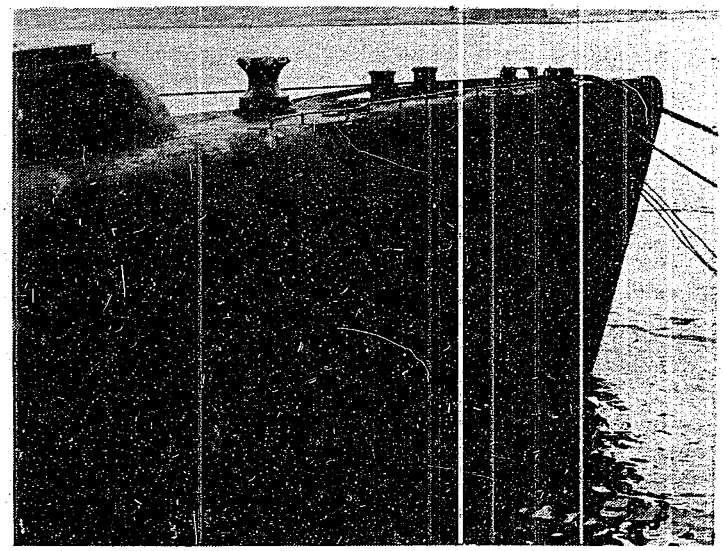


Figure 20

I-400 SHOWING HOUSED BOW PLANES

b. There are forward and after capstans operated mechanically through gearing from electric motors within the ship. There is provision for hand-turning with bars from topside. The anchor windlass operates from the same motor as the bow capstan through an external clutch arrangement.

c. The airplane track and catapult is slightly to starboard at the hangar end and converges toward the centerline at the bow. The catapult track from the launching position is 85 ft. 4 in. in length.

The catapult operates by use of a compressed air piston. Below the catapult track are four H.P. air flasks of 150kg/cm^2 pressure which connect in parallel to the air piston flask. A piston rod extends from the air piston forward and connects to a moving carriage having multiple sheaves. Two wire ropes are connected to the catapult car, led over two sheaves on the end of the catapult, and rove through the movable and stationary sheaves in the cable chamber. When the catapult is fired the piston and movable sheaves travel aft about 8 ft. to 10 ft. while the plane carriage travels forward about 70 ft. to 75 ft. The arresting gear for the carriage consists of a heavy wire rope which is led around movable sheaves that are restrained by spring tension. When not in use, the launching cable is stowed in the cable chamber, a pressure proof door of about 15 in. diameter is secured, and air pressure is bled in to keep water from leaking into it during submergence.

Figure 21

I-400 BOW VIEW SHOWING CATAPAULT

d. The plane boom is on the port side abreast of the after part of the catapult. It is very bulky and from an estimate based on cable size appears to be about five ton capacity. The length of the kingpost is 26 ft. 4 in. and of the boom 38 ft. 10 in. The boom is mounted 15 ft. 10 in. above the kingpost lower pin. It is raised by gearing and shafts from a motor inside the ship. Hoisting is by cable and drum driven by an internal electric motor.

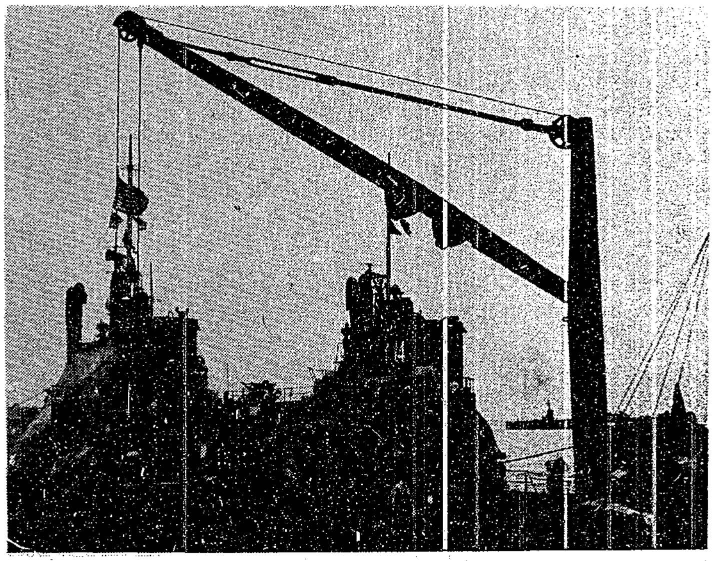


Figure 22
AIRPLANE BOOM, I-401

e. An elevator forms part of the track from the hangar to the catapult. Stowage is provided below the ramp leading to the catapult for plane catapult cradles. There are two wing sections of the deck which might be called elevators to be used in connection with the port and starboard pressure proof stowages. A section of decking is hinged at the forward end. A hydraulic piston allows the after end to be lowered to the length edge of the stowages to facilitate handling of heavy gear.

NRL(M) 30947

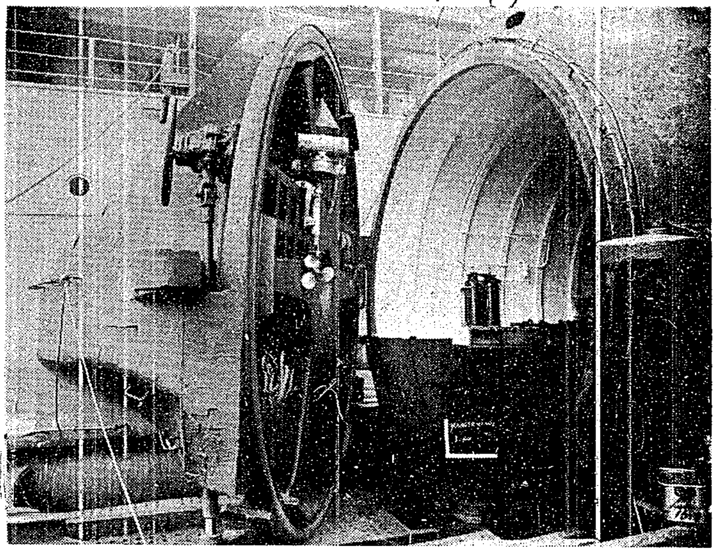
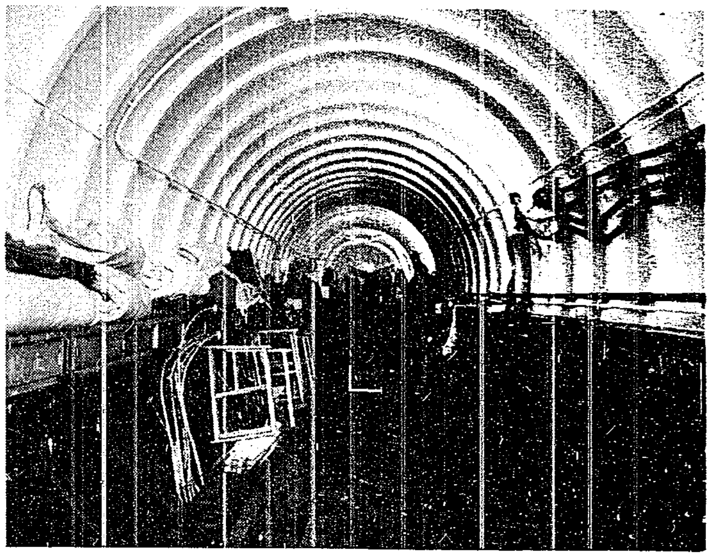


Figure 23
EXTERIOR VIEW
FORWARD PART OF HANGER, I-400

Figure 24
INTERIOR VIEW OF HANGAR, I-400



NRL(M) 30942

Japanese SEIRAN Type Airplane. This is the type plane currently carried by these submarines. The photograph shows a trainer with wheels - when carried floats are fitted. This is essentially a JUDY with folding wings and tail assembly.

Plans for future submarines were made discarding this airplane and substituting the suicide BAKA 53 type of jet propelled bomb.

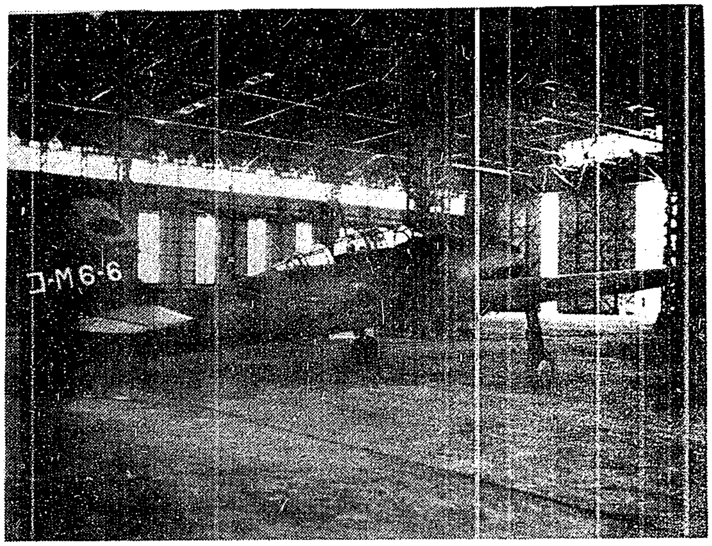


Figure 25

SEIRAN TYPE AIRPLANE

f. A gun ammunition scuttle is installed in the port superstructure fairwater. It is vertical and extends from the magazine which is below the after part of the control room.

g. A 105mm deck gun is mounted on the main deck aft.

h. A radio mast 43 ft. long is installed abreast of the gun and after room hatch. It is raised by an internal electric motor, gears, and endless chain attached to the lower end of the mast below the pivoting point.

i. There are three triple 25mm mounts, one forward of the conning tower and two abaft on the superstructure deck on the center line. There is also a single 25mm abaft the bridge and off the center line to port.

j. There are five shears on the center line of the conning tower. From forward they are for the attack periscope, the high angle periscope, the vertical antenna and secondary SD antenna, the SJ and the SD in that order. The latter two do not hoist and are about two feet higher than the forward three. There is an RDF loop forward and to port of #1 periscope which can be hoisted.

k. A "schnorkle" is installed on the starboard side of the conning tower. It is raised hydraulically and is exhaust and intake for auxiliary engines only.

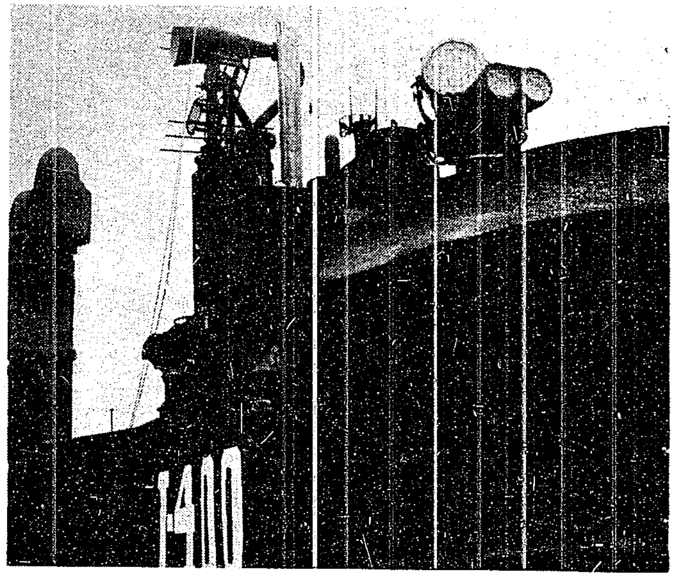


Figure 26
SCHNORKLE INSTALLATION, I-400

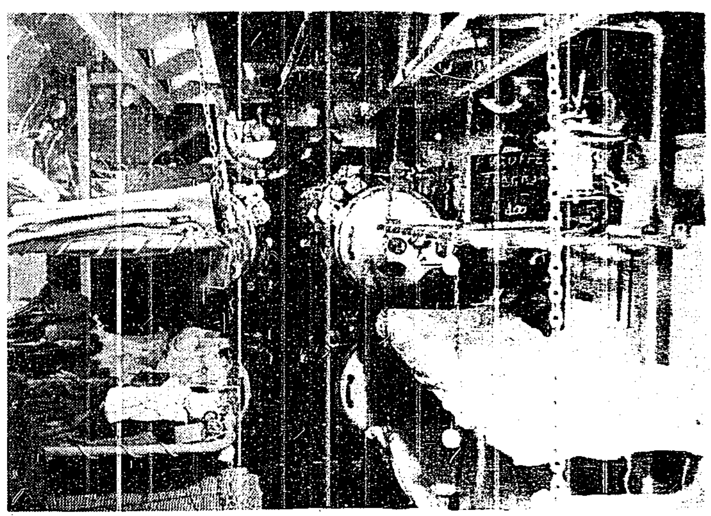
1. There are five sets of large pressure proof binocular TBTs mounted on the bridge. Although heavy, they are well balanced and are 20X.

2. <u>Arrangement of Pressure Hull Compartments from Forward to Aft.</u>

a. In the upper and lower torpedo rooms there are WRT tanks in the after port and starboard corners. The chain locker is on the starboard side just inboard of WRT and increases to about 4 ft. 5 in. diameter at the upper walking flat.

There is a drain pump on the upper flat to starboard and forward of WRT. A trimming pump is installed in the lower torpedo room. Impulse flasks are inside the pressure hull.

Figure 27
UPPER TORPEDO ROOM, I-400



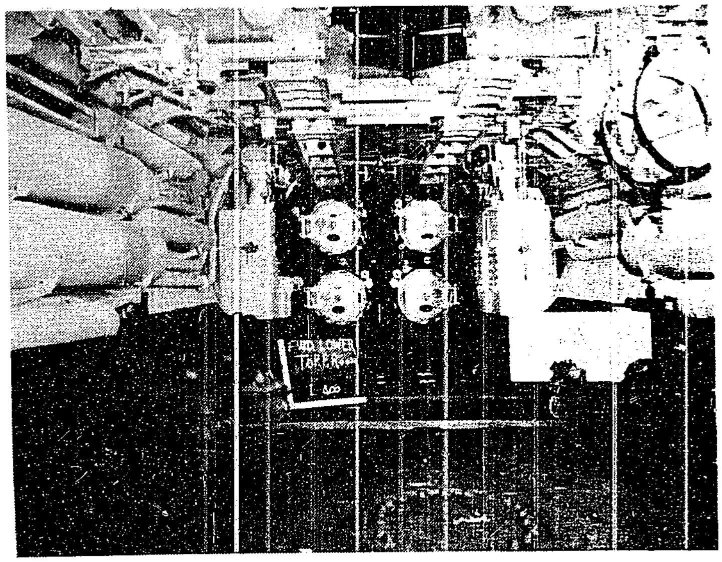


Figure 28
LOWER TORPEDO ROOM, I-400

b. The #2 port and starboard compartments are crew's quarters with tanks below.

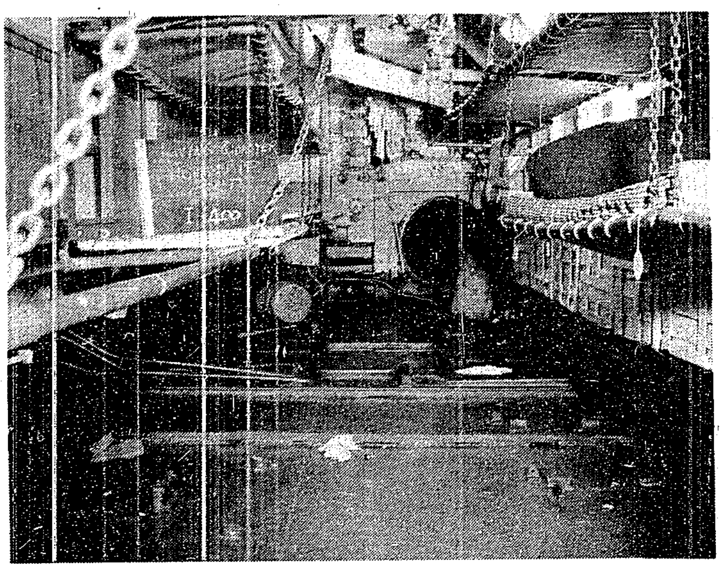


Figure 29
LIVING QUARTERS AMIDSHIPS, I-400

c. The #3 starboard is for crew's berthing and messing. There are three W.C. in the forward outboard corner. The #3 port has a sound room in the forward outboard corner, then officers' galley, followed by warrant officers berthing for six warrants. There are 60 battery cells each under #3 port and starboard walking flats.

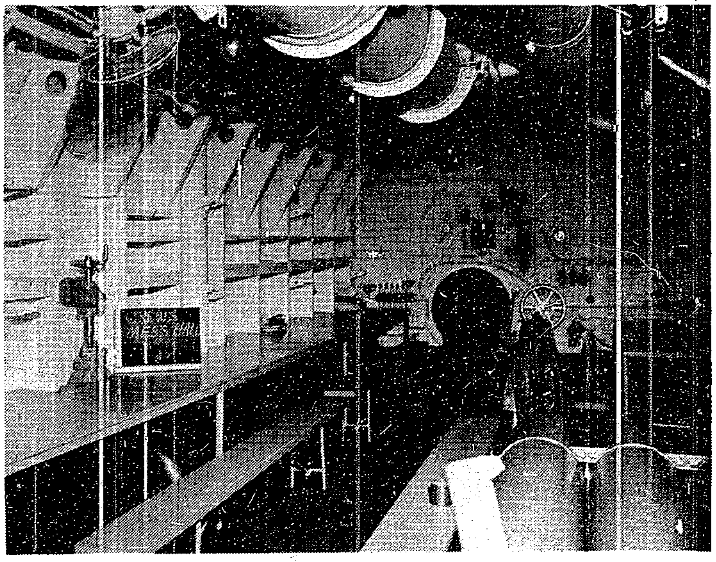
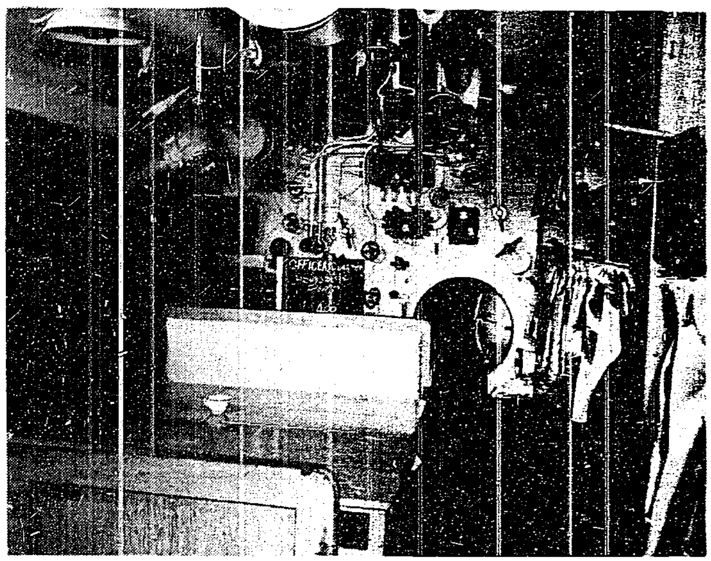


Figure 30
CREWS MESS ROOM, I-400

d. The #4 starboard compartment is for crew's berthing with 120 battery cells and 10 battery water tanks below the walking flat.

The #4 port compartment is officers' quarters and wardroom with 120 battery water tanks below the flat.

Figure 31
OFFICERS MESS, I-400

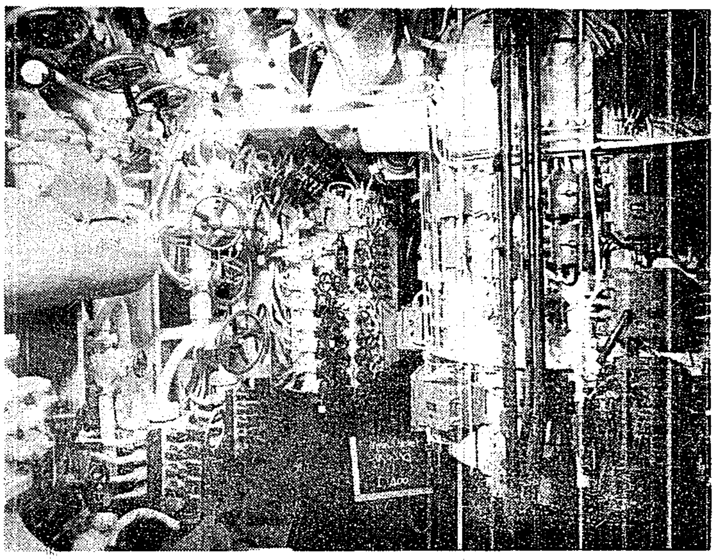


Total battery water tank capacity is about 1820 gallons, plus four gravity tanks.

e. The #5 starboard contains crew's galley in forward outboard corner with a storeroom immediately aft. Abreast of these spaces and inboard is the turbo-blow which discharges through the longitudinal bulkhead into the low pressure blow manifold in the control room. Immediately aft of the turbo-blow, the #1 periscope hoisting motor is secured to the overhead. Two auxiliary engines with generators on the forward end are mounted with passageway between. Two auxiliary distribution boards are installed, one in each after corner. A hatch trunk, with upper and lower hatches, leads to the hangar from just forward of the outboard auxiliary generator. A cold room and bilge pump are located below the walking flat forward. The #5 port contains the hydraulic vent manifold on the forward bulkhead and the L.P. manifold on the longitudinal bulkhead forward and aft of access to the starboard compartment. Main and auxiliary gyros are installed in the athwartships center of the compartment just aft of the trunk leading to the conning tower. The #2 periscope and vertical antenna trunks are immediately aft.

The pump room below the forward third of the control room contains trim pump, drain pump, two ventilation exhaust blowers, and considerable piping and valves for the two pumps, to the negative tank, and to both port and starboard auxiliary tanks, Nos. 1, 2, and 3.

In the remainder of the compartment, the radio room, radar room, ammunition scuttle with magazine below, and storeroom are outboard of the passageway. Ship's office, shower, access to magazine, engineer's log room are inboard of the passageway. The ammunition scuttle is supplied in the magazine.



NRL (O) 30943

Figure 32
CONTROL ROOM, I-400

NRL (n) 30939

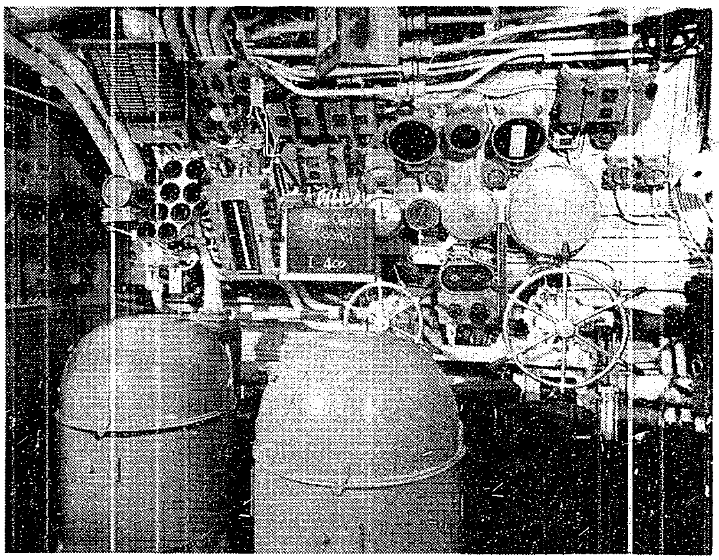
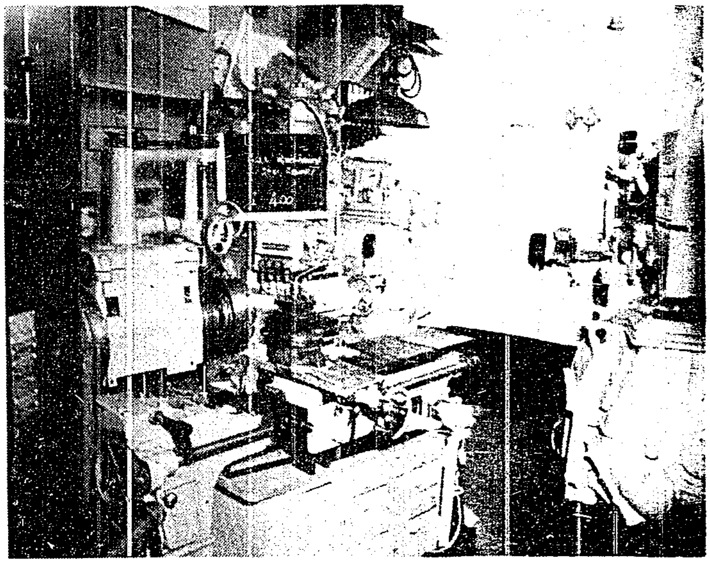
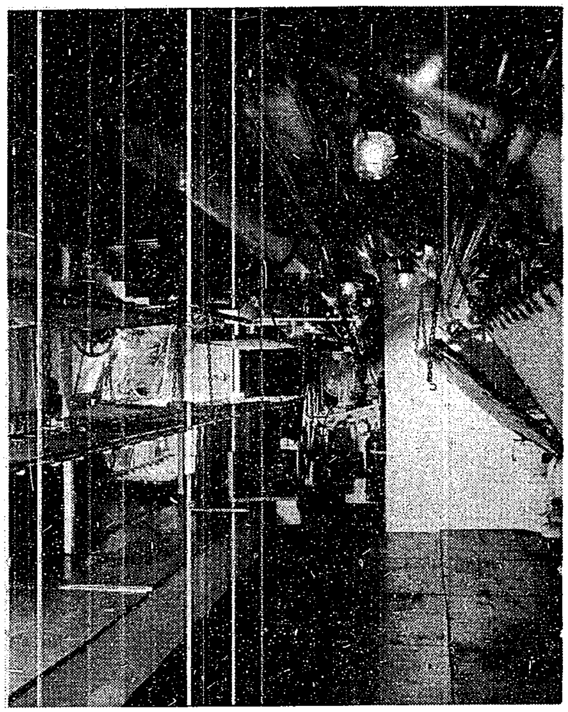


Figure 33
CONTROL ROOM, I-400

f. The #6 port and starboard compartments ar practically identical but to opposite hand. There are two main engines in each compartment with reduction gears at the after end. There is a hydraulic clutch between each engine and its pinion in the reduction gears. Auxiliary equipment such as air superchargers a d circulating water pumps are electric driven. There are ventilation blowers in each forward corner of each compartment. There is a bilge pump in each engine room which can take suction from that compartment or the maneuvering room. At the after end of each main engine is an evaporator which utilizes the heat of engine exhaust for operation. The evaporators also have electric heaters.

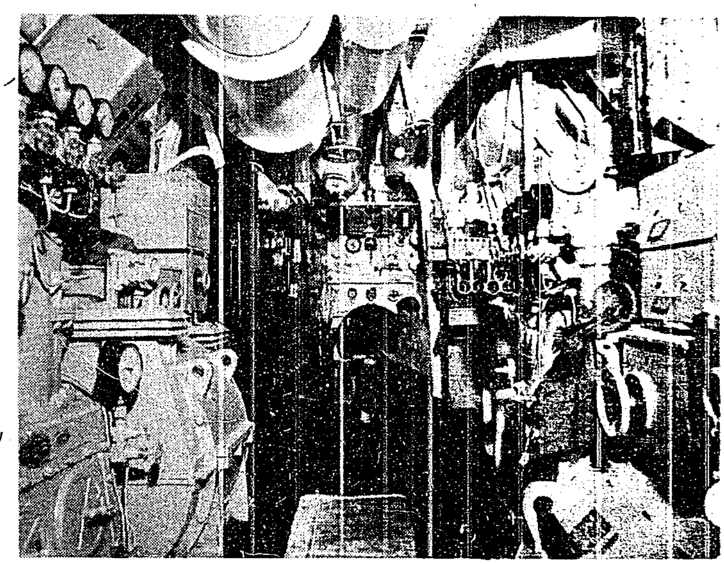
Figure 34
PUMP ROOM I-400





NRL (n) 30944

Figure 35
CREW'S LIVING SPACE, I-400



NRL (n) 30934

Figure 36
ENGINEROOM, I-400

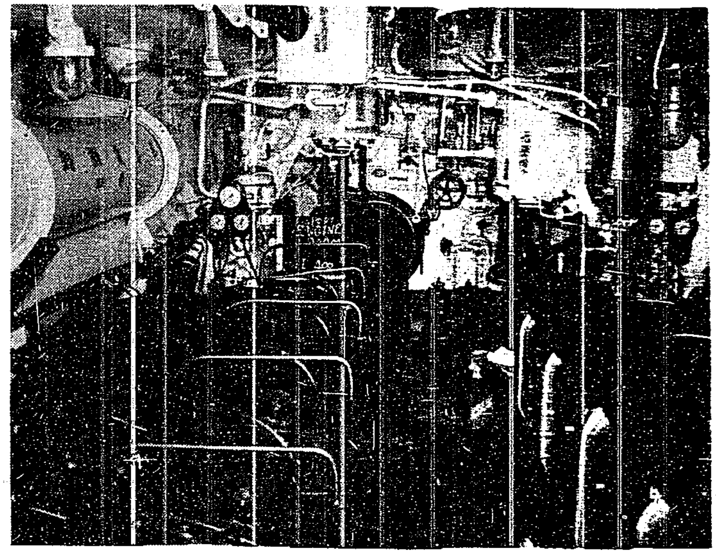


Figure 37 NRL(M) 30931
ENGINEROOM, I-400

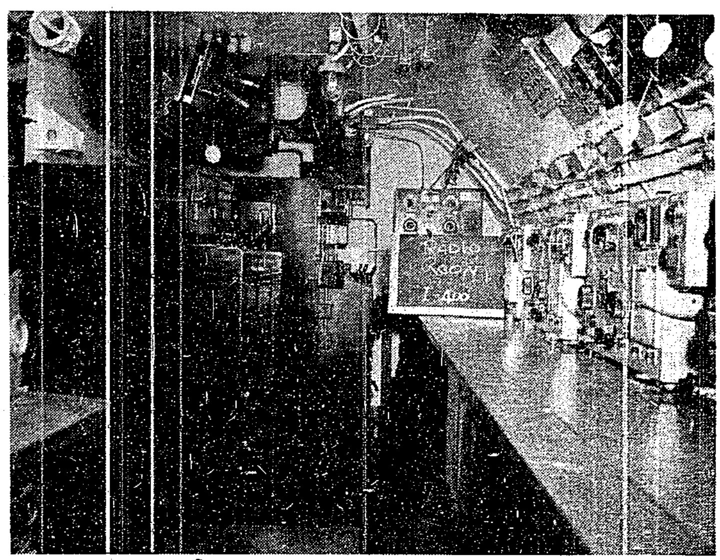


Figure 38
RADIO ROOM I-400

g. The #7 port and starboard compartments are almost identical but to opposite hand except for a storeroom in the after part of #7 starboard.

The control cubicle is outboard of the passageway and faces inboard in each compartment.

There are two air compressors in each compartment.

Duplicate systems of two hydraulic pumps are installed aft and inboard of the passageway in the port room with replenishing tank overhead. Four hydraulic accumulators in parallel are in the lower flats on the port side. The motor on each side is in line and the armature is connected with the shaft from the bull gear and the tail shaft by means of mechanical square-tooth clutches, one forward and one aft of the motor. A friction brake is installed abaft the after clutch on each side.

h. The after compartment is crew's berthing in the forward two thirds of its length. Aft on the port side are the electric motors and mechanism to operate the stern planes. Further aft and on the port side is the steering motor and mechanism with hydraulic rams to the rudder yoke port and starboard. Air flasks are on the starboard side aft. A trim pump is on the centerline and the drain pump outboard at the forward bulkhead. A submerged signal ejector is located to starboard of the centerline in the overhead of this compartment. It is fired by air. There are interlocks so that the inner door cannot be opened unless the outer door is closed and vice versa, and the air firing valve cannot be operated unless the outer door is open.

i. Air flasks are mounted indiscriminately throughout the ship inside the pressure hull. They are under bunks, mess tables, in storerooms, and on the overhead.

j. The conning tower has steering control and hydraulic vent manifold for the last group of tanks to flood before submerging. The DQ mast is on the port side forward of #1 periscope. The torpedo angle solver is on the port side slightly aft of the vertical antenna mast. Sound and radar equipment is in the after portion of the conning tower.

3. Tank Arrangement and Capacities.

a. The exact shape or boundaries of all tanks are not known and have not been determined at the present time. Because of non-availability of plans, it will be necessary to dock the vessel and enter the various tanks to ascertain the exact dimensions. However, the location inside or outside of the pressure hull, approximate longitudinal location, and capacities except for MBT are known.

Tank	Internal	External	Adjacent to Compt. No.	Capacity Metric Tons
#1 MBT		X	Forward of #1	
#2 MBT		X	#1 (Forward)	
#3 MBT		X	#1 (Aft)	
#6 MBT		X	#4 (Middle)	
#7 MBT		X	#4 (Aft)	
#8 MBT		X	#5 (Fwd. End)	
#9 MBT		X	#5 (Aft)	
#10 MBT		X	#5 (Aft)	
#13 MBT		X	#8 (Middle)	
#14 MBT		X	#8 (Aft)	
#15		X	Aft of #8	

Tank	Internal	External	Adjacent to Compt. No.	Capacity Metric Tons
#1 F.W.	X		#5 (Stbd. Fwd.)	11.643
#2 F.W.		X	#5 (Stbd. Mid.)	15.711
#3 F.W.	X		#5 (Port Aft Inbd.)	13.790
#4 F.W.		X	#5 (Port Mid.)	15.711
			Total	56.855 - 15,100 gals.
NFO #1		X	#2 Port	68.330
NFO #2		X	#2 Starboard	70.138
NFO #3		X	#3 Starboard	79.472
NFO #4		X	#3 Port	79.472
NFO #5		X	#6 Aft Starboard	42.094
NFO #6		X	#6 Aft Port	42.094
NFO #7		X	#6 Aft Starboard	43.447
NFO #8		X	#6 Aft Port	43.447
NFO #9		X	#7 Starboard	76.490
NFO #10		X	#7 Port	76.490
NFO #11		X	#8 Stbd. Fwd.	85.682
NFO #12		X	#8 Port Fwd.	85.682
NFO #13	X		#2 Starboard	41.344
NFO #14	X		#2 Port	45.977
NFO #15	X		#3 Starboard	20.844
NFO #16	X		#3 Port	20.844
NFO #17	X		#4 Starboard	19.721
NFO #18	X		#4 Port	19.721
NFO #19	X	#5	#5 Stbd. Aft.	112.106
NFO #20	X		#5 Port Aft.	96.044
NFO #21	X	#7	#7 Starboard	22.447
NFO #22	X		#7 Port	22.116
NFO #23	X		#8 Fwd.	108.304
			Total	1322.306 - 408,000 gals.
#1 FBT		X	#3 Stbd. Aft.	34.679
#2 FBT	#4 MBT	X	#3 Port Aft.	35.459
#3 FBT		X	#4 Stbd. Fwd.	42.365
#4 FBT	#5 MBT	X	#4 Port Fwd.	42.365
#5 FBT		X	#6 Stbd. Fwd.	40.847
#6 FBT	#11 MBT	X	#6 Port Fwd.	40.847
#7 FBT		X	#6 Stbd. Mid.	43.990
#8 FBT	#12 MBT	X	#6 Port Mid.	43.990
			Total FBT	324.542 - 100,000 gals.
			NFO	1322.306 - 408,000 gals.
			Total Fuel	1646.848 - 508,000 gals.
#1 L.O.	X		#4 Stbd. Fwd.	12.619
#2 L.O.	X		#4 Port Fwd.	12.619
#3 L.O.	X		#4 Stbd. Mid.	17.548
#4 L.O.	X		#4 Port Mid.	17.548
#5 L.O.	X		#6 Stbd. Mid. Outboard	12.692
#6 L.O.	X		#6 Port Mid. Outboard	12.692
#7 L.O.	X		#6 Stbd. Mid. Inboard	13.610
#8 L.O.	X		#6 Port Mid. Inboard	13.610
#9 L.O.	X		#6 Stbd. Aft.	4.229
#10 L.O.	X		#6 Port Aft.	4.229
			Total	121.396 - 35,000 gals.

b. Variable Water Tanks.

Tank	Adjacent to Compt. No.	Approx. Capacity (long tons)
#1 Aux. Stbd.	C.R.	27.5
#1 Aux. Port	C.R.	27.5
#2 Aux. Stbd.	C.R.	31.5
#2 Aux. Port	C.R.	31.5
#3 Aux. Stbd.	C.R.	34.4
#3 Aux. Port	C.R.	34.4
#1 Neg. (Torp. Compensating)	F.T.R.	9
#2 Neg.	Pump Room	21.6
Safety	None	-
Forward Trim	Lower F.T.R. (inside)	8
After Trim	Aft Compt. (inside)	8

As noted, there is no safety tank; the auxiliary group is used for this purpose.

The #1 negative tank, according to POW information, is flooded on the surface and dry submerged as is the large negative tank. When torpedoes have been fired, and trimming water has been shifted forward after reloads are made, the #1 negative tank is flooded for the remainder of the patrol thus allowing forward and after trim tanks to have about equal amount of water. The #1 auxiliary tank, port and starboard, is above #2 auxiliary. The #3 auxiliary is the next tank aft outside the pressure hull.

General Comments.

1. All topside surfaces, and probably all of the hull, are covered with an anti-sound substance. Tests should be conducted unless this covering is found to be similar to that discovered on several German U-boats. It has a somewhat resilient foundation of synthetic rubber or asphalt with a thin cement or plastic covering. Adhesion between the rubber and cement is good. Adhesion to metal is fair in general but there is little resistance to impact or abrasion.

2. The main induction and hull ventilation piping topside is considerably different from standard U.S. practice. There are three disc-type valves in the perforated metal fairwater above the superstructure deck and abaft the conning tower. The forward valve supplies air to the port main induction which is connected to the port engine room hatch trunk above the lower hatch which is left open. The upper hatch is closed at sea. A branch leads off from the induction and enters the pressure hull forward to supply air for battery and hull ventilation supply on the port side of the ship.

The second induction valve supplies air to the starboard induction piping which leads vertically down the port side of the hangar, under it, and aft on the starboard side to the engine room hatch. A branch line supplies air to the starboard hull and battery ventilation system. Just below the valve disc in the bridge superstructure the "schnorkle" induction supply branches off with a separate stop valve.

The third disc valve in the superstructure is hull and battery ventilation exhaust. The exhaust line from starboard crosses to port under the hangar, joins the port exhaust line, and goes vertically upward alongside the hangar to the valve. All lines entering the hull have inboard-operated external backing up valves. The schnorkle exhaust piping branches off the two auxiliary engine exhaust pipes above the outboard valves. The two combine and the single pipe leads up the starboard side of the hangar to the schnorkle exhaust.

Although the connection of the main induction, port and starboard, does eliminate two openings in the hull, there is the distinct disadvantage of inability on the part of operating personnel to close the lower hatch should a casualty occur to the topside valve and allow a large stream of water to enter the submarine on diving.

3. The method of securing sectionsof induction piping is of interest. The sections are flanged and riveted with large spacing of rivets. The flanges are evidently bevelled and then welded. After welding they are heavily peened or caulked at the joint to a depth of approximately an eighth of an inch and three eighths wide. Sections of hatch trunks are joined in similar manner. There is no doubt when any joint has been peened.

4. Lubrication of all topside operating gear for cranes, universal joints, valve operating gear, windlass, etc. is accomplished by use of grease cups. Operating personnel have been notably remiss in the application of topside lubrication.

5. There are tank top drains built through the tanks.

6. There are large buoyancy tanks forward and aft which extend up to just below the main deck.

7. Hooks have been welded to all topside hatches for installation of a depth charge securing bar just below the hatch seat. All accesses to the pressure hull have double hatches.

8. The torpedo loading hatch corresponds to the escape door on our forward access trunks. The lower hatch is offset forward slightly and tilted up at the forward end to accommodate the torpedo. This eliminates an opening through the pressure hull.

9. Known locations of ballast are:

   a. Along the longitudinal bulkhead in #2 port and starboard compartment.
   b. In the stowage-locker in the starboard auxiliary engine room.
   c. Topside aft just forward of the after topside tank.

10. There is much evidence that the Japanese leave something to be desired as pipe fitters. On all sizes over approximately 1 1/2 in. diameter the pipes have wrinkles in the inner radius.

11. The torpedo tube outer doors are opened by shafting through the torpedo room forward bulkheads the power for which is either by hand or through an air motor mounted on each tube.

The method of securing sections of induction piping is of interest.

12. The steering is controlled by shafting and gears from the control room to the tilting box of an electrically driven hydraulic pump in the after compartment. As the control worm gear is rotated, a traveling nut moves up or down. A link is pivoted on the traveling nut, the after end of which is connected to a spring-loaded bell-crank follow-up system which does not operate until the rudder steering rams move, and the forward end is connected to a bell-crank which operates the tilting plate. As the port ram moves forward or aft, the follow-up system returns the tilting plate to the neutral position. The hydraulic discharge lines are connected so that there is a pressure on opposite ends of both rams for either direction of rudder movement. Emergency steering utilizes main hydraulic power direct to the rudder rams. Steering stations are on the bridge, the conning tower and the control room.

13. Stern planes operate on the same principle as the bow planes tilting; namely, electric motor, hydraulic A-end, hydraulic B-end, and worm gear and rack on the tilting rod. However there are two stern plane electric-hydraulic A-end sets, either of which may be used through a manifold to drive the one B-end. In addition, there are two hand wheels which through gears and shafting can be used to operate the stern planes using the worm and rack after the hydraulic system has been thrown out by a clutch. Control stations are from the control room or after compartment. Stern planes have a thirty degree angle of tilt, rise or dive.

14. Trim Control. There are two internal trim tanks of about eight tons capacity each (from POW), one located in the lower torpedo room in the after part and one located in the after room toward the after end of the compartment. It has been mentioned that there is a trim pump in each of these spaces. From each tank there is a suction line running to the respective trim pump. The discharge from each pump and another line to each tank join in a common sluice line before passing through any bulkheads. The three-way connection is through a ckeck valve so that the discharge from one trim pump must go to the other trim tank. A relay starting box in each room is turned to the "ON" position when it is desired to operate the system. The actual starting and stopping of the pumps is from the control room. The only valve in the common sluice line is in the control room; although not opened for inspection, it must be a check valve. When the operating lever is in neutral, neither pump is running. Throwing the lever in one direction or the other rotates the check valve so that the flow of water can be allowed from the respective pump which has been started by a contact maker on the check valve operating rod. Vent lines from the forward and after tanks meet at a three-way plug valve in the control room. In the neutral position it allows either tank to vent and the other to draw a suction. Air at about 85 lbs/in^2 is connected to this valve. With the plug rotated to either extreme position water can be transferred by blowing one tank and venting the other.

15. Automatic Buoyancy Control. The automatic buoyancy control has frequently been misnamed the automatic trim. The system consists essentially of a control unit, two auxiliary tanks, and two pneumatically operated flood and discharge valves. Balancing is normally done, according to POW, at a depth of between 130 and 165 feet. No reason was given for this procedure.

The control unit contains a piston which is acted upon by sea pressure from the bottom. The desired depth is set by means of a hand wheel and when the unit is in operation, an electric motor adjusts spring compression in the piston cylinder through a rather complicated differential gear train. POW reports indicate the motor gear feature provides a dampening effect on the operation; however, the mechanism was not disassembled to verify this statement. A lever is secured with the top of the piston as a fulcrum. One end of the lever is rigidly mounted and the other extends between two sets of electrical contactors. A differential pressure on the piston, between sea pressure and spring pressure, caused it to move up or down, thereby completing an electrical circuit through one set of contacts at the end of the lever.

The two sets of contacts lead to two solenoid air valves, the operation of which opens a flooding valve to #1 auxiliary tank or a discharge valve from #2 auxiliary tank. The two valves to auxiliary tanks are located in the control room and have a common overboard connection. Only the #1 and #2 auxiliary tanks on the port side are connected to the balancing system. The air-operated flood and discharge valves are of the piston type and have a hand wheel adjusting and locking spindle to regulate the rate of water flow.

The #2 port auxiliary tank contains water and has an air pressure on it of between 115 and 225 lbs/in^2 from the regular blow connection. When the submarine goes below the depth set, the upper set of contacts in the control unit is closed by the piston lever. This actuates the solenoid valve allowing 225 lbs/in^2 air to open the discharge valve from #2 auxiliary. Since the original pressure in the tank is above that of sea pressure, water is blown out until the submarine reaches the correct depth and the solenoid circuit is broken allowing the discharge valve to close.

It is evident that the system will "hunt", especially if the submarine is not almost in a state of neutral buoyancy for a given depth when it is put into operation. Personnel aboard do not appear to be familiar with the details of the equipment. The POW commanding officer stated that in operation, the balancing equipment made considerable noise. Based on information available and without testing the equipment in submerged operation, a preliminary appraisal is that the overall desirability is to be questioned.

16. The outer hull has comparatively small dead rise for a submarine according to POW information. For the length of the straight keel, there is an outer ballast keel on the center line of the ship. It is about 4 ft. wide adjacent to the hull, 2.6 ft. wide at the bottom, and about 1.3 ft. deep.

17. Most of the auxiliary equipment appears to be somewhat complex, primarily in the number of valves, switches, and indicator lights. As previously remarked, the piping systems are rather extensive and it is believed that additional effort on layout could have simplified most installations. This impression may be due in part to foreigh workmanship and to the fact that this is an experimental class of submarine in which design work was rushed.

18. The I-401 is a sister ship and almost identical. This description applies to either submarine.

B. I-14 Submarines: Hull Construction, Arrangement, and Characteristics

Purpose:

The Japanese submarine, I-14, is designed for transportation of supplies, fuel, and planes to outlying islands as well as for offensive action. It should be noted that this submarine is a new vessel and does not correspond to the old I-14 class.

General Information Books were available on board. The following information has been obtained from translation by the POW commanding officer of portions of these books, by interrogating various members of the crew, and by observation.

General Characteristics:

Length - overall	373 ft
between perpendiculars	365 ft
pressure hull	305 ft
Beam, maximum	38.4 ft
Pressure hull diameter, maximum	19.03 ft
Main deck width, maximum	26.25 ft
Mean draft - normal load	19.3 ft
full load	20.7 ft
Displacement, surface - normal load	3540 long tons
full load	3830 long tons

Test depth	328 ft
Pressure hull - maximum thickness at midship section	1.06 in
frame spacing	23.4 in
Tons per inch immersion - normal load	18.4
full load	17.3
Moment to change trim one inch - normal load	363 ft/tons
full load	349 ft/tons
Moment to change trim one degree submerged	139.5 ft/tons
Keel to main deck - bow	32.15 ft
midship section	28.55 ft
stern	22.65 ft
Height - from keel to - top of conning tower	44.3 ft
bridge deck	45.6 ft
#1 periscope, raised	74.6 ft
#2 periscope, raised	74.6 ft
vertical antenna, raised	76.1 ft
RDF, raised	58.5 ft
from main deck to radio antenna mast aft	42.5 ft
Number of small boats	one
Anchor	1.383 tons
Complement	15 officers, 112 men
Built at	Kawasaki, KOBE
Keel laid	February 4, 1943
Lauched	November 30, 1943
Completed (from POW commanding officer)	April 16, 1945

Propulsion and Endurance:

Cruising speed, surface	12 knots
Endurance - submerged - at 5 knots (approx)	25 hours
at 3 knots (approx)	35 hours
surface - at 12 knots	17,000 miles
food	90 days - 25 tons
Oil - fuel	335,000 gallons
lub.	19,200 gallons
Water - battery	1,160 gallons
fresh	8,720 gallons
Maximum speed - surface	17 knots
submerged	5 knots
Main storage battery	type 1, Mod. 13. 240 cells in two compartments
Generators	two auxiliary diesel 450 kw each
Main motors, electric	two special Mod. 8, 1100 kw each
Type of drive	direct, main motor in line of shafting with shafting with mechanical clutch forward and aft, no reduction gears
Main engines	two Mk. 22, Mod. 10, 5200 S.H.P. total
Propellers	two three-bladed

Armament:

Torpedo tubes	6 type 95, 20 in, bow
Torpedoes	18 total, type 91 and type 95
Guns	two triple 25mm; one single 25mm
Ammunition	11,200 rounds 25mm
Airplanes	two seaplane patrol, special S-type

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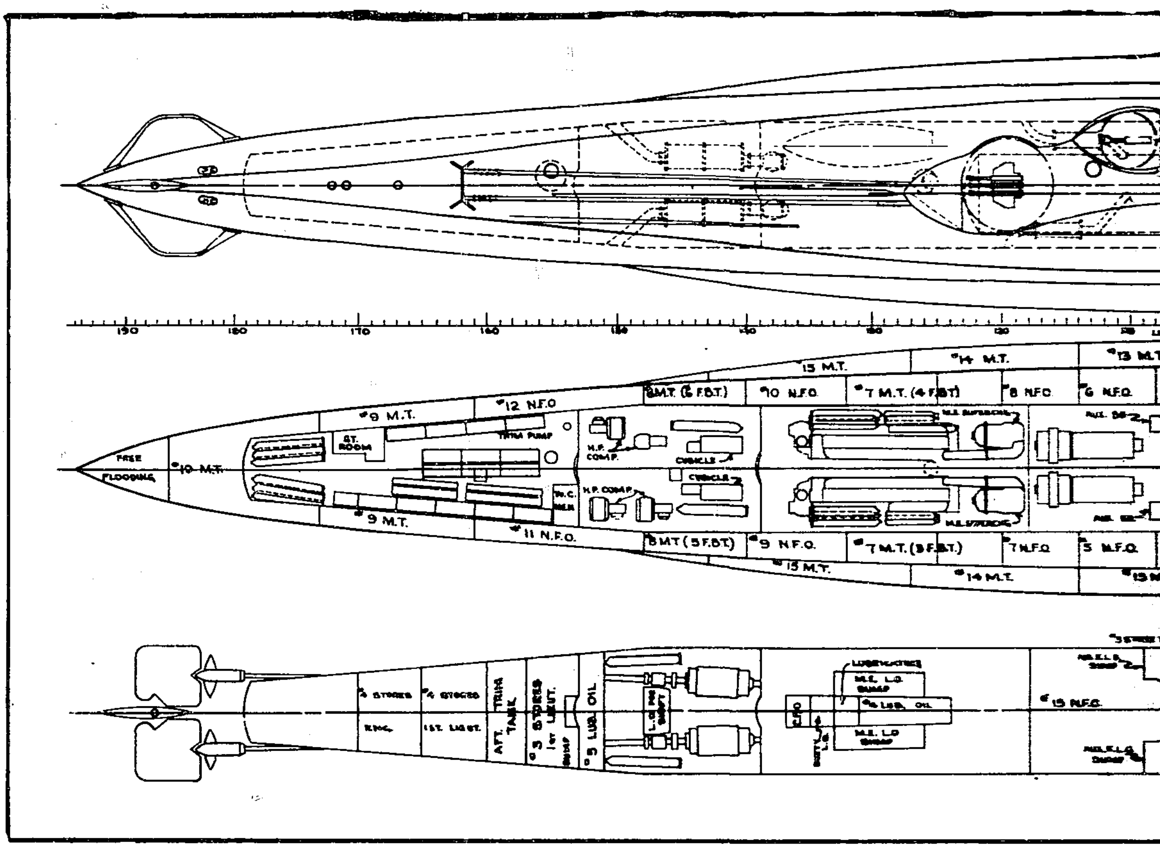

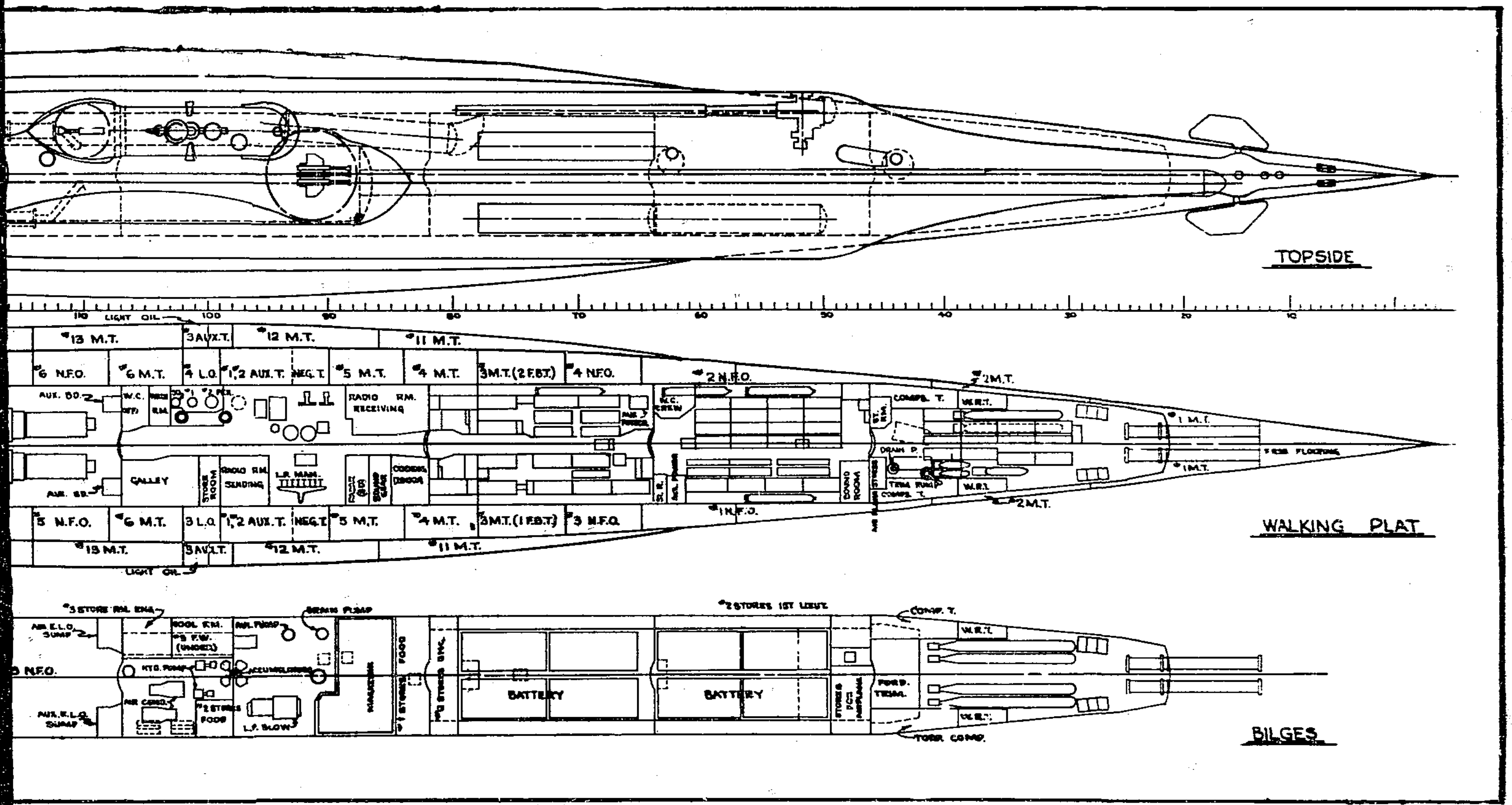

Figure 39
Deck Plans, I-14

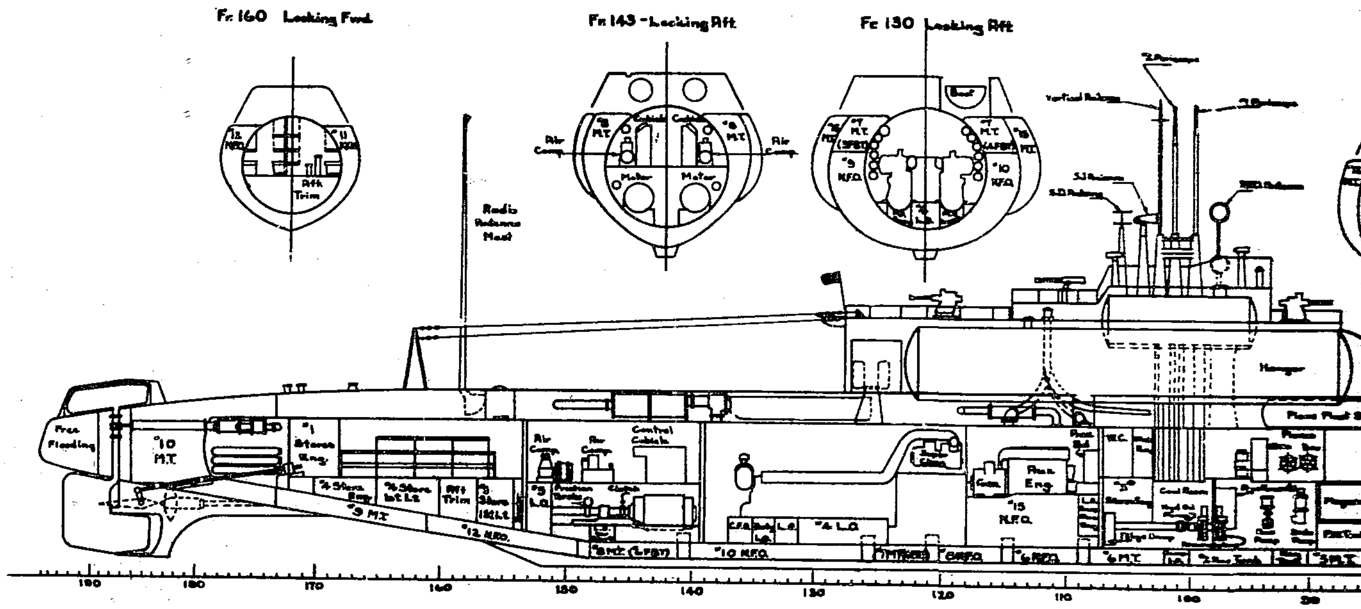

Figure 40
General Arrangment-Profile & Sect

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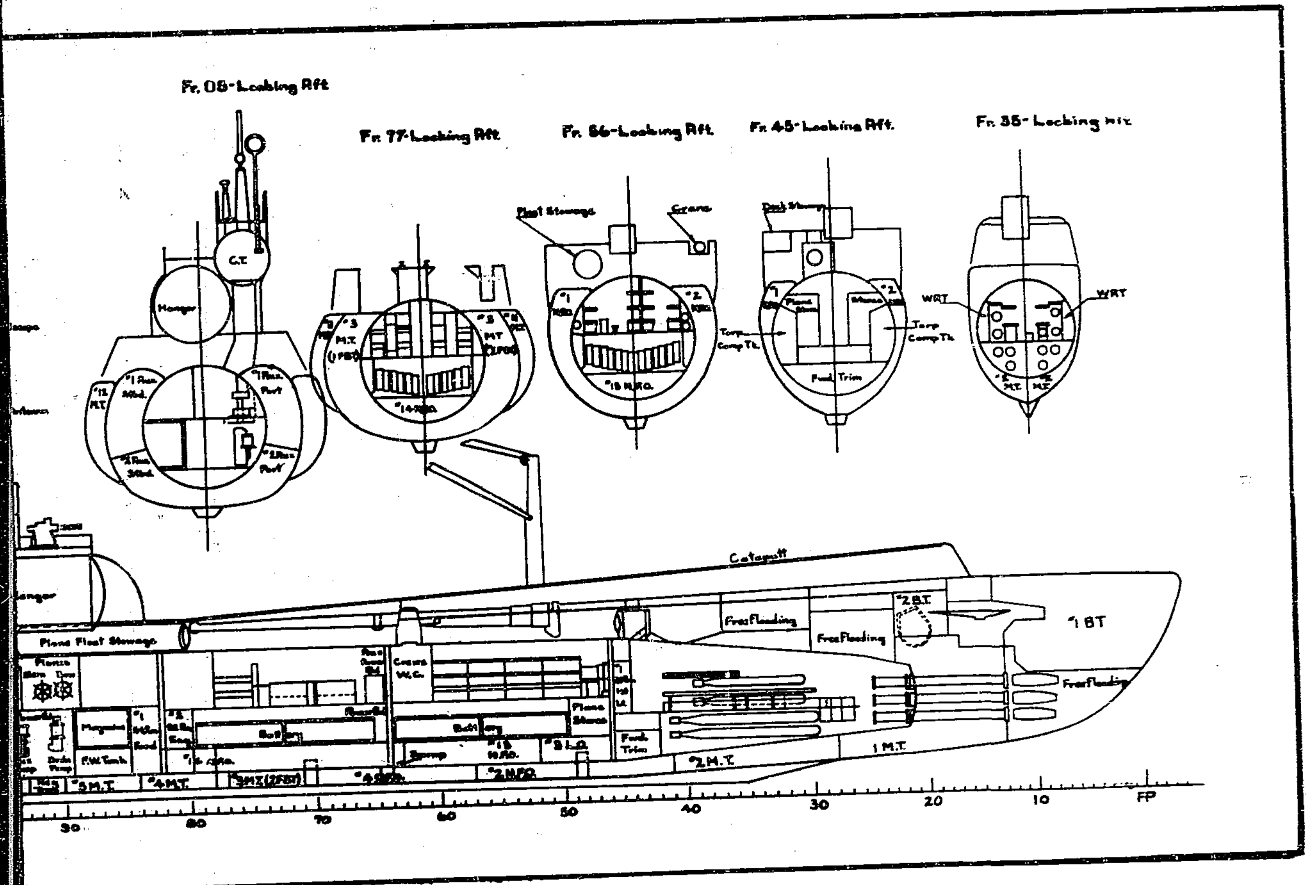


le & Sections. I-14

Construction.

1. The pressure hull is riveted, double-butt strap construction with circular cross section except in the forward torpedo room where it is oval. Pressure hull plating varies from a thickness of 1.06 inches in the constant diameter middle section to .867 inches in the forward torpedo room and to .71 inches in the after compartment. The diameter of the pressure hull is 19.03 feet maximum, decreasing to 9.03 feet at the after bulkhead of the after compartment. At the forward bulkhead of the torpedo room the major axis is vertical and is 9.82 feet with minor axis equal to 9.32 feet.

Frame spacing is 23.6 inches and the frames are of the bulbous angle type with a depth of 9.06 inches amidships and decreasing to a depth of 7.88 inches forward and 7.1 inches aft. Approximately every fourth frame is a built-up Z-bar of slightly greater depth. However, there are so many openings in the pressure hull that the heavier frame spacing is by no means constant.

The pressure hull is designed for a test depth of 328 feet. The POW commanding officer stated that, although he had never done so, he would have little hesitancy in going 20 to 30 meters deeper if the occasion demanded. He also stated that the submarine became about five to six tons heavy after 15 hours submergence at a depth of around 165 feet. The riveting is at least average but where two sections pressure hull framing are joined, the joint is lapped and riveted with the flange of the frame reversed. Reinforcement around hull openings, as on the other submarines, does not appear to be too consistent.

The riveted hard patch over the engineroom has a clear opening of 4.1 ft. by 2.79 ft. while the hard patch over the wardroom country is 3.12 ft. by 1.475 ft. There are no soft patches.

There are six access trunks into the pressure hull, all with double hatches. The hatches are all of 25.6 in. diameter with the exception of the access through the hangar and the conning tower hatch. The conning tower hatch is 24.6 in. diameter. The access trunks are located in the following compartments:

a. Torpedo room.
b. Crew's compartment, forward.
c. Control room, from conning tower.
d. Auxiliary engineroom, from hangar.
e. Main engineroom, upper hatch is in after end of hangar fairwater.
f. After compartment.

The watertight bulkhead doors are circular, 31.5 inches diameter, and have a locking ring for watertight closure. The pressure trunks between the conning tower and the control room are of the following diameter and plate thickness:

Hatch trunk	61 inches	.867 inches
#1 periscope trunk	41.0 inches	.867 inches
#2 periscope trunk	18.25 inches	.867 inches
Vertical antenna trunk	16.55 inches	.867 inches

2. The axis of the hangar is 9.52 ft. above the top of the pressure hull on the centerline. It is 11.6 ft. diameter, 65.6 ft. long, with plate thickness of .985 in. Frame spacing is 23.6 in. The construction and supports are similar to that on the I-400.

3. The conning tower is to port of the centerline of the ship. The axis of the conning tower is 16.55 ft. above the top of the pressure hull. It is of 8.2 ft. diameter, 22.4 ft. long, with 1.1 in. thick end bells dished to a 9.84 ft. radius. The connection of the end bell to the conning tower wrapper plate is a Tee-joint, double fillet weld. The end bell extends approximately 3/4 in. beyond the wrapper plate.

4. There are two pressure-proof airplane float stowage, one to port abreast of the hangar door and one to starboard forward of the hangar. They are of 4.27 ft. diameter, 26.6 ft. long, and .867 in. thick.

5. The outer hull is the boundary for saddle tanks around the pressure hull. Along approximately the middle fifty percent of the ship are port and starboard "blister" or "bulge" tanks.

The outer hull tank plating, except for external pressure tanks, is from .236 in. to .276 in. thick along the vertical sides. The pressure tanks outside the pressure hull are #1, 2, and 3 auxiliary tank port and starboard, negative tank, #3 and 4 fresh water, and the lub oil tank adjacent to the motor room. Plate thickness .985 in. The A-strake of the outer tank varies from .394 in. to .788 in. in thickness and the top strake varies from .55 in. to .63 in. in thickness near the midship section to reduce hogging and sagging. The main tank frames have a web thickness of .315 in. with depth varying from 2.76 in. to 3.94 in. Longitudinal stiffeners of 7.88 in. depth run from frames 48 to 149 in the outer tanks. Frame space in the main tanks is, in general, 19.7 in. There are thirty-four bulkhead sections in the outer tanks, not including pressure tanks, of .276 in. thickness.

The bulge tank plating is from .276 in. to .433 in. thick. The deadrise of the outer tanks is comparatively small. A ballast keel is fitted to the vertical keel. It is 3.94 ft. wide at the top, 2.7 ft. wide at the bottom, 1.35 ft. deep, 252 ft. long, and is filled with "wood and iron" according to a POW. The plate thickness of the ballast keel is .394 in.

Bilge keels 24.6 in. wide run from frames 81 to 122.

<u>Arrangement.</u>

1. The topside arrangement is very similar to that of the I-400 previously discussed in some detail. The major differences are:

a. Shorter airplane hangar, two planes instead of four.
b. Two triple 25mm mounts on the superstructure deck instead of three.
c. No deck gun aft and no ammunition scuttle.
d. Long radio mast aft is on the starboard side.
e. Main deck edge forward is of less breadth and more irregular.

The main deck is teak except for the extreme ends which are light plating.

2. The compartments within the pressure hull are of conventional proportions and are from forward as follows:

a. Torpedo room.
b. Forward crew's compartment, with battery below.
c. Officers' quarters, with battery below.
d. Control room, with large pump room below.

e. Auxiliary engine room.
f. Main engine room.
g. Maneuvering room, with motor room below.
h. After crew's compartment, with steering and stern plane gear.

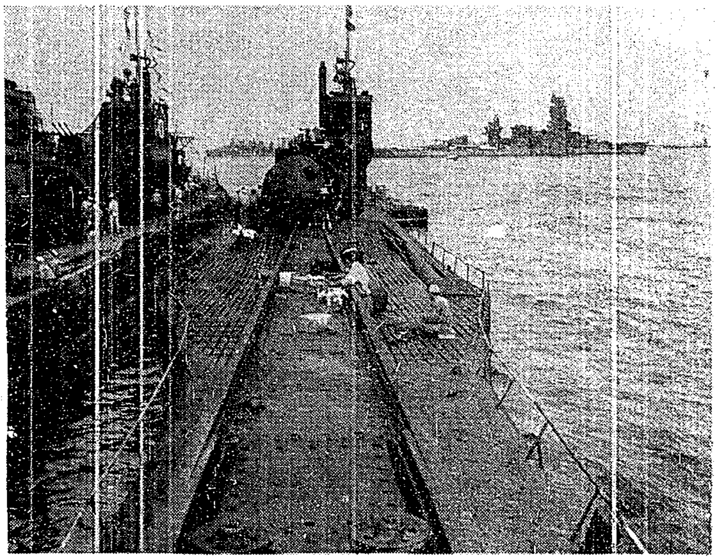
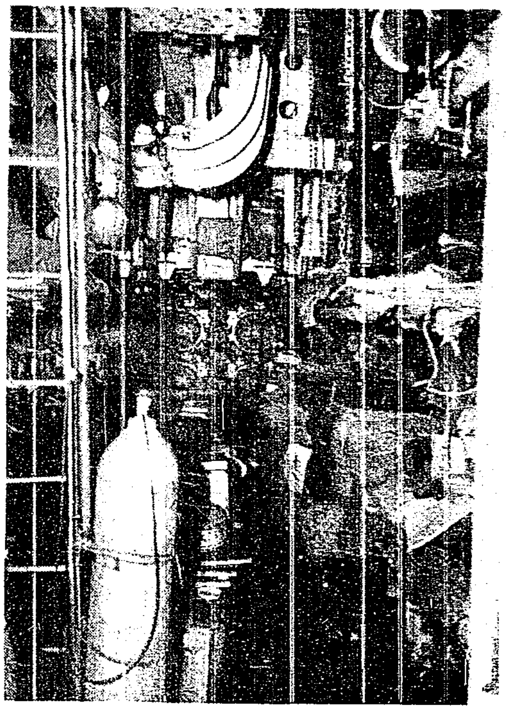


Figure 41
I-14

Figure 42
TORPEDO ROOM, I-14



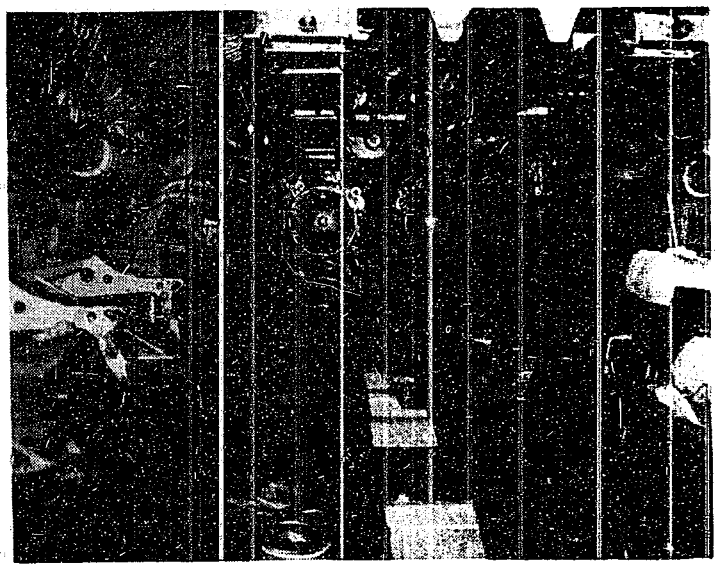


Figure 43
TORPEDO ROOM, I-14

Figure 44
FORWARD CREW'S QUARTERS, I-14

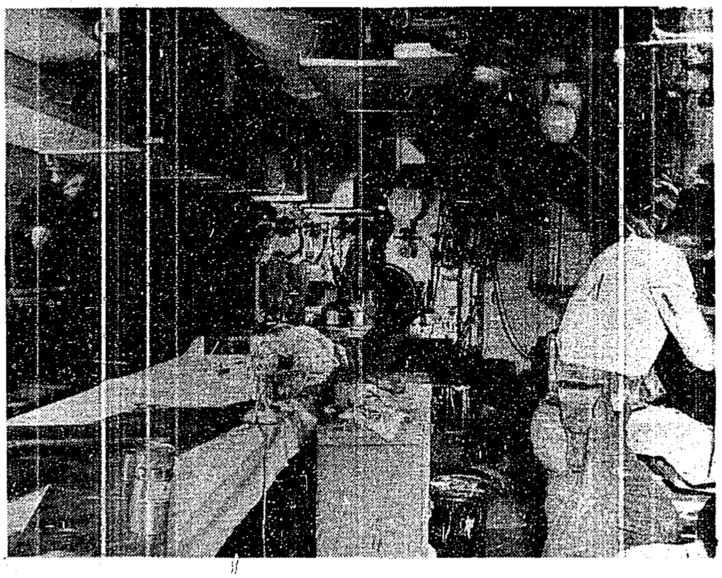


Figure 45
FORWARD CREW'S QUARTERS, I-14

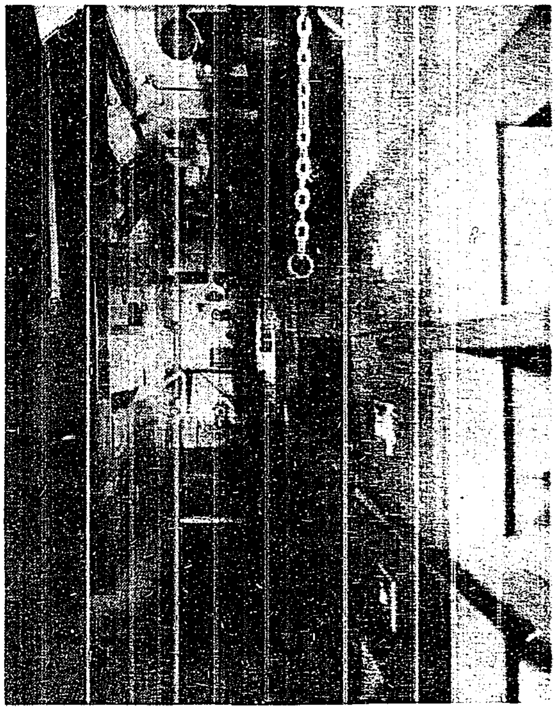


Figure 46
OFFICERS QUARTERS, I-14

Figure 47
OFFICERS QUARTERS, I-14

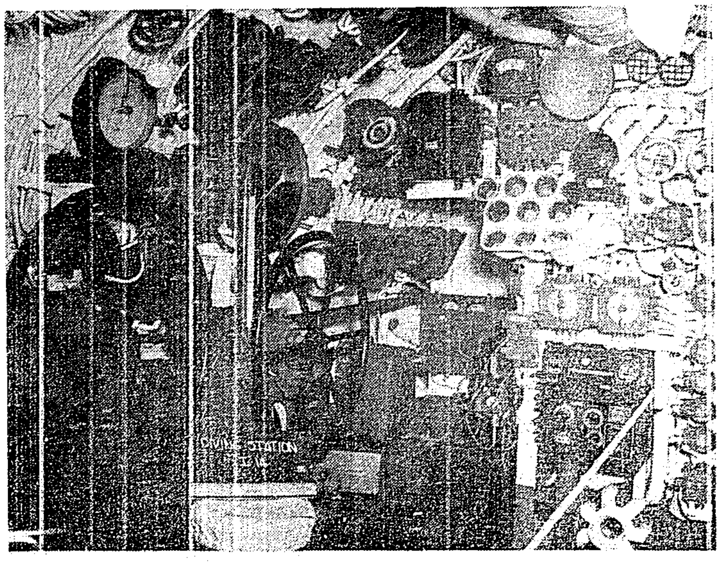


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Figure 48
DIVING STATION, I-14

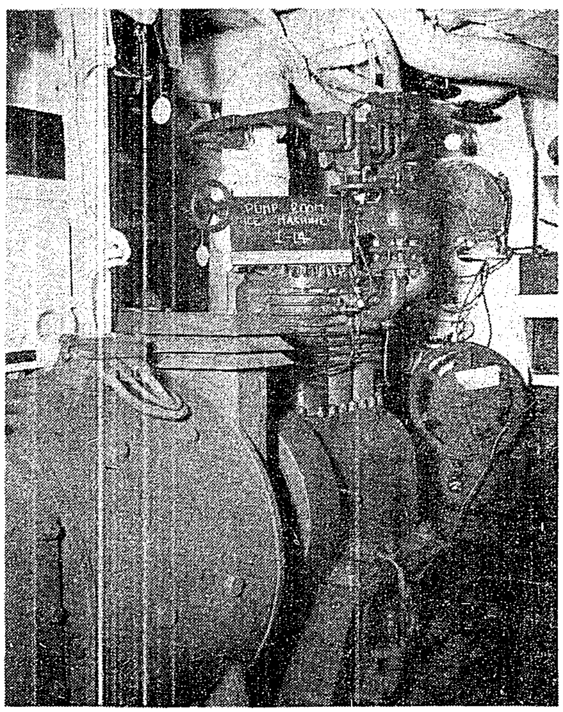
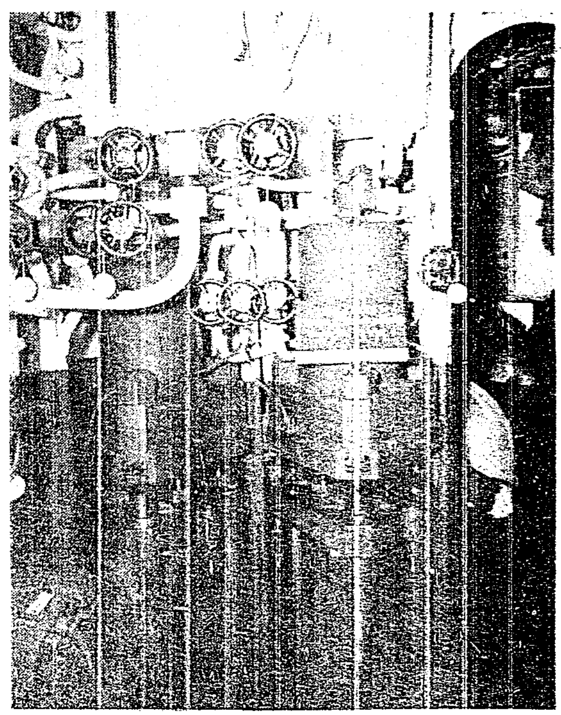


Figure 49
PUMP ROOM, I-14

Figure 50
PUMP ROOM, I-14



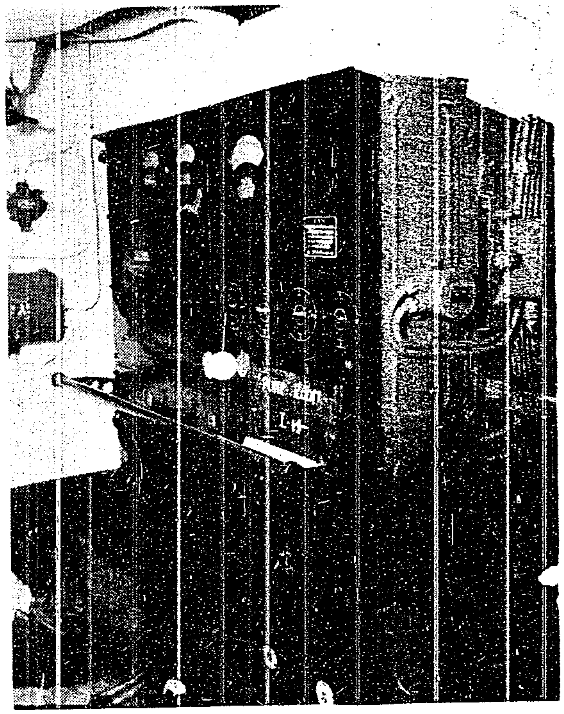


Figure 51
PUMP ROOM, I-14

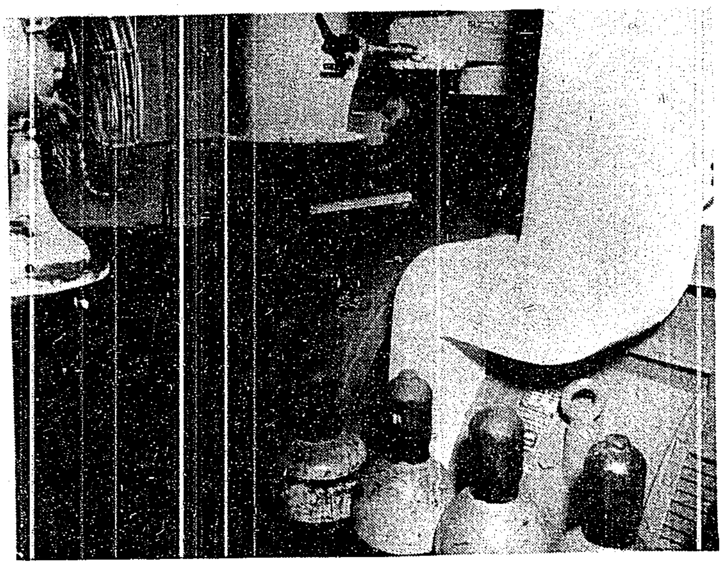


Figure 52
PUMP ROOM, I-14

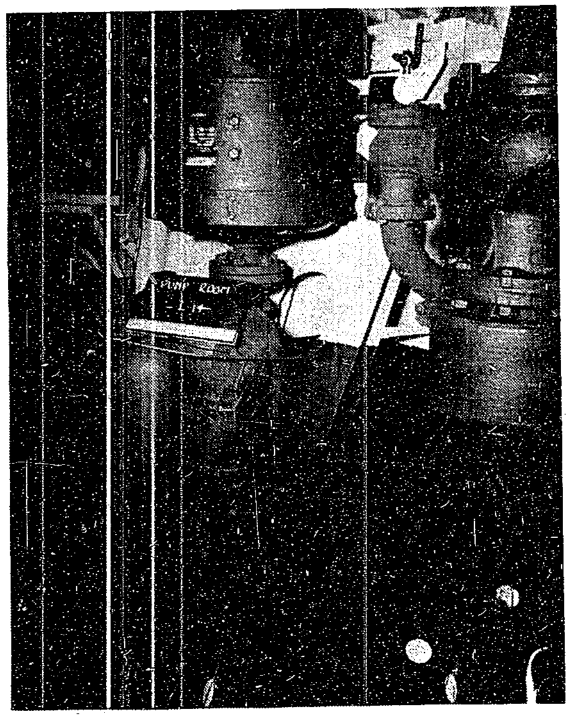
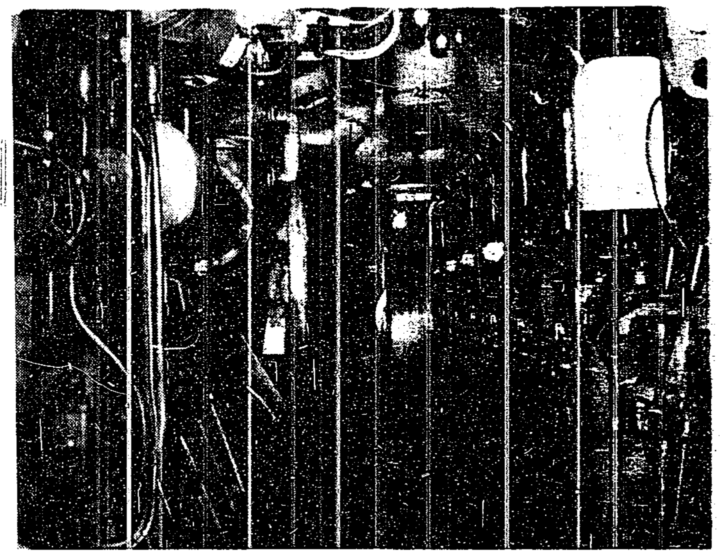


Figure 53
PUMP ROOM, I-14

Figure 54
AUXILIARY ENGINEROOM, I-14



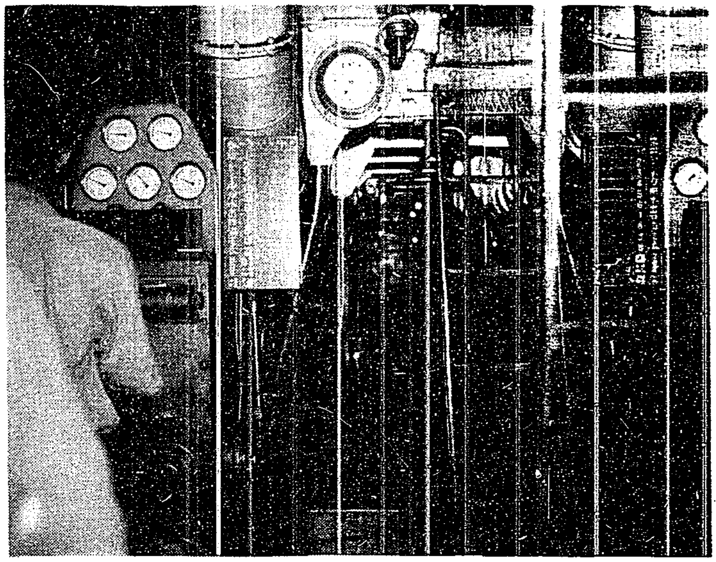


Figure 55
MAIN ENGINEROOM, I-14

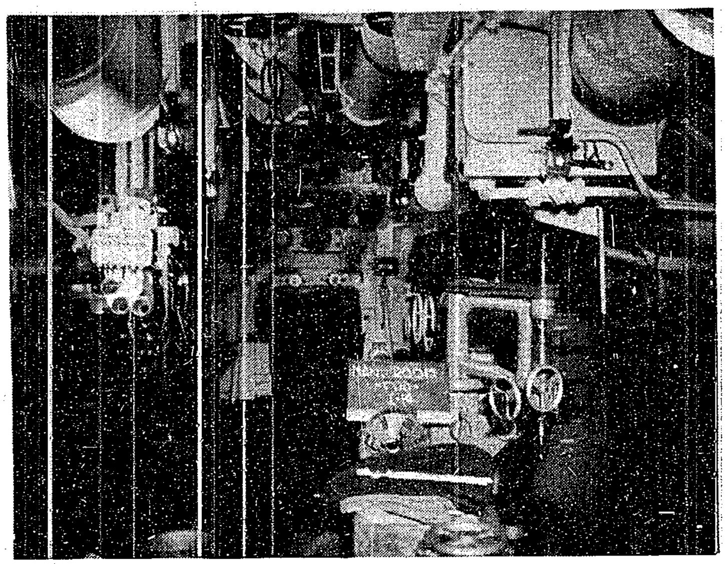


Figure 56
MANEUVERING ROOM, WITH MOTOR ROOM BELOW, I-14

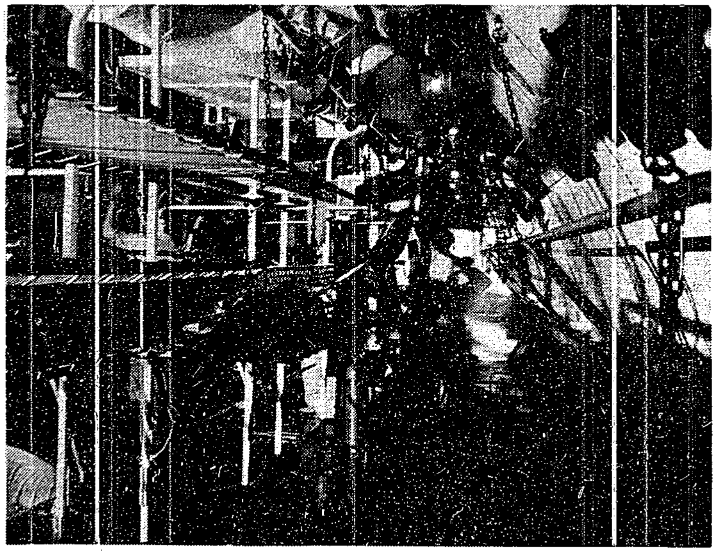


Figure 57
AFTER CREW'S COMPARTMENT, I-14

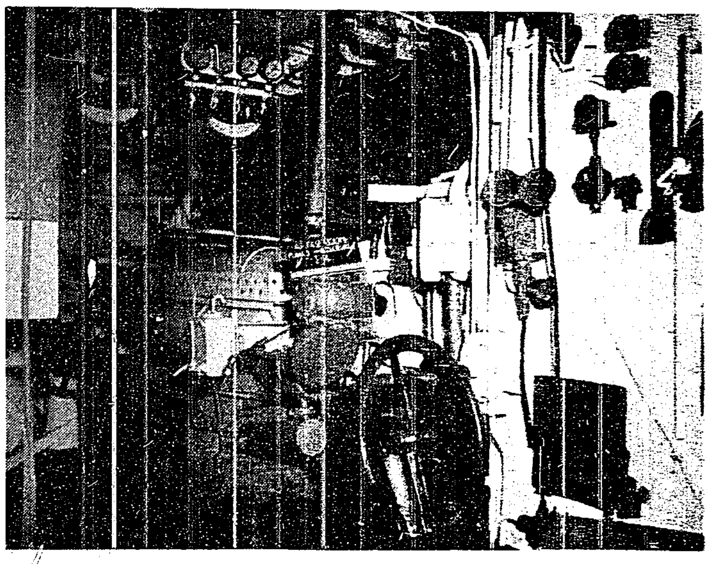


Figure 58
AFTER CREW'S COMPARTMENT, I-14

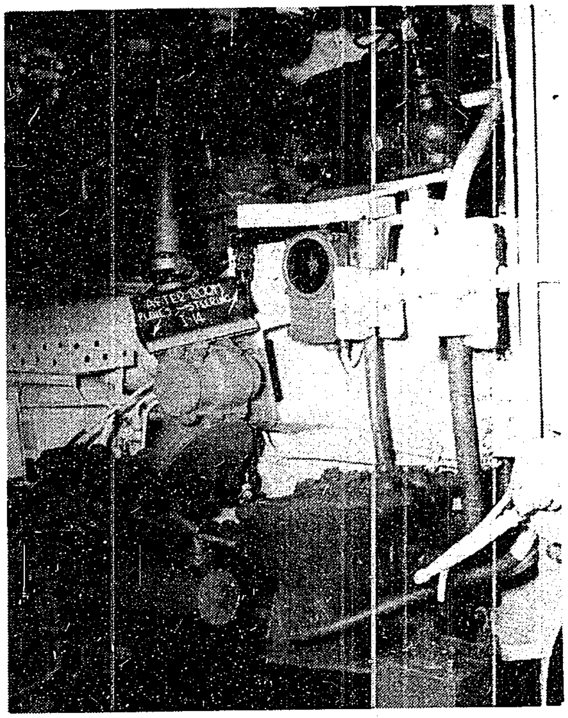


Figure 59

AFTER CREW'S COMPARTMENT

The enclosed sketches, made from the ship's General Information Book, give the location of most important equipment, internal and external tanks, and a profile of the topside. The actual arrangement in the control room and pump room differs slightly from the prints in the instruction book.

The tests for strength and for tightness of compartments and tanks are given in the General Instruction Book. The tests are considerably less rigid than those imposed on our new construction submarines.

<u>General Comment.</u>

1. The I-14 is covered with the same anti-sound coating as the I-400 and I-401.

2. The hull ventilation piping external to the hull and the main induction system is different from that on the larger submarines. A single main induction line originally ran from a topside valve to the main engine hatch trunk similar to that on the I-400. The valve and piping have been removed and the opening in the engine room trunk patched. All air for the main engines is supplied through conning tower hatch. The POW commanding officer stated that air velocity through the conning tower is noticeably high. At present there are two medium sized valves, side by side, in the fairwater abaft the conning tower. The port valve supplies air to the hull ventilation and battery ventilation blower. Just below the topside valve a branch line, with stop valve, leads to the schnorkle for the auxiliary engines. When the schnorkle is used, the

hull ventilation supply line in the auxiliary engine room is opened to provide air for the engines. The starboard valve receives the exhaust from the hull and battery ventilation exhaust. The schnorkle exhaust line branches from the normal auxiliary engine exhaust lines outside the hull, and runs to the topside piping adjacent to the bridge fairwater.

3. Lubrication of topside gear including bow planes, capstans, anchor windlass, hoisting boom, radio mast, and valve operating gear is accomplished with grease cups.

4. The torpedo loading hatch forward is combined with the forward access trunk and eliminates an opening in the pressure hull.

5. There are poppet tanks in the torpedo room for firing torpedoes which fill after the torpedo is fired. The vent to each tank is closed manually when water comes out. The commanding officer stated that the weight of water in the filled poppet tank plus that in a filled torpedo tube was equal to the weight of a torpedo and water around the torpedo in the tube. The water in poppet tanks is either pumped overboard or discharged into the torpedo compensating tanks.

6. Torpedo tube outer doors are opened by hand or by air motors mounted on individual torpedo tubes.

7. The steering system is of the same principle as that described for the I-400. An emergency power source is also provided by mounting the stern plane electric motor in line with the steering electric motor so that they can be connected by a mechanical clutch should either motor fail. The features of hydraulic A-end pump, two piston rams, and follow-up gear are identical with those previously described.

The POW commanding officer stated the following with respect to the turning circle:

a. Submerged at five knots with 20 degrees rudder:
   Starboard - 640 yards.
   Port - 530 yards.

b. Surface at 12 knots with 15 degrees rudder: 850 yards.

The discrepancy between port and starboard submerged turning circles is caused by the moment of resistance of the conning tower and bridge structure mounted to port of the centerline. It was stated that it was necessary to carry seven degrees right rudder submerged to steer a steady course. It was evident that the commanding officer was aware that rudder had to be carried but was not positive of the figures.

8. Bow plane rigging and tilting is similar to the installation on the I-400.

9. Stern plane operation is identical in principle. However, instead of a second motor and hydraulic A-end pump, the steering motor through a clutching arrangement may be used as a standby source of power. There is no hand-power stern plane tilting station in the after room.

10. The trim control is identical with that on the larger class submarine, having forward and after trim pumps, trim tanks inside the pressure hull, common transfer line and common vent and blow line, with all controls in the control room.

11. The buoyancy control system differs only in that #1 and #2 auxiliary tanks on the starboard side are utilized instead of those to port.

12. A submerged signal ejector is installed in the overhead of the after compartment. The signal is ejected by air.

13. The designed high pressure air volume is 685 cubic feet at 3150 lbs/in^2 contained in 50 air flasks stowed in various compartments within the pressure hull. There are actually a total of 55 high pressure flasks aboard; they were not counted. The flasks are charged using from two to four of the air compressors located in the after part of the maneuvering room.

14. The fuel oil compensating system is of interest. The clean fuel oil tank is below the engines inside the pressure hull. There is no single expansion tank but each fuel tank has a small compartment in the bottom to which the compensating line from the topside pressure header box is connected as described by POW, a gooseneck pipe extends from the compartment in the tank to the lowest point in the tank. If a small lower differential pressure exists in the tank as opposed to sea pressure, causing the tank to decrease slightly in volume, the salt water expansion compartment in the bottom is of sufficient volume (about one ton) to prevent fuel oil being forced overboard through the compensating line vent while submerged. The reason given for this construction was that the tank bottoms are so flat that considerable fuel oil capacity would be lost in providing an adequate depth of salt water seal.

15. The commanding officer estimated that it was possible to carry from 20 to 30 tons of cargo, excluding the hangar, but he had no definite maximum figure.

16. The POW commanding officer made the following remarks:

a. "This submarine, she is too big, yes!"

b. No knowledge of the magnitude of metacentric height, although he knew what it meant. With main deck awash, which condition occurs upon surfacing and when submerging before #5 and #6 main tanks are vented, the submarine is a little "tender". When requested to amplify, he stated that a roll of 30 degrees to either side could be expected. His practice was to use plenty of high pressure air on surfacing. The stability on the surface, especially initial stability, should be good because of the wide beam as a result of the blister tanks.

c. Diving time was stated to be about fifty seconds. There is some question as to when this period starts. Vents are hydraulically operated but the hull ventilation and exhaust must be closed by hand. All main tanks between the outer and pressure hulls have flood valves; blister tanks do not.

d. Diving angle is ordinarily eight degrees, although sometimes 20 degrees. The observation was made that other small fleet submarines used a 20 - 25 degree down angle in a normal dive. On the I-14, if all vents are opened simultaneously, she will submerge with a five degree up angle. Consequently, the vents are so arranged that, with the hydraulic manifold in the control room, #1 and 2 bow tanks, #1 and 2, #3 and 4, #7 and 8, #9 and 15, and #10 main tanks are flooded. It is to be noted that these are primarily forward tanks. Immediately afterward, tanks #5 and 6, #13 and 14, and #11 and 12 with controls in the conning tower are vented. It is important that the second group be flooded with no undue loss of time or the bow will go under while the after portion retains positive buoyancy with unpredictable results.

e. Because of relatively small bow planes, and probably also stern planes, depth control is difficult. This is a major weak point in design in the opinion of the commanding officer. At three knots, displacement must be within one ton of neutral buoyancy and at five knots within two or three tons; otherwise depth control cannot be maintained. The use of the automatic depth control was limited to balancing or "hanging" as he termed it. Although the initial amplitude of depth variation was frequently as much as 23 feet, the mechanism soon brought the boat to a constant set depth. Balancing was done normally between 130-165 feet.

f. There was some doubt about the cruising range. The computed distance using estimated efficiencies was very close to 17,000 miles as stated. However, he stipulated that it must be a fairly calm sea and then occasionally some fuel oil leaked out of the tanks, whether through leaking tank structure or ill-fitting fuel ballast tank flood valves was not known.

17. There is considerable auxiliary equipment built into Japane sub-marines which is never used.

18. This submarine, as in the other modern types inspected, is a combination of good and bad shipbuilding, meticulous detail and complicated design, simplicity in main propulsion, carelessness in upkeep, radical departures from previous practice, and utilization of the oldest forms of mechanical advantage in operating gear.

C. <u>I-400 Submarine: Main Engine and Drive Accessories</u>

1. All four main engines are Japanese built, following closely, with a few exceptions, the original M.A.N. design of their standard direct reversible, single-acting, four-cycle, supercharged, 10-cylinder in line, diesel engine.

2. The cylinder bore is approximately seventeen inches, the stroke approximately eighteen and one-half inches. The I.H.P. developed equals 3090.

Figure 60
MAIN ENGINEROOM, I-400

The B.H.P. at full engine speed, (510 r.p.m.) is approximately 2250, considering a mechanical efficiency of about 73% with the engine in good over-all material condition. The maximum piston speed at full engine speed is approximately 1550 feet per minute. The fuel oil on board has a specific weight of .87 and is probably below our standard Diesel fuel of 19,000 B.T.U. per pound. The fuel consumption per engine at cruising speed on four engines, 410 engine r.p.m., 245 propeller r.p.m., ship's speed 16 knots, is seven metric tons per 24 hours, which is approximately 86.5 gallons per hour per engine.

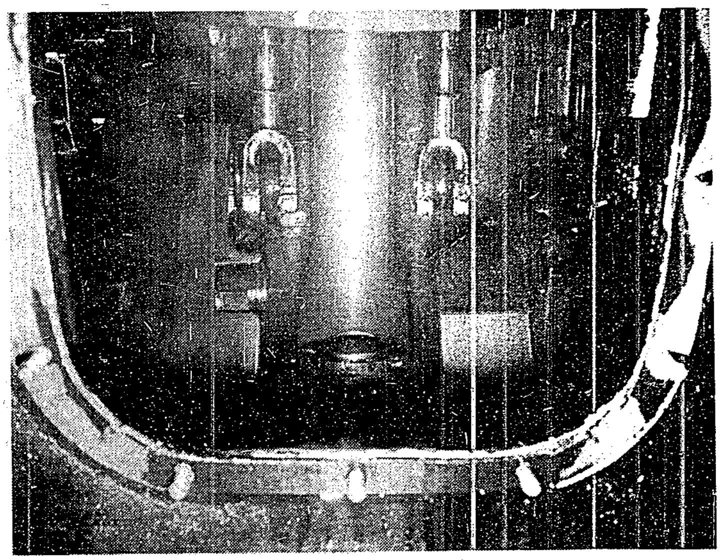


Figure 61

CRANKCASE, MAIN ENGINE, I-400

3. The main engines are arranged in two entirely separate enginerooms. The two compartments are side-by-side (a sort of parallel lay-out split by a longitudinal and watertight bulkhead). Main engines No. 1 and 2 are located in the starboard engine compartment. The lub oil sump tank is placed between the two engines in both engine rooms; each sump is split in two halves by a fore and aft bulkhead, but interconnected by means of a sluice valve to maintain the sump tank levels even. The normal amount of lub oil carried in the sump tanks is approximately 730 gallons.

4. The engine is securely held on the foundation by the conventional method of a series of holding-down bolts, inboard and outboard side. Large tie-rods of approximately two and three-quarters of an inch diameter pass from the crankshaft lower bearing saddle to the top of the engine "A" frame. The lower main bearing half is provided with a removable bearing shell, white metal,lined. The main bearing cap has the white metal lining poured into it, secured with proper dove-tailing. In case of bearing metal failure, the entire cap has to be replaced. A distance piece and shims provide the proper oil clearance. The cap is held in

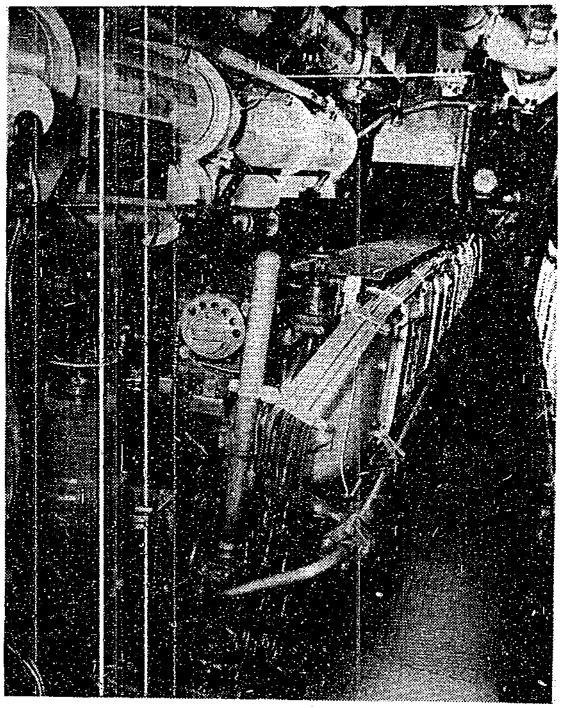


Figure 62
STARBOARD MAIN ENGINES, I-400

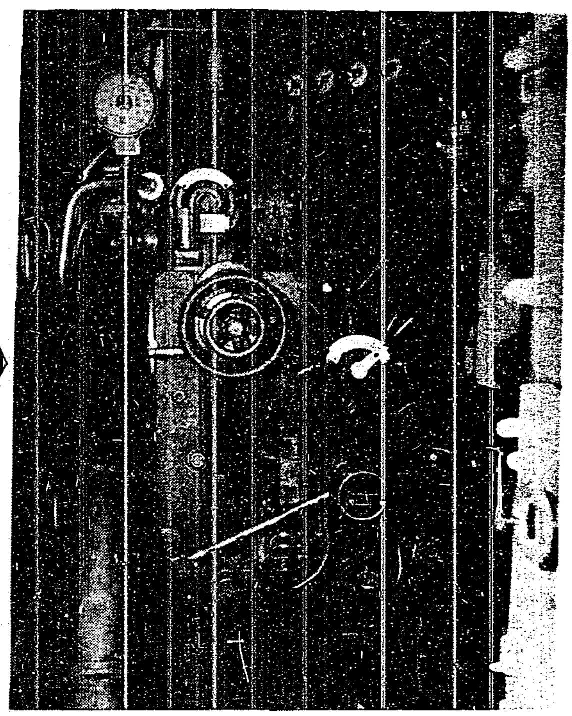


Figure 63
MAIN ENGINE, I-400

place with two large jack screws. There are eleven main bearings: bearing No. 11 is the engine crankshaft thrust bearing. The main bearing diameter is approximately 10.66 of an inch. The crankshaft is force-feed lubricated and approximately 25 feet long. The shaft journal diameter is approximately 10.63 inches. The crankshaft and connecting rod lub oil supply header is entirely separated from the lub oil line feeding to piston cooling, and drains back into the crankcase immediately after completing its own circuit. At the engine operating end of the crankshaft a torsional vibration damper of an approximately thirty-eight inch diameter is attached to the crankshaft. This damper is similar to the fly-wheel type used on our ten-cylinder Fairbanks and Morse engines, but includes a feature of spring-loaded pistons, eight in all, which counteract hydraulic pressure supplied by the detached engine lub oil pump. (Note: the merits of this particular damper should be investigated by our experts at home.)

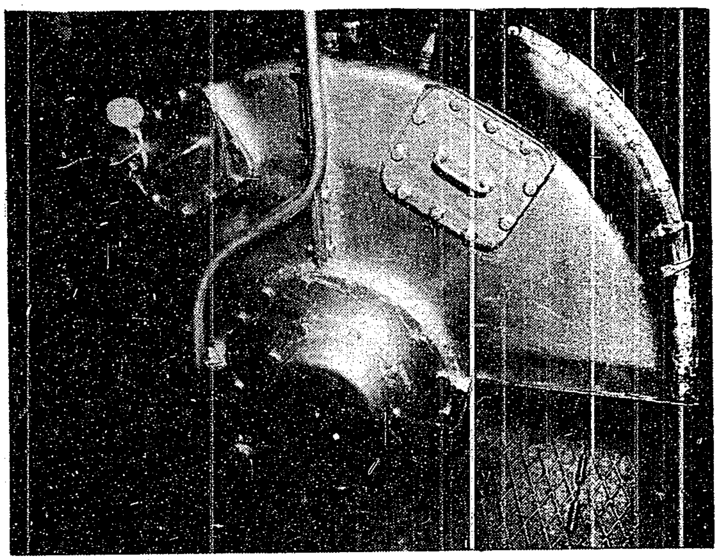


Figure 64

VIBRATION DAMPENER, I-400

5. The camshaft is of the built-in type, being driven by means of proper gearing off the crank shaft at half speed. The ahead and astern cam assemblies are attached to the camshaft in sleeve units and operate the rocker arms and cylinder head valve gear via long push rods and rollers. A pneumatic-hydraulic operated Servo motor will lift fulcrum arms and all valve gear clear of the camshaft to allow for longitudinal shift of cams when reversing; a connecting cam and lever will also reverse the fuel injection pumps.

6. The engine cylinders are individual assemblies, grouped together and secured to the engine "A" frame by means of long studs, approximately two inches in diameter, holding cylinder and cylinder head to "A" frame. The cylinder bore is 16.93 inches, finished to proper tolerances, and re-

cessed on top for cylinder head seal ring. The cylinder jacket is sea water-cooled; the water flow is directed from the inlet at the lower end of the cylinder upward to the cylinder head, exhaust valves, and exhaust manifold. The cylinder wall surface receives its lubrication from force feed lubricators.

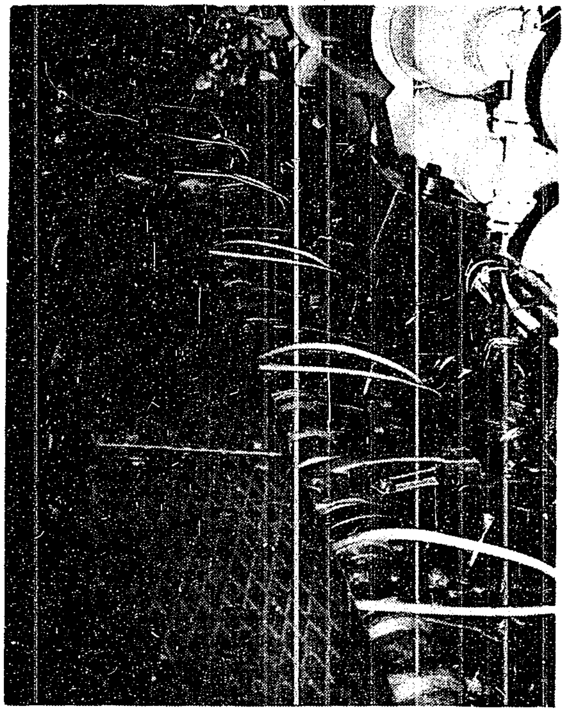


Figure 65
CAMSHAFT, MAIN ENGINE, I-400

7. The cylinder head carries all valve assemblies such as fuel injector, two intake valves, two salt water cooled exhaust valves, an air starting valve, a cylinder relief valve, and an indicator cock mounted on the outboard side of the cylinder head. The crown clearance between the piston top (when on top dead center) and the cylinder head face equals .44 of an inch, or approximately seven-sixteenths of an inch. The supercharge manifold outlet duct and cylinder head intake valves are facing inboard. The exhaust valves and manifold face outboard. The cylinder heads are provided with core plugs and flanges for access to cooling spaces.

8. The main engine pistons are cast and machined all over. The top is not of the conventional cup-shape, but has a fairly wide flange and flat center. The flange rim has four machined-in recesses, apparently to clear the intake and exhaust valves. The four upper rings with step joints are fire rings; the remaining two are oil control rings. The wrist-pin is approximately six and one-quarter inches in diameter, free floating in wrist-pin bushing. The piston is oil-cooled; the oil is supplied from the detached lub oil pump via feedheader and the conventional grasshopper gear to the cooling chamber in the piston head, which provides positive piston-head area cooling. Each grasshopper linkage is equipped

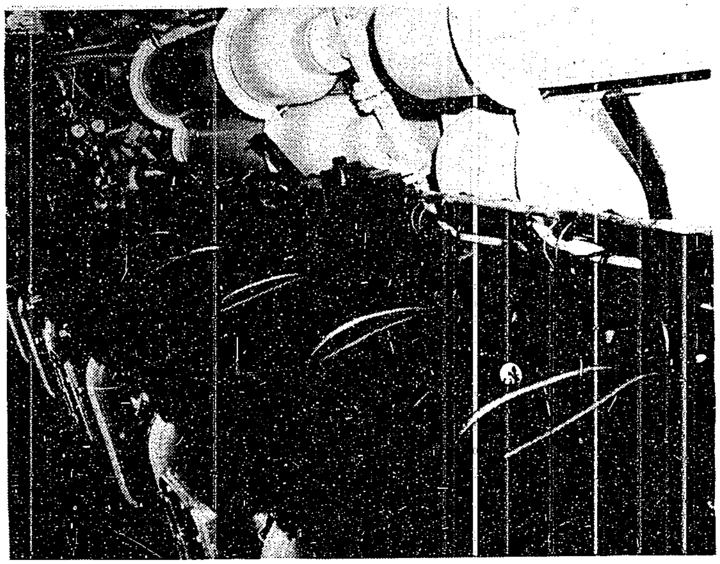


Figure 66

TOP OF MAIN ENGINE, I-400

with a medium-sized surge tank to minimize the inherent pumping action. A tell-tale box with glass face is mounted on bulkhead to observe oil flow to piston cooling assembly. There are also two copper wear rings peened into the piston wall, one below the fire rings and one about one inch and a half from the end of the piston skirt. The piston diameter is approximately 16.916 inches; piston over-all length is approximately twenty-four inches.

9. The connecting rod is forged and has a wrist-pin bushing made of bronze, and lined with white metal. The inside diameter of the wrist-pin bushing is 6.296 inches. The crank pin bearing upper half is of the removable shell type, whereas the connecting rod bearing cap is one piece with the bearing metal poured in and held by proper dove-tailing. Replacements apparently are not so precise as to omit hand-fitting and scraping. The oil clearance is adjustable by means of shims. A bronze distance piece is also placed between the upper and lower bearing halves. Lub oil is fed to the connecting rod through suitable oil passages from the crankpin journal to the connecting rod bearing and wrist-pin.

10. The cylinder intake and exhaust valves are a cast body and machined to permit interchangeability of certain parts. The exhaust valves only are provided with sea water cooling. The valve seat is the standard 45° and disc type, nineteen and three-quarter inches long, with a five-inch head diameter, and a 1.103-inch stem diameter. The intake valve has a three-quarter inch larger head.

11. Each cylinder has its individual fuel injection pump of the cam-operated, steel block type, The pump body is bolted to a cast pedestal and consists of the following parts: pump roller and guide, plunger and barrel, and adjustable suction and discharge valve (by-pass control). The suction and by-pass valve are operated by an eccentric pawl mechanism. There is also attached to the pump body a relief valve and a special connection to take the pump pressure reading. A micro-gauge is furnished for this detail. The injection pump pressure delivered to the high pressure fuel line is approximately 400kg/cm^2 or 5600 lbs. per square inch.

The fuel booster or supply pump is driven directly off the engine, governor end. The fuel injection nozzle body is steel and machined over-all. The lower valve valve body is detachable. The nozzle tip is integral with the lower part of the valve body and has eight drilled spray holes, equally spaced. The nozzle has an inlet and outlet connection for fuel oil cooling of the spray valve. There are two differential pressure fuel passages leading to the lower spray valve. This particular arrangement is to produce better atomization. The escape fuel returns under pressure through the spill line, (which is equipped with a surge dome and metering valve) to the day service tank, which is located overhead the engine. This particular tank is of small capacity, approximately six hundred liters, or approximately one hundred fifty-six gallons. The fuel of this tank is supplied from the normal fuel tank on service via compensating pressure and passes through a battery of fuel oil strainers, (no purifier is installed in the fuel oil system). As a precautionary measure to prevent sea water from entering the service tank, a box, apparently equipped with an electrode, is installed in the transfer line, and a light wired from the electrode will show red over the throttle stand as a warning signal.

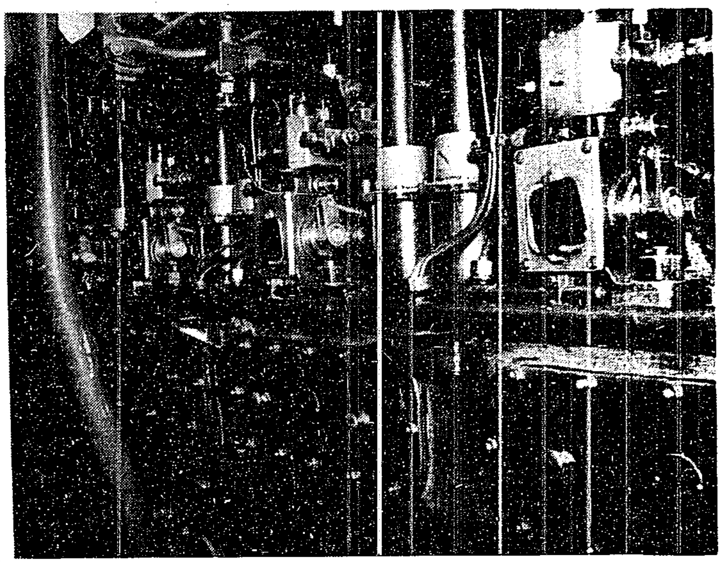


Figure 67

SIDE OF MAIN ENGINE, I-400

12. A cylinder relief valve is installed in each cylinder head letting only the discharge goose-neck protrude above the head. The relief valve is set to open at 65kg/cm^2 or approximately 925 lbs. per square inch.

13. Each cylinder is furnished with an indicator cock located on the cylinder head exhaust side. All cylinders are also fitted with a reproducing linkage and cord hook to facilitate taking of complete cylinder diagram and draw cards.

14. The engine air starting system is completely pneumatic. The air-starting timing-spider is mounted on the camshaft after end. It consists of cam, rollers, small pistons, control cylinders, and pilot air lines.

As the cam contacts each roller as per timing sequence, the small piston is moved, and air of high pressure, but of small volume, is admitted to the actuating valve, which, in turn, will open the air-starting valve, so designed as to admit air of greater volume, but lower pressure. Then the starting air is allowed to enter the cylinder and move the respective piston downward.

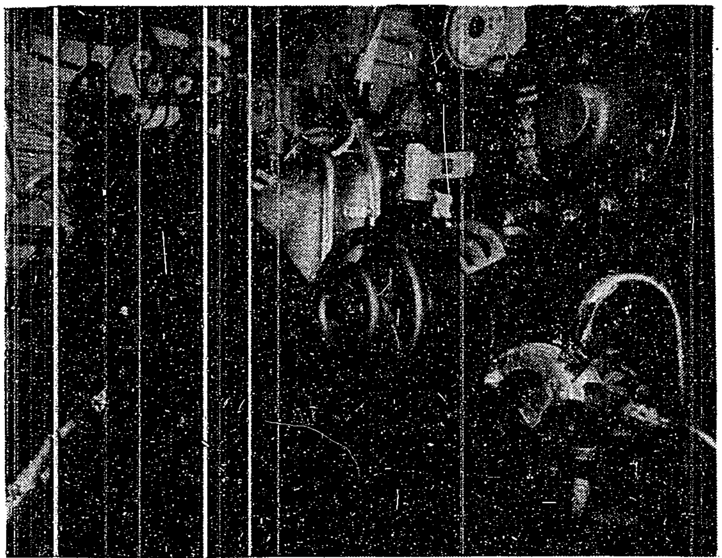
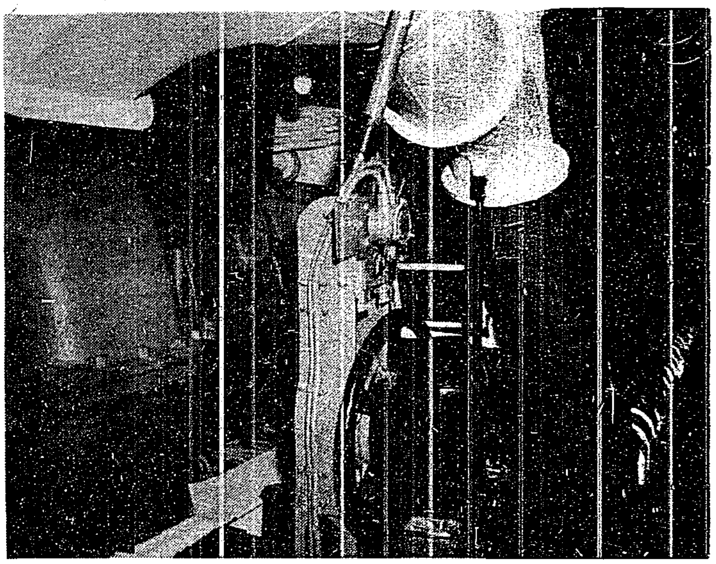


Figure 68
MAIN ENGINE, I-400

15. The detached motor-driven engine supercharger is of the vaned rotor type and delivers approximately five pounds pressure above atmospheric, at 3000 r.p.m. At low loads up to 300 engine r.p.m. the supercharger is usually not cut in until the vernier at engine throttle shows about 5.5mm lift on suction valve.

Figure 69
MOTOR DRIVEN SUPERCHARGER, I-400



16. Due to the long high pressure fuel line from the injection pump to the injection nozzle, which introduces a considerable timing lag, the beginning of the pump stroke is advanced 29° before top dead center. The suction valve lift continues for 17° before the by-pass valve opens to let some fuel escape. The fuel cam roller clearance at the base circle of the cam is standard; the valve gear tappet clearances are set to a clearance of 2mm, or approximately .080 of an inch. The fuel pump stroke equals 20mm, or approximately 13/16 of an inch.

17. The engine governor mounted on the engine after end is actually only an overspeed governor of the centrifugal type. As the engine overspeeds, the fly-balls move out and move the spring carrier upward, counteracting the spring tension above. It is set for a 40 r.p.m. overspeed, and acts upon fuel control, reducing the fuel supply until the engine resumes normal speed. If operating properly it should not shut the engine down. on overspeed, but only reduce the speed to normal. The fuel throttle at the forward end of the engine, with its two vernier scales, one for fuel pump suction valve lift control and the other for the fuel by-pass control, actually handles the fuel to the engine in relation to load and speed.

18. Cylinder lubricators apply the lub oil for lubricating the cylinder walls and piston. These mechanical lubricators are, in nearly all details, similar to our makes (Manzell, etc.). The lubricator tank has a sight glass indicating its oil level and should be checked for refill at least twice a watch.

19. The lub oil purifier (one in each engine room) resembles the De Laval type, and outside of periodical cleaning and oiling, needs little maintenance.

20. The general layout of the main propulsion plant is as follows:

Starboard engine room main engines No. 1 and 2 rotate counterclockwise as viewed from the clutch end of the engine, looking forward. The port engine room main engines No. 3 and 4 turn clockwise, looking forward from

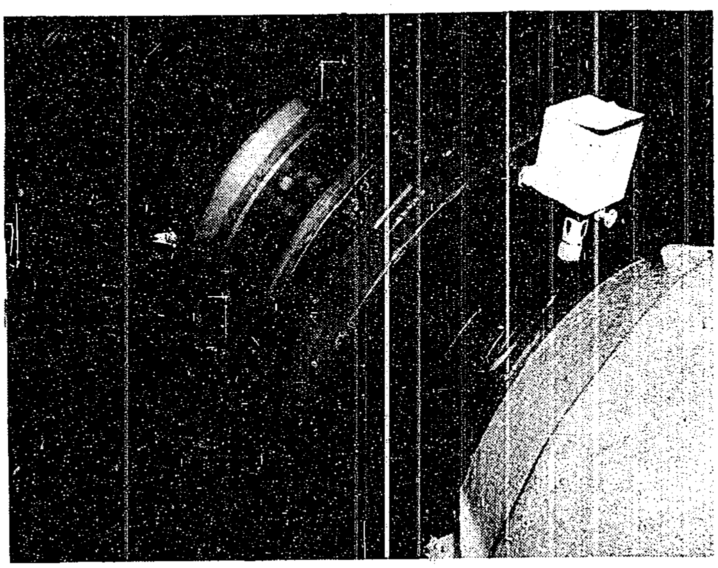


Figure 70

JAW CLUTCH BETWEEN ENGINE AND MAIN MOTORS the after end of the engine. Each engine is driving its respective reduction gear pinion in the same direction, while the bull gear (or main gear) and propeller shaft are turning outboard to propel the ship ahead. The power is transmitted to the shaft and three-bladed screw from the main engines through an oil clutch (Vulcan type) and reduction gears. Both engine rooms and motor rooms are nearly identical in layout. From the clutch and reduction gears the propeller shaft passes through a bulkhead stuffing box, and steady bearings. Two positive jaw clutches are interposed, one before and one after the main motors, which are arranged in tandem.

The shaft thrust bearing is similar to our Kingsbury thrust bearing design. The shaft stuffing box at the last bulkhead appears to be made a little more elaborate than ours.

21. The engine jacking gear is between the after engine end and Vulcan clutch. It is of the gear and worm type design, motor driven. Each engine gear can be separately engaged and disengaged.

22. All engine accessory pumps such as the lub oil pump and clutch filling and sea water pump are detached and separately driven by electric motors. Only the fuel oil booster pump is attached to the engine.

23. Apparently the Japanese use gum rubber indiscriminately, and in such places where oil will cause the natural rubber to deteriorate too rapidly, most gaskets around the engines should be replaced with synethetic rubber.

24. The salt water lines apparently are tinned, and carry zinc or cast iron spools at the flange joints to combat electrolysis. However, the engines, too, should be further investigated for installation of zincs around cylinder liner and cylinder head jacket water spaces.

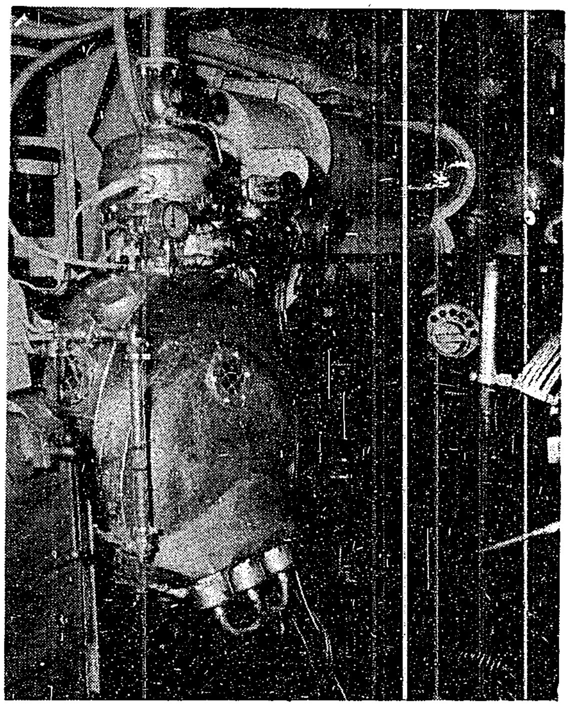


Figure 71
EVAPORATOR, I-400

25. During a recent crankcase inspection everything was found in normal condition, and no engine varnish was observed around piston skirts, which, if present, would usually indicate poor lub oil, bad pistion rings and foul combustion, or a combination of all three.

26. Each engine exhaust header has an evaporator installed between the engine and the inboard exhaust valve. This evaporator is also provided with an electric heater connection.

27. On the propeller shaft, between the thrust bearing and packing gland, is a positive screw-type brake, probably to keep the idle propeller from turning when propulsion is effected by only one propeller.

28. All main engines have two exhaust valves, one inboard and one outboard; also, a large muffler and spark arrester is installed under the superstructure for each main engine.

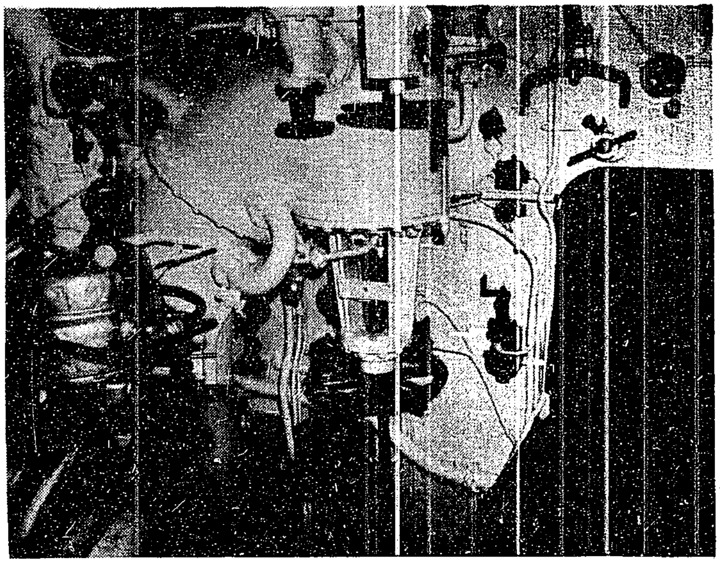


Figure 72

INBOARD EXHAUST VALVE, I-400

29. There are no cylinder exhaust pyrometers installed. However, there is a pet cock in each cylinder to permit the taking of a smoke card, which will give some approximate indication of the condition of the exhaust from each cylinder.

30. The salt water temperatures from cylinder jackets will have to be observed closely to prevent jacket water temperatures in excess of 120°F, so as not to allow possible salt deposits in restricted passages. Also observe regularly the lub oil temperature gauges on top of the piston-cooling oil tell-tale box.

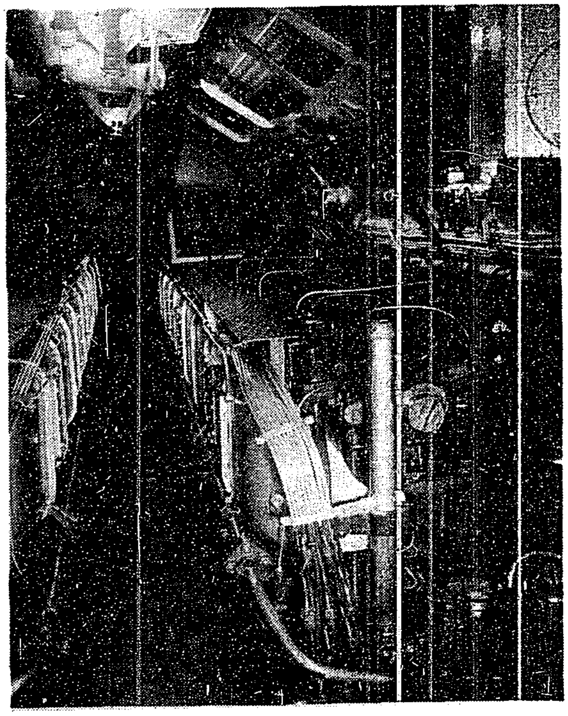


Figure 73
MAIN ENGINEROOM, I-400

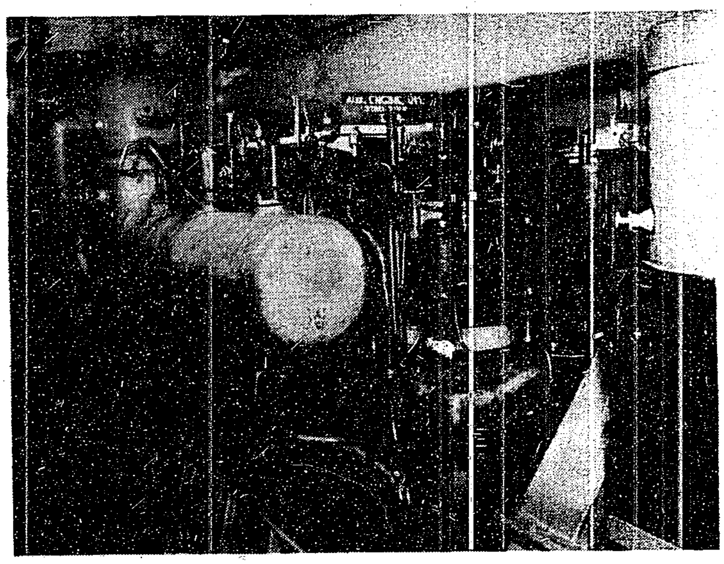


Figure 74
AUXILIARY ENGINE, I-14

D. I-14 Submarine: Auxiliary Engines

1. The auxiliary engines aboard the I-400 and I-401 are identical to those of the I-14. The plant layout differs in this respect, in that the engines are installed end for end with the generators facing forward.

2. The engines are single acting, four-cycle, six-cylinder, and are utilizing generator cooling air discharge to effect some supercharge pressure probably slightly above atmospheric pressure. The engines were built by Mitsubishi, following basically the M.A.N. design.

3. The piston diameter is 310mm or approximately 12 13/64 inches. The piston stroke equals 340mm or approximately 13 13/32 inches. The engine rated speed as per name plate is 630 r.p.m., but has been reduced to 610 r.p.m. apparently for better all around operating performance, which, of course, also reduces in a direct ration, the 450 kw peak load at 630 r.p.m. The cylinder firing order is 1, 3, 5, 6, 2, 4, as per name plate. The valve timing is marked on the rim of the flywheel to match the degrees of travel with a pointer in the conventional manner. Following is the valve timing as per instruction plate mounted on engine:

Cylinder Number:	1	2	3	4	5	6	
Intake valves open:	13	14	13	13	14	13	B.T.D.C.
Intake valves close:	53	52	54	52	51	52	A.B.D.C.
Exhaust valves open:	41	43	44	43	44	45	B.B.D.C.
Exhaust valves closed:	21	22	23	22	22	20	A.T.D.C.
Starting air valves open:	2	0	1	0	0	2	A.T.D.C.
Starting air valves closed:	125	124	125	125	124	125	A.T.D.C.
Fuel Injection pump compression stroke starts	30	29	29	28	30	29	B.T.D.C.
Fuel pump spill valve open	0	1	0	2	1	1	A.T.D.C.

Note: All numbers above are degrees (°).

Figure 75
AUXILIARY ENGINE, I-14

The auxiliary engine is to be considered a constant-speed engine. The auxiliary engines on the I-14 are so installed as to have both operating stands facing forward, the D.C. generators are mounted on the after end of the engines. The starboard engine exhaust header is on the inboard side. The port engine exhaust header is on the outboard side. Both engines rotate counter clockwise. The fuel consumption for 1000 amperes equals approximately 100 liters or approximately 26 1/2 gallons. The auxiliary engine room is located forward of the main engine rooms, on each one of the three I-boats.

4. The general lines of construction and design of the engine frames and elementary engine parts are similar to those of the main engines.

a. The engine "A" frame is of cast alloy steel with certain secondary appendages welded on to the "A" frame.

b. Tie-rods extending from the bottom of the main bearing saddles to the top of the engine "A" frame hold the under slung crankshaft saddles and "A" frame firmly together. Crankcase and "A" frame are secured to the engine foundation with a series of holding down bolts, the body bound bolts being spaced in proper relation to the through bolts, between inboard and outboard flanges of "A" frame and engine foundation.

5. The engine crankshaft is forged of nickel chrome steel. Approximately 11 feet, 6 inches long. The main journal diameter is approximately 8 5/16 inches. The crank pin journal diameter is approximately 7 inches. The D.C. generator armature shaft flange is bolted to the crankshaft flange at fly wheel end of shaft. The crankshaft is supported by seven main bearings of which No. 7 next to the generator is the engine thrust bearing. Similar to the main engine bearings, the lower saddle is provided with a white metal lined removable bearing shell, whereas the main bearing cap has the white metal lining poured into the cap thereby forming one integral part. The main bearing cap is held tight by means of jack screws, between top of cap and "A" frame. The crankshaft bearings are force feed lubricated.

6. The camshaft is of the built-in type driven off the crankshaft at half speed by means of proper gearing. The cams are keyed to the shaft, except that the fuel injection pump cams are bolted to a serrated flange and spacer to allow for radial movement of cam about the shaft axis to facilitate advancing or retarding of the fuel injection timing.

7. The cylinders are separate units and each of the six units is securely held to engine "A" frame by means of long studs secured in "A" frame. There are six studs per cylinder extending from "A" frame into cylinder head. Sleeve nuts are used with a square insert to receive a square bar extension wrench in place of the conventional hexagon head nuts, to hold cylinder and cylinder head together. The cylinder walls and piston rings depend on the oil splash alone for lubrication. The cylinder jackets are sea water cooled.

8. The cylinder heads are cast steel, sea-water cooled and carry the individual assemblies of two intake valves, two exhaust valves, one fuel injection spray nozzle, one air starting valve. Cylinder relief valve and indicator cock are of the "Y" connection combined valve type.

9. The pistons are the conventional trunk type and are cast and machined overall to an approximate diameter of 12 13/64 inches. The piston rings are cast, machined and of the step joint type. The pistons are not lube oil cooled and the lubrication provided between the piston and cylinder bore depends on the lube oil splash alone.

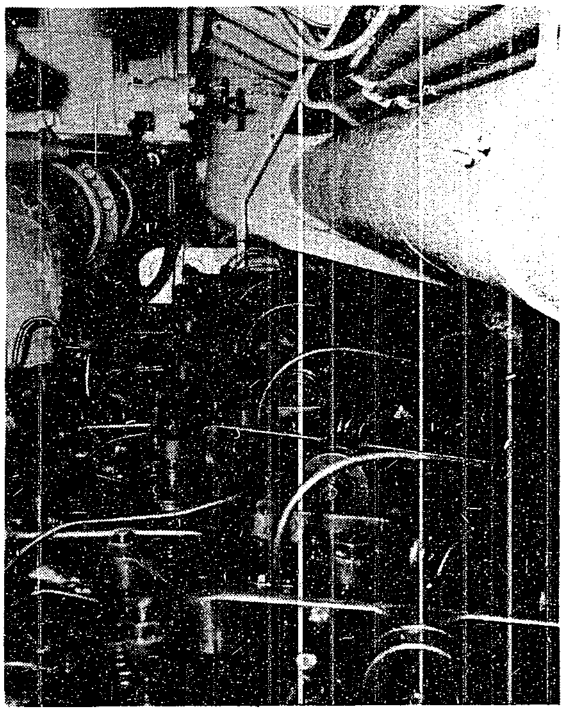


Figure 76
AUXILIARY ENGINE, I-14

10. The connecting rods are forged of alloy steel (nickel and chrome). The length from the center of the wrist pin bushing to center of crankpin bearing is approximately 27 3/4 inches. The connecting rod crankpin bearing diameter is 7.086 inches, the upper half of the connecting rod bearing is a white metal lined detachable shell, whereas the connecting rod cap bearing has the white metal poured into it; properly bonded and held in place by dove-tailing. A brass distance piece and shims to adjust the lube oil clearance are placed between the upper and lower bearing halves. The wrist pin bushings are bronze; machined overall to a diameter of 4.944 inches, and provided with proper oil holes and oil grooves. The lubrication of the piston pin is force-feed coming from the crankshaft through drilled passages.

11. Each cylinder has its own individual fuel injection pump, consisting of the following parts: base, pump block, fuel pump cam, plunger guide, cross head with roller, pump plunger, pump barrel, suction valve, discharge valve with high pressure fuel line and fitting, by-pass or spill valve with adjustable linkage control and vernier scale, and pump relief valve and vent cock. There is a fork attached to the roller guide for hand priming of fuel injection pump. The injection nozzle differs in design from that of the main engine in that it has only one high pressure fuel line leading to injector, compared with the two differential type pressure lines on main engine injectors. The stem operating spring of the auxiliary engine spray valve is pre-loaded with approximately 450kg/cm^2 or approximately 6300 lbs./in^2. This counteracting spring pressure is overcome by the fuel pump injection pressure. Fuel is forced, and thereby atomized through eight small equidistant holes in the spray nozzle tip. The auxiliary engine injection nozzle is not oil cooled. A vent plug and return line is attached to the side of nozzle body. The fuel supply for the cylinder injection pumps come from the service tank

via the service pump (better known to us as the fuel booster pump), at approximately 1 1/2kg/cm2 pressure or approximately 20 lbs./in2 through common and constant pressure header. The fuel passes through a strainer box (one for each unit pump) before entering the fuel injection pump suction valve, which is open in accordance with pump timing sequence. With the suction stroke completed, the pump cycle continues building up to proper injection pressure; with start of fuel injection and start of spill valve opening etc. The injection pump relief valve is set at 500 kg/cm2 or 7000 lbs./in2.

12. The fuel throttle linkage on starting keeps the pump spill or by-pass valves closed and the injection pump suction valves open until the governor, which is a combination of constant speed control and overspeed governor, takes hold. During engine operation evidently the governor acts only upon the spill valve control permitting more or less fuel to escape and return to service tank. The overspeed governor controls the percentage of overspeed and should mainly act during sudden load changes to maintain a rated speed of approximately 610 to 630 r.p.m. The fuel and constant speed control governor is a hydraulic and mechanical combination with the overspeed governor built into the same housing. The overspeed governor is of the fly-ball type counteracting spring tension. A small air dome is mounted over the hydraulic part of the constant speed governor.

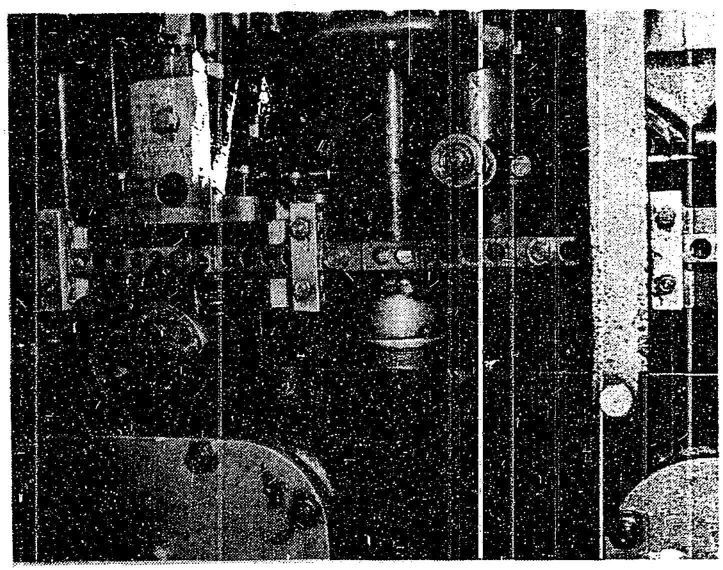


Figure 77

AUXILIARY ENGINE, I-14

13. The cylinder intake valves are equipped with a guide or deflector plate, which is apparently necessary due to the construction of the air inlet passage in the cylinder head. The proper positioning of this deflector plate in relation to cylinder head inlet passage is important, and is accomplished by means of a pilot pin mounted to intake valve rocker arm assembly and a guide plate secured to valve stem and spring retainer plate. If assembled correctly the guide pin will enter a matched hole in guide plate. The intake valves are not sea-water cooled. The valves are operated by the conventional push rod and rocker arm gear. A fabricated supercharge duct is mounted to the air inlet side of cylinder heads.

14. The cylinder exhaust valves have a smaller valve head than the intake valves and do not require a deflector plate. The valve operating gear is conventional except that the exhaust valve rocker arms consist of a long "Y" shaped fork. The exhaust valves are sea-water cooled. The fabricated exhaust header is also sea-water cooled and is bolted to cylinder head outlet side. Directly above the exhaust header is the high vent line for the engine cooling water.

15. The engine air starting system incorporates the same design features as that of the main engines. The starting air supply comes from the main engine room storage bottles.

16. The cylinder relief valve and indicator-cock are combined and built like a "Y" connection. The cylinder relief valve is set for pressure in excess of approximately 65kg/cm² or approximately 900 lbs./in².

17. The lube oil cooler has salt water supply as its cooling medium and is of the tube bundle type construction.

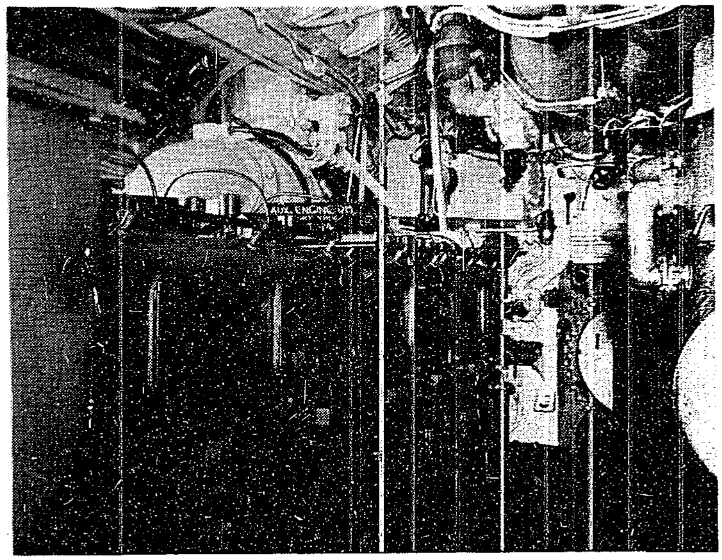


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Figure 78

AUXILIARY ENGINEROOM, I-14

18. The auxiliary engine lube oil sump tanks are located outboard of each engine. Maximum capacity is approximately 2000 liters or approximately 520 gallons.

19. General notes: Each of the outboard crankcase covers is provided with a breather. Also, a one inch crankcase vent pipe runs from the crankcase along each cylinder to a height approximately four inches above the cylinder heads, a fine screen is soldered over the upper end of the vent pipe. The engine jacking gear design is the same ring gear and worm type as used for the main engines.

20. The lube oil sea-water and fuel service pumps are attached to the engine at the engine operating end, located below the engine throttle stand. The operating pressures are: lub. oil pump, 2kg/cm²; fuel oil service pump, approximately 1 1/2kg/cm²; sea-water pump, 1 1/2kg/cm², which is equivalent to approximately 28 to 30 lbs./in² for lube oil pressure, and approximately 20 lbs./in² for fuel oil service and sea-water pump pressures.

21. The auxiliary engine sea-water suction can be primed via a connection from the detached main engine sea-water pump. The engines are not equipped with exhaust pyro meters only smoke test cocks are furnished.

22. The Japanese operating personnel apparently maintained their lube oil temperatures around 60 degrees centigrade or approximately 110 degrees Fahrenheit, and their cylinder jacket water temperature around 50 degrees centigrade or approximately 90 degrees Fahrenheit.

23. From all information available, the service and reliability of their auxiliary engines have not been altogether satisfactory.

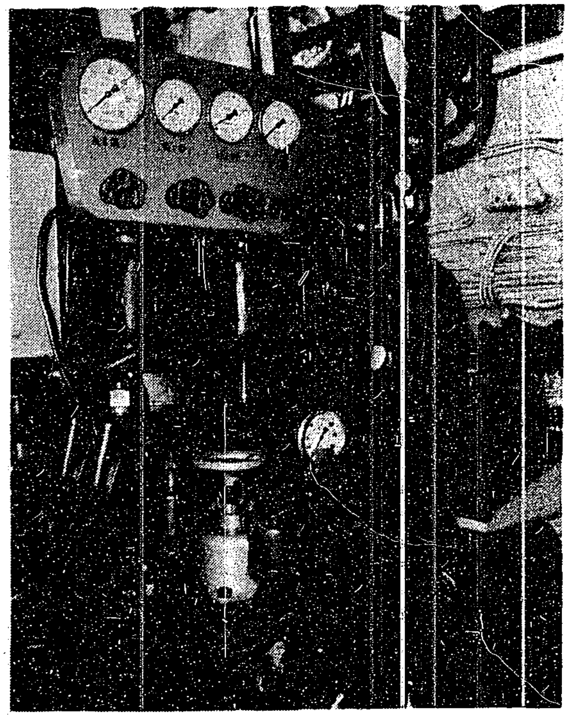


Figure 79

CONTROL STAND AND GAUGE BOARD AUXILIARY ENGINE, I-14

E. I-400 Submarine: Electrical Plant

1. Main motors. The main motors are four in number, with two motors having the same field frame and armature shaft. They are located in separate compartments, port and starboard as the submarine has a longitudinal, watertight bulkhead running almost the full length of the boat.

Figure 80
MAIN MOTOR, I-400

The motors are of a conventional design having a double armature on the same shaft and using the same field frame. There is a commutator at each end of the armature. The bearings are a pedestal type with white metal shells and are an integral part of the motor.

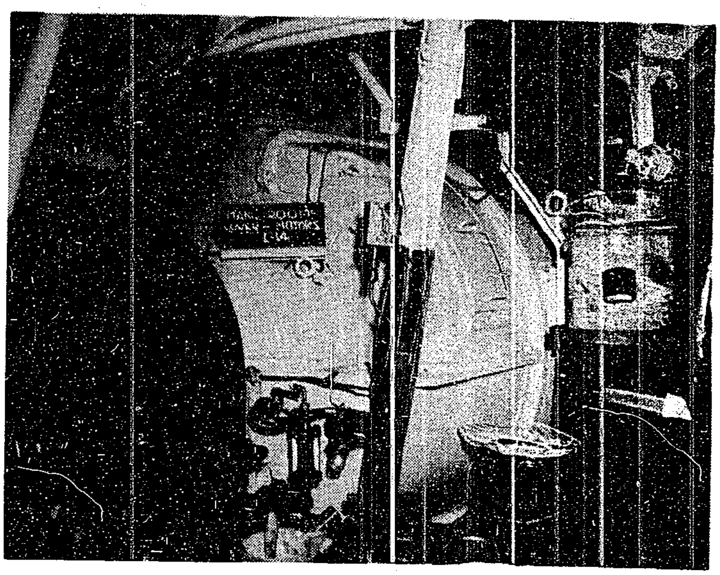


Figure 81
MAIN MOTOR, I-400

The shunt fields are divided, one set at each end of the motor, drawing a total of fifty-five amperes. The fields are connected in series for normal operation.

Without a more complete dissassembly of the motor, it is impossible to examine the motor for interpoles, poleface, and series windings.

The brush arms are twelve in number at each end, with ten brushea per arm. They are arranged in a single row, with individual brush tension springs. The springs are of a coiled type with the bottom face of the spring pressing downward giving the brush its tension.

Nameplates, instruction books, and blueprints were not available. Conversation with Japanese engineering officers and enlisted electricians educed the following information, which from appearances seems reasonably correct.

hp	1650
Volts	340
Armature amps	2600
Field amperes	55
r.p.m.	50 - 290
Temperature rise	Unknown
Weight	Unknown

The cooling system is separate with sheet metal ducts leading from the main motor to the blowers. Each blower has its own motor, a total of four being installed. The air is cooled by coils using sea-water as the cooling agent. Whether the coils are of double construction is not known at the present time.

There is one circulating water pump for the four motors, however the engine circulating water system can also be used.

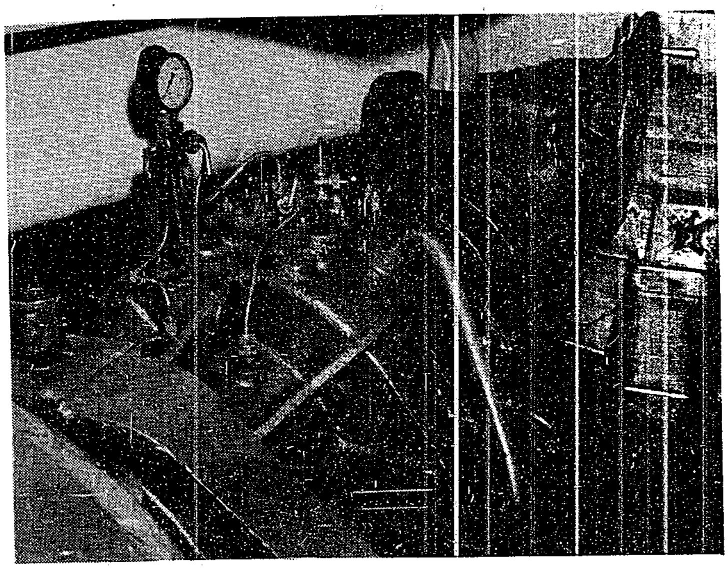


Figure 82
SHAFT CLUTCH, I-400

The lubricating oil system is a pressure feed to the bearings with a sump under each motor. There are two detached lub oil pumps, one in each motor room. The oil is cooled by coolers using salt water from the main motor air cooling system. There is also a gravity tank in the maneuvering room, which is apparently used for priming the system, but might be used in an emergency for the bearings. A hand pump is used to fill the gravity tank.

There are two positive jaw clutches in each motor room. One between the motor and the propellers, the other between the motor and the shaft leading to the engine room. These clutches are manually operated by a permanently installed system of bellcranks and hand screws.

2. Main control cubicle. The main control cubicle is a split system, having two identical cabinets, one in each maneuvering room, port and starboard. The maneuvering rooms are located above their respective motor rooms, with a non-watertight deck between compartments. Each cubicle apparently controls its own motors, and is only connected to the other for the slow position which puts the four motors in series.

The cubicles are neatly enclosed but not of pleasing design. They are simply constructed, with removable panels for easy access. The operating station is dead front, with operating wheels and handles connected by shafts to the switches inside.

The switches are pneumatic with solenoid control valves, using approximately seventy pound air to close the switch. The switches and buses seem light for the current they must carry. There was some evidence of heating about the panel, scorched paint showing in several places.

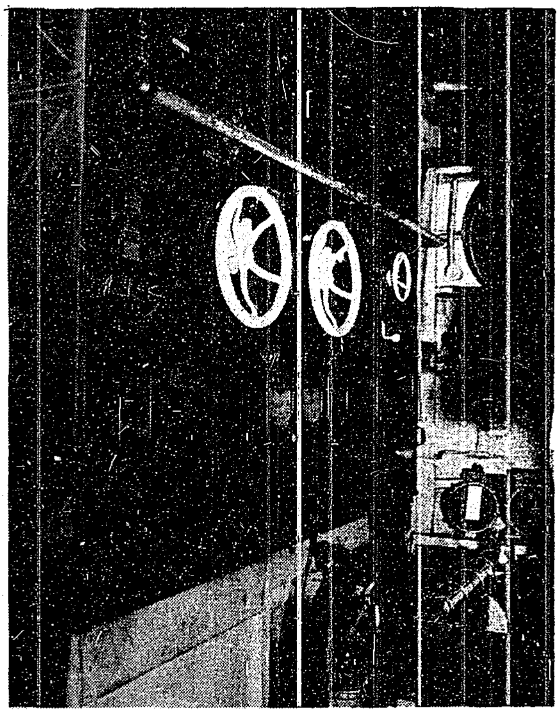


Figure 83

MAIN CONTROL CUBICLE, I-400

Figure 84

MAIN CONTROL CUBICLE, I-400

The front of the panel has four major pieces of operating gear.

The selector which has five positions; series, parallel in the back position. The reversing of the motors is accomplished by this selector through reversing the shunt field which is done when the selector is thrown from the ahead position to back.

The motor starter lever is located underneath the selector and is nothing more than a wheel with six positions. Turning the wheel in one direction cuts out three steps of armature starting resistance, comming back to the stop position and turning the wheel in the other direction cuts in two steps of starting resistance across the armature circuit. This is used for dynamic braking thus facilitating the use of the motor clutches. (CXD) Forward are two large wheels which are connected to the shunt field rheostats. These are of a conventional type similar to any of our ordinary rheostats. The resistance wire for the rheostats is wound on porcelain insulated spools. In addition there are the necessary ammeters, voltmeters and a double scale ammeter for the shunt field.

The system does not appear to be interlocked as the selector can be moved from any position at any time without the motor starter being in the off position. There is a reverse current relay which will kick the batteries off of the line if the engines fail. The only apparent overload protection is on the battery breakers.

3. Main storage batteries. The main storage batteries are located in four separate but adjacent compartments forward of the control room. Each battery is composed of one hundred twenty cells, a total of three hundred and sixty being installed. Two batteries are complete, one in each compartment, port and starboard. The third battery is located in the next two forward adjacent compartments, sixty cells on each side. These batteries are set in tanks somewhat similar to our submarines, that

is, arranged in rows with a catwalk down the center and a watertight but not pressure proof deck with access hatches between the tank and the compartment above. The only lining for the battery tank appears to be pitch with several coats of paint. There is considerable space below the batteries which is used as a bilge.

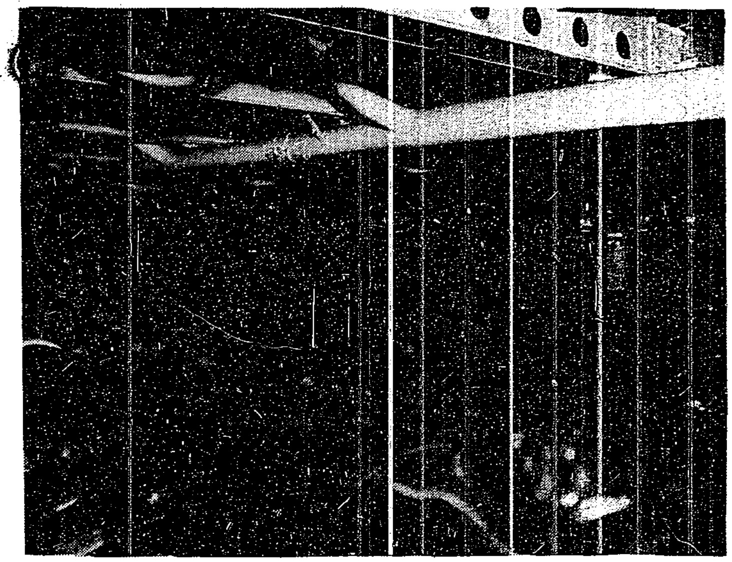


Figure 85

MAIN STORAGE BATTERY VENTILATION, I-400

According to information gleaned from Japanese operating personnel, each cell is rated at ten thousand ampere hours. This figure seems high but might be correct. Looking at the tops of the plates through the ventilation holes, they appear as ordinary paste plates, with wooden separators. Each cell has thirty nine plates and sixteen terminal ports, eight positive. From the top of the plates to normal electrolyte level is 1.38 inches. The outside dimensions of the cell are thirty two inches long, thirteen and a half inches wide, and forty one inches deep.

The battery ventilation follows our design in principle, and differs only in details. Standpipes admit air from the compartment to the battery tank. There are two exhaust connections near the end of each cell, using what appears to be three-quarter-inch garden hose. These in turn lead into the branch exhaust trunks. There is only one air intake which is located in the center of the cell, which would tend to cause the air to pass over most of the electrolyte surface. A special cap is provided for watering purposes.

There are two ventilation blowers located in the pump room, each with its own motor. All the exhaust trunks are brought to the suction side of these blowers. From there the exhaust is either to the engine rooms or overboard.

There is one hydrogen burner installed in the pump room. Its detail or operating characteristics are not known at the present time.

Three hydrogen detectors are installed in the battery compartments. Each detector has a piping arrangement whereby the gas from any battery may be read at each instrument. These instruments are of excellent workmanship and should be fully investigated for accuracy and reliability.

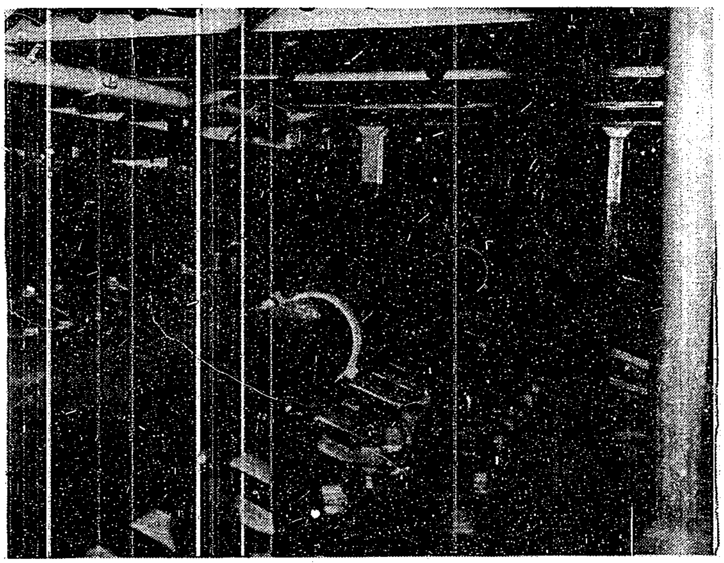


Figure 86
VENTILATION PIPING, MAIN STORAGE BATTERY, I-400

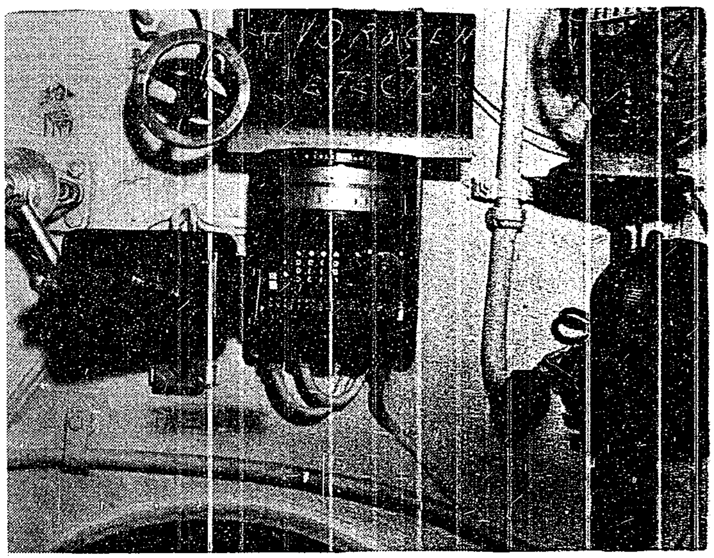


Figure 87
HYDROGEN DETECTOR, I-400

Battery water to the amount of approximately 1800 gallons is carried in tanks outboard of the outboard rows of cells in each battery tank.

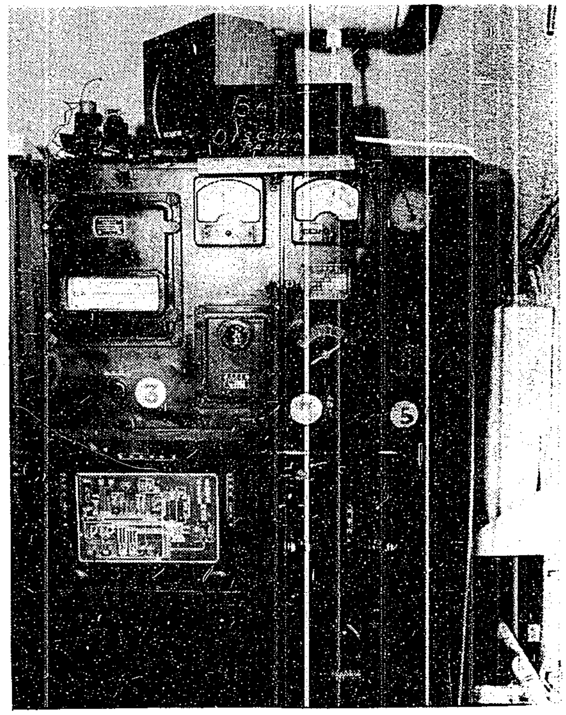


Figure 88

BATTERY DISCONNECT PANEL, I-400

4. Auxiliary generators. The auxiliary generators are two in number and located forward of the starboard main engine room.

They are ruggedly constructed, separately cooled, single commutator machines. They are rated at 1250 amperes at 325 volts, with an engine speed of 610 r.p.m.

The generator on the port side is connected to the port battery buss, and the starboard generator is connected to the starboard battery buss, through circuit breakers. There is a buss tie between the generators.

5. Lighting circuits. The lighting circuits are two in number and run the entire length of the boat on the port and starboard side. The lighting voltage is 220 direct from the battery through a manually operated rheostat which cuts the battery voltage down to the proper value. One rheostat is located in the port maneuvering room. The other rheostat is located in the starboard battery compartment. Of particular interest are the various lighting switch boxes; they have four positions, two off, one fused position and one non fused position for emergency use or depth charge attack.

6. I.C. system. There are two I.C. motor generators delivering 50 volts, 50 cycle and rated at 7.5 hp 7 k.v.a. They are of standard design and look the same as any of our comparable machines. They are supplied from the battery and are controlled manually.

There is a small starting and distribution panel located in the compartment aft the control room.

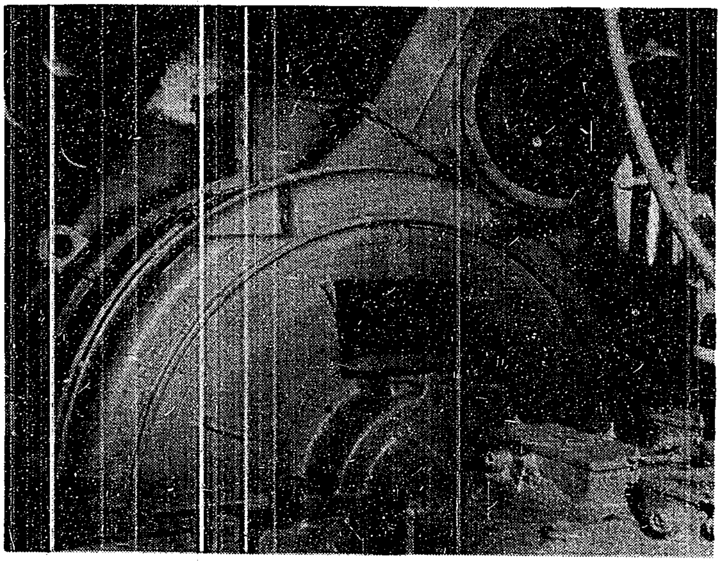


Figure 89
AUXILIARY GENERATOR, I-400

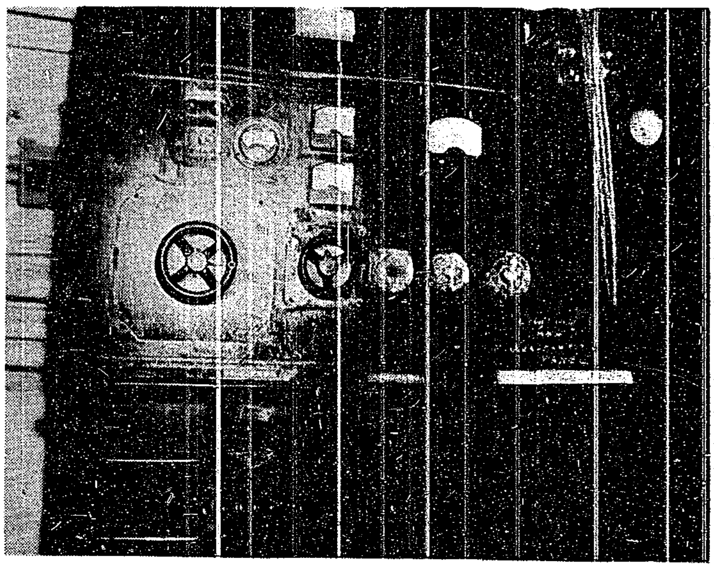


Figure 90
LIGHTING AND AUXILIARY POWER PANEL

7. Main power connections. The main battery cables run from the maneuvering rooms forward on both sides of the boat to the switch panels in each battery compartment. This arrangement might be considered as a loop with the ends opening in each maneuvering room.

Any or all batteries can be connected to this line by air switches, located in switch panels in the battery compartments and having their pilot circuits controlled from the port maneuvering room. This arrangement allows the operator to select the batteries he is going to use for any given evolution.

F. Fire-Control Equipment on Japanese I-Class Submarines

1. Investigation reveals a fire-control system for the control of torpedo firing only. There is nothing provided for the control of gun fire.

2. Installed in the conning tower is an angle solver which receives both manual and electrical inputs and resolves them into torpedo gyro angle which is transmitted to receivers at the torpedo tubes.

3. Examination of the torpedo angle solver proved that although it incorporates a time motor, evidently used as a time index reference, it has no integrator and therefore cannot generate range or bearing. This fact establishes the instrument as an angle solver and not a data computer.

4. Inputs to the angle solver include:

   a. Torpedo Speed - (26 - 56 knots) introduced manually.
   b. Target Speed - (5 - 40 knots) introduced manually.
   c. Torpedo Spread - (plus or minus 10°) introduced manually.
   d. Target Angle - (0° - 180° R & L) introduced manually.
   e. Range - (500 - 4000 meters) introduced manually.
   f. Own Ship's Speed - (0 - 10 knots) introduced manually.
   g. Relative Target Bearing - (0° - 360°) introduced manually or electrically.
   h. Time - Introduced by motor.

5. The output from the angle solver is gyro angle with spread introduced. Maximum gyro angle 120° right or left.

6. Mounted on both periscopes housings and geared to the periscopes are selsyn transmitters which, through the medium of a selector switch, transmit Relative Target Bearing to the angle solver. The input on Relative Target Bearing from the periscopes controls a follow-up motor within the angle solver which gives an automatic and constant value of Relative Target Bearing. This value may be cranked in manually if so desired.

7. Torpedo Gyro Angle, corrected for spread, is transmitted to the torpedo room by four (4) 220 volt selsyn transmitters located in the base of the angle solver. This value is received by four (4) selsyn repeaters, each repeater serving two torpedo tubes. It is duplicated and introduced to the torpedo gyros by a manually operated follow-the-pointer system. It was noted that the pointers can be matched with gyro setting spindles disengaged. Spread may be applied manually at each tube.

8. A Battle Order Transmitter (selsyn) is mounted in the conning tower. It transmits orders to selsyn repeaters in the upper and lower torpedo rooms.

9. The system described above has the inherent weakness that torpedo gyro angle is solved only for instantaneous inputs. In other words, the there is no position keeper and the inputs to the angle solver must be computed through a plot or by other means.

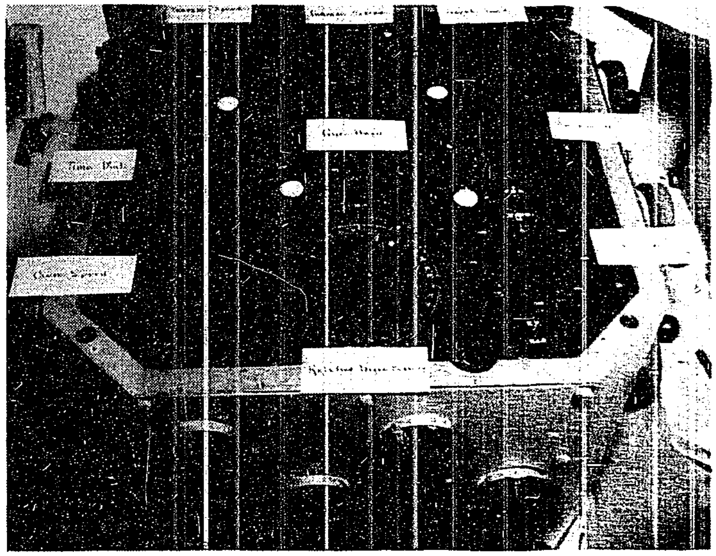


Figure 91
TORPEDO ANGLE SOLVER, I-400

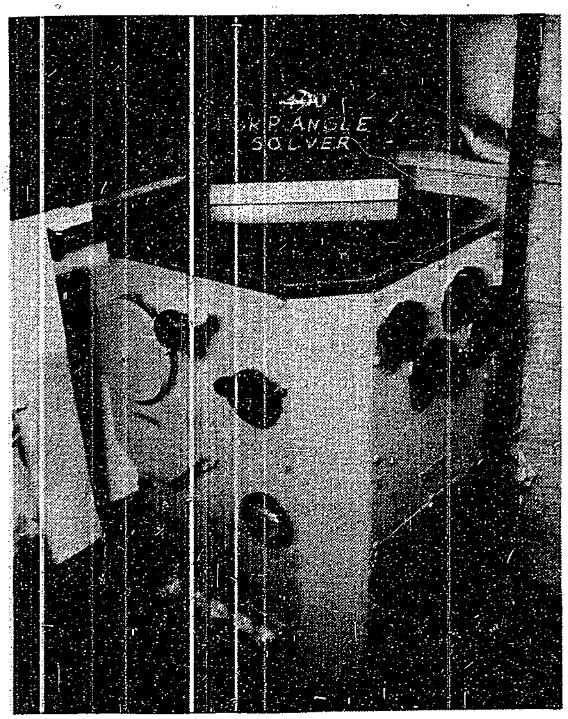


Figure 92
TORPEDO ANGLE SOLVER, I-400

Figure 93
TORPEDO ANGLE SOLVER, I-400

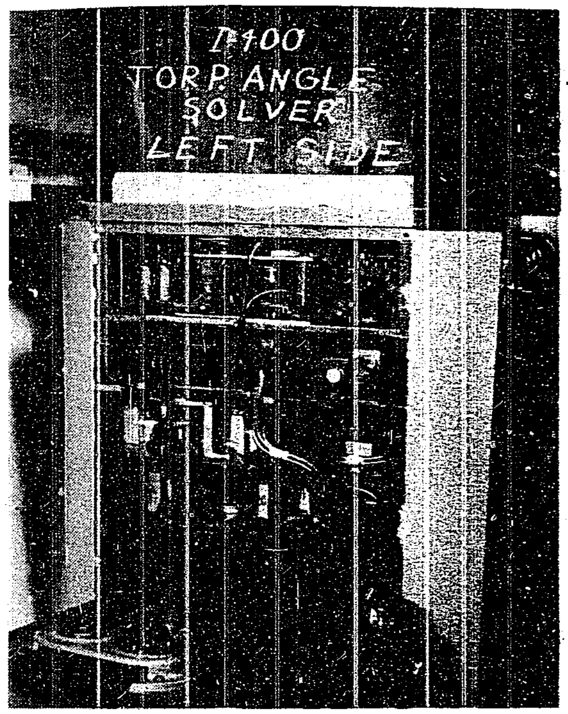
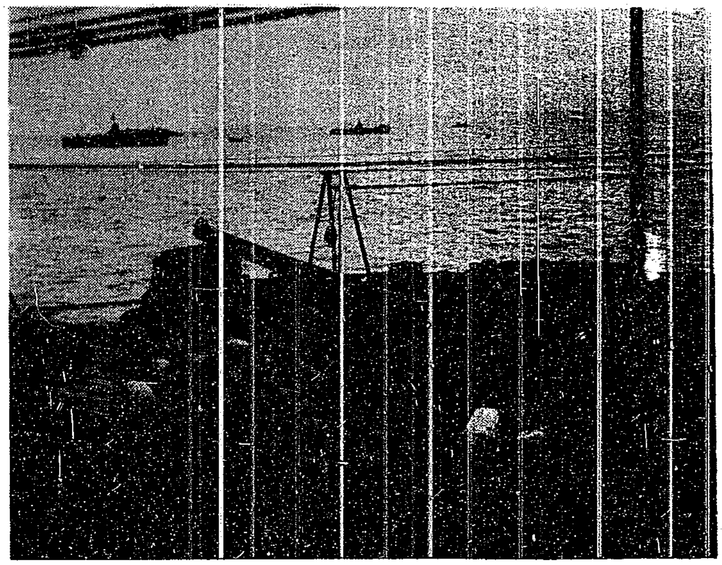


Figure 94
TORPEDO ANGLE SOLVER, I-400

G. Armament on I-Class Submarines

The armament consists of deck gun and ten 25mm A.A. guns, except in the case of the I-14, which mounts seven 25mm A.A. guns and no deck gun.



(M) 30930

Figure 95
DECK GUN, I-400

NRL (M) 30941

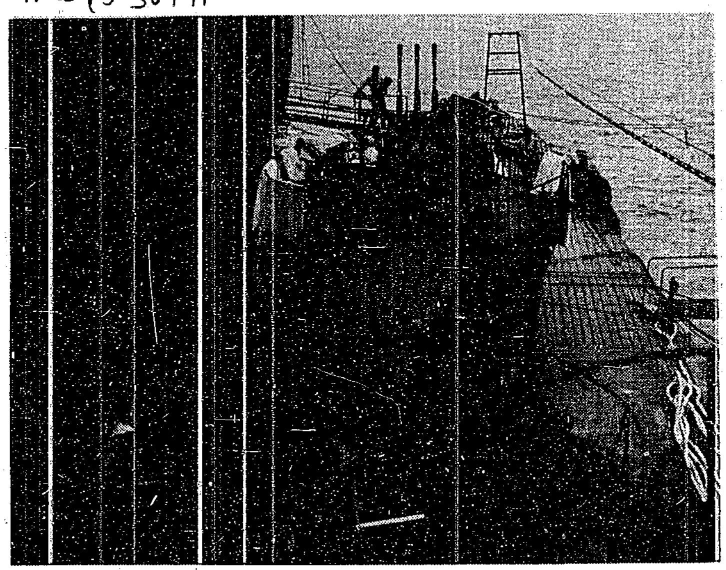


Figure 96
AA GUNS, I-400

5.7 in. Deck Gun

1. The deck gun is a single purpose, wet type gun using bag ammunition capable of 45° elevation and 5° depression. It is mounted well aft on a relatively light pedestal and capable of train through 360°.

2. The breech mechanism is a lever operated horizontal sliding block. It does not possess any characteristic which would classify the gun as a rapid fire weapon.

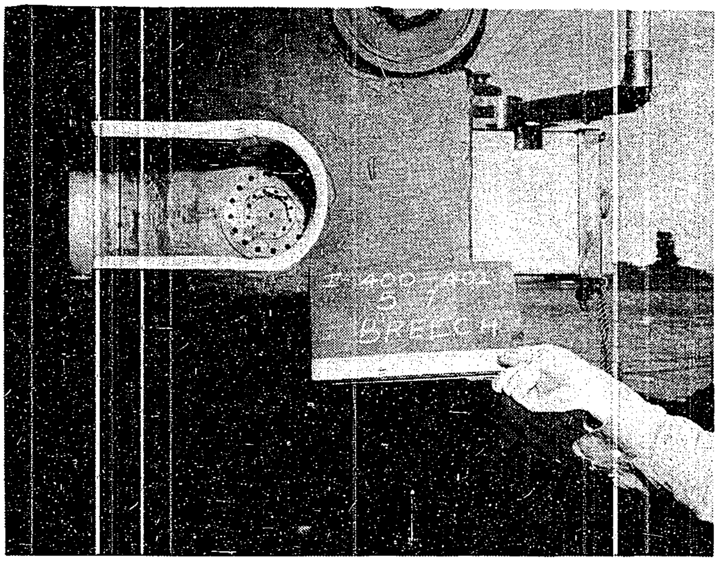


Figure 97
BREECH OF DECK GUN, I-400

Figure 98
BREECH OF DECK GUN, I-400

3. The gun appears to have been made by the "built-up" process, having a bore of about 5.7 inches.and an overall length of 17 feet and 7 inches or about 31 calibers. Although there are vertical and horizontal scribe marks on the muzzle face, the presence of a liner is not obvious and it is felt that the scribe marks are for use in conjunction with the muzzle disc used in boresighting. The bore is not chrome plated.

4. The gun seems to possess the conventional spring-hydraulic counter-recoil system. Both spring cylinders and hydraulic piston are mounted atop the gun.

5. The elevating and training mechanisms are mounted on the left side of the gun resulting in the elimination of that portion of the sight yoke which spans the gun as in American construction. The range scale is graduated to 15,000 meters, ranges being sent to the gun by phone. The sight deflection scale is graduated from 0 to 90 right and 0 to 130 left. It is provided with a moveable reference mark which is provided with two scales, one of which is thought to compensate for drift at ranges indicated while the other is thought to provide means of setting deflections spots.

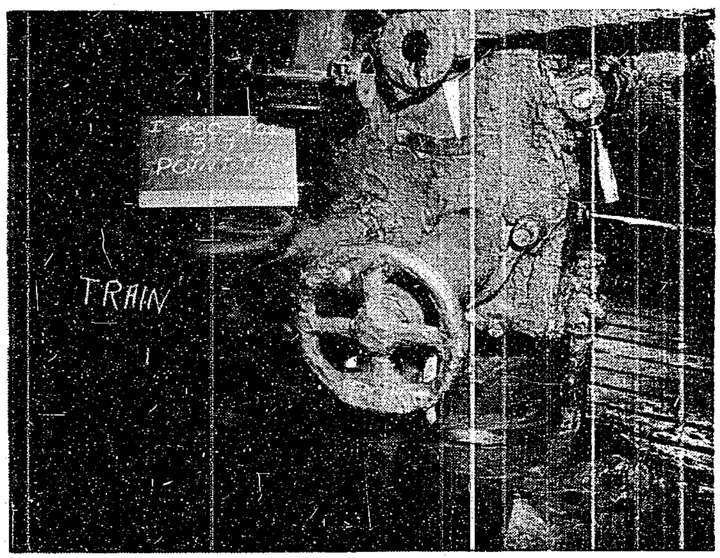


Figure 99

DECK GUN, I-400

6. Ready powder is available in individual watertight tanks at the breech of the gun. Projectiles and additional powder are provided from a hydraulic ammunition hoist located on the port side of the hangar close to amidships.

Figure 100
DECK GUN, I-400

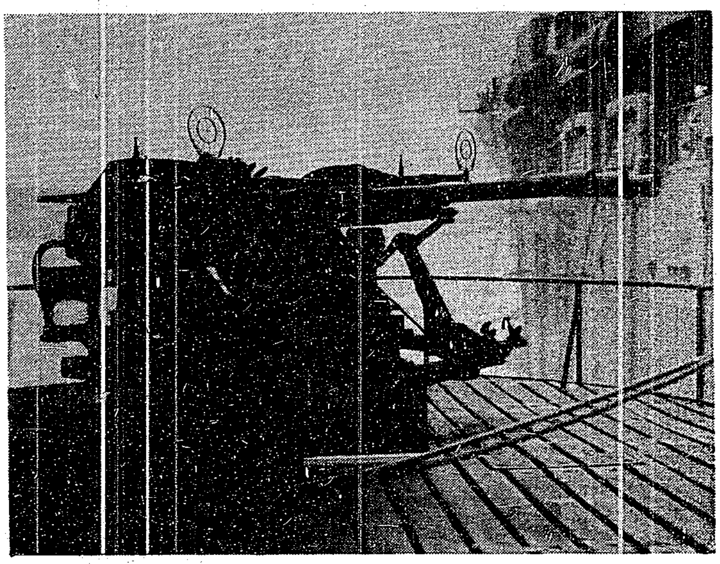


Figure 101
AA MOUNT, I-400

Automatic Weapons

1. The automatic weapons consist of three triple and one single 25mm A.A. guns, resembling the American Army (M-1) 40mm gun in general appearance. They are recoil operated, simple bolt action guns capable of firing about 150 rounds per minute. Training and elevation is accomplished by conventional gearing with the exception of the training handwheel. It rotates in a horizontal plane such as the steering wheel of an automobile.

2. Recoil is taken up and counter-recoil accomplished by means of two counter-recoil springs enclosed in cylinders and mounted one on each side of and parallel to the gun mechanism at the breech end. The recoil rod is anchored to the gun while the cylinder is anchored to the carriage.

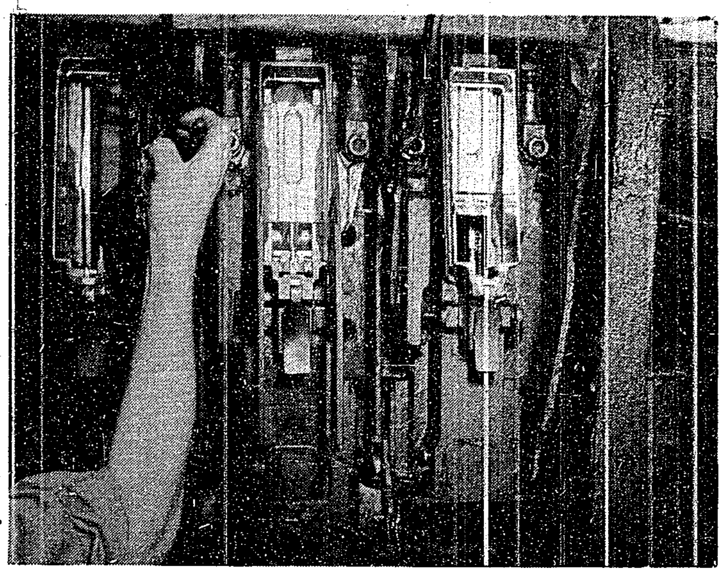


Figure 102

I-14, I-400, I-401
25mm BREECH

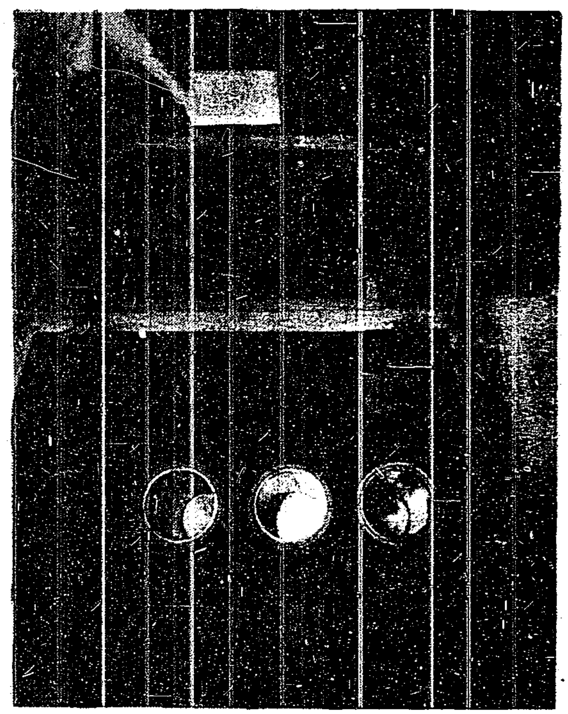
3. The pointer, on the left, and the trainer, on the right, are provided with seats which raise or lower when the gun is elevated or depressed respectively. This feature provides easy access to the conventional open ring sights.

4. Firing is accomplished by means of the conventional foot firing mechanism on the pointer's side. The motion from the pedal is transmitted to the firing pin sear through a series of rods and linkages passing through the left trunnion.

5. Ammunition is provided in clips of 20 to 30 rounds each. Seven such clips are stowed in each of the pressure-proof stowage tanks readily accessible to the gun. The general rule seems to provide one such tank for each gun barrel.

Figure 103
AA MOUNT

Figure 104
AA AMMUNITION STOWAGE



H. Torpedo Tubes on I-14, I-400, and I-401

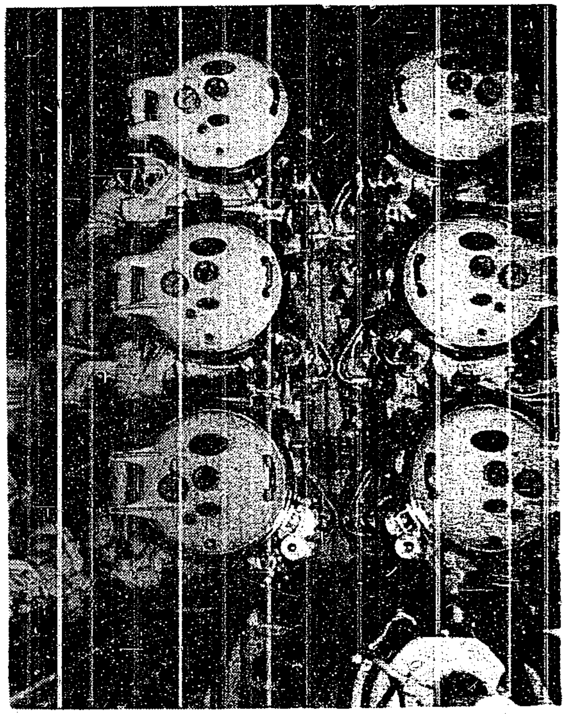


Figure 105
TUBE NEST, I-14

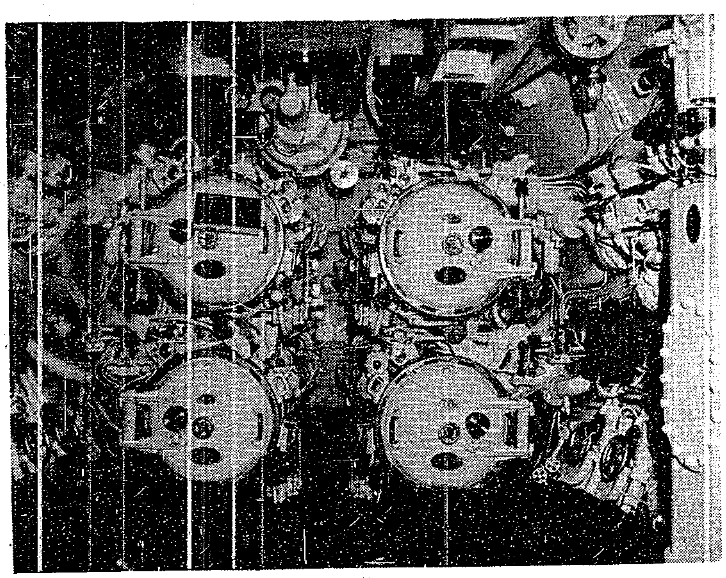


Figure 106
TUBE NEST, I-401

1. Number of tubes. The I-14 possesses six (6) tubes forward, and none aft. The I-400 and I-401 each have eight (8) tubes forward and none aft. The eight tubes are split into two four-tube nests in separate rooms, one above the other.

2. Torpedoes carried. The I-14 carries ten (10) reloads in the torpedo room, making a total of sixteen (16) torpedoes carried. The I-400 and I-401 carry four reloads in each torpedo room, plus four reloads in the crews' compartments immediately aft of the torpedo rooms, making a total of 20 torpedoes carried.

3. Tube construction. The tubes are not equipped with rollers. There are six lands running the length of the tube, two at the bottom, one on each side, and two on top. The guide stud of the torpedo is positioned between these two upper lands.

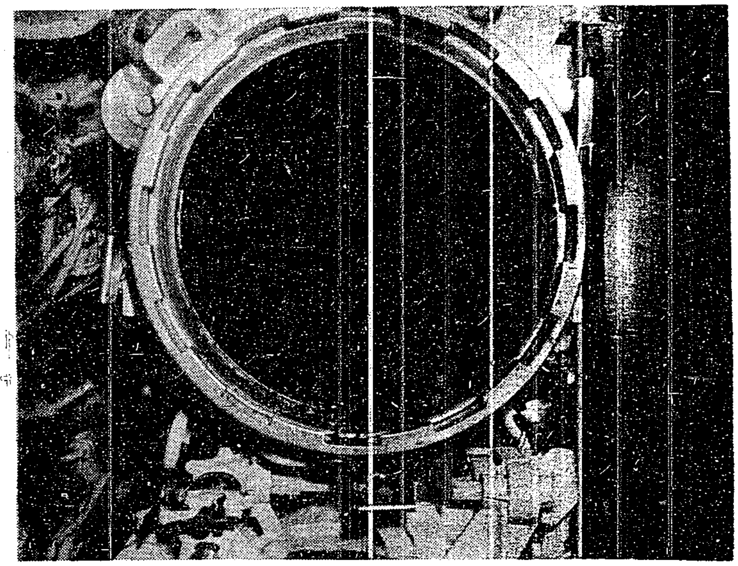


Figure 107
INTERIOR VIEW OF TORPEDO TUBE

4. Doors. The inner doors are similar to ours, with normal locking rings. The outer doors are operated by a revolving shaft, evidently with worm and quadrant. Power for the operation of the outer doors is supplied by an air engine which rotates the operating shaft through a gear train. The details of shutter construction are not known. A clutch is provided to disengage the air engine for hand operation of the outer doors. The inner door is equipped with a normal tail stop.

5. Inner-outer door interlock. The outer door cannot be opened when the inner door is opened because a lug on the breech locking ring opens a relief valve on the air supply line to the air engine. It cannot be opened by hand because another lug prevents placing a wrench on the end of the operating shaft. The inner door cannot be opened with the outer door open because a rod operating on a worm on the shaft (which actuates the tops for the air engine) protrudes into a lug on the breech locking ring.

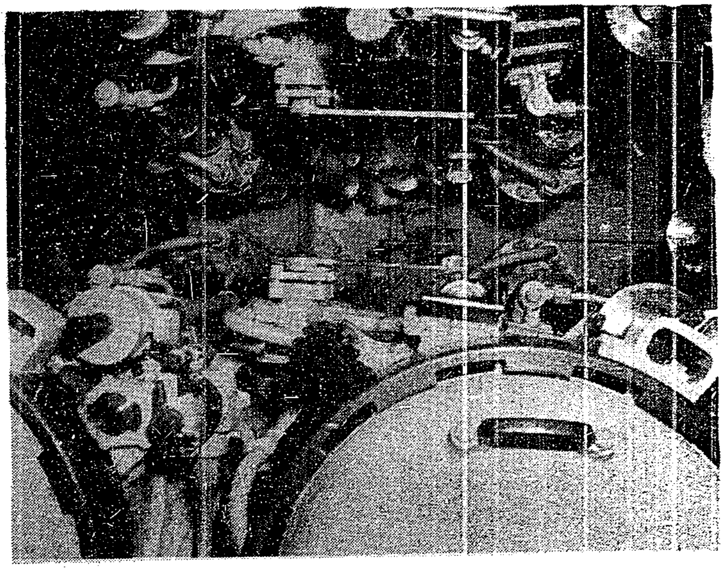


Figure 108

TORPEDO TUBE ACCESSORIES

6. Spindles. The gyro setting spindle (one for each tube) is located about 30 degrees left of top centerline. It is engaged by hand, but is retracted by air supplied from the impulse system. It does not retract automatically when the torpedo is fired. It may be retracted from the bridge by solenoid operation of the retraction control valve.

The depth setting spindle is engaged and retracted by hand. Retraction is not automatic. There is no interlock protection.

There are no speed change spindles.

There are two spindles which engage the torpedo approximately 10 feet forward of the breech end on the right hand side. They engage and retract by air and are equipped with indicator flags. They have no interlock protection. Their purpose is to open the stop valves of the torpedo at the time the tube is made ready for firing. This is necessary because the Japanese use oxygen in their torpedoes and, naturally, have no facilities for charging them aboard ship. With the stop valve of the torpedo closed until the torpedo is ready for firing the leakage is kept to a minimum. These spindles are rotated by a hand wheel which revolves the spindles in the tubes on one side of the torpedo room.

A spindle protrudes into the tube immediately above the stop spindles. This spindle is engaged by hand and is for the purpose of supplying ventilation air for electric torpedoes. It is connected to the low pressure air supply.

7. Stop bolt. The stop bolt itself is located forward of the forward bulkhead of the torpedo room. It is operated by fore-and-aft movement of a shaft which is evidently equipped with a single piston. The air for operation is supplied as part of the impulse system.

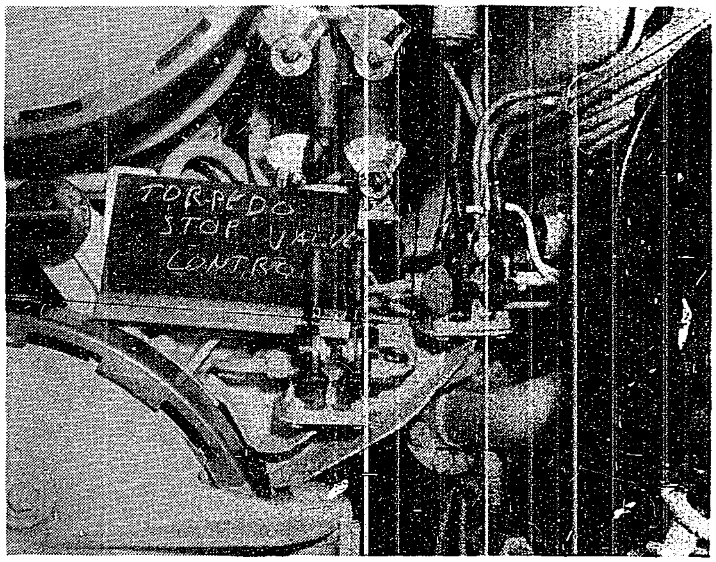


Figure 109

TORPEDO STOP VALVE CONTROL

8. Gyro setting control. Each torpedo room is equipped with two gyro setting regulator indicators, one port and one starboard. It is necessary to match pointers, using hand power to turn the spindles. The spindles on each set of tubes operate together from one handwheel located beside the indicator. Each tube, however, is equipped with a clutch on the gyro setting spindle so that it may be disengaged from the other tubes. This permits setting up individual gyro angles on the torpedoes for spreads. Once the clutch is re-engaged, the spread is maintained when angles on the whole nest are set.

9. Poppet valves. The poppet valves and water checks are in the same bodies at the aft, outboard end of the tubes. It is not known whether the poppets close with or against sea pressure. The poppets are operated by impulse air and are an integral part of the firing system.

10. Poppet tanks. Each tube has an accompanying poppet tank. These tanks hold about 70 gallons and are located immediately behind the tubes in the torpedo rooms. They are equipped with sight gages which indicate how full they are. There are no poppet emergency stops between these tanks and the tubes, but it is possible to close the tank vents which vent the tanks into the hull ventilating system. The tanks are allowed to fill each time a tube is fired according to interrogation. Inasmuch as they can only drain with gravity through a 2 inch line into the bilges or forward trim tanks, it is considered possible that they might not be empty by the time the tubes were reloaded and ready again for firing.

11. Impulse bottles. The impulse bottles are located immediately aft of the poppet tanks. There are no impulse reducers.

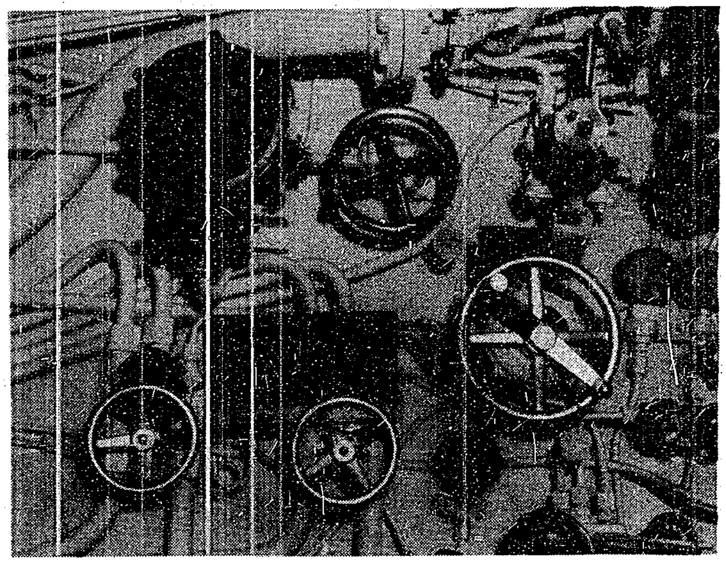


Figure 110
GYRO SETTING REGULATOR

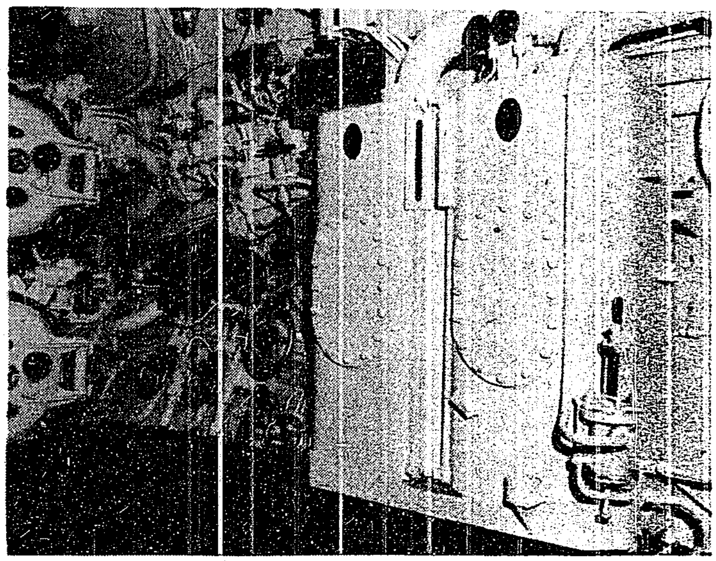


Figure 111
POPPET VALVE TANKS

12. Impulse control system and firing valves. The rough sketch of the firing and poppet control system enclosed with this report demonstrates the principles of operation of the firing system. The impulse bottles are charged through the firing valve. The impulse air is restrained by air balance in the firing valve. #1 firing trip is actuated by solenoid from the bridge or by hand. This releases the air from the stop bolt chamber (not shown on the sketch) and from the top of the inner firing valve. This releases impulse air in sufficient volume to start the torpedo down the tube. When the tail of the torpedo strikes the #2 firing trip (which extends into the tube as part of the tripping latch mechanism) the air is released over the body of the main or outer firing valve body. This gives the torpedo a further impulse. When the air in the impulse bottles has dropped to a pressure set on the impulse cut-off controller (a master valve with pistons for each tube), the controller trips and releases impulse air to close the impulse cut-off valve and to open the poppet valve through the poppet control valve. When the poppet tank is full, shifting the position of the poppet control valve (located beside the proper poppet tank) closes the poppet valve.

When firing water slugs it is necessary to operate #2 firing trip by hand from the outside of tube. An impulse pressure of 30-40 kg with a cut-off pressure of 17-20 kg appear to be normal pressure for firing water slugs.

13. Interlock protection of firing system. A worm on the outer door operating shaft moves a cross-lever on top of each tube which performs the following functions: With the outer door closed, the stop bolt operating rod cannot move aft and thereby lift the stop bolt. The #2 firing trip cannot be operated. The tripping latch is in the raised position and does not drop until the outer door is opened.

Interlock protection for the #1 firing trip is provided by the worm segment on the outer door operating shaft which prevents opening the inner door with the outer door open. Once the trip has been actuated it is locked open until the outer door is closed, at which time it may be returned to the ready position.

It has previously been noted that there is no interlock protection for any of the engaging spindles. There is also no interlock protection for the drain valves.

14. Tube flood and vent system. There are no outboard vents for the tubes. Each tube is equipped with a combination tube vent, WRT blow--WRT vent, tube blow cross-over valve. It is thus possible to blow the tubes full of water from the WRT tanks, and blow them empty to the tanks from one operating station at the breech end of the tubes. It is also possible to pump the tubes dry by pumping the WRT tanks with the torpedo room service pump and venting the tubes. In the I-14, which has one torpedo room, it is evidently common practice to drain the tubes directly to the bilge and then to pump the bilge. The drain lines are quite large and permit quick flooding and emptying of the tubes. There are no reflex gages on the inner doors. Drain cocks in the bilges indicate if the tubes are dry.

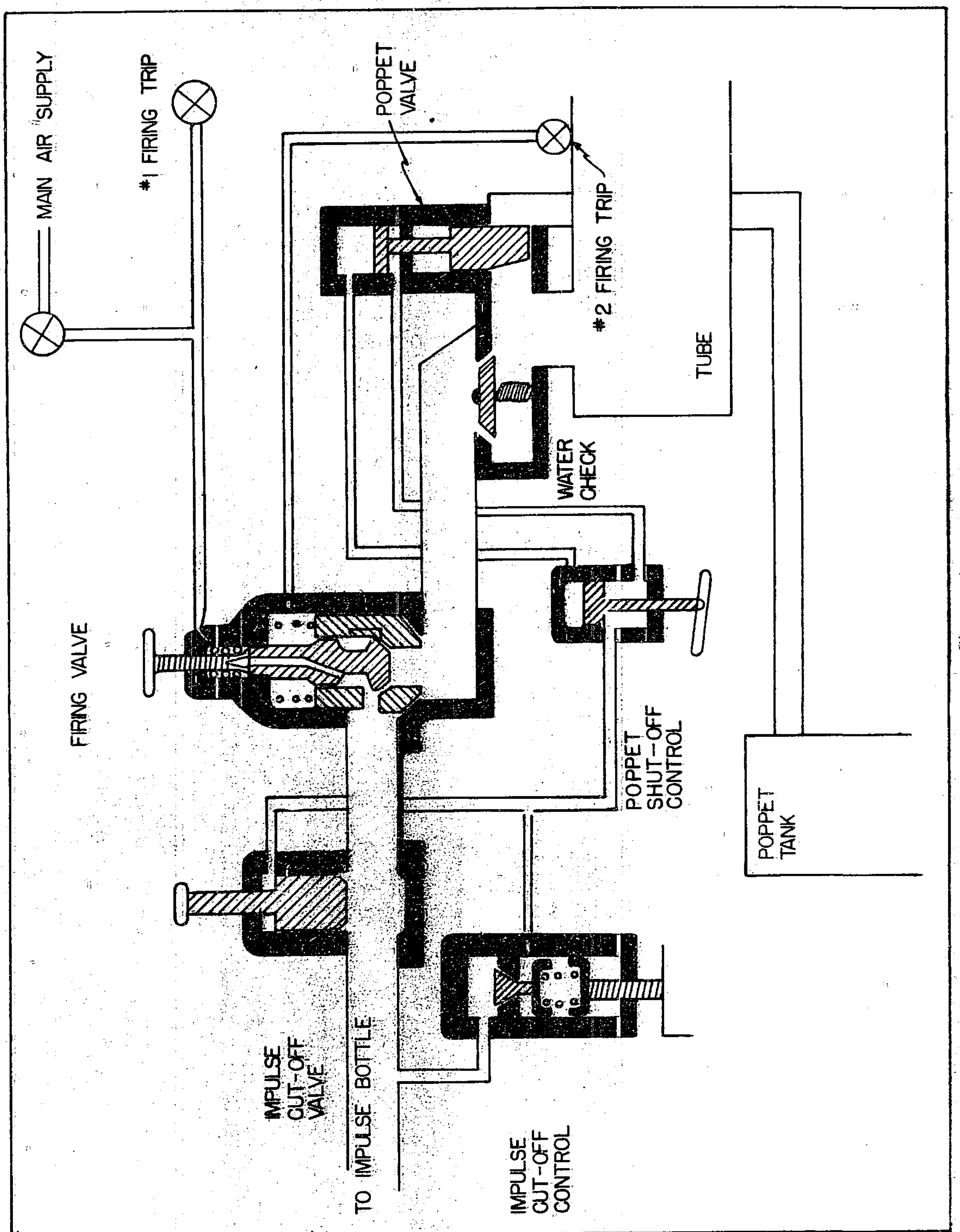


Figure 11a

FIRING VALVE AND POPPET VALVE SYSTEM, I-14, I-400, I-401

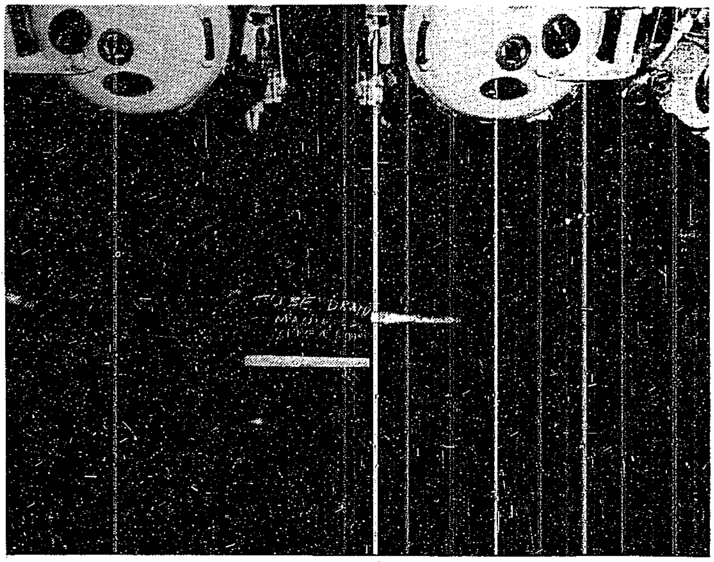


Figure 113

TORPEDO TUBE DRAIN MANIFOLD

15. WRT tanks. There are two WRT tanks located within the torpedo rooms on the outboard after ends of each submarine. These appear to be quite large tanks. They are equipped with a sea chest and connections to the torpedo room service pump as well as to the tubes.

16. Hazards. These tubes are by no means fool-proof. It is possible to open the outer doors with the drain valves open. It is possible to have charged the impulse bottles with the poppet valve in the open position. When this is done, it is necessary to fire the system artifically by turning the impulse cut-off controller up to a pressure above the impulse pressure, which closes the impulse cut-off valve and supplies air to the poppet valve. It is possible to fire a torpedo with all the spindles engaged. It is also possible to fire a "dead" torpedo if the stop valve spindles have not been engaged and the torpedo stop valve opened.

17. Electric torpedo service. Each torpedo room is equipped with one electric torpedo charging panel for two tubes. There is also an auxiliary panel in each room which is, according to interrogation, for the purpose of heating the torpedo batteries. The torpedoes may be charged in the tube, but the inner door must be opened for ventilation exhaust. No provision for hydrogen burning is evident. The heating wire evidently passes through a plug in the inner door rather than through a roller and cutter such as we use. The Japanese crew indicates that these submarines have never carried electric torpedoes.

18. Evaluation. The Japanese are evidently not worried about pressure in the boat. The lack of outboard vents and presence of so much air-operated equipment must introduce large quantities of air into the submarine.

The air operated outer doors are noisy, but the operation appears to be very reliable. Although the tubes had evidently not been maintained very carefully, all the equipment worked properly. The operation of the gyro setters was noted to be remarkably free.

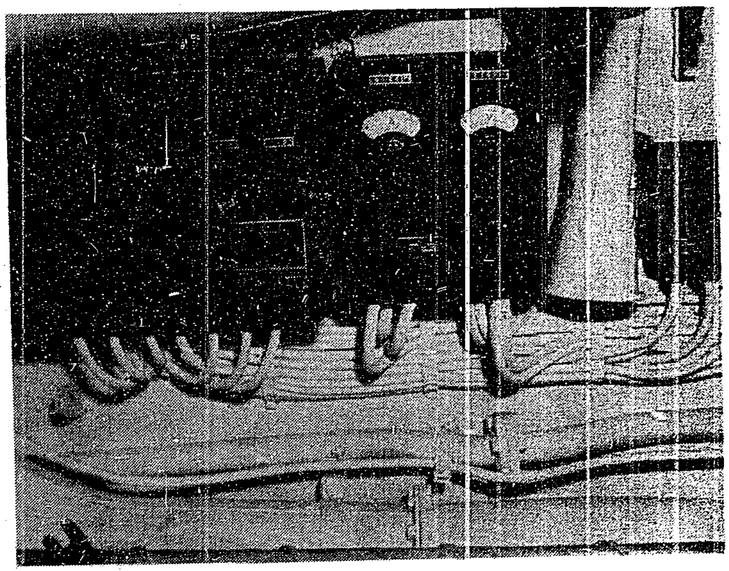


Figure 114

ELECTRIC TORPEDO EQUIPMENT

The simplicity of the firing and poppet control system is worthy of note. Impulse air controls all the necessary functions for firing, including retracting the gyro setting spindles. Supplementary air is necessary only to operate the outer doors and to engage the torpedo stop valve spindles.

The impulse system appears to be very satisfactory, but it is not known what characteristics of torpedo ejection result from its use.

I. <u>I-14 Submarine: Engine Timing Procedure</u>

1. Prepare engine for operation via jacking gear: engage jacking gear, open all indicator cocks, and open all fuel injection pump vent plugs.

2. Jack engine only in direction of rotation (Main Engines on I-14 a not reversible).

Firing Order	STARBOARD ENGINE	- 1,6,2,8,4,10,5,9,4,7
	PORT ENGINE	- 1,7,3,9,5,10,4,8,2,6

Due to the fact that we are dealing with a 4-cycle engine there are 72° of crank travel between firing impulses of each of the ten cylinders.

3. Set vernier pointer of suction valve throttle linkage and escape oil throttle linkage on zero. Remove inspection cover plate from face of pump housing. Put special gauge plate across face of pump housing. The angular cut of 23° on gauge will pass through center of suction valve operating link; if not, adjust via turnbuckle until angular gauge will pass through center of link. The escape valve operating linkage is checked in the same manner, except the angle on that gauge is 42°. Any necessary adjustment is made the same way.

4. Set both pointers on suction valve and escape valve linkage vernier scales to match figure "8"; then trip linkage to disengage pawls from contact pins.

5. Reset both pointers to figure "7" on vernier scales. Mount a dial indicator fixture with swivel arm to pump housing face. Secure it with four small wing nuts. Contact escape valve plunger with inner end of swivel arm and secure outer end of swivel arm to a pipe line directly beneath; the proper size tension spring is furnished for this purpose. The clearance taken up by this method should register on the indicator dial 3.06mm. At this point the crankshaft should be in a position of 40° B.T.D.C. The pump suction valve plunger at this same time should indicate on the dial indicator an opening of .90mm. As the crankshaft travel reaches a position of 18° B.T.D.C., the pump suction valve is shut and the clearance between operating arm and suction valve plunger, which was 0 up to this point, increases to the predetermined clearance. When the crankshaft, during its travel, reaches top dead center, the fuel escape valve (can also be referred to as by-pass valve) starts opening, letting excess fuel spill into the escape header, whence it eventually returns to the service tank. During the 18° injection period, the fuel pump plunger has traveled 8mm upward.

6. Fuel pump plunger actually begins to build up injection pressure approximately 29° to 31° B.T.D.C. to compensate for the time lag due to the long high pressure fuel line from pump to injection nozzle.

7. The valve timing is marked on the flywheel. The pointer and markings can easily be observed through a large inspection cover.

8. It is to be born in mind that this is a 4-cycle engine and that the injection pump timing takes place during the compression and firing stroke. Upon completion of all timing operations, make sure and disengage the jacking gear and close all pump vent plugs including cylinder indicator cocks.

9. Note: In the event a fuel injection pump becomes air bound, there is, on the side of the fuel injection pump, a hand priming attachment, and a vent plug on fuel injection nozzle body for the purpose of bleeding off all air in lines and pump chamber.

J. Low-Pressure Blower on I-14 Submarine

1. Name plate data from D.C. motor and l.p. blower:

a. Motor speed range as marked: 4250/4300 r.p.m.
b. Voltage range as marked: 220/250 V.
c. Ampere range as marked: 1930/1650 A.
d. Power output as marked: 460 E.H.P.
e. Maximum volume as marked 220 cubic meters per minute or approximately 7768 cubic feet per minute.
f. Maximum discharge pressure range: 0.55 to 0.65kg/cm^2 or approximately 9 to 10 lbs/in^2.
g. Maximum time limit for continuous operation, 30 minutes.
h. Maximum temperature 50 to 80° centigrade or 122° Fahrenheit to 176° Fahrenheit.

2. The low pressure blower (turbo type 3 stages) and motor are mounted solidly on a common foundation by means of holding down bolts; the foundation is welded to the inner hull. Motor armature shaft and rotor shaft are held by three bearings. The center and after bearing lube oil sumps are interconnected with a lube oil line running to and from both sumps. The sumps are built into the attached bearing housings. Two small low pressure circulating oil pumps of the gear type are built in

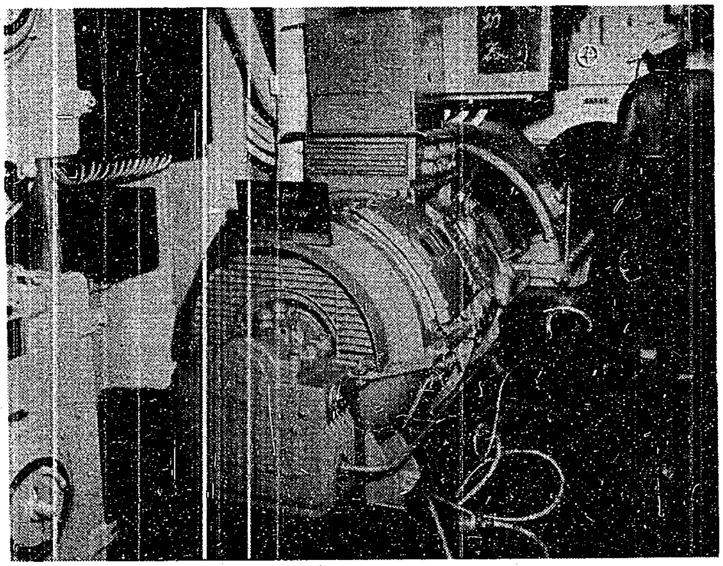


Figure 115
TURBO BLOW MOTOR, I-14

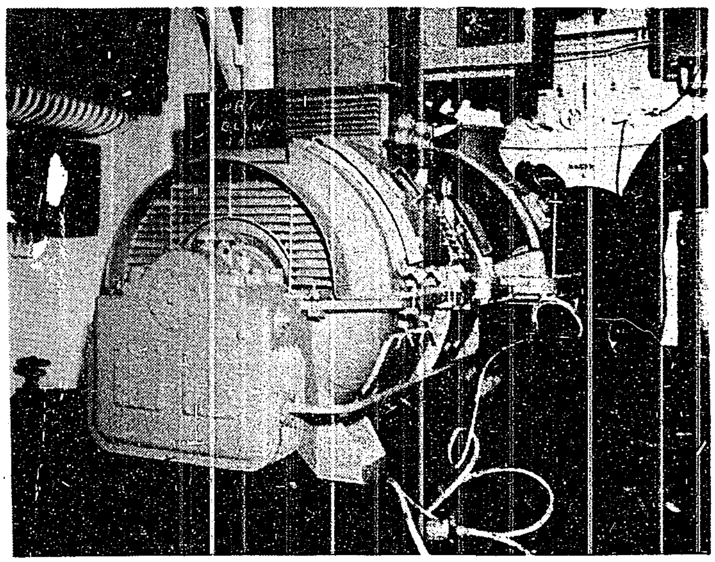


Figure 116
TURBO BLOW MOTOR, I-14

the after bearing housing. The center bearing is also the thrust bearing. The forward bearing is separated in all respects from the center and after bearing, and is equipped with its own small pump. A flinger of the screw type is installed to prevent oil leakage. The conventional type labyrinth seals are installed at both casing ends and between casing and the three stages to prevent leakage from housing ends and between the three stages. There is a 2 1/2 inch diameter pipe, (possibly to help in equalizing the thrust) interconnecting the blower discharge and intake side. The air flow from intake side through the three stages to the air from stage to stage follows the logarithmic curve. The rotation is clockwise and a vibrating reed tachometer (similar to our frame type) is mounted on top of the D.C. motor. The pressure gauge is calibrated in kg/cm^2; the Blower case consists of top and bottom halves.

3. The starting operation of the blower is as follows: Turn the small voltage rheostat on controller box all the way down in a counterclockwise direction. Throw in the power switch on auxiliary board opposite blower on port side. Put the ready light on which will give the operator at the blow manifold in the control room a light signal. Start moving the controller handle through its stages of speed ranging from 0 to 4; allow enough lapse of time while passing through each phase to permit the amperage to settle out. Bring voltage rheostat to the desired voltage and motor speed.

4. The blower discharge pipe leads from the blower directly upward and via a large gate valve to the blow manifold, which has the necessary blow connections with stop valves to all 15 main ballast tanks. A blow line drain tapers off from the main blow supply line into the bilge and has a drain valve installed slightly above the bilge. The blower was made by the Fuji Electrical Manufacturing Company. The serial number is 320828.

K. Periscopes

1. Midget submarine periscopes. The only periscopes in Japanese submarines which could be called truly Japanese are those installed in the midget submarines and suicide torpedoes. These periscopes are the only ones definitely known to be manufactured in Japan and even they follow German design very closely. These periscopes possess very good optical qualities, having a change of power ($1.5^{\circ} \times 6^{\circ}$) and a range of elevation of from 10° depression to 20° elevation. The midget submarine periscopes are approximately 10 feet long by 3 1/2 to 4 inches in diameter, while the suicide torpedo periscopes are four feet in length and 2 1/2 inches in diameter. The midget and suicide submarine periscopes are rigged with hoists for raising and lowering. Both periscopes train through a full 360° circle. Although these small periscopes appear to be crudely manufactured by American standards they are considered well designed for their projected use.

2. Large periscopes (Not installed on any submarines): The larger periscopes (those of 27 to 40 feet in length) found at shore installations and not installed on any boat are all of German design and manufacture. It is possible that one of these instruments (a $10^{\circ} \times 1.5^{\circ}$) is Japanese made, but if so, it has all the characteristics of a German made Carl Zeiss periscope.

3. Large periscopes (Installed on the I-14, I-400, I-401): Each of the three I-class submarines surrendered to Submarine Squadron Twenty, is equipped with two periscopes of German make, approximately 40 feet long and 7.872 inches in diameter. Both the attack periscope and the large head, so called "Night Scope", appear to be excellent instruments both optically and mechanically. The attack periscope elevates 20° and depresses 10° and is an improvement on the American design in so far as the tapered section is concerned being only 1.235 inches at the window. It

is doubtful, however, if this instrument possesses the all round efficiency of an American attack periscope. Both the night and attack instruments employ a split lens stadimeter attachment which swings into the line sight over the observer's eyepiece.

The night periscope is quite similar in appearance to our own radar periscope with a tapered section of approximately 4 1/2 inches in diameter with the head section 3.560 inches at the window. The general mechanical characteristics are the same as the attack scope, but night scope has an elevation of 80° and a 10 power optical system. The diopter setting is fixed at plus 2. The attack scope, on the other hand, is equipped with adjustable focus.

There are two features incorporated in these two periscopes which might be of benefit to the U.S. Submarine Navy. One is an azimuth sight arrangement which projects a portion of the azimuth circle into the field of view of the periscope eyepiece for the purpose of reading the bearing while still keeping both eye and periscope trained on the target. The other, which is of vital interest to both operating and repair personnel, is the ingenious hull gland packing. This packing is similar to the Garlock Chevron design but is a complete ring of heavier construction.

4. Commentary: In general, it is felt by this activity that the Japanese made periscopes are inferior in both quality of workmanship and utility to the newest types now installed in American submarines; and that the German manufactured instruments, although excellent optically, are not as well adaptable to all around operation.

In addition to the six periscopes installed in the I-14, I-400, and I-401, the PROTEUS has on board one attack periscope and one night periscope which will be turned over to Naval optical experts for disassembly and analysis.

L. I-14 Submarine: Anschutz Gyro Compass Equipment

There are two complete Master Compasses installed on the boat, either one of which, through a switching arrangement, may be used to transmit the compass heading to the repeaters. The equipment for both compasses consists of forty-two separate units as follows; and are marked with the same letters as shown.

A1 - 220 v.D.C. supply switch which selects the supply from either bus to either or both compasses. There are two switches, one for each compass, in the unit.

A4 - 50 v. 50 n. supply switch. There are two of these units, one for each compass.

A6 - 3 pole single throw 120 v. - 333 ~. supply switch for the water pump. There are two of these units.

B2 - A fuse panel and jct. box for the A.C. and D.C. supply, gyro supply, follow-up panel supply, water pump supply and a transformer for the alarm unit. Two of these units.

C - A unit consisting of three ammeters to measure the current in each phase of the gyro supply. Two units.

CO2 - Is a damping cut out switch and indicator. One unit for both compasses.

D2 - Is a switch panel with two double throw multiple pole switches and two indicating lights. By the switching arrangement either compass can be operated from either M.G. set. The indicating light shows which generator is being used. One unit.

E - Is a starting switch for the motor generator. Two of these units.

F2 - Motor Generator. The D.C. motor operates on 220 v.D.C. The generator generates 120 v.A.C. 333 cycles. The speed of the set is 3330 r.p.m. Two units.

K - Master Gyro. The sensitive element is sealed within a brass sphere which floats in a low gravity liquid. On the top and bottom and around the horizontal circumference of the sphere there are carbon contact surfaces which evidently make contact thru the floatation liquid to the contacts on the frame which surrounds the sphere and which is kept in alignment with the sensitive element thru gearing to the azimuth motor. The contact surfaces on the sphere make connections to the gyro rotors, damping coil, and a large horizontal coil wound around the lower inner surface of the sphere. A circular tank surrounds the top of the gyro support frame and contains the ballistic oil. The north side of the tank is connected by a tube, thru magnetic valve chamber in the bottom of the frame, to the south tank. The gyros are mounted at right angles to each other and are connected together with a link arm mechanism on the top of the gyros. The bearings are lubricated thru wicking with oil from the oil sump in the bottom of the sphere.

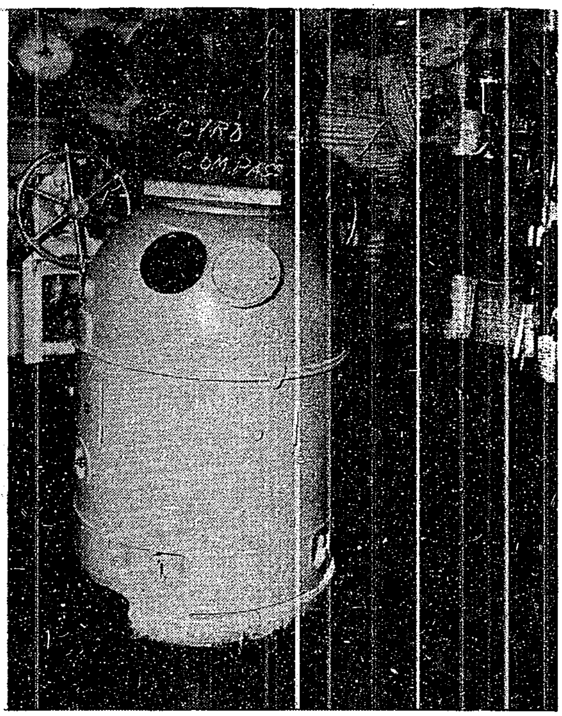


Figure 117
ANSCHUTZ GYRO COMPASS, I-14

The head can easily be disassembled in two parts. The upper part contains the single and 36 speed cards. The lower part has the supply and transmitter jack plugs mounted on it - a vertical column of six slip rings which bring the gyro supply, the damping cutout and follow up circuits to the sensitive element. The cooling water is piped through this part of the head passing thru a rubber hose which has a pinch cock type of valve to increase or decrease the amount of cooling. The valve is operated by a thermostat. The water flows through a coil immersed in the floatation liquid and located just above the sensitive element. The normal temperature of the system is between 30° and 40° centigrade. Above this temperature another thermostat closes an alarm switch causing the alarm to sound. The follow up motor, a type of synchro, is mounted on the upper part of the head. The ExW and NxS levels are mounted on the upper part of the head and are brought on scale merely by placing the required weights around the head. In other words the whole compass within the gimbal system is leveled by this operation. There are two of these units.,

L2 - Is the water pump and is operated from the gyro supply 120 v.A.C. 333 ~. Two units.

M2 - Is the electronic follow up panel and seems to operate on the phase shifting principle. Two units.

N2 - Is the transmitting panel. An A.C. motor with two windings, one of which is energized directly from the gyro supply, and the other from the follow-up panel, is geared to a selsyn type transmitter which transmits directly to the follow up motor and therefore the compass cards are not corrected for lat. and speed errors. The transmitter is also connected to Sv, the lat. and speed corrector unit. The transmitter and repeater system is energized on the stator from the 50 v. - 50 n.a.c. supply. Two of these units.

Sv - Is the speed and lat. corrector unit where the heading to the repeaters, by the use of a selector switch, can be transmitted corrected for the speed and lat. error, or transmitted uncorrected. The unit consists of two synchros one of which records the uncorrected heading. This synchro has to be synchronized with the compass card reading manually, because of the gear ratio involved, between the transmitter and the compass card, 360 revolutions of the transmitter equals 1 revolution of the card. This synchro is geared thru a gear shifting mechanism to a second synchro which, when selected, transmits the corrected heading to the repeaters. The correction is made by finding the number in the table on the cover of the unit which is at the intersection of the speed and lat. desired. By turning the crank on the correction mechanism and watching the indicator until the desired number comes up, the relative position of the correcting transmitter is changed so that the proper correction is made in the repeaters. Two of these units.

N - Is a repeater panel containing the fuses and switches for each repeater. Two units.

N3 - Is a selector switch through which the heading from either compass may be directed to the repeaters. One unit.

O1 - Is an alarm unit. The audible klaxon operates when the floatation liquid gets too hot (about 40°C). The visual indicator, a lamp, shows that the gyro supply is energized. Two units.

P1 - Is a junction box bringing the damping cutout switch and indicator supply from both compasses to the damping cutout unit. One unit.

Rz - Is a repeater junction box. Also contains a rheostat for dimming repeater lights. Five units.

S2 - Is a repeater. Five units.

An auxiliary compass supply system is also included in the system. It is an electronic device converting battery D.C. to A.C., energized from the lighting supply. Meters record the voltage, current and frequency of each phase thru a selector switch. There is also a voltage and frequency control unit. The output of the unit is 120 v. - 4 amp. 333 cycles.

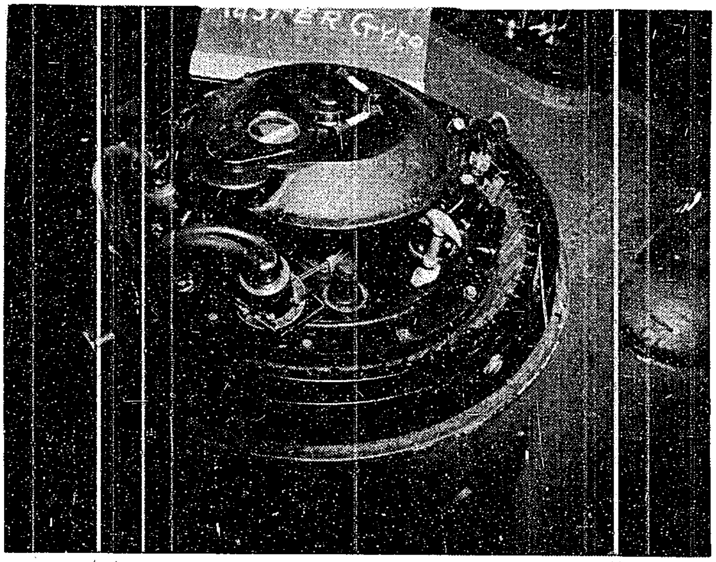


Figure 118
ANSCHUTZ GYRO COMPASS

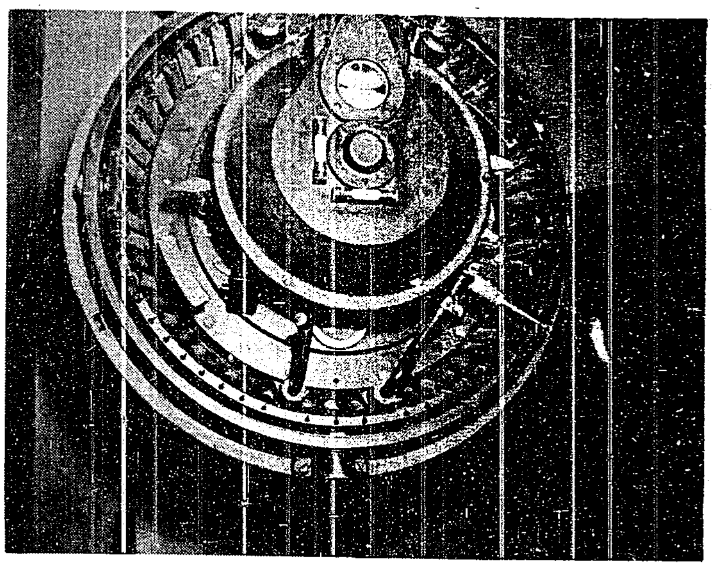


Figure 119
ANSCHUTZ GYRO COMPASS

M. Main Trim and Compartment Drain Pump

1. The primary function of this two stage centrifugal pump (similar to the Gould pump) is to service the auxiliary tanks. The pump manifold is also provided with cross connections to permit using this pump as a compartment drain pump if emergency conditions require it.

2. The pump is shock mounted, wood and rubber are used as shockmounting material. Large flexible couplings are interposed, between suction and discharge lines, pump strainers and valve manifold. The Japanese method and design of flexible mounts as found aboard the I-Class boats apparently disregards the correlated idea of also sound proofing the ship auxiliaries. The pump is located in the pump room approximately 4.5 meters below the water level.

3. In series operation the pump capacity at 1800 r.p.m. equals 50 metric tons per hour at a discharge pressure of 9.55kg/cm^2. The approximate maximum depth for operation in series is 100 meters.

4. In parallel operation the pump has a capacity of 300 metric tons per hour at a discharge pressure of 1.5kg/cm^2 and 1800 r.p.m. pump speed. The maximum depth for parallel operation is approximately 19.5 meters.

5. The priming pump is mounted on top of the pump motor housing. The pump assembled weighs 594kg and was manufactured by the Minohara Co., of Japan.

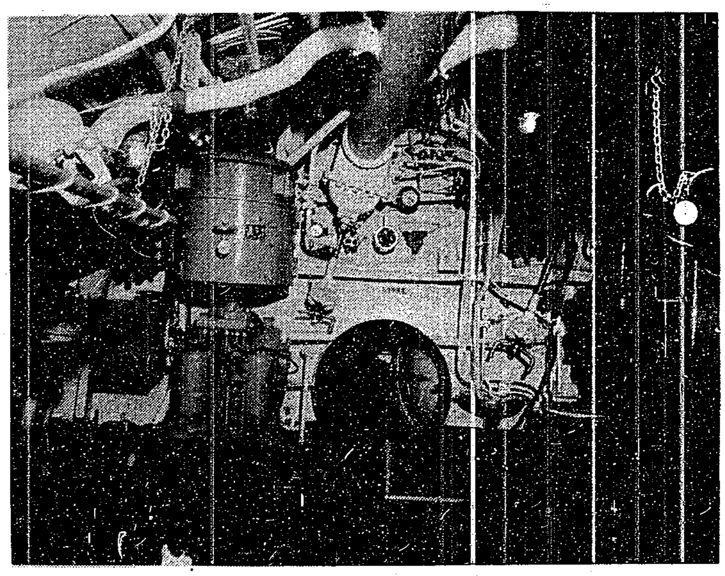


Figure 120

TRIM PUMP, I-400

N. Forward Torpedo Room and After Room Trim Pumps

Each room has a centrifugal single stage pump of 60 ton per hour capacity at a discharge pressure of 1.5kg/cm^2 above suction hg. The maximum pump speed is 2200 r.p.m. The power required to drive the pump at maximum load equals 20 h.p. per pump. The starting switch and rheostat are installed in the same compartment with the pumps but the control mechanism for handling the output of either pump is in the control room and consists of a control valve and handle; to direct the flow and quantity of water pumped between forward and after trim tanks, as the fore and after trim of the ship necessitates it. The remote pump operation control station is in the control room and operates on a semi-automatic principle. The after room pump is connected to sea via cross connections and a hand lifted check valve. The shock mounting of these pumps is in all details similar to that of the main trim pump.

O. Engine Room Bilge Pump

This pump is a four stage centrifugal type and has a capacity at 2300 r.p.m. of 10 tons per hour with a maximum discharge pressure of 6kg/cm^2. This pump can also be used via the proper crossconnections on the main drain line, but normally discharges into No. 11 fuel ballast tank.

P. Drain Pumps

No. 1 is located in the forward torpedo room and No. 2 in the pump room. Both pumps are of the reciprocating 3 cylinder type and are in their overall construction similar to our drain pumps (Portsmouth type). The capacity of each pump is 30 metric tons per hour and the maximum allowable pressure equals 12 kg/cm^2. The maximum speed equals 112 r.p.m. Both pumps are shock mounted similar to the mount used on the trim pumps. The pumps service the W.R.T. tank, torpedo compensating water, the bilges and will pump the forward trim tank to sea. Pump No. 2 in the pump room when used for any of the above mentioned purposes is to be lined up with the main drain line and then crossconnected by opening the proper valves on manifold.

Part IV - OTHER TYPES OF SUBMARINES

A. Midget Submarines

Type I - Midget Submarines with Torpedo Tubes.

Purpose:

Offensive weapon, short range.

General Characteristics:

Length overall	85 ft 8 in
Beam	8 ft 9 1/4 in
Draft (approx) - heavy	7 ft 9 in
light	6 ft 3 in
Displacement heavy (approx)	70 tons
Height conning tower above keel	13 ft
Pressure hull	6 ft 8 in I.D.
Periscopes	one 3.66 in O.D., 10 ft 6 in long. (6.0x1.5x)
Complement	four to six

Propulsion:

Generator	one six-cylinder diesel
Main motor	one connected to propeller shaft through articulated double reduction gear.
Battery cells (approx)	100 small
Propeller	one 5 1/2 in diameter, 3-bladed

Armament:

Torpedoes	two 18 in

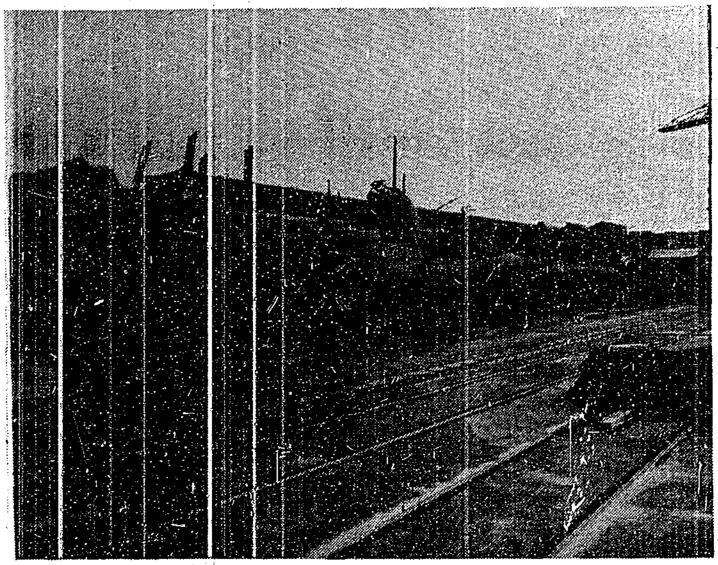


Figure 121
MIDGET SUBMARINE ON BLOCKS

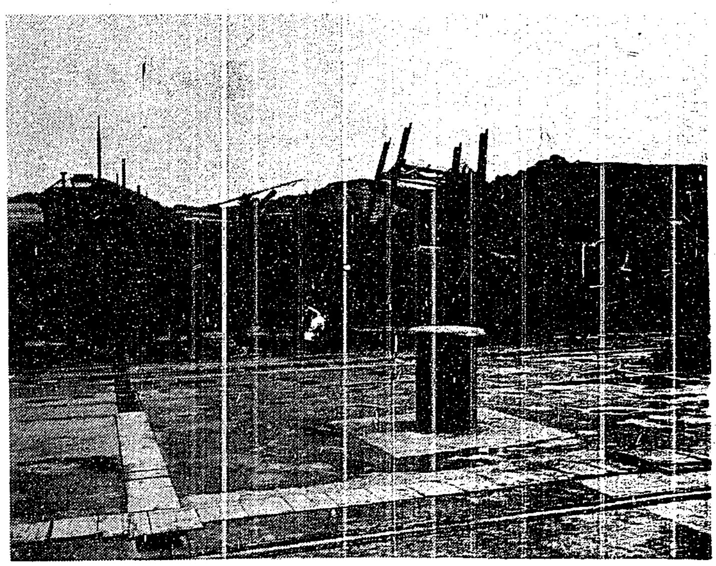


Figure 122
MIDGET SUBMARINE, PORT SIDE VIEW

Figure 123
MIDGET SUBMARINE, BOW VIEW

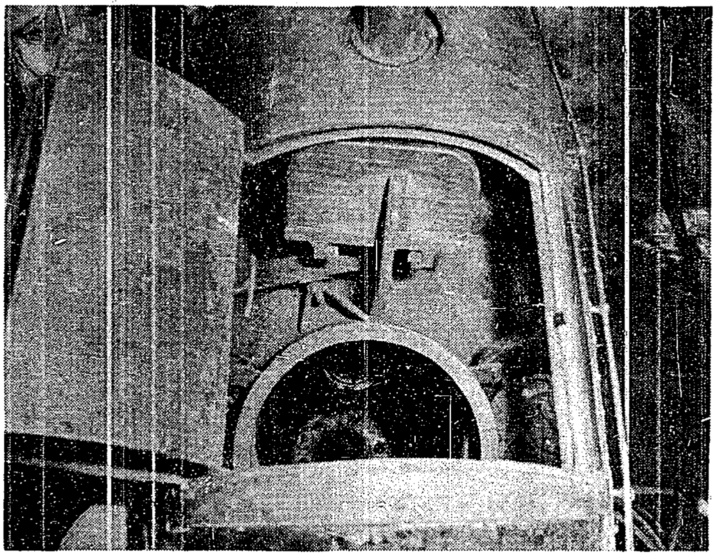


Figure 124
ACCESS HATCH TO CONTROL ROOM, MIDGET SUBMARINE

Construction

1. Pressure hull is 5/8 in. thick and consists of four sections of welded construction. The sections are bolted together with inserted asbestos or fibre gasket. Frame spacing is 12 1/4 in. The frames are 1 3/4 in. by 2 5/8 in. angle.

2. The pressure hull consitutes the maximum beam. The parallel middle body is about 25 feet long. The submarine is well streamlined.

3. Vertical and horizontal stabilizer fins with rudder and stern plane sections are installed just forward of the three-bladed propeller which is on the axis of the pressure hull. There are no bow planes. As viewed from astern the cross-section of the fin is flat on the counter-clockwise at the forward end with respect to the axis of the submarine to counteract the rotating effect of the single propeller.

4. There is a bow bouyancy tank forward built around the upper half of the pressure hull. There are two free flooding holes on each side. The single vent at the after end is operated by hand from the control room. It is probable that this tank is used primarily for compensating with or without torpedoes in the tubes.

5. Two main ballast tanks are built into the superstructure forward and aft of the conning tower blister. The vent for the forward main tank is inside the fairwater which forms part of the blister while the vent for the after tank is in top of the superstructure and well aft. The section of the superstructure around the conning tower blister is free flooding. The after body is free flooding.

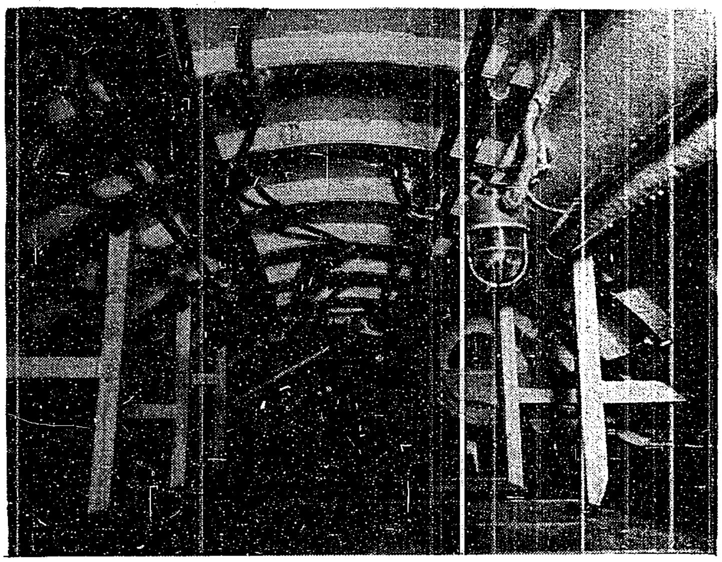


Figure 125

BATTERY COMPARTMENT LOOKING FORWARD

Arrangement

1. The forward section contains two muzzle-loaded torpedo tubes mounted vertically, one above the other on the centerline. There are a high pressure air flask and a torpedo impulse flask on either side of the tubes. Firing valves for the tubes are operated from the control room.

The tubes have a portable 4-dog door which may be secured externally on the muzzle of the tubes for trial runs when torpedoes are not aboard.

PHOTO # NH 78655

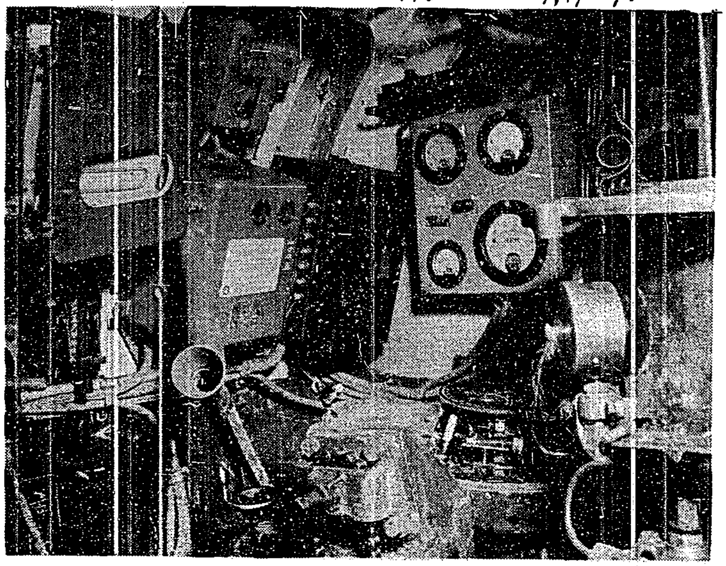


Figure 126
CONTROL ROOM, FORWARD PORT

PHOTO #- NH 78656

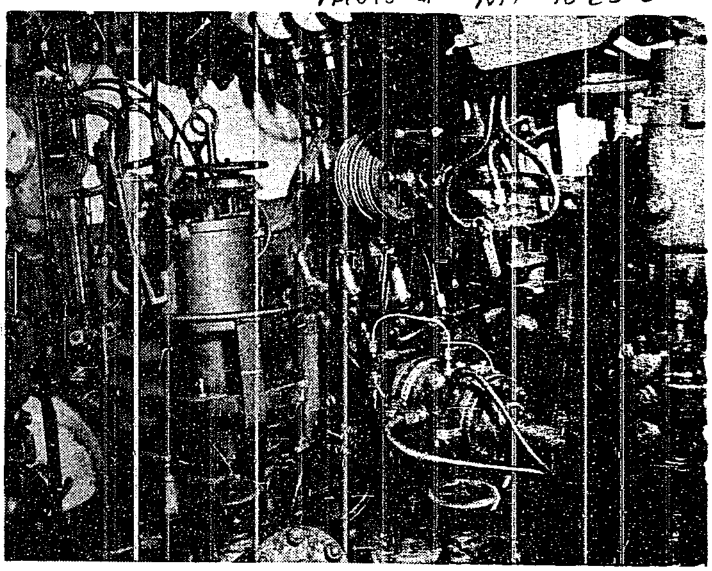


Figure 127
CONTROL ROOM, FORWARD STARBOARD

2. The control room is located directly below the single access hatch. In this area are located a gyro in the forward port corner, the periscope on the centerline forward with cable hoist drum to starboard, automatic and manual control for the stern planes in the forward starboard corner, steering controls along the port side, motor for periscope hoist and reciprocating drain pump to starboard amidships, a radio receiver in the after starboard corner, and an air conditioning coil in the after port corner. A six-valve air manifold is secured to a "periscope well" cylinder of about two foot length which protects the periscope eye-piece and operating gear in the lowered position. Piping for air, hydraulic oil, fuel and drainage systems fill the lower section. There is a ballast tank in the lower portion of the control room inside the pressure hull.

PHOTO # NH 78657

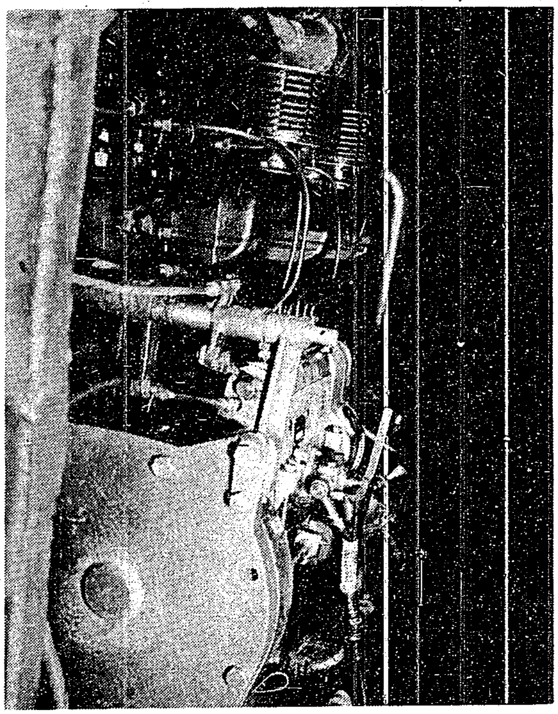


Figure 128

ENGINE, LOOKING AFT

3. The engine compartment is separated from the control room by a watertight bulkhead and door. It contains the six-cylinder diesel with the generator at the after end. A fuel tank is located on the port side extending two-thirds the length of the compartment. A hull ventilation blower is secured in the forward starboard overhead. Immediately aft is the hydraulic oil replenishing tank and hydraulic pump. Main power switches and busses are in the after starboard corner. An air conditioning compressor of about 1/4 ton capacity is located in the after port corner.

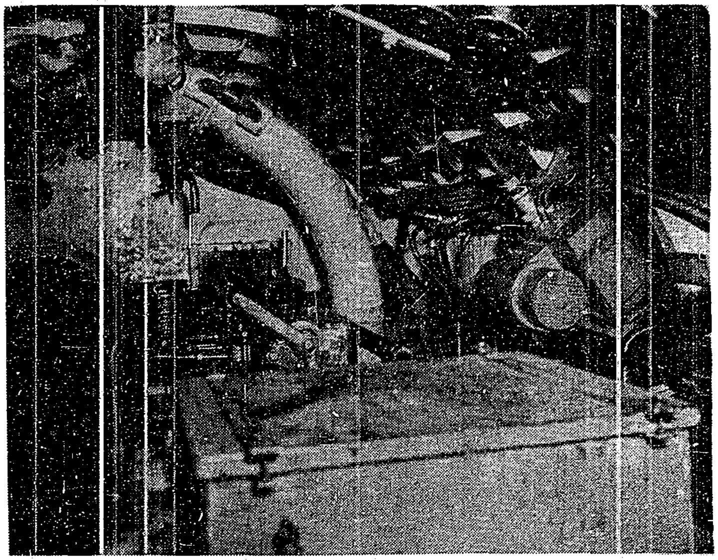


Figure 129
ENGINEROOM, LOOKING FORWARD

PHOTO # NH 78658

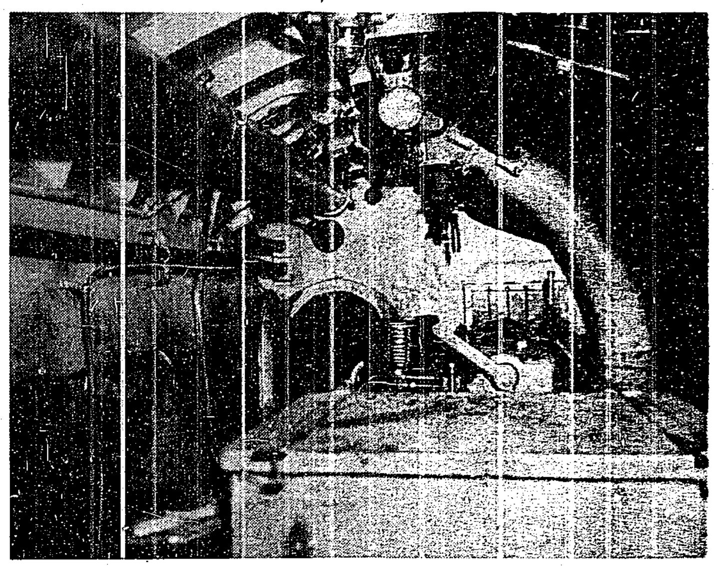


Figure 130
ENGINEROOM, LOOKING FORWARD

4. Abaft the engine room is the after battery compartment separated by a watertight half-bulkhead. Fuel tanks are outboard of the batteries inside the pressure hull.

PHOTO # NH 97659

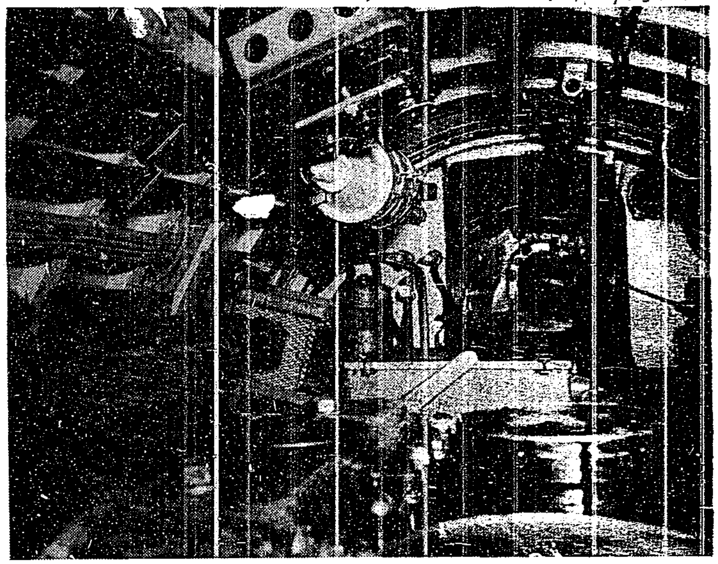


Figure 131
ENGINEROOM, LOOKING AFT

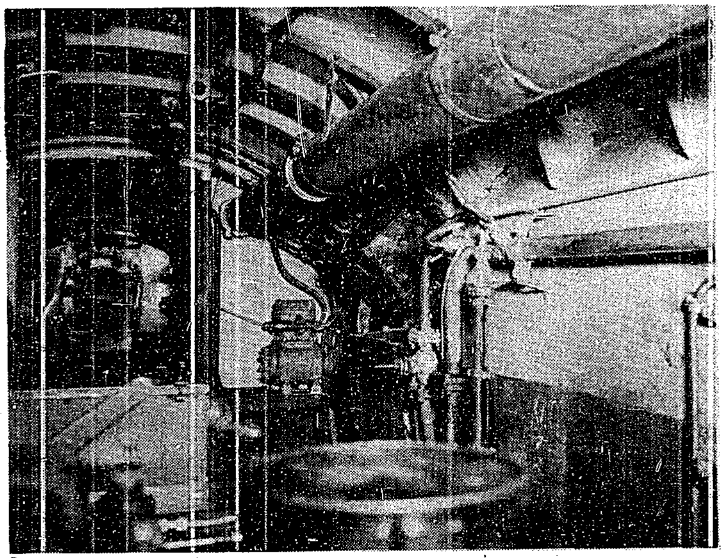


Figure 132
ENGINEROOM, LOOKING AFT

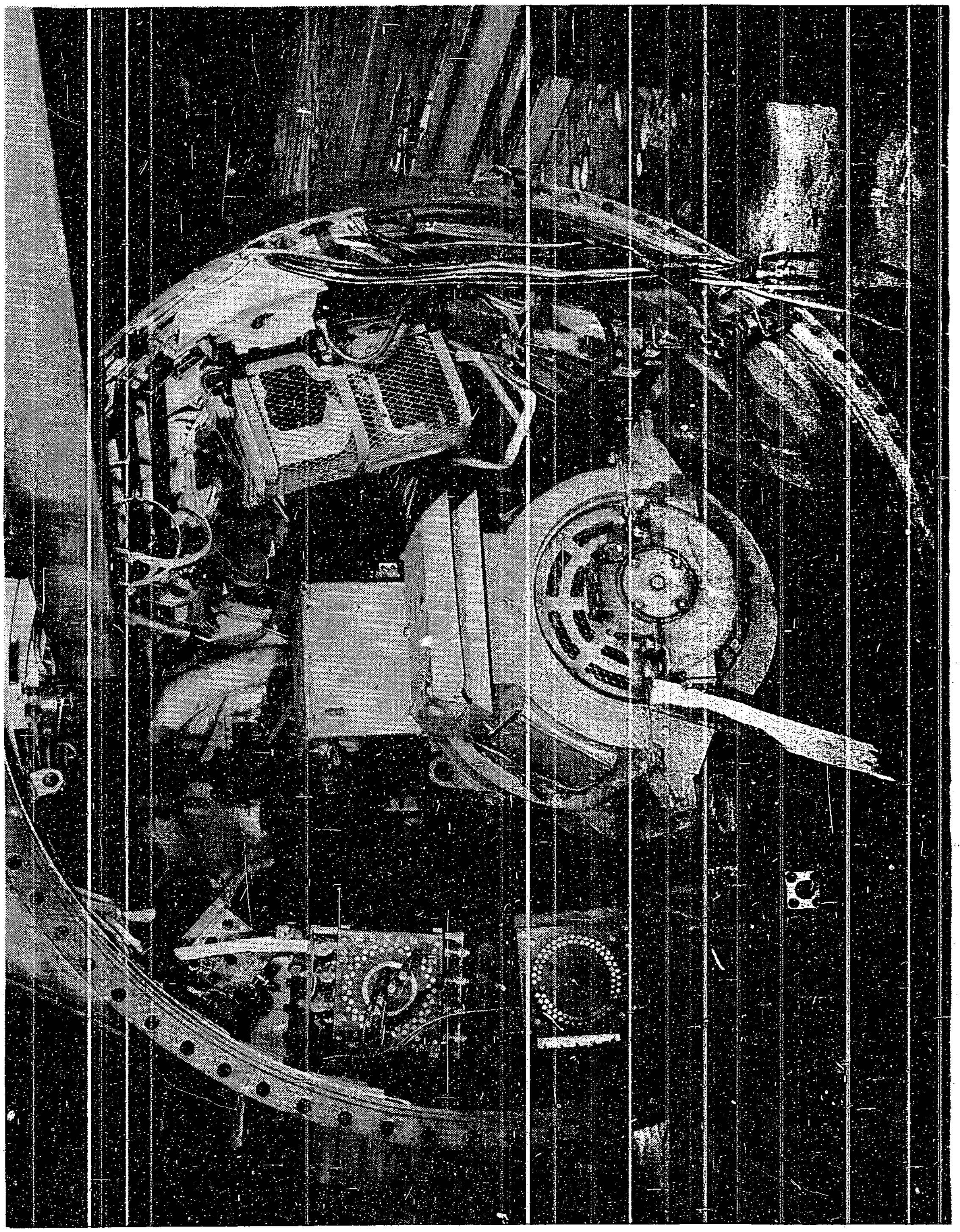


Figure 133
MOTOR ROOM, LOOKING AFT

5. The motor room is separated by a watertight bulkhead and door. The main motor drives the propeller shaft through an articulated double reduction gear.

General Remarks

1. The periscope is hoisted by an electirc-driven double reduction worm and gear drive to the cable drum. There is a clutch arrangement which allows the second worm and gear with cable drum to be disengaged and the first worm and gear engaged to a shaft which has an eccentric on the lower end for actuating a small reciprocating drain pump.

2. The hydraulic oil pressure is supplied by an electric-driven single-gear pump. There is no accumulator. Discharge piping from the pump goes through the pressure hull just forward of the bolted joint in the after part of the engine room, extends completely around the hull for cooling purposes, and re-enters the hull in the same vicinity. A single supply line leads to the control room with individual return lines from various equipment to the replenishing tank in the engine room.

3. Steering is accomplished from the control room through a push-rod and bell-crank arrangement. The upper and lower rudders are not mounted on a single stock but are secured to an athwartship vertical yoke. Power is supplied either by hand or by a hydraulic piston with a manually operated slide control valve.

4. Mechanically the operation of the stern planes is comparable to that of the steering system. The operation of the control valve for the hydraulic piston is a combination of automatic and manual control. The automatic feature affects both trim and depth. A piston is exposed to sea pressure on the lower end and to a handset spring pressure on top. The piston is connected to one side of a lever and a heavy pendulum is supported on the opposite side of the fulcrum. Movement of the hydraulic piston slide control valve is through a slotted arm and sliding block, which is spring loaded, connected to the pendulum. The purpose of the spring-loaded slotted arm is to reduce oscillation. With the above system, if the depth of the submarine is geater than that set by spring tension on the piston, sea pressure moves the piston up which operates the hydraulic control valves and moves the stern planes to "rise". On the other hand, if the boat takes an up or a down angle, the pendulum, in remaining in the vertical, operates the control valve in a direction to move the stern planes in the proper direction to bring the boat to an even keel. Obviously, it is necessary that conditions of neutral buoyancy and good trim be obtained at a desired depth before the above system can possibly operate satisfactorily, since it controls only stern planes. Through a hand-operated lever which increases or decreases the tension of an additional heavy spring attached to the lever on the depth-piston side of the fulcrum, manual control over-rides the effect of the automatic feature.

5. There is no air compressor. The air flasks forward are charged through a charging connection in the conning tower to the air manifold in the control room.

6. The vertical antenna can be raised about 4 1/2 feet from the control room manually by means of worm shaft and traveling nut secured to the mast.

7. The hull ventilation valve abaft the vertical antenna is operated manually. The main engine exhaust valve immediately aft in the conning tower fairwater is also manually operated.

8. A radio antenna about 10 feet long is stowed to starboard and abaft the conning tower. It is raised through ninety degrees by means of worm and quadrant gear.

9. A ballast keel extends below the contour of the pressure hull. It is filled with lead. With the center at about the forward end of the conning tower, the length is 29 feet. Cross section is 13 in. by 6 in.

10. The submarine appears to be fairly well designed. Construction is fair. Freedom of movement within the submarine and accessability are very restricted.

11. No submarines of this type were found to be in operating condition.

Type II - Midget Submarine, carrying External Torpedoes.

This type of midget submarine, by development and construction, falls into three classes:

Class 1. (Designation number less than 1000).

Purpose:

Offensive submarine, short range.

General Characteristics:

Length overall	55 ft
Beam	4 ft 3 in
Pressure hull, diameter	4 ft 3 in
Hull thickness	3/8 in
Displacement (approx)	20 tons
Periscope	one
Complement	two

Propulsion:

Diesel	one six-cylinder
Main motor	one
Propeller	one 3-bladed, 31 in diameter
Battery group	one of approximately 50 small cells

Armament:

Torpedoes .... two external 21 in, 25 ft, 2 3/4 in long
Bow warhead (which can be omitted) fitted inside conical structural bow section.

Construction

This type submarine is of welded construction and is made up of three sections which are bolted together. The parallel middle cylinder is 32 feet, 10 inches long and of 4 feet, 3 inches external diameter. The bow section tapers to the form of a truncated cone and is 6 feet, 6 inches in length. The after body is conical and of 14 feet, 10 inches length. Frame spacing is 21 inches and pressure hull thickness 3/8 inches.

Arrangement and General Remarks

1. A warhead is inserted in the bow section. This can be omitted but upon what occasions is not known.

PHOTO # NH 78660

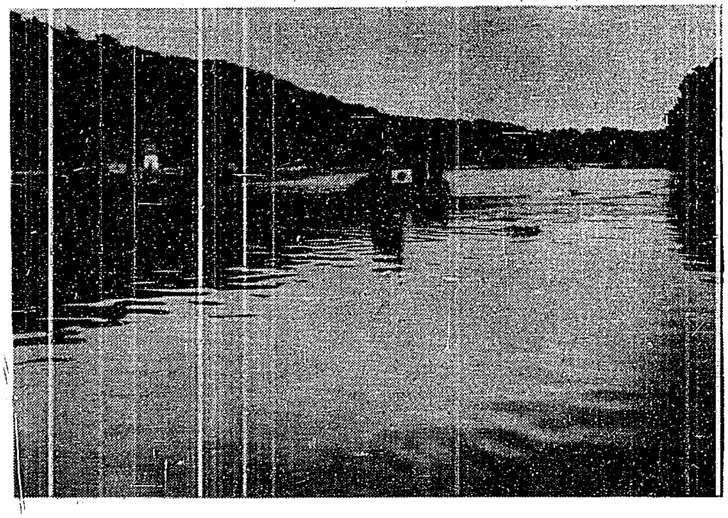


Figure 134
MIDGET SUBMARINE, PARTIALLY SUBMERGED, STARBOARD SIDE

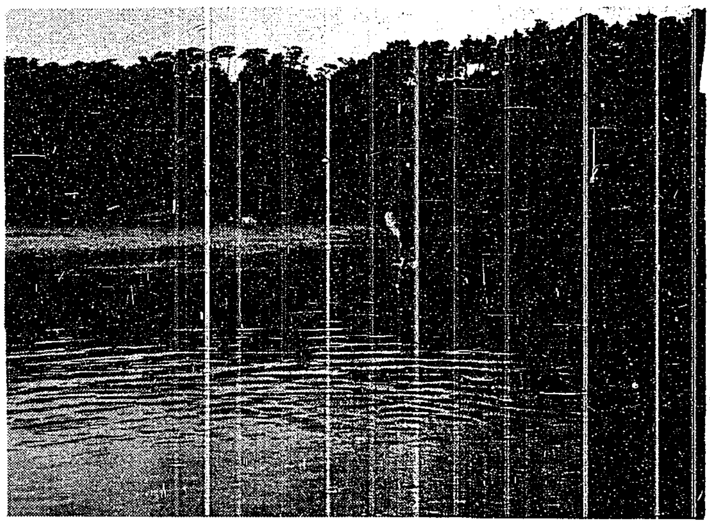


Figure 135
MIDGET SUBMARINE, STERN VIEW

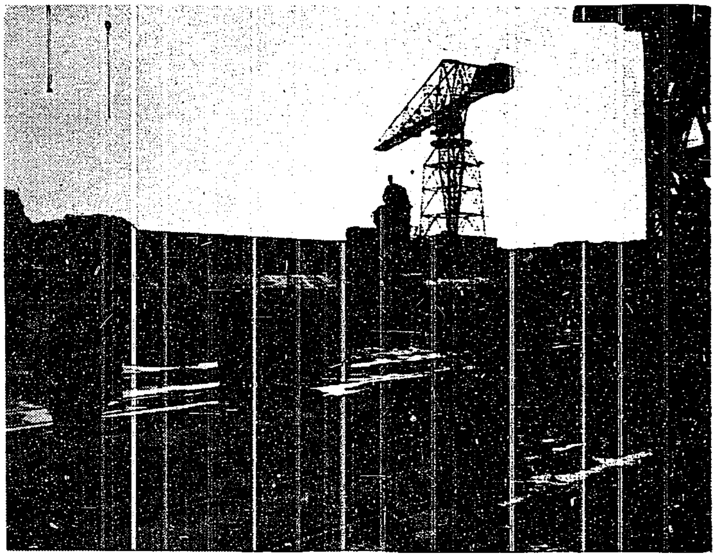


Figure 136
MIDGET SUBMARINE

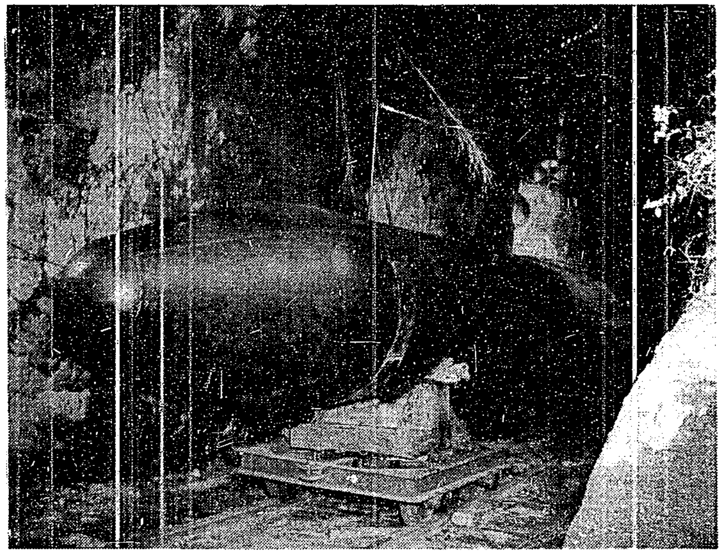


Figure 137
MIDGET SUBMARINE IN CAVE

Figure 138
BOW SECTIONS OF MIDGET SUBMARINE

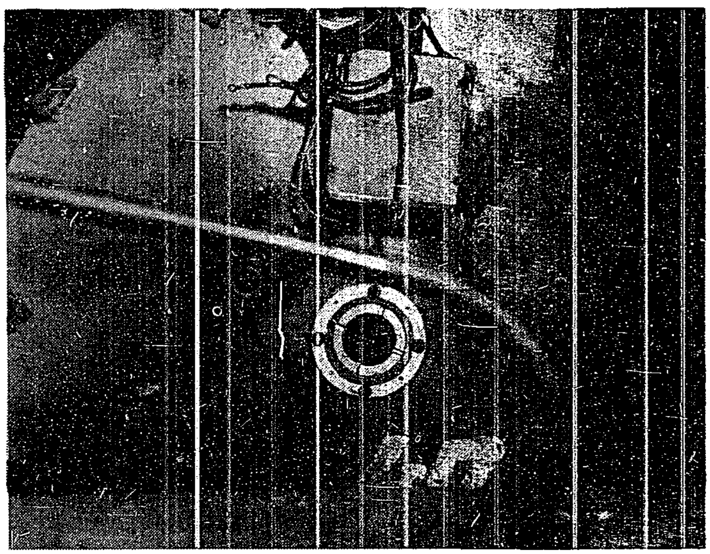


Figure 139
BOW SECTIONS OF MIDGET SUBMARINE

2. A portable fuel tank of pressure hull diameter is installed in the after portion of the bow section followed by a semi-circular tank of 1 foot depth.

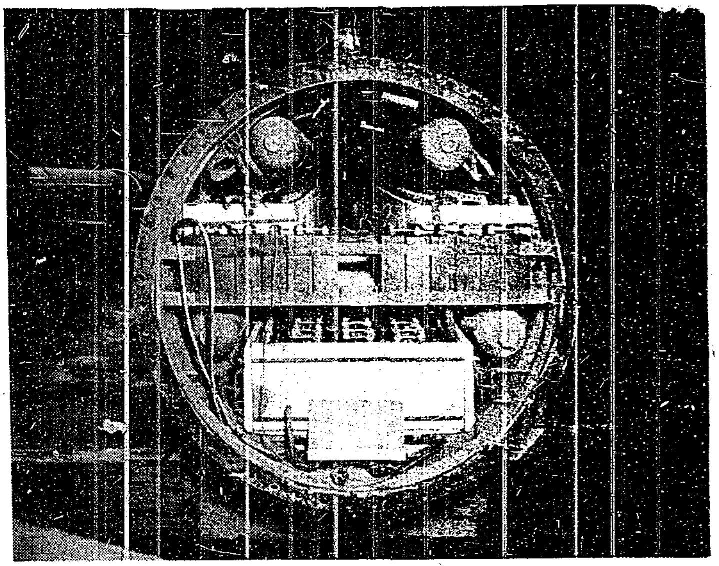


Figure 140
BATTERY COMPARTMENT

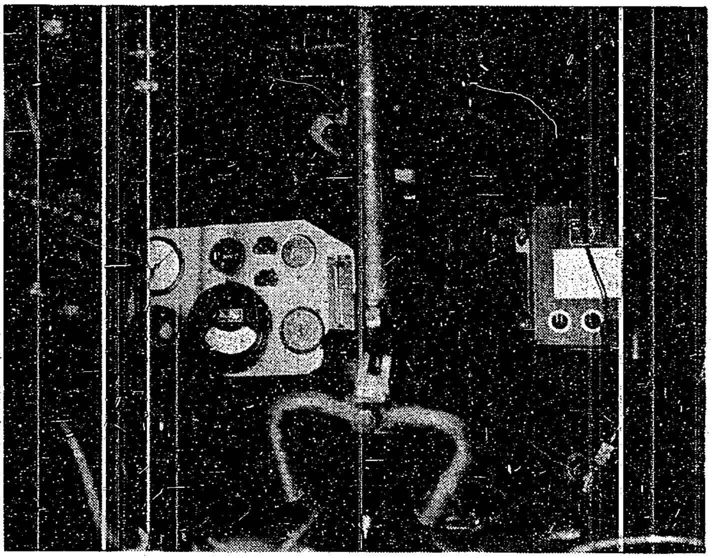


Figure 141
LOOKING FORWARD FROM OPERATOR'S POSITION

3. The control section contains manual operating gear for upper and lower rudders, stern planes and forward planes which are abreast of the conning tower blister. All planes are mounted in stabilizing fins. Operating valves for air, fuel, and water systems are primarily located in this area. Aft of the operators seat is hand-operated periscope cable hoist with a down haul on the starboard side. A blister on the top of the pressure hull immediately aft of the access hatch contains the periscope, hull ventilation and supply valve, and engine exhaust valve. Both valves are opened and closed by a single operating lever connected to spring-loaded push-pull rods.

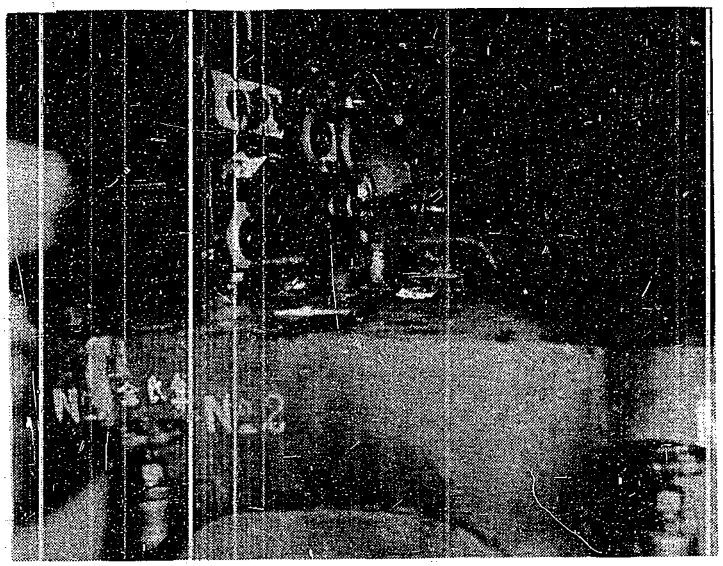


Figure 142

LOOKING AFT FROM PERISCOPE POSITION

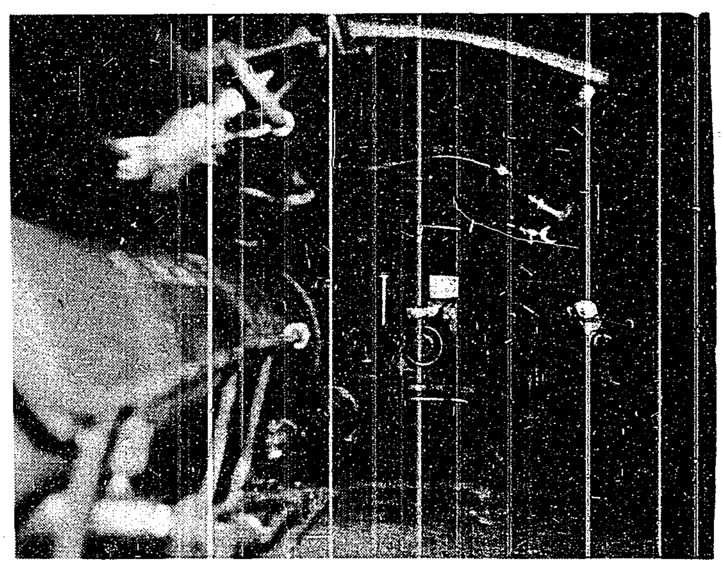


Figure 143

LOOKING AFT FROM FUEL TANK

4. The main fuel tank is abaft the periscope and is of rectangular shape filling the lower half of the hull cross section; it is portable. The engine is installed on the centerline. Circulating water is supplied through the pressure hull just forward and to port of the engine. Inlet and outlet valves are operated by a single lever from the control section. A small fuel tank is abaft the engine with a small lubricating oil tank mounted on the forward side.

5. The engine is connected to the motor through a reduction gear and shafting which runs through a duct in the after fuel tank. The motor connects to the propeller shaft through a second reduction gear. There is a trim tank aft of the motor reduction gear.

6. Ventilation and engine air supply enters the submarine through the upper and forward valve. The engine air suction is through a sheetmetal duct from the forward end of the battery compartment to the engine air manifold. Suction can also be taken from the boat. The engine exhaust discharges through the hull above the after end of the engine and is led through an external pipe to the after valve in the superstructure.

7. There are three sight ports in the access trunk; dead ahead, to port and to starboard.

8. Two external torpedoes are secured at about 35° port and starboard of the keel by means of bevelled wedges on the torpedo fitting into tapered slots built out on the hull. The torpedoes are loaded with the warhead aft and fired astern. There is a single stop and firing bolt on each side which is operated from the control section inside the submarine.

Class 2. (Designation numbers from 1000 and from 2000).

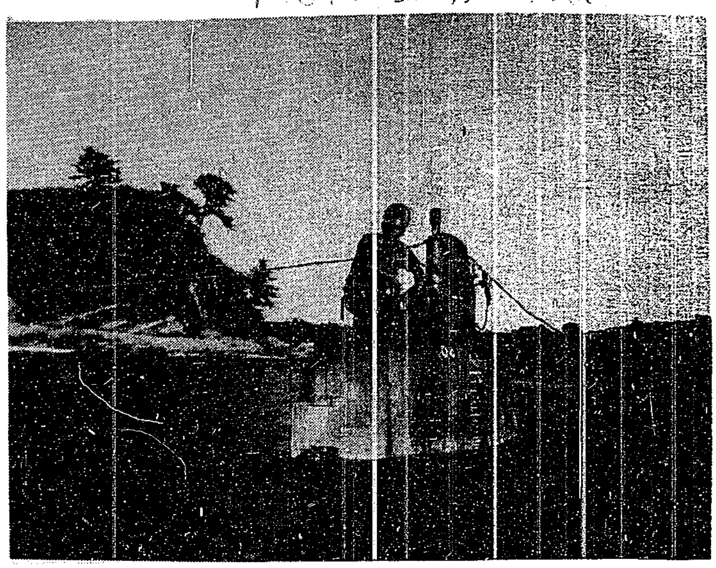


Figure 144

MIDGET SUBMARINE, PARTIALLY SUBMERGED, PORTSIDE

PHOTO NUMBER: NH 75662

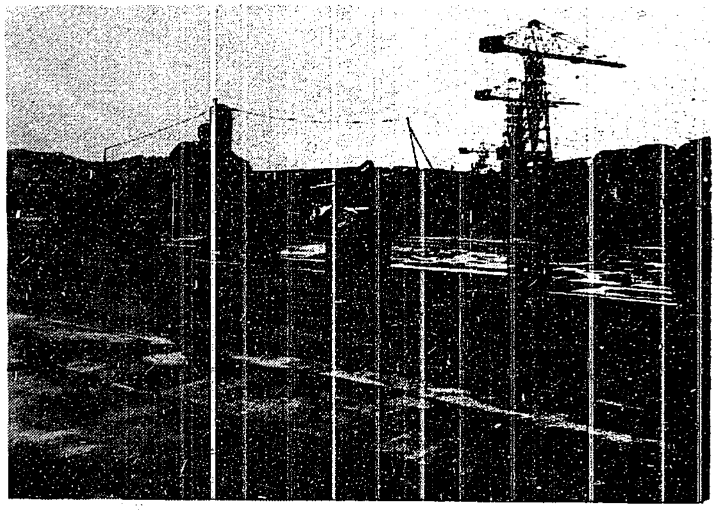


Figure 145
MIDGET SUBMARINE, STARBOARD VIEW

Figure 146
CENTER SECTION BEFORE ASSEMBLY

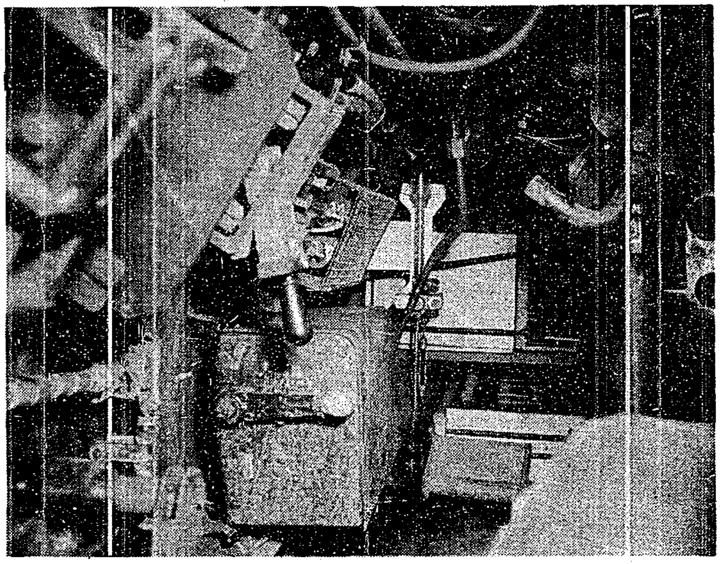


Figure 147
LOOKING FORWARD FROM OPERATOR'S POSITION

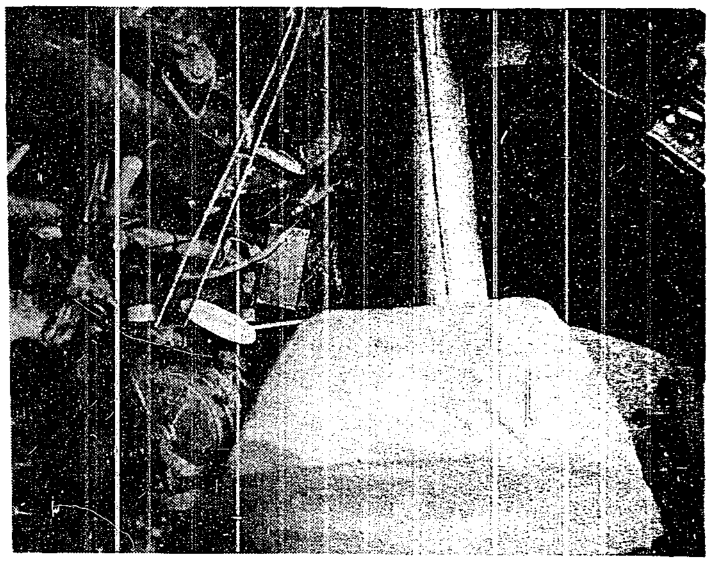


Figure 148
LOOKING AFT FROM OPERATOR'S POSITION

This model of midget submarine differs from that described as Class 1 in minor details only. Pressure hull construction, dimensions, power plant, and arrangement are practically identical.

Differences from Class 1:

1. The main fuel tank amidships is elliptical instead of rectangular in cross-sections.

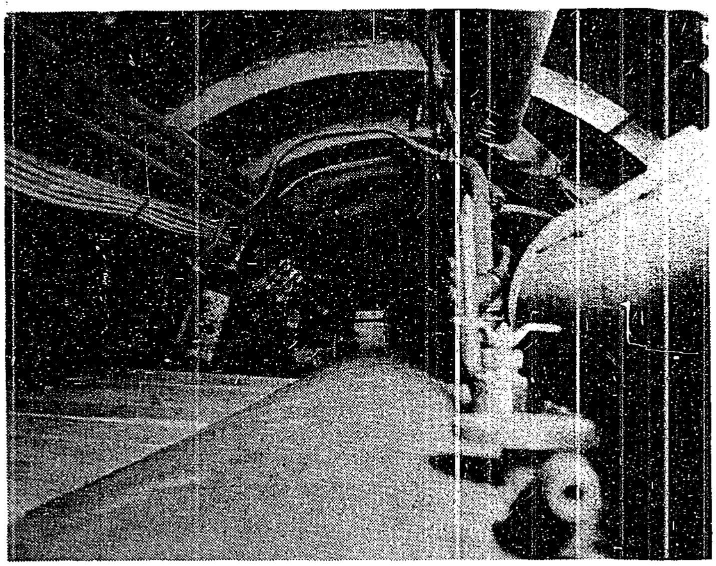


Figure 149

LOOKING FORWARD FROM AFTER END OF FUEL TANK

2. Beginning with midget submarines early in the "1000" group, the small gyro compass forward of the operator's position has been omitted. Instead of the gyro, an external magnetic compass is mounted in the forward part of the conning tower blister fairwater. A light is installed inside the pressure hull in a tube directly below the compass. The compass card is reflected by mirrors through an adjacent tube to a frosted glass screen directly in front of the operator.

The adjustment of magnets for compass compensation must be accomplished externally with the external bolted dome removed.

3. There is but one eyeport to starboard in the access trunk. The port one was omitted and one dead ahead blanked off by the gyro.

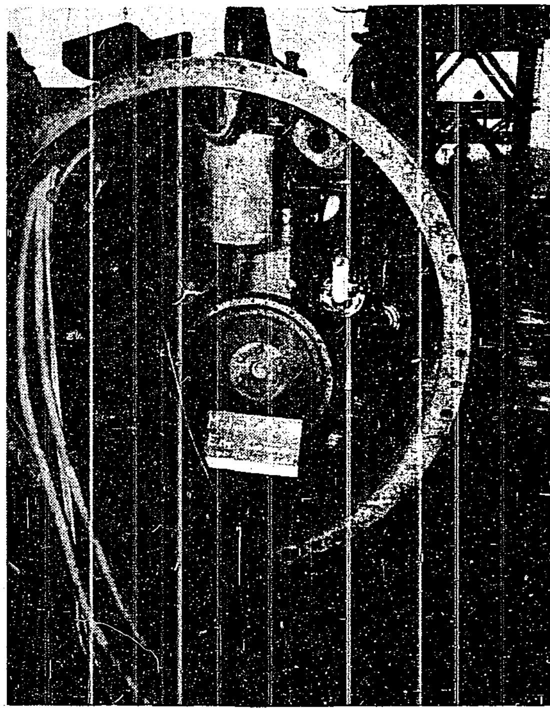


Figure 150
ENGINE COMPARTMENT

Photo # AH 78663

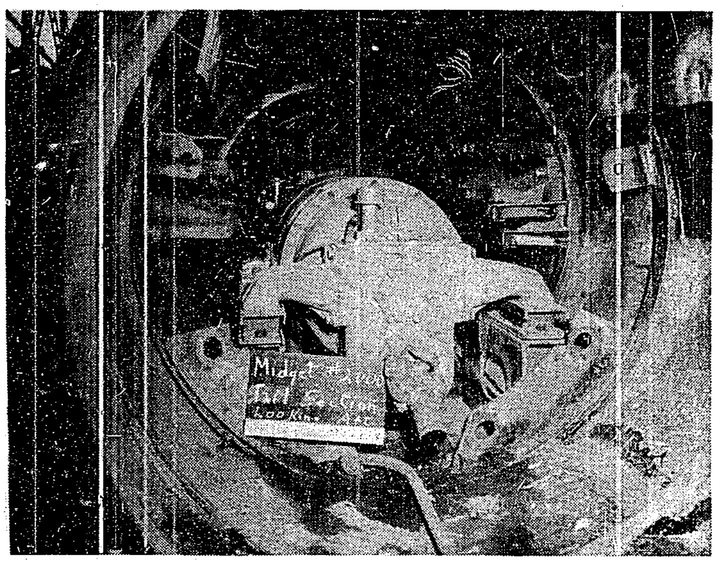


Figure 151
TAIL SECTION, LOOKING AFT

DECLASSIFIED RESTRICTED

<u>Class 3</u>. (Designation numbers starting with 4000)

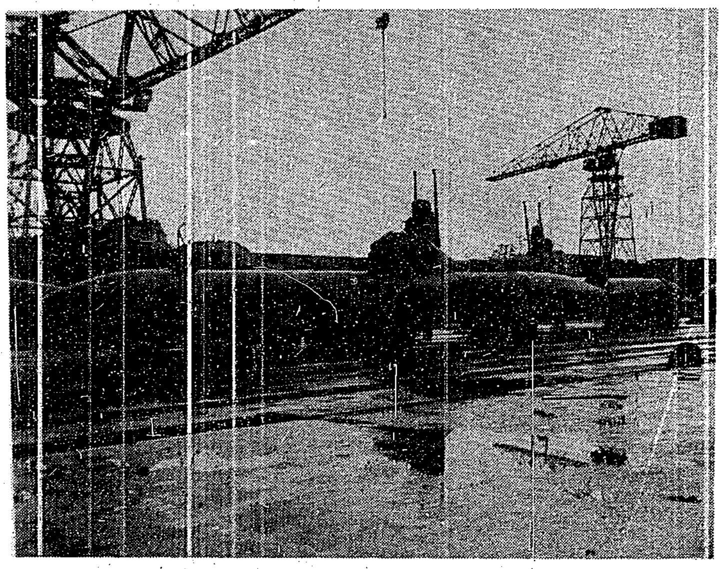


Figure 152
MIDGET SUBMARINE ON BLOCKS, PORTSIDE

PHOTO # NH 78[illegible]

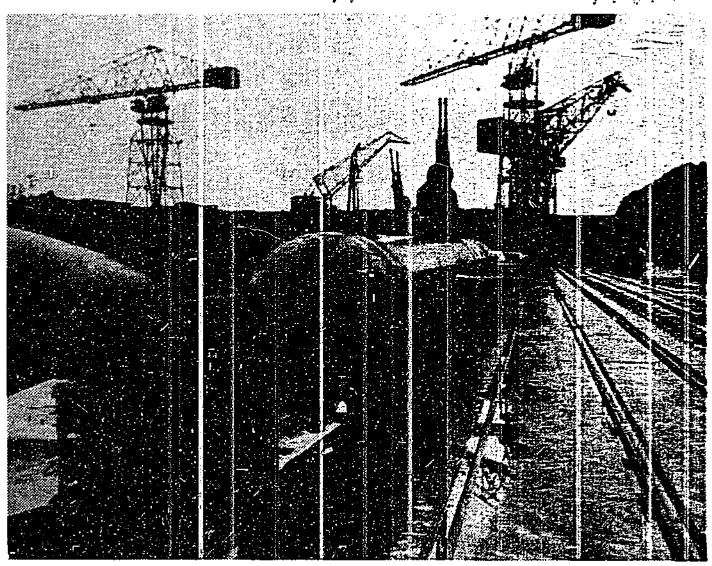


Figure 153
MIDGET SUBMARINE ON BLOCKS, BOW VIEW

This class of midget submarine is in general similar to classes 1 and 2.

Differences from Classes 1 and 2:

1. There are no known instances of warheads installed in the bow section.

2. The parallel middle body is three frame spaces longer, 63 inches, making the overall length slightly less than 60 feet. Bow and tail structural sections are interchangeable with the other classes.

3. Forward horizontal fins and planes have been moved about five feet forward of the conning tower blister, which is in the same position with the other classes.

4. The externally fitted magnetic compass has been omitted.

5. The amidship fuel tank has been relocated forward of the operators position, which is made possible by the extended parallel middle body.

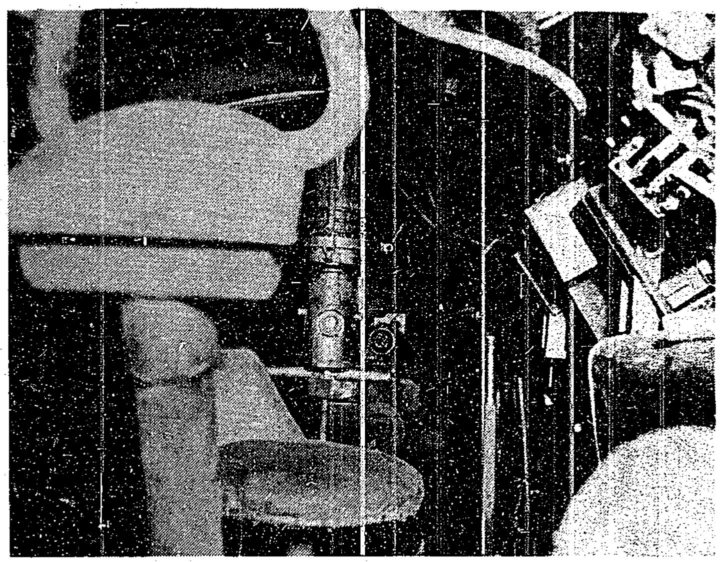


Figure 154

LOOKING AFT FROM OPERATOR'S POSITION

6. A second periscope is installed aft of the original periscope and the hull supply and engine exhaust valves. The second periscope has no hoist but is lifted by hand and the yoke is supported by short cables to the overhead.

7. Complement is probably increased to three. It is possible that this class of midget submarine is used for training purposes.

The one-man midget submarine in general is not impressive in design or layout of piping and miscellaneous equipment. No submarines of this type were found in operating condition.

PHOTO #: NH 78665

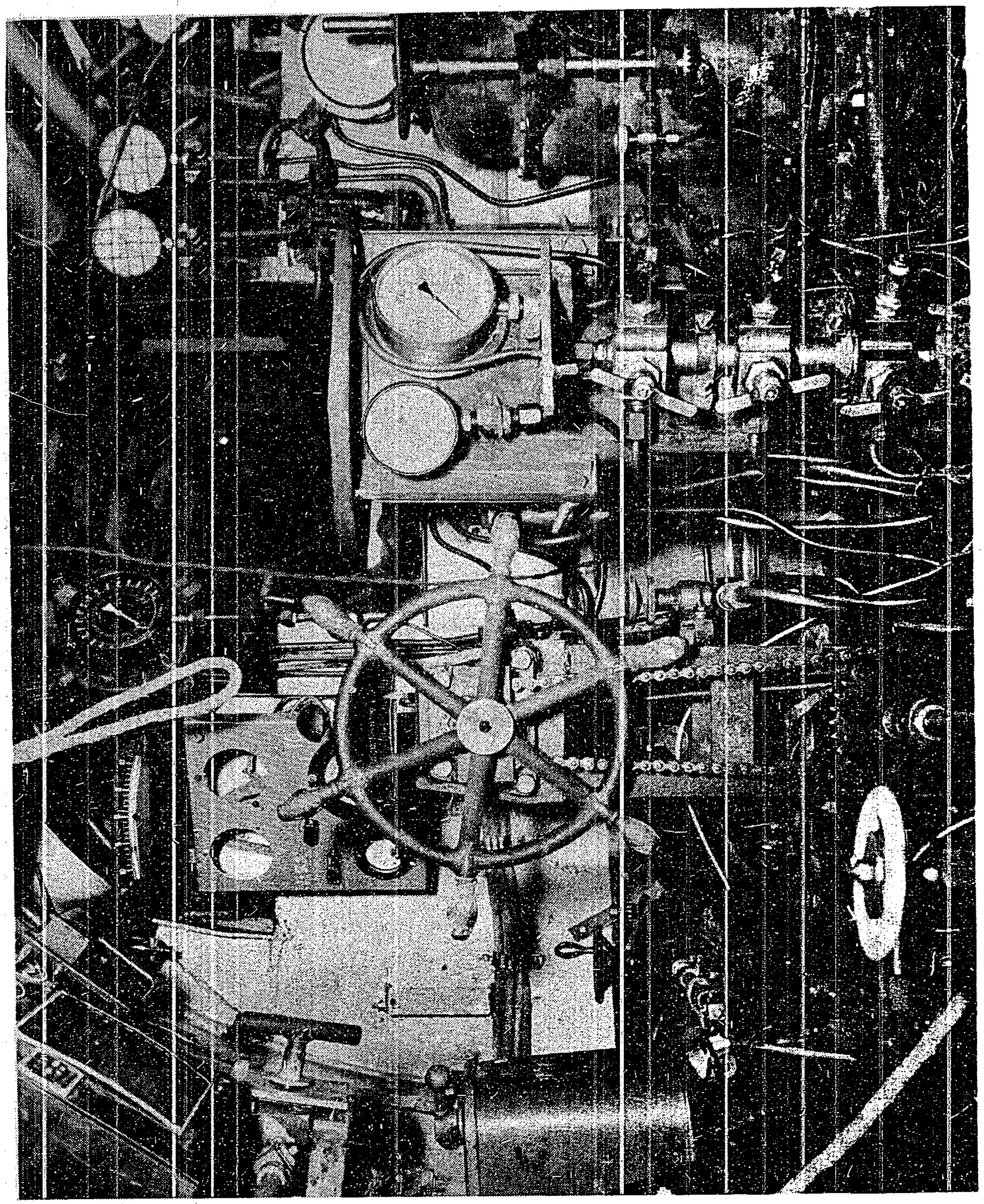


Figure 155
KORYU TYPE "D", CONTROL ROOM LOOKING FORWARD

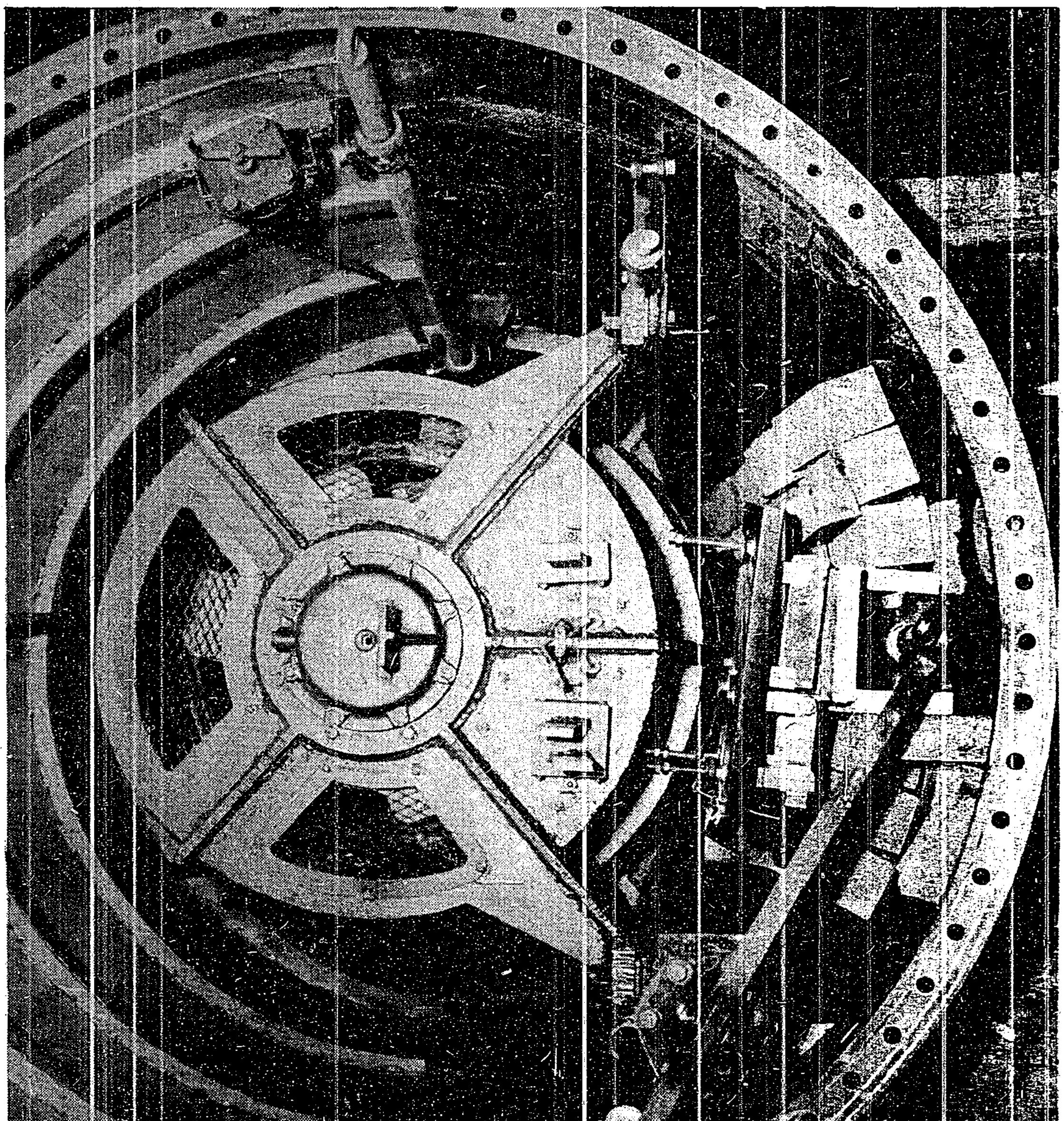


Figure 156.
KORYU TYPE "D", MAIN MOTOR COMPARTMENT LOOKING AFT

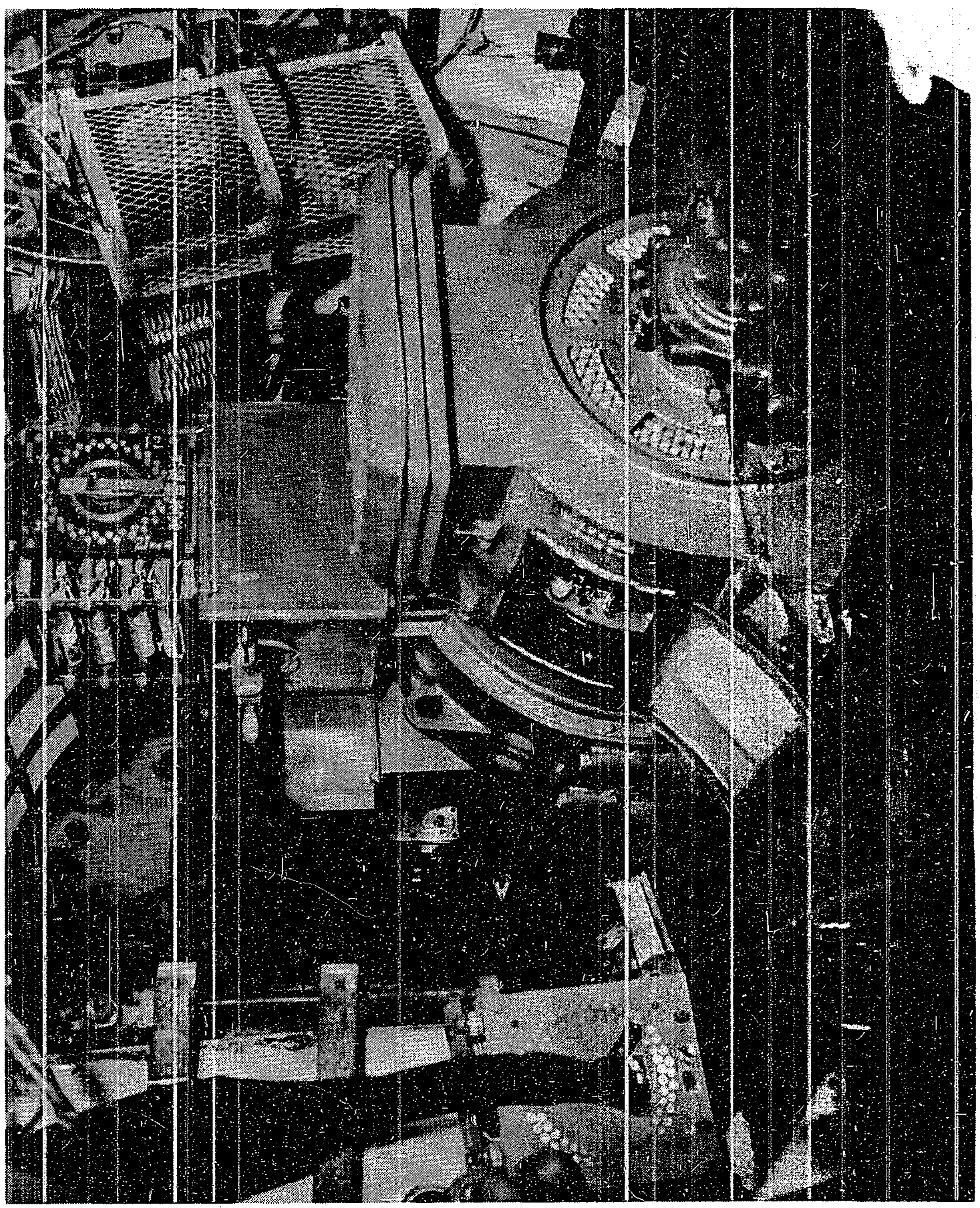


Figure 157
KORYU TYPE "D", ENGINEROOM LOOKING FORWARD

PHOTO # NH 78666

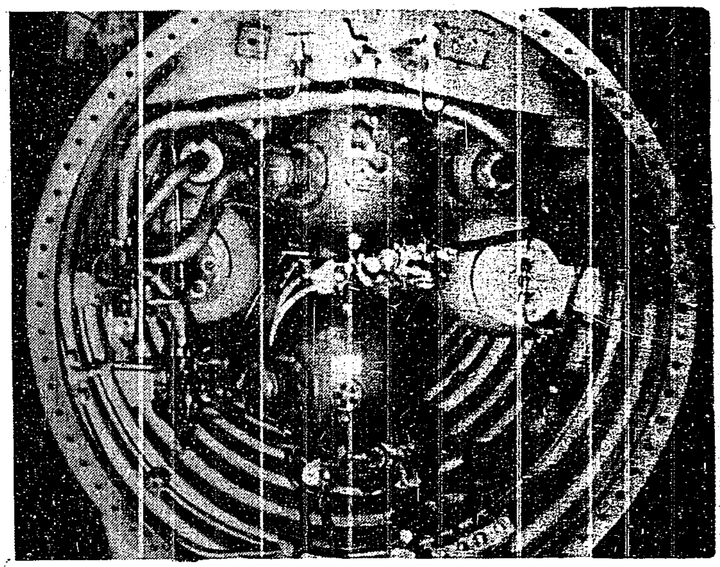


Figure 158
FORWARD TORPEDO ROOM LOOKING FORWARD

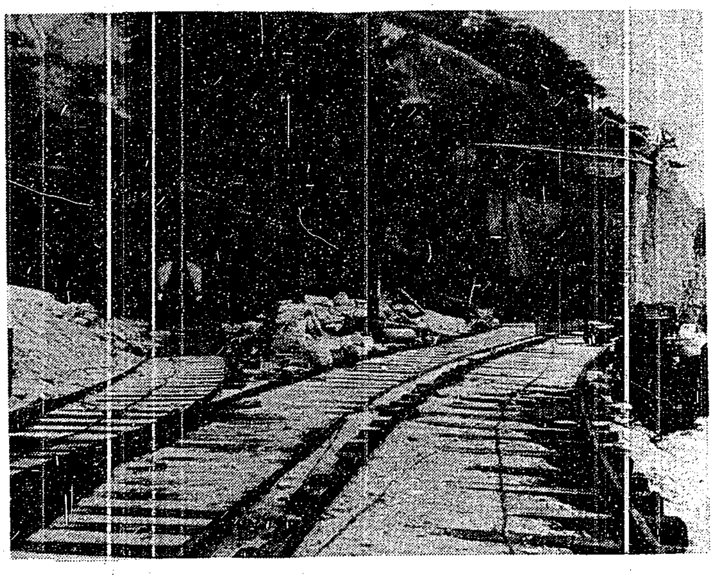


Figure 159
SUBMARINE ASSEMBLY TUNNELS, KURE

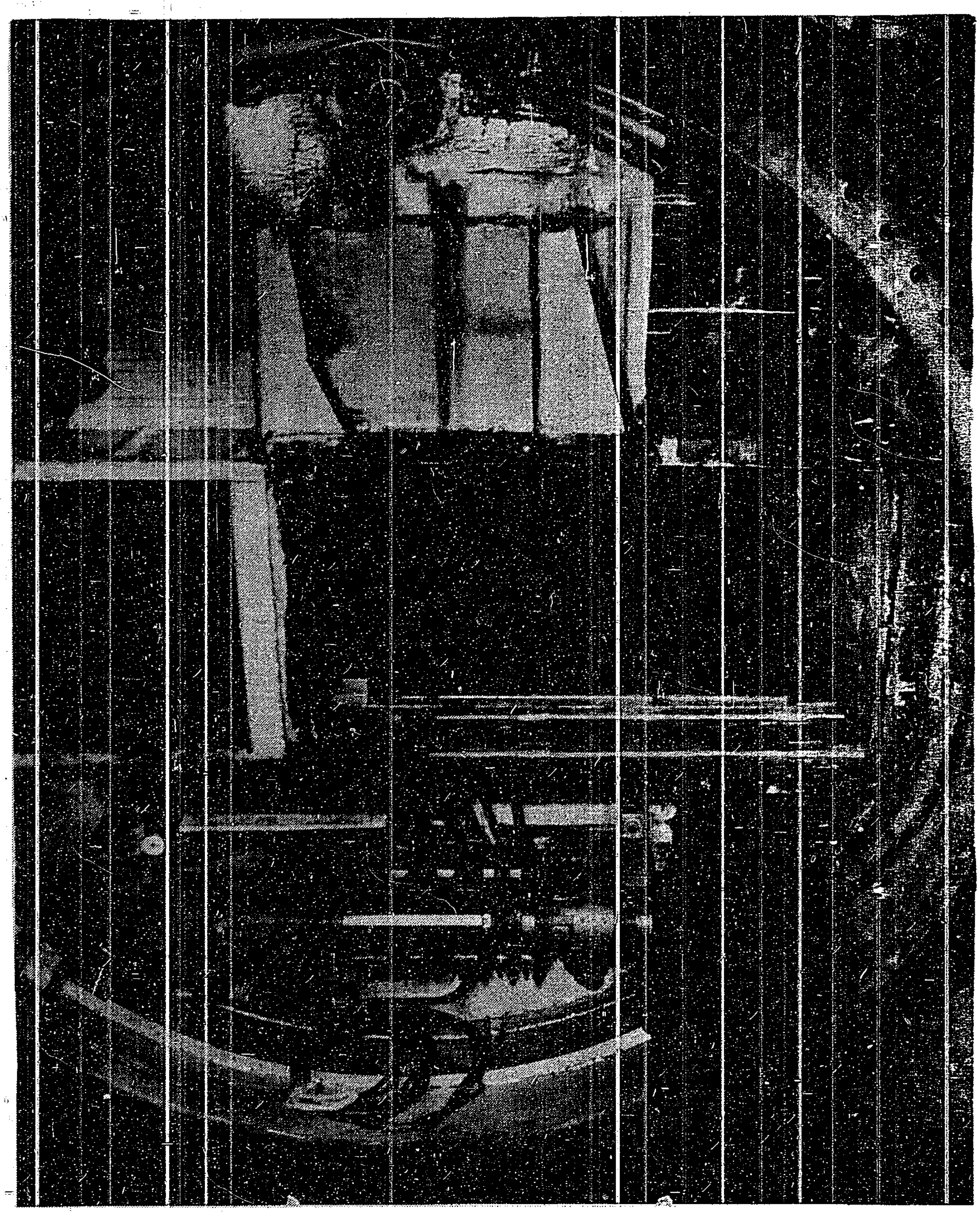


Figure 160
KORYU TYPE "D", AFTER BATTERY COMPARTMENT LOOKING FORWARD

B. Japanese Submarine RO-58

Purpose:

Offensive submarine.

The RO-58 was completed in 1923. It is obviously used for training purposes or coastal patrol at present.

General Characteristics: (from ONI 41-42)

Length	250 ft
Beam	23 ft, 6 in
Draft	13 ft
Displacement, surface	889 tons
Armament - torpedo tubes	four 21 in, bow
torpedoes	eight
gun	one Q.F. 3 in 15, mounted forward on bridge deck level
Complement	65
Propulsion - diesels	two Vickers, 12-cylinder
motors	four
Fuel	65 tons
Horsepower - surface	2400
submerged	1200
Speed - surface	17 knots
submerged	10 knots

The pressure hull is of riveted construction and appears to be in good condition. The submarine is not in operating condition and would require an extensive refit.

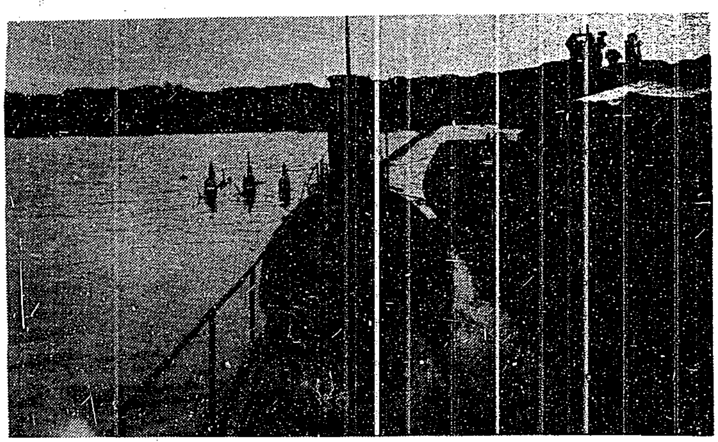


Figure 161

STERN VIEW, MAIN DECK, RO-58

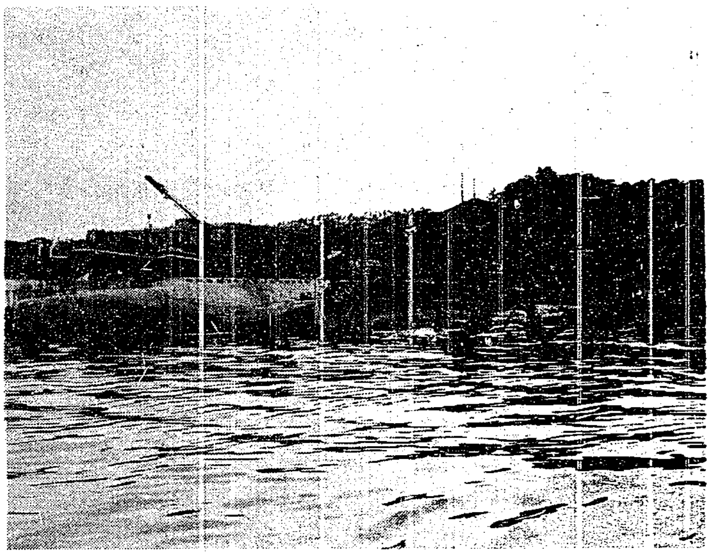


Figure 162
GENERAL VIEW, RO-58

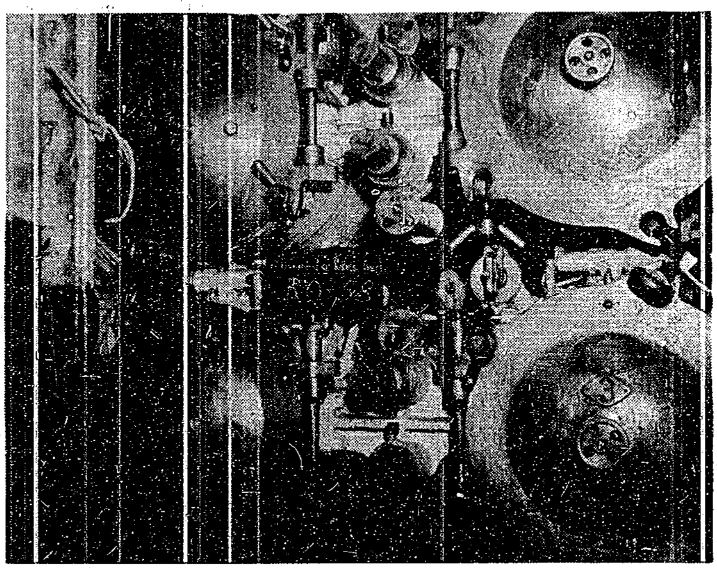


Figure 163
TORPEDO TUBE NEST, RO-58

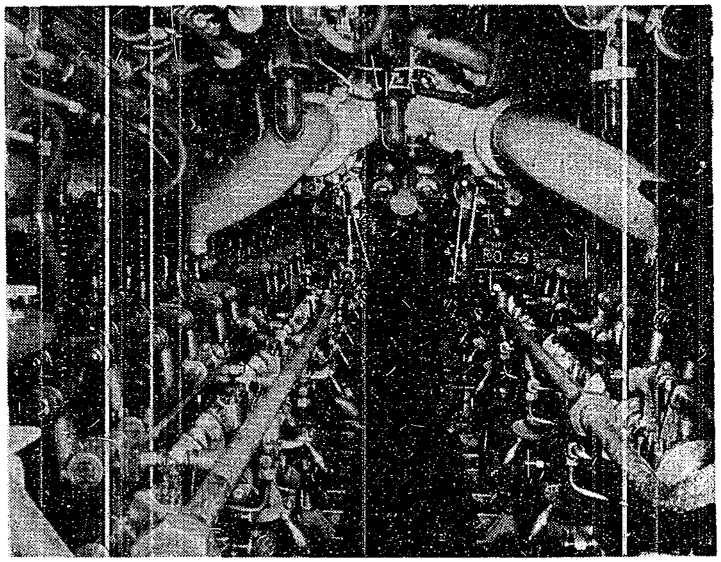


Figure 164
MAIN ENGINES, RO-58

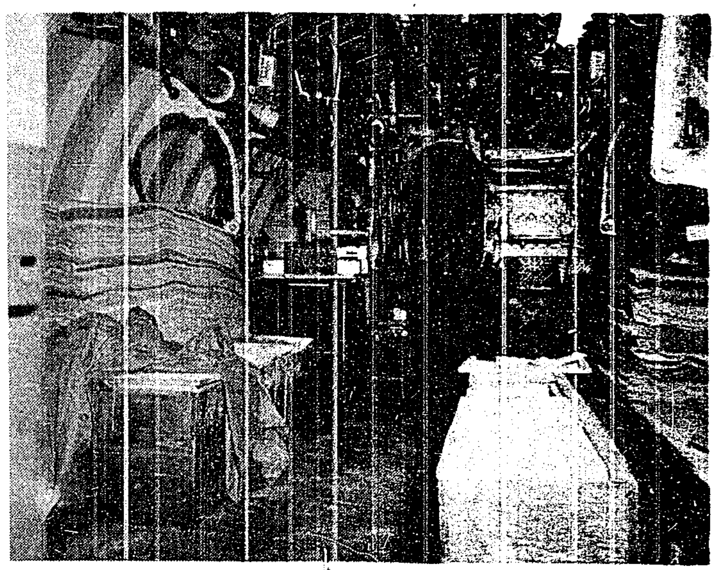


Figure 165
TORPEDO ROOM LOOKING AFT, RO-58

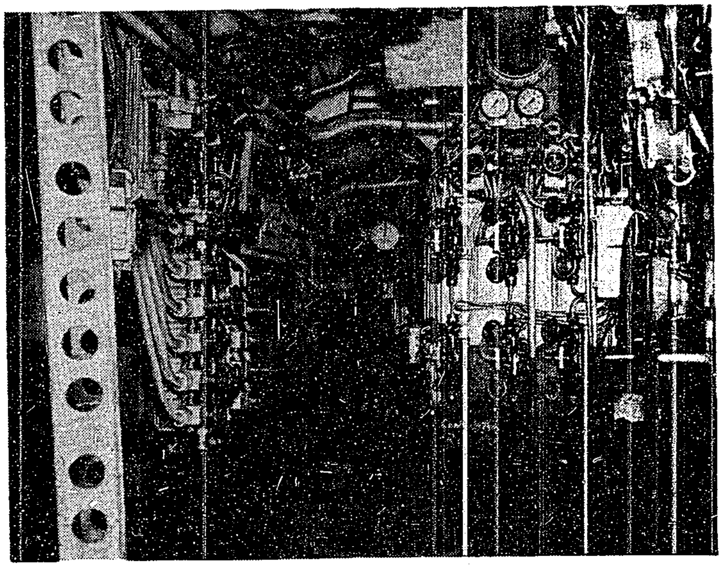


Figure 166
CONTROL ROOM LOOKING AFT, RO-58

C. Japanese Submarines HA-101, HA-102, HA-104

Purpose:

Cargo carrying, slow-speed submarine.

General Characteristics:

Length	145 ft, 11 in
Beam, maximum	20 ft, 6 1/2 in
Pressure hull	12 ft, 9 in I.D.
Test depth	328 ft
Draft (est)	10 ft
Bridge deck (above WL)	5 ft, 7 in
Height of shears (above WL)	9 ft, 8 in
Displacement (est)	400 tons
Complement (est)	30 to 40
Propulsion - diesel	one six-cylinder
motor	one
propeller shaft	one
Armament - guns	one 25mm forward, one 25mm aft
torpedo tubes	none

Hull Characteristics

The pressure hull is 5/8 inches thick and is all-welded construction. The ship is divided into three watertight compartments. There is nothing of unusual interest in the construction of the pressure hull. These submarines are definitely a mass-production model.

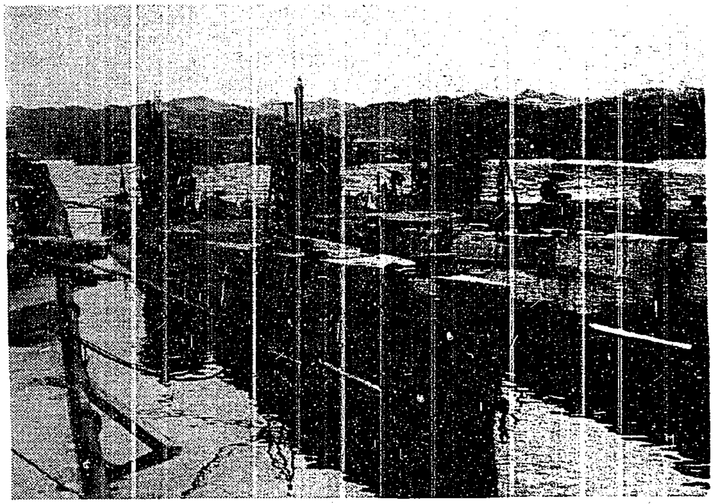


Figure 167
GENERAL VIEW, HA-101, 104, 102

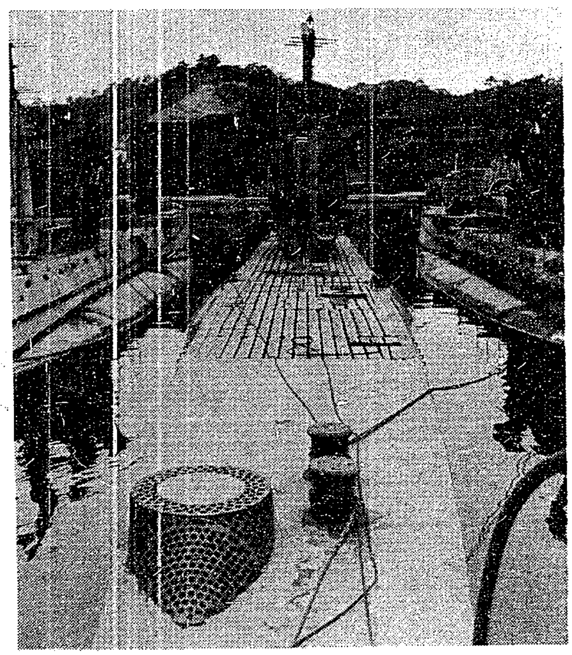


Figure 168
STERN VIEW, MAIN DECK, HA-101

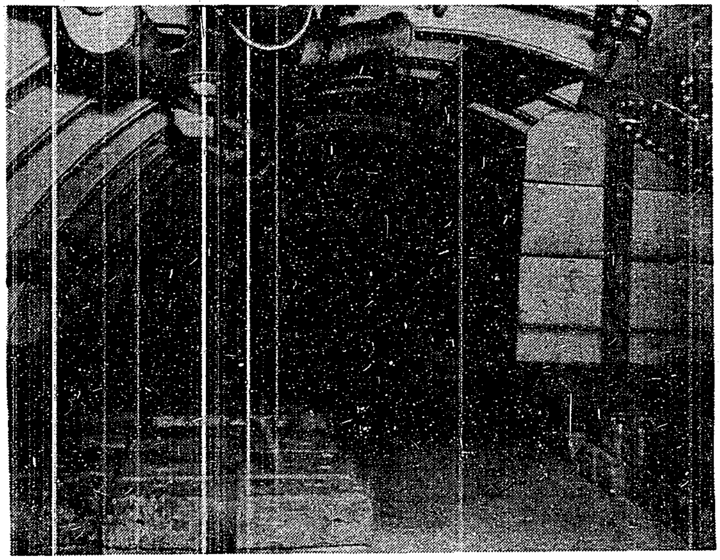


Figure 169
VIEW OF CARGO COMPARTMENT, HA-104

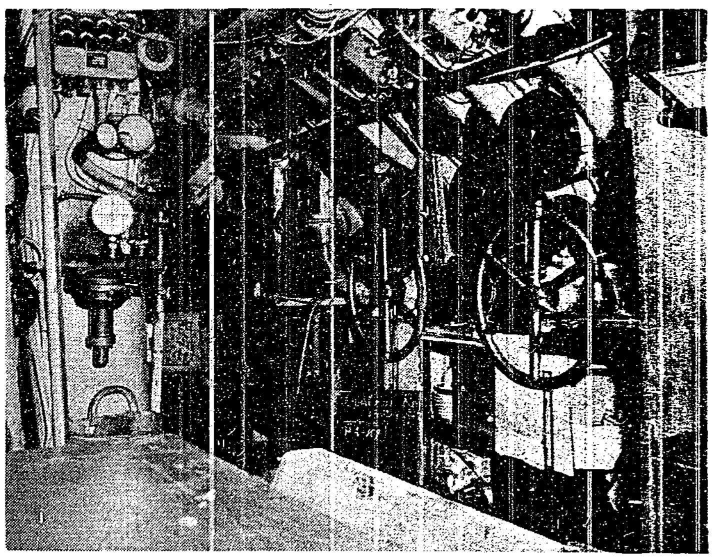


Figure 170
CONTROL ROOM LOOKING AFT, HA-104

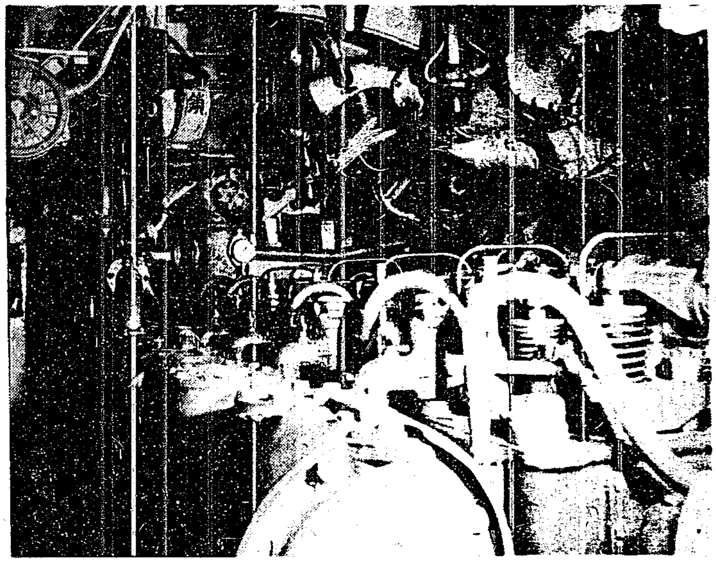


Figure 171
ENGINEROOM, HA-101 CLASS

General Remarks

1. The general impression is that this type of submarine was designed to be built as quickly and economically as possible. The small single engine power plant places it in the slow speed class.

2. The main cargo carrying hold is the forward compartment. There is a 3 foot, 3 1/2 inch diameter hatch forward for loading purposes.

3. The steering gear is of the worm and traveling nut type which moves the single link to the rudder cross head. It is driven by an electric motor.

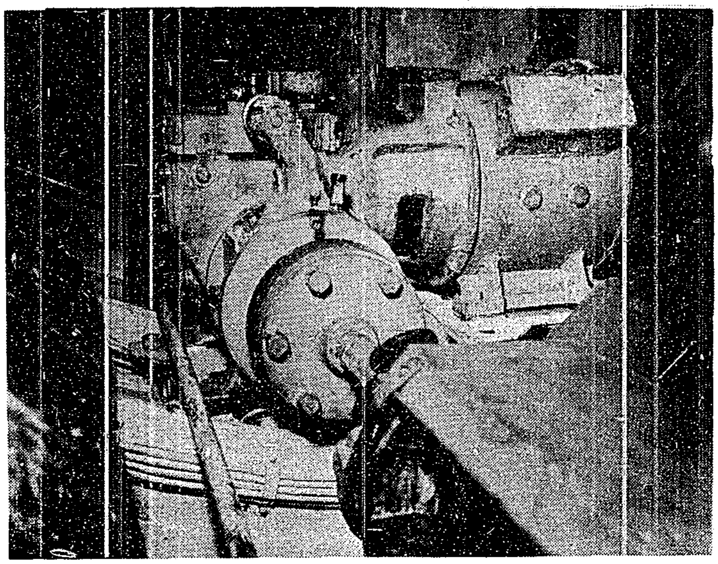


Figure 172
AFTER ROOM STEERING GEAR, HA-101 CLASS

4. The bow and stern planes are operated by hand power through shafting from the control room.

5. HA-101 and HA-104 are equipped with "schnorkle".

6. APR equipment is directional but the ship must be swung to obtain bearings.

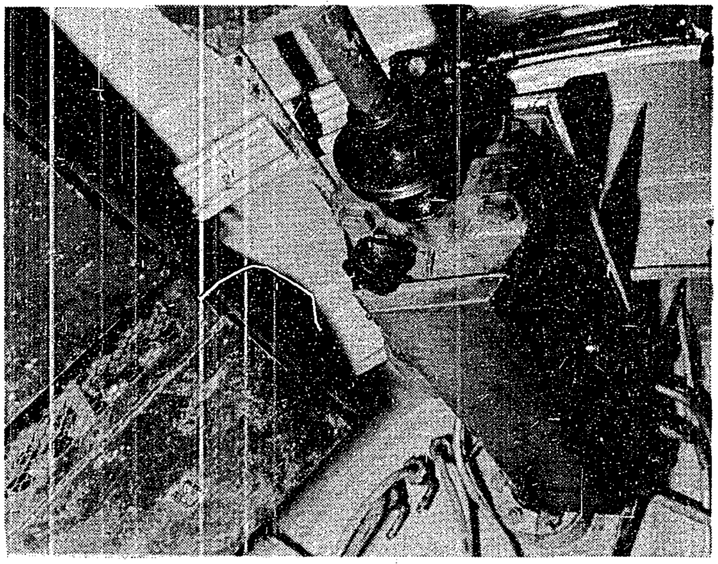


Figure 173
AFTER ROOM STEERING GEAR, HA-101 CLASS

7. All three submarines are covered externally with an anti-sound coating as described for the I-400 class. Its effectiveness is not known.

8. It is not recommended that these three submarines be placed in operating condition. A major overhaul would be required which would be considerably complicated by the problem of obtaining missing parts for auxiliary equipment.

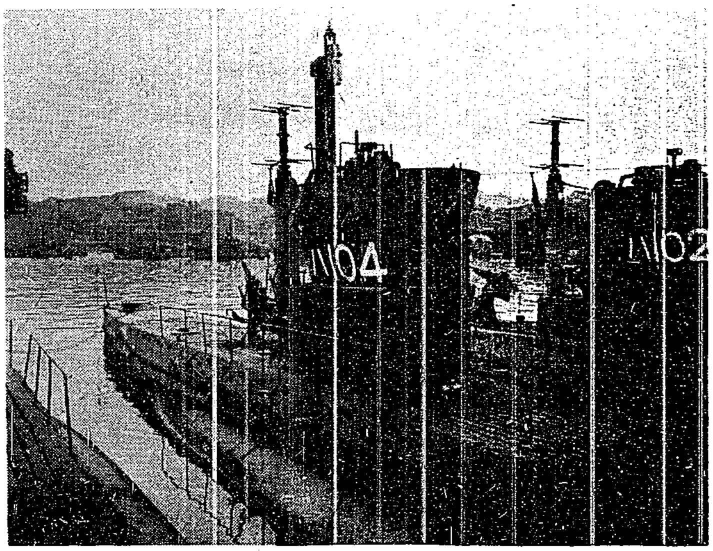


Figure 174
GENERAL VIEW OF BRIDGE STRUCTURE, HA-104

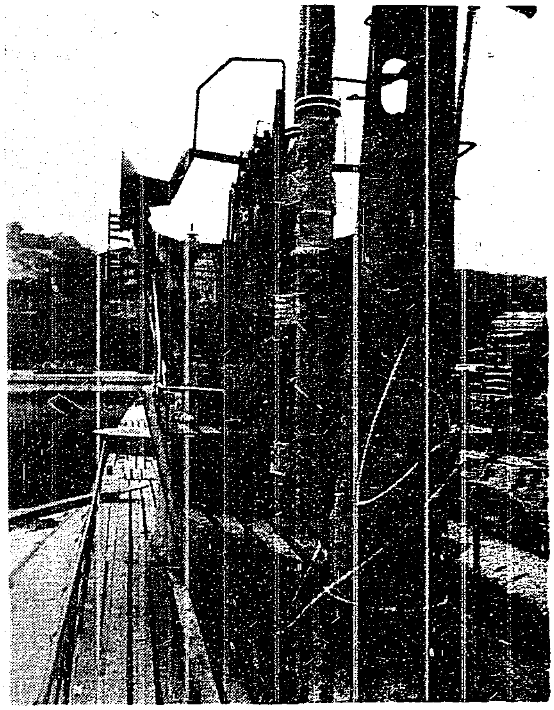


Figure 175
BRIDGE DECK LOOKING AFT, HA-104

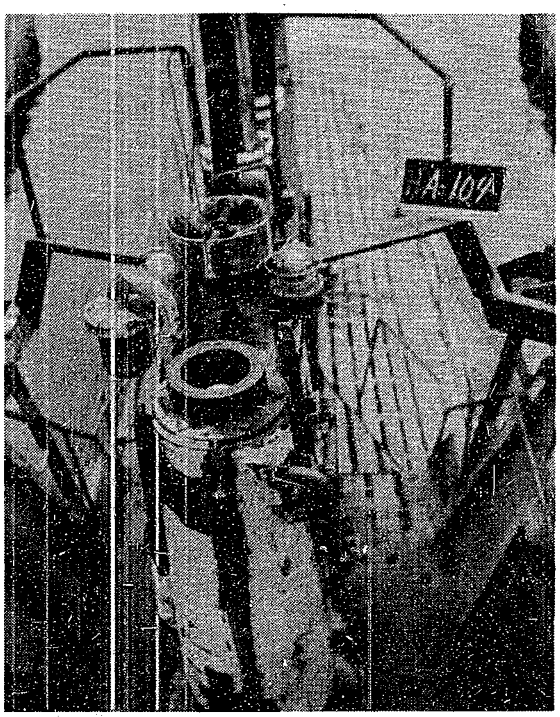


Figure 176
AFTER PORTION OF BRIDGE DECK, HA-104

D. Japanese Submarine I-369

Purpose:

Cargo and fuel carrying submarine.

General Characteristics:

Length, overall	246 ft
Beam	30 ft, 8 in
Draft (est)	15 ft
Displacement (est)	1200 tons
Pressure hull	18 ft, 3 in I.D.
Complement (est)	60
Propulsion - diesels	two eight-cylinder
motors	two
Torpedo tubes	two forward

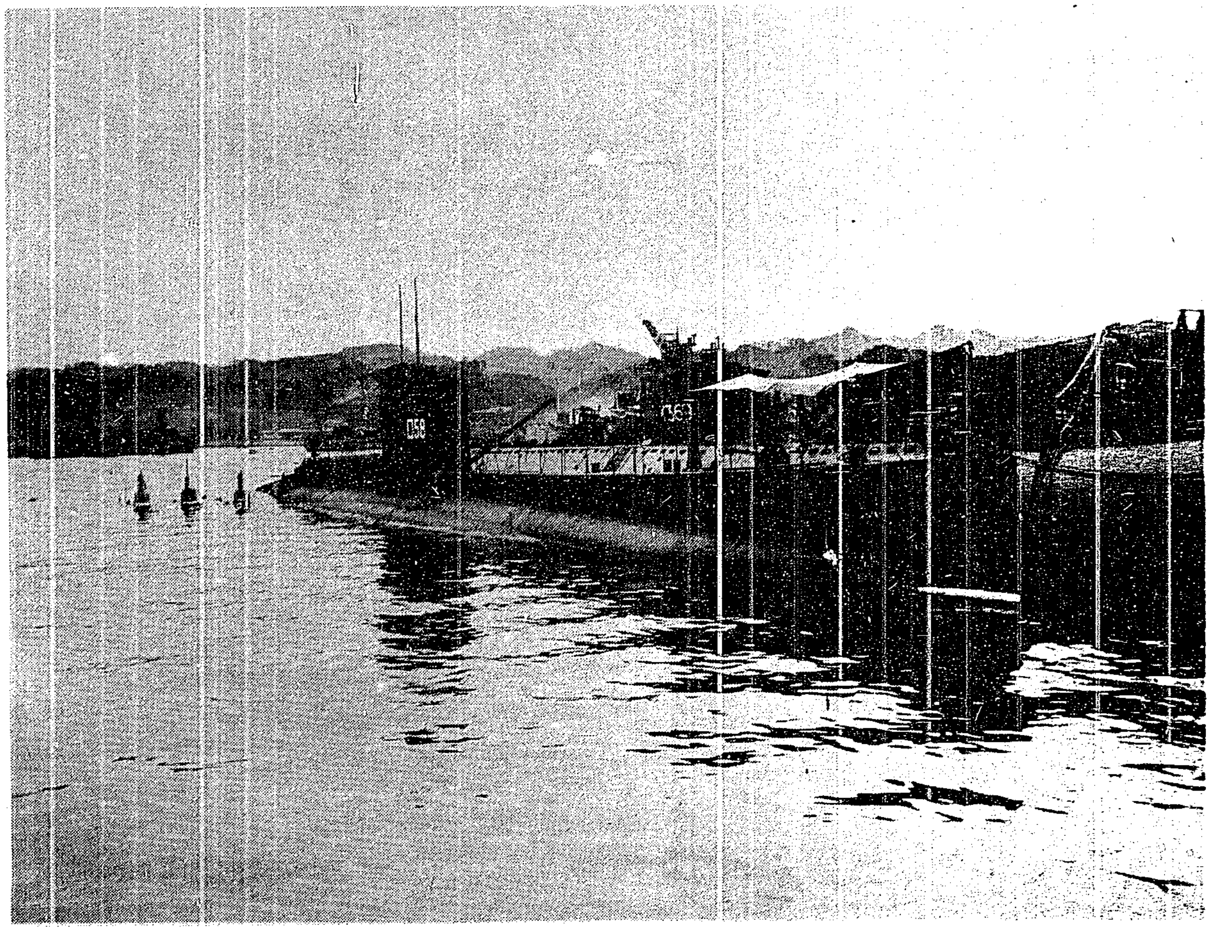


Figure 177
I-369, OBLIQUE VIEW ALONGSIDE DOCK
RO-58 in foreground

Figure 178
I–369 BOW VIEW

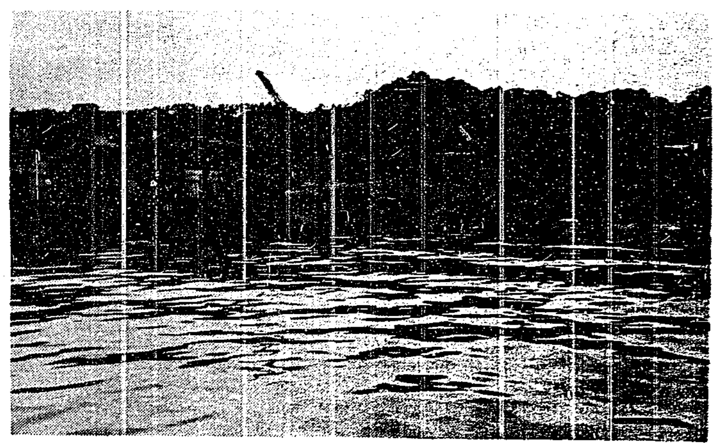


Figure 179
I–369. QUARTER VIEW

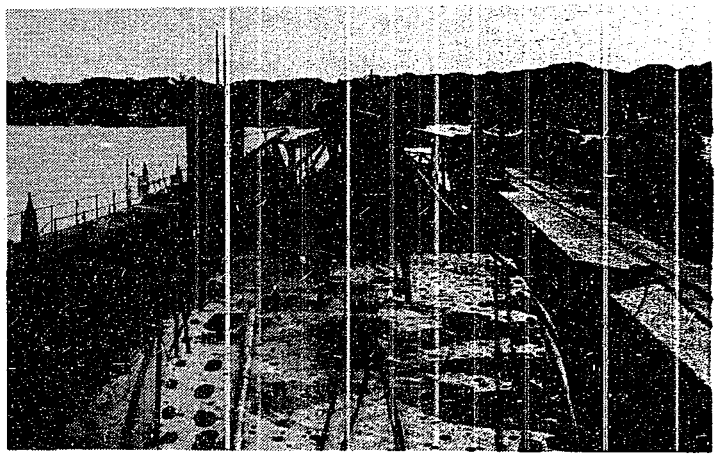


Figure 180
I-369, MAIN DECK, STERN VIEW

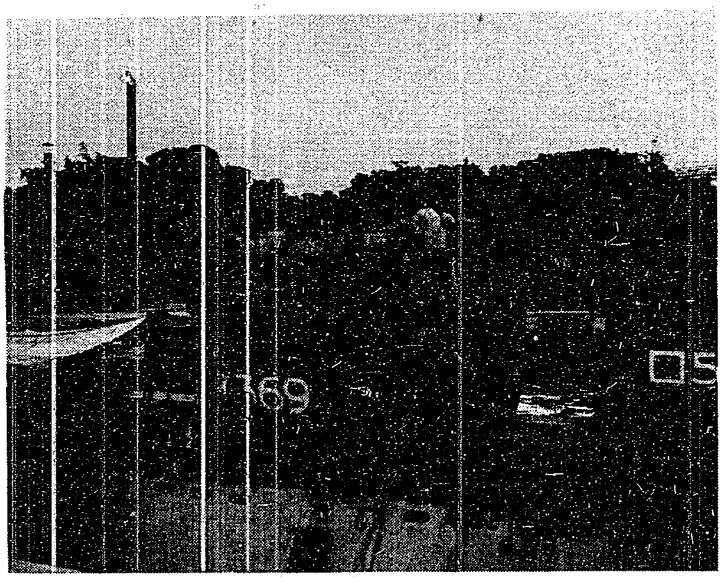


Figure 181
I-369, BRIDGE STRUCTURE

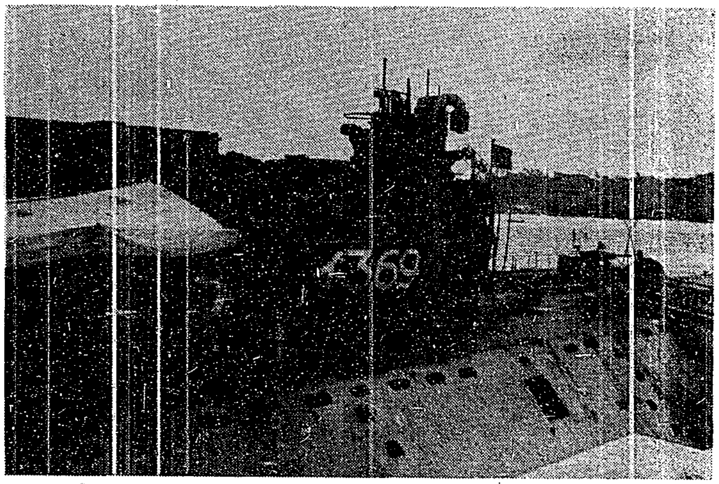


Figure 182
I-369, BRIDGE STRUCTURE, AFT

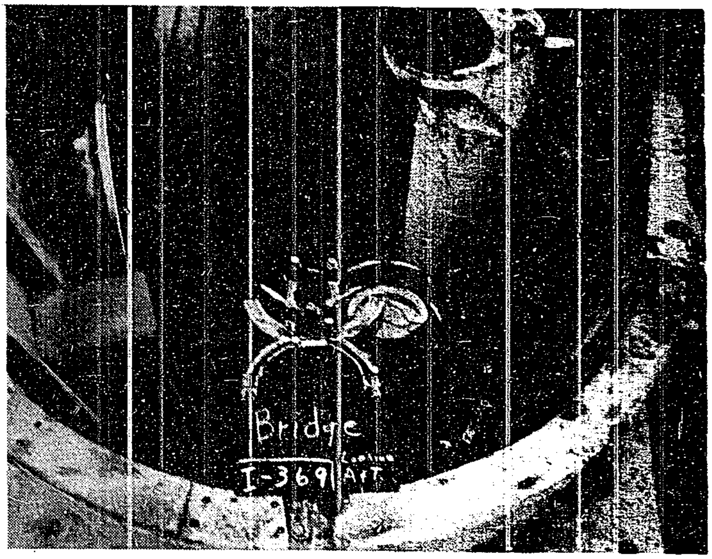


Figure 183
I-369, BRIDGE FROM ABOVE LOOKING AFT

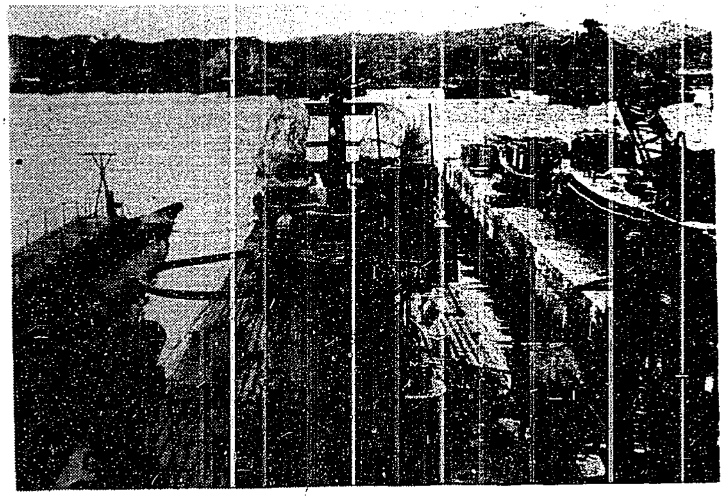


Figure 184
I-369, VIEW FROM BRIDGE LOOKING AFT

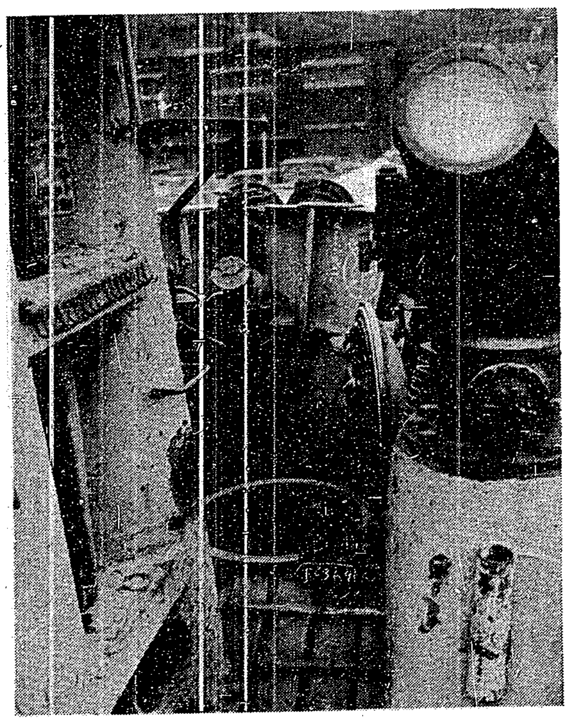


Figure 185
INTERIOR VIEW OF BRIDGE, I-369

Hull Characteristics

The pressure hull is 5/8 inches thick and is of riveted construction. There is nothing unique in the design and for that reason no further investigation was made.

General Remarks

1. The main cargo carrying spaces are the forward room and the compartment aft of the control room. From forward the compartments are: Torpedo and cargo room, living quarters, control room, cargo and crew's compartment, engine room, maneuvering room, and after compartment.

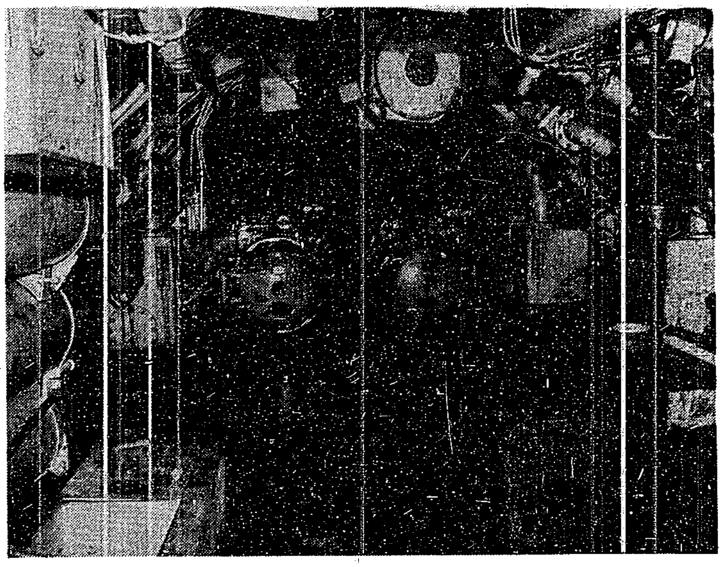


Figure 186
TORPEDO ROOM LOOKING FORWARD, I-369

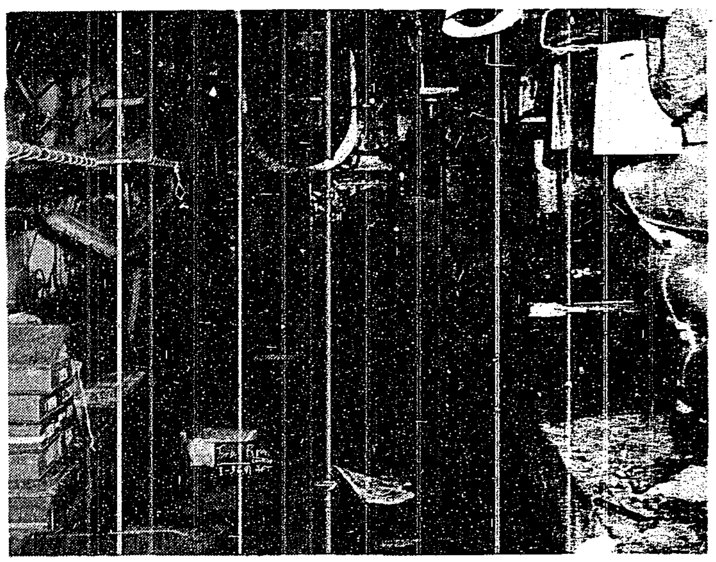


Figure 187
TORPEDO ROOM LOOKING AFT, I-369

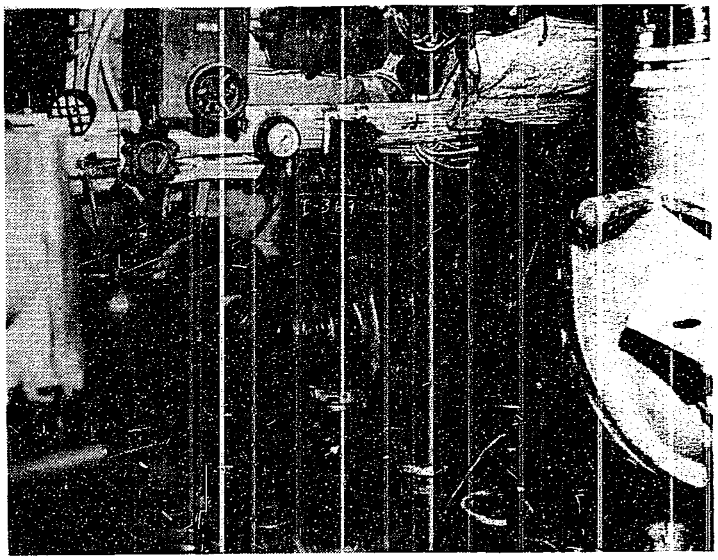


Figure 188
CONTROL ROOM HIGH PRESSURE AIR COMPRESSOR

Figure 189
ENGINEROOM LOOKING AFT, I-369

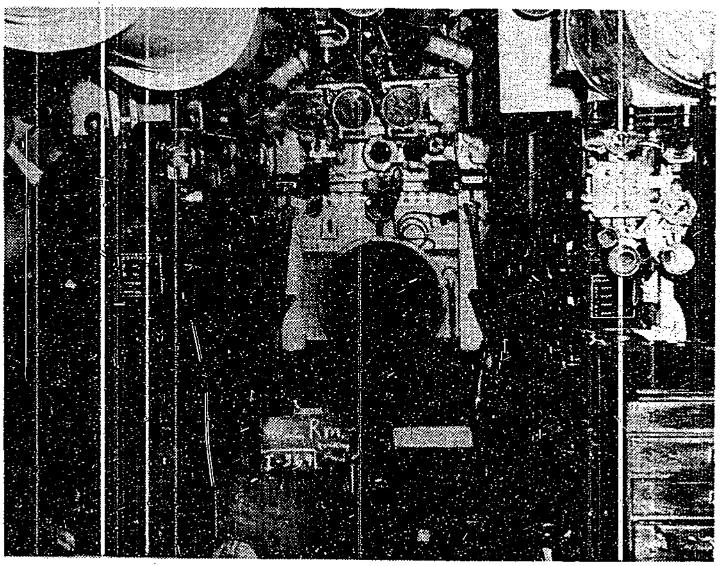


Figure 190
ENGINEROOM LOOKING FORWARD, I-369

2. Steering gear is of electric-hydraulic double cam type with follow-up gear. Control is by hand power from the control room.

3. There are two large fuel tanks aft, external to the pressure hull, one of which extends above the main deck. The arrangement of tanks in the ship was not determined.

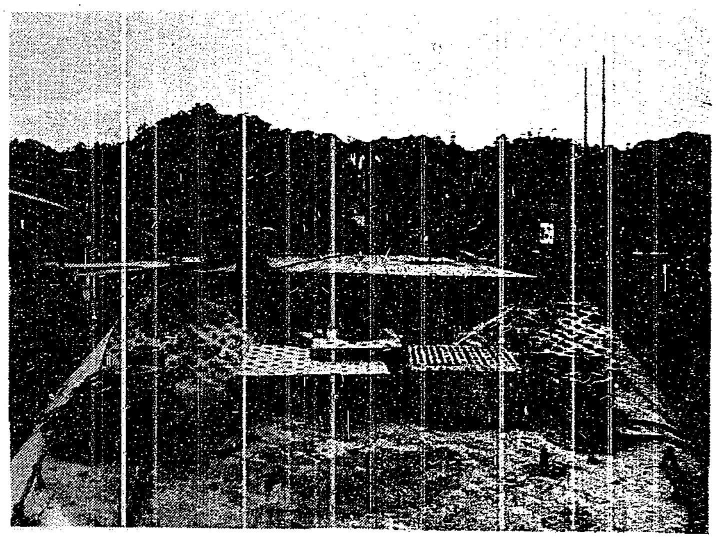


Figure 191
MAIN DECK, STERN VIEW

4. The after cargo compartment had an endless chain elevator installed for unloading stores to the main deck.

Figure 192
AFTER CARGO COMPARTMENT, I-369

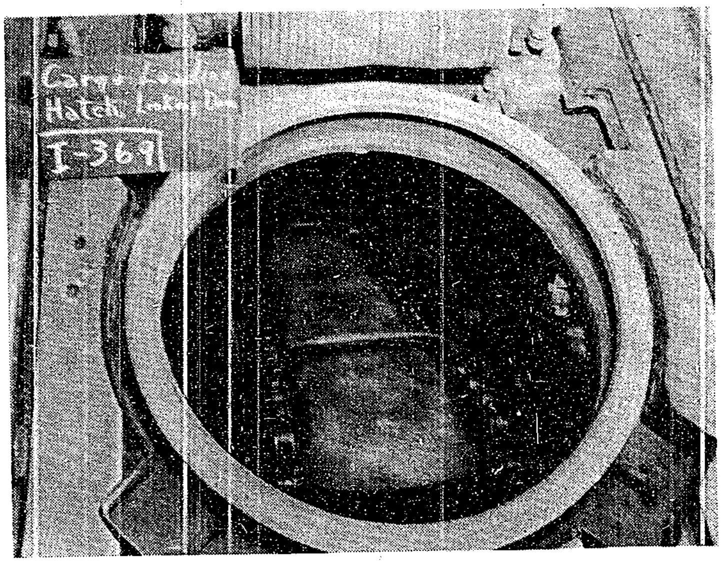


Figure 193
CARGO LOADING HATCH, VIEW FROM ABOVE, I-369

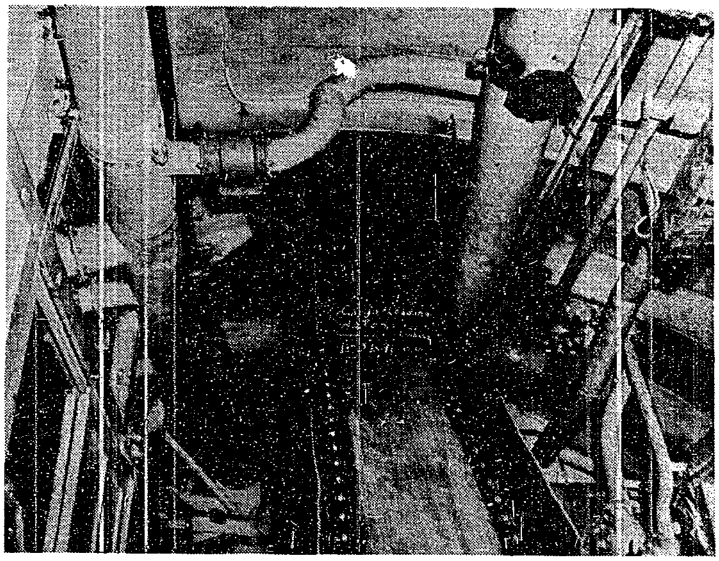


Figure 194

CARGO LOADING HATCH, VIEW FROM BELOW, I-369

5. A "schnorkle" is installed.

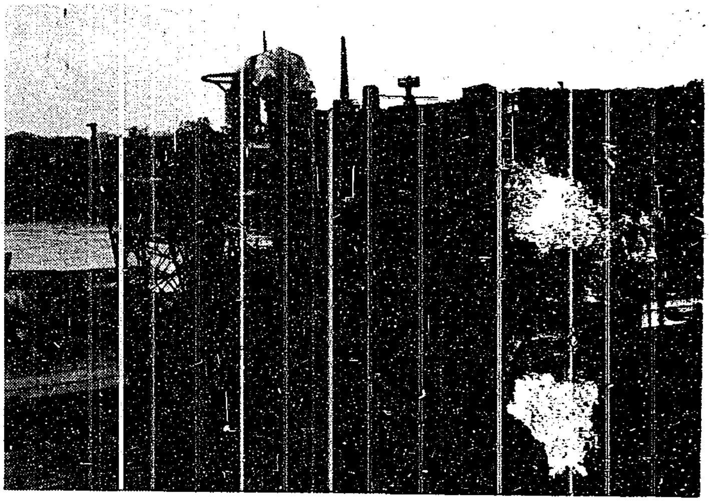


Figure 195

SCHNORKLE VERTICAL PIPING, I-369

6. The exterior is covered with the usual Japanese anti-sound material as described for the I-400.

7. It is not recommended that this submarine be placed in operating condition as an extensive overhaul would be required.

Main Propulsion Equipment - I-369, RO-58, HA-101

1. The main propulsion equipment and installation lay-out aboard the I-369 is somewhat similar to that of the I-14 with the exception of less power, cheaper equipment and all around workmanship of rather poor quality.

2. The engines are designated as type 23 and appear to be the common single acting, four cycle, non reversible and non supercharged, eight-cylinder diesel engine with a cylinder diameter of 370mm, a piston stroke of 500mm, maximum speed of 360 r.p.m. The approximate horsepower output is 1400 B.H.P. Engines are Japanese built and designed; the total weight per engine when dry is approximately 32730kg.

3. The power transmission from engine to propeller is direct, no reduction gears or hydraulic clutches are used; only the necessary positive jaw clutches between engine and main motors and tail shafting are installed. The main motor output is 600 K.W. per side. An exhaust heat evaporator is installed in each engine exhaust line.

4. The RO-58 is powered with two 12 cylinder, four cycle, single acting diesel engines of the Vickers type and were built by Mitsubishi, Japan under an English license. The maximum engine speed is 380 r.p.m.; the S.H.P. developed per engine is approximately 1200. These engines can at very slow or low speeds be operated on four or eight cylinders only, by means of cutting the fuel supply off to the cylinders to be idled in accordance with the timing sequence.

5. The HA-101 is powered by a single six-cylinder, four cycle, single acting and direct reversible type (medium speed diesel engine). The cylinder diameter is 300mm, the piston stroke is 350mm, the maximum speed is 500 r.p.m., normal ships speed 10 knots and the engine weight when dry is 9490kg. Engine output 400 S.H.P.

E. I-201, I-202

Built at KURE

	I-201	I-202
Completed	2 February 1945	14 February 1945
Keel laid	March 1944	June 1944

Purposes:

Offensive submarine, high speed submerged. Single hull type.

Characteristics:

Length - overall	79 meters
between perpendiculars	76 meters
pressure hull	59.2 meters
Beam, main	9.2 meters
Pressure hull diameter	5.8 meters
Draft (stbd) - bow	5.356 meters; 5.532 meters
stern	5.705 meters
Displacement - surface	1305.83
submerged	1503.13
Test depth	110 meters

Diving time to periscope depth .... 50 seconds
Main engines .... two MAN Type, single acting, four-cycle
.... 1500 B.H.P. each, 2700 S.H.P. total
Main motors .... four Type E, 5000 hp total
Battery .... special Type D, 2088 jars
Fuel oil .... 144 tons
Fresh water .... 7.356 tons
Provisions .... one month
Range - at 11 knots .... 8000 miles
at 6 knots .... 15000 miles
at 1.5 knots .... 60 hours
Speed - surface .... 15.43; 17.43 on battery
submerged, for 50 minutes 16.3
Torpedo tubes .... four bow, 53cm, Type 95, Mod. 3
Torpedoes .... 10 Type 95, Mod. 2
Deck guns .... two 25mm Type 96
Gun ammunition .... 1000 rounds
Periscopes - Type 88, Mk 3, Mod 1 special, 8 meter .... one
Type 88, Mk 4, Mod 2 special, 8 meter .... one
Personnel .... 7 officers, 45 men
Auxiliary equipment
Echo sounding equipment .... one
Gyro compass .... one Type 3, Mk 2, Mod. 3 (Anschult)
Magnetic compass .... one Type 4, Mod. 1
Speed log .... one Type 92, Mk 1, Mod. 1 propeller type
Wake recorder (DRT) .... one Type 26, Mod. 2
Sounding machine .... one Type 99 (Submarine Special)
Steering control .... automatic
Balancing apparatus (std type) .... automatic
Drain pump (control room) .... centrifugal - 2 stage
surface - in series .... 125 tons/hour
in parallel .... 300 tons/hour
submerged (110 meters), parallel,..... 30 tons/hour
Trim pump .... reciprocating, 30 tons/hour
HP air system .... 215 kg/cm^2
LP air system .... 50 kg/cm^2
Stability characteristics (standard condition):
GM (beam) .... 0.34 meters
GM (long) .... 147 meters
GB (submerged) .... .146 meters
Moment change trim 1cm .... 7.4 ton meters
Tons/cm immersion 2.28

1. General arrangement of compartments.

a. Torpedo Room (Fr. 19½ - 38). In the torpedo room four torpedoes are stowed on the lower level and two torpedoes outboard on the walking flat. There is the usual arrangement of torpedo firing equipment with impulse flasks, poppet tanks, and compensating tank. The forward trim tank of nine ton capacity is on the centerline just forward of the after bulkhead. Crews bunks are installed over the upper torpedo stowage.

b. Crews Quarters (Fr. 38 - 49). The crews quarters contains the sound room in the forward starboard corner with crews' W.C. in after port corner. #2 fuel oil tank which is inside the pressure hull extends along the port and starboard sides and below the walking flat in the forward half of the compartment. The negative tank, of 3.86 ton capacity, is just forward of the after bulkhead and on the centerline. The speed log is on the centerline immediately forward of the negative tank. The remainder of the space aft of the #2 oil tank is filled with high pressure air flasks and navigator's stateroom.

c. Wardroom and Control Room (Fr. 49 - 78). The wardroom and control room are not separated by any form of partition. Below the walking flat is the forward battery compartment, with #3 oil tank below, followed by #1 auxiliary tank to starboard and #2 and #3 auxiliary tanks to port, with the after and smaller battery space filling out the remainder.

Above the walking flat, officers' country extends to about frame 56 followed by the radio room to starboard and the refrigeration compartment and echo ranging control room to port. From frame 61 to frame 70 are the air manifolds, battery ventilation supply and exhaust blowers, and trim pump to starboard, gyro, periscope and vertical mast trunks on the centerline, and I.C. board, main motor controls, bow and stern plane controls, main drain pump, and drain manifold to port. The after part of the compartment contains storeroom and galley to starboard with room, ammunition magazine, and officers' W.C. to port.

d. Engine Room and Maneuvering Room (Fr. 78 - 112). The engineering space is of conventional Japanese arrangement but with no structural bulkhead between the engines and motors. The air compressors are aft of the split control cubicle. Lube and fuel oil tanks are below the machinery level. The hydraulic pump and accumulator are ahead of the port engine.

e. Steering Room (Fr. 112 - 120). The steering room contains electric driven worm and traveling nut type steering machinery and the electric-hydraulic-worm and rack stern plane operating mechanism. Below the walking flat in the forward end is a storeroom and the after trim tank extends from frame 116 - 120 to two-thirds the height of the compartment. Air signal ejector is mounted in the overhead.

2. Tank arrangement and capacities.

Tank	Location frames	Internal	External	Capacity metric tons
#1 Buoyancy	Stern 10		X	15.264
#2 Buoyancy	28 - 37 P&S		X	21.744 total
#3 Buoyancy	37 - 46 P&S		X	20.768 total
			Total	57.776
#1 Main tank	11 - 22		X	39.407
#2 Main tank	46 - 67½ P&S		X	27.892
#3 Main tank	67½ - 88 P&S		X	25.724
#4 Main tank	111 - 132		X	57.518
			Mt Total	150.54
#1 Residual water in Main tanks on surface.				11.0
#1 Aux. tank	64 - 69 Stbd	X		21.631
#2 Aux. tank	64 - 66 Port	X		8.170
#3 Aux. tank	66 - 69 Port	X		
#1 Torp. Comp.	26 - 29	X		2.853
#2 Torp. Comp.	29 - 39½	X		8.635
Fwd. Trim	33½ - 38	X		9.001
Aft. Trim	116 - 120			
Negative	47 - 49	X		3.863

Fresh water	70 - 78	X		7.356 cubic meters
#1 Oil tank P&S	32 - 38	X		10.304
#2 Oil tank	39 - 43	X		45.624
#3 Oil tank	58 - 64½	X		5.861
#4 Oil tank	81 - 88	X		37.992
#5 Oil tank	90 - 102	X		35.671
#6 Oil tank Port	88 - 110		X	7.281
#7 Oil tank Stbd	88 - 110		X	7.281
Light fuel oil	85 - 88 (overhead)	X		0.750
#1 Lube oil	78 - 82½ Stbd	X		7.840
#2 Lube oil	78 - 82½ Port	X		7.840
Settling tank	88 - 90	X		2.414
Main lube oil tank	90 - 93 P&S	X		9.500
Lube oil for shaft bearings	102 - 105 P&S	X		2.616

3. Arrangement external to pressure hull.

a. The superstructure is very well streamlined. The only objects which project are the forward and after capstans and the irregularities around the upper after end of the bridge fairwater. Deck bits can be housed, the two 25mm guns and stands fold below the deck, the periscope and vertical antenna supports are streamlined and the covered bridge and conning tower fairwater are of smooth contour.

b. The #2 and #3 buoyancy tanks, #2 and #3 main tanks, and #6 and #7 fuel oil tanks are built into the sides of the superstructure.

c. A ballast keel extends from frame 35 - 101. It is 0.8 meters wide at the top, 0.6 meters at the bottom, and 0.3 meters in depth.

d. Distances from ballast keel to:

Main deck - bow .... 7.2 meters
midship .... 7.0 meters
stern .... 6.2 meters
Top - periscope shears .... 12.5 meters
raised periscope .... 16.5 meters
conning tower .... 8.85 meters

e. There is a total of five hatches.

Conning tower, diameter 600mm
Control room, diameter 570mm
Torpedo room - crews' quarters, diameter 650mm
engine room ....

4. Pressure hull and conning tower.

a. The pressure hull is of welded design, being of circular cross-section throughout. The maximum diameter is 5.80 meters and taper to 2.78 meters forward and aft. The pressure hull is 22 meters in thickness over the middle 3/4 of its length and is 18mm thick at the end sections. In construction the pressure hull is prefabricated into eight sections and then assembled. Hull plating is designated as Type 2, the characteristics of which are not known; it may be safely assumed to be mild steel.

b. The pressure hull framing is internal and is in general of the bulbous angle type with spacing of 500mm and 650mm. The first frame of the pressure hull is at frame 21 and the last at frame 118.

c. There are patches at frames 56 and 71 for removal of batteries and hard patches over the engines and control cubicles.

d. The only pressure bulkheads are at frames 38 and 78.

e. The conning tower is flat on top and somewhat oval in plan cross-section. Length is 3.35 meters, beam 1.7 meters, and height 2.74 meters. The side plating is 32mm in thickness and some splinter protection is claimed although it is mild steel.

f. By deflection measurements at 100 meters, the conning tower was determined to be the weak point in the structural design, having a lateral deflection of 6mm. Deflection of the hull as measured in the engine room was plus or minus 3mm.

5. General Remarks.

a. Although this design of submarine has achieved its purpose of high submerged speed, the general layout, especially with respect to trimming moment, was not accomplished without difficulties. After the I-201 had conducted trials, a considerable modification to the tank arrangement was necessary. As originally built, fresh water was carried in #1 port and starboard fuel tanks. Whether fuel was carried in the fresh water tank is not known. The #2 and #3 port and starboard buoyancy tanks were added as were #6 and #7 fuel tanks. The #2 port and starboard main tank forward bulkhead at frame 55 were removed and the tanks extended to the after end of #3 buoyancy tanks at frame 46. An additional torpedo compensating tank was installed in the torpedo room below the walking flat between frames 26 and 29. This considerable modification left a surface trimming moment forward although the submerged condition was deemed satisfactory. To correct the surface condition, three tons of ballast were added to the ballast keel at about frame 97 and a pressure three ton buoyancy tank added in the starboard superstructure at frame 107 to restore the submerged trim.

The internal tank construction is of irregular shapes, primarily to utilize all possible space; however, it is entirely possible a more satisfactory arrangement could have been made which would allow more ease and simplicity in construction.

b. The vent pipes leading from the four tanks of the #2 and #3 buoyancy group connect to four valves arranged in a square between the after ends of the #3 group. The four valves are operated by a single stem and yoke by hydraulic power.

c. Prior to the installation of the additional buoyancy tanks and external fuel tanks, hydraulically operated shutters for the free flooding openings in the superstructure forward and aft were installed. After submerging the shutters were closed to provide a more streamlined surface. It is claimed that the submerged speed was increased 0.5 knots.

d. The original design specified intermittent chain welding of the internal frames to the pressure hull and the I-201 was so constructed. As a result of a lecture on welding by one Dr. Schmidt, a German, the welds on the framing of the I-202 and subsequent submarines of this class were continuous.

e. The telescopic type of "schnorkel" was installed on both the I-201 and I-202 while it had not been installed on the I-203, which is still at KURE, because of cessation of hostilities. It was stated that at "schnorkel" submergence depth, it is possible to run one main engine at full power; however the speed under this condition is limited to five or six knots because of the structural weakness of the extended "schnorkel". At KURE it was stated the "schnorkel" was designed for a submerged speed of seven knots.

f. The usual topside rudder has been omitted. The rudder is of the underhung balanced type. The stern planes are abaft the propellers. The stern fins, which measure 9.2 meters from tip to tip, installed just forward of the propellers provide additional horizontal stability at high submerged speeds.

g. Although the electric-geared bow plane rigging is standard, the tilting is slightly different. The electric tilting motor drives a worm and rack through a reduction gear. The tilting rod, into which is machined the rack, connects to a bell crank attached to the horizontal shaft supported in bearings in a small cylindrical blister installed on the centerline in the overhead of the pressure hull. The other arm of the bell crank is connected to second bell crank on the bow plane shaft.

h. Automatic steering, which is accomplished through selsyn control of the electric steering motor through suitable contacts, maintains the set course to within two to three degrees under the best conditions of wind and sea.

i. No anti-sound paint was applied, in order to hold submerged resistance to a minimum.

j. This I-201 class carries approximately 60 tons of fixed ballast of which 24.5 tons is secured below the air flasks abaft #2 fuel tank and 13 tons is secured in the ballast keel.

Main propulsion equipment of the I-201 Japanese submarine.

a. The main propulsion plant is similar to that of our old S-boat class submarines. Two ten-cylinder, direct reversible, supercharged four cycle, single acting, MAN type diesels are the prime movers.

The main engine driving power is conducted to the propeller shafts via a vulcan oil clutch and reduction gear. The double ended large main motors, two per side, are arranged in tandem with a positive jaw clutch before and after the main motors. Immediately after the second positive jaw clutch are the propeller shaft thrust bearing (similar in design to the Kingsbury thrust bearing), and the friction drum type shaft brake. The brake permits propeller shaft clutching operations while underway.

b. The noteworthy feature, high submerged speed (16.3 knots at the one hour rate), is attained by a special battery and large main motors. The main storage battery, designation Type D (midget), consists of 2088 battery jars, two cells per unit. The forward battery well houses 1396 units, the after battery well, 694. Both battery compartments are located below the control room, and are separated by a watertight bulkhead. Access hatches are fitted to the control room deck. The battery jars are mounted in a horizontal position to save space. The batteries are ventilated by the compartment ventilation method. Verbal information gives the life of the battery as 80 cycles.

7. Engine room and the main engines.

There are two air starting bottles, one outboard of each engine, capacity 18,301 cubic inches, maximum pressure 2240 lbs/in^2. Four lubricating oil tanks, two sump tanks (or "drain tanks", as usually referred to by the Japanese), and two storage tanks are located in the engine room. On the port and starboard sides respectively, (forward end of engine room), are the heavy fuel oil separating tanks. Fuel oil under pressure from the compensating system passes through these tanks to be cleared of sludge and sea water, before passing on to the day service tank via a standard basket type dual fuel filter. Two light fuel oil tanks are located in the engine room about midships. One tank (gravity), is secured to the overhead, the storage tank is mounted on the engine room deck. This fuel is of much higher B.T.U. value and is intended only for cold weather starting. The fuel in all normal tanks is type 2 oil of a specific gravity of .87 to .93, which is similar to a fair grade of bunker C fuel.

The two main engines are MITSUBISHI, Mark 1, diesel engines, built at YOKOHAMA, Japan. The engine cylinder diameter is 300mm, or approximately 11 51/64 inches. The length of piston stroke is 380mm, or approximately 14 13/64 inches. The engine mean effective pressure is given as 7.5 kg/cm2, or approximately 106.65 lbs/in^2. The maximum engine speed at full power is 675 r.p.m. 1500 brake horsepower is developed at full r.p.m.

The fuel consumption at full power is approximately 89 gallons per hour. The lubricating oil consumption for the same time and load combination is approximately seven gallons. This high lubricating oil consumption is due either to engine design, poor engine mechanical condition, or the wrong information from ship's force.

The engine base plate is secured to the foundation by a series of through type and body bound holding down bolts, spaced in proper sequence. The engine base plate, cylinder blocks, and "A" framing are cast and machined.

The engine crankshaft of the I-200 class boats is a one piece forging made of alloy steel, as compared to the two piece forgings in the I-400 class. The lower main bearing saddles are the under slung type and are securely held to the engine frame by means of tie rods. The bearing caps are held in place by the conventional jack-screw method, two screws per bearing cap. The bearing metal is a white metal composition. The crankshaft journal diameter is 195mm, or approximately 7 19/32 inches.

The crankshaft torsional vibration damper is mounted on the operating end of the engine. It embodies the same design principles, but differs slightly in construction from that of the I-400 class torsional vibration dampers.

The camshaft is housed inside the engine "A" frame and carries all valve cams for ahead and astern operation. The valves are operated from the cams via push rods and rocker arms. The power and speed transmission is via gearing from the crankshaft. The camshaft speed is 1/2 the crankshaft speed. The engine cylinders are cast with removable cast iron liners. The cast iron machined trunk type piston is oil cooled via the conventional grasshopper linkage arrangement. The piston is equipped with five fire rings and three lubricating oil control rings. The piston pin bosses are machined to close tolerances. The piston pin is held in place and prevented from floating sideways by locking caps and bolts. The connecting rod is of forged steel; material spec. (nickel-chrome). The crank and bearing diameter is 195mm, plus oil clearances, or 7 19/32 inches. The white metal lined piston pin liner has a diameter of 130mm, or approximately 5 7/64 inches. The distance between bearing centers is 720mm, or approximately 28 5/16 inches. The cylinder heads are cast and carry all the valve gear and accessories. The air intake valves are of a larger valve disc diameter than the exhaust valves. The two intake and exhaust valves are not of the individual cage type. To remove one valve, the entire cylinder head has to be lifted. The fuel injection valve is of the spring-loaded type, and lifts with the oil pressure overcoming the spring pressure. The injection nozzle body is fuel oil cooled, the inlet and outlet connections being located on the nozzle cage securing flange. The cylinder pressure relief valve and indicator cock are of the combined type. The air starting valve is of the pneumatic type. The air starting timing spinder is mounted on the camshaft end.

The timing mechanism consists of cam, roller, small pilot pistons, control cylinders and pilot air lines. The timer, or cam, upon starting, contacts each small piston-roller as per air starting sequence. The small piston is moved and air of high pressure but small volume is admitted to the actuating valve, which opens the large cylinder starting air inlet valve, thereby admitting starting air of larger volume, but lower pressure, into the cylinder, forcing the respective piston downward.

Each cylinder is equipped with its own high pressure fuel injection block type pump, straight plunger and barrel, with suction valve lift and by-pass control. The fuel pump throttle linkage is directly connected to the suction valve lift and bypass control levers. The fuel injection pump test pressure is 600kg/cm2. The normal operating pressure is 180 kg/cm2, or approximately 2620 lbs/in2. The cylinder relief valve is set for pressures in excess of 65kg/cm2, or approximately 910lbs/in2.

The engine is salt water cooled and jacket water temperature in excess of 115 to 1[illegible] should not be tolerated. The over-all length of the engine is approximately 18 feet. All accessories, such as salt water pump, lubricating oil pump, and fuel oil service pump, are attached to the engines. The engine fuel throttle operation is manual. The engine overspeed governor of the flyball and counter spring tension type is attached to the engine end to guard against speed surges above 700 r.p.m. The engine is supercharged by means of a BUCHI type exhaust driven supercharger with a discharge pressure of 0.5kg/cm2, or approximately 7 lbs/in2, at full blower speed, 11,500 r.p.m. At the speed of 8600 r.p.m., the supercharger is capable of moving a volume of air equal to 7250 cubic meters per hour at an air temperature of 17°C. The blower was also built by Mitsubishi and carries the type designation 960 x 45. The exhaust gas turbine end is directly connected to the centrifugal type compressor. The engine exhaust is piped to the exhaust turbine via the upper and lower exhaust headers. The cylinder exhaust outlets are arranged in the following manner: Cylinder nos. 1, 8, 9, 3, 4, and 6 lead to upper header, and cylinders nos. 7, 10, 2, and 5 to the lower. Each exhaust header is subdivided into two sections by a longitudinal full lenth plate to actually form four headers. This arrangement creates a multiplicity of exhaust pipes and is probably done with the thought of causing a pulsating or variable pressure in the exhaust piping so that during the period of scavenging the pressure in the exhaust manifolds is, relatively speaking, considerably reduced, thereby creating a larger pressure difference between supercharger inlet and exhaust header pipes which should result in a violent rush of air through the cylinder combustion space from air in inlet side at inboard side of engine to the outboard exhaust headers. The intake and exhaust valves are permitted to overlap during the exhaust stroke to allow better scavenging and cooling of certain engine parts.

Sections of the turbine casing, including the exhaust header shells are sea water cooled. The exhaust turbine will operate continuously at an exhaust temperature of 550°C., or approximately 1022°F. Temperature above that are detrimental to the turbine. These engines are equipped with exhaust pyrometers (type YEW), similar to a Brown instrument.

No auxiliary engines are provided, and battery charging is accomplished with the main engines. There is no piped main air induction, the air is taken in through the conning tower and during surface operations on the main engines, the watertight engine room bulkhead door has to be locked open. The submarine is equipped with a telescopic type "schnorkel". The variable height equals approximately three meters, which permits battery charging, and perhaps one engine operation submerged. The speed of advance while using the "schnorkel" is limited to five knots. The intake side is sealed by means of a ball type float, which will rise into its seat upon contact with a body of sea water. The top of the "schnorkel" exhaust stack is shaped like a gooseneck and ties in to the regular exhaust piping, which is provided with an inboard and outboard exhaust valve. The "schnorkel" intake is piped into the regular hull ventilation system. The engine room also contains the two lubricating oil coolers, and the following auxiliaries:

One Lube oil purifier (DeLaval type)
One Lube oil stand-by pump

According to instruction, the stand-by pump can be cross-connected and used as a fuel transfer pump. The sea water stand-by pump is mounted on the forward engine room bulkhead. The electric evaporator is placed midships in the after section of the engine room. It is of small capacity, 1/2 metric ton per 24 hours, approximately 150 gallons per day, and has no vapor compressor. The vulcan type oil clutch is mounted on the after end of the engine, between engine and reduction gears. The clutch has a 3% slippage factor. The single type reduction gear ratio between engine pinion and propeller shaft bullgear equals 1.268. The propeller r.p.m. maximum on engine propulsion is approximately 533. A worm gear arrangement is attached to the shaft to facilitate jacking of the reduction gear. The engine reversing mechanism is in most details similar to that of the I-400 class main engine.

The main motor room houses the port and starboard control cubicles and four double ended main motors, two per shaft. The maximum output of each motor end is 625 hp., delivering when necessary a total of 5000 hp to the propeller shafts when on battery power. The main motor casings are of welded construction. Eight main motor air coolers, capacity of 300 cubic meters per hour, are installed, four per side, and are located outboard of the main motors. Eight motor driven detached fans circulate the cooling air between main motors and coolers. One lubricating oil cooler and two gear type lubricating oil pumps are provided for the main motor shaft bearings and shaft thrust bearings.

Following is the pump motor name plate data: Four hp, four pole, 1200 r.p.m., 240 volts, 152 amperes, normal pump pressure 1.2kg/cm^2 or 16.8 lbs/in^2.

There are two single stage main motor air coolers (sea water pumps), of 15 metric tons capacity at 1kg/cm^2 discharge pressure. In the motor room is also located the large bilge and drain pump which services both the motor and engine room. The name plate data is as follows: Six stages, turbine type, four pole, 220 volts, 96.5 amperes, speed 2400 r.p.m., capacity 15 tons per hour discharge pressure in series operation 15kg/cm^2 discharge pressure.

The propeller shaft revolution counter drive is of the chain drive type. The stern tube packing gland has a sort of planetary gear arrangement to facilitate even pressure when taking up on the packing. The two propellers are of the three blade type. The diameter is 1850mm, or approximately 73 inches. The pitch is 1170mm, or approximately 46 inches. Propellers for the I-200 class submarines have been made of both manganese bronze and of a non-corrosive steel similar to stainless steel, for experimental purposes.

The I-200 class submarines, while operating on the surface on battery power are supposed to make 17.4 knots at the one hour discharge rate. According to the best information available, the full 5000 hp main motor power (when on battery power and main motor propulsion) can not be utilized due to cavitation and structural hull and tank design shortcomings.

F. <u>I-36 Submarines: Main Propulsion Equipment</u>

The submarine I-36 was completed at Yokosuka Navy Yard in October 1942. The surface displacement is approximately 2600 metric tons, submerged approximately 3260 metric tons. Ship's draft 5.2 meters. The present maximum surface speed is 22 knots. Designed speed 23.4 knots. The total fuel capacity is 800 metric tons grade No. 2 fuel. The cruising radius at 16 knots is 12,500 miles. The lubricating oil capacity is 53 tons. The fresh water capacity is 26 tons.

The main engines were built by Tama Shipbuilding Co., OKAYAMA, Japan, and completed 16 December 1941. From all available information only the I-36 and I-47 are equipped with ten cylinder, double acting, air injection, direct reversible diesel engines. The engines are of Japanese design, but the best design features of the Swis-Sulzer, MAN and Lachman D.A. diesel engine can easily be detected. The engine is approximately 11 meters long, or 36 feet, 6 inches. The total weight of one engine is given as 150 metric tons which figures approximately 43 pounds dead weight per hp. The cylinder diameter is 470 m/m or approximately 18¼ inches. The piston stroke is 530 m/m or 20 51/64 inches. The maximum engine speed is 350 r.p.m. (designed speed). The maximum shaft horsepower delivered per engine is 5650. Total on two engines is 11,300 shp. The maximum m.e.p. at full load equals 8kg/cm^2 or approximately 112 lbs/in^2. The fuel consumption is approximately 50 metric tons per day for two engines at a speed of 20 knots. The lubricating oil consumption is given as 30 liters per metric ton of fuel.

The engine air is taken in through a series of louvers spaced around the port and starboard top level of the cigarette deck. Two large main trunks provided with the necessary outboard valves direct the air flow into the main induction pipe. The air enters the engine room aft of the engine through a large opening in the inboard piping approximately 2½ feet above the engine room deck. The inboard pipe is provided with a flapper valve near the large inlet elbow. The inboard piping tapers off into the bilge to form a drain line port and starboard side. This air induction piping arrangement appears to be rather sound as there is little presence of rust due to salt water spray.

The holding down bolt arrangement for the main engine bed plate is conventional. The engine "A" frame is held to the bed plate by 12 long tie-rods of approximately 3¼ inches diameter extending from lower bearing saddles to the top of the "A" frame and cylinder blocks. The main bearings are white metal lined, the lower shell is of the removable type, the cap has the white metal poured into it to form an integral part of the cap. The main bearing cap is secured by means of a wedge type lock, departing entirely from the common jack screw method of holding the cap secured. The piston is of the three section type, upper crown, center section and lower crown. The piston is equipped with five upper and five lower fire rings of the plain cast iron type. The piston is oil cooled via the conventional grass hopper gear and hollow piston rod. Oil enters the piston cooling chamber through the inner tubing and returns through the outer passage formed by the tube outer wall and piston rod inner bore. The piston rod outside diameter is approximately 6 11/16 inches. The outer surface has a high polish finish. The piston rod stuffing box contains the spring loaded sectional packing rings and fire rings, a total of 12 rings. The entire stuffing box assembly is very similar to the type used on the Hamilton double acting engine. The division cover contains the oil wiper rings. The oil to stuffing box is supplied by splash and a forced feed line for stuffer cooling is attached. The crank shaft is hollow and the openings between crankwebs are closed off and made oil tight with suitable end plugs. The crank pin journal diameter is approximately 12 inches. All crankshaft and connecting rod lubrication is forced feed. The connecting rod upper shell is removable, the lower is part of the connecting rod cap. The connecting rod fork eyelets are babbitted and carry the crosshead bosses. The crosshead slipper guides are placed in the center and between the heavy engine "A" frame upright sections. The threaded piston-rod lower end passes through the cross-head and is secured with a large lock nut at the bottom of it. The ball and socket joint is not used with this crosshead assembly. Large air domes are attached to the piston cooling inlet and outlets to reduce pumping action in grass hopper gear. The cylinder lubrication is forced feed. The amount of lubricating oil fed to all cylinders can be adjusted by simply changing the length of plunger stroke on all lubricator pumps (similar to our MANZELL type) via the stroke control shaft. All pump cranks ride in a slotted bar which controls the pump stroke by changing the relative position of the control lever on the throttle quadrant. The cylinder heads upper and lower are shaped like a flange type cover. The upper head carries the injection nozzle cylinder relief valve set for a maximum cylinder firing pressure of 50kg/cm^2 and the indicator cock. The lower cylinder head carries two injection nozzles, the air starting valve, lower cylinder relief valve and indicator cock. The piston cooling linkage pivot arm carries the reducing mechanism to facilitate the taking of full indicator cards. The upper injection nozzle spray tip has 10 equidistant holes drilled in. The lower nozzle has only six spray holes in the tip so spaced as to spray the atomized fuel in the shape of a lozenge to prevent fuel spray from touching either cylinder wall or piston rod. Both upper and lower nozzles have high pressure fuel and high pressure air connections. The fuel enters the nozzle at approximately 50kg/cm^2 pressure. The high pressure air enters the nozzle at a pressure range from 60 to 80kg/cm^2 depending on engine speed. The injector stroke and timing can be controlled. An adjusting link is attached to the upper injector operating rocker arm for lift control and a timing adjustment linkage runs the full length of the engine with a connection to each injector. The injector spring tension is also adjustable. The lower injector control is less elaborate and consists of an adjustable arm and lever only. The high pressure spray air can be controlled individually to each cylinder. The two cylinder four-stage air compressor is mounted direct to the forward engine end and is driven off the engine crankshaft. The pressure between stages are: first stage 1kg/cm^2, second stage 7kg/cm^2, third stage 30kg/cm2, fourth stage from 60 to maximum of 150kg/cm^2.

The high pressure air compressor is provided with the necessary inter and after coolers and air separators. Besides the 150 liter high pressure injection air supply bottle there are four air starting bottles of 300 liters (each) capacity, maximum pressure 160kg/cm^2 per engine.

The engine throttle stand is mounted forward of the engine and carries in a neat arrangement the high pressure air compressor control, engine starting and stopping levers, fuel throttle with vernier adjustment and engine reversing gear. The en bloc fuel injection pump is located below the throttle stand. The plunger lift control mechanism is operated from the stand. Above the stand are mounted all gauges and indicators including the piston cooling telltale box. The following pressures are maintained during operation:

Engine cooling water (seawater) .... 1.5kg/cm^2
Piston cooling oil .... 4kg/cm^2
Blower bearing oil .... 0.5kg/cm^2

The scavenging air is supplied by a detached electric motor driven rotary type two-stage blower. Motor power required at full speed 750 hp, r.p.m. range 1750/2700. The blower capacity is 15 cubic meters per second discharge pressure absolute 0.7 to 1.0kg/cm^2. The engine scavenger header is on the inboard side of engine. The single exhaust header for upper and lower cylinders is mounted on the outboard side of the engine. There are three rows of cylinder intake and exhaust ports. The upper and lower rows of intake ports are equipped with stationary scavenging air check valves, six units per row of ports, which permit air to enter but prevent air from being expelled as the piston sweeps upward building up a cylinder pressure above that of scavenging pressure. This method of controlled scavenging may have a good advantage over the rotary valve type.

The engine crank shaft is equipped with a torsional vibration damper similar to the type used on all their multicylinder engines.

The engine reversing mechanism differs from their conventional type. The camshaft is not moved longitudinally. A lay-shaft carries, on eccentrically operated arms, two sets of cam rollers for the injection nozzles and air starting valves. Turning the lay shaft through 90° will change roller contact from the ahead to the astern cams or vice-versa. This operation can be performed hydraulically or by hand. The time required by power is approximately five seconds.

The engine is not provided with an exhaust pyrometer. Direct reading engine jacket water and lubricating oil temperature mercury thermometers are the only guide.

All necessary pumps are detached except the fuel oil service pump. Three lubricating oil pumps, one per engine, and one standby are located in the lower flats. The lubricating oil standby pump can be cross-connected and used as fuel transfer pump. Two large lubricating oil coolers are located between the two large sea water pumps and lubricating oil pumps. One DeLaval type lubricating oil purifier is provided for both engine lubricating oil sumps.

The evaporators have a capacity of five metric tons per day per unit on exhaust heat operation. When operating electrically heated the capacity drops to 0.75 metric tons per unit.

Engine speed equals propeller speed. The propeller drive lay-out is simple; two main engines, two positive jaw clutches, two main motors, one thrust bearing and one shaft friction brake per side. The tailshaft diameter is 300mm. The propellers are the 3-blade type, no information on pitch and prop diameter.

The main motor data is: 500 hp per motor at 220 V x 3710A, time limit 1½ hours. Maximum overload 1250 hp 220 V x 4710A for 10 minutes. Continuous rating 900 hp 220 V x 3300A. Minimum parallel load 380 hp 220 V x 1370A. Series maximum 420 hp 220 V x 1690A.

When used as a generator kw output:

430kw equals 240 V x 1790A
600kw equals 240 V x 2500A
850kw equals 250.290 V x 3400/2930A
600kw equals 340 V x 1765A
770kw equals 340 V x 2260A

When using only one of the two main motors 1500 amperes is maximum. Maximum field amperes 54. Maximum armature temperature 85°C. Field coil temperature maximum 90°C. Interpoles maximum 90°C. Commutator maximum temperature 90°C. The main motor maximum bearing temperature is 75°C. Four main motor air coolers are provided to handle the cooling air. Separate motor driven fans move the cooling air.

The following table is used for the various speed combinations:

	knots	r.p.m.
Slow speed	6	105
Half speed	9	130
Stbd. No. 1	12	170
Stbd. No. 2	14	200

No. 1 Battle speed	16	235
No. 2 Battle speed	18	270
No. 3 Battle speed	20	305
No. 4 Battle speed	21	340
Full speed	22	350
Back full	14, on engines	
Submerged speed	8, maximum	

The ship usually maneuvers on the main motors.

The forward and after battery compartments each contain 120 cells. Capacity 240 volts, 10,000 ampere hours for eight hours.

The ship is equipped with one auxiliary engine. This engine is identical to the 450kw Mitsubishi engines as described in the I-400 class boats with one exception, no "schnorkel" is installed on the I-36 to facilitate battery charging submerged.

G. HA-201 Class Submarines*

1. General Characteristics

The HA-210 type Japanese submarine was designed for mass production evidently to be used in coastal defense. It was manned by a crew of 3 officers and 19 men.

a. Principal dimensions:

Length - overall	53 meters
at W.L.	44.00 meters
Breadth - maximum	4 meters
at W.L.	3 meters
Height from keel to top of - bridge side plating	7.1 meters
periscope shears	7.94 meters
Pressure hull diameter	3.60 meters
Displacement - surface, standard	325 metric tons
submerged	440 metric tons
Surface, diving trim	376 metric tons
Mean draft	3.4 meters
Test depth	100 meters

The surface cruising range was 3,000 miles at 10 knots, with a maximum speed on the engine of 10.5 knots. Maximum submerged speed was 13 knots.

*Information obtained from inspection, instruction books, and interrogation.

b. Tank capacities:

Main Oil Tanks	Capacity (cubic meters)
#1,2	7.824
#3,4	9.606
#5,6	9.307
Gravity oil tank	0.150
Heavy oil separation tank	0.070
Heavy oil accumulation tank	0.519
Light oil gravity tank	0.300

Main Ballast Tanks	Capacity (tons)
#1	31.058
#2	14.658
#3	15.870

Port and Stbd Aux.	9.852
Negative (?)	3.642
Forward Trim	8.846
Aft Trim	4.070
Water Tank (?)	1.497
Lube oil tank	2.422 cubic meters
Oil collection tank (?)	1.182 cubic meters

2. Hull

The hull is primarily designed to cut down all water resistance in order to gain increased submerged speed. Topside fittings, including capstan, cable reels, anchor, etc., are recessed into superstructure deck.

The conning tower is narrow and streamlined. The width of the fairwater is determined by the width of the access trunk. The fairwater encloses the periscope, radar mast and "schnorkel" supports, and fuel header box.

The pressure hull is 14mm thick; it is constructed of six prefabricated welded sections. All sections are welded together except the forward and after ones, which are riveted. Access hatch and periscope trunks are secured to the hull by welded and riveted joints. All pressure hull framing is internal and of angle-bar type. Welding is average to poor. There is the usual Japanese type ballast keel.

Only two accesses are provided:

Torpedo loading hatch.
Conning tower trunk.

There is no water-tight bulkhead inside the submarine.

Compartment arrangement is as follows from forward to aft:

Torpedo room
Sound well
Radio and radar room
Control room and pump room
Engine room

405 liters of air at 250kg/cm2 are contained in four air bottles, two forward and two in the engine room.

Reducers are installed to provide the following pressures:

Engine air start	70kg/cm2	engine air start
Ship's service	50kg/cm2	impulse, WRT, Aux., whistle
Low pressure	12kg/cm2	tube doors and head

Main ballast tanks are blown with high pressure air when submerged, with engine exhaust when on the surface.

Main ballast tanks #1 and #3 are provided with hand operated kingston valves. #2 main ballast tank has flood openings. A single hand operated valve opens four kingston valves in #1 main ballast and a single hand operated valve opens two kingstons in #3 main ballast. #1 and #3 main ballast tanks have single vents, #2 main ballast has a double vent. #1 and #2 vents are operated by a hand wheel and shafting from the control room. #3 vent is operated separately by a hand wheel in the control room.

The trimming system connects forward trim tank, after trim tank, and auxiliary tank. The centrifugal pump is used to shift water internally and the reciprocating pump is used to pump water overboard. There is no trim manifold.

The drainage system is a single line running fore and aft with bilge suctions to all bilges. The trim and drain lines are cross-connected.

The diving planes (rudder area 2.08 square meters) are located amidships. They are operated by hand power through a pinion and worm gear. They can not be rigged in.

The stern planes (rudder area 4.10 square meters) are hydraulic power operated through shafting to the diving station. Hand operation can be used.

The rudder is divided, above and below the hull, and is operated by an electric motor. Hand power can be used. The upper rudder has a surface area of 1.25 square meters, the lower, 2.62 square meters.

Ground tackle, one 200kg anchor and 200 meters of 16mm wire, is man handled. There is a davit and hand capstan.

The periscope Type 88, 7 meters, Mk 4, Mod. 1, 10-1.5 magnification, is operated by electrically powered cable hoist with a stand-by hand hoist. Periscope bearing is transmitted electrically to the torpedo angle solver.

The radio antenna mast is similarly operated with remote control buttons in radio room.

Submarines subsequent to HA-215 have schnorkel which is hoisted by hand power through external gears and cable hoist.

The conning officer stands on a small circular platform about four feet above the control room deck. His head and shoulders extend into a trunk in the pressure hull which forms a semi-conning tower extending four feet, four inches above the pressure hull.

Hull ventilation is provided by one blower which takes a suction from both ends of the submarine. When submerged, the air may be forced through the air conditioning plant before being discharged into the control room. While on the surface the air is discharged to the control room or overboard via a canvas trunk up the hatch.

In HA-210 to HA-214 engine and hull air supply is through the hatch.

There is no refrigeration or commissary storeroom. The galley is a hot-plate and a basin behind the engine. There is no crews messroom. A small table with three stools in the after port corner of the battery compartment is the wardroom.

There is a head in the control room. Fortunately, it has a heavily dogged, rubber gasketed, air tight door.

3. Main power

The HA-201 submarine is direct drive with one main engine and one main motor on a single 5 3/8 inch shaft, and a cruising motor which delivers power to the main shaft by a belt drive. There are mechanical jaw clutches forward and aft of the main motor. The 3-bladed propeller has a diameter of 1.5 meters.

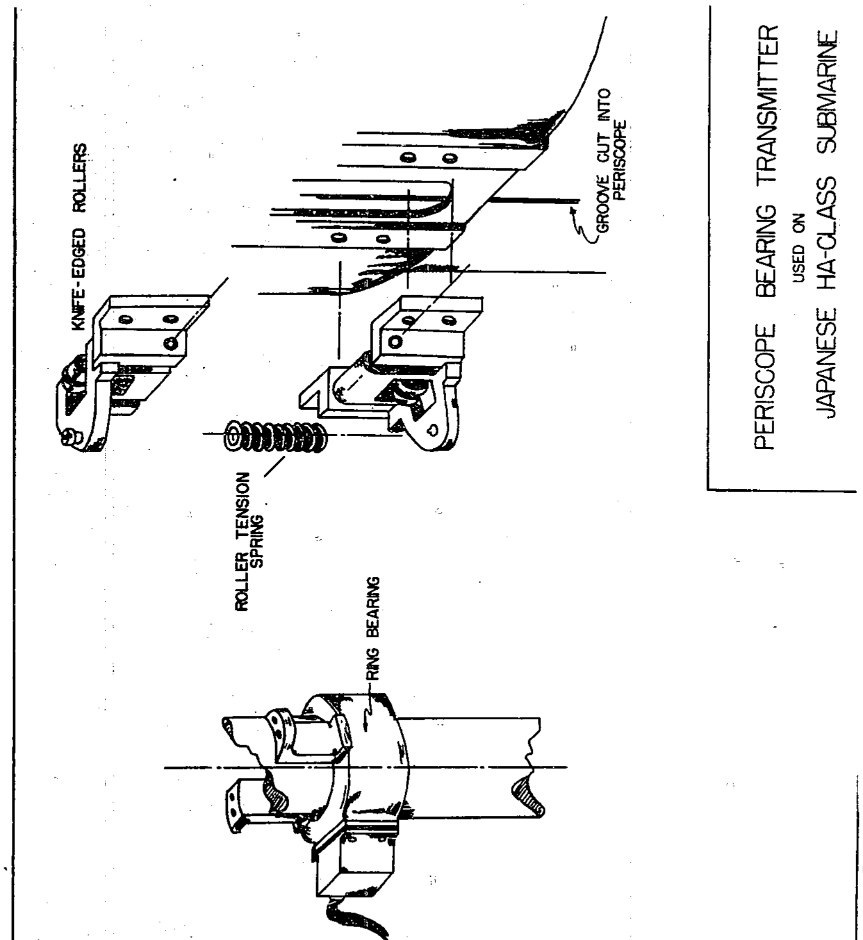

PERISCOPE BEARING TRANSMITTER
USED ON
JAPANESE HA-CLASS SUBMARINE
KNIFE-EDGED ROLLERS
GROOVE CUT INTO PERISCOPE
ROLLER TENSION SPRING
RING BEARING
SELSYN TRANSMITTER
AZIMUTH RING
EXPLANATORY NOTE:
Azimuth Ring rest on Ring Bearing which is fixed to hull. Two sets of Knife-Edged Rollers are installed on Azimuth Ring 180° apart. Adjustable shims are not shown.

Figure 196

Main Engine Characteristics

Type	four-cycle, single acting, non-reversible six-cylinder, solid injection diesel
b.h.p.	400 (charging 500)
r.p.m.	340 (charging 500)
Bore	300mm
Stroke	350mm
Maximum cylinder pressure	60kg/cm²
Weight	11 tons (approx)

The fuel transfer pump is the standby Lubeoil pump.

The engine may be started electrically or by air. The air starting spider is on the after end of the engine. There is no governor or overspeed trip on the engine.

The engine is salt water cooled.

The main engine exhaust can be used to blow main ballast when on the surface.

Surface Speed Table

Knots	r.p.m.	Knots	r.p.m.
4	180	8	295
5	205	9	335
6	230	10	375
7	250	11	415

The main motor is a double ended armature type, mounted directly on the main shaft aft of the main engine.

Main Motor Characteristics

Type	Special E. Model 1
Capacity	motor 1250 hp at 600 r.p.m., generator 330 kw at 500 r.p.m.
Volts	motor 218, generator 265-330
Amps	motor 4700 at one hour rate, generator 3500 continuous
r.p.m.	motor 600, generator 480
Field	shunt wound
Poles	ten

Each armature is cooled by a large separately driven centrifugal fan forcing air over the armature and through salt-water coolers in a closed system.

All motor and generator controls are on the power panel on the port side in the control room.

The cruising motor is a 32 hp motor located on port side of main shaft abaft main motor. It delivers power to the main shaft by means of a 12 belt "V-belt" drive. The driven pulley is concentric with the main shaft and may be clutched to the main shaft by a positive jaw type clutch through a quill shaft arrangement. When the cruising motor is being used for propulsion, the tail clutch between "V-belt" drive and main motor is disengaged.

Speed Combinations:

Cruising motor .... 90-230 r.p.m.
Main motor - series .... 180-400 r.p.m.
parallel .... 350-600 r.p.m.

Submerged Speed Table

Knots	r.p.m.	Knots	r.p.m.
1.5	90	7	325
2	115	8	365
2.5	135	9	410
3	155	10	450
4	200	11	500
5	240	12	540
6	280	13.3	600

According to the instruction book, HA-210 to HA-217 have Type 33 and all later boats Type 12 main storage battery. Each consists of 120 cells arranged in two groups, starboard and port, of 60 cells each, all connected in series. Cells in each group are arranged in four rows of 15 cells. Cells are lead-acid type, 2.0 volts each.

Type 33 Discharge Characteristics

Rate	Capacity	Amps	Low Volt Limit
40 hr	7,000	175	1.82
20 hr	6,800	340	1.82
8 hr	6,240	780	1.80
4 hr	5,720	1,430	1.74
2 hr	5,080	2,540	1.68
1 hr	4,250	4,250	1.50
50 min	4,030	4,836	1.50

Type 12 Discharge Characteristics

Rate	Capacity	Amps	Low Volt Limit
40 hr	5,800	145	1.82
20 hr	5,600	280	1.82
8 hr	5,000	625	1.80
4 hr	4,300	1,075	1.74
2 hr	3,500	1,750	1.68
1 hr	2,750	2,750	1.62

Charging Characteristics:

Rate is cut when voltage reaches 290. Finishing rate is held until voltage reaches 330.

Stopped

	500 hp Starting		400 hp.	
Voltage	265	295	265	295
Starting rate	1,240	1,120	1,000	900
Aux. load	100	100	100	100
Amps in battery	1,140	1,020	900	800

Underway

Speed	10	9	8	7	6	5	4
Generator starting rate - 265 V	200	300	350	350	325	265	210
Generator starting rate - 295 V	180	270	310	310	290	235	190

Aux. load - 100

Initial charge record sheet of HA-207 shows 1.300 sp. gr. Shore based battery shop personnel stated Japanese batteries have 1.260 to 1.280, usually the latter. Operating personnel in HA-207 reported 1.230 gravity and that they charged when gravity dropped 100 points. Initial gravity for only charged observed was 1.117. Final gravity was 1.230.

Power leads from the main battery are connected at cells No. 1 and 120, the outboard after cells in each group. Power cables lead directly to a panel in the control room with no disconnect switches.

There is a center tap between cells 60 and 61 which supplies 110 V current to electronic equipment.

Batteries were poorly wedged and a few cells had no apparent lateral support.

The battery has individual cell ventilation, a hydrogen burner and a hydrogen detector. There is a "No. of amp-hrs Remaining" gauge on the main control panel.

The hydrogen detector has a selector switch with five positions: off, zeroizer, each side of ventilation duct and the compartment.

Ventilation discharges to the control room or overboard via a canvas trunk up the hatch.

There are four battery water tanks about 14 x 14 x 6 next to the skin of the ship on the port side behind the bunks. Battery and fresh water tanks have the same filling connection.

There is a water purification unit between the fresh water tank and the battery water tanks. It contains charcoal. It is bypassed when battery water tanks are filled from outside the ship.

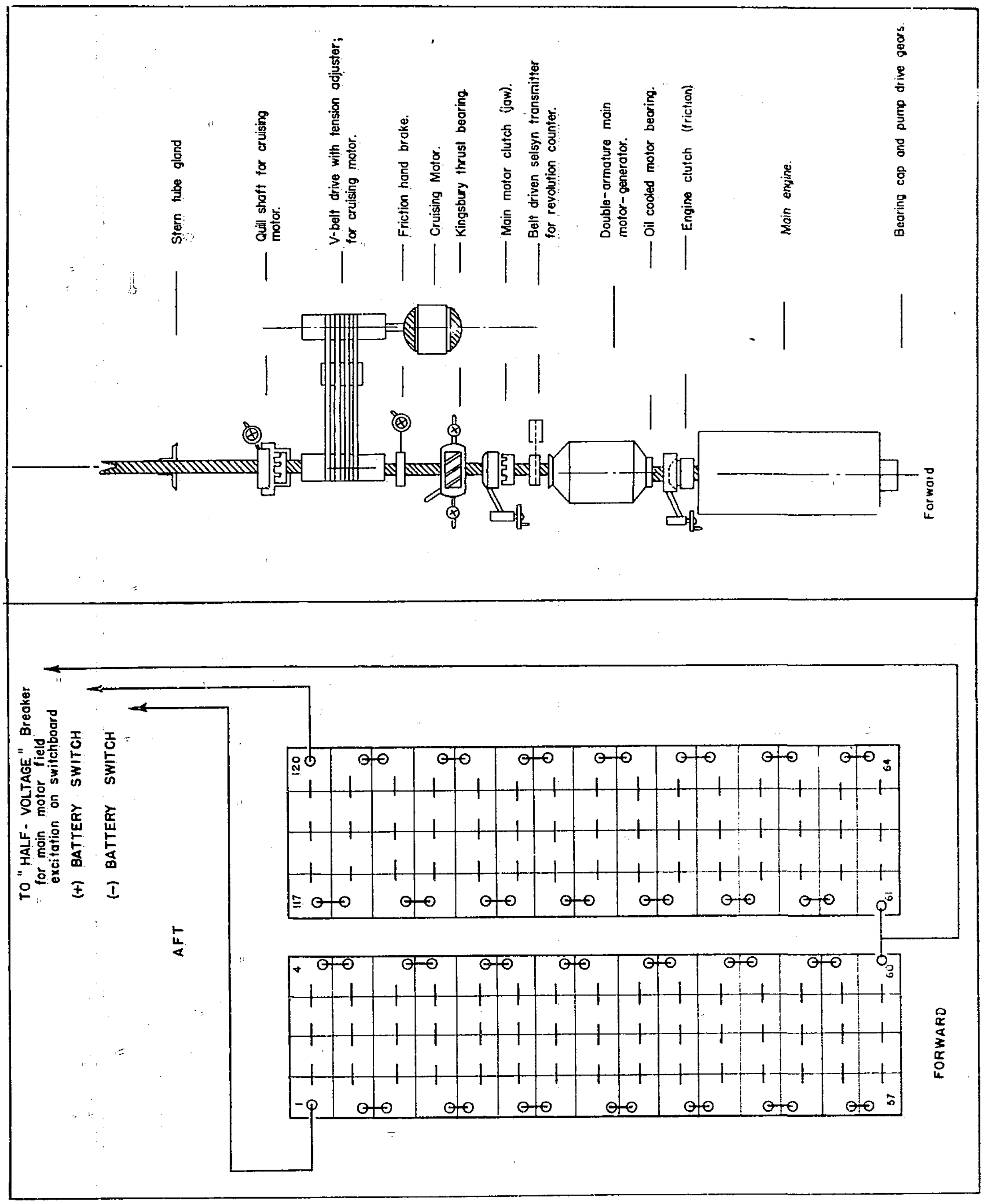


Figure 197

MAIN DRIVE AND SHAFTING IIA CLASS SUBMARINE

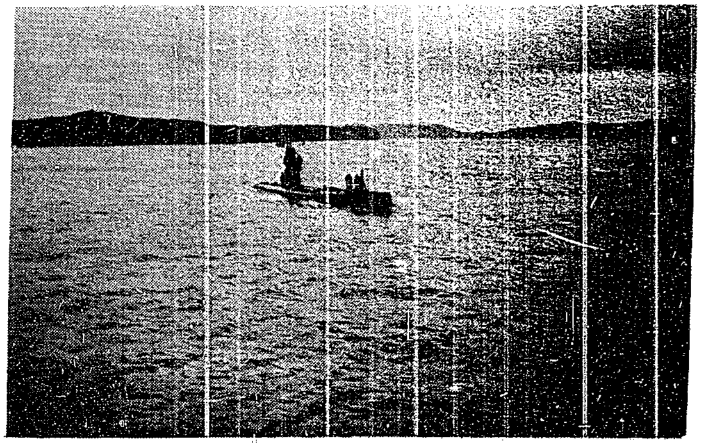


Figure 198
HA-201, OBLIQUE VIEW

Figure 199
HA-201, BRIDGE STRUCTURE

DECLASSIFIED

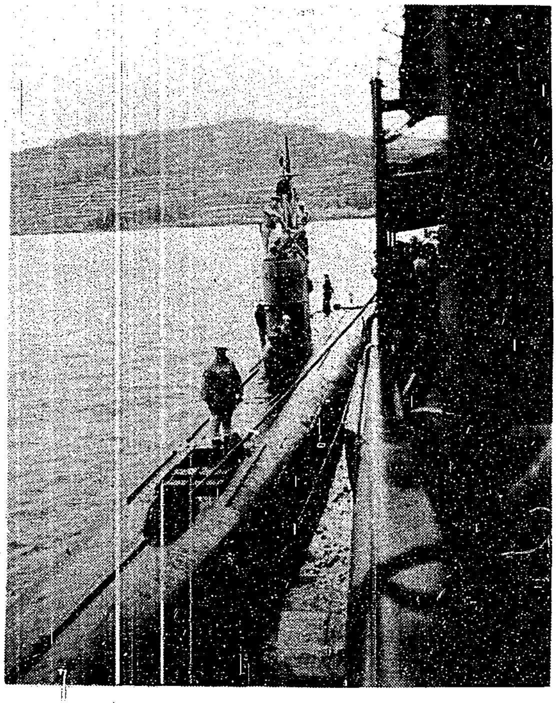
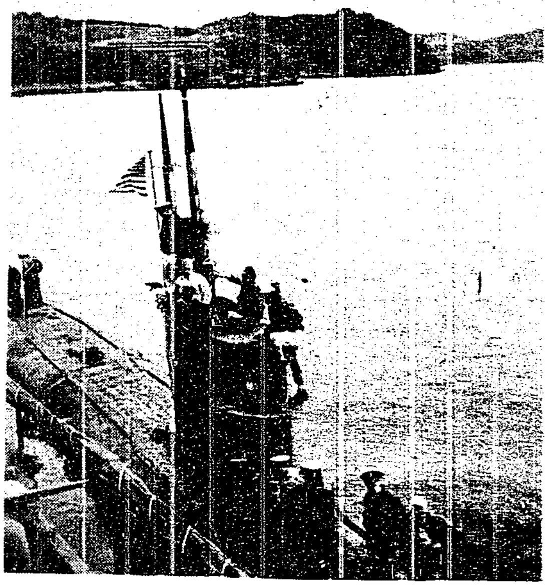


Figure 200

Figure 201



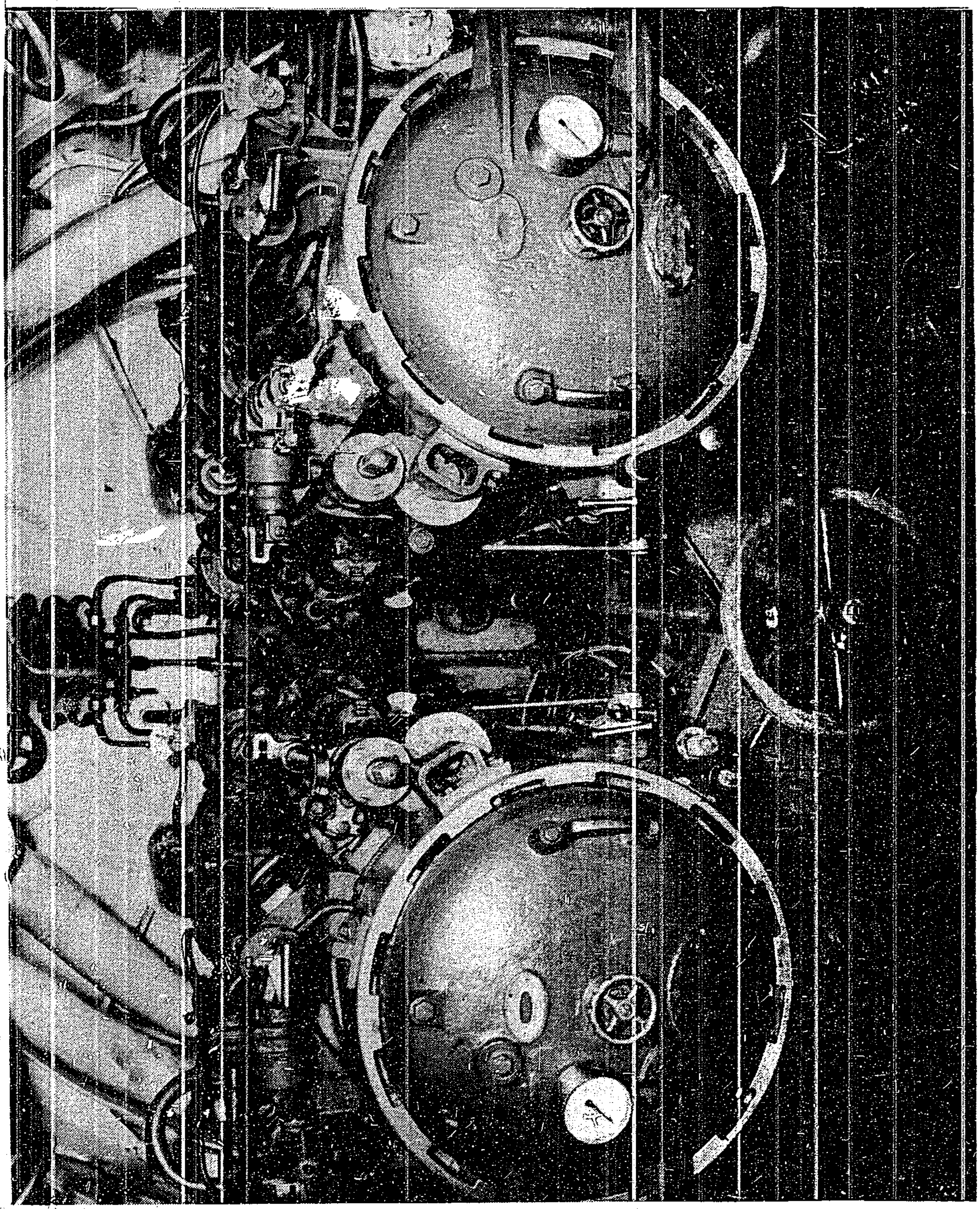


Figure 202
HA-201 CLASS, TORPEDO TUBE NEST

Figure 203
INTERIOR OF TORPEDO TUBE

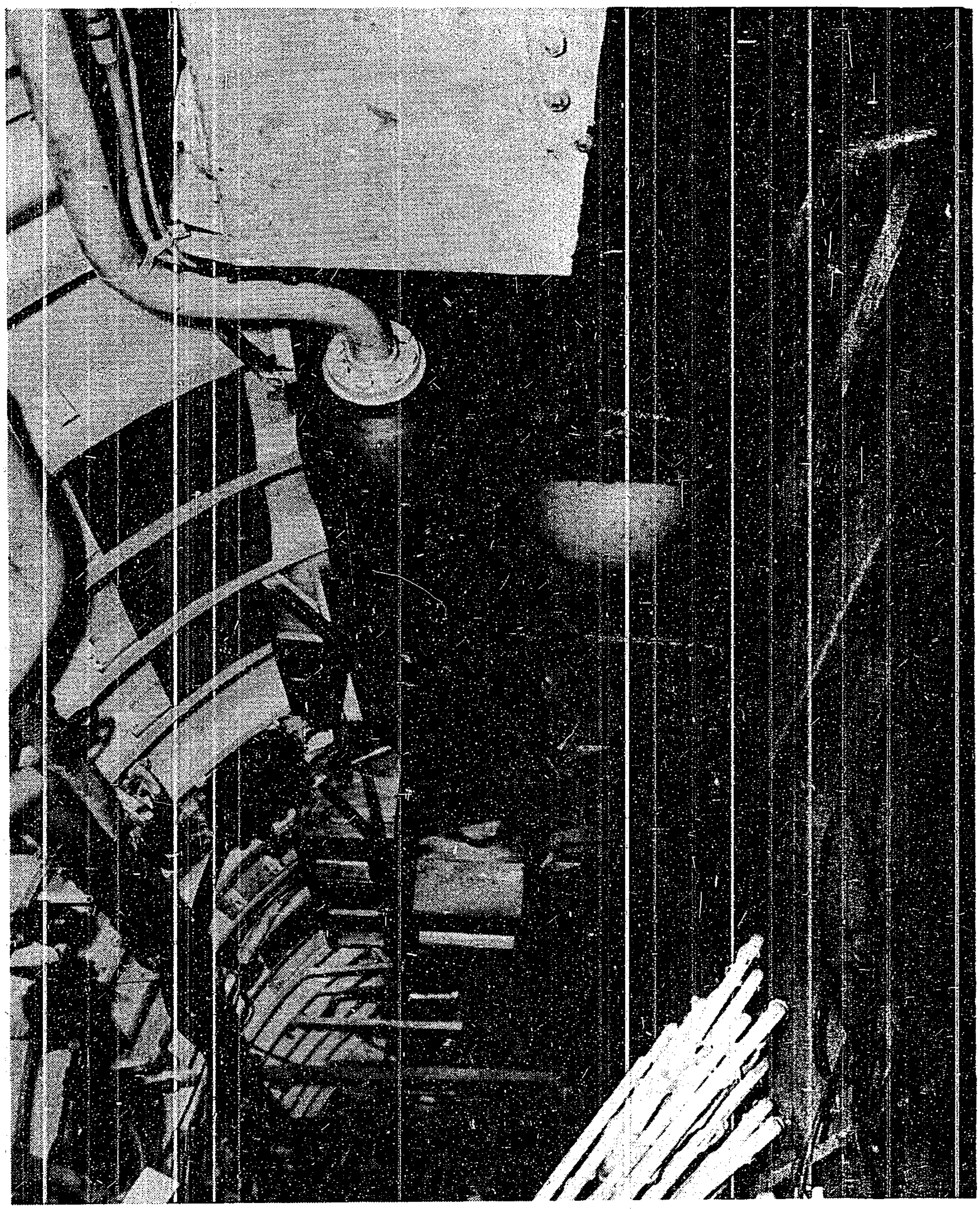


Figure 204

HA-201 CLASS, LOOKING AFT FROM TORPEDO TUBES

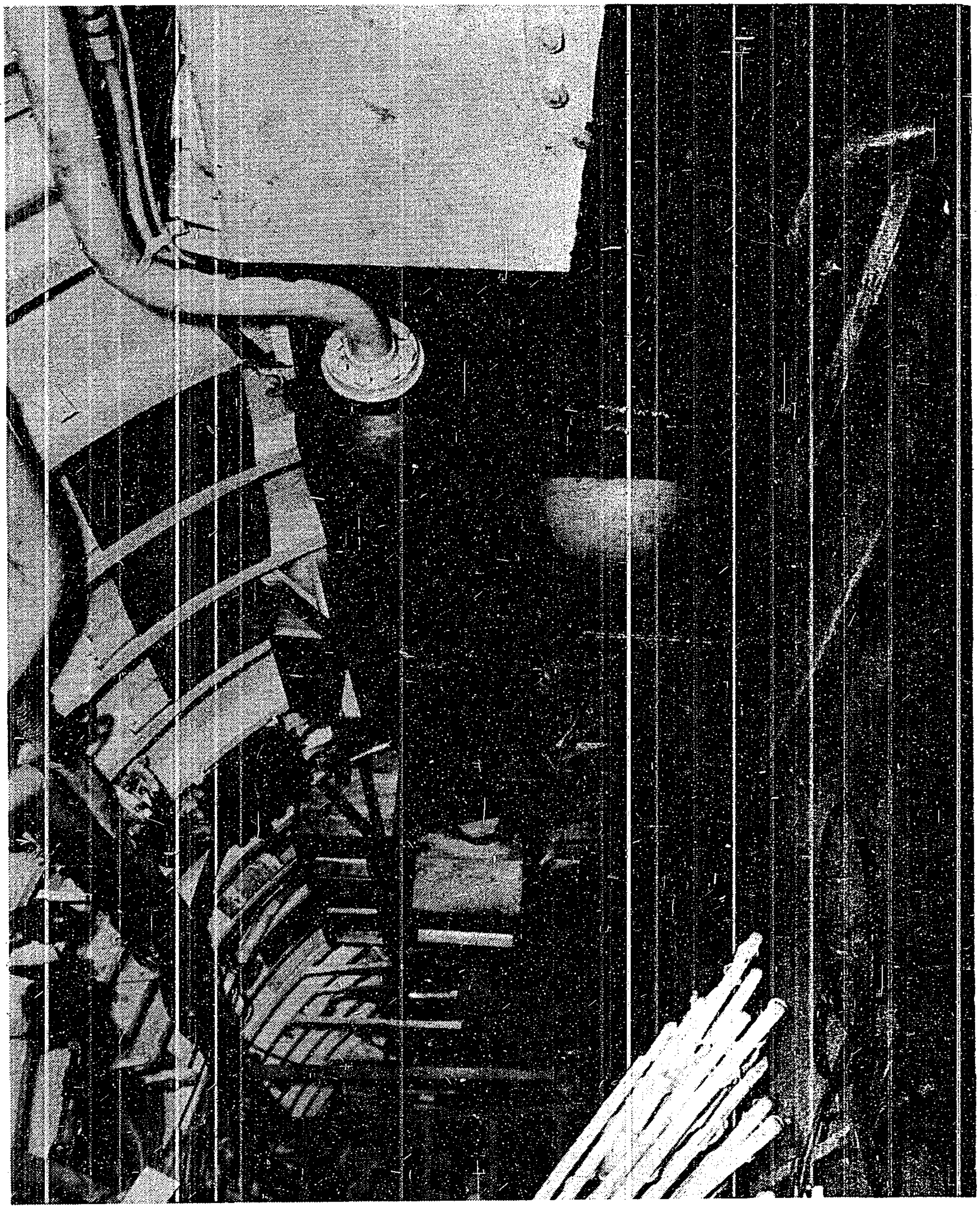


Figure 204
HA-201 CLASS, LOOKING AFT FROM TORPEDO TUBES

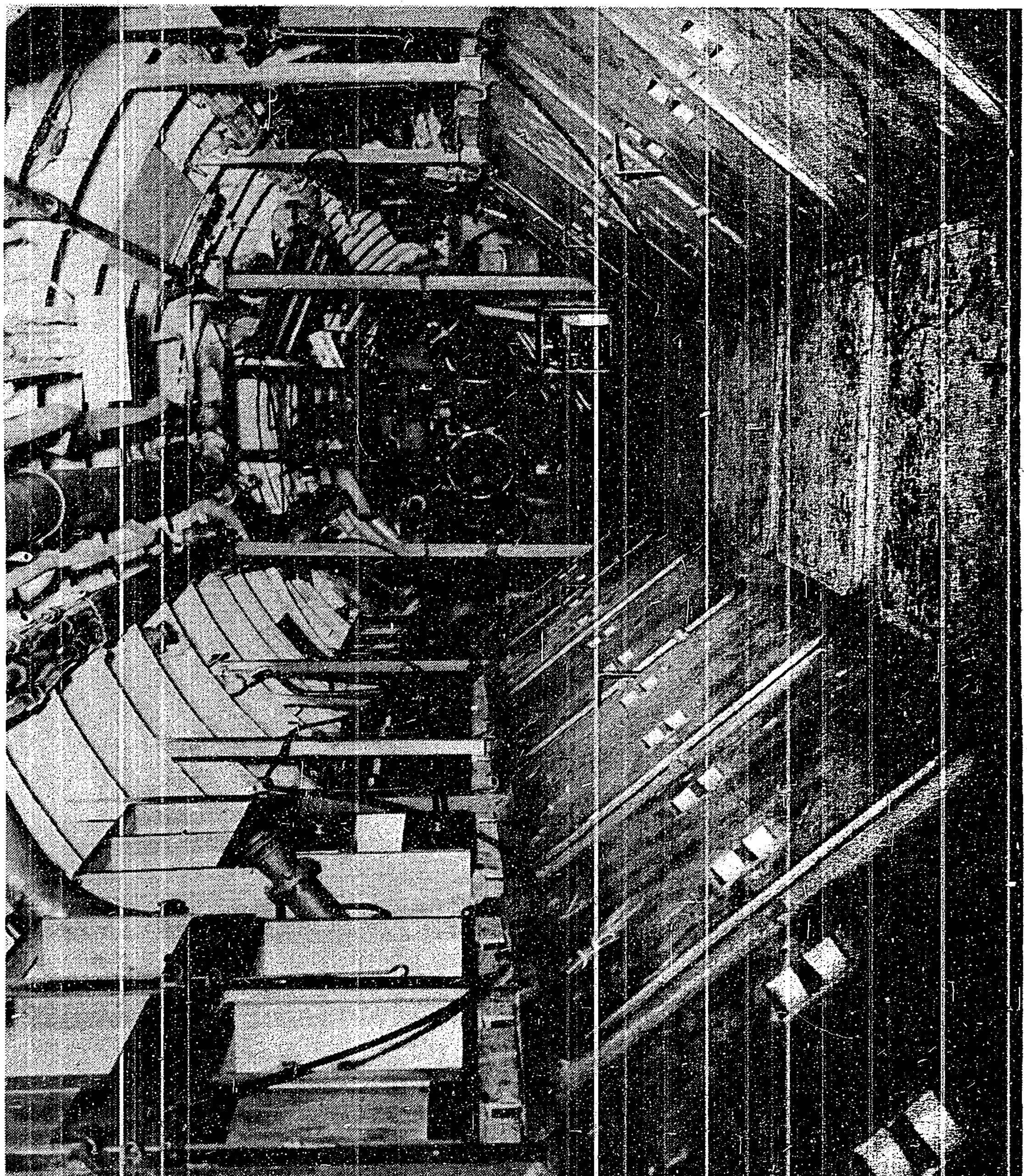


Figure 205
HA-201 CLASS, LOOKING FORWARD FROM AFTER END OF BATTERY

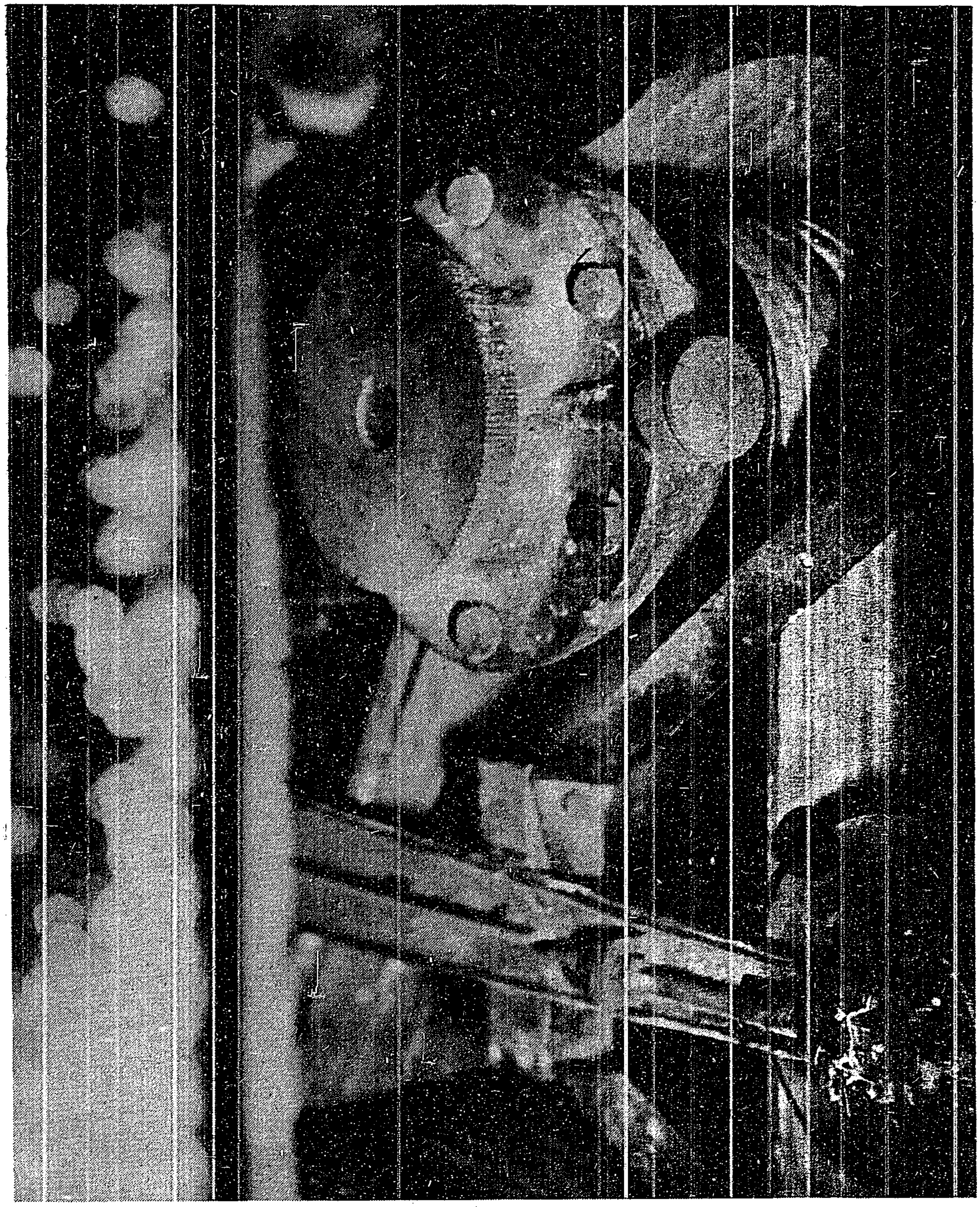


Figure 206

HA-201 CLASS, V-BELT DRIVE FOR CRUISING MOTOR

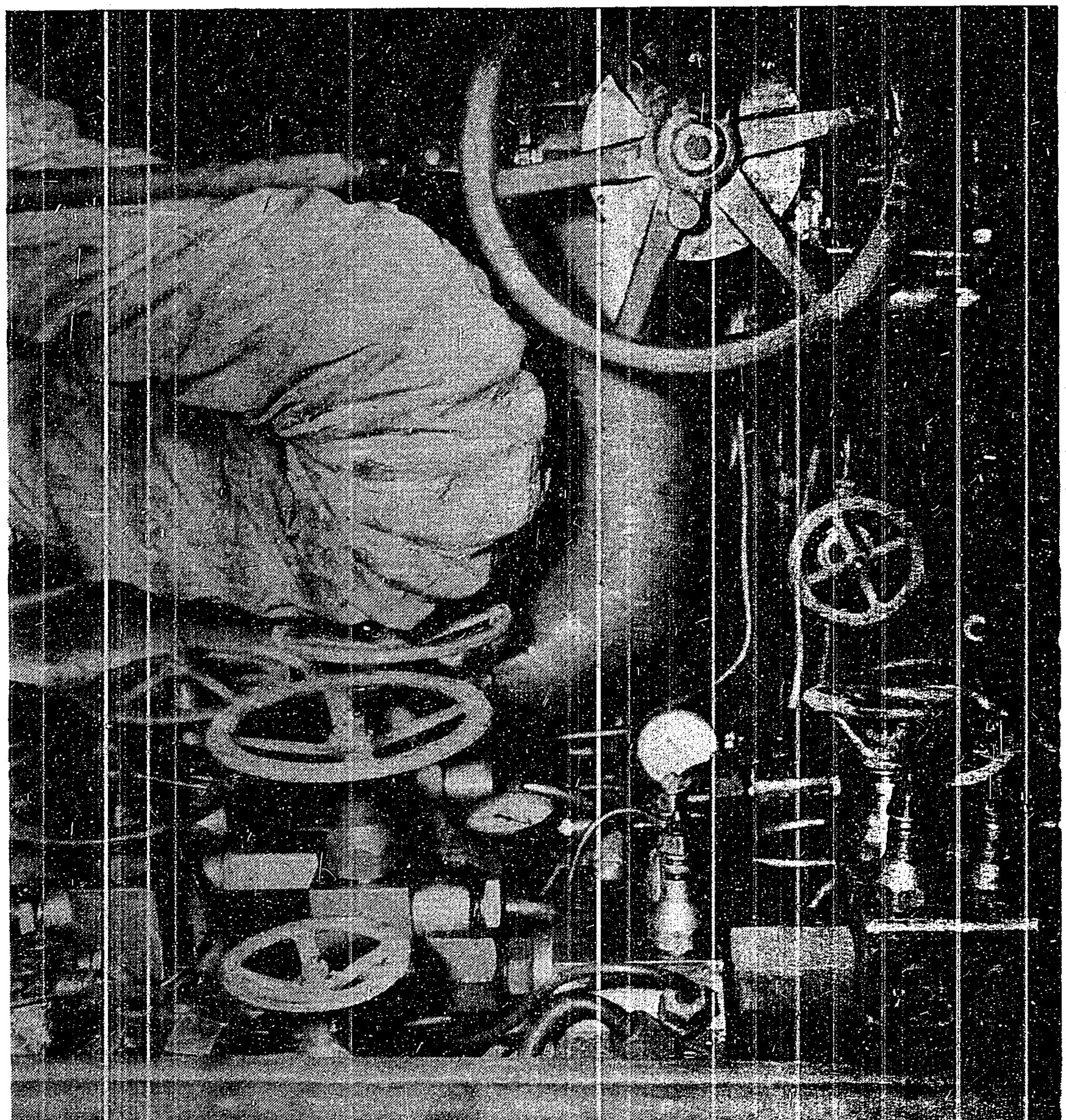


Figure 207
HA-201 CLASS, AIR MANIFOLD

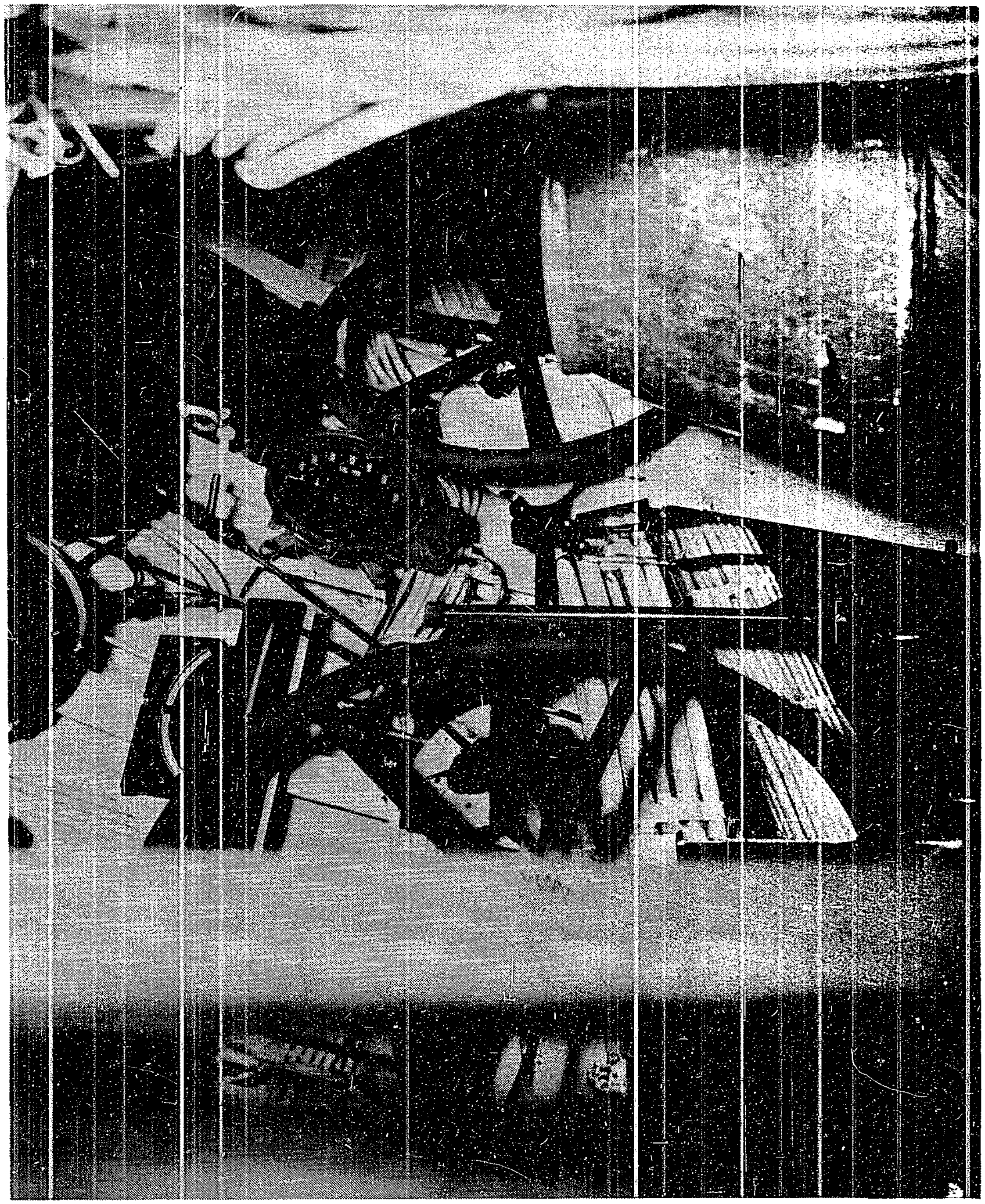


Figure 208
HA-201 CLASS, DIVING STATION

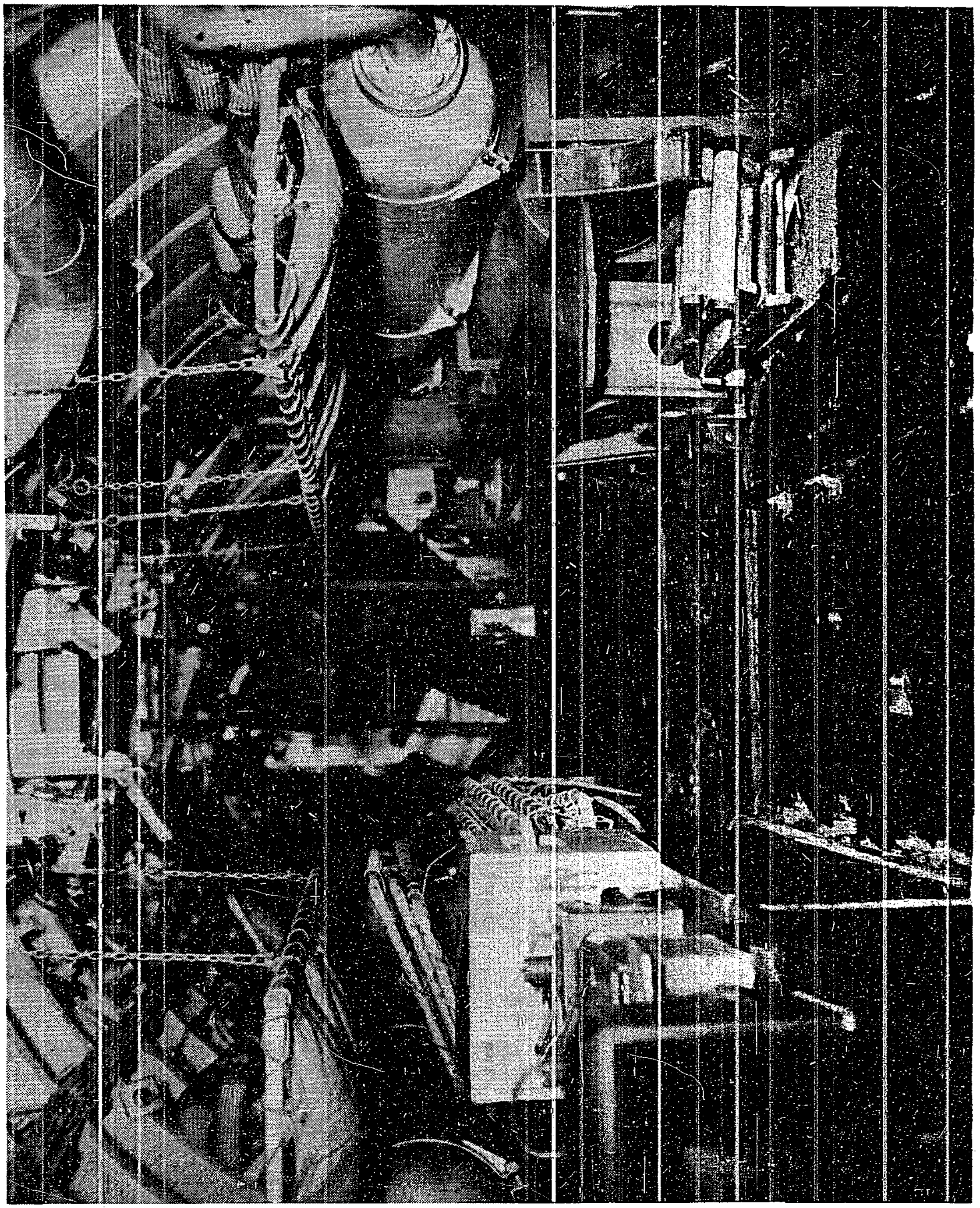


Figure 209
HA-201 CLASS, LOOKING AFT FROM TUBES

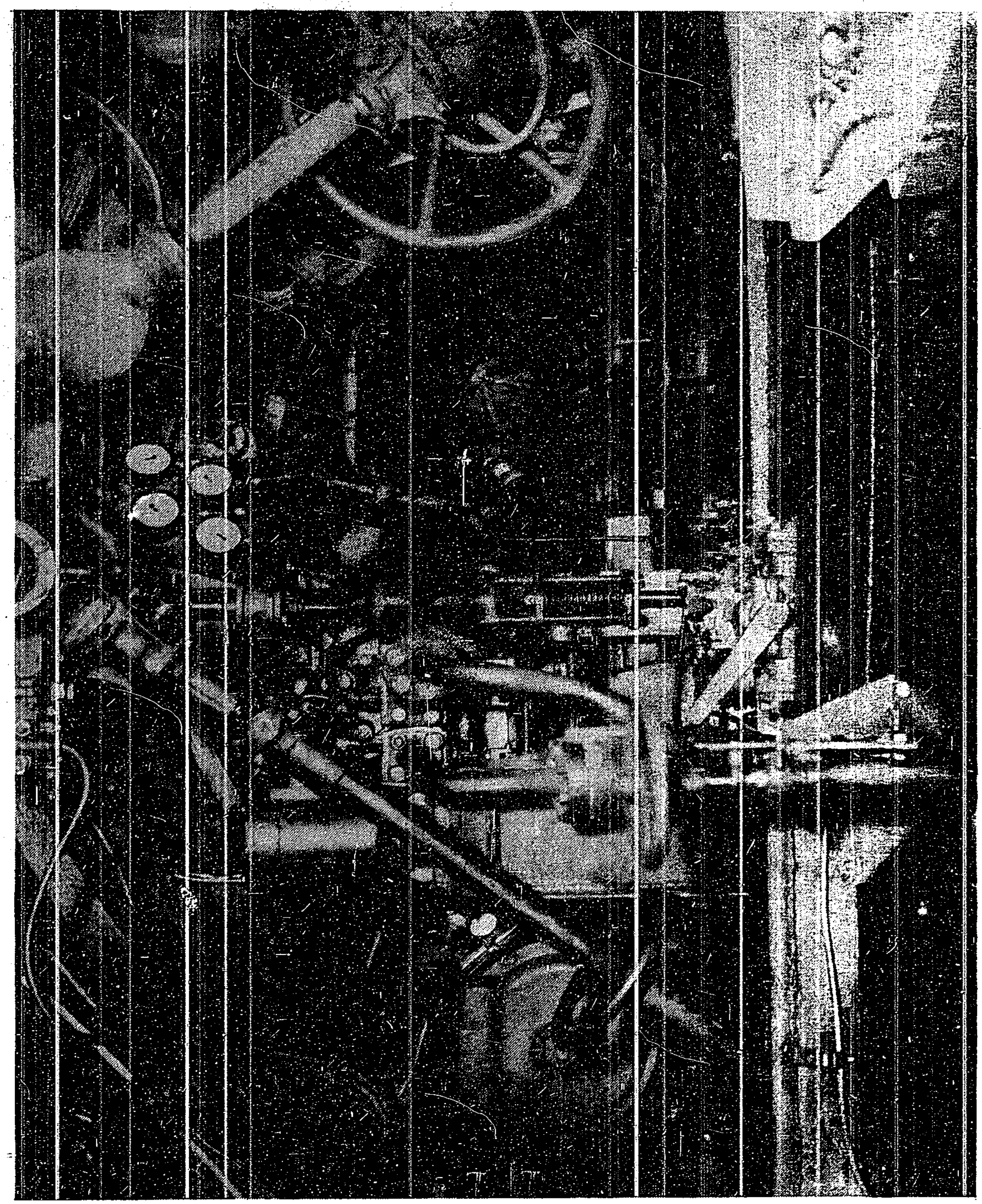


Figure 210
HA-201 CLASS, STEERING MOTOR

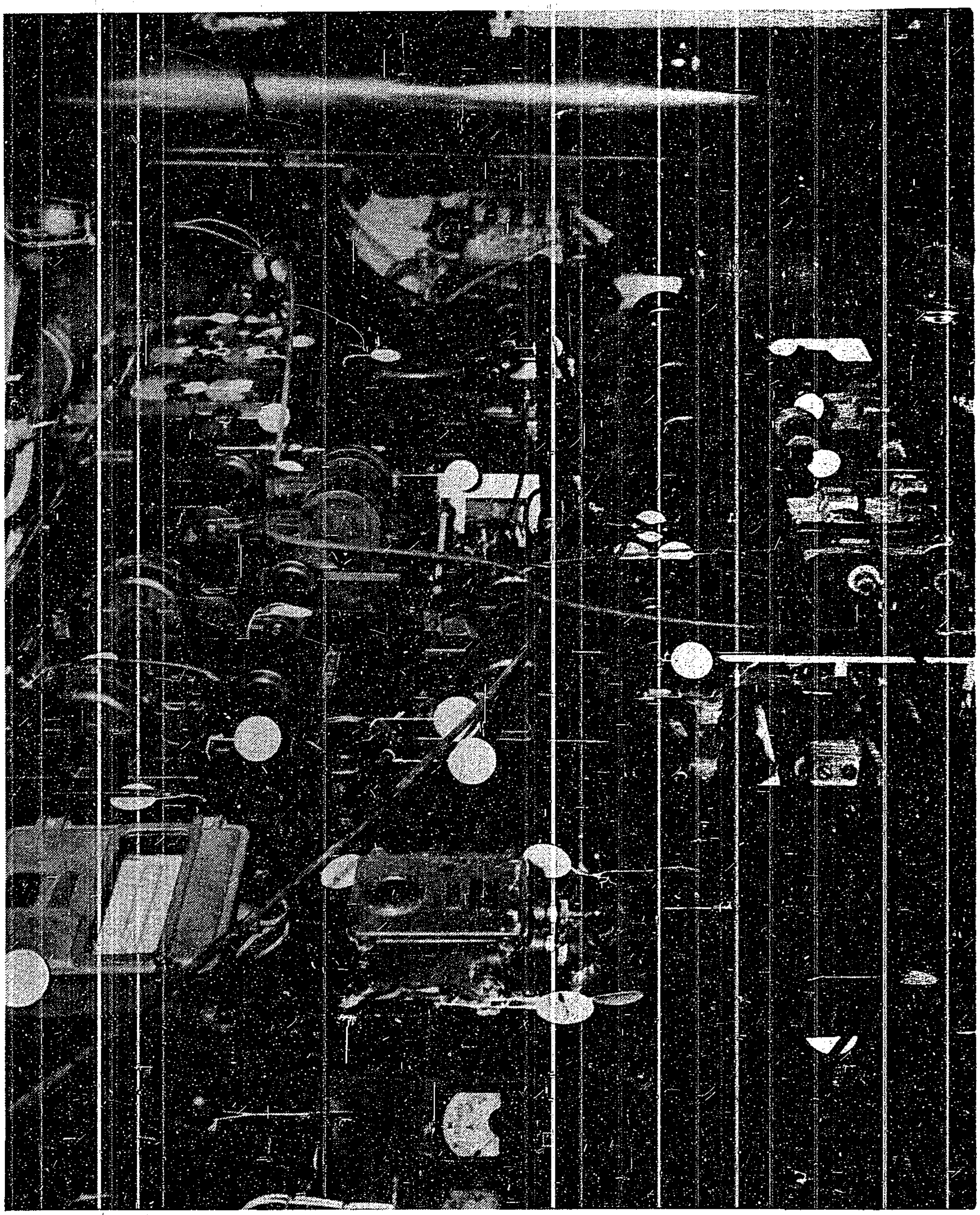


Figure 211
HA-201 CLASS, MAIN CONTROL PANEL

S-01-7

DECLASSIFIED

Part V - Miscellaneous Reports

A. Japanese Production Methods.

A survey of machine production and tooling at the Yokosuka Submarine Base shows the following:

1. Fixtures and jigs as used in the U.S. for production of quantity were not in use; however, the machines in the shops were so placed that each phase of production for each item had only to be moved to the next machine for completion.

2. The precision tools were of American and Swedish patent design of Japanese make. The power tools of mostly English origin, and the milling machine, turret lathe, etc., made by such companies as Brown & Sharp, Landis, and Gisholt, all American concerns.

3. Very little care was given the finish of the products. More care was given rather to accurate dimensions and performance of the finished parts.

4. The graduations of all precision tools were metric. Of these precision tools there was an abundance. In many cases, the tool cribs were stacked better than the tool cribs of many large American machine shops.

5. Inspection of cutters, etc., showed that great care was taken to use these cutters to the utmost of their efficiency and length of service. In many cases, flutes were ground and relined in order to use them far beyond the limits the manufacturer intended.

6. Very little rust or deterioration was found in the shops, even those that had been housed in caves in the hills back of the base. They all showed distinct proof of very recent use, and of production having been stopped suddenly.

B. Celestial Objects Observation Calculator.

1. The Japanese submarines I-400, I-401, and I-14 were equipped with an observation calculator manufactured by the Yokosuka Arsenal Navigation or Instrument Experimental Department. Essentially, the instrument solves the astronomical triangle mechanically by means of a system of calibrated scales and arcs so that a celestial object's position may be fixed. That is, three dimension movement is obtainable and the location of the observed body is set on what might be imagined as a celestial sphere. Having observed a celestial body by sextant, the navigator computes the local hour angle, determines the declination, and assumes a latitude. The instrument then takes the place of any system of navigation as HA-214, or Ageton, so set as to determine the computed altitude and azimuth. The inputs of local hour angle, declination and latitude may be set on the instrument in a matter of several minutes depending on mechanical skill of the operator, and the computed altitude and azimuth may be read instantly. A series of sights previously computed by HA-214 were checked on this instrument and average error in computed altitude was about one minute (i.e., one mile) and azimuths were correct to nearest degree.

2. Description of Instrument: The instrument is permanently mounted in a wooden case 11 inches x 11 inches x 14 inches. Referring to sketch, showing two views, a calibrated disk or plate (A) is free to rotate about a vertical axis by means of an Endless Tangent Screw. This perfect circular disk is calibrated in degrees from 360 to 180 and 0 to 180. A vernier on the screw enables operator to set local hour angle to nearest minute (vernier calibrated 0 to 60). Fifteen seconds could be easily estimated. A declination scale (c) consisting of an arc is mounted with

its axis thru center of disk A. Movement of A swings arc C with its plane perpendicular to plane of disk A. Another disk B (latitude scale) is mounted with its axis perpendicular to axis of arc C and disk A. Fixed to disk B is an arc D and an arc E for altitude and azimuth respectively. The axis of these arcs remain parallel to plane of disk B at all times and any rotation of disk B rotates axis of arcs D and E. Further, the axis of D is fixed perpendicular to axis of E. A vernier and eyepiece on arcs C and D are free to move and may be locked in position and properly matched together by noting a small unit in eyepiece of D is concentric with a small circle of eyepiece C. The latitude scale B is marked 0 to 90° north and south with endless tangent vernier 0 to 60 minutes. The declination scale C is marked from 0 to 80° north and south with traveling endless tangent vernier 0 to 60 minutes. A marker fixed on arc D enables azimuth to be read to nearest degree on scale E.

3. Thus, the instrument is capable of three dimensional positioning of a point in space (the eyepieces aligned). This point represents the observed body on a celestial sphere. Given the local hour angle which includes the assumed longitude, an assumed latitude, and a declination of a star, sun, moon, or planet, the object is fixed and it can have but one correct altitude and azimuth.

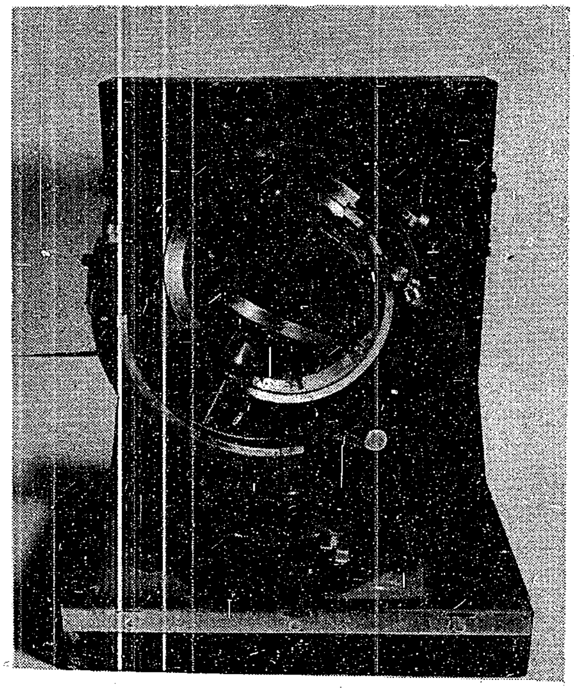


Figure 212

CELESTIAL OBJECTS CALCULATOR, FRONT VIEW

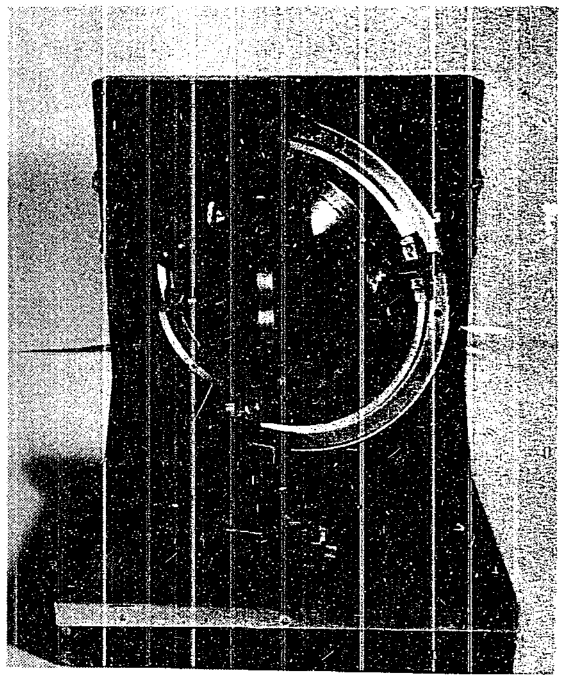


Figure 213

CELESTIAL OBJECTS CALCULATOR, FRONT VIEW

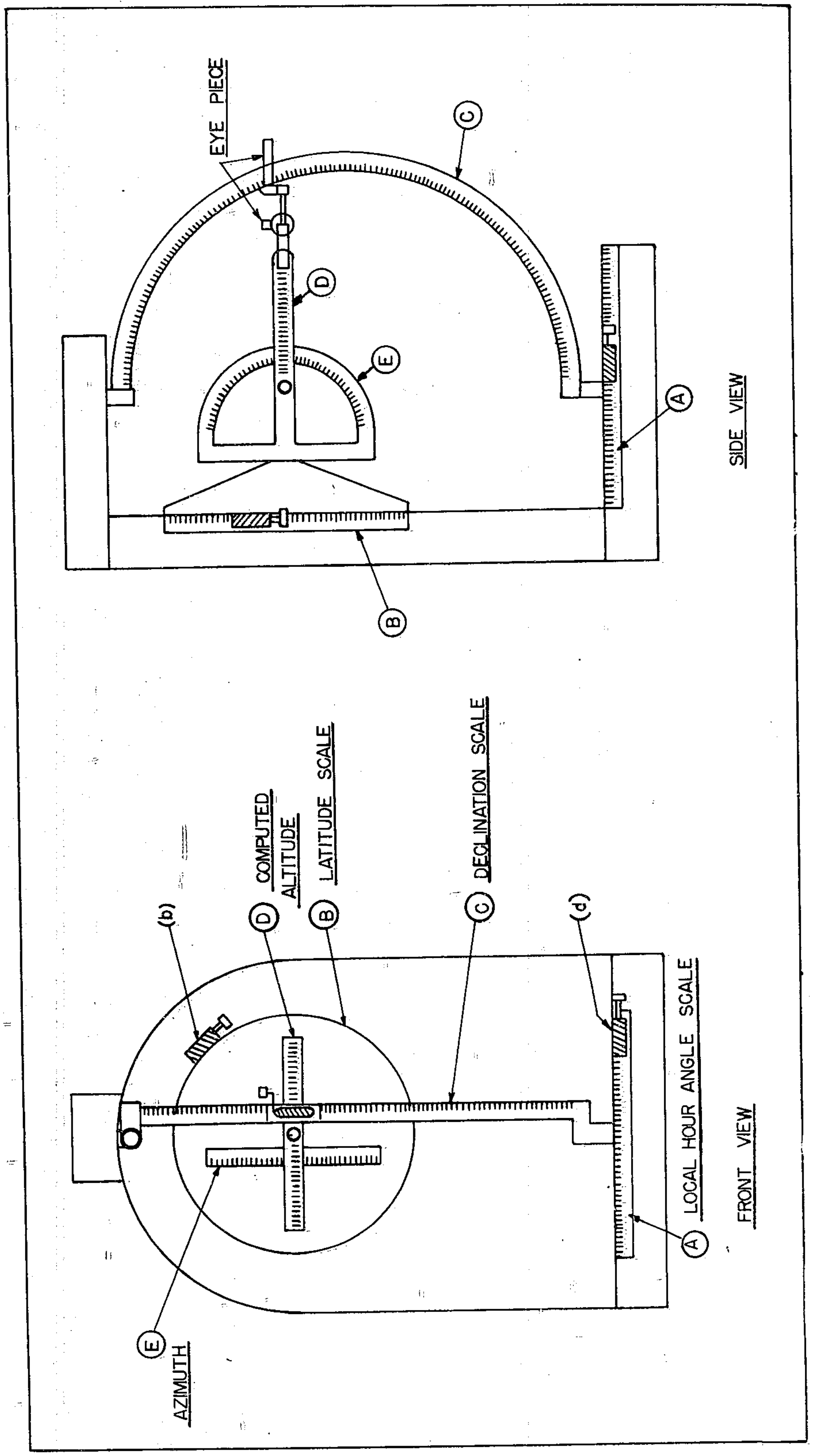


Figure 214

CELESTIAL OBJECTS CALWLATOR

C. Analysis of Electronic-Propeller Type Log

The Underwater Log as examined in our sample equipment and installed in the I-400, is electronic-mechanical. A sword arm extends a few feet through the hull, rigged by means of a chain fall and cable. This sword arm is of round cross-section, approximately three inches in diameter.

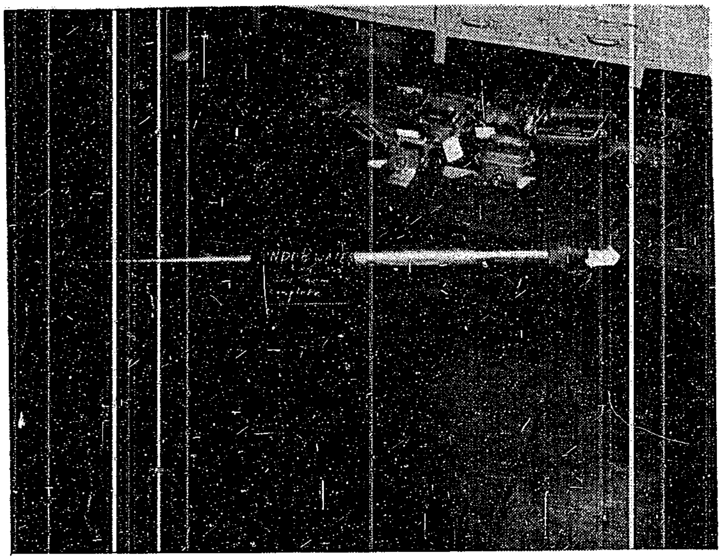


Figure 215
SWORD ARM

Contained in the end extending to sea is a small propeller.

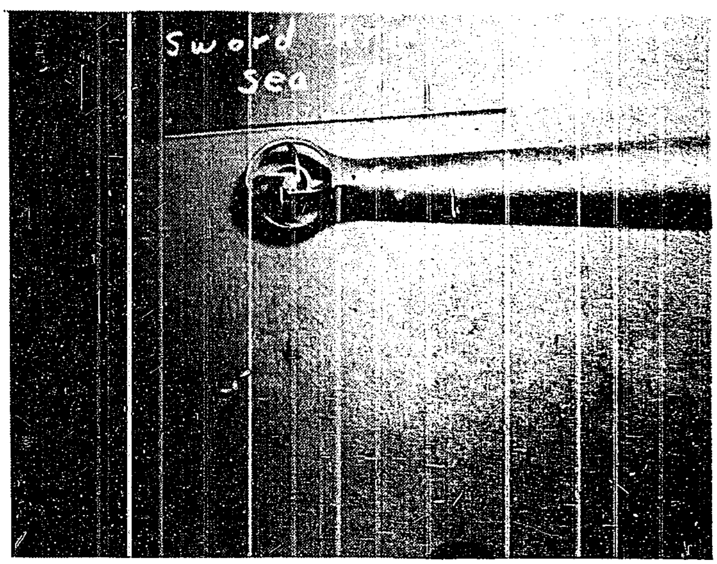


Figure 216
PROPELLER END OF SWORD ARM

Initial signal is received from the sword arm propeller. This propeller, when caused to rotate by vessel's movement through water, makes and breaks contact to ground each revolution. This pulsating make and break of contact is transmitted, through a single lead, from the sword arm to the grid input of an oscillator tube. Oscillation, or lack of oscillation, is dependent upon relative position of the propeller shaft in the sword arm.

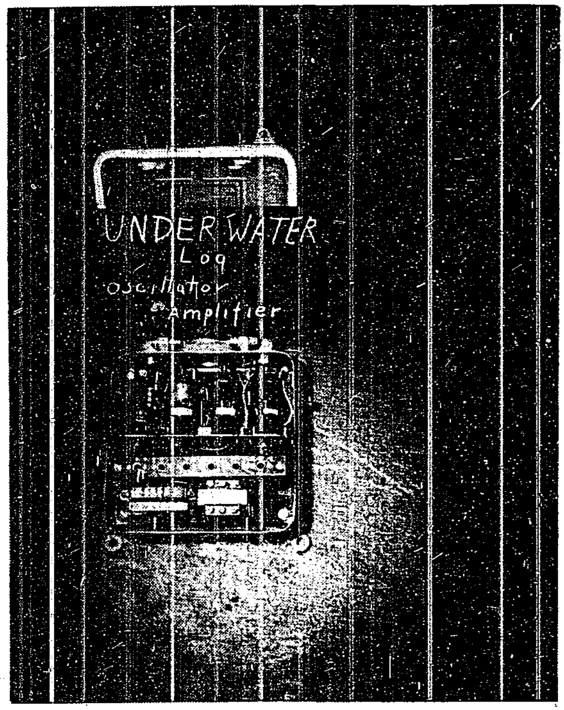


Figure 217
OSCILLATOR AMPLIFIER

Pulsating oscillations are then amplified through power output tubes and an output transformer. The amplified signal is transmitted to the windings of a polarized relay.

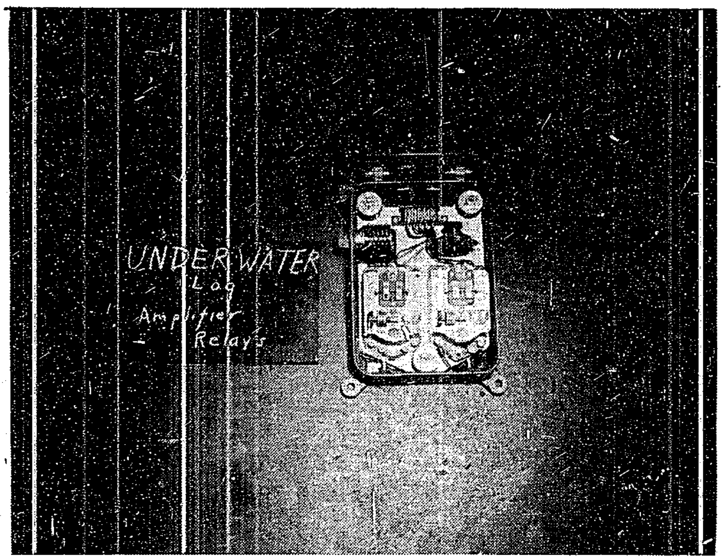


Figure 218
AMPLIFIER RELAYS

Contacts of this relay make and break a D.C. circuit to a small motor. A commutator on the motor shaft is so designed that every impulse of the polarized relay causes the motor to step a partial revolution, much the same as does a "step-by-step" motor.

The shaft of this motor is spring coupled to a gear train and differential. From the gear train, a small magneto is driven, the output voltage of which activates voltmeters calibrated in knots. Thus speed is obtained.

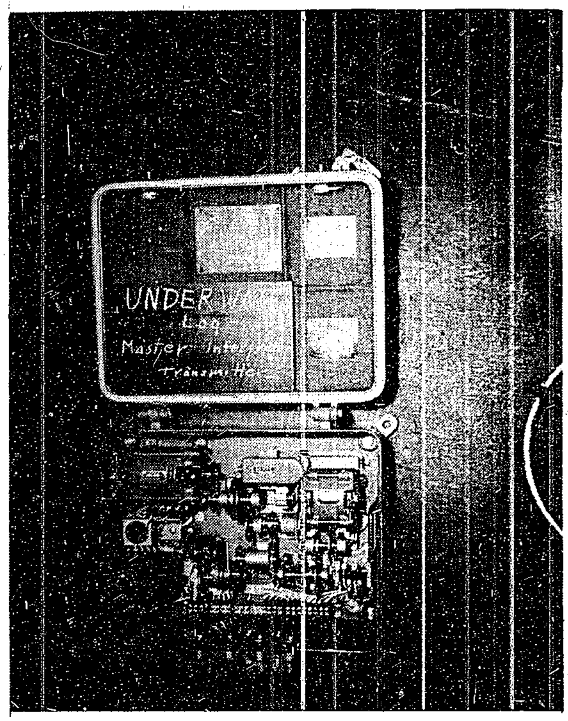


Figure 219

MASTER TRANSMITTER

The spider gear of this same gear train drives a selsyn transmitter operating on 50 volts-50 cyles. Transmissions are then piped to counters recording total nautical miles. Thus, distance is obtained.

Speed recordings are transmitted to knot calibrated repeater from the small magneto previously mentioned.

Distance is transmitted from counters, through step-by-step contacts to the vessel's Dead Reckoning Tracer (DRT) and distance repeaters.

Actual torque necessary in driving selsyn-transmitter and step-by-step contacts is supplied by a small motor attached to the main gear train through a mechanical differential. Outside torque may then be applied, via the differential, without disturbing original speed of the gear train.

Minor parts and their uses in the system follow:

Rotary switch starting panel, facilitating operation of the system from either of two power sources.

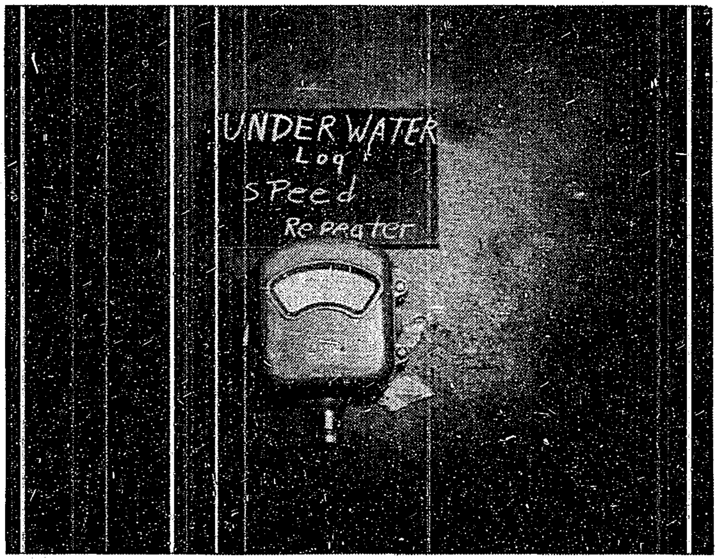
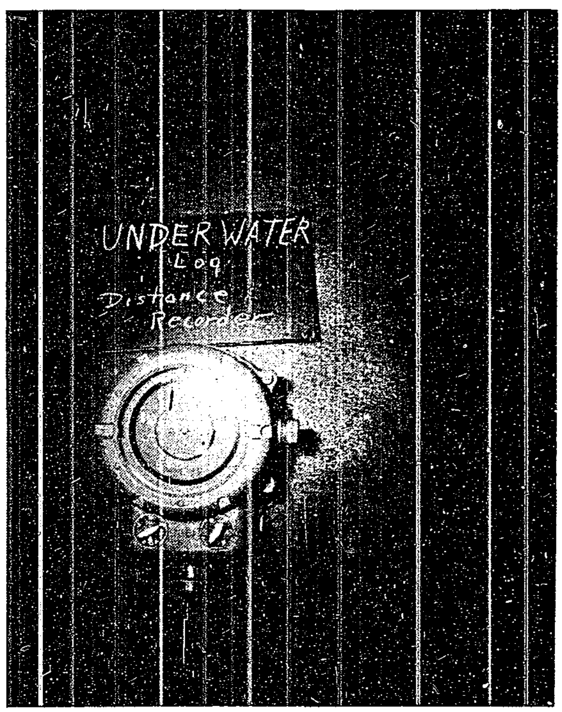


Figure 220
SPEED REPEATER

Figure 221
DISTANCE RECORDER



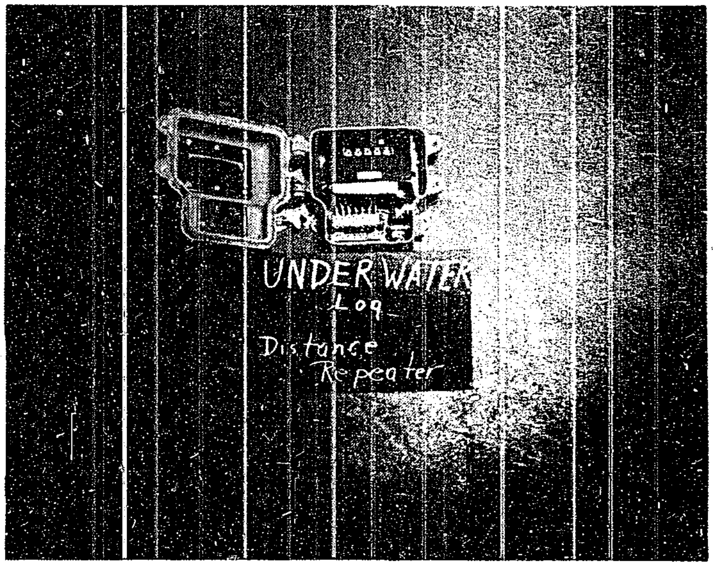


Figure 222
DISTANCE REPEATER

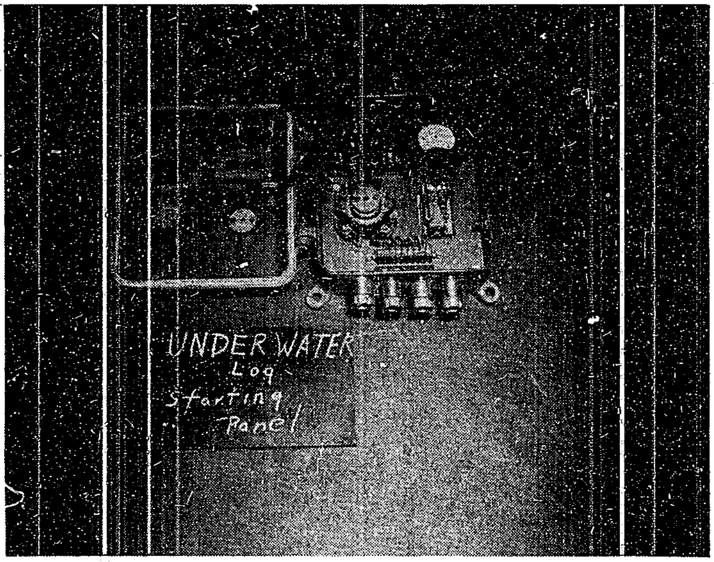


Figure 223
STARTING PANEL

Voltage dividers, developing the voltages necessary for operation of the system by splitting 100V motor generator output.

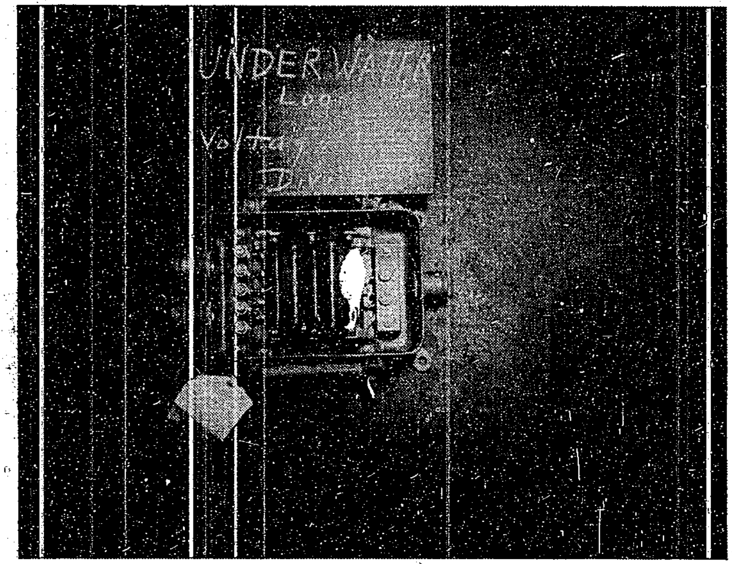


Figure 224
VOLTAGE DIVIDER

Fuse panel, for the several circuits of this equipment, and the 50 volts-50 cycle output transformer.

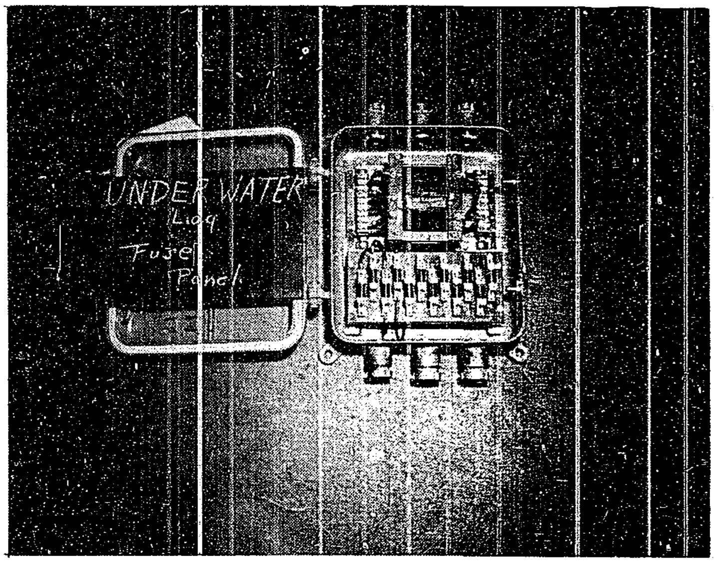


Figure 225
FUSE PANEL

The method used in this log, i.e., obtaining a signal from movement through the water, differs greatly from the method adopt-l in either Pit or Bendix Logs.

Integration is very similar. Construction and design are very satisfactory. The theory appears sound.

This activity has observed also, a few logs apparently identical in theory and operation with Bendix Log, though miniature in comparison. Models examined were 40 knot units approximately 1/3 the size of our 25 knot Bendix equipment. These logs are machined and finished to a higher degree than any Bendix Log worked with.

ENCLOSURE (A)

LIST OF DOCUMENTS FROM SUBRON 20 SHIPPED TO WASHINGTON DOCUMENT CENTER

JAPANESE TORPEDO DOCUMENTS - NavTechJap Document No. ND-50-1159 ATIS Document No. 3283

Torpedo Record Books

ND-50-1159.1	6th Year Type	1
ND-50-1159.2	8th Year Type	1
ND-50-1159.3	Type 2	4
ND-50-1159.4	Type 2 Special	11
ND-50-1159.5	Type 89	12
ND-50-1159.6	Type 90	10
ND-50-1159.7	Type 92, Mod. 1	2
ND-50-1159.8	Type 91, Mod. 2	26
ND-50-1159.9	Type 91, Mod. 3 Special	8
ND-50-1159.10	Type 93, Mod. 1	5
ND-50-1159.11	Type 93, Mod. 3	3
ND-50-1159.12	Type 94	2
ND-50-1159.13	Type 95, Mod. 2	4
ND-50-1159.14	Various Obsolete "Fish-shaped Torpedoes"	12

Torpedo Gyro Record Books

ND-50-1159.15	4th Year	8
ND-50-1159.16	4th Year, Mod. 2	21
ND-50-1159.17	Type 4	2
ND-50-1159.18	Type 2	5
ND-50-1159.19	Type 92	18
ND-50-1159.20	Type 92, Mod. 2	9
ND-50-1159.21	Type 91	26
ND-50-1159.22	Type 98	2
ND-50-1159.23	Type 98, Mod. 1	10
ND-50-1159.24	Explanation Book For the "Specially Attached Warhead of the Type 89 Torpedo"	1
ND-50-1159.25	Firing Records, Mod. 90 Torpedo	1 set
ND-50-1159.26	Torpedo Engine Test (blank)	1

Overhaul and Adjustment Records for the Following Torpedoes:

ND-50-1159.27	6th Year Type	Approximately	25
ND-50-1159.28	8th Year, Mod. 2	Approximately	10
ND-50-1159.29	8th Year	Approximately	10
ND-50-1159.30	Type 91	Approximately	10
ND-50-1159.31	Type 91, Mod. 3	Approximately	15
ND-50-1159.32	Type 2	Approximately	10

DOCUMENTS - NavTechJap Document No. ND-50-1160 ATIS Document No. 3284

ND-50-1160.1	Monthly Wage and Hour Record, 1941	1
ND-50-1160.2	Nav. Inst. (Aux) Insulation Resistance Compilation Log	1
ND-50-1160.3	Storage Battery Working Manual	1
ND-50-1160.4	Algebra Geometry Triangulation, I-14	7
ND-50-1160.5	#2 Compression Pump Op. Log	1
ND-50-1160.6	Electricity Instruction Books	1
ND-50-1160.7	Practical Wireless Manual, I-14	1
ND-50-1160.8	Engine Room Watch Record	1
ND-50-1160.9	Electrical Handbook - Navy Engineer School	1
ND-50-1160.10	Electrical Department Breakdown Record	1

ENCLOSURE (A), continued

ND-50-1160.11	Record Book for Intercepted Signals, I-14 (Blank)	1
ND-50-1160.12	Electrical Installations and Instructions I-14	1
ND-50-1160.13	d.c. Motor Used with Special Mod. 8	1
ND-50-1160.14	Cooling System and Storage Battery Instructions	1
ND-50-1160.15	Standard Condition Operation Record, I-14	1
ND-50-1160.16	#4 Air Compression Pump, Op. Log (Elect. Dept.)	1
ND-50-1160.17	Electrical Appliances, I-14	1
ND-50-1160.18	Applied Electricity Instruction Book	1
ND-50-1160.19	Elementary Electricity Notebook	1
ND-50-1160.20	Electrical School Notes	1
ND-50-1160.21	Radar Detector Log (Blank)	2
ND-50-1160.22	#3 Pump Op. Log	1
ND-50-1160.23	#1 Compression Pump Op. Log	1

INDEX OF CAPTURED PRINTS, DOCUMENTS, AND PUBLICATIONS

A. TORPEDOES AND ORDNANCE, GENERAL:

1. Firing Doctrine (Plans, Methods, Tactics) Tables: - NavTechJap Document No. ND-50-1161 ATIS Document No. 3285

		Index No.
ND-50-1161.1	S/M Torpedo Type 89, anti-capital ship, opposite course	T-1
ND-50-1161.2	S/M Torpedo Type 89, anti-cruiser, same course, bow shot	T-10
ND-50-1161.3	Plan (D), anti-capital ship, stern shots	T-3
ND-50-1161.4	Plan (D), anti-capital ship, stern shots	T-4
ND-50-1161.5	Plan (B), anti-capital ship, stern shots	T-6
ND-50-1161.6	S/M Torpedo Type 95, anti-capital ship, opposite course, bow shots	T-7
ND-50-1161.7	S/M Torpedo Type 95, anti-cruiser, same course, bow shot	T-8
ND-50-1161.8	S/M Torpedo Type 95, anti-cruiser, opposite course, bow shot	T-9
ND-50-1161.9	S/M Torpedo Type 95, anti-capital ship, same course, bow shot	T-13
ND-50-1161.10	S/M Torpedo Type 95, anti-cruiser, opposite course, bow shot	T-14
ND-50-1161.11	Special Plans, anti-capital ship, broadside MOT	T-2
ND-50-1161.12	Special Plans, anti-capital ship, broadside MOT	T-5
ND-50-1161.13	Special Plans, anti-capital ship, broadside MOT	T-12
ND-50-1161.14	Special Plans, anti-capital ship, broadside MOT	T-15
ND-50-1161.15	Plan (D), anti-capital ship, bow and stern shots	T-11

2. Firing Angle Charts: - NavTechJap Document No. ND-50-1162 ATIS Document No. 3286

		Target Speed	Range	Index No.
ND-50-1162.1	S/M Torpedo, "6 year type" (1940)	14 knots		A-1
ND-50-1162.2	S/M Torpedo, "6 year type" (1940)	16 knots		A-2
ND-50-1162.3	S/M Torpedo, "6 year type" (1940)	18 knots		A-3
ND-50-1162.4	S/M Torpedo, "6 year type" (1940)	20 knots		A-4

ENCLOSURE (A), continued

ND-50-1162.5	S/M Torpedo, "6 year type" (1940)	24 knots		A-5
ND-50-1162.6	S/M Torpedo, "6 year type" (1940)	26 knots		A-6
ND-50-1162.7	S/M Torpedo, Type 89 (45K) June 1940	12 knots	6000m	A-14
ND-50-1162.8	S/M Torpedo, Type 89 (45K) June 1940	18 knots	6000m	A-15
ND-50-1162.9	S/M Torpedo, Type 89 (45K) June 1940	20 knots	6000m	A-16
ND-50-1162.10	S/M Torpedo, Type 89 (45K) June 1940	20 knots	6000m	A-16
ND-50-1162.11	S/M Torpedo, Type 89 (45K) June 1940	22 knots	6000m	A-17
ND-50-1162.12	S/M Torpedo, Type 89 (45K) June 1940	22 knots	6000m	A-17
ND-50-1162.13	S/M Torpedo, Type 89 (45K) June 1940	22 knots	6000m	A-17
ND-50-1162.14	S/M Torpedo, Type 92 (no date)	6 knots		A-7
ND-50-1162.15	S/M Torpedo, Type 92 (no date)	6 knots		A-8
ND-50-1162.16	S/M Torpedo, Type 92 (no date)	8 knots		A-9
ND-50-1162.17	S/M Torpedo, Type 92 (no date)	10 knots		A-10
ND-50-1162.18	S/M Torpedo, Type 92 (no date)	12 knots		A-11
ND-50-1162.19	S/M Torpedo, Type 92 (no date)	12 knots		A-12
ND-50-1162.20	S/M Torpedo, Type 92 (no date)	16 knots		A-13
ND-50-1162.21	S/M Torpedo, Type 95 (4 copies)	12 knots		A-18
ND-50-1162.22	S/M Torpedo, Type 95 (4 copies)	14 knots		A-19
ND-50-1162.23	S/M Torpedo, Type 95 (4 copies)	16 knots		A-20
ND-50-1162.24	S/M Torpedo, Type 95 (3 copies)	18 knots		A-21
ND-50-1162.25	S/M Torpedo, Type 95	20 knots		A-22
ND-50-1162.26	S/M Torpedo, Type 95	22 knots		A-23
ND-50-1162.27	S/M Torpedo, Type 95	28 knots		A-24

3. <u>Firing Problem Tables:</u> — Index No.
   - NavTechJap Document No. ND-50-1163 ATIS Document No. 3287

ND-50-1163.1	1929	F-1
ND-50-1163.2	1933	F-3
ND-50-1163.3	1935	F-2
ND-50-1163.4	S/M Torpedo Type 95, anti-capital ship, June 1941 (11 copies)	F-5
ND-50-1163.5	S/M Torpedo Type 95, anti-cruiser, June 1941 (13 copies)	F-6
ND-50-1163.6	S/M Torpedo Type 95, anti-capital ship, June 1941 (3 copies)	F-7
ND-50-1163.7	S/M Torpedo Type 95, anti-cruiser, June 1941 (5 copies)	F-8
ND-50-1163.8	Table Supplement, anti-capital ship	F-4

4. <u>Record Books:</u>
   - NavTechJap Document No. ND-50-1159 ATIS Document No. 3283

ND-50-1159.27	Torpedo Gyro (23)
ND-50-1159.28	Torpedo "fish like" (20)
ND-50-1159.29	Torpedo, "6 year type" (1)

5. <u>Ordnance Blueprints: Design, Construction, and Assembly:</u>
   - NavTechJap Document No. ND-50-1164 ATIS Document No. 3288

ENCLOSURE (A), continued

ND-50-1164.1	Powder filling device	133
ND-50-1164.2	Battery, for electronic motored Floating Mine, YOKOSUKA Type, Mod. 1	6

6. Torpedo Battery Blueprints: Design, Construction, and Assembly: - NavTechJap Document No. ND-50-1165 ATIS Document No. 3289

ND-50-1165.1	Type 92 torpedo	62
ND-50-1165.2	Destroyer torpedo head, Mod. 1-2-3	64
ND-50-1165.3	Fittings, destroyer torpedo head starter	66

B. ELECTRICAL BLUEPRINTS: DESIGN, CONSTRUCTION, ASSEMBLY

1. Storage Batteries: - NavTechJap Document No. ND-50-1166 ATIS Document No. 3290

		Index No.
ND-50-1166.1	Prints #1 to 1000	25
ND-50-1166.2	Prints #2300 to 1300	26
ND-50-1166.3	Prints #1400 to 1500	12
ND-50-1166.4	Prints #1500 to 1700	19
ND-50-1166.5	Prints #2000 to 3000	65
ND-50-1166.6	Prints #2000 to 2100	13
ND-50-1166.7	Prints #2200 to 2300	28
ND-50-1166.8	Prints #2300 to 2400	10
ND-50-1166.9	Prints #2600 to 2900	21
ND-50-1166.10	Prints #2900 to 3000	11
ND-50-1166.11	Prints #3000 to 3500	4
ND-50-1166.12	Prints #4000 to 6000	71
ND-50-1166.13	Prints #5000 to 5200	27
ND-50-1166.14	Prints #5700 to 6300	3
ND-50-1166.15	Prints #6300 to 6700	8
ND-50-1166.16	Prints #6700	16
ND-50-1166.17	Mk. 1-2 (Prints #1000-3000)	1
ND-50-1166.18	Mk. 1 special mod.	22
ND-50-1166.19	Mk. 3	88
ND-50-1166.20	Mk. 3	139
ND-50-1166.21	Mk. 3 Mod. 11-12	17
ND-50-1166.22	Mk. 3 Mod. 16-17	176
ND-50-1166.23	Mk. 3 Mod. 18-19	14
ND-50-1166.24	Mk. 3 Mod. 22-23	122
ND-50-1166.25	Mk. 5	107
ND-50-1166.26	Special "D" Type	99
ND-50-1166.27	Model "M", Special "GOE" Model	182
ND-50-1166.28	Battery record, shore bases in South Pacific	128

2. Secondary Batteries: - NavTechJap Document No. ND-50-1167 ATIS Document No. 3291

		Index No.
ND-50-1167.1	Mk. 1 Mods. 1 through 6 (Prints #400-600)	112
ND-50-1167.2	Mk. 1 Mod. 2 (for I-class S/M)	109
ND-50-1167.3	Mk. 1 Mod. 2 - special	123
ND-50-1167.4	Mk. 1 Mod. 2 through 7	108
ND-50-1167.5	Mk. 3 Mod. 1	164
ND-50-1167.6	Mk. 3 Mod. 2	31
ND-50-1167.7	Mk. 3 Mod. 3	59

ENCLOSURE (A), continued

ND-50-1167.8	Mk. 3 Mod. 3	110
ND-50-1167.9	Mk. 3 Mod. 3 (Prints #50-100)	120
ND-50-1167.10	Mk. 3 Mod. 3 (Prints #100-150)	116
ND-50-1167.11	Mk. 3 Mod. 3	30
ND-50-1167.12	Mk. 3 Mod. 4	2
ND-50-1167.13	Mk. 3 Mod. 6-7	121
ND-50-1167.14	Mk. 3 Mod. 10	32
ND-50-1167.15	Mk. 3 Mod. 20-21	175
ND-50-1167.16	Mk. 3 Mod. 24	29
ND-50-1167.17	Mk. 3 Mod. 98	5
ND-50-1167.18	Mk. 5 Mod. 2	186
ND-50-1167.19	S/M Type, new model	9
ND-50-1167.20	I-23, and ventilation	201
ND-50-1167.21	For motor vehicles	24

3. <u>Miscellaneous Battery - Cells, Ventilation, Fittings, etc.</u>:
   - NavTechJap Document No. ND-50-1168 ATIS Document No. 3292

ND-50-1168.1	Aircraft battery, Mk. 3, Mods 21-22-23 and Air Mod. 3	82
ND-50-1168.2	Dry cells	23
ND-50-1168.3	Lead zinc cells	163
ND-50-1168.4	Battery exhaust, S/M (Prints #1-200)	15
ND-50-1168.5	Battery ventilation system and fittings S/M	114
ND-50-1168.6	Battery exhaust and ventilation, S/M	154
ND-50-1168.7	Battery ventilation, S/M	156
ND-50-1168.8	Secondary Battery, ventilation systems, Mk. 1 through 6	112
ND-50-1168.9	Battery terminals, fittings	119
ND-50-1168.10	Battery fittings and maintenance plans	91
ND-50-1168.11	Battery Assembly Tools, Mk. 1 Mod. 12-13-15	63
ND-50-1168.12	Battery tools, S/M	72
ND-50-1168.13	Battery tools, Mk. 1 Mod. 12-13	97
ND-50-1168.14	Battery water purifier, switchboard, etc.	87
ND-50-1168.15	Sulphuric acid regulator assembly	115
ND-50-1168.16	Seawater batteries, depth charge training, etc.	192

4. <u>Miscellaneous</u>:
   - NavTechJap Document No. ND-50-1169 ATIS Document No. 3293

		<u>Index No.</u>
ND-50-1169.1	Switches and relays, construction and assembly plans	67
ND-50-1169.2	Miscellaneous electrical circuits, systems	80
ND-50-1169.3	Amplifiers, circuit breakers, electrical assemblies	81
ND-50-1169.4	Magnetic detector, construction and assembly	88
ND-50-1169.5	Alarm systems, circuits	92
ND-50-1169.6	Ventilation testing systems	93
ND-50-1169.7	Motors, general arrangement, assembly, design	101
ND-50-1169.8	S/M Control-Bridge electrical circuits, system	126
ND-50-1169.9	Sound filters, antenna	142

ENCLOSURE (A), continued

ND-50-1169.10	Steering indicator, switchboards	155
ND-50-1169.11	Indicator panels, junction boxes, circuits	162
ND-50-1169.12	Electrical Underwater Log - Mod. 92	179
ND-50-1169.13	Miscellaneous small motors	187
ND-50-1169.14	I-44 - S/M electrical equipage - detail general arrangement	195
ND-50-1169.15	I-15, I-29, I-31 - S/M electrical systems	198
ND-50-1169.16	H. SS Class midget S/M electrical plans Oxygen and Hydrogen Testing Equipment	118

C. ENGINEERING AND HULL BLUEPRINTS:

1. Submarine, Assembly and Maintenance Blueprints and Publications: - NavTechJap Document No. ND-50-1170 ATIS Document No. 3294

		Index No.
ND-50-1170.1	I Class	1 bundle
ND-50-1170.2	SS Class (KORYU Class) 2-3 man	4 bundles
ND-50-1170.3	H Class (KAIRYU Class) 5 man	4 bundles

2. Miscellaneous Equipments, Design, Construction and Assembly: - NavTechJap Document No. ND-50-1170 ATIS Document No. 3294

ND-50-1170.4	Machine tools, various cutters	82
ND-50-1170.5	Assembly tools, Mk. 1 Mod. 14	106
ND-50-1170.6	Shaft Assembly, gastesting instrument engine bed layouts	105
ND-50-1170.7	Synthetic rubber fittings, mfg. plans	113
ND-50-1170.8	Gear and shaft (prints and tolerances)	130
ND-50-1170.9	Gear and shaft (prints and tolerances)	131
ND-50-1170.10	Anti-vibration mounts	157

3. Intelligence Publications and Materials in Communications Office Safe (USS PROTEUS): - NavTechJap Document No. ND-50-1171 ATIS Document No. 3295

ND-50-1171.1	Unidentified Instruction Book (I-14)
ND-50-1171.2	I-14 W.Q. & Station Bill
ND-50-1171.3	I-14 Ships Regulations
ND-50-1171.4	I-14 Standard Casualty Procedure
ND-50-1171.5	Machinery Allowance List I-14
ND-50-1171.6	Electrical Schematic (I-14)
ND-50-1171.7	Instruction Book for aircraft lauching (I-14)
ND-50-1171.8	Stowage of Aviation Gasoline on board submarines (I-14)
ND-50-1171.9	Inventory of equipment on three Japanese submarines at YOKOSUKA
ND-50-1171.10	Chart of Cargo carried by Submarines to outlying Japanese Bases.
ND-50-1171.11	Signal Book (Edition I)
ND-50-1171.12	Signal Book (Edition II)

D. NAVIGATIONAL: AEROLOGICAL: METEROLOGICAL BLUEPRINTS:

Note: Asterisk (*) indicates those files containing only blueprints of one particular equipment as specified in the following index. All other files contain items mentioned, and numerous others - a wide variety of similar and dissimilar equipment.

The following illustrates the variety of articles included: anemoscopes, barometers, dead reckoning tracers, fathometers, dynamometers, magnetic, electric-magnetic and gyro compasses, wind vanes, dynamic pressure indicators, coil stabilizers, underwater logs, miscellaneous meteorological and navigational instruments, magnetic detectors, magnetometers, gas cooling systems.

1. <u>Various Equipments, Instruments, Aides - Design, Construction and Assembly</u>:
- NavTechJap Document No. ND-50-1172, ATIS Document No. 3296

		Index No.
ND-50-1172.1	Anemoscope, wind vanes, barometers, etc.	35
ND-50-1172.2	Gyro compass, wind vanes, binoculars	36
ND-50-1172.3	Gyro compass, parts, miscellaneous Mks. and Mods.	37
ND-50-1172.4	Barometers, fathometer, motors, magnetic compass	38
ND-50-1172.5	Miscellaneous tools for assembly of navigation instruments	39
ND-50-1172.6	Miscellaneous tools for assembly of navigation instruments	40
ND-50-1172.7	Magnetic and Gyro compass, barometers	41
ND-50-1172.8	Electro-Magnetic compass, magnetometers	42
ND-50-1172.9	Relays, regulators, gyro compass	43
ND-50-1172.10	Chronometers and parts	44
ND-50-1172.11	Pit log, various units	45
ND-50-1172.12	Compass relays, starting panels	46
ND-50-1172.13	Gyro speed error modifier, underwater log	47
ND-50-1172.14	Wind vanes, barometers, anemoscope	48
ND-50-1172.15	Underwater logs and parts	50
ND-50-1172.16	Signal lights, compasses, barometers, range finders	51
ND-50-1172.17	Underwater logs, speed-direction dials	52
ND-50-1172.18	D.C. Motors, various models	53
ND-50-1172.19	Navigational Instrument wiring systems	54
ND-50-1172.20	* Gyro compass assembly	55
ND-50-1172.21	Fathometer, range finder, wind vanes	56
ND-50-1172.22	Steering controls, pressure indicators circuits	57
ND-50-1172.23	Keels and keel fittings	58
ND-50-1172.24	Magnetic and Gyro compass and parts	60
ND-50-1172.25	Chronometers and parts, barometers	68
ND-50-1172.26	Magnetic Gyro compass, underwater log	69
ND-50-1172.27	Compasses, barometers, wind vanes	70
ND-50-1172.28	* Gyro compass equipment	73
ND-50-1172.29	Anemoscopes, meteorological instruments	74
ND-50-1172.30	Gyro compass, electrical fittings, circuits	75
ND-50-1172.31	Fathometer, underwater log	76
ND-50-1172.32	Gyro compass, lookout instruments	78
ND-50-1172.33	* Gyro compass and repeaters	79
ND-50-1172.34	Magnetic compass, underwater log	83
ND-50-1172.35	Underwater keel log, S/M Mod. 92 (complete)	84

ENCLOSURE (A), continued

ENCLOSURE (A), continued

E. MISCELLANEOUS:

1. Blueprints of Design, Construction, Assembly - and Supply Lists: - NavTechJap Document No. ND-50-1195 ATIS Document No. 3297

ENCLOSURE (B)

LIST OF DOCUMENTS FROM SUBRON 13 SHIPPED
TO WASHINGTON DOCUMENT CENTER

GROUP 1 - BATTERIES

- NavTechJap Document No. ND-50-1140 ATIS Document No. 3146

No.	Contents
1.	Method of suspending batteries while installing in submarines.
2.	Performance date Mk 3 Model 3 and Mk. 3 and Model 4 batteries.
3.	Battery suspension device.
4.	Wooden distilled water tank.
5.	General data on assembly D.C. battery blower.
6.	Arm used for battery suspension with fittings.
7.	Print, metal part sulphuric acid pump.
8.	22cm cut out valve used for exhausting battery gas.
9.	28cm cut out valve used for exhausting battery gas. (2 copies)
10.	Regulations for section in charge of battery charging and maintenance.
11.	Characteristics and handling of storage batteries, dated 1939.
12.	Ordinary paint and acid proof paint for submarine batteries.
13.	Large model submarine storage batteries (rough notes indicating information regarding these - recovered from Battery Shop, SASEBO.)
14.	General information book on storage batteries, SASEBO.
15.	Record of battery installations. (May be helpful in War Records Division of ships arriving and departing SASEBO during war.)
16.	Four copies distilled water tank, capacity 1,150 liters.
17.	Blueprints of parts for Model 3 water purifier.
18.	Layout of battery manufacture and repair shop, SASEBO, steam piping.
19.	Bolt caster for Mk. 3 Model 4 storage batteries.
20.	Blueprints of welding tools for Mk. 3 Model 4 battery, SASEBO.
21.	Blueprints of bolt caster for Mk. 3 Model 4 batteries, SASEBO.
22.	Chart of generator used in charging secondary batteries, SASEBO.
23.	Blueprint of use of ebonite distilled water tank, SASEBO.
24.	Storage battery exhaust gas ducts. (2 blueprints)
25.	Terminal connections for Mk. 3 Model 4 battery, SASEBO.
26.	Terminal connections for Mk. 3 Model 3 storage battery (2 copies), SASEBO.
27.	Blueprint of separators (possibly wood), for Mk. 3 Model 3 storage battery, SASEBO.
28.	Water filling connections for storage batteries (4 copies), SASEBO.
29.	Method of wedging submarine batteries, SASEBO.
30.	Blueprint notes on improvement in battery installation methods, dated 1943.
31.	Method of installation of storage batteries (group 2).
32.	Plans for container for charging batteries of Type 92 (electric) torpedoes (4 copies), SASEBO.
33.	Secondary battery room. (Part 2).
34.	Hydrogen gas tank and fittings (4 copies), SASEBO.
35.	Assembly and plans for Mk. 5 Model 8 storage batteries, SASEBO.
36.	Specifications for battery water distiller.
37.	HA-126 initial battery charge and discharge.
38.	Four copies of blueprint of adjuster for mixing hydrogen gas and air, SASEBO.
39.	Shore connection power supply box for submarines, two copies.
40.	Model 6 blower arrangement for battery ventilation, SASEBO.
41.	Three copies electric blower plan 280 (240/330 v), SASEBO.
42.	Air flow meter diagrams and data, (2 prints), SASEBO.
43.	Formula for making ebonite pipes for discharge of battery gas.
44.	Ratios for sulphuric acid and various specific gravities, SASEBO.
45.	Specifications for phenol-resin (bakelite), SASEBO.

ENCLOSURE (B), continued

GROUP 2 - TORPEDOES
- NavTechJap Document No. ND-50-1141 ATIS Document No. 3147

No. Contents

1. Test results Type 91 Model 3 torpedo, 30 July 1944, KURE.
2. Progress record Type 93 torpedoes, KURE.
3. Theory of depth mechanisms.
4. Torpedo History and Development.
5. Torpedo instruction book with diagrams.
6. Two copies torpedo instruction book.
7. Instruction book, torpedo tube mounts.
8. Workman's notebook, test information, Types 91, 95, 96, and 98 torpedoes, KURE.
9. Listing of various parts of Types 93 and 95 torpedoes, suicide torpedo shop, KURE.
10. German table of torpedo parts, SASEBO.
11. Rough sketch of Type 93, Model 3 torpedo, showing air, water lines, etc., KURE.
12. Notes on Mk. 6 torpedo engine, taken from plant manufacturing suicide torpedoes, KURE, dated December 1944. (2 different notebooks, made by 2 different workmen).
13. Blueprints of oxygen charging plant, SASEBO, where oxygen torpedoes were charged. Prints include manner of compressing air and making oxygen by fractionating column.

GROUP 3 - HYDROGEN DETECTORS
- NavTechJap Document No. ND-50-1140 ATIS Document No. 3146

No. Contents

1. Four pamphlets on hydrogen detector (Wheatstone bridge type), used on Japanese submarines.
2. British pamphlet on hydrogen detector.
3. Blueprints for hydrogen detector.
4. Six copies of hydrogen gas detector connections.
5. Hempel type hydrogen detector (parts 1, 2, and 3 included), SASEBO.
6. Hempel type hydrogen detector (6 copies).
7. Diagram of Model 1 hydrogen detector, SASEBO.
8. Sketches of gas tank used with hydrogen detector, SASEBO.

GROUP 4 - KORYU (5-MAN) SUBMARINES
- NavTechJap Document No. ND-50-1140 ATIS Document No. 3146

No. Contents

1. Complete set prints and data.
2. Production blueprints (not complete) taken from shop at Kure Naval Base, where 2-man, 3-man, and 5-man submarines were being fabricated, (not annotated).

ENCLOSURE (B), continued

GROUP 5 - KAITEN (SUICIDE) TORPEDO
- NavTechJap Document No. ND-50-1140 ATIS Document No. 3146

No. Contents

1. KAITEN suicide torpedo drawings and instructions for increasing heat (?) in combustion pots, taken from Dainiu factory, branch of Torpedo Department, KURE.
2. Details of KAITEN, Types 1, 2, and 10, drawn by KAITEN expert, KURE.
3. Negatives of blueprints, of Type 2 KAITEN, showing full detail. Removed from debris at photographic shop, torpedo development building, KURE.

GROUP 6 - 3T-2 MODIFICATION 1 RECEIVER
- NavTechJap Document No. ND-50-1140 ATIS Document No. 3146

No. Contents

1. Three sets test results and current diagrams, receiver.
2. Circuit drawing, receiver.
3. circuit drawings, receiver, for operator's use.
4. Circuit drawings, exciter.
5. Drawings of power source, receiver and rectifier (2 prints).

GROUP 7 - SUBMARINES - GENERAL
- NavTechJap Document No. ND-50-1140 ATIS Document No. 3146

No. Contents

1. General charts and displacement tables of the following submarines:

I-201	X-351
I-400	I-351 and I-352

2. Rules for ventilating submarines (on wooden board).
3. Log of submarine HA-216.
4. Characteristic data of all types of Japanese submarines obtained from Japanese Naval Engineers at SASEBO.
5. Characteristic data of various types of Japanese combatant ships, obtained from Japanese Naval Engineers at SASEBO.

GROUP 8 - GENERATORS
- NavTechJap Document No. ND-50-1141 ATIS Document No. 3147

No. Contents

1. Test tables and detailed blueprints compound-wound generator.
2. Blueprints Nos. 5 to 86 inclusive, of 570 kw, 900 kw, oil-cooled generator, SASEBO.
3. Information on Mk. 2 electric-motor generator, SASEBO.

ENCLOSURE (B), continued

GROUP 9 - RADAR
- NavTechJap Document No. ND-50-1141 ATIS Document No. 3147

No.	Contents
1.	Radar instruction book for type temporarily designated as Type 3, Mk. 1, radar Model 3 (ships and small craft).
2.	Blueprints of Model 1 rectifier (possibly for radar gear).

GROUP 10 - HULL
- NavTechJap Document No. ND-50-1141 ATIS Document No. 3147

No.	Contents
1.	Blueprint listed as "Automatic Hanging Apparatus." This appears to be automatic balancing control, possibly borrowed from Italians. Printed in English and Japanese. (Might bear more investigation.)
2.	Construction blueprint, showing fitting out for the after part of submarine (Hull No. 4911) engineroom, KURE.
3.	Construction blueprint showing fitting out for amidships section of submarine (Hull No. 4911) engineroom, KURE.
4.	Blueprint of Hull No. 5461. Modification and overhaul of bridge mechanisms, KURE.

GROUP 11 - I-201
- NavTechJap Document No. ND-50-1141 ATIS Document No. 3147

No.	Contents
1.	Auxiliary method of rigging and tilting bow planes on I-201 class submarines.

GROUP 12-- MISCELLANEOUS PUBLICATIONS
- NavTechJap Document No. ND-50-1141 ATIS Document No. 3147

No.	Contents
1.	Laws of Buoyancy, Righting Arms, etc., with Japanese, English and German index, glossary, KURE.
2.	German text: Das Wasserstoffsuperoxyd, Eigenschaften, Herstellung Verwendung by Dr. Oscar KAUSCH, printed in Germany in 1938. (Hydrogen-peroxide engines).
3.	Physics book taken from Kure Experimental Torpedo Building.
4.	Six catalogs listing the scientific books and treatises which comprised the library at Kure Naval Base. (Library itself was evidently either destroyed or removed.
5.	Amounts of submarine displacements and graphic lines relating to buoyancy and righting arms in various situations and conditions of trim.
6.	Conversion table for hydrogen gas, SASEBO.
7.	Data on degaussing of ships, evidently in main drydock, SASEBO.
8.	Alterations to be made to Hull No. 5461, KURE.

ENCLOSURE (B), continued

GROUP 13 - MISCELLANEOUS BLUEPRINTS, PLANS, etc.
- NavTechJap Document No. ND-50-1141 ATIS Document No. 3147

No.	Contents
1.	Print of parts of oxygen-gas generator. (No indication on print if related to German oxygen engine.)
2.	Blueprint of performance data, new Type RIPPLE (?) commutator, SASEBO.
3.	Water cooling mechanisms (?), Hull No. 4601
4.	Deck or bulkhead fittings for Mk. 4 telemotor, also other telemotor prints.
5.	Diagram of gasoline motor-generator.
6.	Blueprints of chronometers.

GROUP 14 - RO-500
- NavTechJap Document No. ND-50-1142 ATIS Document No. 3148

No.	Contents
1.	Main Engine Instructions (2 volumes).
2.	Electrical Instructions (3 volumes).
3.	General Piping Arrangement.
4.	Main Engine and Exhaust Line Arrangement.
5.	Main Propulsion and Shafting Layout.
6.	Lube Oil Piping.
7.	Fuel Oil Piping.
8.	Cooling Water System.

GROUP 15 - RO-68
- NavTechJap Document No. ND-50-1142 ATIS Document No. 3148

No	Contents
1.	General Hull Arrangement.
2.	Main and Auxiliary Engine Systems.
3.	Main Engine and Shafting.
4.	General Instruction Book.
5.	Electrical Wiring diagram.

GROUP 16 - HA-101
- NavTechJap Document No. ND-50-1142 ATIS Document No. 3148

No.	Contents
1.	General and Hull Instruction Book.
2.	Electrical Instruction Book and Wiring Diagrams.
3.	Machinery Instruction Book.

DECLASSIFIED

ENCLOSURE (B), continued

GROUP 17 - I-121
- NavTechJap Document No. ND-50-1142 ATIS Document No. 3148

No.	Contents
1.	Submarine Instruction Book, Volume 6.
2.	Engineering Instruction Book.
3.	Electrical Instruction Book.

GROUP 18 - I-53
- NavTechJap Document No. ND-50-1142 ATIS Document No. 3148

No.	Contents
1.	General Instructions and Information Book.

GROUP 19 - I-202
- NavTechJap Document No. ND-50-1142 ATIS Document No. 3148

No.	Contents
1.	General Hull and Electrical Instruction Book.

GROUP 20 - I-201
- NavTechJap Document No. ND-50-1142 ATIS Document No. 3148

No.	Contents
1.	General Arrangement and Instruction Book.
2.	Machinery Instruction Book.
3.	Electrical Instruction Book.
4.	Auxiliary method of rigging and tilting bow planes.

GROUP 21 - HA-201 (BLUEPRINTS)
- NavTechJap Document No. ND-50-1142 ATIS Document No. 3148

No.	Contents
1.	General Arrangements.
2.	Hull Sections.
3.	Capacity of Tanks.
4.	Tail Clutch.
5.	Engine Switchboard Arrangement.
6.	Arrangement to prevent oil tank leakage.
7.	Living Quarters.
8.	Communications.
9.	Propellers.

ENCLOSURE (C)

LIST OF JAPANESE EQUIPMENT DELIVERED
TO COMSUBPAC BY SUBRON 13

PERISCOPES

Type	Model	Modification	Length	No.
Carlzeiss			7m	5
Carlzeiss			8m	1
German	1		7m	2
Italian			8m	1
KBB			7m	1
88			8m	1
88			10m	1
88	2		8m	1
88	3		8m	2
88	3		9m	5
88	3		10m	1
88	3	1	8m	2
88	3	1 (special)	8m	2
88	3	1	9m	1
88	4	1	7m	3
88	4	1	8m	3
88	4	1	10m	2
88	4	2	8m	3
88	4	2	9m	1
88	4	2	10m	1
Small	2	7	4'8"	1
Small	2	5	3'4"	2
Small	2	6	4'	12
97		Special	10'6"	8
97		2 Special	10'6"	2
No name plate			10'6"	1
			Total	65

EXERCISE HEADS (Torpedo)

	Model	Modification	No.
6th year			9
8th year			9
44			2
89			2
90			2
91			2
91		2	5
91	2		2
93 (small)			9
93 (large)			4
94	2		6
95			5
95	2		7
96 (same as 95 Model 2)			2
2			2
		Total	68

WARHEADS (Empty, for Type 95 Model 2 Torpedo)

Total 3

ENCLOSURE (C), continued

TORPEDOES

Type	Model	Modification	No.
6th year			3
6th year		1	3
6th year		2	3
8th year	2		6
8th year	2	2	3
44	2		3
89			3
90			3
91			1
91		1	1
91		2	1
91		3 (special)	4
92		1	3
93	1		3
93	1	1	3
93	1	2	3
93	1	3	3
93	3		3
(Temporary designation Type 94)	1		3
94	2		3
95	2		3
96			2
(Temporary designation Type 2)			3
Type 2			3
(Temporary designation Type 2 special)			2
Type 2 special			4
		Total	75

GYROS (Torpedo)

Type	Modification	No.
German Mk. 4802		1
German Mk. 4804		1
4th year		36
4th year	1	25
91		24
92		20
92	1	6
92	2	6
92	3	1
98		41
98	1	25
2		24
	Total	210

BATTERIES (for Torpedo Exercise Heads)

Type	No.
2	76
3	37
Total	113

DECLASSIFIED

ENCLOSURE (C), continued

EXPLODERS (Torpedo)

Type	Model	Modification	No.
90			6
91	1		6
91	2		6
91	3		4
1			2
2			6
2		1	[illegible]
2	2		
		Total	42

BATTERIES (Submarine, and Accessories)

Assembled

Type	No.
2	1
12	1
13	1
14	1
15	1

Not Assembled

Type	No.
5	1
12	1
13	1
15	1
Total	9

Hydrogen Tester	1
Battery Water Cleaner	1

TOOLS (Torpedo)

For Type	Boxes
6th year	3
8th year	3
44	1
89	6
90	6
91	2
92	1
93	6
95	3
2	3
Total	34 Boxes

IGNITERS (Torpedo)

Two boxes, 312 each — Total 624

DATA COMPUTER

Boxes marked "Data Computer" — Total 2 Boxes

ENCLOSURE (C), continued

TORPEDO GASKETS

For Torpedo Type	No. Boxes
6th year	2
8th year	2
44	1
90	1
91	3
92	1
93	2
95	4
Total	16

TORPEDO SPARES

For Torpedo Type	No. Boxes
6th year	1
8th year	3
89	3
90	1
91	1
95	2
Assorted	9
Total	20

Miscellaneous Spare Parts (in labelled wooden chests)	6 Chests
Torpedo Spare Parts Charts	18

SPARES (Torpedo Exericse Head)

For Type	No. Boxes
6th year	1
94	1
Total	2

TOOLS (Special Torpedo)

For Type	No. Boxes
6th year	1
89	1
91	2
93	5
95	2
Total	11

TOOLS (Test, Torpedo)

For Type 95 Torpedo   Total   2 Boxes

TOOLS (Ready, Torpedo)

For Type 90 Torpedo   Total   1 Box

ENCLOSURE (C), continued

TOOLS (Air Valve, Torpedo)

For Type 93 Torpedo Total 1 Box

TOOLS (Exercise Head, Torpedo)

For Type	No. Boxes
6th year	2
8th year	2
93	1
Total	5

TOOLS (Gyro, Torpedo)

For Gyro Type	No. Boxes
4th year	1
4th year and Type 92	2
91	1
98	1
No Type	1
Total	6

TOOLS (Exploder, Torpedo)

For Type 90 Total 2 Boxes

TORPEDO ACCESSORIES AND TEST GEAR

Name	Quantity
Pressure gauges	15
Sinker mechanisms (Exercise Heads)	4 Boxes
Torpedo Taps and Dies	1 Set
Charging lines	2
Charging leads	7
Propeller locks	1 Box
Depth testing stands	2
Gyro testing stands	1
Propeller cover for 6th year type torpedo	1
Propeller cover for type 90 torpedo	1

RADIO, RADAR, AND SOUND

Type 93 - Sound Gear

Box 1 of 6	Receiver
Box 2 of 6	Receiver
Box 3 of 6	Seventeen Sound Heads
Box 4 of 6	Four Junction Boxes
Box 5 of 6	Three Junction Boxes
Box 6 of 6	Two Junction Boxes

ENCLOSURE (C), continued

Mod. III - Sound Gear	
Box 1 of 4	Receiver - Indicator
Box 2 of 4	Driver
Box 3 of 4	Rectifier
Box 4 of 4	Eight Junction Boxes
Air Search Radar	
Box 1 of 2	Transmitter
Box 2 of 2	Receiver Indicator
Type 4 - Sound Gear	
Box 1 of 3	Receiver Indicator
Box 2 of 3	Assorted Parts
Box 3 of 3	Microphones
Radio	
Box 1 of 1	Three Portable Transmitters
Miscellaneous Sound Spares	
Box 1 of 1	Sound Spares

ENCLOSURE (D)

LIST OF JAPANESE EQUIPMENT
DELIVERED TO COMSUBPAC BY SUBRON 13

A. TORPEDO	Quantity
Aircraft and Midget S/M Torpedoes:	
Type 2 - 17.7" diameter	3
Type 91 (special 8 vanes) - 17.7"	3
Type 91 - 17.7" diameter	3
Type 2 special	3
Submarine Torpedoes:	
Type 96 (O_2 fuel) 21" diameter	3
Type 95 (recently developed) 21" diameter	3
Type 92 (electric) 21" diameter	4
Cruiser or Destroyer Torpedoes;	
Type 93, Model 1, Mod. 3 (long) 24" diameter	3
Type 93, Model 3 (short) 24" diameter	3
Human Torpedo:	
Minus warhead and conning tower	1
Heads:	
Exercise, complete, 24" diameter (overall length differs)	3
Exercise, complete, 21" diameter (overall length differs)	2
Exercise, complete, 17.7" diameter (overall length differs)	3
Exercise, cutaway	1
Warhead, empty	1
Afterbodies, cutaway	2
Engine, shaft, and propeller (Type 93)	1
Batteries:	
Type 92, 14 section	1
Type 92, 13 section	1
Cells, individual	60
Miscellaneous parts (cutaway)	19
Gyros	29
Gyro, electric	1
Gyro, rotor	1
Exploder pistols	19
Exploders	10
Flooding devices	3
Depth recording mechanism	2
Engines (completely separate)	2
Depth indicator, electric	1
Charging gauge	1
Torpedo firing lock, Type 92, Mod. 1	1
Torpedo tools	3 boxes
Torpedo Firing Aids:	
TDC (mechanical, electrical problem keeper)	1
Iswas	1
Slide rule type iswas	1

B. ORDNANCE	
Sea Mine, Chinese	1
Mine depth and firing control, Chinese (cutaway)	1
Mine depth and firing control, Chinese (complete)	1
Mine, Japanese (BuOrd designation "APRICOT")	2
Mine, Japanese (temporary BuOrd Type "AKEBY") complete - 3 section	1

ENCLOSURE (D), continued

	Quantity
Miscellaneous mine parts	1 box
Sea mine record books (Japanese)	21 publications
Paravane, explosive (empty)	1
Depth charge firing mechanism	1
Japanese mine (charge case, control and housing)	1
Anti-radar window bombs	6
Projectiles	3

C. <u>RADAR, RADIO, SOUND, AND ELECTRICAL</u>

Radar:	
Transmitter Type 3, Mk. 1, Mod. 3	1
Receiver, Type 3 Mk, 1, Mod. 3	1
Receiver Power Supply, Type 3, Mk. 1, Mod. 3	1
Indicator, Type 3, Mk. 1, Mod. 3	1
Detector E-27	1
Frequency meter (for use with Type 3, Mk. 1, Mod. 3)	1
Antenna, radar detector	1
Transmission line, antenna	1
Miscellaneous spare parts	2 boxes
Radio:	
Transceivers	13
Receivers	16
Frequency meters	1
Receiver coils	4 boxes
Receiver tubes	2 boxes
Receiver leads	7 boxes
Long wave condensers	7 boxes
Volt-ammeters	16
Head phones	7 sets
Motor generators	13
Motors	3
Thyrotron tube	1
Cathode ray tube	3
Wheatstone bridge, precision meter	2
Compensating resistor	1
Filter	1
Remote control box	1
Voltmeter	1
Receiver battery set	1
Amplifier	2
D.C. transformers	2
Long wave lengthening coil, Experimental Model 18	1
Power supply units, receiver	5
Amplifying filter	1
Electronics kit	1
Miscellaneous tubes and leads	1
Radio spare parts	1 box
Transmitters, meteorological, parachute type (temperature-pressure-humidity via separate frequencies)	3 cases
Sound:	
Sound oscillator panel	2
Sound amplifier	2
Sonar amplifier, Type 93	1
Sound bearing evaluator, Type 98, Mod. 2	1
Sonar bearing evaluator, Type 3, Mod. 2	1
Sonar phasing mechanism	1

ENCLOSURE (D), continued

	Quantity
Sonar phasing mechanism, temporary Type 3, Mod. 3	1
Sonar bearing transmitter	2
Sonar receiver keying instrument	1
Sound bearing transmitter (repeater)	2
Sonar ranging control board	1
Sonar phasing mechanism (small)	1
Sound heads	2
Sound heads, portable	3
Sound amplifier filter	1
Sound microphone gear, supplementary	1 box
Spare parts, Type 3 echo ranging	1 box
Sound bearing recorder	1
Tool Box, sound training instrument	1
Sound powered phones	5 sets
Magnetic Detectors:	
Electric magnifier for magnetic detector	1
Indicator for mag. detector	1
Alarm device, mag. detector	1
Sensitivity instruments, mag. detector	1
Deflection needle instruments	6
Electrical:	
Meggers	4
Control box	1
Gyro compass	1
Gyro compass repeater	2
Gyro compass, S/M hull type	1
Gyro compass spares and spider element	1
Fuse tool kits	2

D. ENGINEERING AND HULL

High pressure air gauge	2
Inclinometer	1
Pit log:	
Units comprising complete set	1
Sword arm spares	1 box
Miscellaneous spares	2 boxes
Test set	1

E. OPTICS

Periscopes:	
S/M Attack, 33' 7.872" diameter	2
S/M Search	1
Midget S/M	14
Midget S/M (suicide)	1
Eyepiece attachments #20	1
Periscope spare parts kits	4
Night vision aides. periscope	5
Binoculars:	
30x, mount type	1
30x15x2°, mount type	1
22.5x2.5°	4
20x, mount type	3
20x120, prismatic, mount type	2
20x3°, mount type, experimental	1
15x80x4°, mount type	1
15x4°, prismatic mount type (large)	1

ENCLOSURE (D), continued

	Quantity
15x4°, prismatic mount type	3
15x mount type	1
I-class S/M mount type	4
10-5	2
8x30	3
Field periscope type	3
Telescopes	2
Telescopes, with eye piece	3
Binocular Mounts:	
TBT type	1
Miscellaneous mounts	11
Binocular tool kits	6
Range Finders:	
#11	1
Large portable, bubble type	10
Small portable, single lens	17
Bombsight, for aircraft carried on S/M (#5982)	1
Gunsights	4
Battle Comm. glass 10 and 20x	1
Microscope, Welziar	1
Microscope, camera, universal, Zeiss	1
Microscope examining board	1
Engraving machine, telemeter	3
Spectometer, Zeiss	1
Spectometer, Swiss mfg.	1
Telephotograph and tripod	1
Interferometer	1
Optical light measuring instrument	1
Interferometer	1
Cameras:	
Periscope	5
Sighting	6
"Jena" photographer, attachments for	1 box
Diopterlens set	1
Miscellaneous optics (prisms, lens, etc.)	1
Navigational Instruments:	
Midget S/M magnetic compass	1
Bearing converter	1
Parallel rule and protractor	1
Parallel ruler, roller type	1