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

Subject: Target Report - Characteristics of Japanese Naval Vessels, Article 1.

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

1. Subject report, concerned primarily with hull design and machinery features of Japanese submarines suggested by Targets S-01 and S-05 of Fascicle S-1 of reference (a), is submitted herewith.

2. The article was prepared by Capt. A.M. Morgan, USN, who investigated the targets.

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Captain, USN

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S-01-1

CHARACTERISTICS OF JAPANESE NAVAL VESSELS
ARTICLE 1 - SUBMARINES

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

FASCICLE S-1, TARGET 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 1 - SUBMARINES

This article describes the various types of Japanese submarines used in or constructed during the war.

It has been prepared with an effort to provide the type of information which is of general interest to those involved in the design of submarines. While all classes of submarines are listed and their characteristics tabulated, the assembly of complete, detailed descriptions of the submarines has been omitted. This data can best be obtained from the plans listed in enclosure (A), from the reports of Submarine Squadrons 13 and 20, and from the plans, photographs, and information books forwarded by those activities.

The information includes a history of the development of the various classes of Japanese submarines and comments on the more interesting types, the more interesting features, and the less interesting features. Novel installations are described where appropriate.

The article is chiefly concerned with hulls and machinery.

TABLE OF CONTENTS

REFERENCES

A. Submarines Examined at YOKOSUKA, KURE and SASEBO:

I-401 Special, extremely large submarines built for bombing the Panama Canal and possibly large United States cities.

I-14 Special, large submarines built for bombing targets at closer range.

I-369 Large transport submarines (cargo and personnel).

RO-58 Old copies of British "L" Class. Used for training.

HA-101 Small transport.

I-47 Moderate size, cruiser or patrol submarines.

HA-205 Small, high speed submerged, coastal defense submarines.

I-201 Moderate size, high speed submerged, patrol submarines.

RO-50 Moderate size, conventional, patrol submarines.

B. Japanese Personnel Interrogated:

(a) Comdr. FUJIMORI of the Submarine Staff (Operational).

(b) Constructor Rear Adm. KATAYAMA, Head of General Design (formerly of the Submarine Design Section).

(c) Constructor Capt. NAKAMURA, Head of the Submarine Design Section.

(d) Constructor Lt. Comdr. TERADA, Asst. to Capt. NAKAMURA.

(e) Comdr. (Eng.) IWANO, Head of the Storage Battery Section.

(f) Others at TOKYO.

(g) Commanding officers and other officers of submarines visited.

LIST OF ENCLOSURES

(A) List of Documents Forwarded to Bureau of Ships.

INTRODUCTION

The information in this article was obtained from the following sources: the examination of the various types of Japanese submarines at YOKOSUKA, KURE and SASEBO, JAPAN; the interrogation of Japanese technical officers and other Naval officers at these places and in the Navy Ministry in TOKYO; and the inspection of data obtained from United States Submarine Squadrons 13 and 20.

The interrogations in TOKYO were highly productive. Information was obtained not only as to how things were done but why. Incidentally, it is understood that during the latter part of the war surface-ship production was largely abandoned in favor of submarine production, and that Adm. KATAYAMA devoted the largest part of his time to this work. In view of the fact that about 13 classes of submarines were produced during the war, with many special types within classes, the need for this is readily understood. The designers complain that they were overwhelmed with the multitude of classes, each consisting of relatively few submarines.

THE REPORT

1. Development History

When the war began, the following classes of Japanese submarines were under construction:

a. Large cruiser submarines (I-9 to I-12 Class).
b. Small cruiser submarines (I-15 and I-16 Classes).
   (1) With planes (I-15 Class).
   (2) Without planes (I-16 Class).
c. Fleet submarines (I-176 Class).
d. Medium submarines.
   (1) RO-35 Class.
   (2) RO-100 Class.

The large cruiser submarines of the I-9 to I-12 Class carried a small scouting plane and had a long radius of action (16,000 miles at 16 knots). The I-11 was fitted out as a squadron flagship and carried extra communication facilities. In 1942 changes were made in the type (I-11) in which the double-acting two-cycle engines were changed to single-acting, solid injection four-cycle engines. This was to permit increased production and involved a reduction in power from 12400 SHP to 4700 SHP with a loss in speed of from 24 knots to 17.7 knots. However, as the new engines were smaller and weighed less, fuel capacity was increased 37 tons by tankage in the engine room (water-compensated but not pressure-resisting) and the cruising radius was increased to 22,000 miles at 16 knots.

The small cruiser submarines of the I-15 and I-16 Classes were of high speed (24 knots) and moderate radius (14,000 miles at 16 knots). They carried 17 torpedoes and could also be used as fleet submarines. In 1942 the engines in these classes were also changed as in the large cruiser submarines and for the same reason. The fuel was likewise increased and the range increased from 14,000 miles at 16 knots to 21,000 miles at 16 knots. The modified submarines of these classes are the I-52 and I-54 Classes respectively. The speed was reduced from 24 to 17.7 knots as in the larger submarines. (The resistance to propulsion of both large and small was, by coincidence, the same because the increased displacement of the large submarines was accompanied by an increase in length).

The fleet submarines were high speed (23 knots) ships with emphasis on ease of operation, due to size and simplicity, and with greater maneuverability, due to less inertia. The cruising radius was less than with cruiser submarines, being about 8,000 miles at 16 knots. The type was started when the war broke out and building continued until August 1943, at which time it was stopped to concentrate on submarines which could be built in a shorter period of time (RO-35 Class).

The medium submarines of the RO-35 Class were preceded by two experimental submarines, the RO-33 and RO-34 but were under construction at the beginning of the war. In the RO-33 Class, the engines were solid injection, four-cycle but greater speed was desired in the RO-35 Class and a large solid injection, four-cycle engine was developed. This engine used a supercharger of small capacity, driven by an electric motor rather than by exhaust gas. This engine became the standard for practically all Japanese submarines. In 1943 more submarines of the RO-35 Class were under construction than of any other. They were considered very satisfactory. At the same time, submarines of the RO-100 Class were under construction for use in the coastal defense of outlying is-

lands. The object in making the submarines small was to permit the construction of large numbers. The planning officer (General Board) had wanted high submerged speed in the RO-100 Class but speed of building necessitated building ordinary submarines. It is said that the RO-100 Class was successful both in defensive operations and on the high seas. In the SAIPAN action, they attacked ships on the east side of the island.

By this time the losses in German submarines had become so great as to lead the Japanese to go to high submerged speed submarines. Thus, early in 1943, the design of the I-201 Class was started. Building began in March 1944, and continued to the end of the war. An effort was made to complete one ship each month. In addition to high submerged speed, quick diving time (30 seconds) was desired but only a 50 second diving time realized. Bowplanes were used during diving although not intended for the purpose.

Also, approaching the end of the war, and motivated by the need to build submarines in a short building period, a small high speed submarine (HA-201 Class) was designed. This began in the middle of 1944. Emphasis was placed on ease of building and high underwater speed. Materials were becoming critical and therefore only one engine, motor, and shaft were included. The design work was quickly done and construction started early in 1945. The first submarine was completed in May 1945.

The foregoing covers the conventional types of submarines. In addition, there were the following "special submarine classes":

a. Large types with bombing planes (I-400 Class)
b. Supply (gasoline and bombs) (I-351 Class)
c. Large transport (cargo and personnel) (I-361 Class)
d. Small transport (HA-101 Class)
e. Midgets

The design of the I-400 Class was started early in 1942, construction was begun in February 1943, and the first ship was completed late in 1944. The I-401 and I-402 were completed early in 1945 (I-403 was cancelled and I-404 was destroyed during construction). These carried three bombing planes, were of large radius (34,000 miles) and were designed for an endurance of 120 days. Consideration was given to protection from machine gun fire by making the conning tower and upper part of the pressure hull of heavier plating than otherwise required. They carried eight torpedo tubes forward. The building of such large ships required so much time and cost in labor and materials that it was discontinued and, as a substitute, the I-13 Class was modified to serve as bombing plane carriers but with a shorter radius of action.

Supply submarines of the I-351 Class were in design prior to the war. They were for carrying gasoline, bombs, ammunition, provisions, etc. to service seaplanes of the Daitei type (actually these planes carried personnel to SAIPAN and TRUK). Construction was started in 1943 and the first ship completed in 1945. The second was destroyed during the bombing of KURE on July 28, 1945. These submarines were intended to be essentially a floating base for planes. They were of low speed (15.8 knots) with a moderate radius (12,000 miles at 14 knots). The gasoline carried was considerable (365 tons) and was safely in tankage outside the pressure hull and separated from the hull by ballast tanks. It could be supplied quickly. The gasoline pump room was in the after part of the conning tower with the motor in the C.T. connected by a shaft. A watertight bulkhead separated the pump room from the C.T.

The large transport submarines (I-361 Class) were in design in the summer of 1942 and were intended for the purpose of carrying personnel to the Pacific islands. The capacity was 120 armed officers and men. The design was hasty and stock machinery was accepted as the authorities wanted to build large numbers in a short period of time. The result was that low speed was obtained (13 knots) and only a moderate radius (15,000 miles). Construction began early in 1943 and 10 were completed before discontinuing in summer of 1944. At about the time construction began (early 1943), the original purpose of the ships was changed to the carrying of provisions. Again in 1944, the purpose was again changed so that in addition to cargo they could carry gasoline. This latter change resulted in the I-372 which was built without torpedo tubes but with gasoline stowage in main ballast and fuel oil tanks. The I-371 was later similarly modified. These ships had a reduced radius by reason of the loss in fuel oil capacity. However, in order to build submarines in a shorter building period, these were discontinued in the summer of 1944 and smaller transport submarines of the HA-101 Class undertaken.

In the small transport submarines (HA-101 Class) it was also necessary to use ready-made machinery, and the main engine, main motor and storage battery were of this sort. Also, a maximum of cargo capacity was sought (60 tons) and a result of these factors was a sacrificing of speed and cruising radius. A speed of 10 knots surface and five knots submerged was obtained. The cruising radius is 3000 miles at 10 knots. In further regard to the cargo, the limiting factor is volumetric capacity rather than weight availability. Construction was begun late in 1944 and 10 ships were built by the beginning of 1945 at which time the type was discontinued in order to concentrate on Koryu's and on the high submerged speed classes, HA-201 and the I-201.

The midget submarines have developed from the pre-PEARL HARBOR two-man submarine to the Koryu built during the last part of the war and having a crew of five men. The two-man submarines (Ko Hyoteki's) were pure submarines; that is, they were for submerged operation only and no engines or generator were installed. The battery was charged from outside sources of power. These submarines were intended to be carried on surface mother-ships. For this purpose special ships were built; these were the CHITOSE, CHIYODA and NISSHIN. They were completed in 1936-1939. They were never used for their proper purpose and were later converted to aircraft carriers. The NISSHIN was sunk in the war near OMAESAKI (a peninsula just south of FUJI). These special ships were of about 12,000 tons surface displacement and had a speed of 29 knots (except the NISSHIN, which made slightly less than 27 knots). The higher speeds were obtained by turbine drive in tandem with the diesel drive. (The NISSHIN did not have this type of propulsion unit.) There were two diesel engines on each of two shafts, with Vulcan clutches and reduction gears. The operation of the machinery in tandem required skill. These ships were intended to operate with the fleet; each carried 12 Ko Hyoteki's which were launched at the stern. For the PEARL HARBOR attack, however, five submarines of the I-16 class were specially fitted to carry one two-man submarine each. All five two-man submarines were successfully launched and all were lost. The "I" class submarines all returned. Lieutenant IWASE, senior commander of the two-man submarines, reported by radio that he had successfully attacked a battleship of the Arizona class.

From the two-man submarine was developed a four-man submarine also called Ko Hyoteki having diesel electric drive with a 40 SHP engine. This submarine could operate on the surface and charge batteries. It was intended for defensive use at bases.

In March of 1945, a five-man submarine called "Koryu" (this is the only type called Koryu) was developed. The size was greater in order to provide for more satisfactory surface operation. It has diesel-electric drive with a 150 SHP engine. Building in large quantities was undertaken and the purpose was the defense of the home island of JAPAN. These submarines were to operate from bases and were not carred on submarines. They have speed of nine knots on the surface and a range of 1300 miles. They have a speed of 16 knots, for 40 minutes submerged.

Kaiten, or human torpedoes, were developed by the torpedo people rather than the submarine people. They were suicide torpedoes carrying one man. Essentially they are a torpedo with a special compartment for a man.

The Foregoing brings out rather forcibly the weakness of the Japanese in regard to submarines. Changes in type and changes in characteristics within types were so frequently ordered as to prevent either orderly design or construction. Undoubtedly much of this was caused by the course of the war but much appears to be the result of imporper staff work (planning). In any case there was a considerable loss in production by cancellations and the product was not stabilized sufficiently to eliminate the defects normally incurred in new designs.

2. Outstanding Features

In the various classes, there are many features in common. Many of these differ considerably from the corresponding features of United States submarines, while the British and German influence is seen. When each is considered carefully, it is found that there is little of actual technical accomplishment in these features, and few items of possible value to the United States. The outstanding features are:

a. Radar and sound protective coatings. The entire hull and outside decks of most Japanese submarines other than those of the high submerged speed classes, I-201 and HA-201, are coated with a black substance for this purpose. The Japanese advised that the above-water and below-water coatings differ although they look alike. The above-water coatings are for radar protection and the below-water coatings are for sound (echo ranging) protection. The principle involved is stated to be the interference of the reflected wave with the direct wave (as in optical coatings). The effectiveness would therefore be expected to be limited to a narrow range of wave lengths and this range would depend on the thickness of the coating. The coating is apparently applied with a trowel and presents a rough irregular surface which increases propulsive resistance. In the I-400 class, the loss in surface speed is said to be one knot. The underwater coating is said to contain hardening materials and to be covered with anti-fouling paint. It is understood that ComSubRon 13 has obtained samples of the materials and the formulas.

b. High speed submerged submarines using high-capacity, short-life storage batteries and sacrificing deck armament. The Japanese stated that these submarines were necessary because radar had rendered surface operations of diminishing practicability and demanded that emphasis be placed on submerged performance.

c. Direct drive electric motors. These are practically all Japanese submarines, are of the double armature type, and look very much like United States' motors of the SS-417, 435 and 475 classes.

d. Small belt drive motor for low speed, quiet, submerged cruising. These appear in the latest submarines, as in the German XXI design, and the Japanese state that they obtained the idea from the Germans.

e. Double hatches. All submarines except the smaller are fitted with double access hatches, with a trunk between. While not necessary, this feature appeals to operating personnel by reason of the added security. The torpedo loading hatches are similar to those in our earlier V-class. The torpedo loads through a door and a trunk into a hatch. There is an access hatch at the top of the trunk.

3. Features of Interest

a. Riveted construction.
b. Hydraulically operated bow and stern diving gear, stering gear, vent valves, amidships flood valves, schnorchel hoisting, and hangar door opening and closing.
c. Schnorchel (periscopic type) for auxiliary engines only.
d. (1) Radar similar to SD.
(2) Radar similar to SJ.
(3) Radar detectors.
e. Spot microphone type of sound gear.
f. Rudder - upper as well as lower.
g. Sound isolation (crude).
h. Schock mountings.
i. Convex bulkheads in pressure hull and conning towers.
j. Torpedo tube poppet valves.
k. Torpedo handling of overhead trolley and carriage type.
l. Trimming and drainage pumps at ends of ship and amidships.
m. Automatic ballast control for stop-trim.
n. Automatic depth control.
o. Water-tight doors and hatches same as German.
p. Bulb channel pressure hull framing (outside in double hull submarines).
q. Waste heat evaporators.
r. Turbo blowers (large).
s. H.P. air compressors similar to German.
t. Auxiliary engines installed.
u. Bow torpedo tubes only.
v. Elevator type attack periscope (10X and 1½X)
w. Night periscope (10X and 1½X).
X. H.P. air flasks inside pressure hull.
y. Hand operated inboard and outboard engine exhaust valves.
z. Engine induction and hull ventilation supply outboard standpipe.
aa. Battery ventilation exhaust and hull ventilation exhaust standpipe.
bb. Outboard (standpipe) valves hand operated.
cc. Main hydraulic power plants with Vickers type pumps, and accumulators similar to those in United States' submarines.
dd. Periscope hoists electrical with cable drum in recess in periscope trunks - motors outside of trunks.
ee. "Fireman-pole" type of CT to CR ladders - require removal to permit closing lower hatch.
ff. Large lookout binoculars (20X).
gg. Closed cell battery ventilation similar to United States but with power supply to battery tanks.
hh. Power operated torpedo tube muzzle doors.
ii. Air expulsion type water closets.
jj. Horizontally rigged bow planes.
kk. Unusual fuel oil filling and compensating system.
ll. High tensile ("D"-type) steel employed insome classes.

4. Comment on Features of Interest

a. In the later submarines, all welded construction, or nearly so, was employed where the material used was medium steel. In some, however, "D" steel, a high tensile steel developed from the British "Ducal" steel but with a lower yield point, was used. With "D" steel welding was not attemped because of fear of cracking. "D" steel is a .20% carbon, 2.5% manganese steel of the following characteristics:

C	Si	Mn	P	S	Yield Pt.	Ultimate	Elong
.30	.05-.30	1.5-2.5	.04 max	.03 max	40 - 45 kg/mm^2	65 kg/mm^2	15% min

b. The bow and stern plane and steering gear hydraulic pump tilting blocks are controlled by shafting from the control room. This shafting is used for hand control by declutching at the end compartments. In some ships this can be done pneumatically from the control room. Shafting is similar to our old shafting with same universal joints, except that a multiplicity of such joints is used to avoid adverse effect of hull deflections.

c. Vent valves in some ships are piston operated and in others are operated by hydraulic motor located outside of pressure hull, with hydraulic pipes running outside. Flood valves amidships are operated by hydraulic motors.

d. Schnorchel mast is periscopic type, with float valve in induction similar to early German design. Raising is by hydraulic gear similar to British periscope hoist (catapult arrangement). This was adapted in about the middle of 1944, having been observed by Japanese in a German submarine visited at Singapore. It was designed only for use with the auxiliary generator engines and was installed on nearly all submarines. Speed was limited to four to five knots. No troubles were reported.

e. Hangar doors are operated by hydraulic piston, with crosshead, located outside pressure hull with no arrangement to prevent escape of oil which passes piston - considerable leakage observed in operating.

f. Sound isolation mountings are of compression type with motor and auxiliary on common bedplate but with piping connections short circuited. The latter consisted of a rubber pad between bolted flanges, with a guard around flanges and rubber isolated from same.

g. Shock mountings are very flexible and while not visible, are probably rubber in shear.

h. Convex bulkheads in earlier types were castings similar to the German design; in later designs the bulkhead plate is welded to a cylindrical ring which in turn is riveted to the pressure hull.

i. Torpedo tube poppets are similar to the German and therefore to the Dutch from which the Germans are adapted and to ours from the same source. The torpedo tubes are standardized at 18" and 21" (45cm, and 53cm). An impulse pressure of 35 kg/cm^2 is used and the poppet opens when the pressure drops to 18 kg/cm^2. It is closed manually when an individual measuring tank is filled, as shown by sight glass - overflow goes to another tank. The measuring tank compensates for the loss of weight incident to firing a torpedo.

j. The engine induction is lead to the trunk between the upper and lower engine room hatches and thence into the ship through the lower hatch. This avoids a hull opening.

k. The I-201 class (high speed submerged) have two electric stills, said by Japanese crew to be made to German design with a capacity of 120 gallons each per day. They had not used them because of power consumed. The ships had not made any patrols so it is assumed that water was obtained from the beach.

l. The Japanese submarine designer (Rear Admiral KATAYAMA) said stern torpedo tubes were not used because to fire would require too great a gyro angle (he assumed ship headed towards or parallel to target).

m. The elevator periscope has a large well (about five feet dia.) in which there is a platform which is picked up by the periscope lower extension as the periscope is raised, and on which the periscope operator rides up and down in the trunk. The vertical distance usable is only a few feet. The head is small (about 1¼ inch in dia.) and the length of the small portion appears to be greater than that in the German periscope but less than in ours. Both the PROTEUS and the EURYALE have several samples on board for return to the United States.

n. The night periscope is conventional except that there is a device used for obtaining range at night, the working of which was not understandable even with an interpreter.

o. Piping (air and hydraulic) has cone joints. High pressure air is entirely within ship, probably because of leaks. The air manifolds in control room look like and are arranged similar to German's except that there is in addition, a turbo blow manifold with globe type valves.

p. Closed cell battery ventilation is used except in I-201 class (high speed submerged) which has small battery cells. In this class there are 2088 jars, each having two cells, and the open cell type of ventilation is used. Power supply is by longitudinal ducts at the sides under the battery tank top, thence down ducts between the frames to the bottom of the tank. Power exhaust is by a centerline longitudinal duct under the tank top. This ventilation is intended, by the circulation provided, to serve as cooling and ventilation. In the later submarines of the class, larger and fewer cells are used and conventional closed cell ventilation is employed.

q. Power operated torpedo tubes muzzle doors. In the earlier Japanese submarines the operation is by an electric motor driving hydraulic pump and with the oil piped to a piston. However this permitted leakage when the muzzle doors were closed at shallow depths because of leakage of oil by the piston. They then substituted a hydraulic motor for the piston but due to the difficulty of manufacturing sufficient hydraulic pumps for their needs were forced to abandon this system and use pneumatic motors to operate the doors. In the latest class (I-201), the doors are hand operated.

r. Bow plane rigging in all submarines is horizontal, with one plane above the other, similar to earlier United States submarines. The planes themselves are of a poor shape, being thin at the edge all around and nearly semi-circular in plane view.

s. Fuel oil filling and compensation system. There is a headbox in the superstructure, supplied with water from the main engine circulating water system, and leading to a manifold in the engine room. From the manifold the compensation water is led to each fuel tank by separate lines outside the pressure hull. In the bottom of each fuel tank is a small expansion tank to which the water is supplied. From the expansion tank to the fuel tank is a goose-neck to put water in the lower part of the fuel tank. For fuel filling, there is a pipe from the bottom of the expansion tank in each fuel tank leading up through to the fuel tank directly out of the tank top through a valve, and overboard. The piping

is from three to four inches as necessary to permit fueling at the rate of 50 to 100 tons per hour, according to the size of the submarine. The fuel from each fuel tank is led into the ship by individual lines outside the pressure hull to a manifold in the engine room. The system seems to have little merit except for quick fuelling.

5. More Interesting Classes

a. I-201 Class. High submerge speed submarines for patrol use. Standard displacement is 1,070 tons, surface displacement 1,291 tons. The outstanding features are the streamline exterior, abandonment of deck and superstructure guns (except two single housing 25mm machine guns) and their high submerged speed, designed as 19 knots and realizing 16.3 to 17 knots. The surface speed is 16 knots. The battery life is short, being rated at 100 cycles but realizing only about 80 cycles. This battery was replaced in later ships under construction by 300 cycle battery, also of high capacity.

b. I-400 Class. These are the large bombing plane carrying submarines. The standard displacement is 3,560 tons, normal surface displacement 4,663 tons and emergency surface displacement 5,547 tons. The surface speed is 19.7 knots and submerged speed seven knots. Three submarines were completed in late 1944 and early in 1945 but were probably not used. They carry three bombing planes each weighing about four tons, having a speed (without pontoons) of 290 knots and carrying a bomb of 0.8 tons or one 18" airplane torpedo. With the pontoons they can carry a 250 kg bomb. It is believed they were intended (cruising radius 34,000 miles at 16 knots) for bombing the Panama Canal and cities of the United States. The intent, according to the Japanese, was to launch the plane without floats and have the planes return to the submarine and crash (ditch) in the sea. The planes would be abandoned and the pilot rescued. The ships also carry eight torpedo tubes forward in two torpedo rooms (one above the other).

c. I-13 Class. These are large submarines which were converted from the I-9 Class still under construction to simulate the I-400 Class which was too costly in labor and materials to continue. They carry two bombing planes and have a shorter radius. The conversion was made by adding another layer of ballast tanks outboard of the original ballast tank to recover reserve buoyancy and freeboard and obtain the stability need by the addition of the largr airplane hanger. The standard displacement is 2,640 tons, surface normal displacement is 3,603 tons, surface emergency 3,894 tons. The surface speed is 17 knots, submerged 5.5 knots. The cruising radius is about 20,000 miles at 16 knots.

d. HA-201 Class. These are small (376 ton surface) coastal defense submarines carrying about 20 men and having nigh submerged speed (13 knots). The surface speed is 10.5 knots. There are two torpedo tubes forward. The submarines are substantially all welded.

e. RO-35 Class. These submarines are of interest (only RO-50 remains) because the arrangements are, contrary to the usual Japanese submarine, well worked out and compact. Also, because the general arrangement is similar to that of United States submarines. They are of moderate size, standard displacement 965 tons, surface normal 1,108 tons, surface emergency 1,190 tons. They have a speed of 19.7 knots surface and eight knots submerged. They carry four tubes forward. The designers are proud of this class.

Details of the Classes (Characteristics)

a. I-1 to I-6. Built 1926. German design. Small cruiser submarines. None remain.

Displacement, standard	1,995 tons
Length	97.5 meters
Beam	9.2 meters
Draft	4.8 meters
Submergence depth	75 meters
Diving time	60 seconds
Speed	17/8
Torpedo tubes, forward	four
aft	two
Battery	4,000 AH; 480 cells; 240 volts
Engines	four cycle; 6,000 SHP
Hull	riveted, double
Range	20,000 miles at 10 knots

b. I-7 and I-8. Built 1933. Large cruiser type. None remain.

Displacement, standard	1,995 tons
normal surface	2,525 tons
Length	109.3 meters
Beam	9.1 meters
Draft	5.26 meters
Submerged endurance	20 hours at three knots
Submergence depth	100 meters
Submergence time	60 seconds
Speed	23/8
Torpedo tubes	six forward
Planes	one
Battery	5,000 AH; 480 cells; 240 volts
Engines	two cycle diesel; 11,200 SHP
Hull	"D" steel - riveted, double
Range	20,000 miles at 10 knots

c. I-9 to I-12. Built 1941. Large cruiser type. None remain.

Displacement, standard	2,443 tons
normal	2,919 tons
emergency	3,629 tons
submerged	4,149 tons
Length	113.7 meters
Beam	9.5 meters
Draft	5.36 meters
Submerged endurance	30 hours at three knots
Submergence depth	100 meters
Submergence time	60 seconds
Speed	24/8.8
Torpedo tubes	six forward
Planes	one
Battery	10,000 AH; 240 cells; 240 volts
Engines	two cycle; 12,400 SHP
Hull	"D" steel, riveted, double
Range	16,000 miles at 16 knots

d. I-13 and I-14. Built late 1944 and early 1945. Special purpose submarines. I-14 remains.

Displacement, standard	2,640 tons
normal	3,603 tons
emergency	3,894 tons
submerged	4,762 tons
Length OA	113.7 meters
BP	356 feet
PH	305 feet
Beam	11.7 meters
Draft, normal	5.89 meters
emergency	20.7 feet
Submerged endurance	20 hours at three knots
Submergence depth	100 meters
Submergence time	50 seconds
Speed	17/5.5
Range	20,000 miles at 16 knots, 90 das.
Fuel	335,000 gallon
Torpedo tubes	six Type 95, 21" forward
Torpedoes	18, Types 91 and 95
Airplanes	two seaplane patrol, special "S" class
Battery	Type 1, mod 13, 11,200 AH; 240 cells; 240 volts
Motors	two special mod 8, 1,100 KW, direct drive
Engines	two mk 22, mod 10, four cycle, 4,400 SHP
Aux. Engines	2 - 450 KW
Propellers	2 - 3 blade
Hull, type	medium steel, riveted, double
maximum diameter	19.03 feet
maximum thickness	1".06 diminishing to .867".71" aft
frame spacing	23".4 circular cross section
	except in forward torpedo room
	(intersecting circles, with one
	torpedo room over the other)
Complement	15 officers and 112 men
Guns	two triple 25mm one single 25mm
Ammunition	11,200 rounds 25mm

e. I-16, I-18, I-20, I-22, I-24, I-46, I-47, I-48. Built 1940. Small cruiser submarines. I-47 remains.

Displacement, standard	2,180 tons
normal	2,553 tons
emergency	3,215 tons
submerged	3,561 tons
Length	109.3 meters
Beam	9.1 meters
Draft	5.34 meters
Submerged endurance	20 hours at three knots
Submergence depth	100 meters
Submergence time	60 seconds
Speed	24/8.5
Torpedo tubes	eight forward, Type 95
Torpedoes	20 (12 for reload)
Small submarines	one two-man submarine aft
Battery	10,000 AH; 240 cells; 240 volts
Engines	two cycle 12,400 SHP
Hull	"D" steel, riveted, double
Range	14,000 miles at 16 knots

Notes on I-47

The forward torpedo rooms are located in intersecting circles vertically one above the other as in the I-400 class. Framing in the lower torpedo room is inside, although double hull. The reason given by the Japanese is that the space between the inner and outer hulls is inadequate for proper framing and that, therefore, the outside framing of small scantlings was supplemented by inside framing. The inside framing is of Z-bar section. The pressure bulkheads are formed of intersecting vertical cylindrical surfaces with vertical stiffeners at the traces and with a substantial horizontal box girder. The stiffeners are welded to the bulkhead and the bulkhead welded to a flange ring riveted to the hull.

Provision is made for carrying six Kaiten's on deck (two forward and four aft). These are entered at sea through hatches at the bottom and pipes to submarines. Forward the pipes lead to the forward battery compartment hatch trunk between the upper and lower hatches. Similar arrangements are included aft. Additional pressure hull openings are thus avoided.

The main engines have detached 750 HP motor driven scavenger blowers which can be cross connected.

The bridge is closed and at the top of the covered position forward is a binocular periscopic turret for lookout work - it is heavy and is trained by gears, manually.

f. I-15, I-17, I-19, I-23, I-25 to I-45. Built 1940 (concurrently with I-16 class). Small cruiser submarines. I-36 remains.

Displacement, standard	2,212 tons
normal	2,612 tons
emergency	3,233 tons
submerged	3,653 tons
Length	108.7 meters
Beam	9.3 meters
Draft	5.19 meters
Submerged endurance	33 hours at three knots
Submergence depth	100 meters
Submergence time	50 seconds
Speed	22/8.7
*Torpedo tubes	six forward, Type 95
*Planes	one
Battery	10,000 AH; 240 cells; 240 volts Type 13
Engine	2 x 10 cylinder, two cycle, double acting, reversible, 9,000 IHP each, Sulzer type, direct drive, 12,400 SHP, weight 15 metric tons or 43 lbs/hp
Aux. Engines	1 x 6 cylinder, four cycle, solid injection, single acting, 675 HP
Main motors	two double armature, 1,000 HP, Type Five
Hull	"D" steel, double, riveted. Pressure hull thickness 22mm.
Fuel	800 tons
Range	14,000 miles at 16 knots

*Principal difference from I-16 class.

g. I-52, I-53, and I-55. Built late 1943. Small cruiser submarine.

Displacement, standard	2,0 tons
normal	2,56 tons
emergency	3,141 tons
submerged	3,561 tons

Length	108.7 meters
Beam	9.3 meters
Draft	5.12 meters
Submerged endurance	33 hours at three knots
Submergence depth	100 meters
Submergence time	60 seconds
Speed	17.7/6.5
Torpedo tubes	six forward, Type 95, 21"
Small submarines	four Kaiten aft
Battery	11,200 AH; 240 cells; 240 volts
Engines	2 x 10 cylinder, four cycle, super-charged, non-reversible, 3,550 IHP each, 4,700 SHP, total, direct drive
Aux Engines	2 - 6 cylinder, four cycle, solid injection, 600 KW each
Motors	two double armature 1,250 HP, Type eight
Hull	riveted, double, medium steel
Fuel	800 tons (est.)
Range	27,000 miles at 12 knots
	21,000 miles at 16 knots
	19
Torpedoes	One - 25mm twin
Gun	one-Mk 3, one-Mk 4, 10 meters, 10X, 1 X
Periscopes	12 officers and 130 men
Complement	

h. I-54, I-56 and I-58. Built early 1944. Small cruiser submarine.

Displacement, standard	2,140 tons
normal	2,607 tons
emergency	3,184 tons
submerged	3,687 tons
Length	108.7 meters
Beam	9.3 meters
Draft	5.19 meters
Submerged endurance	35 hours at three knots
Submergence depth	100 meters
Submergence time	60 seconds
Speed	17.7/6.5
Torpedo tubes	six forward
*Planes	one
Small submarines	four Kaiten aft
Battery	11,200 AH; 240 cells; 240 volts
Engines	four cycle, 4,700 SHP
Hull	medium steel, riveted, double
Range	21,000 miles at 16 knots

*Principal defference from I-52 class.

i. I-121 to I-124. (Old) Built 1927, German design. Mine laying submarines; cargo and gasoline carrying.

Displacement, standard	1,142 tons
normal	1,169 tons
emergency	1,451 tons
submerged	1,863 tons
Length	82 meters
Beam	7.3 meters
Draft	4.39 meters
Submergence depth	60 meters
Submergence time	60 seconds
Speed	14.5/6.45
Torpedo tubes	four forward
Torpedoes	eight total
Mine tubes	two aft

Mines	42 total
Battery	5,000 AH; 480 cells; 240 volts
Engines	two - MAN, four cycle, 2,400 SHP total
Range	8,000 miles at 12 knots
Fuel	228 tons
Hull	medium steel, riveted, semi-double hull
Cargo	20 tons
Gasoline	20 tons

j. I-153 to I-167. (Old) Built 1927. Fleet submarines (Patrol - later used for training)

Displacement, standard	1,635 tons
normal	1,720 tons
Length	97 meters
Beam	7.8 meters
Draft	4.82 meters
Submergence depth	60 meters
Submergence time	60 seconds
Speed	19/8
Torpedo tubes	six forward, two aft
Battery	5,000 AH; 240 cells; 240 volts
Engines	two cycle, 6,000 SHP
Hull, type	medium steel, riveted, semi-double (like saddle tanks)
thickness	12mm
Range	10,000 miles at 10 knots

k. I-168 to I-175. Built 1934. Fleet submarines.

Displacement, normal	1,785 tons
submerged	2,440 tons
Length	104.7 meters
Beam	8.2 meters
Draft	4.58 meters
Submerged endurance	22 hours at three knots
Submergence depth	75 meters
Submergence time	60 seconds
Speed	23/8
Torpedo tubes	four forward, two aft
Battery	8,000 AH; 236 cells; 240 volts
Engines	two cycle, 9,000 SHP
Hull	medium steel, riveted, double
Range	14,000 miles at 10 knots

l. I-176 to I-185. Built 1942. Fleet submarines.

Displacement, standard	1,630 tons
normal	1,832 tons
emergency	2,130 tons
submerged	2,602 tons
Length	105.5 meters
Beam	8.2 meters
Draft	4.6 meters
Submerged endurance	10 hours at five knots
Submergence depth	80 meters
Submergence time	45 seconds
Speed, surface	23/8
Torpedo tubes	six forward
Battery	8,500 AH; 236 cells; 240 volts
Engines	two cycle, 8,000 SHP
Hull	medium steel, double, riveted
Range	8,000 miles at 16 knots

m. I-201, I-202 and I-203. Built 1945. High speed submerged submarines.

Displacement, standard ..... 1,070 tons
normal ..... 1,291 tons
submerged ..... 1,400 tons
Length OA ..... 79 meters
BP ..... 76 meters
Beam ..... 9.2 meters
Diameter, pressure hull ..... 5.8 meters
Draft ..... 5.26 meters
Submerged endurance ..... 50 hours at two knots
Submergence depth ..... 110 meters
Submergence time ..... 50 seconds
Speed 16/17
Torpedoes ..... 10 Type 95, Mod 2
Torpedo tubes ..... four forward, Type 95, Mod 3,21"

Battery: 2,088 jars, 1,396 in forward and 694 in aft, both under CR with WT bulkhead between. 4,176 cells in 36 parallel lines - 232 volts. 100 cycles. 600 AH each at 20 hour rate, 520 AH at one hour rate. Same as used in early Koryu's. Total AH at 20 hour rate 23,760; at one hour rate 18,720. Being replaced by a new battery because of short life (trouble before first patrol) and because of ventilation problem (cells overheated and some fires). New battery same as new Koryu and HA-201 class battery at KOBE, SASEBO and SENSHU. 480 cells, 120 in series, 240 volts, 300 cycles, 27,200 AH at 20 hour rate and 17,000 at 1 hour rate. WT of old battery 80 kg per cell, total 167 tons. WT of new battery 400 kg per cell, total of 192 tons.

Engines ..... two - 10 cycle, direct, reversible, four cycle,
..... supercharged, single acting MAN type with
..... Vulcan clutch and reduction gears, 2,750 SHP.
Motors ..... double armature, two on each shaft,
..... each 1,250 HP, total 5,000.
Hull ..... medium steel, welded, single, with saddle tank.
Fuel oil ..... 144 tons
Fresh water ..... seven tons
Stores, provisions ..... 30 days
Range ..... 6,000 miles at 14 knots
..... 8,000 miles at 11 knots
..... 15,000 miles at six knots
Guns ..... two - 25mm Type 96 on deck, housing
Ammunition ..... 1,000 rounds
Periscopes ..... one Type 88, Mk 3, Mod 1 special eight meter
..... one Type 88, Mk 4, Mod 2 special eight meter
Complement ..... seven officers, 45 men
Bow plane rigging ..... electrical, slow and very noisy
Forward torpedo room forward bulkhead .. cast steel, welded to a boundary
. ring which is welded to the hull.
Vents ..... hydraulic of the piston type
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 m
(long)	147. m
(submerged)	.146 m
Moment change trim 1 cm.	7.4 ton meters
Tons/cm immersion	2.28

The pressure hull is of welded design, of circular cross-section. The maximum diameter is 5.80 meters and tapers to 2.75 meters and 2.78 meters forward and aft. It is 22 milimeters in thickness over the middle three fourths of its length and 18 milimeters thick at the end sections. In construction the pressure hull is prefabricated into eight sections and then assembled. Hull plating is medium steel. The pressure hull framing is internal and is in general of the bulbous angle type with spacing of 500 milimeters and 650 milimeters. The only pressure bulkheads are at frames 38 and 78.

Although this design of submarines has achieved its purpose of high submerged speed, the general layout, expecially with respect to trim, was not accomplished without difficulties. After the I-201 had conducted trials, a considerable modification to the tank arrangement was necessary in order to shift the C.G. of the ballast tanks. 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. Port and starboard buoyancy tanks #2 and #3 were added, as were #6 and #7 fuel tanks. Port and starboard main tank #2 forward bulkhead at frame 55 was 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 trim forward although the submerged condition was 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 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.

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.

The usual topside rudder was omitted. Large stern fins, which measure 9.2 meters from tip to tip, are installed forward of and above the stern planes for horizontal stability at high submerged speeds.

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

n. I-351. Built 1945. Supply (gasoline, bombs, etc., for planes) submarine.

Displacement, standard ..... 2,650 tons
normal ..... 3,512 tons
submerged ..... 4,290 tons
Length ..... 111 meters
Beam ..... 10.1 meters
Draft ..... 6.14 meters
Submerged endurance ..... 33 hours at three knots
Submergence depth ..... 90 meters
Submergence time ..... 50 seconds
Speed, surface 15.8/6.3
Torpedo tubes ..... four forward
Battery ..... 11,200 AH (total) 480 cells; 240 volts
Engines ..... four cycle, 3,700 SHP
Hull ..... medium steel, riveted, double
Cargo ..... 80 tons
Gasoline ..... 365 tons
Range ..... 12,000 miles at 14 knots

o. I-361 to I-370. Built 1944. Transport (cargo and personnel) submarines.

Displacement, standard ..... 1,470 tons
normal ..... 1,778 tons
emergency ..... 1,869 tons
submerged ..... 2,214 tons
Length ..... 73.5 meters
Beam ..... 8.9 meters
Draft ..... 4.76 meters
Submerged endurance ..... 40 hours at three knots
Submergence depth ..... 75 meters
Submergence time ..... 50 seconds
Speed 13/6.5
Torpedo tubes ..... 0 or two forward (Type 95) four Kaiten aft
Small submarines
Battery ..... 6,000 AH; 360 cells; 240 volts
Engines ..... 2 x 8 cylinder, four cycle, single acting, total 1,850 SHP, reversible, direct drive
Motors ..... two double armature 750 HP each
Hull ..... medium steel, riveted, semi-double hull
Periscopes ..... one-Type 88, 9m and one Type 88, 8m; both 10X and 1½X
Complement ..... 11 officers and 75 men
Cargo ..... 100 tons (60 inside, 40 outside)
Fuel ..... 15,000 miles at 10 knots
Range ..... 292 tons

The ships differ from the usual Japanese submarines in that the stern planes are electrically operated.

One ship of the class is said to have had an anti-escort weapon, consisting of four p.p. tubes about 25" diameter and four foot length recessed in upper deck at 20° to vertical and carrying self-ejection mines.

The cargo space is in the forward torpedo room and the compartment aft of control room. In the after compartment there is an endless chain conveyer sloping up to a cargo hatch. There is another hatch in this compartment which is about four feet in diameter.

The flood and vent valves are hand operated.

The superstructure side plating slopes inward toward the centerline and the conning tower fairwater plating slopes outward. The Japanese state that this is an anti-radar measure of limited effectiveness.

Displacement, standard	2,650 tons
normal	3,512 tons
submerged	4,290 tons
Length	111 meters
Beam	10.1 meters
Draft	6.14 meters
Submerged endurance	33 hours at three knots
Submergence depth	90 meters
Submergence time	50 seconds
Speed, surface	15.8/6.3
Torpedo tubes	four forward
Battery	11,200 AH (total) 480 cells; 240 volts
Engines	four cycle, 3,700 SHP
Hull	medium steel, riveted, double
Cargo	80 tons
Gasoline	365 tons
Range	12,000 miles at 14 knots

o. I-361 to I-370. Built 1944. Transport (cargo and personnel) submarines.

Displacement, standard	1,470 tons
normal	1,778 tons
emergency	1,869 tons
submerged	2,214 tons
Length	73.5 meters
Beam	8.9 meters
Draft	4.76 meters
Submerged endurance	40 hours at three knots
Submergence depth	75 meters
Submergence time	50 seconds
Speed	13/6.5
Torpedo tubes	0 or two forward (Type 95)
Small submarines	four Kaiten aft
Battery	6,000 AH; 360 cells; 240 volts
Engines	2 x 8 cylinder, four cycle, single acting, total 1,850 SHP, reversible, direct drive
Motors	two double armature 750 HP each
Hull	medium steel, riveted, semi-double hull
Periscopes	one-Type 88, 9m and one Type 88, 8m; both 10X and 1½X
Complement	11 officers and 75 men
Cargo	100 tons (60 inside, 40 outside)
Fuel	292 tons
Range	15,000 miles at 10 knots

The ships differ from the usual Japanese submarines in that the stern planes are electrically operated.

One ship of the class is said to have had an anti-escort weapon, consisting of four p.p. tubes about 25" diameter and four foot length recessed in upper deck at 20° to vertical and carrying self-ejection mines.

The cargo space is in the forward torpedo room and the compartment aft of control room. In the after compartment there is an endless chain conveyer sloping up to a cargo hatch. There is another hatch in this compartment which is about four feet in diameter.

The flood and vent valves are hand operated.

The superstructure side plating slopes inward toward the centerline and the conning tower fairwater plating slopes outward. The Japanese state that this is an anti-radar measure of limited effectiveness.

Compensation for cargo is by means of tankage under the cargo space which is divided into sections by transverse bulkheads. Each subdivision has a cargo hatch. Cargo is carried both in and above the tankage.

p. I-371 and I-372. Built 1944. Transport submarines.

Displacement, standard	1,660 tons
normal	1,926 tons
submerged	2,239 tons
Length	74 meters
Beam	8.9 meters
Draft	5.05 meters
Submergence depth	100 meters
Submergence time	50 seconds
Speed	13/6.5
Battery	6,000 AH; 360 cells; 240 volts
Engines	four cycle, 1750 SHP
Hull	medium steel, riveted and welded, semi-double
Cargo	110 tons
Gasoline	150 tons
Range	5,000 miles at 13 knots

q. I-400, I-401 and I-402. Special submarines.

Displacement, standard	3,560 tons
normal	4,663 tons
emergency	5,547 tons
submerged	6,400 tons
Length	122 meters
Beam	12 meters
Draft	6.58 meters
Submerged endurance	30 hours at three knots
Submergence depth	100 meters
Submergence time	60 seconds
Speed	19.7/7
Torpedo tubes	eight forward
Planes	three and Catapult
Battery	11,200 AH; 360 cells; 240 volts
Engine	four cycle, 7700 SHP total 4-10 cylinder MAN supercharged engines
Aux. Engines	2-6 cylinder 400 kw
Main Motors	two double armature, direct drive
Hull	"D" steel, riveted, double
Range	34,000 miles at 16 knots

Notes on I-401

1. The designers stated that the large size of this class was necessary because of the size and number of the airplanes, the size of the airplane hanger, the necessarily large catapult, and the required large radius of action, 34,000 miles.

2. The hull was formed by intersecting circles (except extremities) in order to obtain an adequate metacentric high (by beam) to lift aircraft aboard and to provide a satisfactory engine room arrangement with four engines.

3. Airplane engines were pre-warmed in the hanger (access by hatch into ship) by circulating hot lubricating oil.

4. Bow plane tilting - hydraulic - tilting block controlled from C.R. Hand operation by shaft. Declutching pneumatic. Drive is B-end Vickers. Bow plane rigging electric - chain for hand rigging.

5. Forward torpedo room forward bulkhead dished outward - welded to ring - ring riveted to hull - stiffeners installed. Tubes are bolted to bulkhead like Germans.

6. Torpedo rooms are two, one in each of two intersecting circles with strength (strut) deck between - intersecting circles merge-just aft of tube breeches-into a single circle.

7. Tubes have poppets like German. Muzzle doors operated by pneumatic motor. Breech doors like ours. Tubes are steel, riveted.

8. Hull riveted with double butt and seam straps. Butt straps continuous, seam straps intercostal.

9. Gyro setting locally by "follow the pointer" system.

10. Torpedoes load into lower torpedo room by removal of section of deck and struts at each frame (similar to torpedo loading hatch).

11. Drain pump in upper torpedo room - reciprocating type - sound isolated.

12. Internal chain locker for anchor.

13. Windlass electric.

14. Trim pump in lower torpedo room - centrifugal - single stage.

15. Flood valves hand operated except for middle four tanks (7,8,9 and 10) and two negative tanks which are operated through gears by hydraulic motors. Hydraulic vents. Internal WRT tanks.

16. An air capstan for torpedo handling is provided in lower torpedo room, with cable run to upper room.

17. Torpedo tubes very close together, lower room more so than upper. Center to centers, upper room 560 milimeters, lower 520 milimeters - Upper room tubes extend forward of lower room tubes to suit shape of bow.

18. Hand tilting of bow planes, even at rest in water, very difficult.

19. High pressure air manifold said not to have leakage trouble. Valves dismantled and examined showed no unusual features.

20. Advised that 7 MC system is excellent.

21. Centerline (strut) bulkhead in way of horizontal intersecting circles has vertical stiffeners on each side - welded.

22. One turbo blow - tremendous.

23. Main engines hydraulically clutched through reduction gears to shaft (two on each shaft). Detached auxiliaries.

24. One small four stage centrifugal bilge pump in each engine room.

25. All high pressure air inside ship.

26. Hatch covers have a skirt about one inch long extending down in opening, past the seat. This is to center the hatch and should help to prevent blowing gaskets.

27. Two hull ventilation supply and two hull exhaust blowers.

28. Adequate-appearing air conditioning.

29. Four large air compressors (like German).

30. After compt has trim and drain pumps similar to those forward.

31. Stern diving gear. There are twin Vickers hydraulic pumps each with a motor, in after compartment. Hand control is aft with twin wheels.

32. Steering - single pumps - double rams.

33. Main hydraulic plant - two pumps - four accumulators. No pilot valve. Accumulator trips by-pass valve at bottom of cycle.

34. Conning tower, horizontal cylinder off centerline (to avoid undue height if placed over hanger). End bulkheads convex outward - welded to ring - ring riveted to hull. C.T. frames internal "I" beams with one half of faying flange removed. Other half riveted to hull.

35. Voice tubes - many - plug cocks for W.T. integrity.

36. Patches on pressure hull - riveted - lapped. (common)

37. C.T. hatch trunk of welded construction but connected to hull riveted flange.

r. I-503 and I-504. Old cargo submarines which had passed from the Italians to the Germans and thence to the Japanese. About 1200 tons.

s. RO-33 and RO-34. Built 1935. Middle class submarines.

Displacement, standard	700 tons
normal	960 tons
Length	73 meters
Beam	6.7 meters
Draft	3.25 meters
Submerged endurance	25.7 hours at 3.5 knots
Submergence depth	75 meters
Submergence time	60 seconds
Speed	18.9/8.4
Torpedo tubes	four forward
Battery	5,000 AH; 240 cells; 240 volts
Engines	four cycle, 2,800 SHP
Hull	medium steel, riveted, semi-double
Range	3,000 miles at 16 knots (about)

t. RO-35 to RO-50. Medium class patrol submarine. RO-50 remains.

Displacement, standard	965 tons
normal	1,108 tons
emergency	1,190 tons
submerged	1,444 tons
Length	80.5 meters
Beam	7.0 meters
Draft	4.0 meters
Submerged endurance	nine hours at five knots
Submergence depth	80 meters
Submergence time	50 seconds
Speed	19.7/8
Torpedo tubes	four forward, Type 95, 21"
Battery	6,000 AH; 240 cells; 240 volts

Engines	2 x 10 cylinder, four cycle, non-reversible, supercharged, 4,200 SHP total
Motors	two - double armature, 600 HP each, Type 8
Fuel	216 tons
Range	5,000 miles at 16 knots
	13,000 miles at 12 knots
Complement	nine officers, 64 men
Hull	medium steel, riveted, semi-double

Note on RO-35

The conning tower is formed by three vertical intersecting cylinders in which the common chord struts are at the top and at the walking flat. The load is carried to the struts by vertical stiffeners, outside, at the traces of the intersections.

u. RO-57 to RO-59 (Old). Built 1922. Medium class submarines. Copies of British "L" Class.

Displacement, standard	889 tons
Length	76.2 meters
Beam	7.1 meters
Draft	3.96 meters
Submergence depth	60 meters
Submergence time	60 seconds
Speed	17/8
Torpedo tubes	four forward
Battery	240 cells; 240 volts
Engines	four cycle, 2,400 SHP
Hull	Semi-high tensile, riveted, semi-double

These submarines are very old. They are equipped with a marker buoy (vertical cylinder). The conning tower is a small vertical ellipse for access only. It has eyeports.

v. RO-60 to RO-68 (Old). Built 1923. Medium class submarine (Modified British "L" Class Design).

Displacement, standard	988 tons
Length	76.2 meters
Beam	7.3 meters
Draft	3.71 meters
Submergence depth	60 meters
Submergence time	60 seconds
Speed	16/8
Torpedo tubes	six forward
Battery	240 cells; 240 volts
Engines	four cycle, 2,400 SHP
Hull	Semi-high tensile, riveted, semi-double

Differs from British "L" Class in that there are six torpedo tubes forward instead of four. It was used for training.

w. RO-100 to RO-117. Built 1942. Medium class submarines.

Displacement, standard	525 tons
normal	601 tons
emergency	618 tons
submerged	782 tons
Length	60.9 meters
Beam	6.0 meters
Draft	3.51 meters
Submerged endurance	20 hours at three knots
Submergence depth	75 meters
Submergence time	60 seconds
Speed	14.2/8
Torpedo tubes	four forward
Battery	6,000 AH; 120 cells; 240 volts
Engines	four cycle, 1,100 SHP
Hull	medium steel, riveted, semi-double
Range	4,000 miles at 12 knots (about)

x. RO-500. Ex-German U-511, delivered to Japan in September 1943. Used for training.

y. HA-101, HA-109 and HA-111. Built 1944. Transport submarines (no torpedo tubes).

Displacement, standard	370 tons
normal	428 tons
submerged	492 tons
Length	44.5 meters
Beam	6.1 meters
Draft	4.04 meters
Submerged endurance	20 hours at 2.3 knots
Submergence depth	100 meters
Submergence time	50 seconds
Complement	six officers and 36 men
Speed	10/5
Battery	3,400 AH; 120 cells; 240 volts
Engines	one to six cylinder, four cycle, direct drive
Motor	one to 150 HP
Fuel	70 tons
Range	3,000 miles at 10 knots
	4,000 miles at eight knots
Hull	medium steel, welded, 13mm, saddle tanks
Periscopes	one Type 88 six meter 10X, 1½X
Cargo	60 tons (limited by density)

Some ships of this class can carry ten 18" torpedoes in superstructure. This is the case with HA-108 in which eight are forward of the conning tower in two layers of four and two are aft of the conning tower, over the engine room. The HA-108 is also able, by means of a portable tripod hoist at the stern, to lift the bow of a Koryu for reloading torpedoes.

In this class, the vents and floods are hand operated; the planes are also hand operated. The steering gear is electrical.

The superstructure and conning tower fairwater plating are sloped as in I-369 as an anti-radar measure.

z. HA-201, HA-205, HA-207, HA-210 and HA-216. Built 1945. High speed submerged. Coast Defense.

Displacement, standard	325 tons
normal	382 tons
submerged	440 tons
Length	53 meters
Beam	4 meters
Draft	3.44 meters
Submerged endurance	50 hours at two knots
Submergence depth	100 meters
Submergence time	30 seconds
Speed	10.5/13
Torpedo tubes	two forward, Type 95, 21"
Torpedoes	four total, Type 95
Battery	6,700 AH; 120 cells; 240 volts
Engine	one to six cylinder four cycle, single acting, solid injection, 400 SHP
Motor	single, 1250 HP Type E, Mod. 1, and a 32 HP belt drive motor for slow speed
Hull, type	medium steel, welded, single with saddle tank
diameter	3.6 meters
thickness	14mm
Fuel	24.1 tons
Range	3,000 miles at 10 knots
Periscope	one Type 88, seven meter 10X and 1½X
Propeller	one three blade 1½ meter diameter
Complement	three officers, 19 men
Bulkheads	no interior strength transverse

In this class, the hull has been designed for high submerged speed with all fittings in superstructure recessed. The bridege is narrow and streamlined. A"Schnorkel" is fitted. The hull is built in six prefacricated sections and welded together except that the forward and after sections are connected by riveting. The framing is, of course, inside the pressure hull. There are no bow planes. Small, hand-operated planes are fitted amidships. The stern planes are large and hydraulically operated. The steering is electrical.

aa. Koryu - Midget (Biting Dragon) Type "C".

L.O.A.	26.6 meters
Beam	2.04 meters
Draft	two meters
Depth	3.93 meters
Displacement	59.334 tons
Reserve buoyancy	seven tons
Main Motor	600 SHP, 1800 RPM
Generator	100 KW
Batteries	100
Fuel Oil	4.5 tons
Lub Oil	0.9 tons
Range, surface	1,300 miles at nine knots
submerged	40 minutes at 16 knots
	one hour at 15 knots
	four hours at 8.5 knots
	20 hours at 4.5 knots
	40 hours at 2.5 knots
Torpedo tubes	two - 45 cm (18")
Complement	five
Submergence depth	100 meters

bb. Kaiten - human torpedo. Developed by torpedo designers, rather than submarine designers. Essentially a Type 93 torpedo with a compartment for the man.

Weight	about 16 tons
Warhead weight	1.6 tons picric acid
Speed	10 knots - 30 miles
	35 knots - 12 miles
Fuel	oxygen and kerosene

Claim six submarines sank 16 ships off Cebu in late 1944.

7. General Information.

a. The Japanese strength calculations for circular hull sections are based on the column formula in which the pressure hull frame and the plating (30t) are assumed as the column. In addition they have experimentally established a family of curves similar to ours. In sections which are coned, they ignore the radial component of the longitudinal pressure load. In the case of hull sections consisting of intersecting circles, the supporting column at the common chord is designed to withstand the resultant along the chord of the tangential stress in the circles due to compression.

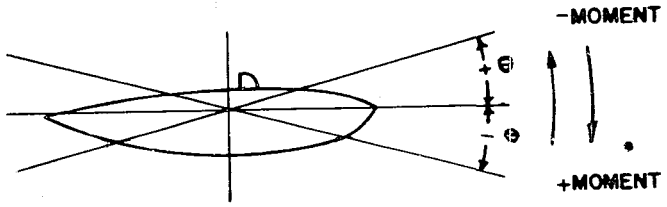
b. In the development of the design of the high speed submerged submarines, I-201 and HA-201 classes, considerable research was undertaken to insure adequate directional stability. This was done with models and the ship tests later confirmed the accuracy of the data obtained. The use of bow planes at high speed submerged was not contemplated (even in the I-201 class in which fitted) because the center of pressure had to be aft of the center of gravity. The bow planes were installed at the demand of the operating personnel to permit control of the submarine at low speeds submerged and while firing torpedoes to resist broaching.

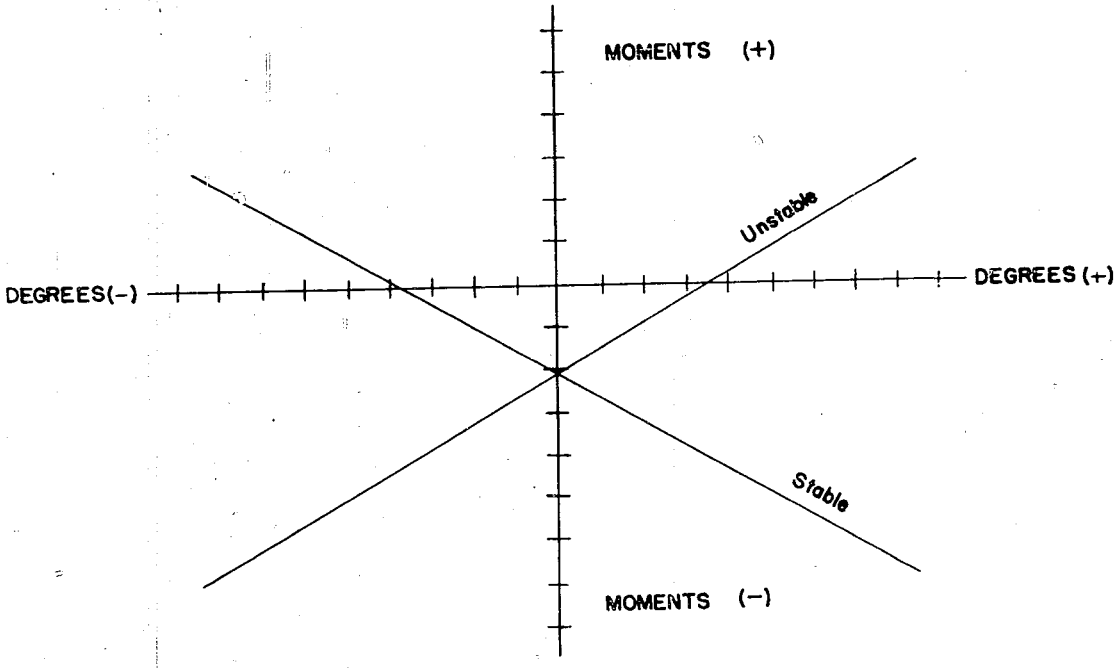
It was found that the I-201 class could obtain stability of direction without fixed fins or planes. These are located above and forward of the stern diving planes. They are of high aspect ratio and large. Their shape is that of an isosceles triangle with the base at the hull. Many shapes were tried in the effort to move the center of pressure aft with as little expense to resistance (drag) as possible. The models were small and were self-propelled. Considering that a plus moment causes an up angle, it was found that at speeds up to about 18 knots, the moment was slightly plus but that at 18 knots the curve crosses the axis and becomes rapidly negative (down angle). The shape of the stabilizing fins was developed so that the negative moment would be small up to 20 knots. These even keel tests were followed by tests in which the submarines were at various up and down angles from zero to five degrees.

The results of these tests are shown on the following page.

It is seen that with two designs of stabilizer having the same negative moment at zero degrees, one design results in a stable ship and the other is an unstable one. In the stable ship, as the angle of the boat changes, the moments change so as to oppose the change in angle of the boat. The reverse is true of the unstable ship.

The stern planes were large having a ratio of planes area to maximum projected waterplane area of 1:45 or 1:47 (designer's memory). In ordinary submarines, the plane areas are based (as in United States submarines) on a ratio to waterplane area of 1:65 for bow planes and 1:55 or 1:60 for stern planes.





c. Where submarines carry gasoline external to the pressure hull, the gasoline is in tankage against the outer hull and separated from the pressure hull by a main ballast tank, in order to avoid gasoline leakage into the ship. The gasoline tank is of medium steel and of completely welded construction.

d. The Japanese name for the "Schnorkel" is "underwater charging system".

e. The organization of the Navy Ministry was as follows:

(1) Prime Minister:
Secretary of the Navy
(a) Assistant Secretary of the Navy
(b) Construction of Ships
(c) Construction of Airplanes

(2) Under the Assistant Secretary:
(a) War Affairs
(b) Education, or training
(c) Supply
(d) Surgery
(e) Law
(f) Finance

(3) Under "Construction of Ships" (Vice Admiral (Eng) SHIBUYA:
- (a) General (control)
- (b) Finance (only for ship construction and repair)
- (c) Ordnance, special steel, and ammunition
- (d) Torpedoes and mines
- (e) Electrics, wireless, and sound
- (f) Ship construction and repair
- (g) Machinery construction and repair
- (h) Navigation and optics
- (i) Material control

(4) Under "Ship Construction and Repair" (Vice Admiral (Const' YESAKI):
- (a) Planning (Capt. NISHISHIMA)
- (b) General Design (Rear Admiral (Const) KATAYAMA)
- (c) Detail Design (Capt. (Const) MAKINO)

(5) Under "General Design":
- (a) Submarines (Capt. (Const) NAKAMURA)
  - (1) Lt. Cdr. TERADA (large submarines)
  - (2) Lt. Cdr. OAKI (Koryu)

ENCLOSURE (A)

LIST OF DOCUMENTS FORWARDED TO BUREAU OF SHIPS

Title	NavTechJap Document No.
I-16 Class:	
(a) Outboard Profile	ND50-1147.1
(b) Inboard Profile and Sections	ND50-1147.2
(c) Deck Plans	ND50-1147.3
I-36 Class (I-15 Class):	
(a) Outboard Profile and Deck Plan	ND50-1149.1
(b) Inboard Profile and Sections	ND50-1149.2
I-176 Class:	
(a) Outboard Profile and Deck Plan	ND50-1150.1
(b) Inboard Profile and Sections	ND50-1150.2
I-361 Class:	
(a) Inboard Profile and Deck Plans	ND50-1151
I-400 Class:	
(a) Inboard Profile	ND50-1152.1
(b) Outboard Profile and Deck Plans	ND50-1152.2
(c) Midship Section	ND50-1152.3
(d) Inboard Profile and Deck Plans before lengthening Airplane Hangar	ND50-1152.4
(e) Catapult Arrangement Plan	ND50-1158
RO-35 Class	
(a) Outboard Profile and Deck Plan	ND50-1153.1
(b) Inboard Profile and Sections	ND50-1153.2
HA-101 Class:	
Inboard Profile, Deck Plans and Midship Section	ND50-1154
HA-201 Class:	
Inboard Profile, Deck Plans and Sections	ND50-1155
I-400 Airplane Crane:	
17 Drawings and four Descriptive Booklets, giving general arrangement and details.	ND50-1156.1 to ND50-1156.21
I-351 Class:	
Inboard Profile, Deck Plans and Sections.	ND50-1157