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

Subject: Target Report - Hydraulic Pumps in Japanese Naval Ordnance.

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

1. Subject report, covering Target O-53(N) of Fascicle O-1 of reference (a), is submitted herewith.

2. The investigation of the target and preparation of the target report were accomplished by Comdr. (E) A.J. Stewart, RN.

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HYDRAULIC PUMPS IN JAPANESE NAVAL ORDNANCE

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

FASCICLE O-1, TARGET O-53(N)

FEBRUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ORDNANCE TARGETS

HYDRAULIC PUMPS
IN JAPANESE NAVAL ORDNANCE

Hydraulic pump motors used in Japanese ordnance are all of conventional and well known design. They are known to the Japanese mostly as "Johnny" engines - a probable corruption of the name "Williams-Janney" engines. They have no high speed (over 1000 RPM) small or large pumps except the 3600 hp turbo direct drive, impeller type pumps used for the 18" turrets of YAMATO and MUSASHI. These pumps were designed and the prototype pump for YAMATO was built in Switzerland by Brown Boveri. Their normal speed is 3700 RPM.

All data given in this report are liable to be revised after translation of the numerous documents sent to the Washington Document Center, since a vast amount of research has been done by the Japanese in recent years, both on hydraulic engines and the fluids used as pressure media. The only fluids so far known by the author to be used in Japanese naval ordnance are: the standard mixture of distilled water and Argolene oil for 14" turrets and above, and mineral oil for 8" turrets and below.

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REFERENCES

Location of Target:

Kure Naval Arsenal.

Various warships, including BBs, CVs, CAs, and DDs.

Navy Technical Department, TOKYO.

Naval Technical Library, YOKOSUKA.

Japanese Personnel who Assisted in Gathering Documents:

Commander ICHINOI, Formerly IJN, Navy Technical Department, TOKYO.

Japanese Personnel Interviewed:

Technical Commander KUDO, Engineer Officer, Navy Technical Department, TOKYO.

Mr. T. OTORI, Engineer, Ordnance Department, Kure Navy Yard.

INTRODUCTION

The object of the investigation was to obtain general particulars of the various hydraulic engines and hydraulic fluids in use by the Japanese for naval ordnance. Details of small, high speed (over 1000 RPM) hydraulic pumps were particularly sought. A list of questions on all types of hydraulic engines was prepared and given to Mr. OTORI, who has long been concerned with the design of hydraulic pumps and motors. The tables of data in Enclosures (B) through (L) are his answers to these questions. A large number of engines were inspected by the writer at KURE during the course of investigations on various mounts. Certain of the data in these tables were checked by translation of the nameplates on the pumps themselves. The information on the turbo driven pumps fitted in YAMATO and MUSASHI was given by Cmdr. KUDO of the Navy Technical Department, TOKYO. Few details were available concerning these pumps, but as they were designed, and one of them built, in Switzerland, full details can no doubt be obtained from that country. Two 500 hp training engines, similar to these fitted in YAMATO and MUSASHI, have been sent to the United States. A number of the smaller pumps and motors will also be available for inspection on the various mounts shipped to the United States. Further, a vast amount of detail will be available after translation of the numerous documents which were collected at YOKOSUKA and sent to the Washington Document Center.

THE REPORT

A. TURBO-HYDRAULIC PUMPS

The only turbo-hydraulic pumps used in Japanese Naval Ordnance were for the 18" turrets in YAMATO and MUSASHI and one trial pump in BB HIYEI. These pumps and the turbines driving them were designed by the Brown Boveri Company in Switzerland. The first set was built by this company and sent to Japan; the remainder were built in Japan at the Hiro Navy Yard from the same designs. The pumps were driven at turbine speed and were of the two-stage impeller type. Conventional, combined speed and pressure, oil operated governors were used. These appear to have been very satisfactory, and very little trouble was experienced in keeping a steady delivery pressure when changing suddenly from "no load" to "full load" conditions.

The following tabulation gives the essential details of the turbines and pumps:

Number of pumps per ship ..... 4 (1 per turret, and 1 standby)

Shaft horsepower of turbine

Normal 3600

Overload 5000

Steam pressure (from memory; probably not reliable)

Before chest ..... 284 lbs/m^2

Chest pressure ..... 227 lbs/m^2

Speed of turbine and pump

RPM (normal) 3700

RPM (overload) ..... approximately 4000

Weight of turbine (incl. bed and aux. machine) .... about 9 tons

Type of pump ..... centrifugal impeller

Number of pumps per turbine ..... one

Number of impellers per pump ..... 3 (2 first stage)

Diameter of impellers, 1st stage ..... 17.73"

Total weight of main turbine, pump, and bed ..... about 20 tons

Capacity of pump

Cubic meters per hour 1100

Cubic feet per hour 38,850

Working pressure ..... 1000 lbs/m^2

Diameter of suction pipes (2 per pump) ..... 14.97"

Diameter of delivery pipe ..... 10.244"

B. STEAM RECIPROCATING PUMPS

Reciprocating pumps were fitted in the older battleships and were similar to those used in British 15" turrets. Some data on these pumps are given in Enclosure (B). Enclosure (C) gives data on various "B" ends used in 14, 16, and 18" turrets. In NavTechJap Report, "Japanese 18" Guns & Mounts", Index No. O-45(N), the author stated that the speed of the 500 hp training engines, when the turret was being trained at its maximum speed of 2°/sec, was 53 RPM and that his figure could not be confirmed. In the data in Enclosure (C) of this report, the speed of these engines is given as 250 RPM when developing 503 1 hp, 350 RPM when developing 704.3 hp. These figures are reputed to have been obtained during test bench trials. Two of these engines have been shipped to the United States. If further trials are run on them, it may be found that their characteristics are such that they are able to produce their power at either of the speeds with a corresponding variation in torque.

C. ELECTRO-HYDRAULIC PUMPS

Data on these pumps is given in Enclosure (D). A number of these pumps were inspected but none was stripped for examination since drawings showed them to be of conventional design. Various pumps fitted to mounts which have been sent to the United States will be available for detailed examination.

In 8" and 6" turrets, it is the practice to fit two independent but similar sets of turrets pumps, either of which is capable of meeting the demand for pressure at full load. The discharge from the pumps is led into an accumulator and thence to the ring main. In 8" turrets two accumulators are fitted, and one is fitted in the 6". (See Figure 20, NavTechJap Report, "Japanese Naval Guns and Mounts, Article 1 - Mounts Under 18" ", Index No. O-47(N).)

In 12.7cm (5") mounts and below, the usual practice is to fit one electric motor driving two "A" ends (at opposite ends of the main shaft). The "A" ends supply pressure to two standard "B" ends for elevating and training. If an ammunition point is incorporated in the mount, as for example in the 10cm Type 98 twin mounts, an entirely separate power supply is fitted, having its own electric motor, and "A" and "B" ends.

D. FLUIDS AND PRESSURES

In 14" turrets and above, a mixture of distilled water and Argolene oil (known to the Japanese as lathe oil) in the proportion of 5 tons of water to 10 liters of oil is used as the pressure medium. In all smaller turrets and mounts, No. 2 mineral oil is used. The working pressure in the power systems of the smaller mounts is between 300 and 400 lbs/m^2. In 8" turrets it is 500 lbs/m^2. In order to save weight in the 6" turret, the pressure was increased to 1000 lbs/m^2. This pressure is also used for all 14" turrets and above.

ENCLOSURE (A)

LIST OF DOCUMENTS FORWARDED THROUGH ATIS TO WDC

NavTechJap No.	ATIS No.	Title
ND21-3403	3636	Report on counter measures against breakdown of hydraulic motors in 16" turret of BB NAGATO (1940).
ND50-3633	4074	Report on research on recoil cylinder liquids and leather (1931).
ND50-3634	4075	Report on experiments on 9 cylinder type of hydraulic motors (1930).
ND50-3635	4076	Notes on hydraulic control valves and materials used (1930).
ND50-3636	4077	Report on experiments on "U.T." type hydraulic motors (1930).
ND50-3602	3639	Report on oil cooler trials for 20cm (8") turrets (January 1938).
ND50-3619	3638	Report on variable speed gear oils.
ND21-3411	3637	Report on hydraulic buffer experiment.
ND21-3406	3635	Report on trials on non-inflammable turret oils (1943).
ND50-3614	3634	Report on anti-freeze ("Cold Proof") hydraulic fluid and oil meters (1941).
ND21-3404	3631	Report on recoil liquids (1939).
ND50-3612	3632	Experimental report on recoil liquids (1930).
ND50-3654	414C	Test on the amount of oil pumped by number 35 hydraulic pump in moving 20cm turrets (1931).
ND50-3655	4141	Static pressure drop, due to the resistance of valves, cocks and streamlining in oil systems, using Number 2 outside mineral oil (July 1935).
ND50-3657	4143	Research on types of oil for ordnance (March 1930).
ND50-3658	4144	Experiments on the performance of hydraulic control valve after modification to remove "self centering" effects when elevating at full and half speeds (December 1935).
ND50-3659	4145	Notes on design of No. 3 electric hydraulic engine (September 1930).

ENCLOSURE (A), continued

NavTechJap No.	ATIS No.	Title
ND50-3660	4146	Report on experiments on frictional resistance of oil in turret pressure systems (November 1930).
ND50-3661	4147	Test on recoil liquids (1930).
ND50-3662	4148	Research on using oil as a buffer at low temperatures (November 1943).
ND50-3663	4149	Report on efficiency of 200 hp swash plate hydraulic engines (January 1933).
ND50-3601	3629	Report on countermeasures for leakages in hydraulic systems in magazines of battleships.
ND50-3641	4127	Report on comparative efficiency of 3 cylinder hydraulic engines, before and after repairs necessary due to use over long periods for loading 36cm guns in HYUGA (May 1933).
ND50-3643	4129	Report on efficency of 7 cylinder hydraulic rammer engine for 36cm guns in BB KIRISHIMA (1935).
ND50-3645	4131	Maintainance and repair of training valves for 36cm turret in BBs HYUGA and ISE.

ENCLOSURE (B)

			Unit	650 HP (Reciprocating) Engine	450 HP (Reciprocating) Engine
HP	Nominal		HP	650	450
	Water		HP	654.2	477.9
RPM				110	110
High Pressure Steam Cylinder		Numbers		2	2
		Diameter	mm	419.1 (16.5")	368.3 (14.5")
Low Pressure Steam Cylinder		Numbers		2	2
		Diameter	mm	838.2 (33.0")	711.2 (28.0")
Pump		Diameter	mm	214.63 (8.45")	187.96 (7.4")
		Dia. of Piston Rod	mm	152.4 (6.0")	132.08 (5.2")
Stroke of Piston Rod			mm	533.4 (21.0")	508 (20")
Delivery of Water				?	?
Steam Pressure		Maximum	kg/cm^2	?	?
		Working	kg/cm^2	?	?
		Exhaust	kg/cm^2	?	?
Delivery Pressure			lb/in^2	1000	1000
Pipe Diameter	Suction		mm	279.4 (11")	?
	Delivery		mm	127.0 (5")	?
	Steam		mm	127.0 (5")	?
	Exhaust		mm	190.5 (7.5")	?
Design				Armstrong Co.	Armstrong Co.
Ships Fitted on				NAGATO, MUTSU = 5 ISE, HUGA = 5 FUSO, YAMASHIRO, KONGO, HARUNA, KIRISHIMA = 1 each	FUSO = 4 YAMASHIRO = 5 KONGO, HARUNA, KIRISHIMA = 3 each

Nominal Horse Power	Water Horse Power		Max. Torque (kg/m) (For Frictionless)		Velocity of Water (m/sec.)			Necessary Water Volume of Engine (dm^3)			Supply Pressure (lb/in^2)	Piston				Dia. of Cylinder Circle (mm)	Pipe Joints of Engine		Pressure Pipe		Area of Fixed Ports (cm^2)	Inclination of Swash Plates	Slips Fitted on
					at Port	at Delivery of Pipe	at Supply Pipe	1 Turn	250 rpm	400 rpm		Dia. (mm)	Area (cm^2)	Stroke (mm)	Nos.		Dia. (mm)	Area (cm^2)	Dia. (mm)	Area (cm^2)			
	250 rpm	400 rpm	800 lb/in^2	1000 lb/in^2																			
44	27.4	43.8	63	79		5.82	5.84	0.710	177	284	1000	38.1	11.4	44.45	14	88.9	25.4	5.06	25.4	5.06	1.63	14°-2'-14"	36cm ⏻ Rammer (Formerly)
60	37.5	60.0	87	109		5.76	8.03	0.977	244	391	1000	44	15.17	46	14	186	30	7.06	25.4	5.06	1.94	14°-5'-11"	36cm ⏻ Rammer
72	45.5	72.8	106	132		6.13	6.22	1.180	295	472	1000	46	16.6	50.72	14	106	32	8.05	31.75	7.92	2.13	13°-27'-15"	40cm ⏻ Rammer
132	87.9	140.6	204	255		6.13		2.281	570	912	1000	57.15	25.65	63.5	14	265.4	44.45	15.52	?	?	3.03	13°-29'-15"	36cm ⏻ Training (Formerly)
152	151.1	241.8	351	439		10.55		3.925	981	1570	1000	71.9	40.58	69.1	14	284.4	44.45	15.52	?	?	5.48	13°-39'-22"	36cm ⏻ Training
200	131.0	209.6	304	380	4.08	5.96	6.99	3.401	850	1360	1000	66	34.21	71	14	300	56	24.63	5.08	20.27	4.95	13°-30'-22.7"	FUSO 36cm ⏻ No. 3 Turret (Formerly)
220	222.2	355.5	516	645	4.04	7.47	7.59	5.768	1442	2307	1000	82	52.81	78	14	328	64	32.17	63.5	31.63	8.50	13°-35.3'	NAGATO, MUTSU 40cm ⏻ Training
450	330.4	462.8 350 rpm	768	960		3.48		8.568	2142	2999 350 rpm	1000	86.36	58.52	133.1	11	441.3	114.3	102.6	?	?	?	17°-9'-0"	Vickers-Armstrong Co.
500	503.1	704.3 350 rpm	1153	1441	3.13	10.68	10.68	12.882	3221		1000	100	78.54	149.11	11	500	80	50.27	80	50.27	15.60	17°-0'-0"	YAMATO, MUSASHI 94 Type ⏻ Training

SWASH PLATE ENGINES

		Unit	Special Size 20A	Special Size 12B	25B	10B	7.5A	7.5B	5A	5B	2.5A	2.5B	1.25A	1.25B	35A
Type			K	K	K	K	K	K	K	K	K	K	K	K	K
Material of Valve Plate and Casing			Special Cast iron	Special Cast iron	Special Cast iron	P.B.	Special Cast iron	Special Cast iron	P.B.	P.B.	P.B.	P.B.	P.B.	P.B.	Special Cast iron
Dia. of Piston		mm	51.796	42.304	1-9 55.463 2-8 57.904 3-7 59.019 4-6 57.059 5 55.316	1-9 43.109 2-8 44.989 3-7 45.822 4-6 44.328 5 42.977	38.976	1-9 36.977 2-8 38.603 3-7 39.347 4-6 38.031 5 36.878	35.413	1-9 34.800 2-8 36.800 3-7 36.800 4-6 35.800 5 34.800	27.831	1-9 26.990 2-8 28.105 3-7 28.646 4-6 27.694 5 26.848	22.110	1-9 21.386 2-8 22.328 3-7 22.757 4-6 22.000 5 21.329	67.038
Stroke of Piston		mm	61.599	50.366	72.756	50.361	48.597	48.597	39.962	39.962	31.27	31.27	25.392	25.392	81.697
No. of Cylinders			11	11	9	9	9	9	9	9	9	9	9	9	9
Tilting Angle		deg.	15	15	20	20	20	20	20	20	20	20	20	20	20
Standard Revolution		r.p.m.	500	500	500	600	600	600	700	700	800	800	850	850	500
Working Revolution		r.p.m.	500	500	500	500	500~750	500~750	500~720	500~720	500~720	500~720	500~850	500~850	500
Standard Delivery		l/min.	712	389	840	420	313	299	248	227	137	136	74	74	1295
Standard Pressure		lb/in^2	1000	1000	400	500	333	333	286	286	250	250	235	235	400
Working Pressure		lb/in^2	1000	1000	330~350	500	350~400	350~400	300~370	300~370	300~350	300~350	300~350	300~350	500
		kg/cm^2	70.3	70.3	23.2~24.6	35.2	24.6~28.1	24.6~28.1	21.1~26.0	21.1~26.0	21.1~24.6	21.1~24.6	21.1~24.6	21.1~24.6	35
Standard Fluid HP*		HP	100	60 (84%)	52.5 (80%)	21.9 (82%)	16.3	15.6 (79%)	11.0	10.1 (76%)	5.3	5.3 (77%)	2.7	2.7 (80%)	80.5
Max. Pressure Safety Valve Opening	Pressure Side	lb/in^2	1500~1650	1500~1650	800~880	800~880	800~880		800~880		800~880		800~880		800~880
	Oil Supply Side	lb/in^2	200												140±7
Dia. of Cylinder Circle		mm	234	191.282	206.375	142.88	133.35	133.35	113.03	113.03	88.9	88.9	72	72	231.775
Dia. of Socket Pitch Circle		mm	238	194.598	212.725	147.24	142.088	142.088	116.84	116.84	91.44	91.44	74.24	74.24	238.862
Electric Motor**	HP	HP	100	60	(50)	(20)	15	(15)	10	(10)	5	(5)	2.5	(2.5)	100
	Volt	V	220	220	(220)	(220)	220	(220)	220	(220)	220	(220)	220	(220)	220
	Ampere	Amp	370	290~300	(230~240)	(100~110)	80~90	(80~90)	50~60	(50~60)	24~28	(24~28)	13~15	(13~15)	370
Stroke of Controlling Shaft		mm	61.6				38.1		33.339		28.575		25.003		68.264
No. of Replenishing Valve			1				2		2		2		2		1
Dia. of Inlet Pipe			80	70	60	50	44	44	40	40	30	30	25	25	127
Dia. of Outlet Pipe			80	70	60	50	44	44	40	40	30	30	25	25	60
Fitted			15.5cm Gun Turrets Motive Power Dump	Not Used	Not Used		Minor Gun Mounts Elevating & Training Combined Gear		Minor Gun Mounts Elevating & Training Combined Gear		Minor Gun Mounts Training Gear etc.		Minor Gun Mounts Elevation Gear etc.		20cm Gun Turret

* Brackets Indicate Output Efficiency

** Parenthesis Indicate "A" End Capacity

VARIABLE SPEED GEARS USED IN MOUNTING AND TURRETS