FINISHED PLAN

INSTRUCTION BOOK

FR-280 TYPE

s\w H-4641

ELECTRO-HYDRAULIC STEERING GEAR

FURNISHED TO

SUN SHIPBUILDING & DRY DOCK CO.,

PURCHASE ORDER NO. 666858-2

HULL NO. 666

FOR

TRANSAMERICAN TRAILER TRANSPORT

ENGINEERED AND DESIGNED BY

KAWASAKI HEAVY INDUSTRIES, LTD.

OIL HYDRAULIC MACH. DEPT.

KOBE JAPAN

[redacted]

FEB 2[illegible] 1974
OIL HYDR MACH DIV.
KAWASAKI HEAVY INDUSTRIES, LTD.

BE

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KOBE JAPAN

BE

Remarks : For the steering gear to be installed in the ship navigating in cold region, the oil marked (*) is recommended.

(2) Filling the steering gear with oil

a. Open the stop valves 50 and the by-pass valves mounted on the oil block valve.

b. Open the air vent valves on the hydraulic cylinders. C3

c. Open the plugs on the hydraulic cylinders and fill up oil little by little.

d. Fill the oil tanks with oil through the filter up to the oil level gauge.

Preliminary Operation

(1) Checking of hunting gear

a. Check that the tiller, the auto-pilot power unit and the trick wheel are exactly in position.

b. Ensure that the floating lever is exactly in neutral position.

Adjust lengths of the connecting rods of the auto-pilot power units and of the buffer springs by means of the turnbuckles, if necessary.

(2) Pump running and expelling air from oil circuit

Prior to running the pump,

a. Ensure that the pump can be rotated freely by turning the coupling of the electric motor and the pump by hand.

b. Disengage the auto-pilot control by pulling out the pins of the connecting rod and engage the trick wheel for local control by inserting the pin (371) in Fig. A-14 in Appendix.

c. Close the air vent valves and the by-pass valves securely and keep the stop valves open.

After satisfying the above instructions, starting up the electric motor and run the pump, and expel air in the oil circuit in the following manner;

a. Operate the steering gear slowly with the trick wheel in both directions to circulate oil in the cylinders and the pipes.

b. Open the air vent valve on the cylinder into which oil is pumped, and expel air.

c. Repeat the above operations a, b, and expel air fully. Hence, <u>never open the air vent valve on the cylinder of non-pressure side.</u>

d. Ensure that any air bubble cannot be found in the oil flow by opening the air vent valve on the oil block valve.

e. Ensure smooth movement of the ram.

(3) Adjustment of hunting gear and checking of rudder angle in pump running

a. The auto-pilot control is now disengaged and the trick wheel for local control is engaged and in neutral (zero) position.

SPARES INVENTORY DATA

SHIP NAME: KAINALU

EQUIPMENT SPECIFICATIONS

EQUIPMENT NO.: [illegible]
MANUFACT. : KAWASAKI HEAVY IND.
SERIAL NO.: H-4641
REFERENCE NO.: S22 1-4

GOVT DESC: STEERING GEAR
MODEL/TYPE: FR-280 ELECTRO-HYD.
RATING:

PART#	PART DESCRIPTION	MANUFACT. PART NO.	MIN.	QOH.	ORD.	PART LOC.
001	MOTOR	FRAME 250M	2		0	
001AA	BEARING, BALL DRIVE SIDE	6316	1	1	0	EE 02
001AB	BEARING, ANTI DRIVE SIDE	7316DB	1	2	0	EE 02
002	SPARES,OIL TK,PIPING,RAM				0	
002AA	PACKING, GASKET	PCPB-85	4	4	0	EM 23
002AB	PACKING, GASKET	PCPB-105	4	10	0	EM 23
002AC	PACKING, GASKET	PCPB-85B	8	8	0	EM 23
002AD	PACKING, GASKET	PCPB-85B	4		0	EM 23
002AE	PACKING, GASKET	PCPB-105	4	4	0	EM 23
002AF	GLASS GAUGE F/OIL TANK	00G6100	2	2	0	EM 23

Available Functions: [illegible] (AltF7)

Ex MORRO ← KAINALU

Steering Pump Motor

MFG- FUJI ELECT. CO

TYPE- VRK

FRAME- 250M

VOLTS- 440

AMP - 80

RPM - 1175

HZ - 60

AMBT.- 50°C

RISE - 50°C

OUTPUT - ~~45 KW~~ 35.2KW

(PART) SER. #3118220252

~~HP~~

HP- 60

POLES- 6

MOD - 1512 A

INSUL - B-CLASS

~~BRG~~ # 6316
7316 DB

CODE- J

RATING- CONT.- 15%
1 HR - 100%
30 SEC - 200%

MFD- NOB 1973

NISHIKOBE WORKS
234 HAZETANI-CHO MATSUMOTO
TARUMI-KU, KOBE, JAPAN
TELEX NO. 5627-297
TEL. SEISHIN (991) 1133
P.O. BOX 49. AKASHI

Chief Eng.
Hull 666

GAR. ITEM 901

July 19, 1974

TECHNICAL INFORMATION

To Messrs. SUN SHIPBUILDING & DRY DOCK CO., Chester, PA.

Re : Motorizing of Stand-by Pump

In order to prevent the excessive motorizing of the stand-by pump in the steering gear where two or more pumps are installed and piping connections are ready for parallel running of the pumps, the Oil Block Valve is provided and its principle of operation as well as the functions are described in the Instructions for our steering gear.

Actually, by the results of our various engineering and tests, we have observed and confirmed that the stand-by pump will never be motorized providing the corresponding oil block valve is in its neutral position. Only possibility of motorzing, however, has been there in the main spool of the oil block valve being in shifted location from neutral. As the main spool is to be actuated by the pilot pressure, it can be shifted a little if a little pressure is accumulated in the pilot line from the oil block valve through the stand-by pump. And oil leakage from the oil block valve to the stand-by pump is a little increased, and the stand-by pump is slightly motorized. Possible case is such that the running pump is changed-over to the stand-by during the main hydraulic cylinder is under loaded condition, because oil in the pipe line from the oil block valve to the stand-by pump is still pressurized by the help of less leakage from the pump even if the pump is changed-over to the stand-by.

Through the above investigation we are to state that a little oil leakage from the oil block valve and slight motorizing are unavoidable but no problem to our steering gear. We have established as our normal practice such a standard that the speed of motorizing of stand-by pump within 5 through 8 percent of the rated speed is permissible when confirming the set pressure of relief valve, because we have enough margin in pump capacity for steering, i.e., designed steering speed is 65 deg/25 sec. for the specified speed of 65 deg/28 sec. and furthermore some margin in the volumetric efficiency of the pump.

Shop test of oil block valve (sheet 1.)

Fig. 1. Circuit of testing equipment

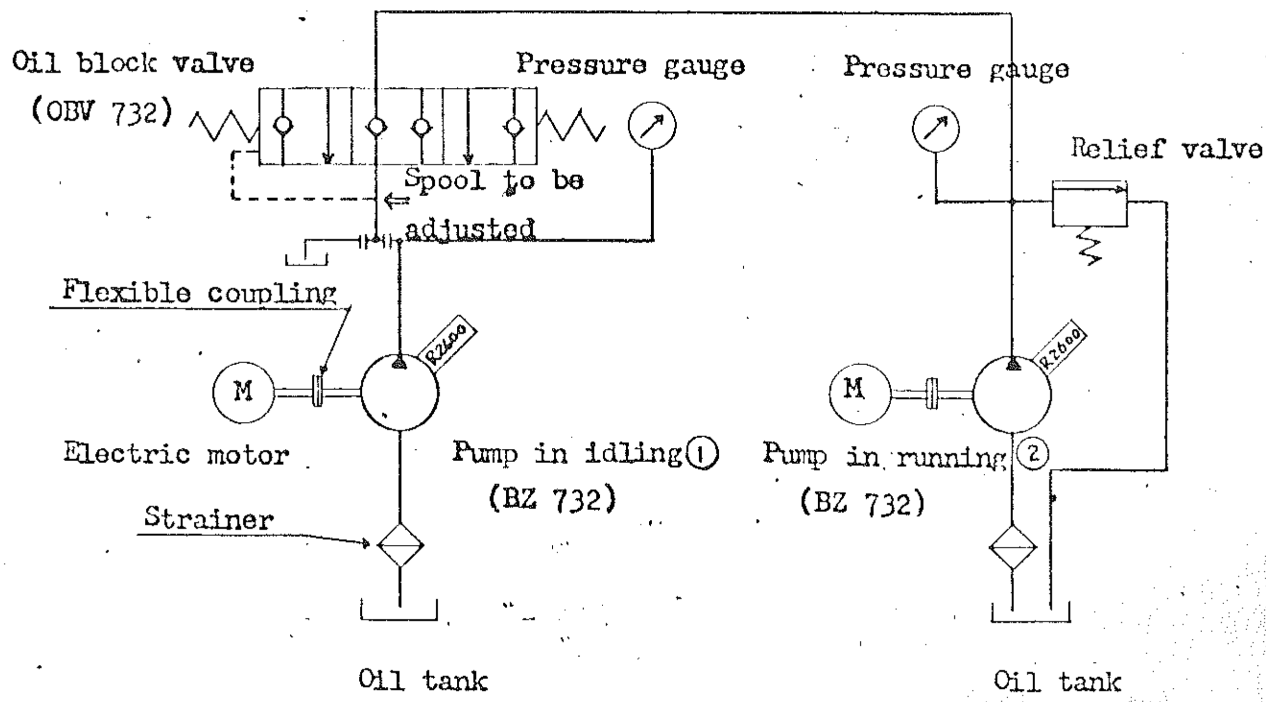
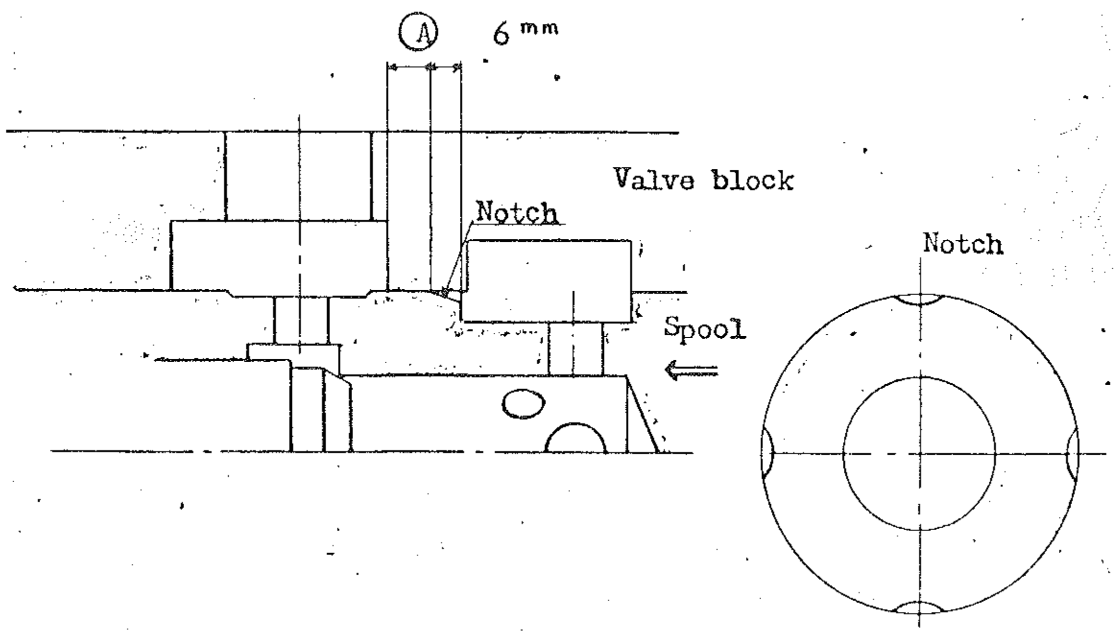


Fig. 2 Oil block valve



1) Dimension Ⓐ is 6 mm when the spool is in neutral position.

2) During test, Ⓐ is adjusted by moving the spool.

For reference, we are enclosing our test results.

Sincerely yours,

(T. Owatari)

Senior Manager of Engineering Dept.
Oil Hydraulic Machinery Div.

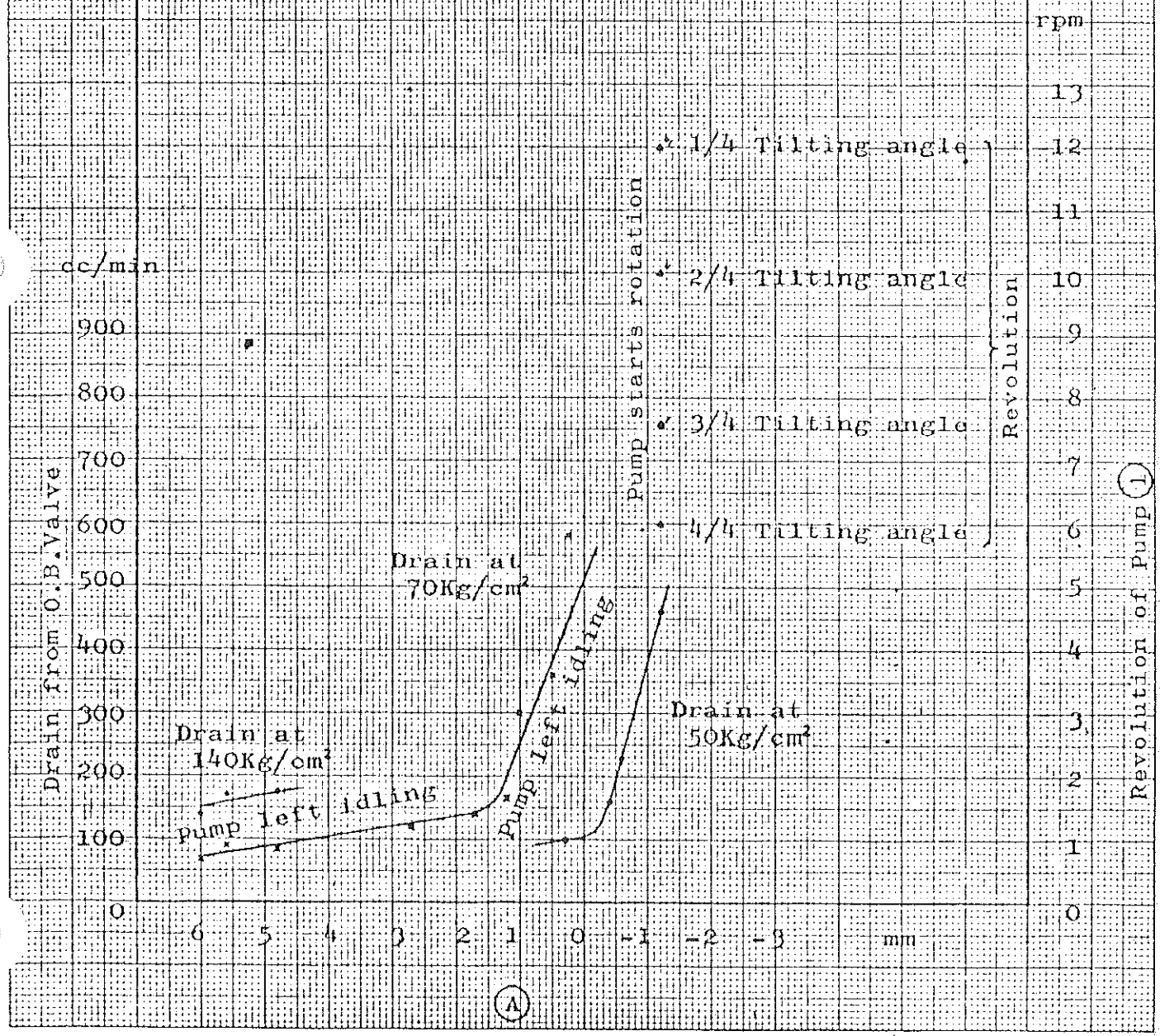
Shop test of oil block valve (sheet 2.)

Fig. 3. Test record

Used oil : #140 Turbine oil

Oil temp. : 20 ~ 23 °C

Max. tilting angle of pump : 25 degrees (4/4)



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PARTICULARS

ELECTRO-HYDRAULIC STEERING GEAR

STEERING GEAR TYPE : FR - 280

2 PUMPS (1 PUMP SPARE)

MAX. CALCULATED TORQUE AT RUDDER STOCK		M - Ton IN-Lb	138 12000000
MAX. TORQUE CORRESPONDING TO MAX. WORKING PRESS (AT 35°)		M - Ton IN-Lb	140 12100000
RUDDER ANGLE FROM HARD OVER TO HARD OVER		Deg.	70
TURNING SPEED OF RUDDER		Deg - Sec	65 - 28
DIAMETER OF RAM		MM IN	280 11.02
NORMAL RADIUS OF TILLER ARM		MM IN	650 25.59
RAM STROKE FOR MAX. STEERING ANGLE (70 DEG.)		MM IN	910 35.83
RAM STROKE FOR LIMIT RUDDER ANGLE (74 DEG.)		MM IN	980 38.58
ELEC. MOTOR	SEMI-ENCLOSED SELF VENTILATED TYPE (2 SETS)	———	
	VOLTAGE	V	AC 3φ 440
	CURRENT	A	
	OUTPUT	KW HP	45 60
	REVOLUTION	R.P.M.	1150
	DUTY 15% CONT., 100% 1 HOUR, 200% 30 SEC.	———	
	OVERLOAD AT MAX. STEERING TORQUE	%	150
	STARTING TORQUE	%	200
HYDRAULIC PUMP	KAWASAKI TYPE (2 SETS)	———	BV-732
	NO. OF PISTON	———	7
	DIAMETER OF PISTON	MM IN	32 1.26
	TILTING ANGLE	Deg.	23.3
	ACTUAL DISPLACEMENT	Lit/Min	246
	MAX. WORKING PRESSURE	kg/cm² Lb/IN²	140 2000
	SETTING PRESSURE OF SAFETY VALVE	kg/cm² Lb/IN²	145 2070
MAIN HYDRAULIC PIPE (OUTDIA. X THICKNESS)		MM	70.0 x 12.0 55.0 x 10.0
PRESS. GAUGE PIPE (DO.)		MM	10.0 x 3.0

PART B. INSTRUCTION BOOK

FOR

THE OPERATION, MAINTENANCE & INSTALLATION

FR - 280 TYPE

ELECTRO - HYDRAULIC STEERING GEAR

KAWASAKI HEAVY INDUSTRIES, LTD.

OIL HYDRAULIC MACH. DEPT.

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Chapter 1. General

The electro-hydraulic steering gear of Rapson slide type comprises:

1-Tiller of split type to be fixed to the rudder stock with keys.
2-Rams complete with their pins and 4-cylinders actuated by oil pressure.
2-Electric motor driven axial piston pumps of variable displacement type complete with their oil tanks and beds.
2-Horizontal shaft, A.C. induction motors for driving the pump.
1-Set of link mechanism for actuating and restoring the pump displacement.
1-Trick wheel.
1-Set of valves necessary for controlling and maintenance.
1-Set of pipings, fittings and pressure gauges.
1-Bed plate
~~1-Hand oil pump complete with valves~~

They are designed to meet the requirement for correct and safe running of the steering gear as follows:

Maximum torque	140 Ton-M
Rudder angle from H.O. to H.O.	70 Deg.
Turning speed of the rudder	65/28 Deg./Sec.
Diameter of the ram	280mm
Normal radius of the tiller	650mm

Hydraulic pump having the max. displacement of 246 L/min under the max. pressure of 140kg/cm^2.
A.C. 3-phase, 60Hz, 1150 r.p.m. induction motor having an output of 45KW as well as the rating of 15% continuous, 100% for 1 hour and 200% for 30 seconds.

For the aboves, reference is invited to the drawing NO.090, 488 "Detail Plans.".

Chapter 2. Detail Description of Main Parts

2.1 Tiller (Fig. A-6,7 in Appendix are referred to)
The tiller made of cast steel is split construction to be bolted together and is fixed to the rudder stock with keys.
Both ends of the tiller have fork typed openings where the hardened steel plates are bolted and withstand high contact pressure due to the ram thrust.

2.2 Ram and Hydraulic Cylinder (Fig. A-6,8 in Appendix are referred to)
The ram made of carbon steel is equipped with the ram pin and the roller bearings in its centre, and is supported by the bronze neck bushings of the hydraulic cylinders. Inside of the hydraulic cylinder the stuffing box consisted of V-formed packings of synthetic rubberized cloth, adaptors, packing gland are also provided, and leakage of oil is prevented.
The stopper to restrict stroke of the ram, the drain plugs are also provided in the hydraulic cylinder.
The hydraulic cylinder is made of Nodular cast iron (ductile cast iron), and feet to be installed on the bed plate, faces necessary for connecting pipes, valves, brackets are integrally cast with the cylinder.
A pair of opposed cylinders is connected with the guide bar and a pair of parallel cylinders is connected with the connecting bracket. Detail arrangement is shown in Fig. A-1.

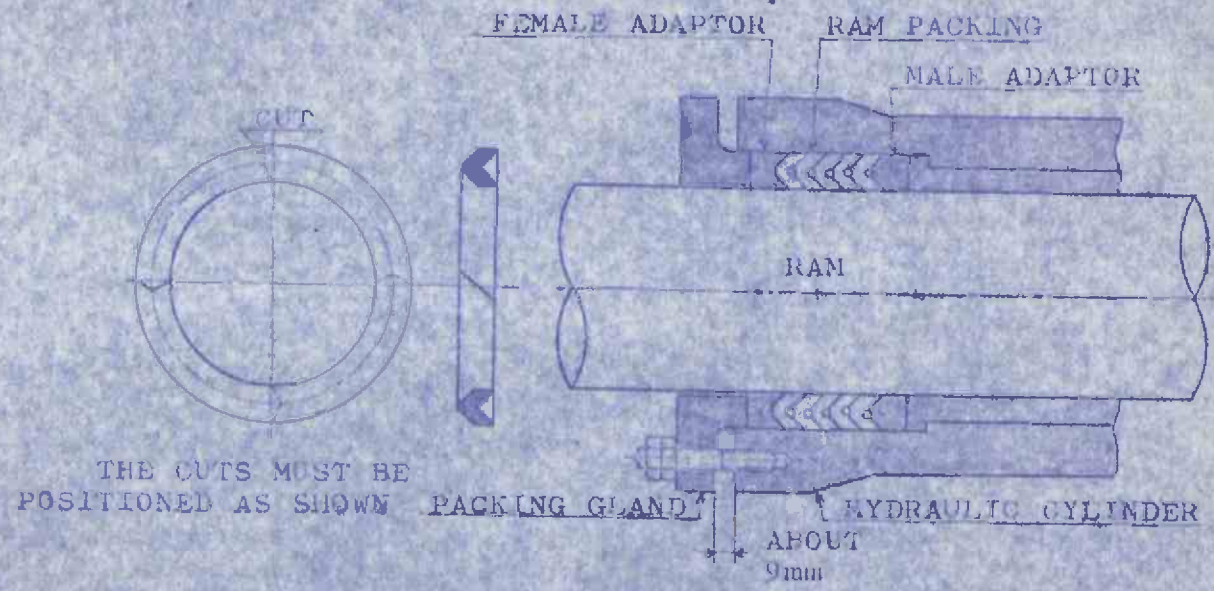


Fig. B-1 RAM PACKING

2.3 Hydraulic Pump (Kawasaki-Brüninghaus pump)

2.3.1 Construction and Name of Parts (Fig. A-9 in Appendix is referred to)

The hydraulic pump, manufactured under the license agreement with Brüninghaus Hydraulik GmbH of West Germany and called as Kawasaki-Brüninghaus pump, is of a variable displacement axial piston type. The pump is installed inside of the oil tank by means of the bolted flange and direct-coupled through the flexible coupling to the electric motor outside of the oil tank.

The pump consists mainly of the cylinder sub-group (NO.151-cylinder, NO.152-needle bearing, etc.) fitted in the cylinder casing (202), the seven piston sub-group (NO.123-piston, NO.121-connecting rod, NO.124-fix ring, etc.) being in reciprocating motion in seven bores of the cylinder(151), the driving shaft sub-group (NOS. 101, 102) which transmits power to the pump, the bearings (NOS. 104, 108, 111) which support the driving shaft and axial thrust, the bearing casing (201), the front cover (251) in which oil seal (103) is provided, the valve cover sub-group (NOS. 253, 350, 351 etc.), the valve plate (171), the pipe flange (254) and the roller bearing (205).

The cylinder (151) is supported by the cylinder casing (202) through the needle bearing (152). The cylinder casing (202) is also supported by the bearing casing (201) through the roller bearing (205). The cylinder casing (202) together with the cylinder (151), therefore, can be tilted arround the axis of the roller bearing (205).

The connecting rod (121) has integrally the spherical ends, whose large end is fixed to the driving shaft by means of the set ring (122) and the set plate (126), and small end is secured to the piston (123) by means of the fix ring (124).

The driving shaft (101) is supported by the bearing casing (201) through the radial ball bearing (104), the radial needle bearing (108) and the thrust needle bearing (111).

Rotating motion of the driving shaft (101) actuated by an electric motor is transmitted to the cylinder (151) through the connecting rod (121), the cylinder (151) is accordingly rotated arround its centre in the synchronous speed of the driving shaft (101). In the case the cylinder (151) is located in the oblique position against the driving shaft centre, the piston (123) reciprocates in the cylinder bore relatively to the cylinder.

The valve plate (171) having a suction-and a delivery port to change over oil with the reciprocating motion of the piston is provided between the cylinder (151) and the valve cover (253). The cylinder (151) is pressed on the valve plate (171) by the cup spring (165) and they are in optimum hydraulic balance during pump running.

Oil to be delivered from and sucked in the pump cylinder passes through the passages in the valve cover (253), the cylinder casing (202) and the pipe flange (254), then it is transferred to the pipe outside of the pump.

2.3.2 Principle of Operation (Fig. A-9 in Appendix, Fig. B-2, 3 are referred to)

The driving shaft (101) of the pump is driven by the electric motor through the flexible coupling. Rotating motion of the shaft is thereafter transmitted to the cylinder (151) through the connecting rod (121) and the piston (123) as described in foregoing sub-section. Refering to the sectional views of the pump in Fig. B-3, principle of pumping action is illustrated. Top of the figures is the longitudinal section along the tilting axis of the cylinder, middle and bottom of the figures are the sections perpendicular to the top figure, and direction of rotation is assumed as clockwise viewed from the shaft end.

In the case that the tilting angle of the cylinder is equal to zero, i.e. the axis of the cylinder aligns with that of the driving shaft as shown in top and middle figures, any relative motion between the piston and the cylinder bore with pump rotation will not occur, no oil will consequently delivered.

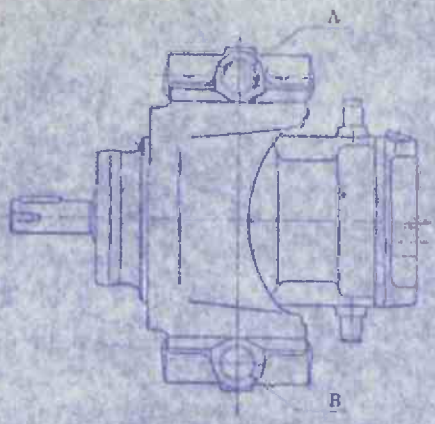
No delivery from the pump with its rotation as above described is called as neutral.

In the case that the cylinder is tilted around its tilting axis as shown in the bottom figure, the pistons below X-Y line are going to withdraw from the bottom of the cylinder bore with their clockwise rotation and suck oil through the port "a" of the valve plate, and the pistons above X-Y line are going to approach to the bottom of the cylinder bore and discharge oil through the port "b" of the valve plate. Displacement per revolution depends on the tilting angle of the cylinder from its neutral position and reaches its maximum value at the tilting angle of 25 degree.

If the cylinder is tilted to the reverse direction of the bottom figure, the reverse action of the pistons relative to the cylinder bore will take place, accordingly the pistons below X-Y line will discharge oil through the port "a" and the pistons above X-Y line will suck oil through the port "b". Such being the case, direction of flow can be changed without altering the direction of rotation of the driving shaft. Relation of direction between oil flow and tilt of the cylinder is shown in Fig. B-2.

The valve plate (171) in Fig. A-9 having two ports "a" "b" in Fig. B-3 is of importance for changing over oil as well as preventing oil leakage through the cylinder end.

Suction valves in the suction valve casing (350) in Fig. A-9 serve for replenishing oil automatically from the oil tank during pump running.



Direction of rotation of driving shaft	Direction of tilt of cylinder			
	Right		Left	
	Discharge	Suction	Discharge	Suction
R	A	B	B	A
L	B	A	A	B

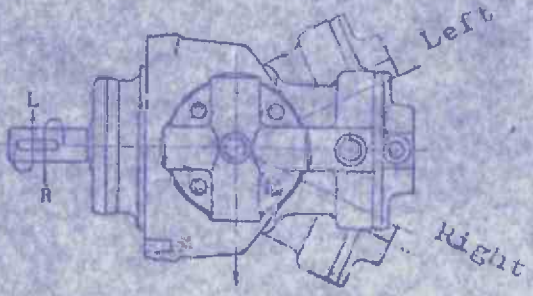


Fig. B-2 RELATION BETWEEN OIL FLOW AND TILT OF CYLINDER