ELECTRICAL EQUIPMENT FOR MARINE SERVICE

By

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I. INTRODUCTION

Electrical apparatus for marine use must not only meet all requirements needed for land use, but also meet the following conditions :

1) They must be compact and light in weight.
2) They must be easily examined and repaired.
3) The insulation for the coils and other parts must be durable against hot salty moisture and oil vapor.
4) Rotating apparatus bearings must stand the thrust even when the ship continuously inclines 15 degrees and rolls up to 30 degrees. Under these conditions lubrication must be assured, and the lubricating oil prevented from draining out.
5) The controlling apparatus must not have false operation due to the rolling mentioned in Item 4., and vibration and shock peculiar to vessels.

Besides the above, provisions are made for the temperature rise of such apparatus according to the class of the ship for which they are equipped.

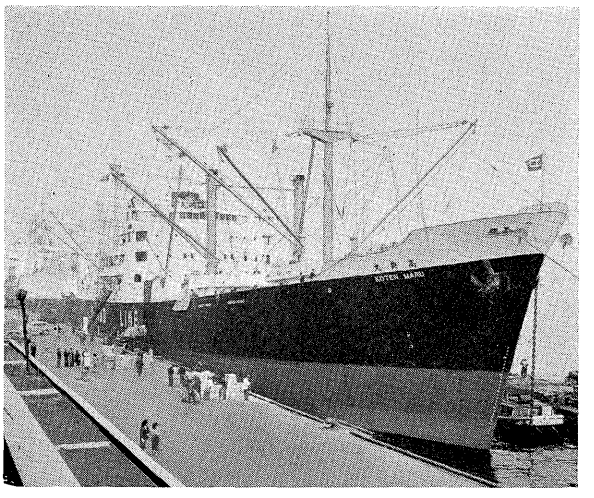


Fig. 1. Cargo ship, Kōten-maru
equipped with Leonard system A.C. appliances

The major classification of ships are

1) Lloyd's Register of Shipping (LR)
2) American Bureau of Shipping (AB)
3) Nippon Kaiji Kyokai (NK)
4) Bureau Veritas (BV)
5) Norske Veritas (NV) etc.

Stimulated by the recent worldwide shipbuilding boom, steel sheet welding techniques have made great strides, and almost all parts which had been made of cast iron as structual parts are now been replaced by those made by welding. This has resulted in the reduction of size and weight of apparatus, contributing favorably to the increase of gross tonnage and weight tonnage of the ships. It has been a general conception that almost all electrical apparatus for marine use have been of direct current machine, but they are now being replaced by alternating current apparatus for the following reasons ;

1) Interchangeable with land apparatus
2) Easy maintenance
3) Economy in shipbuilding costs as a whole

Oil tankers of the latest design are mostly equipped with A.C. machines because they have not many auxiliary apparatus which call for speed control. However direct current apparatus have good reasons for employment, and are still especially used in cargo vessels built for export.

The followings are a brief description of apparatus manufactured by our Company after the World War II.

II. SHIP SERVICE GENERATOR

As mentioned in the preceeding paragraph there are two types of apparatus for vessels, namely A.C. and D.C. types. The number of such electric generators supplied by the company totals 150, including large and small units. For their shafts those which passed careful test in the pressure of the surveyor of the ship's classification, shipowner and shipyard officer were used. In cases of larger generators, the coils and other parts were also inspected and examined from time to time in their various stages of manufacture.

To measure the coil temperature of large generators is at the switchboard, a search coil is sometimes embedded in the slot or to prevent the intrusion of moisture in the machine in stand still, a space heater is provided in the frame.

1. Direct Current Generator

The largest of this type are three 500kW 230V 400 r.p.m. generators driven by a Diesel engine. These generators all have flat compound characteristics, and the armature coil in the slot were those made of our own unique rolled mica baked with phenol resin varnish by a specially designed baking machine, which resulted in a mechanically and electrically durable product, free from deformation and moisture. The commutator has been fully seasoned too.

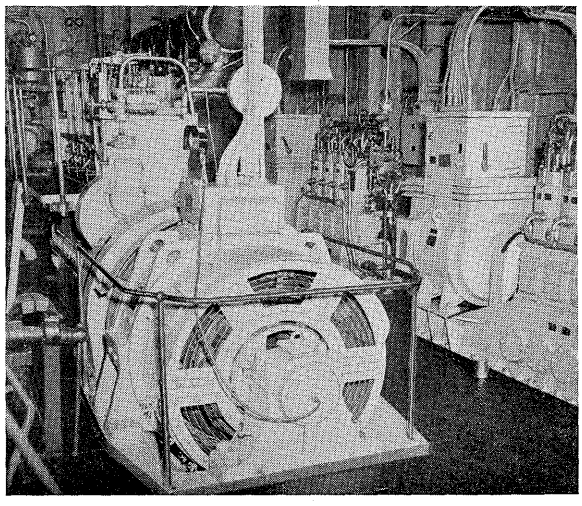


Fig. 2. Diesel driven D.C. generator
(170kW 230V 425 r.p.m.)

2. Alternate Current Generator

The largest of this type were those 6 units of 750kVA, 450V, 60 cycle 1,800 r.p.m., which were manufactured for export oil tankers. Not only will A.C. generators be used for oil tankers, but because, as will be mentioned later, excellent deck machinery were recently built by the company, ordinary cargo vessels are equipped with A.C. machines, giving an impression that all ships will be electrified by A.C. power.

The generators for large size vessels recently built are almost all of 450V, which is common among all the Ship's Class Association regulations and for which construction costs are relatively low. In general their frequency is 60 cycles.

In the exciter, an Isthmus type gap is made at the portions where the yoke and magnetic pole is affixed, and by utilizing the magnetic saturation of this part, the saturation degree of the magnetic pole is increased to regulate the exciter current, thereby making possible a wide range regulation of the A.C. generator voltage, as an automatic voltage regulator which dispenses with the need for regulating the field current of the generator. The rotating type Walz regler which is highly sensitive and of quick response is used.

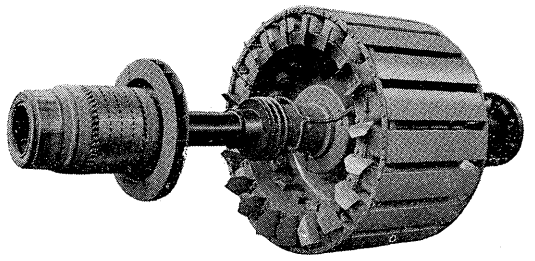


Fig. 3. Rotor for Diesel driven A.C. generator and exciter
(687.5kVA 450V 60c 360 r.p.m.)

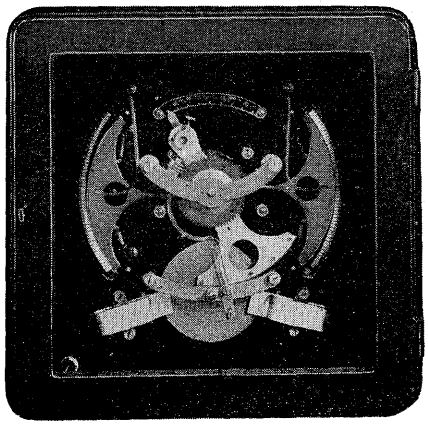


Fig. 4. Rolling type automatic voltage regulator for A.C. generator

III. SWITCHBOARD

The switchboard is made of strong iron framed steel plates, and the apparatus and instruments are arranged with special attention to their functions and appearance. The air circuit breakers and knife switches are strongly built for reliable operation. For the fuses, cartridge fuses approved by Lloyd's Register, American Bureau and Nippon Kaiji Kyokai are used with a rupturing capacity of 16,000A at A.C. 440V and D.C. 440V.

IV. ELECTRICAL APPARATUS FOR THE ENGINE ROOM

Two D.C. motors of 350kW, 230V, 3,150 r.p.m. for the exhaust of Diesel engine and 2,000 A.C.

and D.C. motors are among the motors produced by the Company and now in successful operation. Such a great number and variety of controlling apparatus has been produced for them according to their use and capacity that it is impossible to describe them in detail. Generally, starters are separated into two types according to the requirements of the electric motor, and are known as the low voltage release type and the low voltage protection type. As the low voltage release type is used for those parts vital to propel the ship, it automatically restart in case of voltage failure and the motor stops by some unforeseen causes. Other auxiliary machines which use low voltage release type controls are the rudder, lubricating oil pump, etc. The low voltage protection type must be manually restarted, and the bilge pump, ballast pump, etc., are among them.

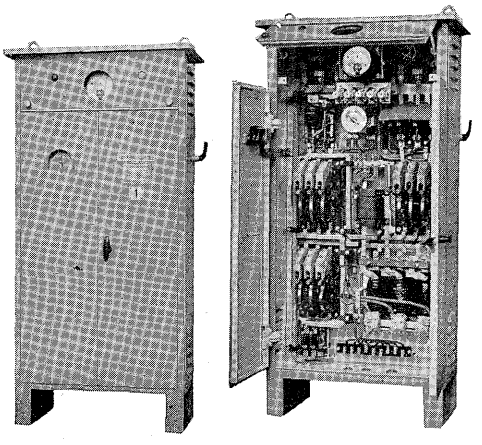


Fig. 5. Reduced voltage system type starter with auto transformer

1. Magnetic Contactor

Magnetic contactors are most extensively used for start, stop and speed control, and among them the type most common is the 25A magnetic contactor capable of controlling up to 10 HP motors on 440 V, 60 cycle circuit. This contactor is not only able to make and break a current above ten times as large as the motor current, but to endure 120 opening and closing operations per hour and has a life of one million mechanical operations and one hundred thousand electrical operations without repair. The other contactors also possess similar performance features.

2. Thermal Overload Relay

The thermal overload relay has been widely used because its overload characteristics are similar to that of motors, but those produced by domestic makers have been far from satisfactory. On the contrary, the thermal relays which our Company has been used with success since the last year after various tests and trial manufacture. (This relay may be seen in the lower left corner of the box with open door in Figure 5.) This relay has excellent ambient temperature compensation characteristics.

V. DECK MACHINERY

Our Company has given the most attention and effort in producing deck machinery, among which our cargo winch has won wide acclaim from shipowners and shipyards as being foolproof, despite of rough handling by inexperienced and careless crews.

1. Component Parts

A) Worm gear material is nickel-chrome steel which is given high frequency, hardening after high precision processing preventing any dimensional distortions. Tapping has also been done to the worm gear. The worm wheel is made of good quality cast bronze, and constitute a highly efficient speed reducing apparatus in combination with the worm gear. The spur gear parts are made of nickel-chrome steel and cast steel in combination, and are carefully finished and heat-treated.

B) Electric motors and generators have been designed with ample margin. Consideration has been given to the winch to enable it to endure several days continuous run.

C) The magnetic contactor relay and master controller have been designed by the Company after many years of research and testing, attaining the state where endurance against heavy duty and operation for long periods of time without repair are assured.

D) The brake is of a disc type operated magnetically and its friction fabric lining area has been designed large. Even if the master controller is placed at the zero notch, the disc brake does not operate before the speed is reduced to a certain extent by dynamic braking, thus minimizing the lining wear.

2. Direct Current Types

A) Cargo Winch

Specifications and the actual results of those that were supplied are shown in Table 1. For example the characteristic curve of the 3 t 30m/min winch marked with an asterisk in Table 1 is given in Figure 7. The following features may be learnt from this characteristic curve.

i) The no-load maximum speed is extremely great. This is an important factor showing the high loading efficiency of this winch.

ii) Two load discriminating relays are provided, so that even when the master controller notch has been advanced in excess, the load may be raised or lowered at a reasonable speed consistent to the load.

B) Mooring Winch, Anchor Windlass, etc.

Specifications and actual supply list are given in Table 2.

3. Alternating Current Type

Formerly deck machinery was considered to be all of the direct current type, and the alternating current one was regarded as another term for low efficiency products. However our Company has embarked on the production of high quality A.C. deck auxiliary machinery based on our rich experience in manufacturing D.C. models. Intense research work has been conducted in this field, with the production of many test models.

A) Characteristics

i) The Ward-Leonard System having an almost perfect load speed curve has been adopted as the controlling system, which has not only won popularity among stevedores but has made possible a

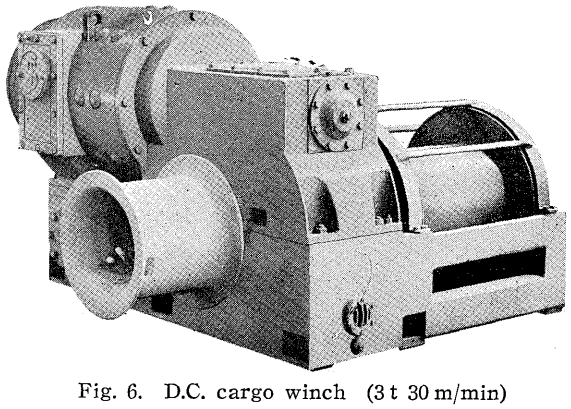


Fig. 6. D.C. cargo winch (3 t 30 m/min)

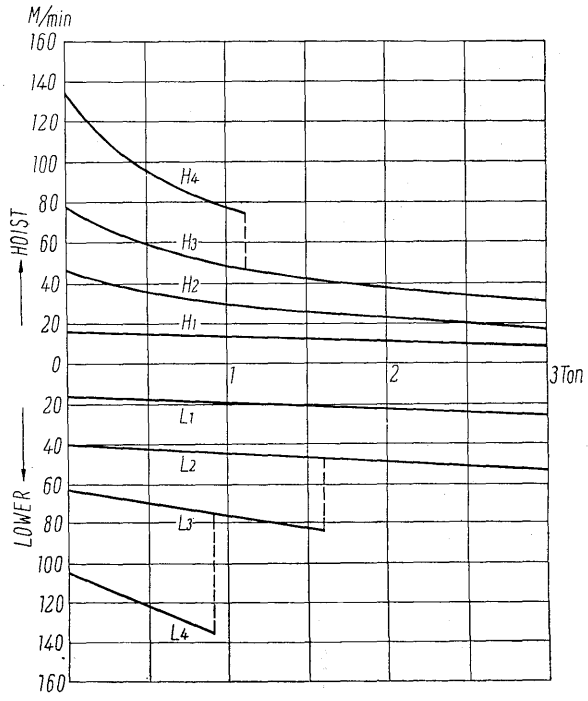


Fig. 7. Characteristic curve of D.C. cargo winch (3 t 30m/min Worm gear system)

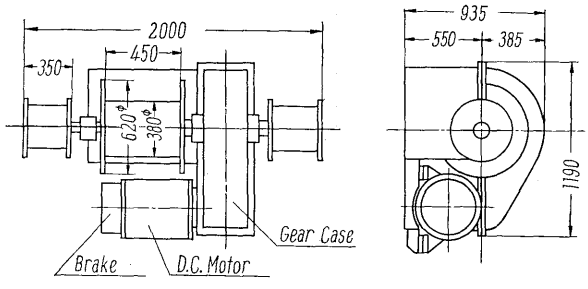


Fig. 8. Diagram of D.C. cargo winch (3 t 30m/min 15 t 60m/min Spur gear system)

Table 1. Specification and actual supplies of D.C. cargo winch

Kinds			Motor Output (IP)	Motor Speed in r.p.m. (r.p.m.)	Control system	Installed place of control panel	Reduction gear	Structure of machine parts	Weight (kg)	No. of units supplied
3 t.	36m/min.		31	450	Remote control (One man control)	Contained in the main body	One step of Worm gear and Worm wheel	Casting	4,200	145
5 t.	40m/min.		53.5						6,900	69
1.5 t.	36m/min.	*	15.5						4,200	1
3 t.	30m/min.	†	41			Installed in the hatch (Drip proof)		Steel plates welded	2,884	16
5 t.	30m/min.		25						4,012	4
5 t.	30m/min.	**	38						6,200	1
5 t. 2.5 t.	30m/min. and 75m/min.	††	38	760			Spur gear 2 and 3 steps (Change-over by clutch)		3,385	1
3 t. 1.5 t.	30m/min. and 60m/min.	††	23	900	Direct control	Installed on the deck (Water proof)			2,330	32
5 t. 2 t.	30m/min. and 75m/min.	††	38	760					3,100	16

Note 1) Voltages are all 220 volts except those marked with *, which are 110 volts.

2) ** They are intended for oil tankers. Being flame proof, they are jointly used with mooring winches of 3 t. 47m/min.

3) Those marked with †† are used by being changed over by a clutch in depending on the weight of loads to be handled.

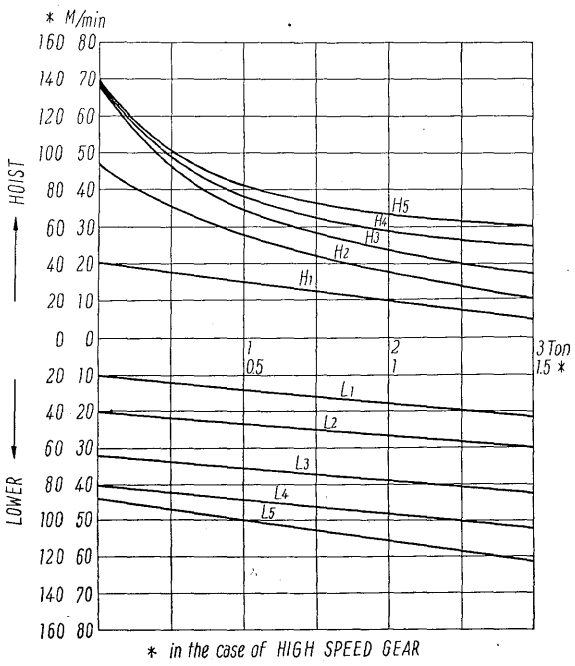
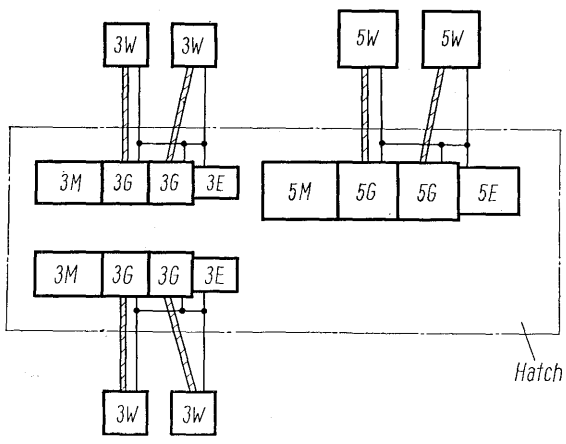


Fig. 9. Characteristic curve of D.C. cargo winch (3 t 30m/min 15 t 60m/min Spur gear system)

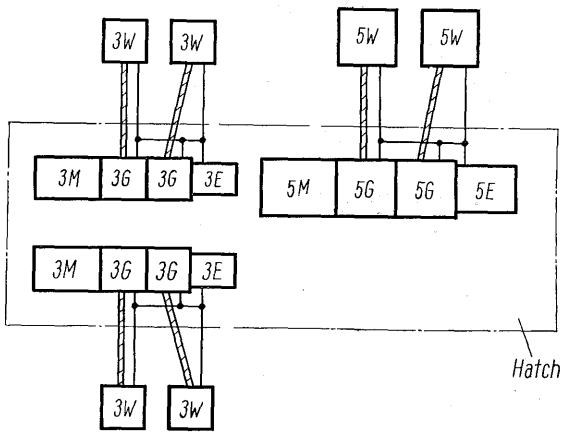
Table 2. Specification and actual supplies of D.C. mooring winches and others

Article	Specification	Motor output (HP)	No. of units supplied
Mooring winch	5 t. 18m/min. 10 t. 20m/min.	31～53.5	8
	5 t. 15m/min.	28	4
Anchor windlass	15 t. 9m/min. 20 t. 10m/min.	60～90	6
	12.5 t. 9m/min.	45	4
Capstan	2 t. 25m/min.	20	5
	2t. 25m/min. and 5t. 8.7m/min. *	25	2
Whale winch	5 t 30m/min.	40	8
	6.2 t. 30m/min.	50	8

Note 1) The whale winch and capstan are used for a whale catcher boat. That marked with * is to be used jointly for an anchor windlass as rated 8.7m/min.



(a) Group X



(b) Group Y

Fig. 10. Skeleton diagram of A.C. Leonard cargo winch

Table 3. Specification and actual supplies of A.C. ard Ward Leonard system cargo winches

Group	Kinds	Winch driving motor		Motor generator set for winch driving motors					Common exciter set					Weight per one set of winch (kg)	No. of units supplied
				D.C. generator		A.C. motor		Installed place	Exciter		A.C. motor		Installed place		
		Output (HP)	Speed (r.p.m.)	Output (kW)	Speed (r.p.m.)	Output (kW)	Speed (r.p.m.)		Output (kW)	Speed (r.p.m.)	Output (HP)	Speed (r.p.m.)			
X	3 t. 36m/min.	30	506	26.4	3 500	85	3,500	Hatch (Drip proof)	12	3,500	20	3,500	Hatch (Drip proof)	3,225	28
	5 t. 40m/min.	53		45.8	1,750	45	1,750							4,750	8
Y	3 t. 36m/min.	31	450	26.4	3,500	50	3,500		3.5		—	—		3,293	46
	5 t. 40m/min.	53		48.4	1,750	90	1,750		3.5	1,750	—	—		3,818	16
Z	3 t. 36m/min.	31		26.4	3,500	32	3,500	Self contained	2.2	3,500	—	—	Self contained	4,153	2

Note 1) The combinations of generators and motors of group X and Y are to be referred to Fig. 14.
2) The group Z contains one A.C. motor, generator and exciter in their body for one winch driving motor.
3) They are all fabricated by welded steel plates.

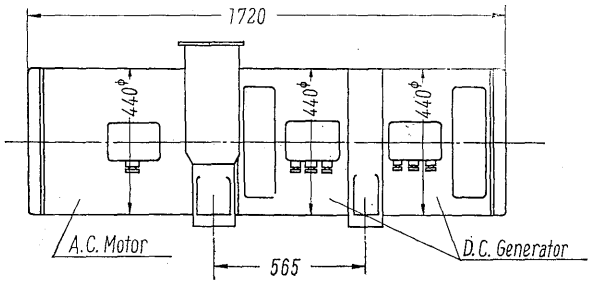


Fig. 11. Motor generator of A.C. Leonard cargo winch (group X 3 t 36m/min)

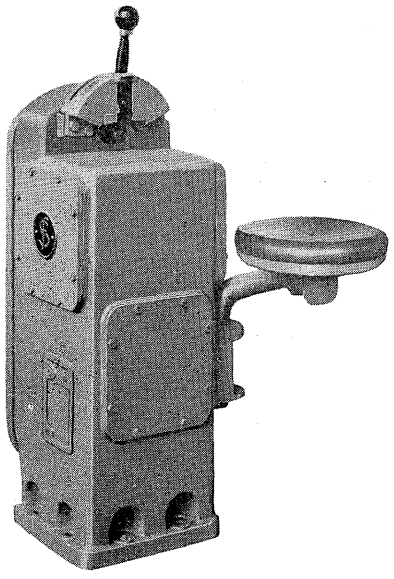


Fig. 12. Master controller for A.C. Leonard cargo winch

more effective loading and unloading. The fact that the machinery and apparatus consist mainly of rotating type machinery has greatly simplified maintenance compared with the conventional D.C. machinery. Furthermore the fluctuation of power source voltage has been greatly reduced, totally eliminating the flicker of lights and disturbance on communication equipment.

ii) With the appearance of this type of deck machinery, it is now made possible to use A.C. power for the entire vessel, cutting shipbuilding costs as a whole compared with D.C. equipment.

B) Cargo Winch

Specifications and the actual supply list are shown in Table 3. The mechanical parts and the construction, arrangements and relations of the electric motor and electro magnetic controller are the same as those shown in Fig. 7.

C) Mooring Winch, Anchor Windlass, etc.

Specifications and actual supply list are shown in Table 4. The Mooring winch and Anchor windlass have motor generator and exciter in joint use with the cargo winch by the connecting method shown in Fig. 15 for the former and Fig. 16 for the later. The windlass also possesses an automatic stalling device.

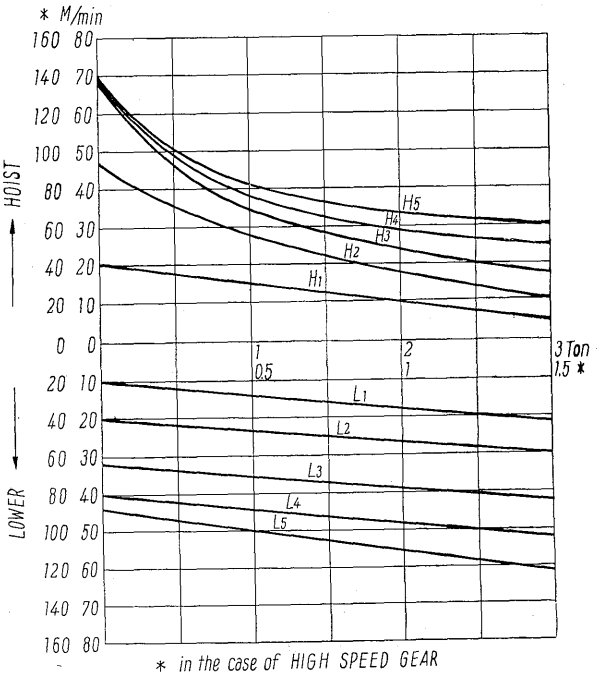


Fig. 13. Characteristic curve of D.C. cargo winch (3 t 30m/min 15 t 60m/min Spur gear system)

Table 4. Specification and actual supplies of A.C. Leonard system mooring winch and windlass

Article	Specification	Motor output (HP)	No. of units supplied
Mooring winch	7 t. 24m/min. ~ 10 t. 17m/min.	53	6
Anchor windlass	17 t. 10m/min. ~ 21 t. 10m/min.	70~90	6

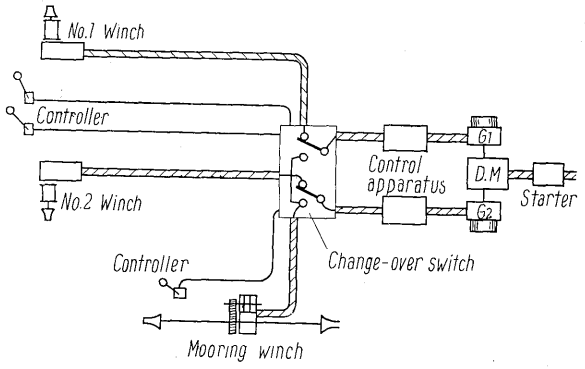


Fig. 14. Connection of windlass and mooring in case of electric source for winch used commonly (case of mooring)

VI. STEERING GEAR

Regardless of the type or size of ships, the steering gear is the most vital part of their machines. It may be classified roughly into electrically operated steering mechanisms and oil pressure steering mechanisms. In this article, electrically operated steering mechanisms which operated the steering gear directly by means of an electric motor are accounted for. As usual the specifications and actual record of those supplied since the war end are shown in Table 5.

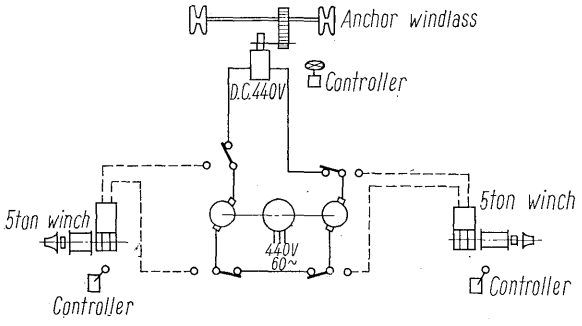


Fig. 15. Connection of windlass and mooring in case of electric source for winch used commonly (case of windlass)

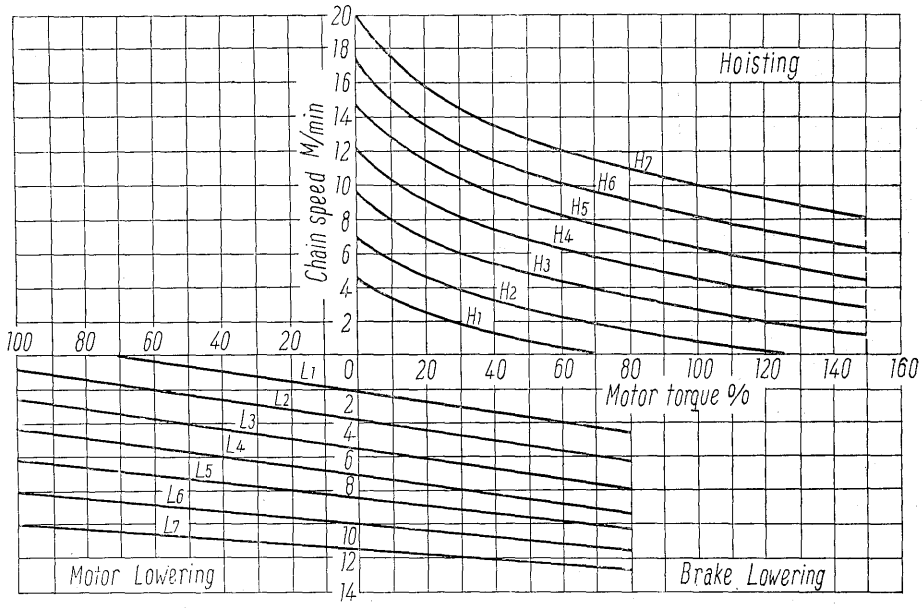


Fig. 16. Characteristic curve of A.C. Leonard anchor windlass

1) Ward-Leonard System Steering Gear

This is the system adopted by all large ships whether operating on a direct or alternate current, and it is well known as the most smoothly operating system. In this method a selsyn transmitter is installed above the steering engine and a selsyn receiver is installed within the steering controller for automatic following up. Usually a one-hour rated

Table 5. Specification and actual supplies of motor operated rudders

A. C. or D. C.	Electric classification	Mechanical classification	Specification		Rudder driving motor		Ship gross tonnage	No. of units supplied
			Torque (t-m)	Speed (H-O-H) (sec.)	Output (HP)	Speed (r.p.m.)		
D. C.	Full electric (Leonard)	Quadrant type	26	28	20	500	8,000	1
A. C.		Screw type	9	22	10	450	1,500	1
D. C.	Electro-mechanical		12	12	20	700	600	4
			11	12	18	900	550	2
			6	12	12	900	500	2
		Steel rope type	3	30	2	450	270~1,000	27

motor is used for steering, and it is required to operate under such severe conditions as a one minute 50% overload, a thirty second 100% overload, and momentary overload of 150%.

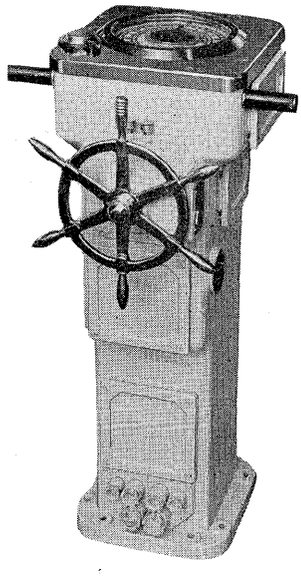


Fig. 17. Selsyn automatic follow steering controller

2) Electro Mechanical Steering Gear

This system is used mainly for relatively small ships having a D.C. power source. In this system the selsyn is not utilized, and the follow up is carried out mechanically by a steering rod connecting the steering engine and the steering controller. If for some reason the power fails to operate causing the steering motor to stop, the clutch attached to the steering controller can be changed-over for manual operation, enabling emergency operation of the steering gear by the steering rod used for follow up during electrical operation. There are two types of these steering engines.

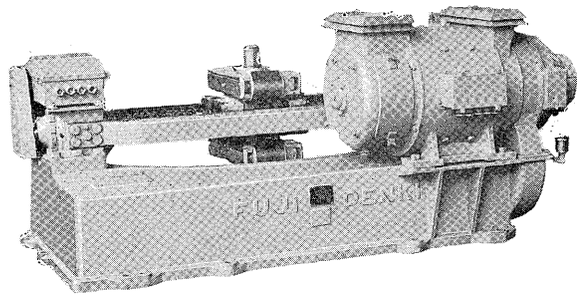


Fig. 18. Screw type steering engine (12 t-m 12 sec.)

A) Screw Type Steering Engine

By rotating the steering motor a nickel chrome steel screw is turned moving an arms bronze nut on this screw to the left or right. A cast steel tiller is inserted in this nut. This tiller effects a Rupson slide movement turning the rudder stock attached to the base of the tiller to the left or right. By this movement the rudder plate is given torque to rotate to the required degree. Adopting this system reduces the weight by 30% from the Quadrant system engine.

B) Steel Rope System Steering Machine

In this system, instead of rotating the above mentioned screw, a drum with steel rope winding is turned, and the steering is made by the Rupson slide structure at the end of the rope.

VII. CONCLUSIONS

Our company has, since its establishment, been manufacturing many varieties and types of heavy electrical machinery for ships, and not only have constantly emphasized the after service of the machinery supplied by ourselves, but have attempted on every occasion to incorporate the ideas and opinions of the user, proceeding step by step until today. We wish to put forth further efforts in the future keeping ahead of world trends, manufacturing even better products to satisfy our clients.