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RESTRICTED

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

Subject: Target Report - Characteristics of Japanese Naval Vessels, Article 2.

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

1. Subject report, covering the machinery design features of Japanese surface warships outlined in Targets S-01 and S-05 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Capt. F.W. Slaven, USN, assisted by Lt. (jg) T.S. Montgomery, USNR, interpreter and translator.

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RESTRICTED S-01-2

CHARACTERISTICS OF JAPANESE NAVAL VESSELS
ARTICLE 2
SURFACE WARSHIP MACHINERY DESIGN

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

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

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

SHIP AND RELATED TARGETS

CHARACTERISTICS OF JAPANESE NAVAL VESSELS, ARTICLE 2 - SURFACE WARSHIP MACHINERY DESIGN

Aside from DD SHIMAKAZE, the latest destroyer and the only ship of her class, there were no really new design features in main machinery plants of major Japanese combatant surface vessels since the late thirties. Design trend was to open firerooms with doublecase boilers. There were centerline bulkheads in practically all main machinery and boiler spaces of cruisers and larger vessels.

The conventional arrangement was to group the firerooms forward of the engineroom. In all later designs the main turbines were of two general types: in battleships, two H.P.'s and two L.P.'s operating in parallel with a cruising turbine connected to one of the H.P.'s in each space through a reduction gear and jaw clutch; and in other ships, an H.P., I.P. and L.P. with a cruising turbine driven through its own gear and a jaw clutch on the outboard shafts only.

The main lubrication system supplied all main turbine auxiliaries except those too low to drain to the main sump. There was a central lubrication system for all auxiliaries in each fireroom.

Apparently a concerted effort was made to install main plants which were economical at cruising speeds even at the expense of considerable increase in weight.

There were emergency steam and exhaust connections to main lube oil pumps from adjoining spaces. Main generators were located outside the machinery spaces. There were no fuel oil booster pumps and no deaerating feed tanks.

Auxiliaries were small, compact, and accessible. Machinery spaces were not cramped. With the exception of diesel generators no equipment appeared to have given much trouble. However, the fireboxes of the few boilers open for inspection did not show evidence of heavy or prolonged steaming.

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REFERENCES

Location of Targets:

Naval Technical Dept., TOKYO (Fifth Section)

Inspection of available vessels now in repatriation service and in Navy yards.

Inspection of blue prints and documents located in the yards and in TOKYO

Ships Inspected:

DD HARUTSUKI
DD YOITSUKI
CV KATSURAGI
CL SAKAWA
CV JUNYO
BB NAGATO

Navy Yards Visited:

YOKOSUKA
KURE
MAIZURU
SASEBO

Japanese Personnel who Assisted in Gathering Documents:

Japanese naval personnel of Fifth Section, Japanese Naval Technical Dept., TOKYO

Japanese Naval Personnel Interviewed:

Rear Admiral I. KONDO
Rear Admiral AMARI
Capt. MATSUI
Vice Admiral SAWADA
Capt. YAMASHITA
Mr. YOSHIDA
Capt. YASUGI
Mr. NAGAI (civilian engineer)
Comdr. IDA
Mr. MATSUSHI (civilian engineer)
Lt. HAMANO
Lt. Comdr. NISHIYAMA
Lt. TAGAI
Lt. NAKAMOTO
Mr. IWANO (civilian engineer)
Lt. SUZUKI

LIST OF ENCLOSURES

(A) Documents Forwarded to Bureau of Ships.

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INTRODUCTION

This report covers broadly the machinery design features of major Japanese combatant surface vessels. No vessel smaller than a destroyer escort is discussed.

The procurement of information was hampered by the extensive destruction by bombs of the original Japanese Navy Technical Department building, the characteristic Japanese secrecy with which military matters were handled even among the Japanese officially concerned both prior to and during the war, and the destruction of certain plans and documents by burning, intentional or otherwise.

The high points of steps in construction of a vessel from the machinery viewpoint, the general machinery arrangements of vessels mentioned, and the salient features of the various engineering piping systems will be discussed.

No attempt is made in this report to go into the details of construction or design of any particular piece of equipment. Booklets of machinery plans, documents containing results of machinery trials, translations of special specifications for machinery plus lists of machinery giving capacities for certain classes of vessels are contained in NavTechJap Report, "Characteristics of Japanese Naval Vessels, Article 4 - Surface Warship Machinery Design (Plans and Documents)," Index No. S-01-4.

It is recommended that the documents bearing NavTechJap Document No. ND50-1024, "Piping plans: Engine rooms, UNRYU class (CV) and NACHI class (CA)," and ND50-1025, "Piping plans: Boiler rooms, UNRYU class (CV). New construction machinery trials: UNRYU class (CV)," be obtained for reference as this report is read.

THE REPORT

1. Summary of Outstanding Characteristics

The following table gives some of the principal characteristics of a representative vessel of each class. All units have been converted from the metric to the English system:

	BB YAMATO	CA MOGAMI	CL OYODO	CL UNRYU	DD TERUTSUKI	DE MATSU
Speed (knots)	28	35	35	34	33.7	27.8
Cruising radius (miles)	7,392	7,673	10,315	8,000	9,062	3,500
Speed for Cruising Radius (knots)	19.4	18	18.2	18	18	18
Horsepower	163,000	150,000	109,000	150,000	51,400	19,000
Boilers	12	8	6	8	3	2
Steam Pressure (psi)	354	313	427	285	427	427
Steam Temperature (°F)	617	572	732	572	662	662
Cruising Turbines	4	2	2	2	2 HP 2 LP	None
Shafts	4	4	4	4	2	2
Fuel Capacity (tons)	1,900	2,310	2,410	3,680	1,071	353
Displacement (approx.)(tons)	69,000	12,200	10,446	19,700	3,400	1,530

Aside from DD SHIMAKAZE, the latest destroyer and the only ship of her class there have been no really new designs in main machinery plants of Japanese men-of-war since the early thirties. SHIMAKAZE was a 560 lb/sq in. 75,000 hp, 39-knot ship.

YAMATO, the latest BB, had a plant very much like that of the NACHI class cruiser (begun in 1924 and completed in 1929) except that the horsepower had been stepped up from 130,000 to 165,000.

The design characteristics of the MOGAMI class heavy cruiser, which the Japanese consider their most successful cruiser, were followed very closely for all succeeding cruisers and the smaller carriers (20,000 tons). The first ship of the MOGAMI class was started in 1931 and completed in 1935. It is interesting to note that, after the building of other cruisers such as CA TONE class, another MOGAMI class was begun, apparently during the war. At some time during construction she was changed to a CVL and was never completed.

Construction was stopped about June 1945.

It was also noted that the TERUTSUKI class destroyers, the latest class consisting of an appreciable number of vessels completed since 1941, had essentially the same main machinery as the DD KAGERO class built about 1935. One of the UNRYU class carriers was also found to have installed four of the KAGERO class destroyer turbine units.

The lack of development was probably brought about by two causes:

a. A concentrated effort to standardize equipment, which is noted on all sides.

b. An extensive modernization from 1935 on of older ships, particularly BB's.

On the other hand, the design trend in 1928-29 was to propeller-type, forced-draft blowers, and since the early thirties, to open firerooms with double-case boilers.

The most conspicuous features of Japanese naval machinery design are:

a. Centerline bulkheads in practically all main machinery and boiler spaces of cruisers and above.

b. Arrangement of all boilers forward and all engines aft.

c. Main lubrication system supplying all main turbine auxiliaries including steam-driven ven sets, except those too low to drain to the main sump- viz: condensate and circulating pumps.

d. Central lubrication system for all auxiliaries in each fireroom.

e. Steam educators for emergency drainage.

f. Efforts to provide economical cruising combinations.

g. Absence of fuel oil booster pumps.

h. Absence of deaerating feed tanks even for the 560 psi. plant.

i. Emergency steam and exhaust connections to main lube oil pumps from adjoining space.

j. Main generators outside of machinery spaces.

Auxiliaries were small, compact, and accessible for repairs. The machinery spaces did not appear cramped and were by far the cleanest portions of the ships inspected.

With the exception of diesel generators, no particular piece of equipment showed evidence of giving much trouble. However, the fireboxes of the few boilers open for inspection did not show evidence of heavy or prolonged steaming.

Essentially the same engineering logs and records were maintained as in the U.S. Navy; however, when under steady steaming conditions, the readings were recorded only once a watch. The records were kept in the ship and destroyed at the end of each year. No reports were submitted to the Technical Department; however, prior to the war an engineering competition was conducted. Reports somewhat similar to our Form "H", but less extensive, were prepared.

As in our service, the Technical Department was not in control of the competition. There were no prizes or awards except commendatory letters placed in the Captains' and Engineer Officers' records.

2. Design and Construction of New Vessels

The Fifth Section (Machinery Design) of the Navy Technical Department was organized as follows:

Officer-in-Charge (Rear Admiral TOKETSU)
- Administration and Personnel (Captain UEDA)
- Design and Research (Rear Admiral A. MORI)
  - Main Machinery, Turbines, Boilers
  - Auxiliary Machinery
  - Propellers and Shafting
  - Installation
- Planning and Production (Captain SOGA)
  - Main Machinery, Turbines, Boilers
  - Auxiliary Machinery
  - Propellers and Shafting

Details of the general procedure in the construction of a new vessel from the naval constructor's viewpoint have been covered in NavTechJap Report - "Characteristics of Japanese Naval Vessels, Article 3 - Surface Warship Hull Design," Index No. S-01-3. The portion involving the machinery division will be covered here.

The Fourth Section (Ship Construction) of the Technical Department received the military requirements for a new vessel. It transmitted to the Fifth Section the required horsepower, the amount of fuel allowed, the weight and space allowable for machinery, and the cruising radius required with its corresponding speed.

From the above, a preliminary design was prepared and returned to the Fourth Section, which combined it with its own proposal and submitted it for approval.

When finally approved, contract plans similar to ours were made up in the Design Branch of the Fifth Section and forwarded to a Navy or private yard, where the detailed plans were prepared. Those prepared in a private yard were supervised by an inspector. All detailed plans, whether prepared in a Navy or private yard, had to be approved by the Technical Department before construction could begin. Nothing corresponding to our General Specifications for Machinery has been uncovered. The customary answer as to why something was done one way instead of another is "judgment and experience". There were special specifications for machinery (classified "Top Secret") for each vessel. The specifications were very brief, especially for vessels constructed during the war. Samples have been translated and are contained in NavTechJap Report - "Characteristics of Japanese Naval Vessels, Article 4 - Surface Warship Machinery Design (Plans and Documents)," Index No. S-01-4.

3. Arrangements in General

With the exception of a few torpedo boats and possibly some other small vessels, the conventional arrangement was to have firerooms grouped together forward of the enginerooms instead of the "fireroom-engineroom-fireroom-engineroom" arrangements of our CA's 26-31 and the CL55 and CA68 classes. Practically all vessels from cruisers up have centerline bulkheads in the engineroom space with one main engine in each engineroom. The same is true for the boiler rooms. The latter BB's YAMATO and MUSASHI, as well as the carriers, had only one boiler to a fireroom. In the case of older cruisers the forward boiler room sometimes extended on both sides of the centerline and contained two boilers, but the after boiler rooms were always segregated into compartments containing one boiler each. Destroyers were invariably three-boiler ships with, in later vessels, two boilers in the forward fireroom and one in the after. There were two enginerooms, one forward of the other but both aft of the firerooms. Earlier destroyers had only one engineroom with the engines side by side, and an auxiliary machinery space aft of the engineroom for the evaporators and turbo and diesel generators.

Typical layouts for various classes of ships are shown in NavTechJap Documents ND50-1016 and ND50-1017.

The turbo-generator for the later destroyers was located in the forward engineroom with the diesel generators in the after engineroom. For earlier destroyers both were in the same space and aft of the single engineroom as mentioned above.

For cruisers and above, all generators were outside of the machinery spaces, in at least four groups, forward and aft, outboard of the machinery spaces and at about the same level as the second platform.

The evaporators were usually in the enginerooms and for all vessels larger than destroyers were in two groups, each in a separate space. YAMATO had two plants in two separate compartments which had been made by "robbing" the after inboard corner of each inboard engineroom.

The advantages and disadvantages of the centerline bulkheads are discussed in NavTechJap Reports, Index No. S-01-3 and in "Reports of Damage to Japanese Warships, Article 1", Index No. S-06-1.

An examination of NavTechJap Documents ND50-1016 and ND50-1017 will indicate a gradual decrease in the number of boilers per ship, which accompanied progress in boiler construction. In later designs BB's had 12 boilers, CA's eight, CL's six, DD's three and DE's two. The six-boiler CL design was not popular with the personnel of the Fifth Section and apparently was forced on them in order to provide space for other activities.

The arrangement of outboard shafts in the after enginerooms and inboard in the forward enginerooms in MOGAMI (CA) should be noted. Unfortunately, no booklet of plans for this vessel was located.

a. <u>Control Spaces</u>

Each fireroom was fitted with a central booth for the man in charge of the watch, through which access was had to the fireroom. The following communication facilities were fitted in the fireroom control booth of SAKAWA, a late CL:

Engine Order Telegraph (indicator only and read from either control room or fireroom floor plates)
Revolution Indicator
Revolution Telegraph (indicator only)
Burner Telegraph
Blower Steam Gage
Air Pressure Gage
Various main steam gages
Separate telephones to each fireroom and control engineroom
Telephone to Switchboard
Smoke Telegraph

The enginerooms were equipped with a similar booth for each space from which the throttle valves in that space were operated by rigid shafting.

In battleships an additional booth provided in one of the forward enginerooms to serve as a central damage control station for the Engineer Officer. Telephones to each main machinery space and to the switchboard were provided, as well as the usual steam gages and engine order indicators. While these booths were not air-conditioned, they were provided with a separate ventilation system to keep them cooler than the machinery spaces themselves.

In smaller vessels the Engineer Officer was stationed in the central booth for the control engineroom.

The following photographs show some of the control spaces of vessels visited.

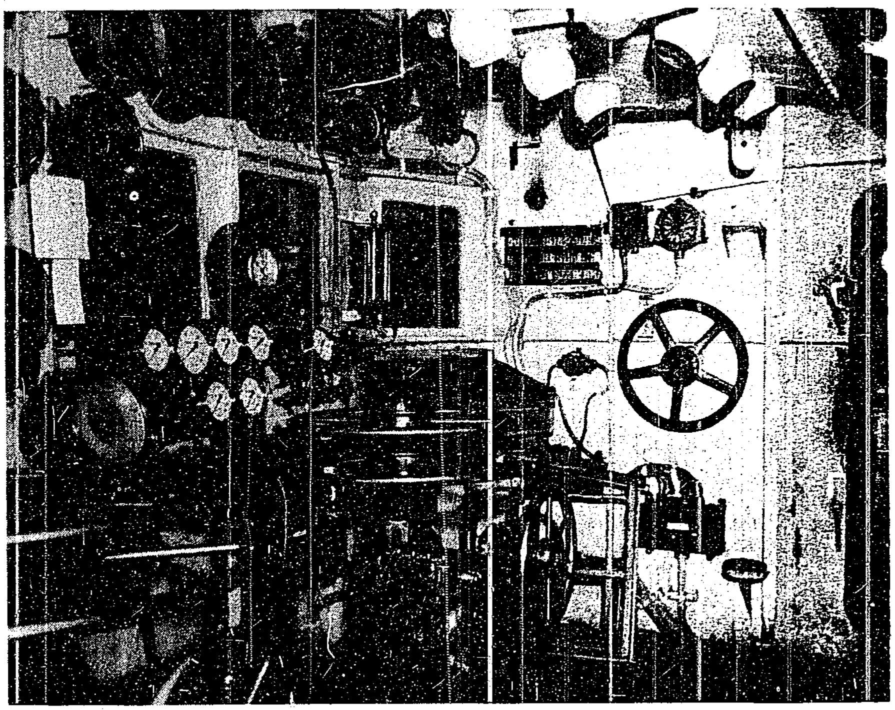

Figure 1

CONTROL BOOTH CENTER ENGINEROOM SAKAWA (CL)

This vessel had two shafts in this engineroom, hence two throttle valve wheels, shown.

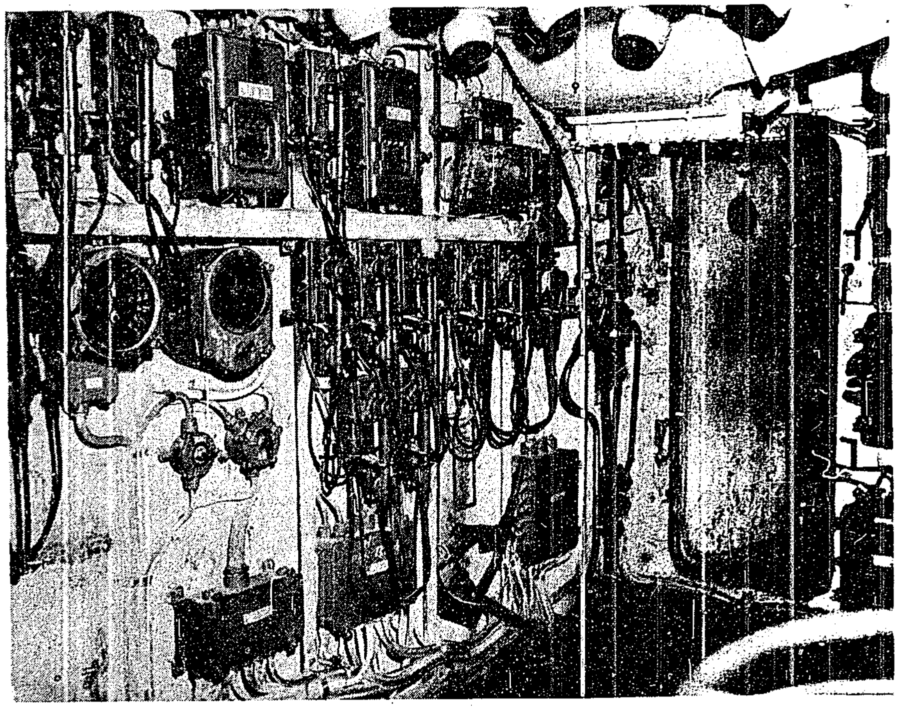

Figure 2
CONTROL BOOTH CENTER ENGINEROOM SAKAWA (CL)

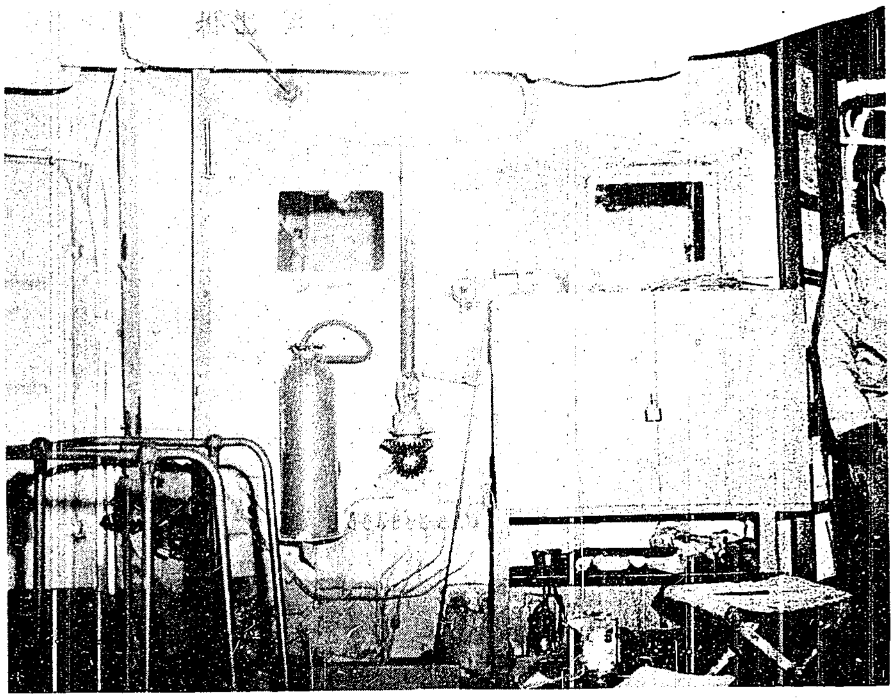

Figure 3
OUTSIDE OF CONTROL ROOM CENTER ENGINEROOM SAKAWA (CL)

Figure 4

ENTRANCE TO ENGINEER OFFICER'S BOOTH NAGATO (BB)

Figure 5

CONTROL BOOTH CENTER ENGINEROOM NAGATO (BB)

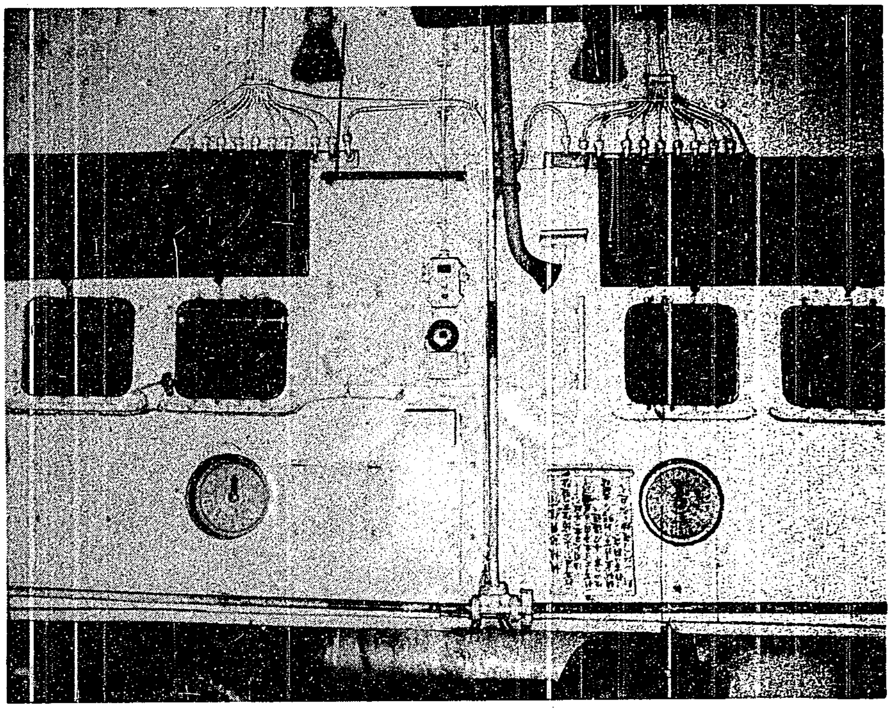

Figure 6

OUTSIDE OF ENGINEROOM CONTROL BOOTH CENTER ENGINEROOM NAGATO (BB)

(Note there are two engines in this space.)

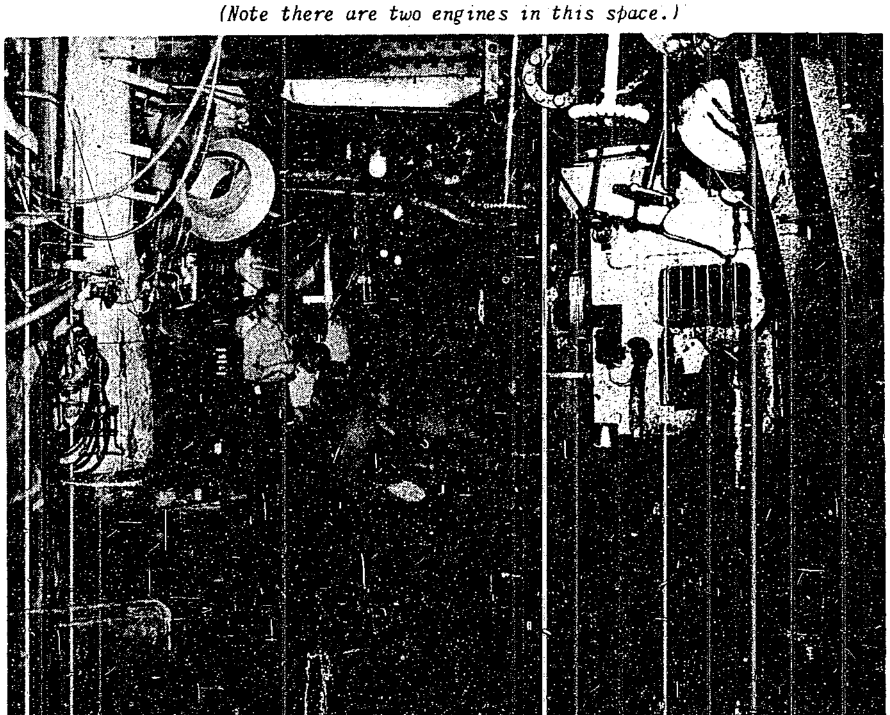

Figure 7

BOILER ROOM SHOWING CONTROL BOOTH NAGATO (BB)

b. Main Turbines

In general, for all later designs the main turbines were of two general types. For BB's each main unit consisted of two H.P.'s and two L.P.'s operating in parallel, with a cruising turbine connected to one of the H.P.'s in each space through a reduction gear and jaw clutch. The cruising turbine was used up to about 21 knots for BB's. The cruiser was then declutched and one H.P. and L.P. used up to about 27 knots for BB's. At this point the other H.P. and L.P. were brought into service. Cooling steam was not admitted to the idling turbines below this speed. The two H.P. turbines were usually aft of the reduction gear and the L.P. forward with a main condenser slung under each L.P.

The other type consisted of an H.P., I.P. and L.P. with a cruising turbine driving through its own gear and a jaw clutch on the outboard shafts only. In such installations the cruising turbine exhausted into the H.P. turbine on the corresponding inboard shaft. In the case of destroyers there were sometimes two cruising turbines, a high and a low pressure cruiser on each shaft, which exhausted directly into the low pressure turbine. These usually drove through a reduction gear fitted with a jaw clutch on the forward end of the I.P. turbine shaft.

On the later vessels there was no provision for bleeding. In some cases, such as YAMATO and OYODO, there was provision for use of auxiliary exhaust in the L.P. turbines.

There seems to have been a concerted effort to install main plants which were economical at cruising speeds even at the expense of considerable increase in weight. This was particularly noted in TERUTSUKI and KAGERO destroyers which had two cruising turbines on each shaft. Some sample fuel rates, with cruising turbines in use, in Kg/shp/hr are given as follows, shp being in Cheval Vapeur units: YAMATO (BB) at 21.69 knots-0.399 (0.891 lb/shp/hr), TONE (CA) at 21.6 knots-0.486 (1.108 lb/shp/hr), UNRYU (CV) at about 21 knots-0.431 (0.962 lb/shp/hr).

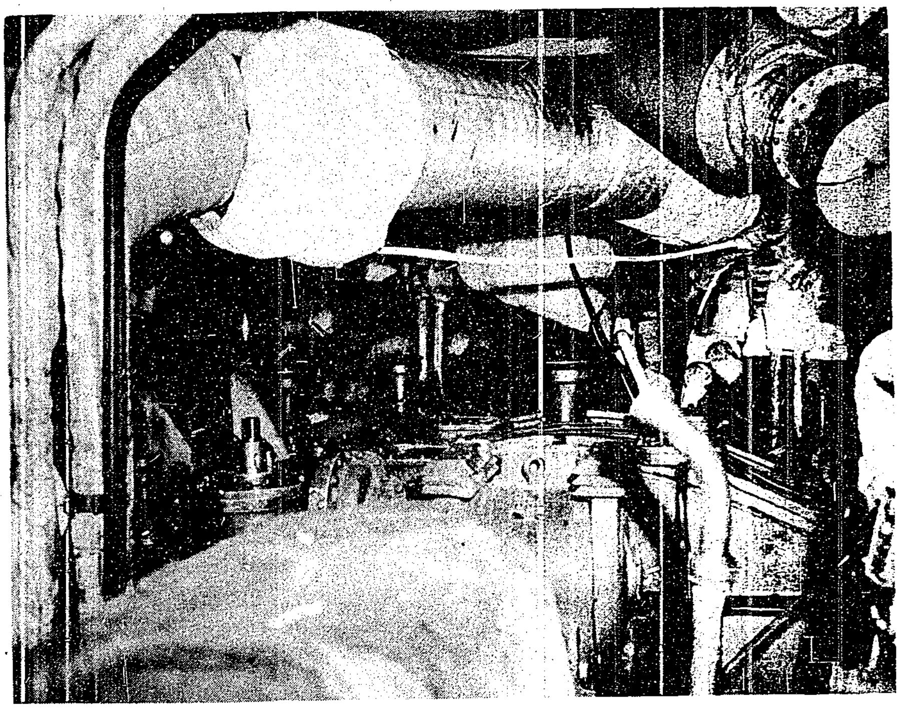

Figure 8
SAKAWA (CL) - LOOKING FORWARD OVER REDUCTION GEAR STARBOARD INBOARD ENGINE

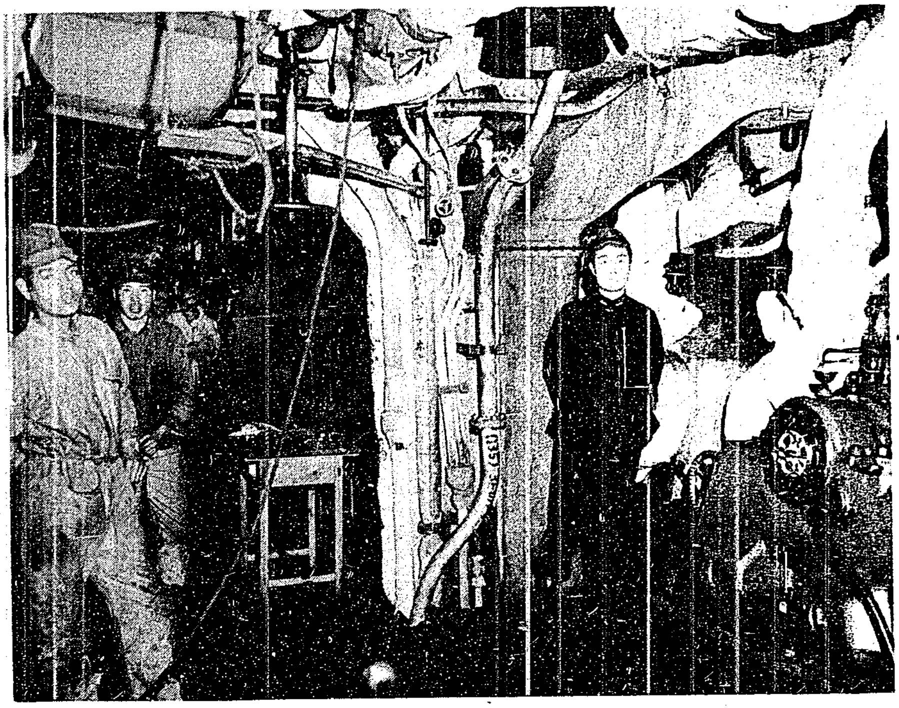

Figure 9
CENTER ENGINEROOM SAKAWA (CL) LOOKING TO STARBOARD
(Port engine not visible.)

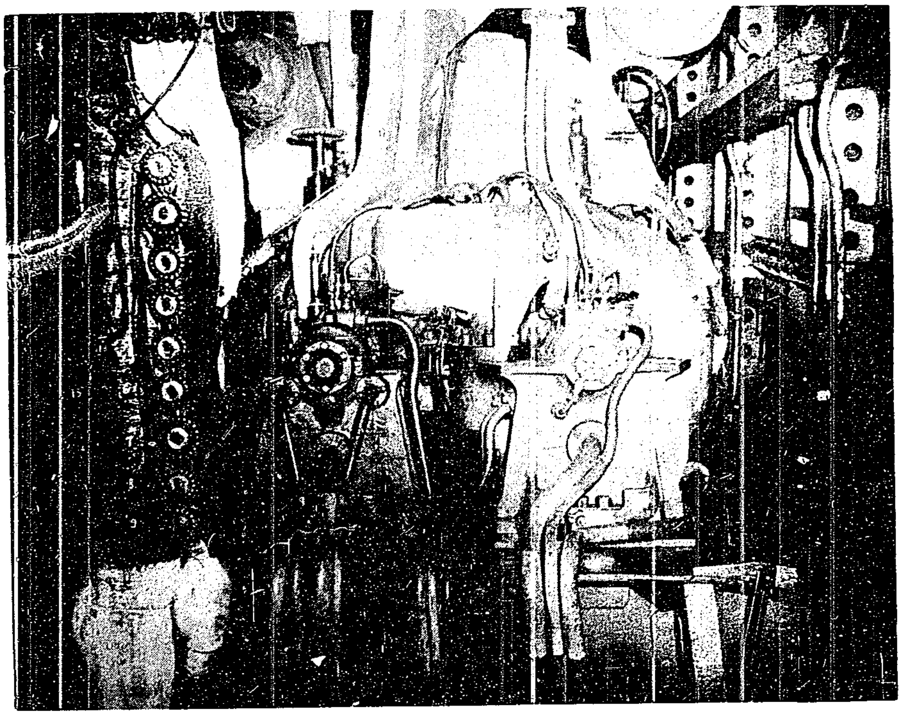

Figure 10
H.P. CRUISING AND L.P. CRUISING TURBINE KAGERO CLASS DESTROYER

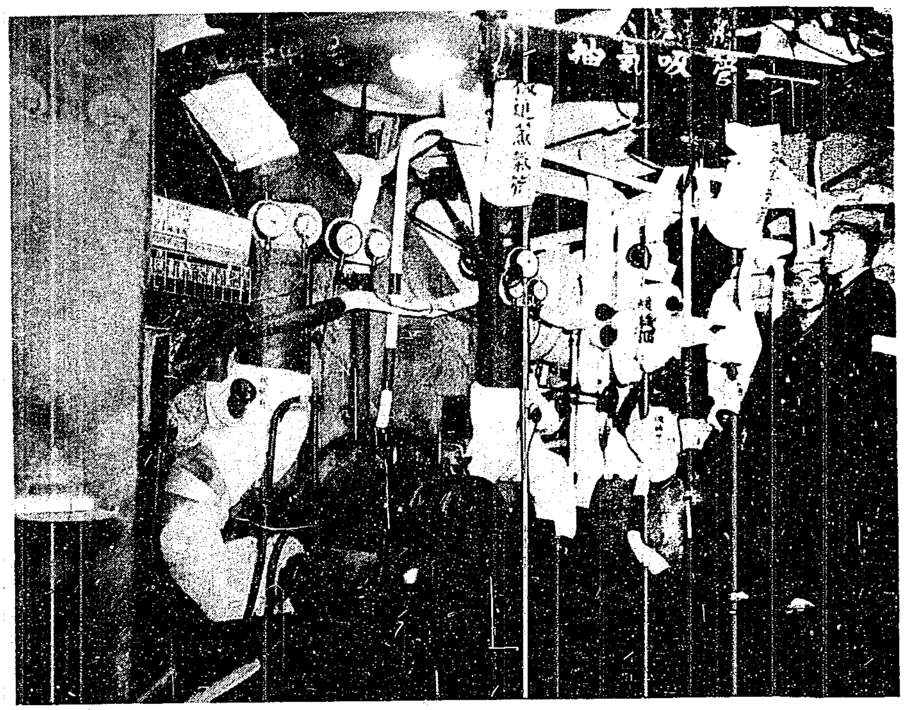

Figure 11
CENTER ENGINEROOM KATSURAGI (CV) KATSURAGI
(Destroyer turbines installed in carrier.)

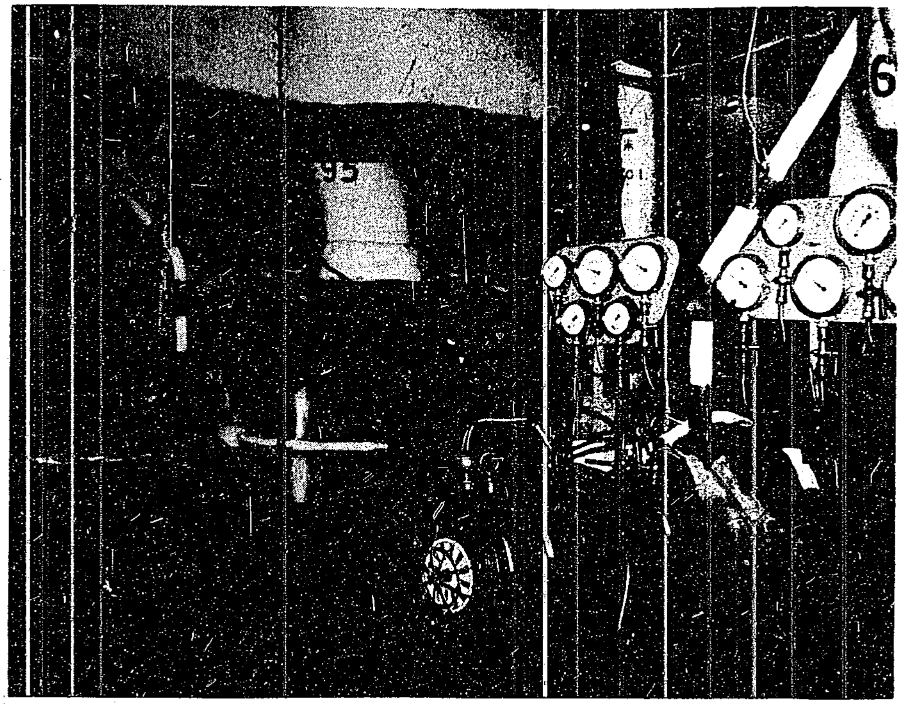

Figure 12
NAGATO (BB) CENTER ENGINEROOM LOOKING AFT

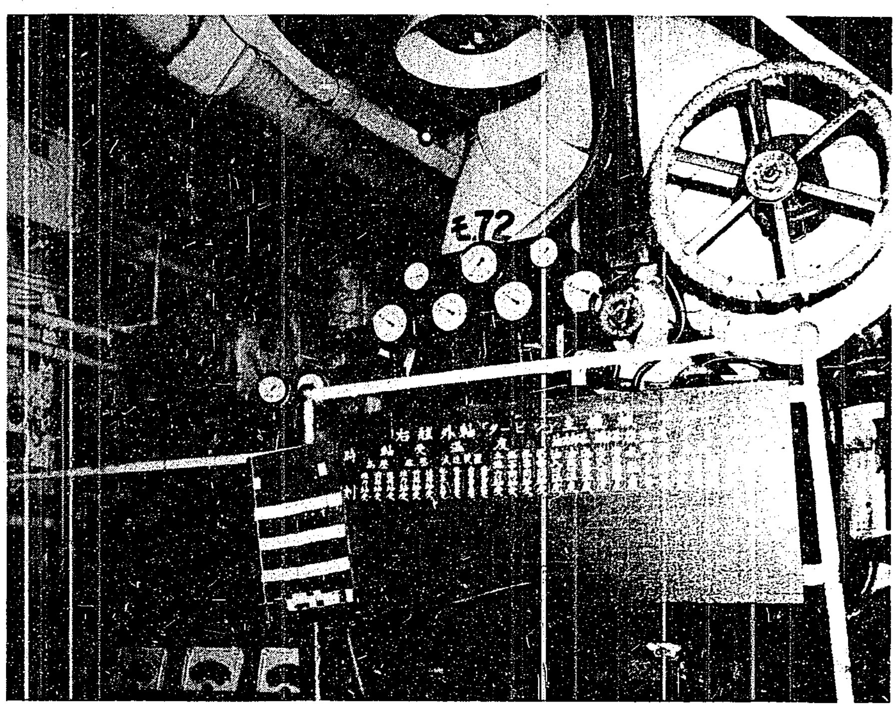

Figure 13
STARBOARD ENGINEROOM NAGATO (BB) LOOKING AFT

4. Piping Systems

a. Main Steam Lines

Main steam lines varied considerably with the number of boilers. In the case of the YAMATO class (12 boilers), the boilers may be considered as four groups of three boilers each in a fore and aft row with the rows athwartships from starboard to port. Each group of three boilers supplied the engine most nearly astern of it, the outer groups supplying the outboard shafts and the inner the inboard shafts. Cross-connecting lines were provided in the forward end of the machinery spaces but aft of the bulkhead stops. It is evident that with this arrangement the two inboard shafts, their enginerooms and the boilers supplying them are afforded the maximum amount of protection.

In the case of eight-boiler cruisers and carriers the lines from the two forward boilers on each side joined in Firerooms No. 3 and 4 respectively, and led aft on the outboard side to the forward engines. The two aft boilers (Nos. 6 & 8, Nos. 5 & 7) on each side led aft on the inboard side, each boiler through a separate line until it passed through the bulkhead of the enginerooms. Just aft of the bulkhead stops, Nos. 6 and 8 joined, to feed the port inboard engines and Nos. 5 and 7 to supply the starboard inboard engines. A cross-connecting line lead athwartships just aft of the fireroom bulkhead connecting the main steam lines of all four shafts.

In six-boiler ships (CL's) the forward boilers fed through lines passing outboard to the outboard engines. Boilers No. 3 and 4 fed through separate lines passing inboard to the respective inboard engines. Boilers No. 5 and 6 fed to a "Y" which joined the line from the forward boilers (Nos. 1 or 2) on the outboard side and the line from Nos. 3 or 4 on the inboard side. The junction takes place aft of the bulkhead stop on the engineroom side. It is interesting to note that this arrangement which appears in the OYODO, the latest CL, differed from that in former six-boiler CL's. In the AGANO class Boilers No. 1 and 3 supplied No. 1 shaft; Boiler No. 5, No. 2 shaft; Boilers No. 4 and 6, No. 3 shaft; and Boiler No. 2, No. 4 shaft. In any six-boiler ship it was difficult to supply four engines satisfactorily and maintain a split plant.

In the case of three-boiler ships (DD's) Boiler No. 1 fed the port engine in the forward engineroom, while Boiler No. 2 fed the starboard engine in the after engineroom. The line from Boiler No. 3 could supply both engines, feeding to a "Y" which joined each of the two main lines in the forward engineroom aft of the bulkhead stop. A cross-connection between the main steam lines was provided in the forward engineroom.

In all classes of vessels from DD's and above a bulkhead stop was provided on the engineroom side of all main steam lines that come through the fireroom bulkhead. This valve, a piston type, was held open when in use by the steam pressure under the seat, but could be closed by admission of steam to a piston. This operation could be controlled from the deck above. Plans of this valve are contained in NavTechJap Documents ND50-1018 to ND50-1020.

A cross-connection to the auxiliary steam line was provided in each engineroom of all vessels. A cross-connection between main steam lines was provided just aft of the fireroom bulkhead in all vessels. Where enginerooms were abreast each other, as in YAMATO or the two forward enginerooms of cruisers, the cross-connecting valves were operable from both sides of the fore and aft bulkhead. For all of the later classes of vessels where the boilers could be evenly divided among the four engines, the arrangement was satisfactory for a split plant and as well protected as was consistent with an arrangement of all boilers forward and all enginerooms aft. The arrangement in YAMATO class was particularly good as concerns protection. However, this protection was obtained at the expense of a listing movement created in case the outboard firerooms on one side became flooded as a result of rupture of the torpedo defense system.

All three and six-boiler ships were, of course, unable to steam at full power with a split plant. However, the situation was no worse than in BROOKLYN class cruisers or the CA 39 and CA 42 of the U.S. Navy. As a general rule, the main steam lines were relatively straight, with expansion joints between fixed mountings. There seemed to be no consistency as to whether there was a bulkhead flange at the bulkhead or a stuffing box where lines passed through bulkheads.

Expansion bends were provided between some fixed mounting near the throttle valves, which were all relatively remote from the turbine casing and the turbines. Expansion bends were also provided between the boiler stops and the point where the line joined the main steam line or some fixed mounting. In a number of cases these expansion bends consisted of two and sometimes three smaller lines feeding from a "Y" at each end of the bend. The total area of both lines closely approached that of the main from which they emanated.

Difficulties with leaks were reported with the packed expansion joints.

b. <u>Auxiliary Steam Lines</u>

As in the case of the U.S. cruisers up to CA 38, the auxiliary steam line operated at the same temperature and pressure as the main. This permitted cross-connection of the two systems in each space so as to receive all steam for the engine room auxiliaries from the main steam in each space, if so desired. Indications are that this was done under battle conditions. Furthermore, there were cross-connections in BB's to the adjacent enginerooms and in cruisers to both the engineroom forward or aft plus the one abreast. Bulkhead valves were provided, but with no remote control.

Special cross-connections were provided for a standby steam supply to the L.O. pumps from the adjacent engineroom on that side of the ship in YAMATO class and from the corresponding engineroom on the other side of the ship for cruisers. No such cross-connection was noted in the UNRYU carriers.

It is also noted that the steam bilge ejectors with which all vessels were fitted for emergency use were provided with steam from the adjacent engineroom on the same side of the ship in YAMATO class.

In YAMATO the only cross-connection between the auxiliary steam mains running aft to the enginerooms in four groups was in the forward firerooms. It was the practice, however, to keep this cross connection closed when steaming with a split plant. Four mains ran aft, one through each group of firerooms with a connection to the auxiliary steam system of each fireroom of its group. Here again it was not the practice to use these mains when steaming with a split plant. Under split plant conditions each fireroom furnished its own auxiliary steam, and the enginerooms received their steam from the cross connection to the main steam line in its own space. Here again, in the firerooms steam to the bilge eductors for emergency use came only from the adjacent fireroom on the same side of the ship.

The same general setup existed in cruisers. A cross connection from port to starboard was provided in the two forward firerooms only. Here too, the bulkhead valve was closed when operating split. Two mains ran aft and outboard on each side from the forward firerooms to the enginerooms with a connection to the auxiliary steam lines in each fireroom traversed. Again it was the practice not to use this line, each fireroom supplying its own steam, and the engineroom receiving steam through the main to auxiliary cross connection in each space.

Destroyer systems followed the same general practice. One main ran up one side outboard connecting to the auxiliary steam system in each fireroom and then on to the engineroom. Another line ran the length of the firerooms only, on the other side of the vessel. Wherever possible, the steam bilge eductors were supplied with steam from a line in another fireroom or from the engineroom. SHIMAKAZE, the latest Japanese destroyer, followed the above general trend except that both the fore and aft mains extended into the enginerooms.

The carriers followed the same general trend as the cruisers, except that the mains, instead of running outboard, ran up the center line. The only cross connection was in the forward boiler rooms. Contrary to usual practice, the steam to the bilge eductors was from the local steam system.

c. Auxiliary Exhaust Lines

The auxiliary exhaust system in the boiler rooms of YAMATO consisted of four separate systems running down to outboard sides of the four groups of boilers. There were no cross connections between the systems in the firerooms, nor were there any bulkhead valves. Six-boiler ships, such as OYODO (CL), had essentially the same system in the firerooms, except that there were two systems instead of four. In the enginerooms of YAMATO (BB) there was a main cross connection between each engineroom and the one adjacent, in addition to the peculiar lube oil pump set up, which will be explained later. In the case of the CL's, which have the same lube oil system, there was only one additional athwartship cross connection which was in the after engineroom.

Eight-boiler ships such as UNRYU class (CV) had four auxiliary exhaust systems. Two serviced the two forward boiler rooms on each side (No. 2 and 4 and Nos. 1 and 3) and ran aft and outboard to each of the two forward enginerooms; the other two systems served the two after firerooms on each side and ran inboard to the two after enginerooms. There was a cross connection between the forward and after systems on each side in each forward engineroom. There was also a connection between the lube oil pumps in the two forward enginerooms and likewise in the two after enginerooms. There was also a cross connection between the systems in the two after enginerooms and another for the forward enginerooms. The bulkhead valve on the former was operable from both sides of the bulkhead.

Destroyers had two systems. Boiler No. 1 auxiliaries exhausted to one system outboard and aft on the port side. It was this system which also ran forward to the anchor engine. The port system continued aft to the forward engineroom which it served. There it branched to a "Y" and entered the after engineroom on both sides of the ship where it joined the starboard system in two places.

Likewise, the auxiliaries of Boiler No. 2 exhausted to a line running aft on the starboard side to the after engineroom, where it branched out to all auxiliaries, and cross connected to the other system in two places, one on each side.

Boiler No. 3 auxiliaries in the after fireroom could exhaust to either system and thus constituted a cross connection in that fireroom.

d. Boiler Feed System

The boiler feed system used on all ships corresponded to what has been termed a "semi-closed" feed system in U.S. naval vessels. However, the Japanese referred to it as a "closed" feed system. The main condensate pump took a suction from a well in the bottom of the condenser and discharged through the air ejector coolers and low pressure feed heater located in the engineroom. Upon leaving this heater, of which there was one for each engine, the feed water line connected to a cross connection line in the forward enginerooms for cruisers and carriers and through all enginerooms of YAMATO. From this cross connection line a line led forward to connect with each feed system of the firerooms. For destroyers the cross connection was in the fireroom.

Just after leaving the low pressure heater, a branch led off to the float control tank, thus maintaining constant condensate pressure on the float control tank at all times. In addition to this connection, the float control tank had connections to the condenser well and the main feed tank, or surge tank in U.S. naval terminology. The operation of the float control tank was automatically controlled by the level of water in the condenser well. If the level was too high, the valve operated so that part of the condensate was discharged to the surge tank and the level dropped.

If the level was too low, the valve operated so that water flowed from the surge tank to the condenser. Thus all water fed to the main feed pump passed through the main condenser with the minimum amount of contact with air. The surge tank was vented and not under a vacuum as in the U.S. closed system. A print of the float control tank is shown on NavTechJap Document ND50-1021.

In the firerooms the water went to the boiler or boilers which supplied the engines from which the condensate came. The water passed in turn to the main or emergency feed pump, to the feed heater and to the boiler. There was a main feed pump and a high pressure feed heater for every boiler. The auxiliary feed pump could discharge directly to the boiler via the auxiliary check valve without using the feed heater. In the case of cruisers and carriers, there was an emergency cross connection from the feed heater discharge to the feed heater discharge of the adjacent fireroom on the other side of the center line. This valve was operable by rigid shafting from both sides of the bulkhead. In the case of YAMATO the cross connection existed only between adjacent boiler rooms on the same side of the ship. The cross connection on YAMATO was also different in that an additional line on each side of the ship ran from the evaporator room through the center engineroom and on through the center firerooms. In each fireroom through which this line passed it connected to the cross connection on the main feed lines described above. The valve on this connection was operable from both sides of the bulkhead. This line was fed from a port-use, electric-driven feed pump in the evaporator room.

In the case of destroyers, the main condensate followed essentially the same course in the enginerooms as in other vessels. In the firerooms a line ran down each side of the vessel and cross connected in each fireroom. Normally the condensate returned to the boiler which originally supplied it as steam. However, with the above cross connections it could be lead to any feed pump. Cross connections were provided between the outlets of the feed heaters so that in an emergency any pump could feed any boiler.

e. Fuel Oil Service System - Suction and Discharge

In the case of YAMATO, each group of two boiler rooms, such as the two forward on the port side or the two aft on the starboard side, had its own fuel oil system. Each system was in fact two systems, each with its own pump, heater and accessories, but cross connected to the other both on the suction and discharge sides by means of valves operable from both sides of the bulkhead. All suction was from local tanks either under or adjacent to the fireroom. There were two tanks from which each service pump could take direct suction and two more could be made available by means of the cross connecting valve mentioned above. The service pumps could take suction from no other tanks, nor did the Japanese employ a fuel oil booster pump. They had a fuel oil distributing pump, which will be covered under the fuel oil transfer system. (see 4f.)

The installation on cruisers and carriers was somewhat like that on YAMATO except that, being only half as large, it had only half as many systems, and the cross connections crossed the centerline of the ship, instead of running only between the boiler rooms on one side of the ship. There were more oil tanks in the neighborhood of the boiler rooms providing more standby suctions, of which there were at least three without opening the cross connection. Another difference is that the system in the after firerooms connected to the fuel oil transfer system for suction in the starboard forward engineroom on the starboard side and the port forward engineroom on the port side.

In the case of destroyers the same tendency to cross connect was noted. In the TERUTSUKI class there were two boilers in the forward fireroom and there were two complete fuel oil systems. The two fuel oil pumps in the forward fireroom could each take direct suction from one tank under Boiler No. 1 or one tank under Boiler No. 2. The other pump could take suction from the corresponding two tanks on the other side of the ship. The after boiler, which supplied steam to both shafts, could take direct suction from about four tanks. Suction from other tanks could be obtained through cross connections to the fuel oil transfer system. In this class of vessels the same lines to the tanks were used for filling and suction, which was not the case in larger vessels. Cross connection were provided between the high pressure sides of all systems between the pump and the heater, as was the case in all Japanese vessels.

SHIMAKAZE, the latest Japanese destroyer, had essentially the above system arranged in three boiler rooms instead of two.

There were electric fuel oil service pumps provided for port use, two per BB, CA, DL and CV and one per DD.

f. Fuel Oil Filling and Transfer System

In general, the fuel oil filling and transfer system was very complicated. Within the machinery spaces there were two complete systems with two connections to each tank, one for suction and one for discharge. Where a fuel oil service pump took suction from a tank, no other suction was provided.

Within the machinery spaces all discharge lines fed to the tanks through an open funnel, apparently in order to prevent a pressure being placed on a tank. In many cases several tanks could be fed from one funnel.

This was not the case for tanks forward and aft of the machinery spaces, where the same pipelines were used for suction and discharge. YAMATO class had a pumproom forward and another aft of the machinery spaces from which tail pipes ran to each of the forward and after tanks respectively. These pumprooms also connected to the fuel oil filling and transfer systems in the machinery spaces. Five pumps were located in each of these pump rooms. Two more were located in the evaporator rooms (one in each).

In the case of destroyers, the double system of two pipes to each tank was not used.

The loop of the fuel oil transfer system so characteristic of U.S. naval vessels was missing in Japanese design. However, they recognized the danger of running lines fore and aft through athwartship bulkheads and endeavored to eliminate as much of this fore and aft piping as possible. Where piping had to pierce athwartship bulkheads, the piping was carried as high in the ship as practicable.

The fuel oil transfer pumps could not discharge to the suction of the service pumps. There were no booster pumps on any of the combatant vessels.

g. Fire and Bilge Piping in Machinery Spaces

In UNRYU class of CV's the fire main in the machinery spaces was very extensive, running in a complete loop with cross connections at each group of pumps (through Firerooms No. 1 and 2, Firerooms No. 5 and 6 and the two forward enginerooms). There was a fire and bilge pump in each fireroom and each engineroom, half the pumps being turbine driven and half electric driven, and their locations were so staggered that no two of the same type were in the same athwartship section of the ship.

Stop valves were provided in the loop between each cross-connection and on either side of each riser leading to the firemain proper on the upper decks. Stop valves were also provided at either end of each cross-connection and where the cross-connection crossed the center lines.

Each of the above pumps was also a bilge pump and was cross connected so that it could take suction either from its own space or from the corresponding machinery space on the other side of the center line. A stop valve operated from both sides of the bulkhead was provided at the centerline bulkhead.

The above system was in striking contrast to that of, for example, a six-boiler light cruiser such as OYODO, which had a total of four fire and bilge pumps with no loop in the machinery spaces. In OYODO risers went from the pumps vertically to the fire main on the upper decks. Spaces not having a pump received firemain pressure from a vertical line led down from the fire main.

Drainage in OYODO was split among the pumps. The pump in Fireroom No. 1 served Firerooms No. 1, 2 and 3, while the one in Fireroom No. 6 served Firerooms No. 4, 5 and 6. The pump in each after engineroom drained the engineroom ahead of it. There was also a cross-connection between the two after engineroom systems. A line ran aft from the engineroom system to drain the shaft alleys.

In the case of the latest destroyers, there was a total of three pumps, one in Fireroom No. 1 and one in each engineroom. The fire main ran down the starboard side of the ship with branches to plugs in each space and risers to the fire main in the upper decks. The two engineroom pumps were also bilge pumps, and were connected to an engineroom drainage main through which both enginerooms could be drained. The fire pump in the Fireroom No. 1 had no bilge suction connection. The only drainage in the firerooms was through the steam eductor drainage system.

In addition to any drainage furnished by bilge pumps, all DD's and above were equipped with at least two steam drainage eductors in each engineroom and one per fireroom. In most cases steam supply for these eductors was furnished from another space.

h. Fresh Water Transfer System

The fresh water transfer system consisted of one line running fore and aft through the machinery spaces with connections to a hose connection near each reciprocating emergency feed pump. By means of this hose connection, any auxiliary feed pump could take suction from its own reserve feed bottom and discharge to any other reserve feed bottom. As is the case in other systems, YAMATO's consisted essentially of two cruiser or carrier systems side by side.

i. Main Lubricating Oil System

The main lubrication system was similar to that in U.S. naval vessels in some respects. The following were the major differences:

(1) The steam driven supply and exhaust vents were supplied from the main system.

(2) The lube oil pumps themselves were lubricated from the main system.

(3) Water for vessels of cruiser size and larger had a separate lube oil cooler pump operating on a system independent of the firemain to supply cooling water for the cooler.

(4) Lubrication for the lube oil cooler pump was supplied from the main lubrication system.

(5) In cruisers and above there were three lubricating oil pumps for each unit. The steam and exhaust connection were such that at all times one pump could be lined up to use steam and exhaust from another space in case of failure of steam in the immediate space.

It is to be noted that not all of the auxiliaries in the engineroom were lubricated off the main system. The condensate pumps, the main circulator, the fire & bilge pumps and evaporator pumps had their own lubrication.

On the other hand, each fireroom had its own lubricating oil system for all auxiliaries except the reciprocating pumps. The lubricating oil pum and the lube oil cooler pump were both driven by the same turbine. Furthermore, there was a cross-connection between the high pressure sides of the two firerooms in the same athwartship section of the ship in the case of cruisers and carriers, and between those in same athwartship section of the ship but on the same side of the centerline for battleships. There was also an equalizing line between the sumps corresponding to the above cross-connection.

In the case of destroyers, there was a complete system for each boiler, and here again there were cross-connections between the high pressure sides and equalizing lines between the sumps. In this particular class of vessel the cross-connections connected all three systems.

It is also to be noted that main lubricating oil pumps of all vessels had a standby steam and exhaust connection from another space. Connections were such that the standby pump could be lined up on the adjacent space for steam and exhaust.

j. Steam Drains

All low-pressure drains from auxiliary turbines, main steam valves, etc., led to open funnels, which in turn led to bottoms directly under the compartment. A valve was located where the line pierced the inner bottom. No open funnel drain systems passed fore and aft through bulkheads.

Most main turbine drains ran to the main condenser. Closed high-pressure drains discharged through a trap to the large tanks in the enginerooms.

The superheater drains discharged through a steam trap directly to the reserve feed bottoms under the boilers.

All feed heater and fuel oil heater drains led directly to the condenser of the plant being supplied by the feed heater and boiler in question.

Condensate from the turbo-generators was led to the surge tank through a closed system; condensate from galley, laundry, heating system, etc., also discharged through a closed system to the feed tank.

The low pressure feed heater drains in the enginerooms discharged to the main condenser in the same space.

There were no closed steam line drains from the main and auxiliary steam lines in the fireroom.

5. Distilling Plants

The Japanese distilling plants operated on a drowned-tube system. The coils were copper and wound in a double spiral with the inlets and outlets connected to adjacent manifolds. The distiller was used as the first stage of feed heating and as a vapor heater for the second and last stage. There was no coil-drain heater.

The plant was designed to operate on either live steam or auxiliary exhaust. When operating on the former, atmospheric pressure was maintained in the shell and distiller. The incoming steam passed through a two-stage jet pump which took suction on the evaporated vapor from the shell, compressed it, and forced it back into the coils. When operating under these conditions, about 392°F was maintained in the inlet manifold to the coils.

When using exhaust steam, a vacuum of about 10 in. Hg. was maintained in the distiller by means of the exhaust ejector.

Diagrammatic sketches of the system, plus a brief set of operating instructions, are shown on NavTechJap Documents ND50-1022 and ND50-1023.

6. Pumps in General

In general, all pumps in later vessels were rotary except the auxiliary feed pump, which was a reciprocating type. All of the rotary pumps were turbine-driven except the fuel oil transfer pumps and some of the fire and bilge pumps.

The fire and bilge, main condensate, and main feed were centrifugal pumps. The main circulator and lube oil cooler were propeller type, as were the forced-draft blowers. All lubricating oil and fuel oil pumps were gear type.

The turbines had been standardized in the following sizes of pitch diameter of the rotor wheel: 120, 180, 270, and 360mm. All drove through reduction gears.

The machinery spaces were relatively roomy, with ample space to overhaul machinery. The pumps and their turbines were relatively small and accessible for overhaul. Spare impellers for centrifugal pumps were stowed on brackets around the machinery spaces.

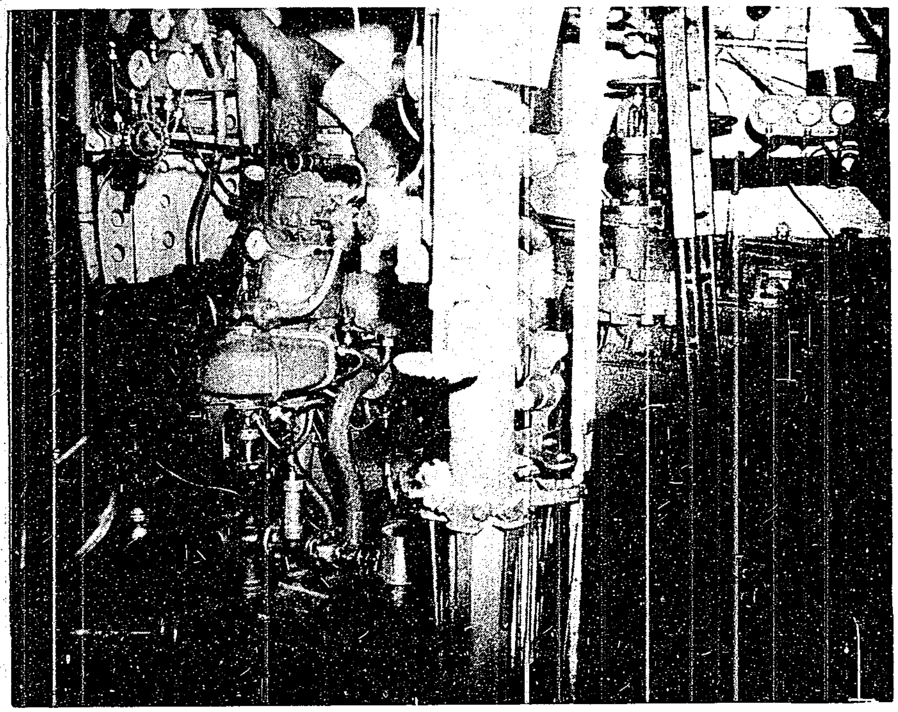

Figure 14
PUMPS IN BOILER ROOM KAGERO CLASS DESTROYER

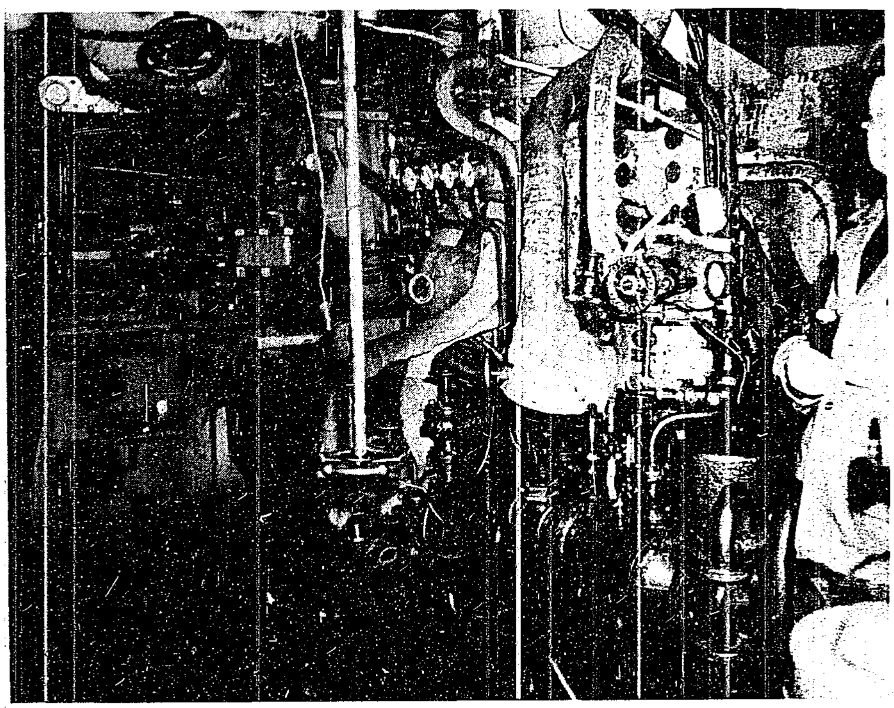

Figure 15
PUMPS IN BOILER ROOM AGANO CLASS LIGHT CRUISER

7. Boilers in General

In general, boilers were all of one type: an "A" boiler with superheater in the middle of each bank and an air preheater over each bank. The fireroom was not under air pressure, since double casings with air pressure between were used. The fire sides of several boilers were inspected, and while the brickwork was in good condition, the boilers did not show any evidence of heavy steaming over any long period of time.

8. Turbo-Generators (steam-end only)

In general, except for destroyers, which had the turbo-generators in the machinery spaces, all of the turbo-generator auxiliary pumps, such as circulator and condensate, were operated from the generator turbine. In starting up, the vacuum was brought up to about 15 in., using the steam air ejector and the cooling water which was in the condenser by reason of its location below the waterline. A hand pump provided the necessary lubrication until the self-contained pump began to operate. As the turbine speeded up, the circulator started a flow of cooling water. The machine was operated at no-load until the vacuum was up. It is reported that from "cold" it took about 15 minutes to place a turbo-generator on the line. In order to be anywhere near ready for service they had to be kept running idle.

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ENCLOSURE (A)

DOCUMENTS FORWARDED TO BUREAU OF SHIPS

NavTechJap Document Number	Title of Document
ND50-1016	Machinery arrangements of various Japanese naval vessels.
ND50-1017	Machinery layout of several Japanese naval vessels.
ND50-1018 ND50-1019 ND50-1020	Plan of main steam stop valve.
ND50-1021	Plan of float control valve.
ND50-1022	Schematic diagram of distilling plant.
ND50-1023	Print of name-plate data of distilling plant.