Serial No. 81

PLAINTIFF'S EXHIBIT

WH-1103a

1250-Kw. Geared Turbine Generator

WESTINGHOUSE ELECTRIC

for

U. S. Battleships

BB-61 U.S.S. IOWA
BB-62 U.S.S. NEW JERSEY
BB-63 U.S.S. MISSOURI
BB-64 U.S.S. WISCONSIN
BB-65 U.S.S. ILLINOIS
BB-66 U.S.S. KENTUCKY

NAVY CONTRACT NOs 70862

WESTINGHOUSE ORDER WG-31965-TP

YEAR OF CONSTRUCTION 1942

INSTRUCTION BOOK 6340

In the event that it becomes necessary to return any part of this equipment to the South Philadelphia Works, it should be tagged with the Sender's name and address and the serial number of the unit. Shipments by freight, express or parcel post should be addressed to:

Westinghouse Electric & Manufacturing Company
South Philadelphia Works
Essington, Pa.

Printed in U.S.A. (6-43)

SERIAL NUMBER ASSIGNMENT

Vessel	Unit No.	Turbine Serial No.	Generator* Serial No.	Exciter* Serial No.
U.S.S. Iowa	1	1-A-9179-1	1-S-10P812	1-S-10P815
	2	1-A-9179-2	2-S-10P812	2-S-10P815
	3	1-A-9179-3	3-S-10P812	3-S-10P815
	4	1-A-9179-4	4-S-10P812	4-S-10P815
	5	1-A-9179-5	5-S-10P812	5-S-10P815
	6	1-A-9179-6	6-S-10P812	6-S-10P815
	7	1-A-9179-7	7-S-10P812	7-S-10P815
	8	1-A-9179-8	8-S-10P812	8-S-10P815
U.S.S. New Jersey .	1	1-A-9179-9		
	2	1-A-9179-10		
	3	1-A-9179-11		
	4	1-A-9179-12		
	5	1-A-9179-13		
	6	1-A-9179-14		
	7	1-A-9179-15		
	8	1-A-9179-16		
U.S.S. Missouri ...	1	1-A-9179-17		
	2	1-A-9179-18		
	3	1-A-9179-19		
	4	1-A-9179-20		
	5	1-A-9179-21		
	6	1-A-9179-22		
	7	1-A-9179-23		
	8	1-A-9179-24		
U.S.S. Wisconsin ..	1	1-A-9179-25		
	2	1-A-9179-26		
	3	1-A-9179-27		
	4	1-A-9179-28		
	5	1-A-9179-29		
	6	1-A-9179-30		
	7	1-A-9179-31		
	8	1-A-9179-32		
U.S.S. Illinois ...	1	2-A-7899-1		
	2	2-A-7899-2		
	3	2-A-7899-3		
	4	2-A-7899-4		
	5	2-A-7899-5		
	6	2-A-7899-6		
	7	2-A-7899-7		
	8	2-A-7899-8		
U.S.S. Kentucky ...	1	2-A-7899-9		
	2	2-A-7899-10		
	3	2-A-7899-11		
	4	2-A-7899-12		
	5	2-A-7899-13		
	6	2-A-7899-14		
	7	2-A-7899-15		
	8	2-A-7899-16		

* The symbol "S" in generator and exciter serials stands for "Stator." Rotors have corresponding numbers with "R" in place of "S". Serial Assignments for BB-62 to 66 inclusive were unknown at date of publication.

VALVE SETTINGS

(Clearance between Valve-Lifting Bar and Valve Stem Adjusting Nuts)

BB-__ U.S.S. _____

TURBINE SERIAL NUMBER	VALVE NUMBER					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
1-A-9179-___						
1-A-9179-___						
1-A-9179-___						
1-A-9179-___						
1-A-9179-___						
1-A-9179-___						
1-A-9179-___						
1-A-9179-___						
2-A-7899-___						
2-A-7899-___						
2-A-7899-___						
2-A-7899-___						
2-A-7899-___						
2-A-7899-___						
2-A-7899-___						
2-A-7899-___						

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TURBINE AND GEAR		
Turbine Assembly	25-J-501	BB61-S61-02
Gear Assembly	25-J-502	03
Assembly of Auto-Stop and Back-Pressure Safety Stop	25-J-503	04
Auto-Stop Governor Details and Bill	25-J-504	05
Back-Pressure Safety Stop Details and Bill	25-J-505	06
Bearing Housing and Oil Ring Details and Bill	25-J-506	07
Bearing (Turbine Pinion and Gear Shaft) Details and Bill	25-J-507	08
Bearing (Thrust) Details and Bill	25-J-508	09
Bed Plate Details and Bill (For BB-61 To BB-64 Incl.)	25-J-509	010
Bed Plate Details and Bill (For BB-65 and BB-66 Only)	25-J-572	011
Blading (Curtis) Details, Assembly and Bill	25-J-510	012
Blading (Curtis) Baffle Details, Assembly and Bill	25-J-511	013
Blading (Curtis) Stages 1 to 8 Incl. Details and Bill	25-J-512	014
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Bridge Gage, Details and Bill	25-J-514	016
Coupling Details, Assembly and Bill	25-J-518	020
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Gear Housing Base Details and Bill	25-J-525	027
Gear Housing Cover and Name Plate, Details and Bill	25-J-526	BB61-S61-028
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Governor Details and Bill Sheet No. 3	25-J-489	*
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Low-Pressure Oil Alarm Contact-Maker Assembly and Bill	25-J-532	033
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Nozzle Block (Curtis Stage) Details, Assembly and Bill	25-J-534	035
Nozzle Diaphragm, Details, Assembly and Bill (1st Rateau Stage)	25-J-535	036
(2nd Rateau Stage)	25-J-536	037
(3rd Rateau Stage)	25-J-537	BB61-S61-038

DRAWING LIST

DRAWING TITLE	WESTINGHOUSE Drawing No.	BUREAU OF SHIPS' Type "D" Numbers
TURBINE AND GEAR		
Nozzle Diaphragm, Details, Assembly and Bill (4th Rateau Stage)	25-J-538	BB61-S61-039
(5th Rateau Stage)	25-J-539	040
(6th Rateau Stage)	25-J-540	041
(7th Rateau Stage)	25-J-541	042
(8th Rateau Stage)	25-J-542	043
Oil Cooler Assembly and Bill	25-J-266	044
Oil Piping Assembly and Bill	25-J-543	045
Oil Piping Details and Bill	25-J-544	046
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Oil Strainer Details, Sheet No. 2	25-J-577	050
Outline (Turbine, Gear and Generator)	25-J-549	051
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Relief Valve Details and Bill (Exhaust Casing)	25-J-551	053
Relief Valve (Oil Line) Details, Assembly and Bill	25-J-580	054
Seal Strip (Diaphragm and Dummy) Details and Bill	25-J-552	055
Sentinel Valve (Exhaust Casing) Detail, Assembly and Bill	25-J-579	056
Spare Parts List (BB-61 and 62 Only)	25-J-553	BB61-S61-057
Spare Parts List (BB-63 to 66 Only)	25-J-427	*
Speed-Changer Details and Bill, Sheet No. 1	25-J-554	BB61-S61-058
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Speed-Changer Motor	31-J-755	060
Spindle Details Assembly and Bill	25-J-556	061
Spindle Clearances	25-J-557	062
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Spindle Position Indicator and Journal Micrometer Detail and Bill	25-J-561	BB61-S61-066
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Steam Chest Details and Bill	25-J-492	*
Steam, Drain and Gland Piping, Assembly and Bill	25-J-565	BB61-S61-069
Steam, Drain and Gland Piping Details	25-J-575	070
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Throttle Valve Details, Sheet No. 1	25-J-567	074
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DRAWING LIST

DRAWING TITLE	WESTINGHOUSE Drawing No.	BUREAU OF SHIPS' Type "D" Numbers
TURBINE AND GEAR		
Two-Way Valve Details, Assembly and Bill	25-J-578	BB61-S61-078
Wrenches and Tools, Details and Bill	25-J-573	BB61-S61-079
Oil-Level Indicator	25-J-581	BB61-S61-080
1250-KW. (1562-KV-A.), 450-VOLT, A-C. GENERATOR		
Outline and Sections of Generator and Exciter	31-J-650+	BB61-S61-082
Manufacturer's Descriptive Data	31-J-651	083
Generator Stator Punchings, Assembly, Vent and Finger Plates; Revolving Field Punchings and Spider Punchings	31-J-652	084
Generator Stator Frame	31-J-653	085
Front End Bells and Cooler Housing	31-J-654	086
Generator Stator Coil and Wiring-Around-Frame	31-J-655	087
Generator and Exciter Shafts	31-J-656	088
Revolving Field Winding and Assembly	31-J-657	089
Rear End Bells and Air Seal	31-J-668	092
Pedestal and Bearing	31-J-658	090
Collector and Brush Rigging	31-J-659	BB61-S61-091
16-KW. 120-VOLT - D-C. EXCITER		
Exciter Uniform Specification	5-A-9812	BB61-S61-097
Exciter Frame, Frame Covers, Poles, Terminal Board and Air Shield	31-J-207	093
Exciter Bracket and Details; Rocker Ring and Details	31-J-208	094
Exciter Wiring-Around-Frame and Details, Brushholder, Coils and Brushes	31-J-209	095
Exciter Armature Assembly and Details	31-J-210	096
Outline and Sections	31-J-650+	082
Shaft	31-J-656	BB61-S61-088
NAVY TYPE "BN-2" VOLTAGE REGULATOR		
Manufacturer's Reference Drawing	31-J-276	*_____
Schematic Wiring Diagram	35-J-589+	BB61-S61-0108
Type "BN-2" Main Control Element	35-J-586+	BB61-S61-0105
Auxiliary Equipment	31-J-275	*_____
Auxiliary Equipment	35-J-588	BB61-S61-0107
Uniform Specification	35-J-590+	BB61-S61-0109
Temperature-Indicating Equipment	31-J-289+	*_____
Field Discharge Resistor	5-A-9347	*_____
Spare Parts List	35-J-591	BB61-S61-0110
Motor-Operated Rheostat (For BB-61 To BB-64).	31-J-483+	*_____
Motor-Operated Rheostat (For BB-65 And BB-66)	35-J-224+	BB61-S61-0112
Contactor Panel	31-J-277	*_____
Exciter Field Rheostat	5-A-9346+	*_____
Rheostat Motor	35-J-426	*_____

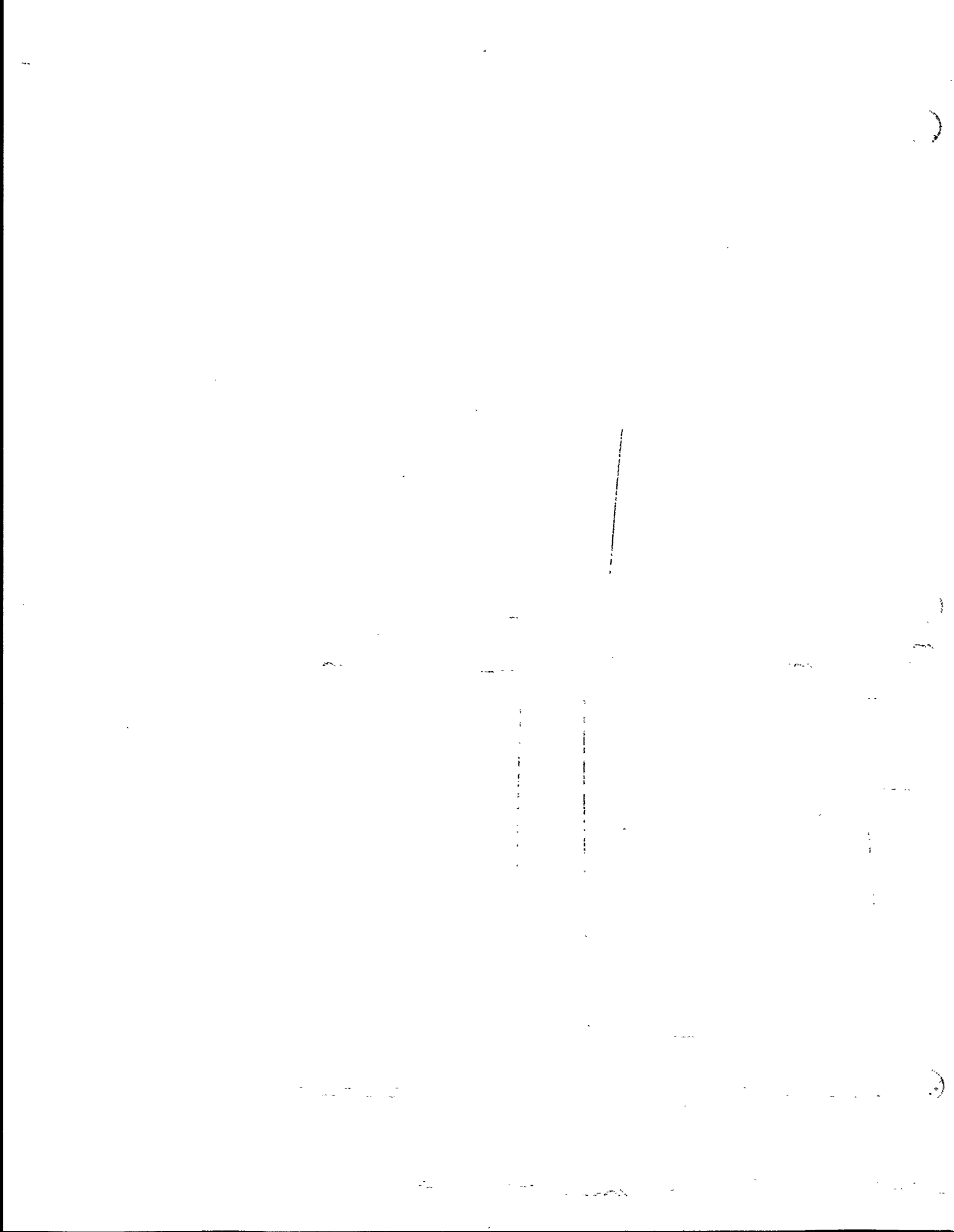
DRAWING LIST

DRAWING TITLE	WESTINGHOUSE Drawing No.	BUREAU OF SHIPS' Type "D" Numbers
GENERATOR AIR COOLER		
Generator Air Cooler Assembly	A-3153+	BB61-S61-098
Generator Air Cooler Core Assembly and Details	A-3154	099
Generator Air Cooler Details	A-3155	0100
Generator Air Cooler Details	A-3156	0101
Generator Air Cooler Details	A-3157	0102
Generator Air Cooler Details	A-3158	0103
Generator Air Cooler Details	A-3159	BB61-S61-0104

* Not available at time of publication
\+ Included as an illustration of Part VI of this instruction book

PART I

TURBINE AND REDUCTION GEAR



PART I

(Section 1) GENERAL DESCRIPTION

TURBINE AND REDUCTION GEAR CHARACTERISTICS

1. Each unit consists of a High-Speed Condensing Turbine arranged to drive an A-C. Generator and D-C. Exciter through the medium of a Reduction Gear, which serves to reconcile the high speed required for efficiency in the turbine to the lower practicable generator speed. The turbine, gear and generators are mounted on a common bedplate, to which are secured also the oil cooler, etc. An outline arrangement plan of the unit is shown in Figure T-1.

2. Eight identical units are supplied for each ship. The nominal rating of each unit is 1250 kw. on an 80% power factor, 3-phase, 60-cycle, 450-volt a-c. generator; including 16 Kw. on a 120-volt, d-c. exciter.

3. The turbine is designed to operate on steam at a throttle pressure of 540 lb/in^2 gage with 825° F. total temperature and 1 lb/in^2 absolute exhaust pressure. It will develop rated capacity with steam conditions of 432 lb/in^2 gage, 825° F. total temperature and 1 lb/in^2 absolute exhaust pressure. It is capable of operating with a maximum pressure of 618 lb/in^2 gage and 850° F. total temperature, or 575 lb/in^2 gage, dry and saturated.

4. The turbine exhausts into the auxiliary condenser at 1 lb/in^2 absolute exhaust pressure.

5. An opening is provided in the cylinder base, normally blanked off, through which steam could be extracted, should it at any time be deemed desirable to provide the necessary means. The quantities of steam which could then be extracted under various load conditions are shown on Figure T-32.

6. The normal operating speed of the turbine is 8050 rpm. and that of the generator 1200 rpm.

7. The pinion and gear are of the double-helical type and the gear is designed to transmit a normal load of 1748 BHP. with the pinion operating at 8050 rpm. and the gear at 1200 rpm. Under these conditions the gear bearing pressure is 73.5 lb/in^2 of projected area, the pinion bearing pressure is 155 lb/in^2 of projected area, and the tooth pressure is 71.6 lb/in face/in. P.C. diameter.

8. The turbine bearing pressures are 60 and 67 lb/in^2 of projected area for the thrust and coupling ends respectively and the turbine and pinion journal speeds are 109 feet per second, and 140 feet per second, respectively. The gear journal velocity is 26.2 feet per second.

9. Oil System Capacity - At high level 104 gallons; normal 99 gallons, and at low level 94 gallons.

DESCRIPTION OF TURBINE AND GEAR

General Description

10. The turbine, of straight-impulse type, a longitudinal section of which is shown in Figure T-2, consists of a combination of Curtis and Rateau stages. The Curtis element consists of one pressure stage with two velocity stages. This Curtis stage is followed by eight Rateau stages.

11. The steam, after passing through the throttle valve and the steam chest valves enters the first-stage nozzles where it is expanded to the pressure existing in the impulse chamber. The velocity energy acquired in this expansion is converted into rotative energy by the impulse blades. The steam is then expanded successively through the Rateau stages to the pressure maintained in the condenser thus imparting further rotative energy to the rotor.

12. The turbine cylinder is supported at the gear end by lugs on the cylinder base at the level of the turbine centerline, which rest on the gear housing and are restrained from axial movement relative to the housing by keys set half in the lug and half in the housing. The lugs can slide transversely on the keys thus allowing for differential expansion but transverse movement of the turbine as a whole is prevented by a vertical key on the end of the cylinder base, held between gibs on the gear housing. The thrust end is supported by a transverse plate which is bolted to the cylinder and the bedplate. The web of the transverse plate provides the necessary flexibility for longitudinal expansion and contraction of the cylinder.

Cylinder

13. The turbine cylinder is made from cast alloy-steel and consists of a base and cover, bolted together on the horizontal flange and each made in two pieces joined at a vertical joint between the second and third Rateau stages. This joint is made up permanently at initial assembly and the cover and base thenceforth treated each as one piece. The horizontal joint flanges are carefully machined to a full bearing surface and the metal-to-metal joints made tight.

14. The cylinder is protected from excessive steam pressure by a relief valve which is set at 10 lb/in^2 gage. This valve is shown in Figure T-3. A sentinel valve is also provided and is set at 2 lb/in^2 gage to give warning of an abnormal pressure condition. The turbine cylinder is also protected by a back-pressure trip which will trip closed the throttle valve when the back pressure at the turbine casing reaches 5 lb/in^2 gage pressure.

15. The turbine rotor is machined from a solid alloy-steel forging. The overspeed trip body is screwed onto one end and the other end is coupled to the reduction gear pinion through a flexible coupling (shown in Figure T-11). After the blades are installed the entire rotating assembly is dynamically balanced.

Curtis Blading

16. The blading is shown in detail in Figure T-4. The Curtis element consists of one pressure stage with two velocity stages. After the steam has passed through the steam chest valves it enters the nozzle block. This block is made of stainless steel and is secured to the turbine cylinder with wedges and screws. The steam is expanded through curved foil passages in the block to the pressure existing in the Curtis wheel chamber. The blades blades are milled from bar stock of stainless steel with integral shrouds which form a closed passage for the steam flow. Supplementary shrouds are provided, riveted over tenons on the ends of the blades, by means of which the blades are secured together in groups to raise their natural frequency of vibration as a protection against vibrational stresses.

17. The rotating blades are secured to the turbine rotor by a type of fastening consisting of a double T-root. The blades are held against the top of the groove by half-round segments caulked in place at the bottom. With this type of fastening it is, of course, necessary to widen the groove at one point in order to enter the blades in the T-shaped groove. The row is completely filled with blades and the last blade at this starting point is secured by pins. The stationary blades are secured in straight-sided grooves by a series of short keys which fit in auxiliary grooves cut in the blade shank and in the side of the main groove.

18. Blade shields are secured to the cylinder and extend around that portion of the wheel circumference which is not utilized for the steam admission nozzles. These shields isolate the blade paths from the remainder of the steam space and thus decrease the windage loss due to the blades rotating in the comparatively dense steam. In order to prevent any accumulation of condensation in the bottom of the shields, holes are drilled at the bottom on the vertical centerline, to allow any condensation to flow to drain.

Rateau Blading

19. The Curtis element is followed by eight Rateau stages divided from the former and from each other by interstage diaphragms. The nozzles for the Rateau stages are machined units welded into inner and outer rings to make complete diaphragm assembly. The latter are made in halves and extend completely around the rotor. The nozzles in the first three stages, however, occupy only a portion of the circumference, varying in area in succeeding stages in accordance with the increase in the volume of the progressively expanded steam. The Rateau blades are similar in design and method of fastening to the Curtis wheel blades described previously.

20. Steam leakage from stage to stage between the stationary diaphragms and the rotating shaft is minimized by means of interstage labyrinth seals. These consist of labyrinth strips machined integrally in ring segments mounted in L-shaped grooves in the diaphragms and held in the position of minimum clearance by means of garter springs, as indicated in Figure T-5.

Curtis Wheel Chamber Labyrinth Seal

21. In order to minimize leakage of high-pressure steam from the Curtis wheel chamber, and to lighten the load on the turbine gland at the high-pressure end, an integrally cast diaphragm or "dummy" is provided between the Curtis wheel chamber and the gland. This diaphragm is fitted with 12 rows of labyrinth seal packing as shown in Figure T-5. The steam that does escape through this labyrinth, being thereby throttled to a much lower pressure, is carried away to a connection between the third and fourth Rateau stages and therefore gives up most of its available energy in the lower stages of the turbine blading before passing to the exhaust.

Bearings

22. The rotating element consisting of the turbine rotor, flexible coupling and pinion is carried in four bearings which are similar in general design. These bearings are illustrated in Figure T-6. They consist of steel shells made in halves, and lined with genuine tin-base babbitt. The two halves of each bearing are doweled together with pins and the bearing is prevented from rotating within the housing by a stop dowel which projects into a notch cut in the housing. Oil is admitted at the horizontal centerline, the babbitt being relieved on either side to provide ample space for the distribution of oil along the journal surface. At the end of the bearing nearest to the turbine, the shell is grooved and a slot is cut at the bottom of the vertical centerline to permit the oil which flows to this end

of the bearing to flow freely to drain. This oil groove is not required in the pinion and gear bearings. The pinion bearings have a normal clearance of .010" to .012" with a maximum clearance before re-babbitting of .024". The turbine bearings have .007" to .009" clearance with a maximum of .015" before re-babbitting.

Oil-Seal Rings

23. The oil-seal rings, which are used to prevent the escape of oil along the shaft from the bearing housings, consist of bronze rings made in halves, and baffle plates also made in halves. Any oil which creeps along the shaft is caught in the grooves in the oil ring and flows downward through a series of holes into the pocket in the lower half of the ring. Holes are drilled in the baffle which permit the oil to flow to drain. These holes are drilled at a sufficient height to maintain an oil level in the pocket, thus preventing the escape of oil vapor through the drain holes. The oil-seal rings may be seen in Figure T-2.

Turbine Glands

24. At the points where the turbine rotor shaft extends through the ends of the cylinder, leakage of steam from, or air into the cylinder is prevented by means of glands of the carbon-ring type. Each gland has a casing consisting of an outer and two inner sections, each divided in halves and the outer casing bolted against the cylinder. Each of the inner sections of the casing contains two carbon rings of three segments each, held together around the shaft by means of garter springs. The space between the two sections is connected to a source of sealing-steam supply. The glands are illustrated in Figure T-7.

25. The inner gland-ring casings have their bottom halves held in the cylinder base, while the upper portions are held partly by the cylinder cover and partly by a separate outer casing half bolted to the cylinder cover.

26. In order to remove the gland without lifting the cylinder cover, the outer casing half is first unbolted and removed. Then the upper half of the first inner gland-ring casing may be removed, after which the carbon ring segments may be removed and the bottom half of the ring casing rolled around the shaft and removed. Then the second inner ring casing may be pulled along the shaft into the place of the outer casing and it may then be similarly removed. Replacement will be accomplished by performing the above operations in reverse order.

27. The turbine glands have three segments per ring. All the rings are fitted with a clearance around the shaft and remain stationary in the gland case. The rings are made in the shape of a frustrum of a cone and are held in by a retainer of corresponding shape, and garter spring. When the retainer is put under tension of the garter spring, the resulting compression acting on the conical surfaces of retainer and carbon ring, presses the ring tight against the side of the groove thus preventing leakage between the ring and the groove wall.

28. This is an important feature of the design of these glands. It will be noted that in the exhaust and gland the tapers are not all in the same direction. If the gland is dismantled, care must be taken to see that the rings are re-assembled in the same manner as found originally. The following instructions cover in detail the method of assembling the glands and the fitting and "running-in" of new rings.

ASSEMBLY OF NEW RINGS

29. When assembling new rings proceed as follows:

Step 1. The gland-ring casings and outer casing halves as well as the turbine shaft must be carefully cleaned.

Step 2. Slip the lower half of the inner casing into the cylinder base.

Step 3. Loop a garter spring on the shaft. Slip two segments under the garter spring and slide them around on the shaft into the lower half chamber, keeping enough tension on the spring to prevent the segments from parting company. Then assemble the remaining segment making sure that the locking pin comes at the joint. Repeat for the second ring.

Step 4. Put upper half of the ring case over assembled rings and push the inner case along the shaft into its proper place. For use in disassembling, a tool is provided for withdrawing the inner case (Figure T-30, Items 10 and 16).

Step 5. Repeat given assembly instructions with next two rings.

Step 6. Outer Casing Half
(a) Put outer casing half in place very carefully.
(b) Make sure that no dirt lies on the horizontal joint before bolting up the joints.

RUNNING-IN OF NEW RINGS

30. Be sure that sufficient steam is being supplied to the gland. It is practically impossible to determine off-hand the operating shaft temperatures along the shaft axis. Therefore, the "cold" ring clearances are determined by means of an empirical formula. It is, however, still possible, in fact very probable, that the ring clearances are either too large or too small.

I. Carbon Clearances Are Too Small

31. This can be determined by either of the two conditions.

(a) The turbine starts to vibrate. Vibrations get worse if speed and temperature are kept constant.

(b) The shaft overheats due to friction and starts to show heating colors.

Step 1. In either case the turbine speed must be lowered immediately. If the vibrations do not stop, or the shaft shows some additional heating colors, the turbine must be shut down.

Step 2. The packing must be disassembled. The inside surface of the rings will show spots and should be carefully scraped. After this the rings are installed again.

Step 3. If the clearances are only slightly too small, and this is usually the case, the carbon rings can be run in without having to take the packings apart. This, however, can only be done, if the opportunity exists of operating the turbine for some time at low speeds

(a) Operate the turbine for 1 hour at each speed with the maximum steam temperature available for this speed. Start approximately at 1000 rpm.

(b) If vibration should start or heat-coloring of the shaft show, lower the speed immediately. Raise and lower the speed several times slowly, keeping the temperature constant. Afterward operate again at the speed where the vibrations started. In most cases the vibrations will not occur again.

(c) If the above described procedures will not eliminate the vibrations, the packing must be taken apart and scraped-in.

Step 4. If vibrations are caused by the packing, they will very quickly become more severe if speed and temperature are held constant. If, however, the vibrations start and stop without changing speed and temperature, they are not caused by the packing and must have another source.

II. Carbon Clearances Are Too Large

32. When carbon clearances are too large proceed as follows:

Step 1. If the packing is not tight, that is, if excessive steam leakage occurs at full speed and full load (maximum operating temperature) the carbon clearances are too large.

Step 2. The packings must be taken apart again and the rings taken up. This is done by filing off some carbon with a very smooth and fine file on one surface per joint. A fine emery cloth can also be used.

Step 3. Care must be taken that the joint surfaces stay flat and that the joint is tight after assembly of the rings.

Step 4. Do not remove large quantities of graphite. Approximately one thousandth of an inch per joint should be removed, if the packing leaks badly.

Step 5. Before assembling the rings again, they must be thoroughly cleaned.

33. Long life and good performance of the packings will more than compensate for the work involved in proper fitting or the time required in running-in the rings. In most cases not more than two fittings of the rings are required.

Steam, Gland and Drain Piping

34. The diagram of the steam, gland and drain piping is shown in Figure T-8. Sealing steam for the glands is supplied in part from the auxiliary exhaust line and in part from the low-pressure valve stem leakoff, at approximately 10 lb/in^2 gage pressure and a valve and gage are furnished for controlling the pressure at each individual gland. Approximately 25 pounds per hour of steam will be required for this purpose. The steam pressure at the glands should be maintained at not more than 2 lb/in^2 gage. It will be noted that the main steam inlet line, the steam strainer body and the impulse chamber of the cylinder have drains controlled by globe valves. These valves should be opened during the starting periods in order to remove the condensation resulting from heating the turbine parts. Further reference to these drains and Figure T-8 will be found under the subject "Operation".

Thrust Bearing

35. The end thrust on the rotor is transmitted to the stationary parts by means of a thrust bearing of the Kingsbury type, illustrated in

Figure T-9. It is located on the exhaust end of the turbine shaft and is also shown in Figure T-2.

36. This bearing is of the double thrust type having babbitt thrust shoes on both sides of the collar which is a separate piece mounted on the shaft. Each side of the bearing is provided with six shoes.

37. The shoes "6" are supported on the leveling blocks (or "plates") "5" and "8", which by rocking upon each other allow the shoes to move relatively to one another so that the babbitt faces are all pressed against the collar with equal force. Hence each shoe takes an equal share of the load. The upper leveling plates, "5" rest upon the lower leveling plates, "8", which in turn are carried in the base ring "4", made in halves.

38. As may be seen in Figure T-2(longitudinal section through turbine and pinion) the base ring is supported in the housing. It is centered by the key "10" shown in Figure T-9. The thrust bearing is located by liners between it and the housing at each end.

39. The correct axial position of the thrust bearing, and hence the correct axial location of the rotor, is determined by the thickness of bearing liner (shown also in Figure T-2) the base ring "4" and the housing. The thickness of this liner must be such that with the rotor barred toward the exhaust end as far as it will go, the clearance between the nozzle block and the first row of Curtis blades is as shown on the clearance diagram, Figure T-26.

40. The actual internal clearance of the bearing should be between .009" and .015" in order to permit establishment of a proper oil film between the collar and the shoes. After the liner of correct thickness (as described above) has been installed, the proper running clearance is obtained by adjusting the thickness of the liner which is located between the thrust bearing outer end and the housing. This clearance should be checked by rolling the rotor and barring it from one extreme axial position to the other, measuring the end travel with a dial indicator.

41. If the bearing has been disassembled for cleaning or repair, the following notes will assist in simplifying reassembly.

42. First clean and inspect all parts carefully. Oil bearing surfaces when assembling.

43. All bearing parts are to be assembled radially with housing cover removed. See Figure T-9. With shaft in position first rotate lower half "1" of brass oil control ring into place under collar. Note that longer lug belongs on upward side of collar's rotation.

44. Put leveling plates "5" and "8", and six shoes in position on the split halves of base ring "4", and secure by screws"3". Rotate lower half of base ring into place on each side of collar, with parts attached, and follow with upper half and its key "10".

45. Bolt upper half "12" of oil-control ring to the lower half "1".

46. Turn base ring "4" to bring joint vertical, and test end-play by jacking shaft endwise and measuring movement with feelers. Adjust thickness of one or both end filler pieces, by shimming or machining, to make total end-play of shaft between .009 and .015". When found correct, turn base ring to bring key "10" to top center, and bolt housing cover down.

47. Do not force when assembling. If parts do not go together easily, something is out of place.

Rotor-Position Indicator

48. The rotor-position indicator which is bolted to the end of the thrust-bearing housing is shown in Figure T-10. A reading is taken by pushing lightly on the pad "A" on the pointer "12" until the ball "6" makes contact with the end of the rotor. The indicator was set at the factory, but nevertheless immediately after installation the rotor should be barred toward the exhaust end (making sure that all clearance is taken up) and while in this position the pointer should be checked and, if necessary, adjusted to zero, loosening the clamp screw on the pointer to adjust it and then tightening up securely, and pinning. Thereafter when a reading is taken displacement of the pointer from zero will indicate an axial displacement of the rotor, one division on the graduated scale "16" representing a displacement of the rotor of .002". A small spring "8" holds the ball out of contact with the pinion when the indicator is not being used. It is obvious that readings should be taken either with the machine carrying load or with the rotor barred toward the exhaust end. Otherwise, the clearance in the thrust bearing may cause an erroneous reading.

Coupling

49. The turbine rotor and the reduction gear pinion are connected by means of a coupling of the "Fast" type, illustrated in Figure T-11.

50. As may be seen in the detail in the illustration the coupling is of the internal involute-toothed type. The coupling heads are pressed and keyed to the turbine and pinion shafts respectively and the two halves of the sleeve are bolted together to make the driving connection.

51. Lubrication is supplied by means of sprays of oil directed into the lip of the sleeve from nipples in the pinion bearing ends and a positive circulation of oil, to prevent sludging of the tooth clearances, is maintained by virtue of a number of outlet holes on the periphery of the lip at the turbine end. Further information will be found under "Installation" and under "Maintenance".

Throttle Valve

52. Steam is admitted to the turbine by a vertically disposed throttle valve which is shown in Figure T-12. This valve is manually operated by a handwheel, but is closed automatically by a compression spring when the trip release latch is tripped by the overspeed trip or by the back-pressure safety stop.

53. The valve shown in Figure T-12 consists of a single-seated disc operated by means of a handwheel which rotates a screw spindle in a sliding nut. The sliding nut is spring-loaded and arranged so that when the spring has been compressed, the sliding nut is held by the trip latch against the force of the spring. With the valve in the latched position, rotation of the handwheel will open the valve to admit steam to the turbine. With the valve wide open, it will be tripped closed automatically if the overspeed-trip mechanism functions. When the overspeed trip acts it rotates the shaft carrying the latch which holds the sliding nut against the operating-spring compression. This movement disengages the latch and releases the spring force, so that the valve is driven instantly to its seat.

54. The valve is installed so that the steam enters above the seat, or in the direction indicated as the inlet by an arrow on the valve body. When the valve is closed full steam pressure acts over the total area of the disc, holding this to its seat. When the valve is being opened, the first movement of the stem lifts the pilot valve and releases the pressure acting on the disc, decreasing the pressure in the balancing cylinder to approximately the same pressure as that on the outlet side of the disc. Under

these conditions the valve is practically balanced, and further movement of the valve stem opens the main disc without requiring excessive force.

Tripping and Resetting

55. In order to latch the valve, rotate the handwheel in the direction marked "Reset" on the handwheel. This causes the sliding nut to be raised, and rotation of the handwheel should continue until the sliding nut comes to a definite stop. Do not try to force rotation beyond this point.

Adjusting Screw, Function and Use

56. One very important feature is the controlled leak into the balancing cylinder, which is regulated by the adjusting screw in the valve cover.

57. All valves shipped from the factory, have the adjusting screw wide open, and this should be adjusted at installation to suit the actual operating conditions. If the valve is sluggish in operation, this may be due to excessive pressure in the balancing cylinder, and should be corrected by rotating the adjusting screw in a clockwise direction, to reduce the amount of steam flowing into the balancing cylinder.

58. If the adjusting screw is closed off too far, there may be a tendency for the main valve to jump when first moved off the seat. The adjusting screw should be backed off counter-clockwise until this jump is no longer felt. The jump is caused by the steam pressure acting on the seating area of the main disc as it is moved off its seat. This pressure force must be counteracted by maintaining a sufficient pressure in the balancing cylinder. When the adjusting screw has once been set for actual operating conditions, no further adjustment will be necessary.

Steam Chest And Governor

Steam Chest

59. The steam chest and governor are shown in Figures T-13, T-14, and T-15, the first being a section of the steam chest and linkage, the second being a sectional view of the governor and the third a plan view showing the arrangement of the speed-changer. The steam chest body is an integral part of the turbine cylinder, and the cover serves also as the linkage support. The turbine is provided with six valves which are arranged in parallel within the steam chest; that is, all valves are surrounded with steam at approximately throttle pressure.

60. These valves are of the single-seated type. The seats are pressed into the steam chest body and can be replaced, if necessary. The governor servomotor raises and lowers the valve bar "30", keeping it perfectly horizontal at all times. The bar, in turn, lifts the valves by engaging the adjusting nuts "29". The adjusting nuts are threaded on the valves and hence the point at which each valve opens, and the amount of opening can be varied by means of these adjusting nuts. Of course, there is an unbalanced steam force tending to close the valves but, in addition, a positive closing force is obtained by the lower edge of the bar engaging the shoulder on each valve.

61. The valve bar stem packing consists of closely fitted bushings "25" and "26" with suitable leak-off openings. Two leak-offs are provided as shown in the Figure, the upper one is led to a point at atmospheric pressure. The lower one is led to the impulse wheel chamber of intermediate pressure in the turbine.

62. The operating lever is "V" shaped and mounted on a rock shaft, with the central arm connected to the governor and each of the two branch

arms connected to a valve bar stem. Universal joints are used in the connecting links to insure correct alignment of the moving parts. The operating linkage is fulcrumed so that downward movement of the governor servomotor piston opens the valves and upward movement of the piston closes them.

63. The operating lever "4" is secured through universal links to the governor servomotor lever "19" which in turn is connected to the servomotor piston rod, "51" of Figure T-14.

64. Since the governor servomotor piston spring "58" tends to move the valves in the closing direction it requires oil pressure above the piston to open the steam chest valves and with the unit at rest the relationship of the parts is such that the steam valves must be opened manually to get the unit into operation. For this purpose a hand lever, a cam and a lever ("1", "16" and "12" of Figure T-13) are provided with which the linkage can be manually raised to open the valves. When steam is admitted and the unit comes up to speed, the movement of the linkage as the governor takes control releases the hand lever and the cam and lifting lever drop into the "Off" position.

65. For establishing the proper lifts for the several steam chest valves a special fixture is provided, the application of which is illustrated in Figure T-16.

66. Referring to Figure T-16, in order to use this fixture first remove the valve linkage and the steam chest cover. Screw the valve-stem extension rods onto the valves, as indicated, and assemble the valve-lifting bar and the valves with the reference bar and bolt the latter to the steam chest body in place of the steam chest cover. Before tightening the nuts on these bolts make sure that the reference bar is so located that the valves all seat properly and the extension rods slide freely through the bar.

67. Mount the measuring bar on the valve-lifting stems and make sure that it is parallel with the reference bar when all the valves are properly seated.

68. With a depth micrometer (the bearing-wear micrometer may be used for this purpose) measure accurately the distance from the top of each extension rod to the top of the measuring bar and record the readings.

69. Now raise the measuring bar until the spacer blocks provided can be set under the ends. Make sure that the measuring bar is down tight on the blocks and that the latter are standing squarely on the reference bar. Measure again from the top of the bar to the tops of the extension rods and record the readings.

70. The difference between the first and second readings on each valve will equal the clearance between the valve adjusting nuts and the valve lifting bar when all the valves are seated. The valve lifts when recorded from tests in the factory will be listed under "Valve Settings" at the front of this book and in the event of a complete dismantling of the steam chest the test lifts should be reproduced when the unit is reassembled.

Governor

71. The governor is of the vertical-shaft, fly-ball type, in which the revolving weights move radially in response to changes in centrifugal force, resulting from changes in speed.

72. The changes is centrifugal force of the weights are transmitted to a relay which controls the flow of high-pressure oil to and from the governor servomotor cylinder. Movements of the servomotor piston are

transmitted by a lever to the steam-chest linkage. The oil required to operate the servomotor piston is supplied by the main oil pump and is led to the high-pressure oil-inlet chamber of the relay through passages drilled in the governor housing.

73. Referring to Figure T-14, the governor hub which holds the weights is driven from the end of the gear wheel shaft by means of spiral gears. The governor weights are secured to a strap of spring steel mounted across the diameter of a ring held by the governor hub. The spring is formed into an inverted "U" at the center and the forces acting on the weights flex the strap, thus transmitting the forces through the spring seat to the cup valve. When the governor is at rest, the governor spring "18" holds the governor weights in their innermost position.

74. The complete rotating element is carried in two bearings. Each of these bearings is a combined radial and thrust bearing mounted in the bearing bracket. This bracket is centered in and bolted to the gear housing cover. The vertical clearance between the thrust faces can be adjusted by means of the liner "7" provided between the gear "8" and the spacer "3". This can be done by machining the liner. This clearance should be from .003 to .006".

75. The cup valve "64" rests on a ball "69" supported on the pin "75" in the center of the spring seat "70" which is secured to the governor weight strap.

76. The space beneath the relay piston "34" is supplied with high-pressure oil through drilled orifices, in its periphery, and the cup valve, by determining the ratio of its area to the centrifugal force of the weights, controls the pressure acting under the relay "34".

77. The balance of forces in any given operating condition consists of the centrifugal force of the weights acting upward through the strap, ball and cup valve, opposed by the governor oil pressure acting downward on the cup valve. The value of the governor oil pressure is determined by the area of the cup valve and the part of the centrifugal force of the weights not balanced by the spring forces, hence, every turbine speed (and consequent value of centrifugal force on the governor weights) determines a value of the governor oil pressure.

78. The relay is secured to the pin "37" which is subjected to the compression of the spring "40". Therefore, the oil pressure under the relay determines the degree of compression of springs "40" and hence the position of the relay in the ported bushing "36". This, in turn, controls the flow of oil to and from the servomotor cylinder.

79. The upper spring seat "43" of the spring "40" is connected through stem "41" and the follow-up linkage and lever "50" to the servomotor piston so that movement of the piston, consequent upon a change in the governing pressure under relay "34", is immediately followed by a corresponding change in the compression of spring "40", sufficient to balance the change in governor oil pressure and restore the relay to its neutral position.

80. The operation of the governor is as follows:- With the turbine at rest, the governor weights are held in their innermost position by the governor spring, and the governing valves are held closed by the servomotor piston which is held in its uppermost position by the spring "61" when no oil pressure is available. In order to start the unit it is necessary first to open the steam chest valves manually by means of the handle "58" and the lever "54" (Figure T-14) which forces the servomotor piston down against the resistance of spring "61". When the turbine speed increases sufficiently

for the oil pump to provide enough pressure to open the governing valves, the latter will open wide allowing the handle "58" to drop back to its original position. As the speed approaches normal the centrifugal force of the governor weights will overcome the force of the governor spring and the weights begin to move outward. The unit then comes under the control of the governor.

81. If the load increases, the speed decreases and the centrifugal force acting on the weights is reduced. The governor spring-force being constant, the reduction in centrifugal force is balanced by a reduction in governor oil pressure. This results in a downward movement of the relay which opens the ports admitting high-pressure oil above the servomotor piston, and connects the space below the piston to drain. The piston therefore moves downward, opening the governing valves sufficiently to maintain the required speed. As the piston moves downward, the follow-up lever decreases the compression of spring "40" thus restoring the relay to its neutral position.

If the load decreases, the speed increases increasing the centrifugal force on the weights and this increase in force is balanced by an increase in oil pressure. The increase in oil pressure under the relay causes it to move upward, uncovering the ports which admit high-pressure oil below the servomotor piston and connecting the space above to drain. The piston therefore moves upward, closing the governing valves sufficiently to maintain the required speed. Upward movement of the piston, acting through the follow-up lever, compresses the spring "40" until the increased oil pressure is compensated for and balance has again been restored.

82. Thus it is seen that following any relay movement the resulting movement of the servomotor piston changes the spring compression so as to restore the relay to its neutral position where it remains until another change in speed (or load) occurs.

Speed-Changer:

83. The hand or motor-operated speed-changer, by means of which the speed or load can be varied, is shown in Figures T-14 and T-15. As shown, it is in mid-position. The principal parts of the electrically operated portion are:- the motor, shaft, worm and worm wheel. The principal parts of the hand-operated portion are:- the handwheel and shaft. Both the electrically operated and hand-operated portions act to regulate the speed through the worm "100" and worm wheel "23" (Section B-B, Figure T-14) which is threaded on the transformer housing "29".

84. Since the housing "29" is stationary, rotation of worm wheel "23" on it produces vertical motion of the worm wheel, which through ball bearings "22" supports the governor spring seat "21" and spring "18". Consequently, movement of worm wheel "23" changes compression of the governor spring "18" and hence the speed, or load, corresponding to a given governor weight position.

85. For hand operation, rotation of the handwheel is transmitted directly through the shaft "92" to the worm "100" which meshes with the worm wheel "23", thereby moving the worm wheel upward or downward on the transformer housing "29". For motor operation, the worm "108" (Section G-G, Figure T-15) meshes with the worm wheel "98" (Section B-B, Figure T-14) and drives through the collars "91" and "95" and the handwheel, to the second worm and worm wheel. The collars "91" and "95", faced with clutch plates "93" and "94", form a friction-type clutch which is held in engagement by the spring "99". This clutch slips when the hand-operated feature is used and also serves as a safety device in the event of overtravel of the speed-changer motor.

Governor Disassembly And Adjustment:

86. The governor is thoroughly tested and adjusted at the factory and should operate satisfactorily as received. However, from time to time during the life of the unit it will be expedient to completely disassemble the mechanism for examination, cleaning, or replacement of worn parts, and at such times when reassembling, it will be advisable to check the accuracy of the adjustment. At other times partial disassembly for examination of specific portions of the mechanism may be indicated, and on all such occasions, the following information should be noted:

87. To Disassemble Governor

A. Complete Disassembly

Step 1. Disconnect steam-chest linkage from steam chest.

Step 2. Disconnect follow-up linkage.

Step 3. Remove cylinder cover bracket "47", together with servomotor piston "59".

Step 4. Remove servomotor spring "61".

Step 5. Remove governor cover "44" together with stem "41".

Step 6. Lift out spring seat "43" and spring "40".

Step 7. Lift out bushing "39". (This bushing serves as a stop to prevent overloading of the spring "40" and the follow-up linkage in case of excessive overspeed - for example, while testing overspeed trip. It serves also, incidentally, as a spigot to position the governor cover "44").

Step 8. Lift out spring seat "38" and relay "34", using threaded rod screwed into a tapped hole provided for the purpose.

Step 9. Remove speed-changer handwheel "87".

Step 10. Unbolt and remove access plate "62". When this plate has been removed, the speed-changer worm shaft assembly may be withdrawn as a unit.

Step 11. If it is desired to completely disassemble the speed-changer mechanism, loosen the set screws securing the speed-changer clutch collars "91" and "95" and remove these collars. (The outer one will slip off while the inner "95" must be unscrewed from worm wheel "98").

Step 12. Remove whorm wheel "98" and bushing "89".

Step 13. Rotate the worm shaft "92" to screw the worm "100" out of mesh with worm wheel "23" and withdraw the worm shaft.

Step 14. Unbolt the bottom flange of the governor housing "73" and lift the housing straight up until the governor parts are cleared, and then swing the housing away. When the governor housing has been lifted clear of the rest of the mechanism, make sure that the upper race of the ball bearing "22" has not been lifted with the housing. If it has, remove it immediately to avoid possibility of its dropping loose later and being damaged.

Step 15. Carefully remove the ball bearing "22".

Step 16. For access to governor weights, etc., remove governor casing "19".

Step 17. For access to the cup valve, etc., turn the governor housing upside down and remove the bolt "63" and the cap screws.

Step 18. Lift out the cup valve assembly.

Step 19. Turn the cup valve assembly right side up and remove the fillister head screws holding the cup valve seat. Remove the seat "31".

Step 20. Remove the cup valve "64".

B. Partial Disassembly

There are three partial disassembly sequences which may be required for access to specific portions of the governor mechanism. These are:

Group I. Access to cup-valve seat and cup valve for examination and cleaning.

Group II. Access to the governor weight assembly.

Group III. Access to the governor bearings and the axial clearance adjustment liner.

To make these three partial disassemblies, proceed as follows:

Group I - Follow steps 1 to 8 inclusive of "Complete Disassembly", Sequence A, described above.

Step 9. Lift out the governor spring seat "33" and the spring "32", using for the former the same threaded rod previously mentioned and for the latter, a hook-ended piece of wire.

Step 10. Unscrew the fillister head screws in the cup-valve seat "31" and remove the seat by means of the threaded rod screwed into a tapped hole provided for the purpose.

Step 11. Lift the cup valve "64" using the same threaded rod.

Group II- Follow steps 1, 2, 14, 15 and 16 of "Complete Disassembly", Sequence A, described above.

Group III- Follow steps 1, 2, 14, and 15 of "Complete Disassembly", Sequence A.

Step 16. Remove the fillister head screws holding the brackets "9" to the gear-housing cover.

Step 17. Lift out the governor hub and bracket assembly straight up until clear of the housing. Remove this assembly to the work bench.

Step 18. On the work bench loosen the set screw "2" and remove sleeve nut "1".

Step 19. Stand the assembly on end, and by pushing down on the bracket, push the collar "3" off and remove the liner, Item 7.

88. To Adjust and Assemble Governor

The governor is assembled by reversing the order of the steps given above. However, if the mechanism has been entirely disassembled, the adjustment should be checked before reassembly. In connection with the reassembly, remember that there is no gasket used between the governor housing and the gear-housing cover.

89. To Adjust the Governor Relay Mechanism

Step 1. Check the vertical clearance in the governor-spindle thrust bearing, that is, the clearance between the bearing and the spindle sleeve. This vertical clearance should be .003" to .006" and is obtained by replacing or machining the liner "7" as the case may require. The radial clearance in the governor-spindle bearing should be .003" to .006" on the diameter.

Step 2. When the governor hub and bracket assembly have been replaced in the gear-housing cover, remove the governor spring seat "21" and the governor spring "18".

Step 3. Place a scale across the top of the governor case "19" and measure the downward deflection of the governor weight strap "15" against the adjusting screw "12" by pressing down on the spring seat "70". This downward deflection should be 1/32". Readjust the position of adjusting screw "12", if necessary, bearing in mind that 1/4-turn of this screw produces a vertical motion of .015".

Step 4. When the governor housing has been reassembled on the gear-housing cover, remove all the liners "30" from under the flange of the cup-valve seat "31". This will permit the cup-valve seat to rest on the cup valve "64".

Step 5. Measure from the top of the cup-valve seat "31" to a scale laid across the top flange of the governor housing, being sure that the gasket "42" is not on the flange.

Step 6. Replace all of the liners under the cup-valve seat "31", and repeat this measurement. The difference between the two measurements should be 1/32". Change the liners if necessary, to obtain this figure.

Step 7. Set the governing valve lifts according to instructions given in the description of the steam chest.

Step 8. Adjust the length of the connection to the governor valve lever so that all the governing valves are closed tightly when the servomotor piston "59" is 1/4" away from its upper limit of travel.

Step 9. In reassembling the follow-up mechanism, be sure that the follow-up lever fulcrum pins "80" and "83" are placed in the same holes in which they were found originally, in order to maintain the same regulation.

Step 10. The speed-changer limit stop consists of lugs on the plate "27" and the ring "28". To set the limit stops, proceed as follows:

(a) Start-up the unit and hold the generator speed at 1240 rpm., without load, by means of the throttle valve. Turn the speed changer in the "INCREASE" direction until all the governing valves are wide open. This will be determined by measuring the lifts, and checking them against the figures given in the valve lift tabulation. This represents the full-load position.

(b) Shut the machine down and lock the limit stop in this position. To do this, remove the access plate "62". The ring "26" is saw-cut in the horizontal plane so that tightening the nut "63" locks the stop "28" securely. Since the upper and lower lugs on the stop ring "28" are a constant distance apart, the speed-changer range is fixed, and no further adjustment of the lower stop is possible.

90. The following data were used by the Manufacturer in making the governor adjustments. The values are approximate and are given as a guide in the event the governor requires readjustment.

Step 1. Locate follow-up lever fulcrum pin in hole No. 2.

Step 2. Set relief valve for 90 lb/in^2.

Step 3. With governor controlling speed in no-load position adjust servomotor spring to give secondary governing pressure of 40 lbs/in^2.

Step 4. Adjust the speed-changer to give 1200 rpm. and observe stability.

Step 5. Close the throttle valve till the governor is just wide open.
The drop in speed should be 60 rpm.
Speed variation 5%.
The drop in secondary governing pressure should be 22 lb/in^2 $\pm$ 5%.

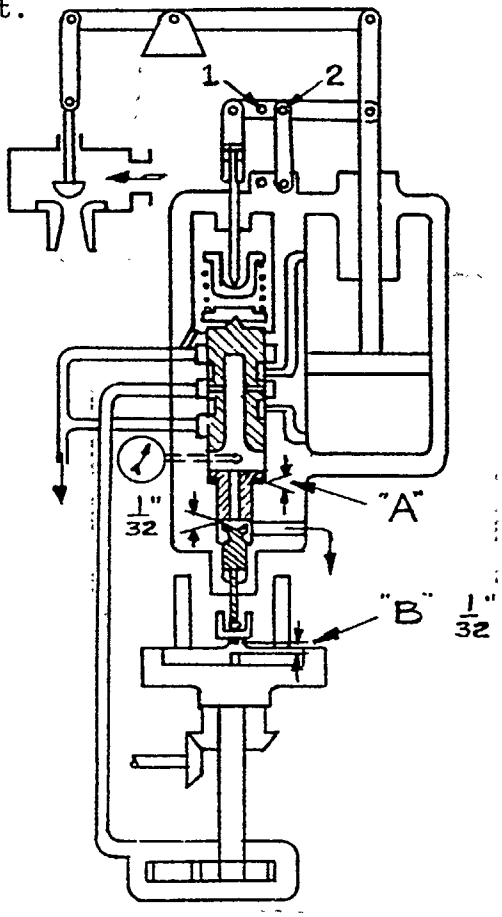
Step 6. Hold the speed at 1240 rpm. by means of the throttle valve and run the speed-changer in the opening direction until the governor is just wide open.

Step 7. Shut down and lock speed-changer limit stop in this position.

No Load to Full Load	=	13/32" governor valve travel 3% speed changer

"A" Shim to obtain 1/32" clearance between cup valve and seat.

"B" Set for 1/32" clearance when strap is clamped in place but with spring removed.



There is a 1/4" pipe tap for gage connection in the flange located on the side of the governor for obtaining secondary governing oil pressure.

Extraction

91. As shipped from the factory, it is not intended that steam should be extracted from the blade path of the turbine. However, a nozzle is provided in the cylinder base at one side, from which steam could be extracted at some future date, if desired. This opening is blanked off at the factory. For the convenience of the operating personnel, should it be decided in the future to employ extraction, a curve is given in Figure T-32 showing the quantities of steam which could be extracted at various loads.

Reduction Gear

92. The longitudinal section through the pinion shaft is shown in Figure T-2 and the longitudinal section through the reduction gear is shown in Figure T-17. The gear wheel is pressed onto the gear shaft, and is further secured by set screws. The shaft is carried in the gear bearings (Figure T-17), the bearing on the turbine end acting also as the thrust bearing. Machined collars on the shaft act as the thrust bearing collars and liners are provided by means of which the axial location of the gear wheel may be adjusted. The gear wheel and generator rotor are dynamically balanced after being bolted together.

93. The gear housing base is mounted in the bedplate and forms the oil reservoir for the unit. An oil-level gage is provided to show the amount of oil in the reservoir. The main oil pump, which is driven by the bevel gears, takes its suction from the reservoir as shown.

94. A lug on the housing cover matches with a bracket on the base and the two are pinned together so that the cover may be swung open without the necessity of removing it completely. A support arm may be bolted to cover and base to hold the cover in the open position for inspection or work on the gear.

95. Between the generator end gear bearing and the coupling there are two oil-thrower rings turned on the shaft and an oil ring, the labyrinths of which drain back into the gear housing. Also between the coupling and the generator there is a second double oil ring with a leak-off from between the sections so that the possibility of any vapor being drawn into the generator winding is eliminated.

96. The gear teeth are lubricated by means of pinion sprays which discharge oil between the pinion and gear teeth.

Gear Bearings

97. The pinion bearings, shown in Figure T-6, consist of steel shells, babbitt-lined, similar to the turbine bearings except that the pinion bearings, being enclosed by the gear housing do not require oil baffles, as do the turbine bearings. The pinion bearings have normal clearance of .010-.012" with maximum of .024" before re-babbitting. The gear bearings shown in Figure T-18 have .008-.010" normal clearance with maximum of .018" before re-babbitting. The turbine-end main gear bearing is provided with bolted-on thrust rings at either end. Shoulders on the gear shaft serve as thrust collars so that this bearing is a combined journal and thrust bearing. Split liners between the bearing wheel and the thrust rings permit adjustment of the location of the main gear wheel in the housing and of the axial clearance of the bearing.

Alignment of Pinion And Gear

98. For proper operation of the unit the pinion and gear should be parallel. This condition exists when the pinion and gear-shaft centerlines lie in the same plane and are equidistant at both ends. For use in obtaining and checking this condition the gage and the fixture (Figure T-30), are provided.

99. The fixture is laid on the gear with the pads at the square end resting on the gear journals. If the pinion and gear are in the same plane the pads at the round end should simultaneously touch the pinion journals.

100. If this does not occur adjustment may be made by scraping the bearing lower half at the end which is touched, to bring the high end down so that both pads will touch. This scraping must be carefully done and should not in any case be carried to the extent of increasing the total bearing clearance beyond the maximum permitted. In such a case it would be necessary to re-babbitt or to install new bearings. However, the likelihood of such a condition occurring is most remote.

101. Parallelism is obtained when the gage "9" (Figure T-30) will just fit between the pinion and gear aligning shoulders at both ends.

Main Oil Pump

102. The main oil pump, which is shown in the reduction gear assembly, Figure T-17, is located in the turbine end of the gear housing base. it is of the gear type and is driven from the governor body, which in turn is driven from the main gear shaft through spiral gears.

103. The pump body is bolted to an internal bracket in the gear housing base. The suction is taken from close to the bottom of the reservoir through a short intake pipe. The pump is driven by means of a vertical shaft splined at both ends. The upper end engages the governor body sleeve nut, which is secured to the governor body. The lower end engages splines in a hollow shaft or driving sleeve to which the pump gear (driver) is keyed and which rotates in the pump bearing bushings. A bushing pressed into the bore of the driving sleeve prevents the splined driving shaft from dropping down. The driven pump gear is keyed to a short idler shaft. The bushings which serve as bearings for the gears are made of tin-base babbitt.

104. The pump takes oil from the reservoir and discharges into a line leading through the gear housing to the duplex strainer and thence to the oil cooler.

Oil System

105. The arrangement of the oil system is shown diagrammatically in Figure T-19. This system consists essentially of a reservoir formed by the reduction gear housing, a main oil pump described above, a duplex strainer, a cooler, a hand-operated auxiliary pump for use when starting and stopping the unit, and the connecting piping.

106. The level of the oil in the reservoir is shown by the float-type of level gage which is located on the turbine end of the gear housing. The oil level should be maintained so that it is between the high and low-limit marks on the gage plate with the machine in operation.

107. In normal operation, the main pump discharges at approximately 35 lb/in^2 gage pressure. A part of this oil is led through cored passages to the governor mechanism to operate the steam chest valves. The remainder is led through external piping through the strainer and cooler to lubricate the bearing and reduction gear teeth. The maximum permissible temperature of oil leaving any bearing is 180° F. The temperature rise of oil passing through any bearing is not to exceed 50° F. The flow of the oil through the bearings is regulated by relief grooves cut at the horizontal joint of the bearing.

108. A relief valve, connected to the bearing supply line, is set to discharge a part of the oil directly to the reservoir if the pressure at the bearings exceeds 10 lb/in^2 gage. Also the low-pressure alarm contact-maker is connected to the system so as to sound an alarm if the pressure at the bearings drops to 4 lb/in^2 gage. A by-pass valve, Figure T-23 around the cooler is provided so that the cooler can be taken out for cleaning and repair while the unit is running. The cooler is preferably by-passed when starting the unit, until normal bearing operating temperatures have been established. When the cooler is put in service the water circulation should be carefully adjusted so as to prevent under-cooling of the oil.

Auxiliary Oil Pump

109. The hand-operated auxiliary pump takes its suction from the reservoir and discharges through a check valve into the strainer and thence to the lubricating system. This pump should be operated when starting the unit until the speed increases sufficiently for the main pump to supply the lubricating requirements. This pump should also be operated when slowing down the unit until the shaft is at rest.

110. The auxiliary oil pump is shown in Figure T-21 like the main pump it also is of the gear type, but is driven manually by turning the handle "9", which drives through the step-up gears "4" and "5". These gears have a 4:1 ratio. The pump driving shaft "12" passes through a stuffing box "15", "16" and "22" containing packing, which minimizes leakage of oil from the pump into the driving gear casing.

111. The pump gears "6" and "7" may be examined by taking off the gear housing cover "2" and removing the screws "21" which secure the driving gear housing to the pump body "3". The pump body "3" may then be removed, exposing the pump gears. If complete disassembly is required, the gear "5" must be removed from the shaft and the stuffing box loosened so that shaft may be withdrawn through it. Care must be used in removing pump body, to see that the pump gear (driven) "7" does not drop off the idler shaft "13".

112. The handle, items "9", "10" and "24", is hinged so it will drop out of the operator's way when the pump is not in use. The oil cup "17" is provided for priming the pump gears when starting.

Oil Strainer

113. The oil strainer is shown in Figure T-22.It is of the duplex type and is equipped with magnets for the removal of ferrous material from the oil. The basket, through which the oil must flow, is made with sides of wire mesh and perforated sheet, and contains the magnet assembly which consists of the magnets "24" and the rod "25".

114. The flow of oil to the strainers is controlled by the plug, which is so designed that when turned on its seat by means of the change-over

lever, it will direct the oil to either strainer, but will prevent the oil from being completely cut-off during change-over from one strainer to the other. The indicator on the change-over lever points toward the side of the strainer which is in use. The stem of the strainer plug "18" is loose-coupled to a jack screw "8" which is threaded through the top of the bonnet "6" and carries a handle "13". Rotation of this handle in a counter-clockwise direction will pull the plug upward thus breaking its contact with the body and facilitating the change-over operation, while by turning it in a clockwise direction, after the change-over has been made, the plug can be seated tightly in the body, thus eliminating leakage around the plug.

115. In order to clean a strainer it is only necessary to swing the change-over lever to the opposite side, back-off the handle "10", remove the cover "20" and lift out the strainer basket.

Oil Cooler

116. Figure T-23 shows the oil cooler with its pipe connections. The oil enters the cooler shell at the top left end (looking toward the unit) and passes around the outside of the tubes, being directed back and forth across them by the baffles and leaves the cooler by the outlet connection at the top of the other end. The water enters the water bonnet and passes through the tubes on one side to a reversing bonnet and back through the tubes on the other side to the outlet. The tubes are rolled into both tube sheets.

117. Provision is made in the shell by means of a double diaphragm structure, for relative expansion of the shell and tubes, the tube sheet being secured directly to the shell at each end.

118. The dry weight of the complete cooler is 835 pounds. Each cooler has 98 tubes and is designed to cool 55 gallons per minute of oil of a quality meeting Navy Symbol 2190 from 150° to 120° with 20 lb/in^2 pressure drop when supplied with 90 gallons per minute of water at 85°F. with 2 lb/in^2 water-pressure drop.

Lubricating Oil

119. Oil, Navy Symbol #2190 having a viscosity of 185-205 S.S.U. at 130°F. should be used in the lubrication system.

DESCRIPTION OF SAFETY DEVICES

Overspeed Trip And Back-Pressure Safety Stop

120. The overspeed trip mechanism which trips the throttle valve and thus shuts down the turbine in case it overspeeds is shown in Figure T-24. The actuating device consists of a weight located transversely in a hole in the body which is screwed into the end of the turbine rotor. The weight is located with its center of mass slightly off the axis of rotation and is held in place by the spring and the retainer which is secured by the nut. As the speed of the rotor increases the centrifugal force of the eccentric weight becomes greater until at a predetermined speed (10 to 12% above normal full-load speed) the centrifugal force is sufficient to overcome the resistance of the spring, whereupon the weight moves outward radially until it comes into contact with the trip lever. This lever is struck sharply by the weight and the resulting movement disengages the latch from the reset handle, these latter pieces being held in engagement by hardened plates "37". When the reset handle is released the tension spring pulls the trip rod smartly toward the throttle valve trip lever to which one end of the spring

is attached, and through which the trip rod end moves until the weight engages the lever with a hammer blow effect which is sufficient to actuate the throttle valve tripping mechanism and close the valve as described in the section on throttle valve. The speed at which the auto-stop will

function can be adjusted by means of liners "6" of Sect. A-A. Increasing the thickness of the liners increases the tripping speed. Decreasing the thickness of the liners decreases the tripping speed.

121. When this mechanism has operated it must be reset by hand. This is accomplished by returning the reset handle to the vertical position when the latch plates will again be engaged. This resetting cannot be done until the turbine speed has decreased sufficiently to allow the overspeed trip weight to return to its normal position which will occur at slightly below normal turbine speed (approximately 1000 rpm. of generator.)

122. A special jig is furnished as shown in Figure T-30 by means of which the overspeed trip spring may be compressed, thus making it easy to remove the retainer halves from the weight when making a change in the setting or overhauling these parts. As shown in Figure T-30, the two halves of the jig are inserted through the holes in the overspeed trip retainer, thus permitting the spring to be compressed sufficiently to clear the groove in the retainer. Then by spreading the jig halves apart the retainer halves can be freed from under the trip weight head, and the mechanism taken apart.

123. In putting the parts together again the jigs may be pressed down with one hand while pressing the retainer halves together with the other hand, so that as soon as the spring clears the retainer groove the retainer halves may be squeezed together under the trip weight head and the assembly locked by releasing the pressure on the jigs.

124. Figure T-24 also shows the back-pressure safety stop, which protects the turbine cylinder against excessive pressure by closing the throttle valve if the exhaust pressure exceeds 5 lb/in^2 gage. This mechanism operates through the same levers and trips the throttle valve in the same manner as described above. The diaphragm is clamped between the disc and the plate and is subject to the pressure existing in the turbine exhaust through the pipe connection as shown. If the exhaust pressure becomes high enough to overcome the compression of the spring, which holds the lever in position, the rod is moved outward and the rod end strikes the pin and pulls the latch so as to disengage the latch plates and release the handle, which in turn trips the throttle valve and shuts down the turbine in the same manner as when tripped by the overspeed trip. The spring is set at the factory for pressure reported under the heading "Performance Data". It may be adjusted by means of lock nuts for any desired pressure.

Low Oil-Pressure Alarm Contact-Maker

125. The contact-maker which closes the alarm bell circuit to warn the operator of dangerously low oil pressure is shown in Figure T-25. It is adjusted to operate if the bearing oil pressure falls to a predetermined minimum 4 lbs. The operation of this device is as follows:

126. The diaphragm "15", held between the base "16" and the case "12" is subjected to bearing oil pressure on its under face through one or the other of the oil connections indicated. The diaphragm, in turn, when flexed, actuates the pressure plate "14", which can move upward a small amount determined by the depth of the recess in the case into which it fits.

127. Upward motion of "14" opens the contact in the totally-enclosed switch unit "11" and thus opens the circuit. This is the normal condition and will exist as long as the bearing oil supply remains normal. If through casualty, sludging, or any other means the bearing oil pressure is reduced

to the predetermined limit, the compression of the spring "8" overcomes the reduced oil pressure, forcing down the pressure plate "14" and closing the contact in the switch "11", which causes the alarm to ring. A condenser "4" prevents sparking and radio interference.

128. Adjustment of the spring pressure is accomplished by removing the lock-screw "18" (section B-B), thus exposing a screw driver slot in the adjusting screw "6". Rotation of the screw "6" moves the spring seat "17" up or down thus decreasing or increasing the spring compression.

129. Initial adjustment of the switch "11" is made by releasing the spring compression and pushing the pressure plate "14" into its uppermost position. Then, with the cap screws "20" loosened move the switch assembly "11" until the contact just breaks; tighten the screws "20" in that position.

Testing of Safety Devices

130. Overspeed may result from a variety of causes such as dirt or scale lodging under the steam valve, damage to seats so that the leakage is more than the steam requirement at light loads, excessive friction in the governor parts due to foreign matter, or damage to working parts. Consequently, all parts should be kept in good condition at all times. Overspeed could also result from steam entering through the extraction opening (if this opening, which is normally blanked off, were being used) with no load on the unit and with high vacuum. Periodically, about once each month, the operation of the safety devices should be checked as follows: (with the generator disconnected from the line and meters) -

Test 1. The operation of the overspeed trip should be tested as follows:-

Referring to Figure T-13 (Steam Chest) disconnect the steam chest valve-lifting rod link from the lever and block the valves in the open position by inserting suitable blocks between the valve-lifting bar stem shoulders and the stem bushings. Then start the turbine and gradually increase the speed to the tripping point. The overspeed trip should function at 10 to 12% above normal speed (1320 to 1350 rpm). The throttle valve should be opened very gradually. During this test, the speed of the unit should be watched continuously with a hand tachometer on the generator, and the operator should be ready to trip this valve instantly by hand in case the overspeed governor does not function at the proper speed.

Test 2. The low oil-pressure alarm may be checked when shutting down the unit by noting when the alarm sounds, and observing the reading of the bearing oil-pressure gage on the gage board. The alarm should ring when the bearing oil pressure reaches approximately 4 pounds gage.

Test 3. The back-pressure trip can be tested periodically with compressed air, followed by a test operating the unit at no-load and building up back pressure by cutting off the circulating water pump and air ejector. This trip should function at approximately 5 pounds gage.

PART I

(Section 2) INSTRUCTIONS FOR INSTALLATION

Alignment of Unit And Setting of Turbine Rotor

1. The bedplate of the unit is supported at six points on seating pads and is bolted down at these points only, as shown in the sketch at the upper left-hand corner of Figure T-1.Each turbine generator unit was carefully aligned in the shop, the bedplate having first been set perfectly level. After the several parts had been set on the bedplate and correctly aligned, they were doweled to the bedplate. It is therefore evident that if the bedplate has been set upon a properly leveled foundation in the ship, the parts will be in proper alignment as established at the factory.

2. In the initial erection of the unit in the factory, the pinion and gear bearings were checked for plane and parallelism by using mandrels. The generator stator was set up and the generator outboard bearing was brought into alignment with the gear bearings. Next the turbine cylinder base was set up and the turbine bearing aligned with the pinion bearings, using liners under the turbine supports as necessary.

3. The turbine rotor was placed in the turbine cylinder cover and located axially in order to obtain the proper clearance dimension between the nozzle block and the first rotating row of impulse blades, as shown on the rotor clearance diagram, Figure T-26. The distance from the low-pressure end of the cylinder cover to the face of the turbine rotor at the exhaust end, was then measured. This dimension was recorded and is also stamped on the turbine cylinder base horizontal-joint flange at the low-pressure end.

4. The rotor was next placed in the cylinder base and a liner of .100" thickness was installed in the thrust bearing as shown in Figures T-2, T-9 and T-26. The thrust bearing cover and the upper half of the turbine bearing (pinion end) and the bearing cover were assembled and bolted in place. After this the rotor was moved as necessary to obtain the 3/16" dimen dimension between the coupling faces as shown in Figure T-26, and the cylinder base was adjusted in an axial direction, until the dimension from the end of turbine rotor to the cylinder face was in agreement with that stamped on the cylinder base horizontal flange. The cylinder base was then doweled and keyed to the bedplate in this position.

5. The clearance in the thrust bearing was next measured and the thickness of the filler ring "14" shown in Figure T-9 was adjusted to the proper thickness, to provide this clearance. The gear and pinion were adjusted to drawing clearances by shifting the liners (See Figure T-17) in back of the gear bearing thrust faces as necessary.

6. If it should become necessary to install a spare turbine rotor, the following procedure should be followed:-

7. With the new rotor placed in the cylinder cover, the dimension from the end of the rotor to the cylinder cover gland face should be determined as described above. Install the new rotor in the cylinder base and locate it axially to agree with the dimension from the gland face to the end of the rotor as found in the cylinder cover. Measure the axial clearance at the outboard end of the thrust bearing in order to obtain the proper thickness for the rotor locating liner, shown in Figure T-2. With this liner installed, the turbine rotor will be in its proper running position. Now measure the thrust bearing clearance and if this is not found to be within the prescribed limits, change the thickness of the liner "14" (Figure T-9) as described above to provide the proper clearance.

8. With the rotor in place, check the alignment as follows:

9. The method of checking the internal alignment of the reduction gear has been described under "Reduction Gear". To check the alignment of the pinion and the turbine rotor, disconnect the flexible coupling between them and check the angular alignment by taking feeler-gage readings between the faces of the coupling hubs at top, bottom and both sides. Also check the horizontal and vertical alignment of the coupling hubs at the periphery on top and at the sides. The pinion and turbine should be in line.

10. Check the alignment of the gear and generator. To do this, roll out the bottom half of the forward gear-shaft bearing and measure at the center of the bearing the amount that the gear-shaft journal drops when not supported. This drop should be .011". If it differs from this value the outboard generator pedestal should be adjusted upward or downward as necessary to produce the .011" drop required. As a cross check on this measurement the forward bearing may be replaced and the aft gear bearing rolled out instead. If this is done the journal should drop in the housing .007". Recheck these readings by rolling the gear shaft and generator rotor over 180° and repeating the operation.

Pipe Connections

11. The steam pipe connected to the turbine throttle valve must not be rigid because, if it were, it might move the unit out of alignment. It should be made with long radius bends and supported at a point near the turbine. In making this connection, the pipe should never be sprung into place. It should be made so that the joints match properly.

12. The exhaust line should have a flexible expansion joint close to the turbine, preferably at the turbine-exhaust flange. The exhaust pipe should be supported just beyond the expansion joint to prevent its weight from damaging the expansion joint or the turbine. The expansion joint should have enough flexibility to insure that no undue strain will be imposed on the turbine exhaust.

13. Before connecting the steam pipe to the turbine, the line should be thoroughly blown out with high-pressure steam to remove any foreign matter such as dirt, scale, joint compound, etc, which if carried into the turbine, might prevent the closing of the steam chest valves and cause overspeeding; or plug up part of the nozzle throat, thus reducing the capacity and efficiency of the unit.

14. Wet steam is objectionable as it causes much more rapid erosion of the blades and nozzles than dry steam. It also reduces both efficiency and capacity of the unit. Slugs of water, whether from priming of the boilers or the picking-up of condensation in the pipe line, if carried through the turbine cause serious shocks, vibration and speed fluctuations or may trip the overspeed trip mechanism. If the pipe connections are such as to allow condensation to collect in the turbine or steam pipe, drains must be installed for use when starting up.

PART I

(Section 3) INSTRUCTIONS FOR OPERATION

To Start

1. To start up a turbine proceed as follows:-

Step 1. See that circuit breaker and main switch are open.

Step 2. Cut in all resistance in the field rheostat.

Step 3. See that the throttle valve is in its closed position with the throttle valve trip latch in place. Make sure that the overspeed trip mechanism is in operating condition.

Step 4. Check the oil level in the reservoir and the temperature of the oil.

SPECIAL CAUTION: Units should not be started up until the oil in the reservoir is at least 60° F. Oil below 60° F. should be removed from reservoir and heated to at least 60° F. before unit is turned over.

When starting up with oil in reservoir between 60° and 100° F., the unit should be operated slowly until such time as the inlet oil to the bearing is 100° F. or until such time as there is a free flow of oil from the bearings, at which point full speed may be attained and load applied.

Due caution should be used when starting up with cold oil; lower temperatures require lower warming-up speeds.

Operating temperatures of 110° F. to 130° F. to the bearings should be obtained soon after full speed is reached.

Step 5. Drain the steam and exhaust piping.

Step 6. Open the throttle valve, steam strainer and cylinder drains. These drains are shown in Figure T-8.

Step 7. Turn steam on glands, using not more than 3-pound pressure.

Step 8. Open the exhaust valve wide, or, if the unit is connected directly to its own condenser and no valve is fitted between them, start the condenser auxiliaries and establish vacuum in the condenser.

Step 9. Prime the lubricating system thoroughly with the auxiliary oil pump before attempting to run.

Step 10. Open the steam chest valve by means of the jacking lever under the governor-operating piston rod. Then open the throttle valve, starting the turbine rolling immediately so that the turbine rotor will heat evenly. Bring up to about 1000 rpm. on the generator in 5 to 10 minutes. Then bring speed up until the governor controls the speed. This can be determined by observing when the jacking lever ("1" of Figure T-13) drops to the "Off" position, and noting that the linkage then moves in the closing direction as the governor

partly closes the steam chest valves to hold the unit to no-load speed. See that the bearing oil pressure is maintained between 5 and 10 pounds.

Step 11. Close all drain lines.

Step 12. Circulate water through the oil cooler.

Step 13. Adjust the rheostat for normal voltage of the generator.

Step 14. Connect the generator to the line and put on load.

To Parallel

2. To put one machine on the line when the other unit is in operation:

Step 1. Bring the unit up to normal no-load speed, as described above.

Step 2. With the speed-changer, bring the speed down to the synchronous speed of the system.

Step 3. Observe the synchroscope and manipulate the speed-changer until synchronism is indicated.

Step 4. Throw the unit on the line.

Step 5. Readjust the speed-changer until each unit takes its share of the load at the proper speed.

3. The proper voltage to obtain before throwing one generator in parallel with the other, can be found best by trial. It may vary slightly from line voltage, depending upon local conditions.

To Shut Down

Step 1. Reduce the load to practically zero by manipulating the speed-changer.

Step 2. Throw off the load by opening circuit breaker, and then open, finally, the main generator switch.

Step 3. Close the turbine throttle valve. This can be done by striking the overspeed trip latch tip "39" or pulling on the back-pressure safety stop trip rod end "46" in Figure T-24.

Step 4. Operate the auxiliary oil pump when slowing down until the shaft is at rest.

Step 5. Shut off the water to the oil cooler.

Step 6. Shut off the steam to glands.

Step 7. Clean the machine and put it in readiness for the next run.

Precautions

4. The following operating precautions should be carefully observed:-

Point 1. Avoid passing steam through the turbine with the rotor at rest. With the throttle and steam chest valves closed, the steam strainer drain should be open.

Point 2. Avoid air being drawn through the glands with the rotor at rest.

Point 3. Periodically (about once each month) inspect the overspeed trip weight to see that it works freely in the body. Also test all safety devices to see that each one functions properly.

Point 4. Keep the throttle stem and the steam chest valve-lifting rods clean and free of corrosion. (Do not paint these stems).

Point 5. Keep bearing oil pressure between five pounds and ten pounds gage.

Point 6. Keep the oil level in the reservoir between the limits indicated on the "Oil Level Gage".

Point 7. Keep the oil strainer clean.

Point 8. Keep the oil cooler clean.

Point 9. Leave all switches open when machine is not running.

Point 10. At the least sign of trouble, stop machine immediately. Investigate and correct the trouble before starting the machine again.

(Section 4) INSTRUCTIONS FOR CARE AND MAINTENANCE

Inspection

1. About once each year, depending on the nature of the service, the unit should be dismantled and thoroughly inspected and cleaned. Erosion of the blades, nozzles and valves, wear of bearings (including the Kingsbury thrust bearing), and changes in clearances, are the main points to be inspected. The gear case cover should be raised to permit inspection of the gear teeth. If the gear tooth bearing is not well-distributed over the tooth surfaces, the parallelism of the pinion and gear bearings should be checked.

2. The oil cooler, oil strainer, and steam strainer should be cleaned. All oil piping should be disconnected and thoroughly washed and cleaned. A light coat of shellac should be applied to the flange faces in making up the joints.

Weights

3. The weights of the principal parts of the unit, which may require handling are as given in the table below:

One Unit (Assembled complete)-Actual Weight	27480 lbs.
A-C Generator and Exciter (Complete)	14000 lbs.
Turbine (Complete)	7620 lbs.
Turbine Rotor (Bladed)	1250 lbs.
Cylinder Cover	2320 lbs.
Gear and Bedplate	7850 lbs.
Gear Case Cover	760 lbs.
Gear Wheel and Shaft	1162 lbs.
Generator Rotor	5050 lbs.
Generator Stator	6475 lbs.
Governor	365 lbs.
Throttle Valve	685 lbs.
Oil Cooler	835 lbs.
Oil Strainer	135 lbs.
Generator Air Cooler	790 lbs.

4. The weight of one complete set of turbine gear and generator spare parts (without boxes) and one set of tools is approximately 8990 pounds.

5. For the assistance of the operator in checking the condition of the unit and in performing such repairs as may become necessary, the following information and materials are furnished.

Rotor Clearance Diagram

6. Figure T-26 shows the normal clearances and the clearance limits throughout the turbine. These clearances should be checked whenever an inspection of the turbine is being made.

Bridge Gages

7. In order that the operator may have warning of any undue wear in the bearings of the unit, a set of three bridge gages is provided as shown on Figure T-27. One of these is for the turbine bearings, one for the pinion bearings, and one for the gear bearings. Each gage bears a plate which is stamped with the turbine serial numbers and the clearances that were found at the initial assembly. Holes are provided in the horizontal joint flanges in order that the bridge gages may be located by the pins "2" and "4". Each gage is provided with two finished surfaces as shown in the elevation view, and the clearances between these finished surfaces and the journal are measured with feeler gages. Any deviation from the clearances originally established indicates lateral displacement of the shaft or wear of the bearing as the case may be.

Rotor Lifting Gear And Guides

8. Figure T-28 shows the arrangement of the rotor lifting gear and guides. The guides are bolted to the turbine cylinder base, one at either side of the exhaust end and one at either side at the coupling end, the bearing pedestal covers, auto-stop cover and spindle-position indicator first having been removed. The guides serve to hold the rotor central when lifting and thus lessen the danger of damaging the blading. The lifting gear is fabricated from pipe and plate. The slings fit around the rotor as shown and then over the collars. The hanger is welded to the pipe at a point which balances the two ends and thus keeps the rotor level while it is being lifted.

Rotor-Lifting Device for Removing Bearing Shells

9. In order that the turbine and pinion bearings may be examined or removed without the necessity of lifting the turbine cylinder cover, two rotor-lifting yokes are furnished as shown in Figure T-29. By slipping these yokes into place as indicated in the figure and applying pressure on the jack screws the rotor may be raised sufficiently so that the lower halves of the bearings may be rolled out for examination or replacement. The jack support for the exhaust end is supported from two of the bearing housing-flange studs on either side and that for the coupling end from the two end studs of the gear housing flange, as shown in the illustration. Care should be taken when using these jacks to make sure that the rotor is raised just enough to take its weight off the bearings, because by the use of the jack screws the rotor might be lifted sufficiently to damage the thin seal strips around the blading and dummy.

Tools And Wrenches

10. Figure T-30 is shown for the purpose of enabling the operator to familiarize himself with the special wrenches and tools and the purpose for which they are intended. Those tools, the use of which is not immediately obvious, are referred to at appropriate points in the foregoing text.

Cylinder-Joint Sealing Grooves

11. While the turbine horizontal and vertical joint flanges are carefully machined to a full bearing surface and the metal-to-metal joints made tight, in addition, the joint-flange surfaces are grooved and pipe-tapped holes are provided, so that the grooves may be pumped full of sealing com-

pound if a leak should develop while the machine is in service. A pressure pumping gun for filling these grooves is supplied with the tools.

12. The arrangement of the sealing grooves and their filling connections is shown in Figure T-31. For the horizontal joints, tapped and plugged holes are provided in the cylinder cover flange five on each side. The figure shows one half of the cylinder cover the other half being symmetrical with the view shown. As will be noted by the arrows, three holes have been designated as inlet holes, and the other as outlet holes.

13. To fill the grooves, start at hole 1, leaving holes 2 and 3 open. Apply the pressure pumping gun and pump in compound until it flows out of holes 2 and 3. Then transfer the gun to hole 3 and pump until compound flows out of holes 2 and 4. Then proceed to hole 5 and pump until compound flows out of hole 4.

14. For the vertical flange, six openings are provided and the method of filling is similar to that described above.

15. Note that care should be exercised to see that no air pockets remain in the groove. For example, after pumping at hole 1 until compound has flowed out of hole 2 when the gun is then put on hole 3, compound may shortly flow out of hole 2 and the operator may believe that he has filled the groove between holes 3 and 2. However, the first compound that appears out of hole 2 when pumping in hole 3 is probably some that was pumped past when pumping into hole 1. Therefore, the operator should disregard the first compound that comes out of hole 2 when pumping into hole 3 and make sure that he has expelled all of the air between hole 3 and 2.

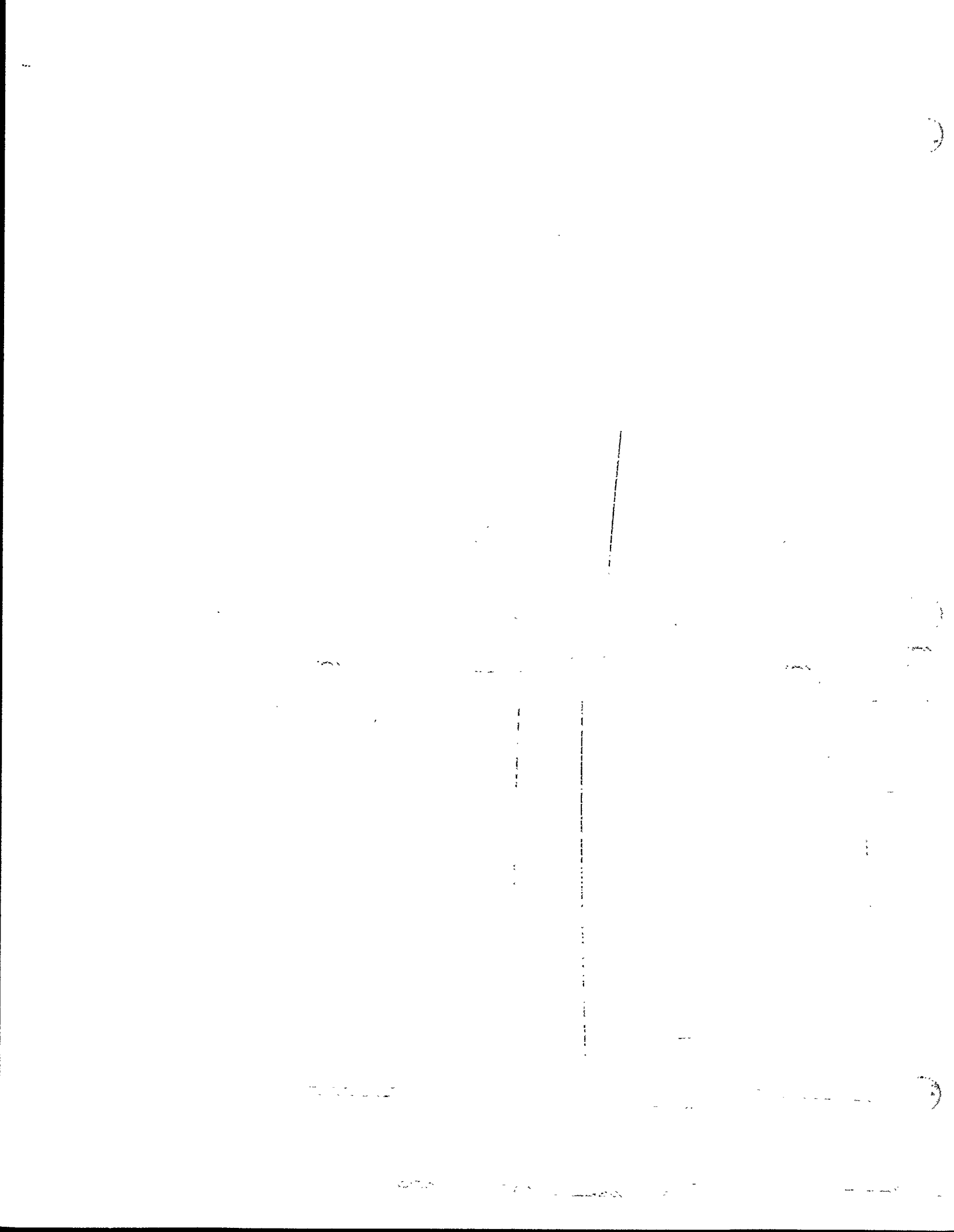
Repair Parts

16. The lists which face the several turbine (T-) illustrations Part VI have been compiled to facilitate ordering spare or renewal parts by name and number. Whenever parts are ordered, it is of utmost importance to give the serial number of the turbine or gear on which the parts are to be used.

17. A complete list of spare parts as supplied with the original equipment will be found in Pages 515 to 530 of Part V of this instrction book.

PART II

A-C. GENERATOR, D-C. EXCITER AND AIR COOLER



PART II

(Section 1) DESCRIPTION OF A-C. GENERATOR

DESCRIPTION OF 1250-KW. A-C. GENERATOR

Rating (Dwg. 31-J-651)

1. These generators are rated 1250 kw. (1562 kv-a.), 450 volts, 80% power factor, 3 phase, 60 cycles, 1200 rpm.; excitation 120 volts, 133 amperes d-c.; temperature per Table No. 1, Method No. 2 for rotor, and Method No. 3 for stator. These generators are also designed to carry 125% load for 2 hours with temperature rise of 15° C. higher than specified by Table No. 1 for continuous duty. In addition to the above ratings, the generators will carry 150% load for 5 minutes.

2. Complete rating table taken from Drawing 31-J-651 is as follows:

A-C. GENERATOR RATING								D-C. GENERATOR RATING		
Voltage (B-9) 450; 3 Phase (B-11); 60 Cycles (B-10)										
Load and Time Rating (B-8)	Kw. (B-6)	P. F. (B-7)	Kv-a.	Amps.	Guaranteed Efficiency (D-12d)	D-C. Excitation Required *		Voltage 120		
						Kw.	Amps.	Kw.	Amps.	Effi.
50% Cont.	625	.80	781	1003	93.0	10.5	87.4	8	67	Incl. in A-C. Gen. Effi-ciency
75% Cont.	938	.80	1172	1504	94.9	12.2	101.3	12	100	
100% Cont.	1250	.80	1562	2005	95.5	13.9	115.3	16	133	
125% 2 Hrs.	1562	.80	1952	2506	....	15.9	132	20	167	
150% 5 Min.	1170	.50	2340	3008	....	19.8	165	..	...	
150% 5 Min.	....	.80	....	3007	....	....	155	18.6	155	

* Including Rheostat Losses

3. GENERATOR CLASSIFICATION (DWG. 31-J-651)

(a)	Ambient Temperature of Reference	(B-3) 50° C.
(b)	Table and Method of Measurement	Table No. 1, Method No. 2 for Rotor; Method No. 3 for Stator
(c)	Class of Insulation	(B-4) "A"
(d)	Degree of Enclosure	(B-5) Enclosed
(e)	Method of Cooling	(B-5) Water-Cooled
(f)	Type of Rotating Member	(B-12) Revolving Field
(g)	Means of Excitation	Direct Connected D-C. Generator
(h)	Parallel Operation	The Eight A-C. Generators on each Ship are Suitable for Operating in Parallel
(i)	Manufacturer's Type and Class: ..	Special 6-44 x 22 Frame, S.O. 10-P-812, 13-P-145 or 15-P-184

4. GENERATOR TEST EFFICIENCY

(a) At Rated Load = 96.3%
(b) At 3/4 Load = 95.9%
(c) At 1/2 Load = 94.8%

5. NAME PLATE DATA

1250 Kw.	3 Phase
1562 Kv-a.	60 Cycles
450 Volts	1200 Rpm.
2005 Amperes	120 Exciting Volts
80% Power Factor	133 Exciting Amperes

Frame And End Bells (Dwgs. 31-J-653, 31-J-654 and 31-J-668)

6. The frame is of the enclosed box-type composed of structural steel plates, sheets and forms which are securely welded together. The main portion consists of a heavy steel-ring frame and end plate. The armature punchings are stacked on transverse ribs and are securely held in position by means of a key.

7. Sheet-steel end bells are fastened to the front and rear ends of the frame which provide an effective drip-proof enclosure. These end bells also distribute the cooling air which enters the machine near the shaft. This air is distributed radially throughout the rotor, passing across the air gap into the ventilation slots of the stator. After leaving the stator slots, the air is collected into an air duct which surrounds the machine and is returned to the air cooler located on the top of the machine.

8. Heavy, steel-slab feet, welded to the lower portion of the frame end rings insure rigid attachment of the generator to the bedplate. These feet are machined parallel to the shaft and are drilled for foundation bolts, and dowels. Heavy lifting eyebolts can be screwed into heavy blocks at the top of the frame.

Core (Dwg. 31-J-652)

9. The core is built-up of special silicon-steel laminations, annealed and treated to prevent ageing and obtain minimum iron losses. The punchings are in the form of segments, with six segments making a complete circle and are held in position by a rectangular key. The laminations are spaced by 13 vent plates and have finger plates at each end to prevent loosening of the teeth. This arrangement permits cooling air to enter the inner portion of the core furnishing means for dissipating heat from the core. The core is held in place by two rolled-steel end plates, one of which is integral with, and the other keyed to the frame. Seventy-two slots, 0.525" wide by 2.325" deep (finished size) are used.

Terminals (Dwgs. 31-J-655 and 31-J-650)

10. The main generator leads which are marked "A", "B", and "C" are brought out at the bottom of the generator frame. Two Micarta terminal boards, namely a temperature-detector board and a space-heater board are located on the bottom left-hand side of the frame as viewed from the turbine end.

11. Armature (Stator) Winding (Dwgs. 31-J-651 and 31-J-655)

TABULATION OF WINDING

6 Pole - 3 Phase - 6 Parallel - 3 Leads - 72 Slots.
Throw of Coil No. 1 - No. 12 Slots
4 Coils Per Group - 3 Groups per Pole - 18 Groups total per Generator.

12. The stationary armature has an inner bore of 31" and has 72 slots. The finished size of slot is .525" wide by 2.325" deep. The armature coil is of the diamond type, and is composed of 2 turns, each turn consisting of ten strands of .081" thick by .204" wide double-cotton-covered copper ribbon placed 2 wide by 5 deep in the slot. The first coil lies in slots No. 1 and No. 12. The conductors are bound together with one layer of .0045" cotton tape, not lapped. Coils are then treated once in a moisture and oil-resisting plastic varnish (Navy Spec. 52V13, Grade BB). The straight parts of the coils embedded in the slots are insulated with 1-1/2 turns of fish-paper and mica, each turn being .012" thick. The end portions of the coils

are insulated by hand-taping with one layer of half-overlapping .010" varnished-cambric tape and finished with a layer of .007" cotton tape not lapped over the straight parts, but half-overlapped on ends. Coils are then treated twice all over, with two additional treatments on ends, in moisture and oil-resisting varnish (Navy Spec. 52V13, grade BB). The assembled stator is given two treatments in a moisture and oil-resisting varnish.

13. The finished coils are laid in the armature slots which have special fishpaper cell linings .007" thick, which extend slightly beyond the core at each end. Treated fibre wedges are used to hold the coils in place in slots. The wedges are only as long as the packages of punchings in order to facilitate the entrance of air into the vent ducts.

14. Six resistance-coil temperature detectors are located between the armature coils in slots numbers 7, 19, 31, 43, 55, and 67.

15. Coils are roped to insulated steel rings on each end of the winding to prevent distortion in case of short-circuits.

Spider And Shaft (Dwgs. 31-J-652, 31-J-656, and 31-J-657)

16. The shaft is made from forged steel and is provided with a flanged coupling on one end for connection to the turbine while the other end is machined to receive the flange of the exciter coupling. The spider is made up of .125" steel punchings and is held to the shaft by means of a key. Slots in the spider engage with the pole dovetails which are held in the slots by means of tapered keys.

Bearings (Dwg. 31-J-658)

17. The exciter end of the shaft is supported by a pedestal bearing. This bearing is of the split-sleeve type, having an upper and a lower steel bearing shell lined with babbitt. The bearing is lubricated from the forced-feed lubrication system of the turbine. In addition to oil throwers machined on the shaft, oil seals are provided to prevent leakage from the bearing.

Field Poles (Dwgs. 31-J-652 and 31-J-657)

18. The six poles are constructed of laminated electrical-steel punchings which are securely bound together by through rivets. The punchings in the main portion of the poles consist of .063" thick laminations. Sheet-aluminum coil supports are riveted to each end of the pole ends. Five copper damper bars are provided in each pole and are brazed to angle segments. A copper ring is bolted to the angle segments, one on each end of the rotor, which completes the damper-winding circuit from pole to pole.

Field (Rotor) Winding (Dwg. 31-J-657)

19. Each field coil consists of a total of 111 turns of copper strap, wound on edge Every fourth turn is extended 1/2" beyond the others at the ends of the coil in order to expose more surface to the ventilating air. There are 82 turns at the top of the coil consisting of .032" x 2" copper strap and 29 turns at the bottom of coil of .047" x 2" strap. Two thicknesses of .007" non-ferrous asbestos paper treated by shellac are placed between turns and the coil pressed to size. During the pressing operation, the coil is heated by circulating current through it. The insulation to ground consists of .005" thick Kraft paper built up to a thickness of 1/16" with an .034" thick fishpaper cell covering. Micarta

insulating washers are placed at the top and bottom of the coil when assembling on the pole. The field resistance is 0.524 ohm at 75° C.

Collector Rings (Dwg. 31-J-659)

20. The two steel collector rings are located on the exciter end of the shaft and are insulated from the shaft by means of mica. Leads are brought from the a-c. generator field coils to the collector along the outside of the generator shaft.

Brush Rigging (Dwg. 31-J-659)

21. Four brushes and four brushholders are furnished for each collector ring. The brushholders are made of a bronze alloy and are arranged to use a brush 2" long by 1-1/4" wide by 3/4" thick. National Carbon Company SA-3538 brushes, Navy Spec. 17B8, Grade A are used. These brushes are manufactured by the National Carbon Company for the Westinghouse Electric & Manufacturing Co.

Mechanical Rotation (Dwg. 31-J-650)

22. The rotation of the generator is clockwise as viewed from the exciter end.

Phase Rotation (Dwg. 31-J-655)

23. When the mechanical rotation of the generator is clockwise viewed from the exciter end, the emfs. induced in the phases will reach positive maximum values in the following order A-B-C.

Temperature (Dwg. 31-J-651)

24. The ambient temperature of reference for these machines is 50° C. The test report which forms a part of this instruction book contains detailed temperature rise data for the machine.

Voltage Regulation:

25. Since these generators are equipped with voltage regulators the inherent voltage regulation of the generators is of little importance. However, the inherent voltage regulation was determined by computation from the open-circuit and zero-power-factor saturation curves of the machine.

26. With the generator operating at rated load, voltage, power factor and with 115.3 field amperes, when the load is reduced to zero the voltage rises 25.1%, that is, the inherent regulation of the generator is 25.1%

27. Voltage regulators will operate automatically to maintain the normal 450 volts alternating current (average of 3 phases) within the following limits, with the alternating current generators operating at any load up to rated load and at any power factor from .80 to unity.

(a) With small variations in load the voltage will not vary more than $\pm$ 1%.

(b) With a sudden increase in load amounting to not more than 50% of full-load current at normal voltage, the generator voltage will fall not more than 5% and will return to normal within two seconds. These limits are still good even though the load increase may be at low power factor such as would be the case if an induction motor were started.

28. In order to fulfil these requirements, the generators are designed with a transient reactance not to exceed 20% and with a voltage drop across the collector rings of approximately 65 volts at full load, rated voltage and power factor.

Short-Circuit Currents

29. The sustained short-circuit current per phase is calculated to be as follows:

(1) With the regulator in operation approximately 7750 amperes.
(2) Without the regulator in operation and with full load excitation, approximately 4220 amperes.

The windings are designed to withstand the stresses incident to short-circuits when the machine is operated at full load, rated voltage and power factor.

Phase Unbalance

30. These generators are designed to carry a maximum single-phase load of 25% of their rated line amperes, simultaneously with a balanced three-phase load. Under conditions of a single-phase, unity-power-factor load of 25% of rated amperes, the regulation will not exceed 25% of rated line amperes, the regulation will not exceed 5%.

Parallel Operation (Dwg. 31-J-651)

31. When two or more of these generators are operated in parallel, using automatic voltage regulators, under load conditions varying from 20% to 125% of the combined generator rating, the maximum difference in the current supplied by any one generator from that supplied by any other generator will not exceed 10% of the rated current of one generator.

Illustration:

32. See Figure G-1 (Dwg. 31-J-650) Assembly of A-C. Generator and Exciter.

PART II

(Section 2) INSTALLATION AND CARE OF A-C. GENERATOR

INSTALLATION OF A-C. GENERATOR

Handling

1. It is easily possible, by rough handling or careless use of bars or hooks, to do more damage to a machine before or during erection than it would receive in years of regular service.

2. Care should be taken in transporting and handling the machines to see that the windings are not damaged. A blow upon any part of the windings is liable to injure the insulation and result in a burn-out of the coil.

3. Lifting of the machines by cranes should be done with the greatest care. The stators are provided with lifting rings screwed into inserts in the tops of the frames, into which the crane hooks should be inserted. D-C. generator frames and the combined unit consisting of an a-c. and a d-c. generator may be lifted by means of these two rings. The bottom of the air gap should be shimmed before lifting.

4. The rotors should be lifted preferably with rope slings looped around the shafts or around the poles. If chains are used, they should not be looped around the journals unless the latter are properly protected. In no case should the ropes or chains be allowed to exert pressure on the windings, collector rings, or damper windings.

Drying Out

5. If there is reason to believe that the windings have been exposed to moisture during shipment or erection, it is well to subject them to a drying process before putting the machine into regular operation. The windings can be dried by passing current through them or by the use of the space heaters mounted within the generator frame.

6. One way of circulating current through the windings without subjecting them to full voltage is to drive the machine and short-circuit the armature, applying enough field excitation to give somewhat less than full-load armature current. A second method is to apply a low voltage from an external source to the armature winding. If the current is kept down to less than full-load current, there is a possibility that the machine will not rotate. If it does not rotate or if it rotates at less than synchronous speed, the damper winding should be watched to see that it does not overheat. The field winding should be short-circuited during the drying operation.

7. In all cases of drying by means of current in the windings the temperature measured by thermometer should not be allowed to exceed 65° C. In general, the drying should proceed slowly at first and the heating gradually increased as the insulation dries. It is well to take readings of insulation resistance by means of a "megger" at intervals as this gives a good indication of the state of the insulation.

8. In some cases it is impracticable to dry the windings by heat generated within the machine and external heat must be used. A tarpaulin should be used to cover the machine and some source of heat, preferably electric heaters, placed within the enclosure.

Insulation Resistance

9. The insulation resistance of windings is measured usually with an instrument called a "megger". This measurement gives an indication of the condition of the insulation, particularly with regard to moisture and dirt. The actual value of resistance varies greatly in different machines, depending on the size and voltage. The chief value of the measurements, therefore, is in the relative values of resistance of the same machine taken at various times. During a drying-out run, for example, the insulation resistance rises as the winding dries out, although it may fall slightly at first. When measurements are made at regular intervals as part of the maintenance routine, it is thus possible to detect an abnormal condition of the insulation and take steps to remedy it before a failure occurs.

10. The insulation resistance of stator windings of machines in good condition is usually not less than the following:-

$$\frac{\text{Insulation Resistance}}{\text{(In Megohms)}} = \frac{\text{Machine Voltage} \times 3}{\text{Rated Kv-a.} + 1000}$$

EXAMPLE: 1250-Kw. (1562-Kv-a.) 450-Volt, A-C. Generator

$$\frac{\text{Insulation Resistance}}{\text{(In Megohms)}} = \frac{450 \times 3}{1562 + 1000} = 0.526$$

Adjustment of Air Gap

11. In lining-up the generator on the bedplate, great care must be exercised in adjustment of the air gap between the armature core and pole faces, as any inequality in the gap will cause unnecessary friction and heating of the bearings, and unequal heating of the armature iron. During these adjustments, gage the air gap at different points from each side of the machine. Gages for this purpose should extend to the center of the core. Necessary feeler gages are included in the spare parts and tools furnished for each vessel. The may also be made from thickness or "feeler" gage stock that can be procured in various micrometer thicknesses and any suitable length.

Brush Fit

12. Brushes and brushholders should be examined before the machine is started up to make sure that the brushholders are in the proper position and that there is a proper fit between the collector and the brushes, so that the brush is free in the holder. If the faces of the brushes do not conform to the collector, it will be necessary to grind them in. This operation is always necessary when new brushes are installed. In the case of fitting new brushes or damaged brushes, the operator should use sandpaper "Grade 1-1/2" for the roughing cut and "Grade 0" for the final fit. Draw the sandpaper in the direction of rotation under the brushes releasing pressure as the paper is drawn back being careful to keep the ends of the paper as close to the collector as possible and thus avoiding rounding the edges of the brushes. It will be found by this means a satisfactory contact is quickly secured, each brush being similarly treated in turn.

CARE OF A-C. GENERATOR

General Rules

13. Leave all switches and breakers open when machine is not running.

14. At all times keep the machine clean and free from oil and dust, especially from carbon or copper dust. It is good practice to use

dry compressed air to blow out dirt which accumulates in the windings. The pressure used should not exceed 50 pounds per square inch, as a higher pressure may lift the insulation wrappings on the windings and blow dust inside the coils. (In cases where higher pressure air supply is available, a throttling valve should be used). Always allow any accumulation of water in the pipes to be blown out before turning the air blast on the machine. Cleaning with air pressure should be followed by thorough wiping with a cloth. The dirt which clings to the field coil washers should be removed carefully, since it may accumulate and form a conducting path from coil to ground. A coat of insulating varnish applied to armature and field coils, after they have been cleaned, will protect the insulation. An air hose should be applied to the air ducts through the stator punchings, since an accumulation of dirt at this point will impede the free flow of cooling air.

15. In case oil vapor has been allowed to enter the machine and deposit on the coils:- dirt, carbon dust, etc. will stick to the coils and cannot be removed by blowing out. This can be removed by wiping the coils and swabbing out the vent ducts with cloths which have been dampened with carbon tetrachloride. It is necessary to remove the rotor in order to clean out the ducts. The major source of oil deposit on the windings is leakage from the gland seal on the gear bearing.

(a) Leakage from the gland seal on the gear bearing. This can be detected by carefully cleaning the shaft outside the bearing and chalking it. The chalk will be discolored if oil is leaking from the seal. If the seal leaks, the vent pipe leading to the labyrinth should be examined to make sure it is not stopped up and that it terminates in still air and where air pressure is atmospheric.

16. Keep small pieces of iron, and bolts and tools away from the machine. Any such fragments attracted to the armature or to a pole may jam between the armature and pole and cause serious damage.

17. Occasionally remove the drip-proof covers and end bells and give the machine a thorough inspection.

Causes of Insufficient Voltage

18. The following causes may prevent generators from developing their normal voltage:

(a) The switchboard instruments may be incorrect and the voltage may be higher than that indicated or the current may be greater than is shown by the readings.

(b) The regulator may be set to regulate for too low a voltage.

(c) Part of the field or armature windings may be shorted or improperly connected.

19. This generator and regulator unit is designed to maintain practically constant voltage through the range from no-load to 150% load. Loads greater than 150% or lesser loads with power factors below rated load may cause insufficient voltage. However, the regulator will operate to overload the machine or over-excite the generator field in case of low power factor or underspeed, rather than permit insufficient voltage throughout the range from zero to full load.

Phase Sequence

20. The phase sequence obtained on these generators referred to the correct direction of mechanical rotation is stated in a preceding page of this

instruction book, under the heading "Phase Rotation". The phase sequence will be reversed if the generators are rotated mechanically in the opposite direction. Reversing the field does not affect the phase rotation. Should it be desired to reverse the phase rotation of the Emfs. of the bus to which the generator is connected, disconnect any two of the bus leads from the generator terminal board and reconnect them each to the terminal from which the other was disconnected.

Excitation

21. When a generator operates alone, without being paralleled with other generators, the field current is adjusted for each change in load so as to maintain rated voltage by the voltage regulator.

22. A generator operated in parallel with another generator may have its excitation varied through a fairly wide range while delivering the same kilowatt output at rated voltage. A change in field current under these conditions changes the power factor of the generator, that is, the reactive kv-a. of the system is shifted between it and the generator with which it is paralleled. No change in kilowatt output can be effected by variation of the field current. When duplicate generators are operated in parallel it is desirable to divide the reactive kv-a. load of the system between them in the same proportion as the kilowatt load is divided. This is accomplished by the provision of cross-current compensation in the voltage regulator which automatically adjusts the field current on the two machines so that reactive current cannot circulate between them.

Collector Rings And Brushes

23. One of the most common sources of trouble with synchronous machines is sparking at the collector rings. Much of this trouble is due to the lack of proper care. The collector is one of the most important parts of the machine and should be frequently inspected.

24. Any black spots that appear on the surface of the collector should be removed by rubbing lightly with fine sandpaper the first time that the machine is shut down. It is very important that this be done because while these spots are not serious in themselves, they will lead to pitting of the rings and the necessity of regrinding. However, no harm is is done to the rings if the condition is corrected at once.

25. Sometimes an imprint of the brushes will be found on a machine which is subjected to moisture or acid fumes which will act on the surface of the ring. In case the machine is shut down for any length of time, the fumes will act upon the surface of the ring, except where it is in contact with the brushes. The surface of the ring will be slightly high at this point. This causes the brush to jump slightly and to arc and thus burn its imprint on the ring. In such an installation it is good practice for the operator when shutting down the machine to apply a little paraffin to the rings as the machine comes to a stop and while they are still warm. In general, rings give better service when the machine is run continuously than when it is shut down a part of the time.

26. Another cause of brush imprint on the rings is a slight unbalance in the rotor which causes a jerk or movement of the rings once every revolution. This results in the brush jumping with a consequent small arc, which in time burns an imprint of the brush on the ring.

27. Brush imprints due to fumes will occur at any point where the machine happens to stop. Imprints due to rotor unbalance will always occur at the same place on the ring relative to the rotor.

28. Since there is always an electrolytic action on the surface of a ring, the collector operation is improved by occasionally reversing the polarity of the rings. Sometimes trouble will occur on one ring only and by reversing the polarity every day or so, the trouble will entirely disappear.

29. Occasionally ring trouble will arise from a ring not being of uniform hardness so that it wears unevenly. Such a ring should be replaced.

Ordering of Renewal Parts

30. When ordering renewal parts, give the name plate reading. Always give the name of the parts wanted, also the stock order and serial numbers of apparatus on which the part is to be used. The latter will be found stamped on the name plate and in the metal under the name plate.

31. A list of Spare Parts, as provided with the original equipment will be found on Pages 501 to 504, Part V of this instruction book.

PART II

(Section 3) GENERATOR AIR COOLER

Installation

1. Ports are provided on the inlet and outlet cover for connections to sea-water line. The upper ports may be used for inlet and the lower ports for outlet, or vice-versa.

2. Strainers or filters, if used to exclude foreign matter or solids, must be installed on the inlet side. The cooling water must be free of foreign matter larger than .250" screen openings. Strainers or filters are essential if liquids circulated through the cooler contain foreign matter larger than specified.

3. 5/16"-18 Tapped holes are provided in the angle frames for attachment of the cooler in the air duct.

4. The 1/8" pipe plugs which are inserted in the tell-tale holes before shipment should be removed before the cooler is put in operation.

Operation

5. Open water valves fully.

6. Manipulate handwheels until desired air temperature regulation is secured.

7. No other operating instructions are necessary.

Maintenance

8. Clean strainers in sea-water inlet line as frequently as required to provide unrestricted flow.

9. The inside of the tubes should be cleaned as frequently as necessary to provide unrestricted flow of sea-water. The unit should be inspected at long intervals to see if the fins on the outside of the tubes require cleaning from deposits of oil and grease from leaky bearings, or carbon from brush wear.

10. Coolers are provided with zinc electrodes to centralize electrolysis. The electrodes should be examined 30 days after installation, and checked every 30 days thereafter.

11. Observe notations on applicable assembly drawings.

Cleaning

12. Close valves in pipe connections to and from cooler; disconnect air ducts, and remove the unit from the piping.

13. Disconnect inlet and rear covers to expose inside of tubes.

14. Clean inside of tubes by application of steam jet and use of rods where necessary.

15. Clean outside of tubes by use of steam jet, drying with compressed air.

16. Clean any foreign matter from inside of inlet and rear covers.

17. Reassemble, using new gaskets when necessary.

18. Reinstate operation by following instructions under "Operation"

Illustration

19. See Figure G-2 (Drawing A-3153) "Generator Air Cooler" in Part VI of this instruction book.

Spare or Renewal Parts

20. For spare or renewal parts, see Pages 507 to 508, Part V of this instruction book.

PART II

(Section 4) DESCRIPTION OF D-C. EXCITER

DESCRIPTION OF 16-KW. D-C. EXCITER

Rating (Dwg. 5-A-9812)

1. These generators are rated 16-kw., 120 volts, 1200 rpm.; temperature per Table No. 1, Method No. 2. These generators are also designed to carry 125% load for 2 hours with a temperature rise of 15° C. higher than specified for continuous duty.

2. Complete rating information taken from Drawing 5-A-9812 is as follows:-

3. GENERATOR RATING

(a) Volts - 120, 2-wire
(b) Amperes - 133
(c) Kw. - 16
(d) Rpm. - 1200
(e) Duty - Full load continuous, 125% load for 2 hours,
(f) Method of temperature measurement - Table No. 1, Method No. 2.

4. GENERATOR CLASSIFICATION

(a) Degree of Enclosure - Drip-proof - Open
(b) Method of Cooling - Natural
(c) Class of Insulation - Class "A"
(d) Type of Winding (fields) - Shunt Wound with Stabilizing Series and Commutating Field Coils.
(e) Ambient Temperature of Reference - 50° C.
(f) Manufacturer's type and class - Special 103-6 Frame, Type "SK", S.O. 10-P-815, 13-P-148 or 15-P-187

5. GENERATOR TEST EFFICIENCY

(a) At Rated Load = 90.3%
(b) At 3/4 Rated Load = 90.2%
(c) At 1/2 Rated Load = 89.0%

6. NAME PLATE DATA

16 Kw.	1200 Rpm.
120 Volts	2.4 Shunt Field Amperes
133 Amperes	Stabilized Shunt Wound

Frame (Dwg. 31-J-207)

7. The frame is fabricated from hot-rolled steel slab. The inner surface is bored to provide a seat for the field poles, and is accurately spaced and drilled for the pole bolts which pass through the frame into tapped holes in the pole pieces. The feet are fabricated from heavy steel plate welded to the frame to insure rigid support.

Terminals (Dwg. 31-J-207)

8. Three exciter leads, marked "F1", "A2", and "S1" are brought out to an ebony-asbestos terminal board located at the bottom of the frame. This board is provided with approved type solderless connectors for connecting to the ships' cables. Leads "S1" and "A2" are provided with connectors suitable for type DHFA-100 ships' cable and lead "F1" with connectors for type SHFA-4 ships' cable.

9. The clockwise rotation as viewed from the commutator end, lead "A2" should connect to the plus (+) line, lead "F1" to the field rheostat and then to the plus line, and lead "S1" to the minus (-) line.

Main Poles (Dwg. 31-J-207)

10. The six main poles are constructed of laminated electrical-steel punchings which are securely bound together by through rivets. The poles are located symmetrically with respect to the magnet frame. The main pole single air gap is 5/64". Individual field poles are secured to the magnet frame by tap bolts which screw into tapped holes in the pole body.

Commutating Poles (Dwg. 31-J-207)

11. The six commutating poles are machined from a solid hot-rolled steel slab and have a single air gap of 5/32". The pole face is machined to give the correct commutating field form. The coils are held securely in place on the pole by means of two steel support strips. These poles are secured to the magnet frame in the same manner as the main poles.

Field Windings (Dwg. 5-A-9812)

12. Each shunt field coil consists of 879 turns of .064" single-cotton-covered round copper wire. The coils are wound on a shell consisting of 1/16" thick Micarta tube and 1/8" thick fullerboard end washers. L-shaped pieces of .015" fishpaper are placed along sides of coils to protect them from coming in contact with the generator frame and pole tips. A piece of .024" thick paper and cloth insulation is placed on each end where the series coil hangers rest. The wound coil is taped overall with a layer of .007" cotton tape half-overlapping and then impregnated by the vacuum-and-pressure method. The finished coil receives one treatment of shellac and two dipping-and-baking treatments in an insulating varnish.

13. The coil ends are made from 41 strands of .010" braid-covered cable and are 10" long. The shunt leads to the exterior of the frame consist of 19 of .0142 rubber-insulated water-proof cable. The field resistance is 23 ohms at 75° C.

14. Each series field coil consists of 5-1/2 turns of .289" double-cotton-covered square copper wire. The coil is wound on a 1/16" thick paper tube formed on a mould. The coil is taped overall with three half-overlapped layers of .007" cotton tape. A piece of .010" treated cloth is placed under the second layer of tape on each end where the sheet steel hanger is fastened. The hanger is insulated from the coil by a piece of .028" cotton duck and fastened to the coil with several layers of .007" cotton tape. The coil is then impregnated by the vacuum-and-pressure method. The finished coil receives one treatment of shellac and then two dipping-and-baking treatments in an insulating varnish. The series coil fits over the shunt coil and is held tightly in position by means of sheet-steel hangers and steel springs between the coil and magnet frame.

15. Each commutating field coil winding consists of 14-1/2 turns of .25" x .5" bare copper strap, edgewound with 2 thicknesses of shellac-treated asbestos paper .007" thick between turns. The coil is assembled in a shell consisting of a 1/16" thick Micarta center tube and 1/8" thick fullerboard end washers. The finished coil receives 4 treatments in an insulating varnish. The coils are firmly held in position by two sheet-steel strips fastened to opposite sides of the pole and bent into the shape of a flat "U".

Armature Core (Dwg. 31-J-210)

16. The core is built-up of special sheet-steel punchings carefully annealed and treated, so that the iron losses will be a minimum. The punchings which are a complete ring with slots for taking armature coils are stacked directly on the shaft. A key between the punchings and shaft keeps them in a fixed position on the shaft. The punchings have 45 slots .317" wide by 1.155" deep (finished size).

Armature Winding (Dwgs. 31-J-210 and 5-A-9812)

17. The armature has 45 coils of the open-diamond type. The coil is made 3 wide by 2 deep from 6 strands of .064" x .204" double-cotton-covered copper ribbon. The coil is pulled to shape, then dipped and baked with an insulating varnish (Navy Grade BB, Specification 52-V-13). The coil is insulated on the slot portion by means of .012" thick fishpaper and mica interwoven between conductors and finished with 1-1/2 turns around the outside of the coil, taped with a layer of .005" cotton tape which is half-overlapped on ends and slightly spaced on the slot portion. The coil is then dipped and baked in an insulating varnish (Navy Grade BB, Specification 52-V-13). A .010" thick paraffined fishpaper slot liner is used when winding the coils into the core. The first coils lie in slots No. 1 and No. 8 and connected to commutator bars No. 1 and No. 46. The winding is of the wave-progressive type with a "dead" coil. The ends of the coils are held in place by a 1-1/4" wide banding made of 0.0453" diameter steel banding wire. The wound armature is then given three dipping-and-baking treatments with an insulating varnish (Navy Grade BB, Specification 52-V-13).

Commutator (Dwgs. 31-J-210 and 5-A-9812)

18. The commutator is the V-ring bound type. The bars are of hard-drawn copper with a slotted neck portion for receiving the armature coil ends. The bars are held between steel V-rings insulated with formed mica "V" plates. The 134 bars are insulated from each other with mica plate .032" thick, undercut 1/32". The armature conductors are soldered into the slotted commutator necks and banded on top. A ring nut located on the threaded front end of the shaft is provided for securing the front V-ring in place on the shaft.

Brush Rigging (Dwgs. 31-J-208 and 31-J-209)

19. The brush rigging if of the rocker-ring type. The brass brushholders are supported from 6 round steel rods pressed and bolted into a heavy Micarta rocker ring. The rocker ring is bolted to the front bracket and can be shifted by loosening the two bolts which clamp, by means of a friction joint, the rocker ring to the bearing housing. After determining the proper position of the rocker ring these bolts are tightened and the ring doweled in place to the bracket. There are 18 single, brass d-c. brushholders. The brushholders clamp tightly by means of clamping screws to the brush rod. The brushholder connections are taken directly from this clamping screw. The brushholders are the proper size for one brush, 3/8" thick x 3/4" wide x 1-1/2" long. Stackpole WL-27 brushes are used which meet the requirements of Navy Spec. 17B8, Grade B. These brushes are manufactured by the Stackpole Carbon Co. for Westinghouse Electric & Manufacturing Co. Each brushholder has a spring that presses firmly against the top of the brush insuring correct pressure of the brush on the commutator. Brush pressure is adjusted by moving the brushholder either up or down in relation to the rectangular brush rod. 90° grooves of 1/16" pitch on both the brush rod and brushholder serve to hold the brushholder in the position selected. Spring pressure must be 1 pound at tip of brush. The brushes are provided with flexible copper shunts from the brush to the holder so that the contact between the sides of the brush and holder is not depended upon to carry the current.

Shaft (Dwg. 31-J-656)

20. The shaft is made from a steel forging and has a forged flange for bolting to the a-c. generator shaft.

Bearing (Dwg. 31-J-208)

21. The exciter end of the shaft is supported at the commutator end by a split-sleeve type babbitt-lined bearing. The bearing is lubricated from the forced-feed lubrication system of the turbine.

Rotation (Dwg. 31-J-650)

22. The rotation of the exciter is clockwise facing the commutator end.

Temperature (Dwg. 5-A-9812)

23. The ambient temperature of reference is 50° C. The temperatures are in accordance with Table No. 1, Method No. 2, Navy Spec. 17G7. These generators are capable of carrying 25% overload for 2 hours with a temperature rise of 15° C. higher than specified for continuous duty.

Voltage Regulation (Dwg. 5-A-9812)

24. The exciter has windings which give a voltage regulation as required to best suit the characteristics of the alternating-current generator and voltage regulator.

Illustration

25. See Figure G-1 (Dwg. 31-J-650) "Assembly of A-C. Generator and Exciter".

PART II

(Section 5) INSTALLATION AND CARE OF D-C. EXCITER

INSTALLATION OF D-C. EXCITER

Handling

1. It is easily possible, by rough handling, or careless use of bars or hooks, to do more damage to a machine before or during erection than it would receive in years of regular service.

2. The armature is liable to damage, since its own weight is sufficient to crush the winding if it is lowered on or swung against a projection. Never support the armature entirely or in part by the commutator either when raised by blocking, or when held by a rope sling. Lift it by a rope sling about the shaft, taking great care that the ropes do not touch the windings at the back end of the armature. Do not allow workmen to stand on the commutator.

3. The end bracket when attached to the frame, protects the field coils somewhat against damage from an outside source. However, under this condition, coils and wiring-around-frame connections in the rear are exposed to external blows if the frame is swung against projections. If the end bracket is not in place, the field windings can be easily damaged. Therefore, careful handling of these parts is necessary.

Drying Out

4. If a generator has been exposed to dampness, as in the case on shipboard when not in use for a considerable time, or before being started in regular service, it should be run with a low voltage, adjusting the load to give a current which will raise the temperature to approximately 70° C. This temperature should be maintained during the drying process by raising or lowering the current as required.

5. There is always danger of overheating the windings of a machine when drying them with current, as the inner parts, which cannot quickly dissipate the heat generated in them, and which cannot be examined, may get dangerously hot, while the more exposed and more easily cooled portions are still at a comparatively moderate temperature. Therefore, the temperature of the hottest part accessible should always be observed, while the machine is being dried out in this way, and should not be allowed to exceed 80° C. total temperature.

6. If it is found that the generator is in a very damp condition, it will require several hours to dry it out, as the insulation is more easily injured when damp than when comparatively dry. In such extreme cases, it will be better to bring up the temperature slowly at first--- not allowing the maximum temperature to be reached until part of the dampness is expelled.

Insulation Test

7. In order to determine whether the drying-out process as indicated above, has been sufficiently thorough, the process is supplemented by an insulation test conducted either by the use of a megger which gives the resistance in megohms, or in the following manner: Use a direct-current voltmeter, of which the resistance in ohms is known (generally marked on label inside the instrument cover). Connect this to a direct-current circuit, and note the indication of the voltage. Then connect the resistance to be measured in series with the voltmeter and take a second reading.

8. The measured resistance is calculated from the formula:

$$R = \frac{r(V-v)}{v}$$

V = Voltage of the line.
v = Voltage reading with insulation in series with voltmeter.
r = Resistance of voltmeter in ohms.
R = Resistance of insulation.

9. If a grounded circuit is used in making this measurement, care must be taken to connect the grounded side of the line to the frame of the machine to be measured, and the voltmeter between the windings and the other side of the circuit.

Brush Position

10. The correct brush position has been located at the factory and the rocker ring doweled to the end bracket to prevent any movement.

Brush Fit

11. The brushes and brushholders should be examined before the machine is started up to make sure that the brushholders are in the proper position and that there is a proper fit between the commutator and the brushes. If the face of the brush does not conform to the commutator, it will be necessary to grind the same as illustrated in Figure (b) page 220. This operation is always necessary when new brushes are installed. In the case of fitting new brushes or damaged brushes the operator should use sandpaper, "Grade 1-1/2" for the roughing cut and "Grade 0" should be used for the final fit.

Staggering Brushes

12. Staggering is done to cause the commutator to wear evenly and should be done, theoretically, in pairs of arms (not alternate arms) that is, one positive with one of its adjacent negative arms should be set, to the right or left, of the initial pair. The third pair should trail the first pair; the fourth the second, See Figure (a) page 220.

CARE OE D-C. EXCITER

General Rules

13. At all times keep the generator clean and free from oil and dust, especially from copper or carbon dust. With high-voltage machines a small accumulation of dust on the windings may be the cause of serious burnout. It is good practice to use compressed air to blow out dirt which accumulates in the windings. The pressure used in such service should not exceed 25 pounds per square inch, as a higher pressure may lift the insulation wrappings on the windings and blow dust inside the coils. (In cases where higher pressure supply is available a throttling valve should be used). Always allow any accumulation of water in the pipes to be blown out before turning the air blast on the machine.

14. Keep small pieces of iron and bolts and tools away from the frame. Any such fragments that are attracted to the pole of a field magnet may jam between the armature and pole and cause serious damage.

15. Occasionally give the machine a thorough inspection.

Causes of Insufficient Voltage

16. The following causes may prevent generators from developing their normal voltage.

(a) The speed of the generator may be below normal.

(b) The switchboard instruments may be incorrect and the voltage may be higher than that indicated, or the current may be greater than is shown by the readings.

(c) Part of the shunt field may be reversed or short-circuited.

(d) The brushes may be incorrectly set.

(e) An excessive part of the field rheostat or other unnecessary resistance may be in the field circuit.

Reversing Polarity

17. To change the polarity of a generator keeping the same rotation, it is necessary to reverse the residual magnetism which is done by exciting the shunt field momentarily in the opposite direction from some outside source.

Excitation

18. When starting up, a generator may fail to excite itself. This may occur even when the generator operated perfectly during the preceding run. It will generally be found that this trouble is caused by a loose connection or break in the field circuit, by poor contact at the brushes due to a dirty commutator, or perhaps to a fault in the rheostat, or incorrect position of brushes. Examine all connections; try a temporarily increased pressure on the brushes; look for a broken or burnt-out resistance coil in the rheostat. An open-circuit in the field winding may sometimes be traced with the aid of a magneto bell, but this is not an infallible test as some magnetos will not ring through a circuit of such high resistance as some field windings have, even though it be intact. If no open circuit is found in the rheostat or in the field windings, the trouble is probably in the armature.

19. If it can be found that nothing is wrong with the connections or the winding it may be necessary to excite the field from another generator or some other outside source. Calling the generator we desire to excite No. 1, and the other machine from which the current is drawn No. 2, the following procedure should be followed: Turn field rheostat on generator No. 1 to the "All-In" position, open all switches and remove all brushes from generator No. 1, connect any one positive brushholder on generator No. 1 to any one positive brushholder on generator No. 2; also connect two negative brushholders together (it is desirable to complete the circuit through a switch having a fuse of about 15 amperes capacity in series). Close the switch. If the shunt winding of generator No. 1 is all right its field will show considerable magnetism. If possible, reduce the voltage of generator No. 2 before opening the exciting circuit; then break the connections. If this cannot be done, throw in all the rheostat resistance of generator No. 1; then open the switch very slowly, lengthening out the arc which will be formed until it breaks.

20. If the generator does not pick-up voltage after it has been established that the shunt field is functioning, it is evident that there is something wrong with the armature, either a short-circuit or an open-circuit.

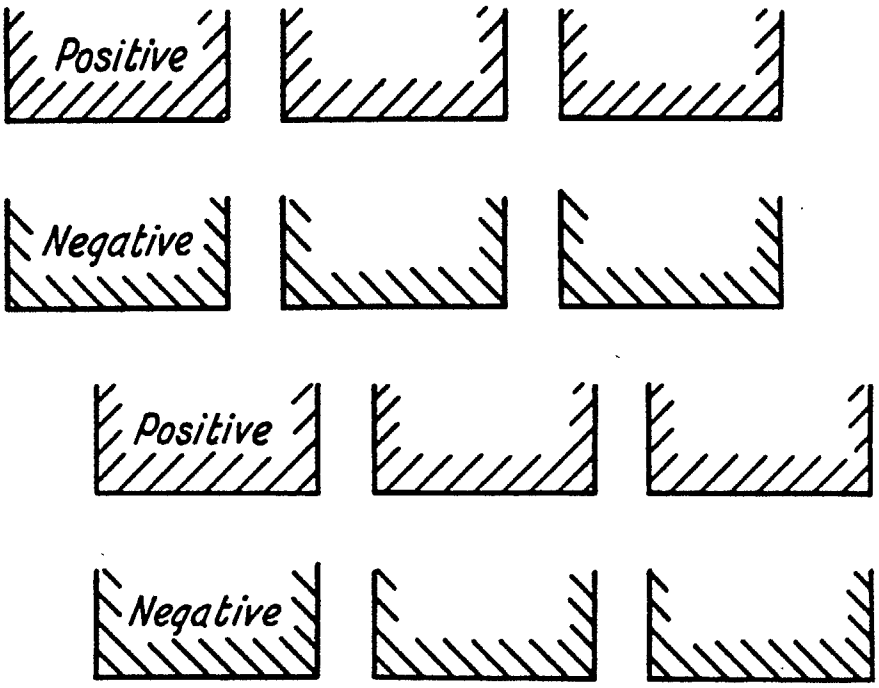


Fig. (a) - Correct Method of Staggering Brushes

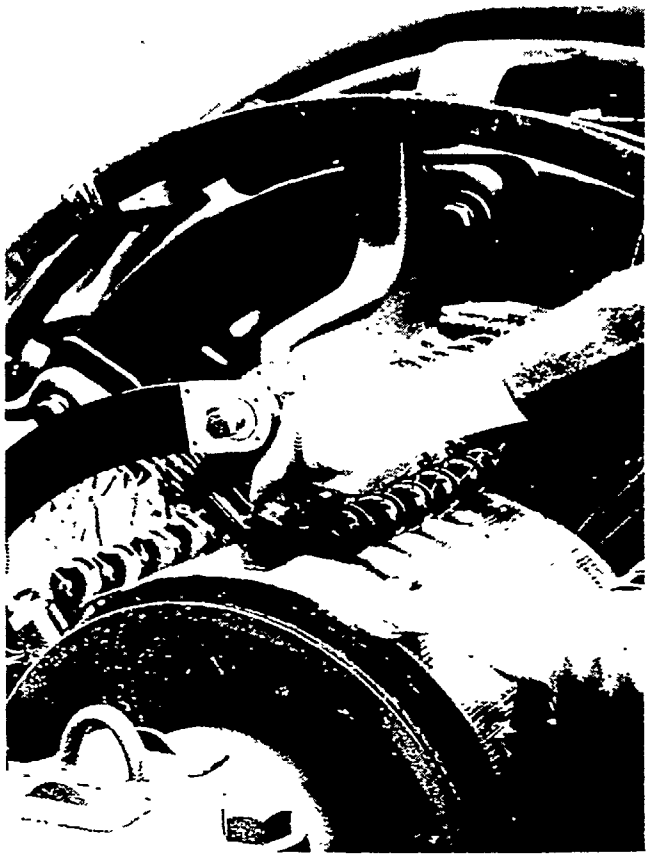


Fig. (b) - Proper Method of Grinding Brushes

21. If a new machine refuses to excite and the connections seem to be all right, reverse the connections, i.e., connect the wire which leads from the positive brush to the negative brush and the wire which leads from the negative brush to the positive brush. If this change of connections does no good, change back and locate the fault as previously described.

Brushes

22. The ends of all brushes should be fitted to the commutator so that they make good contact over their entire bearing face. This can be most easily accomplished after the brushholders have been adjusted and the brushes inserted. Lift a set of brushes sufficiently to permit a sheet of sandpaper to be inserted. Draw the sandpaper in the direction of rotation under the brushes releasing the pressure as the paper is drawn back being careful to keep the ends of the paper as close to the commutator surface as possible, thus avoid rounding the edges of the brushes. It will be found by this means that satisfactory contact is quickly secured; each set of brushes should be similarly treated in turn. (See Figure(b) page 220).

23. With brushes of good quality, no oil is necessary for lubricating the commutator; oil has a tendency to "gum" the surfaces of the brushes. If lubrication is required use a piece of canvas impregnated with paraffin.

24. Make frequent inspection to see that:

(a) Brushes are not sticking in holders.
(b) "Pig-tail" shunts are properly attached to brushes and holders.
(c) Tension is changed as brush wears.
(d) Worn-out brushes are replaced before they reach their limit of travel and break contact with the commutator.
(e) Remove any free copper picked up by the face of the brush.

Commutator

25. The commutator is perhaps the most important feature of the whole machine in that it is most sensitive to abuse. Under normal conditions, it should require little attention beyond frequent inspection. The surface should always be kept smooth and if through extreme carelessness, neglect or accident, it becomes badly roughened, the armature should be removed and the commutator turned down in an engine lathe.

26. Sometimes a little sandpapering is all that is necessary. Emery cloth or paper should never be used for this purpose on account of the continuous abrasive action of the emery which may become embedded in the copper bars and brushes. Even when sandpaper is used the brushes should be raised and the commutator wiped clean with a piece of canvas lubricated with a very small quantity of vaseline. Cotton waste should never be used and an excess of lubricant must be avoided.

27. All commutators are thoroughly baked and tightened before leaving the factory, but if a bar should work loose it should be attended to promptly. The same may be said of flat spots or "flats" which will sometimes occur, due to a loose bar, unusually soft copper, or even to severe flash or short-circuit.

28. Under normal conditions the commutator should become dark and highly polished after a few weeks' operation, and so remain unchanged for years.

29. Trouble is sometimes experienced from the burning-out of mica insulation between segments. This is most commonly caused by allowing the mica to become oil-soaked or by the bars loosening and thus allowing foreign conducting material to work its way between them. It is rarely, if ever, definitely traced to excessive voltage between bars. When this burning does occur it may be effectively stopped by scraping out the burned mica and filling the space with a solution of sodium silicate (water glass) or other suitable insulating cement.

30. Even with the most careful workmanship, high mica will sometimes develop and start sparking, which burns away the copper and aggravates the difficulty. By prompt action serious damage can be prevented by cutting away the mica to a depth of 3/64 of an inch.

Sparking at The Brushes

31. Sparking at the brushes may be due to any of the following causes:

(a) The machine may be overloaded.
(b) The brush may not be set exactly on neutral.
(c) The brushes may be wedged in the holders or have reached the end of their travel.
(d) The brushes may not be fitted to the circumference of the commutator.
(e) The brushes may not bear on the commutator with sufficient pressure.
(f) The brushes may be burned on the ends.
(g) The commutator may be rough; if so, it should be smoothed off.
(h) A commutator bar may be loose, or may project above the others.
(i) The commutator may be dirty, oily or worn out.
(j) The carbon brushes may be of an unsuitable grade.
(k) The brushes may not be spaced equally around the periphery of the commutator.
(l) Some brushes may have extra pressure and may be taking more than their share of the current.
(m) High mica.
(n) Vibration of the brushes.
(o) Incorrect brush angle.

32. These are more common causes, but sparking may be due to an open circuit or loose connection in the armature. This trouble is indicated by a bright spark which appears to pass completely around the commutator and may be recognized by the scarring of the commutator at the point of open-circuit. If a lead from the armature winding to the commutator becomes loose or broken it will draw a bright spark as the break passes the brush position. This trouble can be readily located, as the insulation on each side of the disconnected bar will be more or less pitted.

33. The commutator should run smoothly and true, with a dark glossy surface.

Heating of Field Coils

34. Heating of field coils may develop from any of the following causes:

(a) Too low speed.
(b) Too high voltage.
(c) Too great forward or backward lead of brushes.
(d) Partial short-circuit of one coil.
(e) Overload.

Heating of Armature

35. Heating of the armature may develop from any of the following causes:

(a) Too great a load.
(b) A partial short-circuit of two coils heating the two particular coils affected.
(c) Short-circuits or ground on armature or commutator.

Heating of Commutator

36. Heating of commutator may develop from any of the following causes:

(a) Overload.
(b) Sparking at the brushes.
(c) Too high brush pressure.
(d) Lack of lubrication on commutator.

Bucking

37. Bucking is the very expressive term descriptive of what happens when arcing occurs between adjacent brushholder studs. In general, bucking is caused by excessive voltage, or by abnormally low surface resistance on the commutator between brushholders of opposite polarity. Any condition tending to produce poor commutation increases the danger of bucking. Among other causes are the following:

(a) Rough or dirty commutator.
(b) A drop of water on the commutator from leaky steam pipes or other source.
(c) Short-circuits on the line producing excessive overloads.

Cleanliness

38. Particular care should be exercised towards keeping all parts of the machine reasonably clean. This applies particularly to turbo-generators and other high-speed machines. The high rotative speed in these draws air into the armatures and other parts with a velocity sufficient to carry with it particles of dirt or oil vapor that may be in the air. The rotating part must be cleaned out as necessary or the machines will ultimately short-circuit between commutator necks or break down to ground over insulation surfaces. Some types of stationary windings should be well-cleaned for the same reason, and more than merely blowing out by compressed air as previously described.

Repairs to Insulation

39. If a defect develops in the outside of a field or armature coil, it can sometimes be repaired by carefully raising the injured wire or wires and applying fresh insulation.

40. If it is desired to remove one of the commutating pole coils loosen the bolts which hold the pole to the frame and disconnect the coil from those on each side. The pole piece and coil can then be removed easily from the frame.

41. In case it is necessary to remove a shunt-field coil the bolts holding the pole pieces should be removed. This will make it possible to remove the pole piece and coil, after which the coil may be removed from the pole piece and repaired or replaced. Care should be taken in replacing the coil so to place it on the pole piece as to obtain the proper polarity of the coil. A very simple means of testing the polarity is by means of a needle or a piece of steel wire suspended from the middle by a string.

The polarity should be alternately North and South around the frame. Bring the polarity needle within the magnetic field of any pole. One end of the needle will point towards this pole and this end should be repelled by the next pole and so on around the frame. If this reversal of the needle does not occur there must be a wrong connection of the field coil.

Armatures

42. A simple method of making temporary repairs in an armature in case of a short-circuit or open-circuit of one of the coils is to cut-out that coil by cutting the leads which connect the coil with the commutator bar and then short-circuiting the bar thus cut-out, with the following bar. This may readily be done by simply soldering the two necks together. By this means an armature may be kept in service until there comes a convenient time to replace the damaged coil or coils.

Ordering of Renewal Parts

43. When ordering renewal parts, give the name plate reading. Always give the name of the parts wanted, also the stock order (S.O.) and serial number of apparatus on which the part is to be used. The latter will be found stamped on the name plate and in the metal under the name plate.

(Section 6) DISMANTLING A-C. GENERATOR AND EXCITER

To Remove Exciter Stator

Step 1. Disconnect exciter armature and field leads at terminal board.

Step 2. Lift brushes clear of commutator.

Step 3. Disconnect oil inlet and outlet.

Step 4. Unbolt frame feet, and move stator out until clear of shaft and lift out.

To Remove Exciter Armature

Step 1. Disconnect oil inlet and outlet.

Step 2. Remove leads from brushes.

Step 3. Unbolt bracket from frame and lift out.

Step 4. Place slings over ends of shaft and unbolt from generator shaft.

Step 5. Break pilot fit and move out until clear of exciter frame and lift out.

To Remove Generator Bearing

Step 1. Disconnect oil lines and collector leads.

Step 2. Unbolt and remove bearing seals, bearing cap and top half of bearing.

Step 3. Jack rotor off bearing and roll out bottom half of bearing.

Step 4. To remove pedestal, unbolt from base and move toward exciter until clear of shaft and lift out.

To Remove Generator Rotor

Step 1. Remove exciter and pedestal.

Step 2. Remove front and rear end bells and cooler housing.

Step 3. Shim bottom of air gap.

Step 4. Place slings over both ends of shaft and unbolt gear coupling.

Step 5. Slide out until center of rotor clears ends of stator coils on exciter end.

Step 6. Place sling around center of rotor and slide out until gear flange clears stator coils and lift out.

PART II

(Section 7) SWITCHBOARD TEMPERATURE INDICATOR WITH RESISTANCE COIL DETECTOR

Application

1. These instructions cover the application of permanent-magnet, moving-coil switchboard instruments for the measurement of temperatures in electrical machinery operating in temperature ranges between 0°C. and 250°C.

General

2. The temperature indicator operates on the resistance-coil-detector principle, the detecting coil forming one branch of a Wheatstone Bridge, which is energized by rectified a-c. control circuit. The detecting coils are embedded in the machinery windings and are wound with copper wire to an exact resistance of 10 ohms at 25°C. Six detecting coils are provided with each machine and are so located as to measure the temperature at "hot spot" locations. A selector switch allows the indicator to be connected to any coil desired.

3. When the detector coil is at a predetermined temperature the bridge is in balance and no potential exists on the instrument. This point is called the balance temperature and is selected depending upon the scale range of the instrument.

4. At any other temperature the resistance of the detector coil changes and therefore there will be an unbalance of the bridge. This results in a potential difference which deflects the pointer of the instrument. This potential difference is directly proportional to the resistance of the coil and thus the scale is calibrated in temperature of the coil.

5. The balance point is selected at the temperature at which the greatest accuracy is desired. At this temperature the indications will be independent of control circuit voltage. This point is marked by a red line on the indicator scale.

6. At other temperatures the error due to incorrect voltage will be the difference between the actual temperature and the balance temperature, multiplied by deviation in control voltage. This error is small and can be neglected for ordinary variations in voltage, as the balance point is chosen near ordinary operating temperatures, and the error near the balance point is very small. For any reading and any incorrect control voltage the true reading, if desired, can be found as follows:

B = Balance Point Temperature
T_1 = Observed Temperature
E = Rated Control Voltage
E_1 = Actual Control Voltage
T = True Temperature

$$T = B - \frac{E}{E_1}(B - T_1)$$

For Example if:

Balance Point Temperature = 100°
Observed Temperature = 80°
Rated Control Voltage = 125 Volts
Actual Control Voltage = 115 Volts

$$T = 100^{\circ} - \frac{125}{115} (100^{\circ} - 80^{\circ})$$

$$T = 100^{\circ} - 21.75^{\circ}$$
$$T = 78.25^{\circ} \text{ an error of } 1.75^{\circ}$$

This error can usually be neglected for ordinary variations in control voltage.

Installation

7. The complete outfit includes the indicator proper, leads, bridge box, terminal block (on machine), selector switch, test resistor, calibrating rheostat and "trickle" charger. A selector switch is required for each machine or group of six search coils.

8. The leads to the search coils may be several hundred feet in length, but their resistance should be kept below .2 ohm for best results, and it is important that the resistance of lead 2 from bridge box to search coil be equal to resistance of any lead 4 from bridge box, through switch to search coil.

9. Best accuracy is obtained when three leads are brought out from each search coil, and connected as shown on Drawing 31-J-289 (Figure G-3).

Zero Adjustment

10. The pointer of the indicator should rest at the red mark or "balance point" on the scale when no voltage is applied to the circuit.

Calibration

11. Turn the selector switch to test coil position and apply control circuit. The indicator should show 0°C. If the indicator reads too high, it will be necessary to reduce the series control resistance in the bridge box. Final adjustment can be made with the calibrating rheostat mounted on the panel. The latter can be used for correcting control voltage at any time before readings are taken.

12. The test resistor is desirable whenever control voltage is subject to variations or when recalibrating the instrument. It can be eliminated if control voltage is known to be always steady at the value for which the indicator is calibrated.

13. The test resistor has a constant resistance of 9.037 ohms which is equivalent to the resistance of a 10-ohm exploring coil at 0° Centigrade. Thus with the test resistor connected in place of the exploring coils, the instrument should read zero on the scale.

14. The panel-mounted rheostat is desirable when the line voltage fluctuates, or when extreme accuracy with ease of adjustment is required. Otherwise, voltage variations can be corrected by means of the rheostat on the trickle charger. The trickle charger rheostat may not be as accessible as the panel-mounted rheostat.

Calibration Data

15. The following table gives the resistance of the search coils for which this instrument is calibrated, at various temperatures.

Temperature °C.	Resistance Ohms
0	9.037
25	10
50	10.962
100	12.887
150	14.812

16. The detector coil balances the bridge circuit at the temperature indicated by the red line on the scale of the instrument.

PART III

TYPE "BN-2" AUTOMATIC VOLTAGE REGULATOR

PART III

TYPE "BN-2" AUTOMATIC VOLTAGE REGULATOR

Purpose

1. Careful reading of these instructions will provide information for proper care and handling of the generator voltage regulating equipment and avoid damage to the equipment which may impair its performance when placed in operation.

Storage

2. The generator voltage regulating equipment should be stored where it will not be subject to excessive moisture or damage to containers which will permit entrance of dust and dirt. The apparatus is designed to operate under relatively clean atmospheric conditions and if allowed to accumulate too much foreign matter, failure of equipment may result or performance be impaired when placed in service.

Unpacking

3. Small packages should be opened only when the apparatus can be promptly placed in its final position on the switchboard panel or other location.

Installation

4. When equipment such as motor-operated rheostat or contactor panel is placed in position prior to the installation of other large apparatus nearby, the electrical equipment should be covered with wrapping paper or canvas and protected by box or crate parts, or sections of plywood paneling.

DESCRIPTION OF GENERATOR VOLTAGE REGULATING EQUIPMENT

5. In each installation one regulator controls one generator. Two complete voltage regulator equipments plus one "Emergency" or "Spare" main control element is mounted on each switchboard. The spare element is provided with a regulator element "Transfer" or "Selector" switch and the control wiring is so arranged that the spare element may be used to substitute for either of the two normally-connected elements in an emergency. When the regulator element transfer switch associated with each switchboard is thrown to either of the "Emergency" positions, the emergency element has complete control of that particular unit.

A-C. Potential Transformers

6. Two potential transformers are used to step down from A-c. generator voltage to the usual value of 112 volts which is applied to the regulating equipment. The voltage transformers are located back of the switchboard panel.

7. The potential transformers are Westinghouse Electric & Manufacturing Company type "VN" and are connected as follows:

Primary:- Two transformers connected "open delta" receive 3 phase, 3 wire, 60 cycle, 440 volts.
Secondary:- Two transformers connected "open delta" give 3 phase, 3 wire, 60 cycle, 110 volts.

Rectox Rectifier Unit

8. The 3 phase a-c. voltage is rectified by the 3-phase, full-wave Rectox rectifier in order to provide d-c. current for the main coil of the voltage regulator control element. The rectifier unit is located back of the switchboard panel. When a-c. generators operate in parallel a compensator is used for the purpose of making the generators share proportionally the reactive load. A current transformer connected in one phase of the a-c. generator between the generator terminals and the bus provides energy to the compensator. The output potential terminals of the compensator are connected in the a-c. potential leads between the potential transformer and the rectifier terminals.

Control Switches

9. A regulator control switch is always provided mounted on the switchboard, for the purpose of connecting the voltage regulator control element for operation as marked under regulator name plate "Manual-Indicating-Regulating". In the "Manual" position the generator voltage is under manual control. In the "Indicating" position the generator voltage is also under manual control but the regulator element is energized and its action is indicated by means of indicating lamps which show whether the regulator is attempting to raise or lower the voltage. In the "Regulating" position, the generator voltage is under the control of the regulator.

10. When the regulator control switch is in the "Manual" or "Indicating" position the generator voltage is controlled manually by use of the rheostat motor control switch, also mounted on the switchboard. This has two positions, "Raise" and "Lower" with the handle spring-returned to the normal "Off" position.

11. A voltage regulator "Selector" switch is also used for the purpose of selecting between the main and "Emergency" or "Spare" regulator control element.

Voltage Adjusting Rheostat

12. This is mounted on the switchboard. Turning the handle of this rheostat raises or lowers the value at which the regulator holds the generator voltage.

13. The rheostat is Ward Leonard type "RC" having 100 ohms, 43 steps and identified as Westinghouse Electric & Manufacturing Company, Style No. 1250157.

14. An adjustable fixed resistor having 750 ohms is mounted on the rear of the voltage adjusting rheostat and identified as Westinghouse Electric & Manufacturing Company, Style No. 1115103. This resistor is shown on the schematic diagram as "R-1" and is connected in series with the voltage adjusting rheostat "R-2".

Motor-Operated Generator Field Rheostat And Contactor Panel

15. This unit is sometimes built into the switchboard, or may be located apart from the switchboard. The motor-operated rheostat provides the means for changing resistance in the a-c. generator field circuit either by manual control, or under the control of the voltage regulator element. The contactor panel includes two small contactors, one "Raise" and the other "Lower" for energizing the rheostat motor in either the forward or the reverse direction, under the control of the voltage regulator. Heavy-duty, high-speed, field-forcing contactors are also located on this panel, one for field-forcing-up and the other for field-forcing-down, for the purpose of restoring the voltage more quickly to normal in case of relatively large load changes.

16. The resistor tubes mounted on the contactor panel are identified as follows:

R-8	6500 ohms	S#1250276
R-9	168 ohms	S#1250277
R-10	6500 ohms	S#1250276
R-11	24000 ohms	S#1250278
R-12	24000 ohms	S#1250278

Voltage Regulator Main Control Element

17. This element is located on the switchboard. The moving arm carries two sets of contacts "Normal-Response" (R & L) and "Quick-Response" (AR & AL). The former controls the motor-operated rheostat and adjusts the generator voltage automatically when necessary on account of relatively small changes in load on the a-c. generator. The "Quick-Response" contacts control the quick-response field-forcing contactors to restore the a-c. generator voltage to normal in case of relatively large changes in load on the a-c. generator. The regulator element includes anti-hunting devices which change the spacing of the regulator contacts temporarily as required in order to prevent hunting or over-shooting of the generator voltage.

18. The regulator main control coil is rated 65 ohms., 0.2 ampere and identified as Westinghouse, Style No. 1087427. The coil is wound with 3000 turns of No. 25 enameled wire.

19. The anti-hunt coils are rated 7000 ohms, 0.25 ampere and identified as Westinghouse, Style No. 1247173. The coil is wound with 30,000 turns of No. 38 enameled wire.

Indicating Lamps

20. Two approved Navy type "VG-7" indicating lamps are used to enable the operator to adjust properly the regulator control element when it is transferred in and out of service. These lamps indicate when the excitation is correct to make such a transfer and safeguard against transfers during periods of excitation change. When the a-c. voltage is normal, both lights burn brightly. When the regulator is changing the position of the motor-operated field rheostat, either the "Raise" or "Lower" lamp is short-circuited, which not only indicates that a change is taking place but also indicates the direction of the change. The red lamp indicates "Raise" and the green lamp indicates "Lower".

Compensator

21. When a multiplicity of regulator-controlled a-c. generators operate in parallel on the same bus, it is necessary to droop the regulated voltage with respect to wattless generator current. For this purpose an inductive compensator is used, which is a small transformer with an air gap in its magnetic circuit, and is energized from a current transformer. The manner in which this compensator is connected and operates is explained under "Cross-Current Compensation".

PRINCIPLE OF VOLTAGE REGULATOR OPERATION

22. Reference should be made to the schematic diagram and the wiring diagram supplied with the generator voltage regulator or switchboard equipment. In each installation one regulator controls one generator. For the first trials the generator line circuit breaker should be opened, the main exciter-field circuit closed and the exciter voltage at normal rated value.

23. The type "BN-2" generator rheostat voltage regulator controls the voltage of the a-c. generator by varying the resistance in the generator field circuit by means of a motor-operated rheostat. When the a-c. voltage is normal all parts of the regulator are stationary. For small deviations from normal voltage the regulator operates to change the position of the generator field rheostat thus effecting the required change in field current to bring the generator voltage back to normal. For large deviations from normal voltage, the regulator operates by means of high-speed contactors to insert or short-circuit suitable blocks of resistance in the generator field circuit, thus effecting a relatively large change in field current, at the same time turning the rheostat to a new position.

Main Control Element

24. The important parts of the main control element are a torque motor which carries a spring-mounted moving arm, and two anti-hunt devices. The torque motor is made up of a stationary coil mounted on an iron magnetic circuit in the shape of a square "C". The moving arm, which is non-magnetic, carries a small iron armature supported on the arm so that it can move in the fixed air gap of the magnetic circuit. The magnetic pull on the iron armature is balanced by a coiled spring.

25. The coil receives its energy from a 3-phase, full-wave, Rectox rectifier, the a-c. side of which is fed by potential transformers connected to the a-c. generator voltage. The regulator therefore responds to a d-c. voltage which is proportional to the average of the 3-phase a-c. voltage. The regulator adjusts the generator field rheostat to whatever position is required in order to maintain normal voltage, by means of the rheostat motor control relays and the high-speed field-forcing contactor.

26. The voltage adjusting rheostat is used to raise or lower the value of the regulated voltage. This is done by changing the value of the resistance in the d-c. coil circuit of the regulator.

27. The compensator is energized from a current transformer in one phase of the a-c. generator load circuit. It is used to equalize the amount of reactive current carried by each generator when two a-c. machines are operated in parallel.

DESCRIPTION OF VOLTAGE REGULATOR ACTION

Normal Corrective Action

28. Refer to the "Schematic Diagram" (Figure R-1) which is found in the rear of this instruction book. In the schematic diagram the regulator is shown energized and in control. The regulator element transfer switch is shown in the "Normal Reg." position and regulator control switch in the "Regulating" position. The regulator moving arm is in the mid-position, with the indicating lamps "RL" and "LL" burning.

29. Assuming that a small drop in voltage takes place and requires correction, the control element main contacts "R" close, causing the lamp "RL" to blink, and energizing the "NR" rheostat motor control relay.

30. This relay completes the following operations:

(a) Energizes the rheostat motor which turns the generator field rheostat in the direction to cut out resistance, and increase the generator field current.

(b) Energizes the coil "NH" of tne normal-response anti-hunting device. The spring-mounted armature of this device moves to increase the distance between the "R" contact thereby opening the circuit at this point.

(c) Energizes the condenser connected across the "NR" relay coil. The action of this condenser (and resistor circuit) maintains current in the "NR" coil for a sufficient time to permit the rheostat motor to move the rheostat arm approximately one step.

(d) The contact-spreading action of the anti-hunt device is only momentary, the contacts returning to their normal position in two or three seconds. Should further movement of the generator field rheostat be required the contacts "R" will again close and continue notching action as required.

31. In case the control element "L" contacts close to lower the voltage, similar action takes place.

Heavy-Load Corrective Action

32. When a large drop in voltage occurs, due, for example, to a large block of load being thrown on the system or due to a fault, the normal-response contacts "R" on the regulator close, followed by the closing of the quick-response contacts "AR". The "AR" contacts complete the circuit to the quick-response "field-forcing-up" contactor "QR", which short-circuits a block of resistance in the generator field circuit, thus applying full exciter voltage to the field circuit. This starts the generator voltage to return towards normal very rapidly.

33. When the field-forcing contactor "QR" closes, auxiliary contacts of this device close at the same time in the circuit of the anti-hunt device "QH". This operates to spread the "AR" contacts, as described for the "NH" device and the "R" contacts. Therefore, if the deviation of normal voltage is within the recalibration effect of the "QH" anti-hunt device, the field-forcing contactor will close and open rapidly while the rheostat arm approaches the required new position. If the deviation from normal voltage is greater than the recalibrated setting of the "QH" anti-hunt device, the field-forcing contact will close and remain closed until the voltage is brought within the setting of the anti-hunt device. However, when the a-c. voltage gets within the setting of the "AR" contacts, the normal-response "R" contacts take control and by notching the rheostat, return the a-c. voltage to normal. Since the rheostat turns at maximum speed while the quick-response contacts are closed, it takes only a minimum of additional movement after the normal-response contacts take control, to return the voltage to normal.

34. In a similar manner, when a large block of load is removed from the system, thus causing a large increase in voltage, the quick-response contacts "AL" will close and energize the quick-response field-reducing contact "QL" which is normally closed. This contactor then opens its main contacts and inserts a block of resistance in the generator field circuit, causing the generator voltage to fall very rapidly. When the a-c. voltage gets within the setting of the quick-response "AL" contacts, the normal-response "L" contacts take control and settle the voltage by notching action of the rheostat.

PLACING VOLTAGE REGULATOR IN OPERATION

First Time In Control

35. For the first trials the generator line circuit breaker should be open with generator speed and exciter voltage normal.

36. To check generator field rheostat operation the regulator control switch should be turned to the "MANUAL" position. In this position the rheostat is under "REMOTE MANUAL CONTROL" by means of the rheostat motor control switch. The regulator element and the regulator contact circuits are not energized. With the generator field circuit open, the rheostat motor control switch should be turned first to the "LOWER" and then to the "RAISE" position, and the operation of the rheostat observed to check proper direction of operation, free action of moving parts, and reliable operation of limit switches. After checking, the rheostat should be turned to the approximately "ALL-IN" position for the following test.

37. With the regulator control switch still in the "MANUAL" position, close the generator field switch and observe the effect of the field-forcing-up contactor "QR" by carefully closing it momentarily by hand. In a similar manner the effect of the field-reducing contactor "QL" may be observed to determine that connections have been properly made.

38. The regulator control switch should now be turned to the "INDICATING" position. In this position the regulator main coil is energized from its potential transformers, and exciter voltage is applied to the regulator circuits, which includes the normal-response "R-L" contacts, the "NR" and "NL" rheostat motor control relays, anti-hunting circuits, and regulator position indicating lamps. If either the "R" contacts or the "L" contacts close and the corresponding rheostat motor control relay closes, one of the indicating lamps will be out, and the other will burn brightly. The regulator contacts which are closed may also be determined by inspection, and the voltage adjusting rheostat turned to the position where the lever arm is balanced between the contacts, at which time both indicating lamps will burn brightly.

39. With the regulator control switch still in the "INDICATING" position, the voltage adjusting rheostat may be turned either way through a small angle to observe the correct operation of the "NR" and "NL" relays. At the same time observe contact-spreading action of the anti-hunt device and proper closing of the "NR" and "NL" auxiliary contacts.

40. Normal a-c. voltage may now be obtained by using the rheostat motor control switch to turn the a-c. generator field rheostat to the proper position. Then by means of the voltage adjusting rheostat find the position where both the indicating lamps burn brightly, thus indicating that the regulator main control lever arm is floating between the contacts. The regulator control switch may now be turned to the "REGULATING" position, thus placing the regulator in control of the a-c. voltage.

41. By turning the voltage adjusting rheostat through a small angle, the regulator will operate to raise or lower the voltage by means of the "R" or "L" contacts and the "NR" or "NL" rheostat motor control relays.

42. If the voltage adjusting rheostat is turned quickly to a larger angle the "AR" or "AL" contacts will operate the "field-forcing" or the "field-reducing" contactors to bring the voltage to the new setting.

43. When the normally-open field-forcing contactor "QR" closes, the voltage will rise rapidly and the motor-operated generator field rheostat will move in a direction to reduce the resistance in the field circuit.

In like manner, when the normally-closed field-reducing contactor "QL" opens, the voltage will decrease rapidly and the motor-operated rheostat will move to increase the resistance in the generator field circuit. It is necessary that these conditions be obtained for successful operation of the regulator. After correct operation of the regulating equipment in line with the preceding is obtained, the generator may be connected to the load. If voltage is comparatively steady, it should be varied by picking-up or dropping-off different loads to check regulator performance.

Taking Regulator Out of Control

44. The removal of the regulator from service requires only the turning of the regulator control switch to the "INDICATING" position at a time when the regulator is at rest, as shown by both indicating lamps burning brightly.

Manual Control

45. Manual control of the generated voltage of each unit is obtained by means of two switches mounted on the switchboard. The regulator control switch has the three positions "MANUAL-INDICATING-REGULATING"; turning this switch to the "MANUAL" position cuts the regulator out of the circuit and completes a circuit to the rheostat hand control switch. This switch has the three positions "RAISE-OFF-LOWER". When turned to the "RAISE" position it completes a circuit to the "S2" coil of the rheostat motor, turning the arm in a direction to reduce resistance in the generator field circuit. When the switch is turned to the "LOWER" position it completes a circuit to the "S1" coil of the rheostat motor, turning the arm in a direction to increase resistance in the generator field circuit.

46. In addition to provision for manual operation by means of these two switches, the rheostat is arranged so that it may be operated by a handwheel located on the front of the switchboard.

Cross-Current Compensation

47. Where two or more a-c. machines are operated in parallel, each provided with an individual exciter, it is necessary that each one be provided with its own individual regulator.

48. The division of the kw. load among paralleled a-c. generators is dependent upon the power supply to each generator and is controlled by the governor of its prime mover. Thus the division of the kw. load is practically independent of the excitation. However, changes in the field excitation of paralleled a-c. machines does affect the reactive kv-a. or wattless component of the output. Since the voltage regulator acts directly on the field excitation, it will be seen that although the division of kw. load between machines is unaffected by the voltage regulator, the division of wattless current is directly affected by the operation of the regulator.

49. Thus, when a-c. machines are operated in parallel, each under control of an individual regulator, this will cause circulating wattless current between the a-c. machines unless some provision is made to cause each machine to shirk wattless current. To secure stability in parallel operation it is, therefore, necessary to give the regulated voltage a droop with increase in the wattless component of the machine current. In general, a satisfactory droop in the regulated voltage will be obtained if there is 6% reactive drop between two a-c. machines. This reactive drop may be obtained artificially by giving the regulator a drooping characteristic from a cross-current compensator energized from a current transformer.

50. Where the cross-current compensator scheme is used, one compensator and one current transformer is required for each a-c. machine and its

regulator as shown in the schematic diagram. The compensator is designed to supply compensating voltages in two legs of the 3-phase regulator potential circuit, which insures applying a balanced 3-phase voltage to the regulator element.

51. Two dial switches are provided on each compensator. One of these switches gives a coarse adjustment and the other a fine adjustment of the compensation. A total of 24 steps are available on the two switches, which in the case of the standard 12% compensator gives a 1/2% change in compensation per step. The 12% compensation is on basis of 4 amperes from the current transformer. Should the current-transformer ratio give some other value of secondary current the compensation settings will be affected proportionally. 6% Compensation is ample for the usual application.

ADJUSTMENT OF VOLTAGE REGULATING EQUIPMENT

52. In case of difficulty with the regulating equipment a careful check should be made of wiring to make sure that it agrees with the wiring diagram and also making sure that there are no open or loose connections.

Voltage Adjusting Rheostat

53. This rheostat provides for adjustment of the regulating voltage through a range of 18 volts on the potential-transformer secondary terminals. Should it be desired to raise or lower this range, it may be done by readjustment of the slider on the resistor tube mounted on the back of the voltage adjusting rheostat. Initial trials should be made with the factory setting.

Potential Transformer And Rectifier Circuits

54. Two potential-transformers of standard 100-volt-ampere capacity are used, connections being made to the regulating element as shown on the diagram supplied with the equipment. Should it be necessary to check polarity of the Rectox rectifier, this may be done by using low-voltage d-c. circuits (6 to 12 volts) with lamps (6 to 12 volts) in series, testing a stack of discs, section by section. With current flow in the normal direction, the lamp will glow. With the same d-c. voltage circuit connected to the Rectox in the reverse direction, the lamp will not glow.

Control Element, Internal Adjustment - (See Dwg. 7-D-6187)

55. After the regulator is mounted on the switchboard panel, and ready for service, the cover should be removed, and the element inspected internally to see that there is no dust or dirt present, and that parts appear to be intact and in place. The left-hand end of the moving arm should be free to move through about 1/8-inch of travel without interference or friction. Since the moving arm is supported by crossed leaf-type springs, there are no pivots or bearings to wear or require adjustment.

56. The armature which is fastened to the moving arm and which moves in the air gap of the magnetic circuit should be centered in this air gap. Close inspection should be made to see that there is no foreign matter in the air gap.

57. Should adjustment of the element become necessary, the following procedure is given:

Step 1. Set the main coil current at .2 ampere d-c. An accurate d-c. ammeter with full-scale reading of .25 or .5 ampere should be used. It may be connected in series with the coil at C (plus) stud on rear of the element.

Step 2. Adjust the tension of the main coiled spring "A" connected to the moving arm so that the moving arm is horizontal. The travel of the moving arm is limited by the stop screws "B" and "C". With the arm in its mid-position the contacts on the arm should just clear the stationary contacts "L" and "R" mounted on the anti-hunt device. If the moving arm is horizontal, (arm parallel to top surface of magnet) and the contacts mounted on the anti-hunt device are not evenly spaced from the corresponding contacts on the moving arm, the contacts on the anti-hunt device should be adjusted until the spacing between each set of contacts is the same.

Step 3. Now increase the coil current to .202 ampere and adjust the "L" or upper rear stationary contact screw until the contact just "makes". This is located on the left-hand anti-hunt device.

Step 4. Decrease coil current to .198 ampere and adjust the "R" or lower front stationary contact screw also on left-hand anti-hunt device so that the contact just "makes".

Adjustments (Steps 3 and 4) give the regulator element a sensitivity of $\pm$ 1% for normal response.

Step 5. Increase coil current to .208 ampere and adjust the "AR" or upper rear (quick-response) contact screw on right-hand anti-hunt device so that contact just "makes".

Step 6. Decrease coil current to .192 ampere and adjust the "AR" or upper rear (quick-response) contact screw on right-hand anti-hunt device so that contact just "makes".

Adjustments (Steps 5 and 6) give the regulator element a sensitivity of $\pm$ 4% for the quick-response contacts. Satisfactory performance should be obtained when this adjustment is of the order of 3% to 5%.

Anti-Hunting Device

58. Two duplicate anti-hunting devices are used, the "Normal-Response" contacts "R" and "L" being carried by the device on the left-hand side of the element (front view) and the "Quick-Response" contacts "AR" and "AL" on the right-hand device. The purpose of the anti-hunt device is to separate the regulator contacts shortly after they have closed due to a small deviation from normal regulated voltage, and to provide a predetermined length of time for the motor-operated rheostat to make a correction in the excitation, prior to the contacts of the anti-hunt device returning to their normal position. When the coil of the anti-hunt device is energized, the moving armature of the device acts to pull its contact away from engagement with the corresponding contact on the regulator moving arm. The action of the anti-hunt armature in separating the contacts is fast but the return of the armature to its normal position is relatively slow, depending upon the adjustment of the anti-hunt device coiled spring. The time of return of the contacts to their normal position is adjustable from approximately .25 second to 4.0 seconds.

59. The anti-hunt device can be set to separate the regulator element contacts either a large or a small amount. Normally the maximum opening (normal-response or quick-response contacts) should not exceed about 1/8-inch. Decreasing this amount will cause the motor-operated rheostat to operate more frequently than is necessary. Increasing this amount will cause the motor-operated rheostat to operate less frequently, and will provide somewhat longer time between successive corrections (notching action) of the rheostat.

60. By slowly turning the voltage adjusting rheostat the exact point where the "R" contacts or the "L" contacts close may be determined by observing the corresponding indicating lamp. By slowly turning the voltage adjusting rheostat a little further, in the same direction, the limit of the contact-spreading action of the anti-hunt device may be determined. For the normal-response contacts, this limit should be approximately 3%. For the quick-response contacts this limit should be about 8%. The spread of the contacts (with the anti-hunt coil energized) should in general not be disturbed from the factory setting.

61. The anti-hunt device is set to take approximately 3 seconds to return the contacts from the fully-spread position to the normal position; provided the factory adjustment of the coiled spring has not been disturbed. See that there is no dirt or obstruction in the air gap at the rear end of the anti-hunt device armature.

Rheostat Motor Control Relays

62. The auxiliary contacts on the "NR" and "NL" relays should close at about the same time as the main contacts. An adjustable capacity condenser is connected in parallel with the coil on each of these contactors and this arrangement causes them to operate as definite-time-delay devices. The time-setting may be changed to suit the individual installation by changing the amount of condenser capacity. It is desirable however for the auxiliary contacts which complete the circuit to the condenser to close a small amount ahead of the contacts which energize the anti-hunt device coil. Contacts should be properly lined-up, contact-holding screws tight, and the main contact gap approximately 1/4-inch.

Quick-Response Contacts "QR" And "QL"

63. Alignment of parts, and inspection for dirt or foreign matter on the main contacts, should be checked. The action of auxiliary contacts should be inspected.

Field-Forcing-Up And Field-Reducing Resistor Setting

64. Initial trials should be made using the factory settings of the resistors. If necessary, the settings may be changed to obtain improved performance. Too much resistance across either set of contacts is likely to cause over-shooting of the voltage with consequently longer time for settling after a disturbance, and the possibility of hunting which the regulator may be unable to stop.

65. The setting of the field-reducing resistor depends upon the characteristics of the generator and the conditions under which it is to operate. With the voltage adjusted to its rated value through manual control of the motor-operated field rheostat the field-reducing resistor should, as a first approximation, be set to return voltage to normal after a large load change in the minimum time consistent with smooth operation. This resistor is introduced into the circuit by the opening of the normally-closed field-reducing contactor. For the purpose of testing the adequacy of the resistor adjustment, this contactor may be opened manually. Several values should be tried, in order to determine best operation. More than the required amount of resistance is supplied in order to take care of unusual circumstances. Only that portion which is required for the particular installation, should be used.

Motor-Operated Main Field Rheostat

66. The motor-operated rheostat is of the open-frame construction, with heavy-duty faceplate provided with 200 contact segments in circular

arrangement, which are connected on the rear to suitable resistance units mounted in the upper portion of the rheostat frame. The rheostat frame is designed so that the contactor panel may be mounted on the front lower portion below the rheostat faceplate.

67. The motor-operated rheostat provides means for changing resistance in the a-c. generator field circuit either by manual control, or under control of the type "BN-2" voltage regulator element. The voltage regulator controls the voltage of the a-c. generator by varying resistance in the generator field circuit by means of the motor-operated rheostat. When the a-c. voltage is normal the rheostat is stationary. For small deviations from normal voltage the regulator operates to change the position of the rheostat thus effecting the required change in field current to bring the generator voltage back to normal.

68. A d-c. motor of the split-field, series-wound type, is used to operate the rheostat. This type of motor permits readjustment of speed to meet operating conditions and requires minimum control apparatus. Tapped resistor "R-6" connected in series with the motor armature is provided for speed control. This resistor should be set to give a rheostat travel of 20 seconds from one extreme limit to the other limit. This is the factory setting.

69. Arm movement should be free and limit switches operating properly.

70. After the rheostat is in place and ready for service, the small vent screw in the gear box should be removed providing a "breather" for the gear box. If this is not done changes in temperature may force some of the lubricant out through otherwise tight packing seals.

71. The rheostat assembly in addition to the rheostat resistance also includes the field-forcing-down resistor "R-5" and field-forcing-up resistor "R-3", each of which is provided with a slider for adjustment. Initial trials should be made using the factory settings of the resistors. If necessary, the setting may be changed to obtain improved performance.

Reactance Compensator

72. As noted under "Cross-Current Compensation" one cross-current compensator and one current transformer are furnished with each regulator for the purpose of making the generators share proportionally the reactive load. Care should be taken to see that the current transformer and compensator external connections agree with the wiring diagram.

73. The correct connections between the current transformer, compensator and voltage regulator can be determined as follows:

Step 1. Set compensator dial switches at zero compensation.

Step 2. By governor adjustment, pick-up approximately 1/2 load on the generator.

Step 3. Increase the lagging reactive kv-a. of generator by turning the control switch of the motor-operated rheostat in the direction to raise voltage.

Step 4. Turn the regulator control switch to the "INDICATING" position and balance regulator by means of voltage adjusting rheostat until indicating lamps "RL" and "LL" burn brightly.

Step 5. Increase compensation by moving dial switches on the compensator until the "LL" lamp blinks. If the "RL" lamp blinks the compensation is reversed and should be corrected by reversing the current-transformer connections at the compensator terminals "C" and "CO".

CAUTION - Avoid opening the secondary of an energized current transformer.

Step 6. After the proper connections of all current transformers have been checked independently, the correct value of compensation will have to be determined by operating conditions. 6% Compensation is ample for the usual application. A smaller amount may be used provided satisfactory division of reactive kv-a. between machines is secured. Once the proper connections and setting of the compensator have been made, no further adjustment or attention is required.

Step 7. If it should be necessary to operate generators at different power factors, this adjustment should be made by means of the regulator voltage adjusting rheostat.

Illustrations

74. See Figures R-1 to R-4 included in Part VI of this Instruction Book.

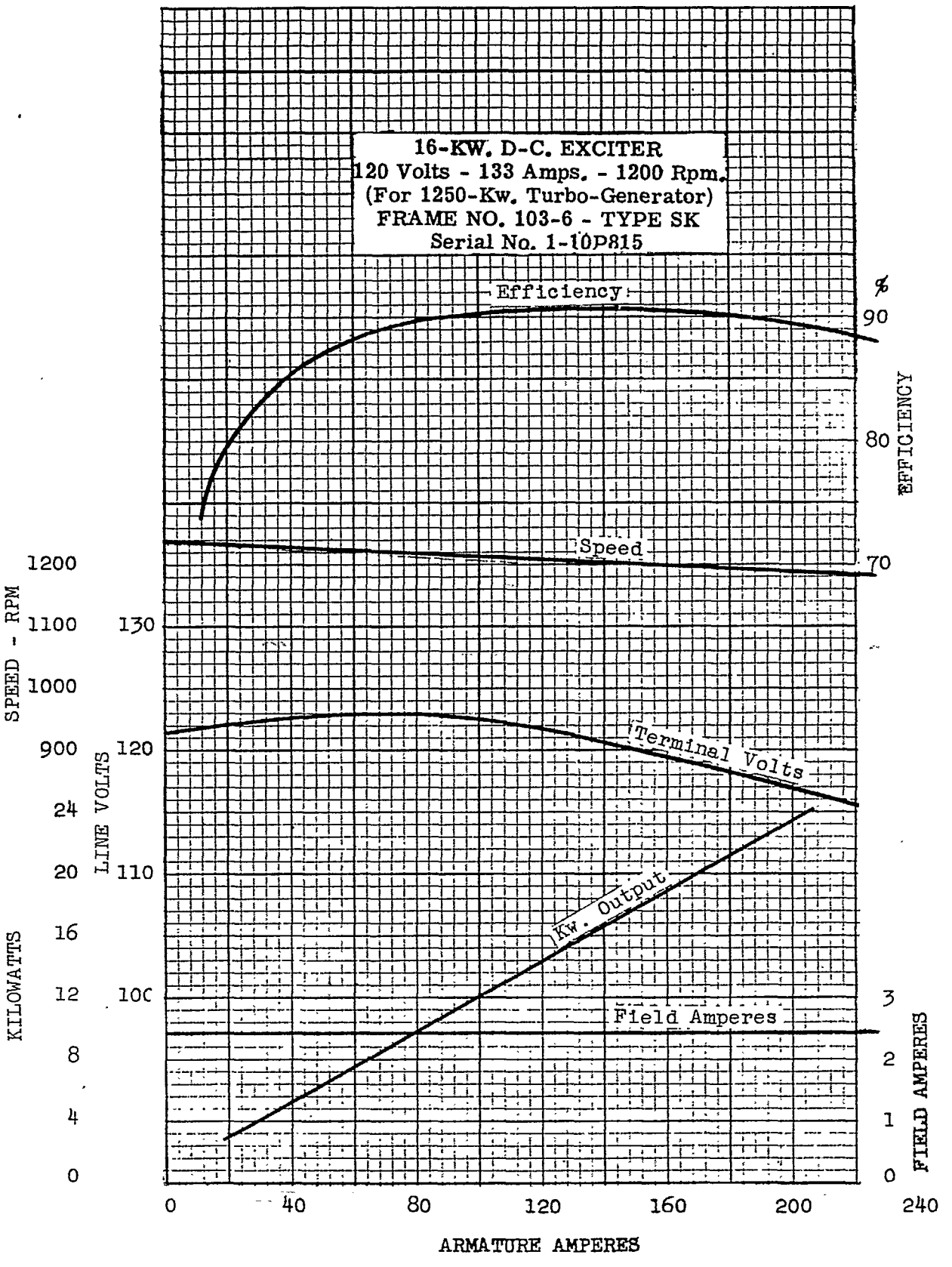
Spare Parts

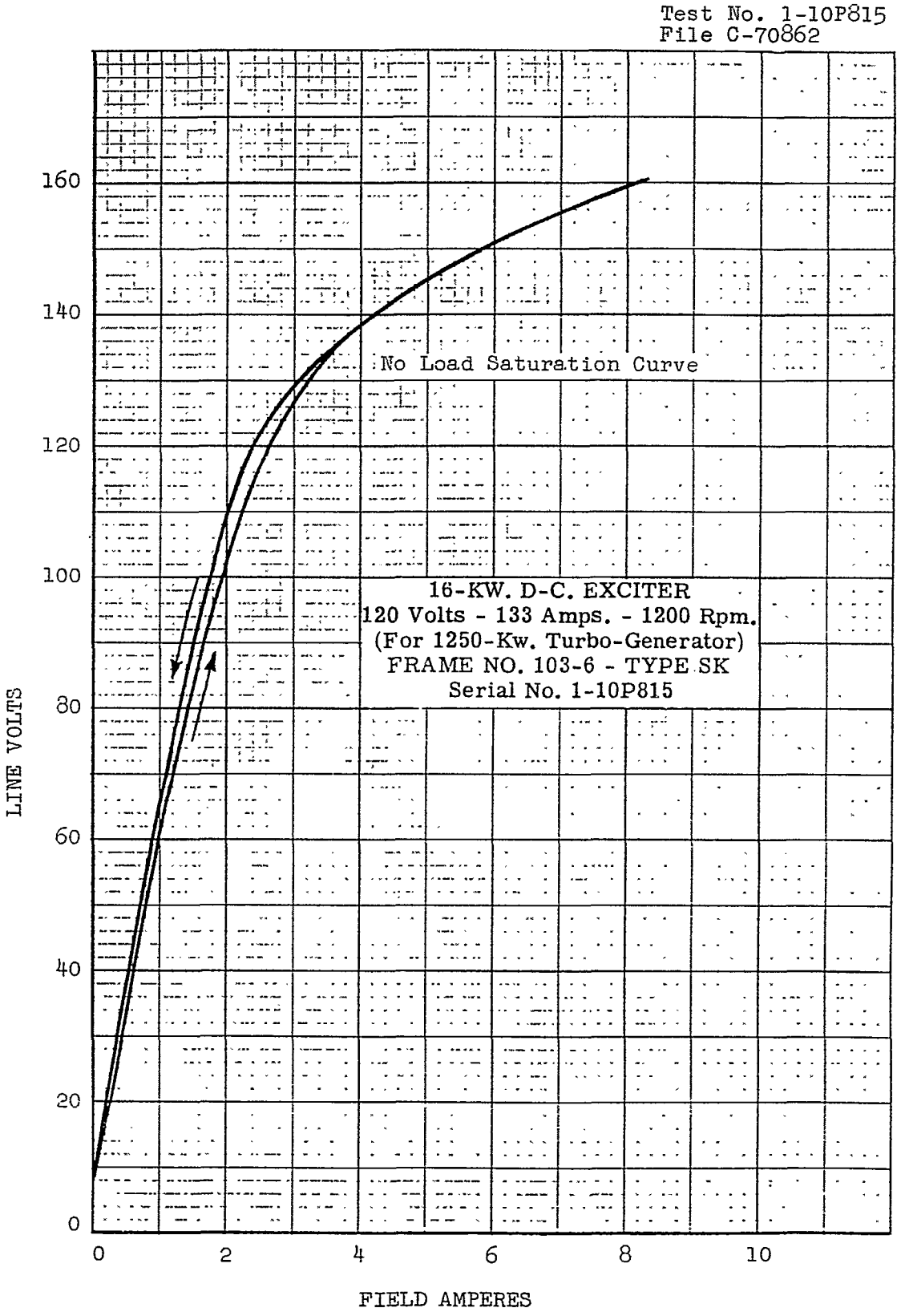
75. A list of Spare Parts as supplied with the original equipment will be found in Pages 509 to 514, Part V on this Instruction Book.

PART IV

PERFORMANCE DATA AND TESTS

Test 1-10P815
File C-70862




Test No. 1-10P815
File C-70862
No Load Saturation Curve
16-KW. D-C. EXCITER
120 Volts - 133 Amps. - 1200 Rpm.
(For 1250-Kw. Turbo-Generator)
FRAME NO. 103-6 - TYPE SK
Serial No. 1-10P815
LINE VOLTS
0
20
40
60
80
100
120
140
160
0
2
4
6
8
10
FIELD AMPERES

Test No. 1-10P815
File C-70862

(r) Tests or generator shunt field rheostat—*Continued.*

Resistance gradation (step by step), voltage drop per step, rheostat in "all in" position, holding the current constant

Temperature rises, at normal setting 71.5 volts drop across rheostat and 2.54 amperes:- 130°C. rise on resistance imbedding material, 43°C. rise for air one inch from edge of rheostat plates, at room air temperature of 27°C.

Dielectric strength: Volts 1600 Time 1 Minute Remarks OK.

Insulation resistance: (a) Cold, 25 ° C. 120 megohms. (b) Hot, 50 ° C. 700 megohms.

(s) Tests of miscellaneous spares (enumerate articles and state character of inspection and tests) All spares checked for interchangeability.

(t) Tests of spare armatures: Running tests. Each of the 4 spare armatures were given complete Routine Tests including - No-Load Saturated Curves, Voltage Regulation, Overload and Overspeed.

Cold resistance .022 ohms, at 26.5 ° C.

Insulation resistance 100 ohms, at 40 ° C.

Dielectric strength: Volts 1600 Time 1 Min. Remarks OK

(u) Does the generator meet the specifications in every respect Yes. This test record represents the performance of 16 similar generators - Serials No. 1 to 16-10-P-815. All were given Routine Tests per Navy Specifications 17G7.

(v) Tests made at Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Inspector's signature (Signed) J. J. Courtin

See 2 attached curve sheets marked 1-10P815.
This type test also represents 16 exciters, Serials No. 1 to 16-13P148 for BB63-64, and will represent 16 more exciters, Serials No. 1 to 16-15P187 for BB65-66, when they have been tested.

Test No. 1-10P815
File C-70862

(k) No-load saturation curve at normal rated speed (speed remaining constant throughout test):

ASCENDING		DESCENDING	
Generator volts	Shunt field amperes	Generator volts	Shunt field amperes
3.8	0	161	8.25
45.2	.74	149	5.58
59.8	1.02	134	3.56
77.9	1.36	120	2.43
98.6	1.84	103.4	1.82
108.4	2.13	88.6	1.54
120.0	2.57	73.4	1.18
139.8	4.12	54.5	0.85
161.0	8.25	49.8	0.76
		3.8	0

NOTE.—Plot curves on cross section paper, using above data, and attach them to this test report.

(l) For test data concerning voltage and speed regulation, parallel operation, heating, overload, and input—output, refer to Test Record ____ on supplementary Form ____ attached hereto.

(m) Commutation:

0–100% load, with gradual changes in load: Satisfactory — Comm. #1
0–125% load, with rapid changes in load: Satisfactory — 1
150% load: Satisfactory — 1

(n) Efficiency:

I^2R losses in windings	49.2	197	444	786
~~Bearing friction and windage~~				
~~Brush friction~~				
Core losses & F & W	555	555	555	555
Brush contact I^2R loss	66	132	200	266
~~Stray load losses~~ Loss	127.3	126	122	116
~~Miscellaneous losses~~				
Calculated efficiency at ¼ load	83.5	½ load 89.0	¾ load 90.2	¼ load 90.3

(o) Overspeed: R. P. M. 1500 Time 15 Min. Remarks Satisfactory

(p) Dielectric strength: Volts 1400 Time 1 Min. Remarks Satisfactory

(q) Insulation resistance, megohms:

Following dielectric strength tests .4 Megohms at 50 ° C.
After generator has cooled down .45 Megohms at 25 ° C.

(r) Tests of generator shunt field rheostat:

Manufacturer Westinghouse Elec. & Mfg. Co. Serial or type No. Style No. 1169119
Number of resistance steps 66 in main plates, and 33 in 2 ohm vernier. Total resistance, cold (approx. 25° C.) 36.95 ohms

Range of voltage adjustment, per cent of rated voltage, volts	Number of resistance steps included in the range	Voltage variation per step, per cent of rated voltage	Resistance cut into circuit, or variation in resistance, to cover voltage range, ohms
Minimum to 90 per cent 102.5 to 108			
90 per cent to 105 per cent 108 to 126			
90 per cent to 96 per cent 108 to 115			
96 per cent to 105 per cent 115 to 126			

With generator operating without load, at rated speed:

Rheostat position	Shunt field amperes	Generator volts
All in	1.24	102.5
All out	7.65	162
Normal-load setting	2.38	120

Revised 4 Jan. 1943

TEST No. 1-10P815
File C-70862

Date 28 April 1941

FACTORY TEST RECORD—D. C. GENERATORS

ISSUED BY THE BUREAU OF ENGINEERING, NAVY DEPARTMENT

To be used in connection with Navy Department Specifications 17G7 of latest issue

PRIME MOVER

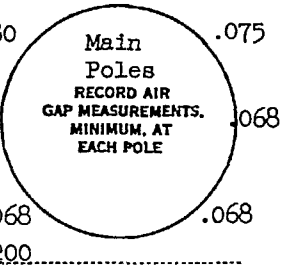
Manufacturer .....
Manufacturer's serial No. .....
Refer to Test Record on supplementary Form ....., attached.

GENERATOR - EXCITER

(a) Manufacturer Westinghouse Electric & Manufacturing Company
Manufacturer's type and class Type SK - Frame #103-6 WG-31965-TP
Schedule No. ..... Contract No. 70862 Navy Yard (or shipyard) Dwg. 5-A-9812
To be installed on U. S. S. Iowa - BB61; U.S.S. New Jersey - BB62.

(b) Generator classification:

(1) Prime mover Turbine
(2) Degree of inclosure Drip-proof - open
(3) Method of cooling Natural
(4) Distribution system
(5) Maximum unbalance in neutral (if 3-wire)
(6) Type of insulation, class A
(7) Voltage 120 Kilowatt 16 R. P. M. 1200



(c) Generator serial No. 1-S-10P815 Armature serial No. 1-R-10P815
Weight of generator 1161 Weight of armature 250
Number of poles 6 Diameter of armature 12 Diameter of commutator 9-1/4
Number of brush studs 6 Number brushes per stud 3 Brushes per set 18
Brush size 1-1/2 x 3/4 x 3/4 Brush grade B Brush manufacturer Stackpole Carbon
Collector ring brushes: Number None Size ..... Grade ..... Manufacturer .....

(d) Resistances:

	Calc. - At 75°C.	(Cold) 25° °C.	(Hot) 63° °C.
Armature	.02660	.02230	.02640
Shunt field	23.15.	19.4	22.2)
Series field	.01018	.008525	.00979)
Interpole field	.00770	.006455	.00740) Calc.
Compensating field (if used)			

(e) Adjustment, fit, and materials Satisfactory in accordance with approved plans and specifications.

(f) Effectiveness of inclosure (type tests) Drip-proof as specified.

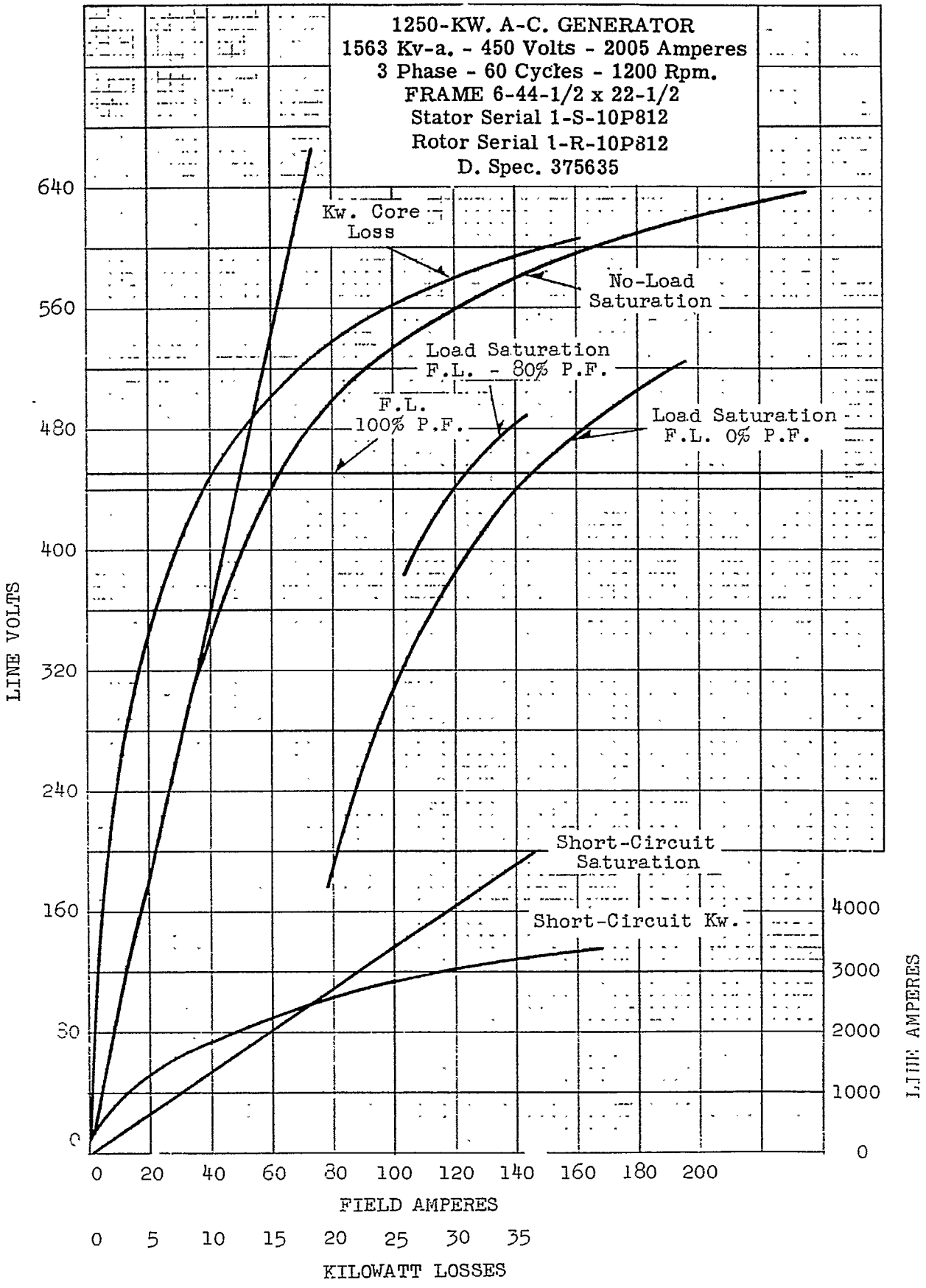
(g) Noise Not excessive.

(h) Balance Good

(i) Lubrication Oil - Navy Symbol 2110.

(j) Inclined operation 15° inclination test run made with exciter coupled to generator Serial No. 1-10P812
To be made on turbo-generator combined unit tests.

Curve No. 266180



Test No. 1-10P812
File C-70862

15. Insulation resistance (on each generator, see par. F-17):
(a) Insulation resistance in megohms: R = Rotor S = Stator.
(1) R100, S100 megohms, while generator is hot (approximate temperature of generator 70 °C.)
(2) ..... megohms, after generator has cooled (approximate temperature of generator ..... °C.)

16. Tests of generator field rheostat (with generator for which intended, see par. F-19): Face Plate Type, S#444485
(a) Heating and smoothness of voltage adjustment (at least one of each size and type on order): #5-44-Y-485 L&M-83Y500
(1) Temperature rise at generator rated load: 123 amperes and 63 volts drop in rheostat set on contact segment #24.
(a) Metal of resistive conductor ..... 293 °C.
(b) Imbedding material ..... None °C.
(c) Issuing air, 1" from resistor in top row 270 °C. Issuing air 1 foot above top row of resistors-- 96°C.
Resistance of gen. field at 40°C. is .464 ohm
(2) Smoothness of voltage adjustment:
(a) Range of close voltage adjustment from 90% 405 volts to 105% 472 volts.
Steps No. V66 to V58 Variation .75% 3.4 volts per step between 90% 405 volts and 96% 432 volts.
Steps No. V58 to V40 Variation .5% 2.2 volts per step between 96% 432 volts and 105% 472 volts.
(3) Smoothness of grading the resistance:
(a) Field current with no load maximum 179 amps., minimum 23 amps.
(b) Open circuit generator voltage for each rheostat point; voltages: Max. 610, Min. 368
(b) Check tests (on each rheostat with generator for which intended):
(1) Dielectric test of 1,500 volts, 60 cycle A. C. for one minute OK. Insulation Resistance 400+ megohms.
(2) Total ohmic resistance of rheostat 4.8 ohms.
(3) Graduations in the resistance, steps 149. Step to step resistances OK by volts drop test.
(4) Other comparisons with rheostat given complete test: Satisfactory.

17. Tests of automatic voltage regulator (see par. F-20): N.D. Spec. 17-R-2. Only Tests on component parts here:-
NOTE.—This test shall be made and reported on combined unit test (Form ISM-36A or B).
Parts were given standard tests for control equipment. Each voltage regulator element /

18. Tests of generator spares (all spares, see par. F-18): Spare Parts List on Dwg. No. 31-J-651.was calibrated.

ITEM	SPARE PARTS AS APPLICABLE TO GENERATOR FURNISHED	INSPECTION TESTS AND COMMENTS
A	Rotors, complete in every respect Serial No. 1-R-10P813,	2-R-10P813, 1-R-13P146, 2-R-13P146
	(a) Revolving field Tested in Frame	Tested in Fr. No.
	(b) ~~Revolving armature~~	Tested in Fr. No.
B	Bearings or bearing linings (sleeve bearings shall be complete sets)	OK
C	Oil gages for sleeve type bearings (one complete unit of each type)	None
D	Brushes, carbon, complete set	OK
E	Brush holders, complete (three extra springs for each)	OK
F	Brush rigging insulation (complete sets of insulating pieces used)	OK
G	Coils of each size and type—including stator coils (complete sets)	OK Resistance readings Checked
H	Slot insulation (complete sets)	OK
I	Slip rings (complete assembly)	OK
J	Bearing lubricant seals (sets)	OK
K	Tools Packed with Exciter Spares.	OK
L	Protection and boxing Steel Boxing. Spec. 42B9	OK

19. Does the generator and spare parts meet the contract or order specifications and approved plans in every respect? Yes. This type test represents 32 generators, Serials No. 1 to 16-10P812, No. 1 to 16-13P145, 4 spare rotors above, and will represent 16 generators, Serials No. 1 to 16-15P184 for BB65-66, when these have been tested. A routine test was made on each generator. The 2nd generator given temperature tests as in Par. 11 was Serial No. 5-13P145; the rises were nearly the same as for this 1st generator, Serial No. 1-10P812.

Tests were made at the East Pittsburgh Works of the Westinghouse E. & M. Co. (1st on 7/1/41)

Inspector's signature,
(Signed) F.C. Hartman

Test No. 1-10P812
File C-70862

11. Heating (see par. F-13):

Specified ambient temperature 50 °C.

MAXIMUM TEMPERATURE RISES

Name of Part. Here list names of parts on which temperatures are recorded. (See table 1, appendix 1)	On Each Generator: At 100% load with designed P. F.		On at Least One Generator of Each Size and Type on Each Order: At 125% load for 5 hr designed P. F.		At 150% load for 5 min. with designed P. F.		At 150% load for 5 min. with 0.5 P. F.	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
Stator Core	32.5		47.5		22.5			
Stator Copper	24	*40.5	38.2	*60	23			
Stator Copper	#41.5		#60		#29.5			
Rotor Copper	31	31	62					
Air Gap Iron	29.5		42					
Collector Rings	49		37					
Dampers	24		33					
Front Bearing	13							
Stator Res., Phase A-C. in ohms - .00130							.00113	at 21°C.
Gal. of Water/minute through Cooler		50		50				
Temp. of Water going in Cooler		26°C.		24°C.				
Temp. of Water out of Cooler		29°C.		28°C.				
Temp. of Air blowing out of Cooler		43°C.		48°C.				
Temp. of Air blowing in Cooler		32.5°C.		31.5°C.		30.5°C.		
Temp. of Room Air		24°C.		29°C.				
Ambient Temperature	31°C.		31°C.		30°C.			

Comments: *By temperature detectors, Method 3. # By thermo-couple put on for test. Ambient temperature for forced air-duct ventilation.

12. Efficiency (one of each size and type on each order, see par. F-14):

(a) Conventional efficiency losses in ~~kva~~ kilowatts:	½ Load	¾ Load	¼ Load
(1) I^2R loss in ~~rotor~~ and stator			8.24
(2) Friction and windage loss			8.52
(3) Core loss			10.05
120 x fld.amp. (4) Brush contact loss and I^2R in rotor & rheostat			14.82
(5) Stray load losses			4.38
(6) Miscellaneous losses			
(a) Excitation energy losses			
(b) Field rheostat losses			
(c) Blower losses			
(d) Direct connected exciter loss (if used exclusively for excitation)			2.03
(7) Totals			48.04

(b) Calculated efficiency at ½ load 94.8 %; ¾ load 95.9 %; ¼ load 96.3 %. 5/4-load-96.5% 1/4-load-91.2%

(c) Alternate methods:

13. Overspeed (on each generator, see par. F-15):

(a) Maximum overspeed 1500 r. p. m. (25% greater than normal for 30 minutes).

(b) Check for: Noise Not excessive Dynamic balance and smoothness of running Satisfactory

Evidence of distortion None Injury None apparent.

Noticeable change in condition of any part (comment):

14. Dielectric strength (on each generator, see par. F-16):

(a) Test voltage applied each circuit Stator 2000 volts. To space heaters 1600 volts.

(b) Test voltage applied field windings 2600 volts. To imbedded temperature detector coils 1600 volts.

Comment: All OK.

Test No. 1-10P812
File C-70862

2. Effectiveness of enclosure (on each type, see par. F-4) Satisfactory for totally-enclosed, drip-proof. Due to closed system of ventilating air ducts, a suction of .7 inch of water is developed in the end bells and therefore the end bell hand hole covers should be kept tightly closed.

3. Inclined operation (at least one of each size and type on each order, see par. F-5)
NOTE.—This test shall be made and reported on combined unit test (Form INM-36 A or B).

Test on Space Heaters:- Stator winding temperatures after space heaters had been on 2 hours were 38°C. on Right Front, 32° on Lt. Fr., 26° on Rt. Rear, 25° on Lt. Rear with Room Air 22°C.--therefore space heaters should keep windings an average of 8°C. above room temperature.

4. Noise (on each generator, see par. F-6)
NOTE.—This test shall be repeated and reported on combined unit test (Form INM-36 A or B).

Not excessive.

5. Balance (see par. F-7):

(a) Mechanical balance (on each generator) Good. Each generator tested with its exciter assembled.
NOTE.—This test shall be repeated and reported on combined unit test (Form INM-36 A or B).

(b) Electrical balance (on each generator) Good. Voltage balance within 1% variation.

(c) Phase unbalance (at least one generator of each size and type on each order) Voltage unbalance 3.1% on
NOTE.—This test shall be repeated and reported on combined unit test (Form INM-36 A or B).

single-phase resistance-rack load of 25%: 503 amperes and phase voltages of 450, 436, and 436. Order of phase rotation for line terminals: A-B-C.

6. Lubrication: (At least one generating unit of each size and type on each order, see par. F-8)
NOTE.—This test shall be repeated and reported on combined unit test (Form INM-36 A or B).

(a) Temperature rise (on complete tests) 13°C. on Front bearing.

(b) Does lubricating system perform satisfactorily? (Other machines on order.) Yes, on each machine. Pressure-fed oil lubrication.

7. Voltage regulation, S. C. ratio and transient reactance (see par. F-9):

(a) Combined unit inherent voltage regulation
(At least one of each size and type, see pars. F-9 and F-20)
NOTE.—This test shall be made and reported on combined unit test (Form INM-36 A or B).

(b) Generator inherent voltage regulation 25.1% See Curve No. 266180. (Page 409)
By method No. 2—saturation curves ____ percent (each generator).

(c) Short circuit ratio (at least one of each size and type on each order) 1.068

$$\frac{\text{Field current at rated open circuit armature voltage and rated frequency}}{\text{Field current at rated armature current on sustained symmetrical short circuit at rated frequency}} = \text{short circuit ratio.}$$

(d) Transient reactance (at least one of each size and type on each order). Oscillogram No. L-1526, Curve 264085.
Transient reactance 19.8 percent. Subtransient reactance 15.1%

8. Parallel operation (all generators, see par. F-10)
NOTE.—This test shall be made and reported on combined unit test (Form INM-36 A or B).

Test on space heaters:- 4 units in parallel, Style No. 1085726; 115 volts, 250 watts each; Measured input 115 volts, 8.6 amperes.

9. Wave shape (at least one generator of each size and type on order, see par. F-11):

(a) Deviation factor on all phases by means of oscillograph: Oscillogram No. P-1087, Field Amperes 118.5:-
On open circuit terminal voltage 564 volts 9.5 percent.
On 125 percent rated load voltage 21st.4% 11th.5 percent.; 9th.5%; 7th 1.0%; 5th 1.3%;
Harmonics in voltage wave 27th .5%; 25th 5.16 percent. 23rd 4.40%; 1st 99.75%; 3rd .6%.

10. Short circuit (on each generator, see par. F-12)

(a) Condition of windings after single phase dead short circuit for 2 minutes No change evident.

(b) Condition of windings after three phase dead short circuit for 2 minutes No change evident.

Comments: 2760 sustained short-circuit amperes on 3-phase test with 79.2 amperes in field. 4074 sustained short-circuit amperes on single-phase test with 76.4 amperes in field.

Test No. 1-10P812
File C-70862

Date 4 January, 1943

FACTORY TEST RECORD—A. C. GENERATORS

ISSUED BY THE BUREAU OF ENGINEERING, UNITED STATES NAVY DEPARTMENT

To be used in connection with Navy Department Specifications 17G8 of latest issue

IDENTIFICATION DATA

CONTRACT OR ORDER DATA:

Contractor Westinghouse Electric & Manufacturing Company

Navy contract or shipbuilding order No. NOs. 70862 Date 11 January, 1940

To be installed on U. S. S. IOWA BB61, NEW JERSEY BB62, MISSOURI BB63, WISCONSIN BB64, ILLINOIS BB65, KENTUCKY BB66.

Navy Yards: Brocklyn and Philadelphia.

PRIME MOVER DATA:

Type and manufacturer Geared Steam Turbine by Westinghouse E. & M. Co., Essington, Pa.

Manufacturer's serial No.

Refer to factory test record Nos.

VOLTAGE REGULATOR DATA:

Type and manufacturer Navy Type "BN-2". Westinghouse Electric & Manufacturing Company

Uniform specification data plan—manufacturer's No. 31-J-276 Bu. Eng. No. BB61-S61-____ *

Rheostats or resistances serial Nos. S.O. 83-Y-500 Dwg. 31-J-483 BB61-S61-____ *

Refer to factory test reports on voltage regulator and rheostat component units See remarks in paragraph 17.

(Forms INM-23 and 35) Nos. (attached).

D. C. GENERATOR (EXCITER) DATA:

Type and manufacturer Type SK-103-6. Westinghouse E. & M. Co. Serial No. 1-10P815

Uniform specification data plan manufacturer's No. 5-A-9812 Bu. Eng. No. BB61-S61-097

Exciter rating: Volts 120 Kw. 16 Amperes 133

Refer to factory test report (Form INM-22) Nos. 1-10P815 (Pages 410-414) (attached).

A. C. GENERATOR DATA:

For (service application) Ships Power and Light

Type and manufacturer Special Fr. 6-44-1/2 x 22-1/2 by Westinghouse E. & M. Co. WG31965-TP

Uniform specification data plan manufacturer's No. 31-J-651 Bu. Eng. No. BB61-S61-083

Rating: Kw. 1250 P. F. 80% Kv.-a. 1562 Amperes 2005

Voltage 450 Phases 3 Cycles 60 R. p. m. 1200

Generator serial No. 1-S-10P812 Rotor serial No. 1-R-10P812

INSPECTION AND TEST DATA

(Refer par. F-1)

1. Adjustment, fit, material, and weight (on each generator, see par. F-3):

(a) Materials According to plans and specifications.

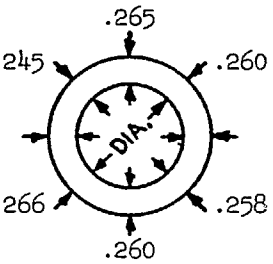
(b) Workmanship Good

(c) Fit Good

(d) Adjustment Satisfactory

(e) Air gap measurements (record on figure at right) Average .260 inch

(f) Does design conform in all particulars with approved plans? Yes.



(g) Weights:

(1) A. C. generator	12,638 lb.		
(2) D. C. exciter	1,145 lb.		
(3) A. C. generator with exciter (complete)	13,783 lb.	Total.	
(4) A. C. rotor	5,055 lb.		
(5) D. C. armature	240 lb.		
(6) A. C. generator spares (less spare rotor)	6,137 lb.	for 8 generators.	4354#)Without
(7) D. C. exciter spares (less spare armature)	127 lb.	for 8 generators.	92#) Boxes
(8) A. C. generator field rheostat	1,200 lb.		
(9) D. C. exciter field rheostat	30 lb.		

* Not available at date of publication.

PRELIMINARY FACTORY TEST REPORT

JUMP TEST

1250-KW. TURBO-GENERATOR TURBINE SERIAL 1-A-9179-1

% LOAD	KW. LOAD	THROTTLE Pres.	THROTTLE Temp.	EXHAUST Vacuum	SPEED Rpm.	CONDITION
100	1248.0	540	750		1200	Steady
0	0				1280	Jump
0	0	540	750		1240	Steady
100	1248.0				1160	Jump
100	1248.0	540	750		1200	Steady
125	1404.0	540	750		1192	Steady
0	0				1290	Jump
0	0	540	750		1240	Steady
125	1404.0				1150	Jump
125	1404.0	540	750		1192	Steady

PARALLEL TEST

1250-KW. TURBO-GENERATOR TURBINES SERIAL 1-A-9179-1 and 1-A-9179-2

LOAD	THROTTLE Pres.	THROTTLE Temp.	EXH'ST Vacuum	SPEED Rpm.	WATTS 1-2	WATTS 2-3	LOAD KW.	LOAD	THROTTLE Pres.	THROTTLE Temp.	EXH'ST Vacuum	SPEED Rpm.	WATTS 1-2	WATTS 2-3	LOAD KW.
[illegible]	[illegible]	[illegible]	28.4	1230	142	110	300								
[illegible]	[illegible]	[illegible]	28.4	1225	229	220	538.8								
[illegible]	[illegible]	[illegible]	28.4	1216	310	325	762.0								
[illegible]	[illegible]	[illegible]	28.4	1210	418	436	1024.8								
[illegible]	[illegible]	[illegible]	28.4	1200	508	542	1260								
[illegible]	[illegible]	[illegible]	[illegible]	1190	640	685	1590								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28.4	1202	528	736	1277.2
[illegible]	[illegible]	[illegible]	[illegible]	1210	[illegible]	[illegible]	1039.6	80	540	790	28.4	1210	440	436	1051.2
[illegible]	[illegible]	[illegible]	28.4	1215	[illegible]	[illegible]	[illegible]	60	540	770	28.4	1215	307	318	750.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28.4	1224	220	218	532.4
[illegible]	[illegible]	[illegible]	28.4	[illegible]	[illegible]	[illegible]	234.4	20	540	775	28.4	1230	115	130	301.6

PRELIMINARY FACTORY TEST REPORT

LOAD-TEMPERATURE TEST

1250-KW. TURBO-GENERATOR

TURBINE SERIAL 1-A-9179-1

% Load	THROTTLE Pres.	THROTTLE Temp.	EXH'ST Vacuum	SPEED Rpm.	COOLER OIL In	COOLER OIL Out	COOLER WATER In	COOLER WATER Out	SPINDLE BRG'S No.1	SPINDLE BRG'S No.2	PINION BRG'S No.1	PINION BRG'S No.2	GEAR BRG'S No.1	GEAR BRG'S No.2	GEN. BRG'S No.1	GEN. BRG'S No.2	THRUST BRG.	OIL PRES. Gov.	OIL PRES. Brg.	KW. LOAD
0	540	730	27.7	1239	143	120	34		125	154	125	123	110	113	95	97	113	86	17	0
20	540	755	27.8	1228	143	120	34		125	154	125	123	110	113	95	97	113	87	16	248.9
40	540	800	29.0	1224	143	120	34		125	154	125	125	110	113	95	97	113	85	16	504.0
60	540	825	29.0	1216	143	120	34		125	154	125	125	110	114	95	97	114	85	15	756.0
80	540	815	28.8	1210	143	120	34		125	166	125	125	110	115	95	98	114	85	16	1014.0
100	540	740	29.0	1202	143	120	34		127	170	125	129	110	115	95	100	114	85	16	1248.0
125	540	750	29.0	1190	143	120	34		127	170	125	130	110	115	95	98	114	83	16	1584.0
100	540	750	29.0	1200	143	120	34		130	170	125	130	110	115	95	98	115	85	16	1248.0
80	540	760	28.9	1210	143	120	34		130	168	125	127	110	115	95	97	115	85	16	1002.0
60	540	780	28.9	1213	143	120	34		130	160	125	126	110	115	95	97	115	85	16	762.0
40	540	790	28.9	1222	143	120	34		130	156	125	126	110	115	95	97	115	85	16	498.0
20	540	790	28.2	1230	143	120	34		128	156	125	125	110	115	95	97	115	85	16	246.0
0	540	790	28.0	1236	143	120	34		125	154	125	125	110	115	95	97	117	85	16	0

150% LOAD NORMAL STEAM & VACUUM

Max.	540	820	28.0	1173	143	120	34		126	164	122	125	110	112	94	97	116	82	16	1980

80% LOAD NORMAL STEAM & VACUUM

Max.	432	815	29.0	1167	143	120	34		128	162	122	125	110	115	94	97	114	82	16	1476

11. With gradual changes in load from 0% to 125% the variations in speed expressed in percentage of normal operating speed was within 4% of normal full-load speed.

12. With gradual changes in load from 20% to 100% the variations in speed expressed in percentage of normal operating speed was within 3% of normal full-load speed.

13. One unit was tested with the oil cooler out of service for a period sufficient to permit the tube bundle to be removed and replaced.

PART IV

PERFORMANCE DATA TESTS

1. The following data were obtained during tests conducted at the plant of the manufacturer.

STEAM CONDITIONS

NORMAL

Pressure at throttle ..... 540 lb/sq. in. gage
Total temperature at throttle ..... 825 deg. F.
Exhaust pressure ..... 1 lb/sq. in. absolute

2. When operating under the normal steam conditions, as given above, the following performance was obtained:

Kw. Load on A-C. Generator	Kw. Load on D-C. Exciter	Total Steam Consumption Lbs/Hr.	Water Rate Lbs/Kw./Hr.
625.0	Excitation	6841	10.946
937.5	Excitation	9649	10.292
1250.0	Excitation	12530	10.024
1562.5	Excitation	15700	10.048

3. The performance curve for the above tests is shown in Figure T-33.

4. The turbine is also capable of delivering 1250 kw. (full load on a-c. and d-c. machines) with 432 lb/in^2 gage throttle pressure, 825° F. total temperature and 1 lb/in^2 absolute, back pressure.

5. When operating under normal steam conditions the turbine carried 150% load 1875 kw. on a-c. generator plus excitation for a period of five minutes.

6. The parts of the turbines subjected to high steam pressures and temperatures were tested hydraulically as follows:

Steam Inlet Pipe ..... 930 lb/in^2 gage
Throttle Valve ..... 930 lb/in^2 gage
Steam Chest Chamber of Turbine Casing . 930 lb/in^2 gage
Turbine Casing (H.P. End) ..... 450 lb/in^2 gage
Turbine Casing (L.P. End) ..... 50 lb/in^2 gage

7. The turbine exhaust casing relief valve was set at 10 pounds gage, and the sentinel valve at 2 lb/in^2 gage.

8. The excess back-pressure safety trip was set to trip the throttle at 5 lb/in^2 gage.

9. The low oil pressure alarm switch was set to operate at 4 lb/in^2 gage.

10. The overspeed trip mechanism was set to operate at 10% above normal full-load speed (or 1320 rpm. of the generator), and will trip the throttle within 8% to 12% above normal full speed.

PART V

SPARE PARTS AND TOOLS

LIST OF SPARE PARTS AND TOOLS

PER VESSEL

REPRODUCED FROM MFRS. DRAWING NO. 31-J-651 **BUREAU NO.** BB61-S61-083

NAMES AND NUMBERS OF VESSELS: BB61 TO 64 INCLUSIVE

8 GENERATORS PER VESSEL. ONE SET OF SPARES CONSISTS OF ITEMS 1 TO 14 INCLUSIVE

APPLICATION SHIP'S POWER & LIGHT

NAVY CONTRACT NOs 70862 **APPLIANCE** 1250-KW. A-C. GENERATOR

SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO. PC.	MFRS. DRAWING AND PIECE NO. DWG. NO.	PC.	DWG. NO.
1	1	1	Rotor Complete in Every Respect (Revolving Field) Stored at Navy Yard	D. 31-J-656 Items 2-3-4-6-7	2-3 4-6 7	31-J-656		
				D. 31-J-652 Item 11 850 Pounds Per Machine + Item 17	11 17	31-J-652		
			For All Replacements Order the Following Parts Drawing 31-J-652, Item 12 1940 Pounds Per Machine + Items 15, 16, 18. 31-J-657 Group #3	D. 31-J-652 Item 12 1940 Pounds Per Machine+ Items 13 To 16	12 13 TO 16	31-J-652		
				D. 31-J-657 Group #1	5 TO 64	31-J-657		
				D. 31-J-659 Group #2	27 TO 41	31-J-659		

BB61-U.S.S. Iowa
BB62-U.S.S. New Jersey
BB63-U.S.S. Missouri
BB64-U.S.S. Wisconsin

WG-31965-TP Spare Rotor S.O. 10-P-813 and S.O. 13-P-146

Spare Rotor for Use With 1250-Kw., A-C.Turbine Generator, Frame 6-44-22-1/2. Built on S.O. 10-P-812 and S.O. 13-P-145

Net Wt. 5050

LEGEND—
S—STYLE NUMBER
D—DRAWING NUMBER
L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NUMBER OF SHEETS 4 SHEET NUMBER 1

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. PER VESSEL 31-J-651 **BUREAU NO.** BB61-S61-083

NAMES AND NUMBERS OF VESSELS: BB61 TO 64 INCLUSIVE
8 GENERATORS PER VESSEL. ONE SET OF SPARES CONSISTS OF ITEMS 1 TO 14 INCLUSIVE

APPLICATION SHIP'S POWER & LIGHT

NAVY CONTRACT NO s 70862 **APPLIANCE** 1250-KW. A-C. GENERATOR

SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO.			
					PC.	DWG. NO.	PC.	DWG. NO.
2	2	72	Stator Coils Leads	D. 31-J-655 Items 1-2-3	1-2 3	31-J-655		
3	2	1 Set	Slot Insulation (Complete Set)	D. 31-J-655 Group #3	5-9,12 13,16 20,66	31-J-655		
4	2	6	Rotor Coils 2 Open 1 Open 2 Crossed 1 Crossed	D. 31-J-657 Items 5,6,14, 16 7,8 14,18 9,10,13,15 11,12,13,17, + 19,30,31,35, 36,37	5-19 30,31 35-37	31-J-657		
5	2	1	Bearing Lining	D. 31-J-658 Items 26-29	26-29	31-J-658		
6	8	8	Brushes, Carbon, Complete Sets	S. 1 240 018	26	31-J-659		
7	1/4	8	Brushholder Complete	D. 31-J-659 Items 15-22,24	15-22, 24	31-J-659		
8	3/4	8	Brushholder Spring	D. 31-J-659 Items 16,17, 18,20,21,22	16,17, 18,20, 21,22	31-J-659		
9	2	1	Brush Rigging Insulation	D. 31-J-659 Items 3-7	3-7	31-J-659		
10	8	2	Bearing Oil Seals	D. 31-J-658 Items 16, 31-34,40	16,31 To 34,40	31-J-658		
11	1	2	Oil Gages for Bearing	(Supplied by Turbine Builder)				
13	1	1	Collector Complete with Bushing	D. 31-J-659 Group #2	27-37 39-41	31-J-659		
14	8	1	End Bell Airseal	D. 31-J-668 Items 62-71	62-71	31-J-688		

WG-31965-TP Spare Parts S.O. 10-P-814 and S.O. 13-P-147

Spare Parts for Use With 1250-Kw., A-C. Turbine Generator Frame 6-44-22-1/2. Built on S.O. 10-P-812 and S.O 13-P-145

Generator Cooler Spares Supplied By Harrison Radiator Division, Lockport,N.Y.
BB61-U.S.S. Iowa
BB62-U.S.S. New Jersey
BB63-U.S.S. Missouri
BB64-U.S.S. Wisconsin

LEGEND—
S—STYLE NUMBER
D—DRAWING NUMBER
L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NUMBER OF SHEETS 4 SHEET NUMBER 2

LIST OF SPARE PARTS AND TOOLS

FOR TWO VESSEL

REPRODUCED FROM MFRS. DRAWING NO. 31-J-651 **BUREAU NO.** BB61-S61-083

NAMES AND NUMBERS OF VESSELS: BB65 AND BB66 ONLY

APPLICATION 8 GENERATORS PER VESSEL. ONE SET OF SPARES CONSISTS OF ITEMS 2 TO 15 INCLUSIVE SHIP'S POWER & LIGHT

NAVY CONTRACT NOs 70862 **APPLIANCE** 1250-KW. A-C. GENERATOR

SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO. PC.	MFRS. DRAWING AND PIECE NO. DWG. NO.	PC.	DWG. NO.
2	1	72	Stator Coils	D. 31-J-655 Items 1-2-3	1-2 3	31-J-655		
3	1	1 Set	Slot Insulation (Complete Set)	D. 31-J-655 Group #3	5-9 12-13 16-20 66	31-J-655		
4	1	6	Rotor Coils	D. 31-J-657	5 TO			
			2 Open	Items 5-6-14-16	19			
			1 Open	Items 7-8-14-18	30	31-J-657		
			2 Crossed	Items 9-10-13-15	35			
			1 Crossed	Items 11-12-13-17-+19-30-35-36-37-68	36 37 68			
			Spares for Storage Ashore BB65-U.S.S. Illinois BB66-U.S.S. Kentucky					

WG-31965-TP Spare Parts S.O. 15-r-104

Spare Parts for Use With 1250-Kw., A-C. Turbine Generator Frame 6-44-22-1/2. Built on S.O. 15-P-184

LEGEND—

S—STYLE NUMBER

D—DRAWING NUMBER

L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NUMBER OF SHEETS 4 SHEET NUMBER 3

LIST OF SPARE PARTS AND TOOLS

PER VESSEL

REPRODUCED FROM MFRS. DRAWING NO. 31-J-651 **BUREAU NO.** BB61-S61-083

NAMES AND NUMBERS OF VESSELS: BB65 AND BB66 ONLY

8 GENERATORS PER VESSEL. ONE SET OF SPARES CONSISTS OF ITEMS 2 TO 15 INCLUSIVE

APPLICATION SHIP'S POWER & LIGHT

NAVY CONTRACT NOs 70862 **APPLIANCE** 1250-KW. A-C. GENERATOR

SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO. PC.	MFRS. DRAWING AND PIECE NO. DWG. NO.	PC.	DWG. NO.
5	1	1	Bearing Lining	D. 31-J-658 Items 26 To 29	26 To 29	31-J-658		
6	5	8	Brushes, Carbon, Complete Sets	S. 1 240 018	26	31-J-659		
7	1/4	8	Brushholder Complete	D. 31-J-659 Items 15, 17 To 20, 22, 44, 45, 46	15,17 To 20 22,44 45,46	31-J-659		
8	1-3/8	8	Brushholder Spring	D. 31-J-659 Items 17, 18. 20,22,44,45, 46	17,18 20,22 44,45 46	31-J-659		
9	1	1	Brush Rigging Insulation	D. 31-J-659 Items 6, 7, 47, 48, 49	6,7, 47 48 49	31-J-659		
10	5	2	Bearing Oil Seals	D. 31-J-658 Items 48 TO 50	48 To 50	31-J-658		
14	5	1	End Bell Air Seal	D. 31-J-688 Items 82, 83	82 83	31-J-688		
15	1	1	Oil Gage for Bearing	(Supplied by Turbine Builder)				

Spares for Aboard Ship

BB65-U.S.S. Illinois
BB66-U.S.S. Kentucky

WG-31965-TP Spare Parts S.O. 15-P-184

Spare Parts for Use With 1250-Kw.
A-C. Turbine Generator.
Frame 6-44-22-1/2. Built on S.O. 15-P-184

LEGEND—
S—STYLE NUMBER
D—DRAWING NUMBER
L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NUMBER OF SHEETS 4 SHEET NUMBER 4

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. 5-A-9812 **BUREAU NO.** BB61-S61-097

NAMES AND NUMBERS OF VESSELS: BB61 U.S.S. IOWA, BB62 U.S.S. NEW JERSEY, BB63 U.S.S. MISSOURI, BB64 U.S.S. WISCONSIN, BB65 U.S.S. ILLINOIS, BB66 U.S.S. KENTUCKY

APPLICATION EXCITERS FOR A-C. GENERATOR

NAVY CONTRACT NOs 70862 **APPLIANCE** D-C. EXCITER

SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO. PC.	MFRS. DRAWING AND PIECE NO. DWG. NO.	PC.	DWG. NO.
			SPARES FOR ONE VESSEL					
* 1	2	1	Armature Complete	D. 3-B-8878		31-J-210		
* 2	1/4	45	Armature Coils (11 Coils)	D. 5-A-9807	10	31-J-210		
* 3	3	1	Bearing Complete	D. 84-C-168	6	31-J-208		
* 4	4/9	18	Brushholder	S. 828 217		31-J-209		
* 5			Brush Stud Insulation Consisting of					
		1	Rocker Ring	D. 69-D-381	17	31-J-208		
* 6	1-3/9	18	Brushholder Springs Complete Brushholder Supplied	S. 828 217		31-J-209		
* 7	8	18	Brushes	S. 782 769	35	31-J-209		
* 8	1/6	6	Commutating Field Coil	L. 372 273	22	31-J-209		
* 9	1/6	6	Series Field Coil	L. 372 273	21	31-J-209		
*10	1/3	6	Shunt Field Coil	L. 372 273	20	31-J-209		
*11	1		Set of Slot Insulation and Binding Material Consisting of:					
		45	Slot Liners No. 979 Treated Paper, .010" x 4-1/4" x 5"					
		4	Insulation Under Bands, No.980 Treated Fullerboard, .035" x 1-3/4" x 40"					
		10	Insulation Between Coils on Ends Treated Duck, .030" x 1-3/4" x 34"					
		4	Insulation Between Coils on Ends, Treated Duck, .030" x 2-1/4" x 34					
		134	Tapered Maple Blocks for Separating Commutator Necks While Soldering 1-1/4" Wide x 2-1/4" Long, 5/32" Wide at Top 1/16" Wide at Bottom					
		1	Twine for Binding Around Mica at Ends of Commutator BU 50 Ft.					
		1	Qt. Can No. 672 Red Enamel					
		45	Fibre Wedges 5/32" x .488" Wide x 4" Long					

Continued on Next Page

WG-31965-TP Spare Parts S.O. 15-P-186, S.O. 10-P-816 and S.O. 13-P-149

Spare Parts for Use With Type "SK", Frame No. 193-6 Horizontal, 16-Kw., 120-Volt 1200 Rpm., D-C. Exciter, Built on S.O. 10-P-815, S.O. 13-P-148, and S.O. 15-P-185

LEGEND—
S—STYLE NUMBER
D—DRAWING NUMBER
L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NUMBER OF SHEETS 1 SHEET NUMBER 1

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. 5-A-9812 **BUREAU NO.** BB61-S61-097

NAMES AND NUMBERS OF VESSELS: BB61 U.S.S. IOWA, BB62 U.S.S. NEW JERSEY, BB63 U.S.S. MISSOURI, BB64 U.S.S. WISCONSIN, BB65 U.S.S. ILLINOIS, BB66 U.S.S. KENTUCKY

APPLICATION EXCITERS FOR A-C. GENERATOR

NAVY CONTRACT NOs 70862 **APPLIANCE** D-C. EXCITER

SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO.			
					PC.	DWG. NO.	PC.	DWG. NO.
*12	1	1	185 Ft. of .0453" Dia. Banding Wire					
*13	1	24	Tinned Sheet Steel Banding Clips .013" x 1/2" x 1-3/4"Long					
*14	1	1	Feeler Gage, Per Page 2 of D. Spec. 376035					
*15	1	1	Spring Balance, Per Page 2 of D. Spec. 376035					

*Note - For BB65 and 66 Only the Quantities of Spares should be as follows:

Item	No. of Sets
1	1 Stowed on Shore
2	Omit
3	2
4	1/9
5	O.K.
6	5/18
7,8,9	O.K.
10	1/6
11,12,13	Omit
14, 15	O.K.

WG-31965-TP Spare Parts S.O. 15-P-186, S.O. 10-P-816 and S.O. 13-P-149

Spare Parts for Use With Type "SK", Frame No. 193-6 Horizontal, 16-Kw., 120-Volt, 1200Rpm., D-C. Exciter, Built on S.O. 10-P-815 S.O. 13-P-148 and S.O. 15-P-185

LEGEND—
S—STYLE NUMBER
D—DRAWING NUMBER
L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NUMBER OF SHEETS 1 SHEET NUMBER 1

LIST OF SPARE PARTS AND TOOLS

HRC FORM 127

HARRISON RADIATOR DIVISION
GENERAL MOTORS CORPORATION

PARTS PRICE LIST

Sheet No. 1

CUSTOMER WESTINGHOUSE ELECTRIC & MFG. CO. MODEL HE-103-5

CUSTOMER'S PART NO. HARRISON PART NO. HARRISON O.M. NO.

HARRISON PART NO.	CUSTOMER'S PART NO.	DESCRIPTION	UNIT PRICE	REMARKS
8502030		Vent Air Cooler Assem.		
127933		Screws, Name plate (2)		
8500116		Plate, Name		
8502031		Gasket, Top & Bottom (2)		
8501736		Gasket, End Top (2)		
8501737		Gasket, End Bottom (2)		
8502036		Screw, Mounting Plate & Angle (6)		
8502451		Bolt, Top & Bottom Plate (26)		
8501100		Nuts, Top & Bottom Plate 3/8" (6)		
3107088		Lockwasher 3/8" (6)		
8502034		Angle, Mounting Top & Bottom		
8502035		Plate, Mounting (2)		
8502038		Frames & Bottom Plate Assem.		
8502031		Gasket, Top & Bottom (2)		
8502036		Screw, Mounting Plate & Angle (6)		
8502451		Bolt, Top & Bottom Plate (26)		
8501100		Nuts, Top & Bottom Plate 3/8" (6)		
3107088		Lockwasher 3/8" (6)		
8502034		Angle, Mounting Top & Bottom		
8502035		Plate, Mounting (2)		
8502039		Frame Assem. (Left Hand)		
8502040		Frame, Top & Bottom L. H. (2)		
8502041		Frame, Side L. H. (2)		
8502042		Frame Assem. (Right Hand)		
8502043		Frame, Top & Bottom, R. H.		
8502044		Frame, Side, R. H.		
8502045		Bottom Plate Assem.		
8502047		Baffle, Large (2)		
8502048		Baffle, Small (2)		
8502046		Plate, Bottom		
8502049		Top Plate Assem.		
8502047		Baffle, Large (2)		
8502048		Baffle, Small (2)		
8502050		Plate, Top		

ABOVE PRICES NET F. O. B {LOCKPORT, N. Y. ~~Home Town, N.Y.~~

PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

PLEASE USE OUR PART NUMBER WHEN ORDERING.

EFFECTIVE May 25, 1942

LIST OF SPARE PARTS AND TOOLS

HRC FORM 127

HARRISON RADIATOR DIVISION
GENERAL MOTORS CORPORATION

PARTS PRICE LIST

Sheet No. 2

CUSTOMER WESTINGHOUSE ELECTRIC & MFG. CO. MODEL HE-103-5

CUSTOMER'S PART NO. HARRISON PART NO. HARRISON B-M NO.

HARRISON PART NO.	CUSTOMER'S PART NO.	DESCRIPTION	UNIT PRICE	REMARKS
8502051		Core & Cover Assem. (2)		
8501590		Pipe, Plug 1/4" (8)		
8501100		Nuts, Cover 3/8" (100)		
3107088		Lockwasher 3/8" (100)		
8502052		Cover, Inlet & Outlet (2)		
8502053		Cover, Rear (2)		
8502054		Gasket, Inlet & Outlet Cover (2)		
8502055		Gasket, Rear Cover (2)		
8501635		Gasket, Zinc Support Cover (2)		
8501636		Zinc Support Cover Assem. (2)		
3110932		Cotter Pin (2)		
8501458		Nut, Zinc Support (2)		
8501459		Washer, Zinc Support (2)		
8501637		Zinc (2)		
8501460		Stud, Zinc Support (2)		
8501638		Cover, Zinc Support (2)		
3111727		Zinc Assem. (4)		
3111728		Zinc (4)		
3111729		Plug, Zinc Support (4)		
8502056		Core Assem. (2)		
8501363		Stud, Header Plate, Short (90)		
8502061		Stud, Header Plate, Long (10)		
103865		Pipe Plug (8)		

ABOVE PRICES NET F. O. B {LOCKPORT, N. Y. / [illegible]}

PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

PLEASE USE OUR PART NUMBER WHEN ORDERING.

EFFECTIVE May 25, 1942

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. 35-J-591 BUREAU NO.

NAMES AND NUMBERS OF VESSELS: BB-61 TO BB-66 INCLUSIVE

APPLICATION VOLTAGE CONTROL

NAVY CONTRACT NO. 70862 APPLIANCE CONTROL ELEMENT

SHIPBUILDER'S ORDER NO. MANUFACTURER W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL.	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO. PC.	MFRS. DRAWING AND PIECE NO. DWG. NO.	PC.	DWG. NO.
			TYPE "BN-2" CONTROL ELEMENT	S.O. 84-Y-572 S.O. 84-Y-570 S.O. 84-Y-427		35-J-586		BB61-S61-407
1	1	4	Stud Contact	S. 844 172	9	35-J-586	9	BB61-S61-407
2	1	2	Contact with Long Spring	S. 847 838	10	35-J-586	10	BB61-S61-407
3	1	2	Contact with Short Spring	S. 942 827	11	35-J-586	11	BB61-S61-407
4	1	1	Main Coil	S. 1 087 427	12	35-J-586	12	BB61-S61-407
5	1	2	Anti-Hunt Hinge Spring	S. 1 257 683	13	35-J-586	13	BB61-S61-407
6	1	2	Short Hinge Spring	S. 1 247 162	15	35-J-586	15	BB61-S61-407
7	1	2	Long Hinge Spring	S. 1 247 179	16	35-J-586	16	BB61-S61-407
8	1	1	Main Spring	S. 1 166 946	20	35-J-586	20	BB61-S61-407
9	1	2	Anti-Hunt Coil	S. 1 247 173	38	35-J-586	38	BB61-S61-407
10	1	2	Anti-Hunt Main Spring	S. 1 257 684	39	35-J-586	39	BB61-S61-407
11	1	1	Set of Tools	S. 1 019 379	1,2,3	50-C-889		

SPARE PARTS FOR TYPE "BN-2" VOLTAGE REGULATOR CONTROL ELEMENT USED WITH THE 1250-KW., 1200-RPM., 450-VOLT, 60-CYCLE, 3-PHASE, SHIP'S SERVICE GENERATOR.

LEGEND—

S—STYLE NUMBER

D—DRAWING NUMBER

L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NO. OF SHEETS 6 SHEET NO. 1

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. 35-J-591 **BUREAU NO.**
NAMES AND NUMBERS OF VESSELS: BB-61 to BB-66 INCLUSIVE

APPLICATION VOLTAGE CONTROL
NAVY CONTRACT NO. 70862 **APPLIANCE** CONTACTOR PANEL
SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO. PC.	MFRS. DRAWING AND PIECE NO. DWG. NO.	PC.	DWG. NO.
				S.O. 84-Y-573				
			CONTACTOR PANEL	S.O. 84-Y-571	2,3	31-J-277	2,3	BB61-S61-29
				S.O. 82-Y-117				
			CONTACTORS "QR" & "QL"					
1	1	2	Coils	S. 861 701		31-J-277	25	BB61-S61-29
2	1	2	Blowout Coil	S. 895 986		31-J-277	27	BB61-S61-29
3	1	2	Stationary Contact	S. 897 493		31-J-277		BB61-S61-29
4	1	2	Moving Contact	S. 942 830		31-J-277		BB61-S61-29
5	1	1	Spring For Contactor "QL"	S. 1 020 920		31-J-277		BB61-S61-29
6	1	1	Spring for Contactor "QR"	S. 1 019 698		31-J-277		BB61-S61-29
7	1	1	Interlock Stud Contact	S. 943 348		31-J-277		BB61-S61-29
8	1	1	Interlock Spring Contact	S. 809 437		31-J-277		BB61-S61-29
			CONTACTORS "NL" & "NR"		4	31-J-277	4	BB61-S61-29
9	1	2	Blowout Coil	S. 1 247 163		31-J-277		BB61-S61-29
10	1	2	Main Silver Stationary Contact	S. 942 773		31-J-277		BB61-S61-29
11	1	2	Main Silver Moving Contact	S. 944 937		31-J-277		BB61-S61-29
12	1	4	Auxiliary Spring Contact	S 793 013		31-J-277		BB61-S61-29
13	1	4	Auxiliary Stationary Contact	S. 1 040 923		31-J-277		BB61-S61-29
14	1	2	Main Coil	S. 966 753		31-J-277		BB61-S61-29
15	1	2	Spring	S. 440 876		31-J-277		BB61-S61-29
16	1	1	Rectox	S. 971 249	7	31-J-277	7	BB61-S61-29
17	1	2	Condenser	S. 918 694	8	31-J-277	8	BB61-S61-29
18	1	2	Resistor(R8 & R10) 6500 Ohms	S. 1 250 276	36	31-J-277	36	BB61-S61-29
19	1	2	Resistor (R9) 168 Ohms	S. 1 250 277	37	31-J-277	37	BB61-S61-29
20	1	2	Resistor (R11 & R12)24000 Ohms	S. 1 250 278	38	31-J-277	38	BB61-S61-29

SPARE PARTS FOR TYPE "BN-2" VOLTAGE REGULATOR CONTACTOR PANEL USED WITH THE 1250-KW., 1200-RPM., 450-VOLT, 60-CYCLE, 3-PHASE, SHIP'S SERVICE GENERATOR.

LEGEND—
S—STYLE NUMBER
D—DRAWING NUMBER
L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NO. OF SHEETS 6 SHEET NO. 2

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. 35-J-591 BUREAU NO.

NAMES AND NUMBERS OF VESSELS: BB61 TO BB66 INCLUSIVE

APPLICATION VOLTAGE CONTROL

NAVY CONTRACT NO. 70862 APPLIANCE AUXILIARY EQUIPMENT

SHIPBUILDER'S ORDER NO. MANUFACTURER W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO.			
					PC.	DWG. NO.	PC.	DWG. NO.
			AUXILIARY EQUIPMENT					
1	1	6	Rectox Unit	S. 1 253 324	13	35-J-588	13	BB61-S61-408
2	1	1	Voltage Adjusting Rheostat Plate	S. 1 250 157	5	35-J-588	5	BB61-S61-408
3	2	8	Type "VG-7" Neon Lamp	S. 1 166 955	11	35-J-588	11	BB61-S61-408
4	1	1	Resistor (R-1)	S. 1 115 103	6	35-J-588	6	BB61-S61-408
5	1	1	Type "VN" Potential Transformer	S. 1 294 692	9	35-J-588	9	BB61-S61-408
* 6	1	1	Type "UN" Current Transformer 3000/5 Amperes	S.O. 71-R-627 S.O. 99-K-898	12	35-J-588,	12	BB61-S61-408
+ 7	1	1	Cross-Current Compensator	S. 1 257 682	2	35-J-588	2	BB61-S61-408
# 8	1	1	Type "FB" Current Transformer 3000/5 Amperes	S.O. 99-K-392	14	31-J-275	14	BB61-S61-27
‡ 9	1	1	Cross-Current Compensator	S. 1 114 839	13	31-J-275	13	BB61-S61-27

\+ For BB-65 and 66 Only
‡ For BB-61, 62, 63 and 64 Only
* For BB-63, 64, 65 and 66 Only
\# For BB-61 and 62 Only

SPARE PARTS FOR AUXILIARY EQUIPMENT FOR TYPE "BN-2" VOLTAGE REGULATOR USED WITH THE 1250-KW., 1200-RPM., 450-VOLT 60-CYCLE, 3-PHASE SHIP'S SERVICE GENERATOR.

LEGEND—
S—STYLE NUMBER
D—DRAWING NUMBER
L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NO. OF SHEETS 6 SHEET NO. 3

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. 35-J-591 **BUREAU NO.**

NAMES AND NUMBERS OF VESSELS: BB-61 TO BB-66 INCLUSIVE

APPLICATION VOLTAGE CONTROL

NAVY CONTRACT NO. 70862 **APPLIANCE** TEMPERATURE INDICATION

SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO. PC.	MFRS. DRAWING AND PIECE NO. DWG. NO.	PC.	DWG. NO.
			TEMPERATURE INDICATOR SWITCH	S.O. 44-Y-494 S.O. 49-Y-108	5	31-J-289	5	BB61-S61-34
1	1	20	Contact Finger	S. 1 070 951				
2	1	2	Stop Finger	S. 1 114 883				
			TEST RESISTOR FOR TEMPERATURE INDICATING EQUIPMENT	M.S. Item 2	2	31-J-289	2	BB61-S61-34
3	1	1	Resistor	S. 724 093				
			CALIBRATING RHEOSTAT FOR TEMPERATURE INDICATING EQUIPMENT	S.O. 46-Y-962 S.O. 49-Y-110	6	31-J-289	6	BB61-S61-34
4	1	1	Rheostat	S. 1 216 573				
			RECTOX RECTIFIER FOR TEMPERATURE INDICATING EQUIPMENT	S.O. 46-Y-961 S.O. 49-Y-109	4	31-J-289	4	BB61-S61-34
5	1	1	Transformer	S. 708 946	4	5-B-3751		
6	1	1	Rectox Rectifier	S. 1 224 733	26	5-B-3751		
7	1	1	Rheostat	S. 1 216 747	17	5-B-3751		

SPARE PARTS FOR AUXILIARY EQUIPMENT USED WITH 1250-KW., 1200-RPM., 450-VOLT, 3-PHASE, 60-CYCLE, SHIP'S SERVICE GENERATOR.

LEGEND—
S—STYLE NUMBER
D—DRAWING NUMBER
L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NO. OF SHEETS 6 SHEET NO. 4

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. 35-J-591 BUREAU NO.

NAMES AND NUMBERS OF VESSELS: BB-61 TO BB-66 INCLUSIVE

APPLICATION VOLTAGE CONTROL

NAVY CONTRACT NO. 70862 APPLIANCE MOTOR OPERATED RHEOSTAT

SHIPBUILDER'S ORDER NO. MANUFACTURER W. E. & M. CO.

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO. PC.	MFRS. DRAWING AND PIECE NO. DWG. NO.	PC.	DWG. NO.
			RHEOSTATS FOR 1250-KW. TURBO-GENERATOR	S.O. 83-Y-500 S.O. 83-Y-501 S.O. 82-Y-116		31-J-483 35-J-224		BB61-S61-31
1	1	80	Stationary Contact	S. 1 224 730	39	35-J-224	39	BB61-S61-31
2	1	40	Stationary Contact	S. 1 224 731	40	35-J-224	40	BB61-S61-31
3	1	40	Stationary Contacts	S. 1 224 732	41	35-J-224	41	BB61-S61-31
4	1	1	Resistor	S. 896 439	55	35-J-224	55	BB61-S61-31
5	1	1	Resistor	S. 896 440	55	35-J-224	55	BB61-S61-31
6	1	1	Resistor	S. 896 447	55	35-J-224	55	BB61-S61-31
7	1	1	Resistor	S. 896 442	55	35-J-224	55	BB61-S61-31
8	1	1	Resistor	S. 896 450	55	35-J-224	55	BB61-S61-31
9	1	1	Resistor	S. 855 986	55	35-J-224	55	BB61-S61-31
10	1	1	Resistor	S. 1 189 149	55	35-J-224	55	BB61-S61-31
11	1	1	Resistor	S. 943 767	54	35-J-224	54	BB61-S61-31
12	1	2	Brush and Brushholder Complete	S. 1 129 346	27	35-J-224	27	BB61-S61-31
13	1	2	Brush and Brushholder Complete	S. 1 224 729	28	35-J-224	28	BB61-S61-31
14	1	1	Resistor	S. 1 189 150	55	35-J-224	55	BB61-S61-31
			FIELD DISCHARGE RESISTOR FOR 1250-Kw. TURBO-GENERATOR	S.O. 44-Y-487 S.O. 13-P-572 S.O. 15-P-188				
15	1	1	Resistor	S. 389078	2	5-A-9347	2	BB61-S61-33
			RHEOSTAT FOR 16-Kw. EXCITER	S.O. 44-Y-486 S.O. 13-P-571 S.O. 15-P-187				
16	1	1	Main Rheostat Plate	S. 1183606	13	5-A-9346	13	BB61-S61-32
17	1	1	Vernier Rheostat Plate	S. 1183607	14	5-A-9346	14	BB61-S61-32

SPARE RESISTORS AND DETAILS FOR FIELD RHEOSTAT USED WITH 1250-KW., 1200-RPM., 450-VOLT, 3-PHASE, 60-CYCLE, SHIP'S SERVICE GENERATOR.

LEGEND—

S—STYLE NUMBER

D—DRAWING NUMBER

L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NO. OF SHEETS 6 SHEET NO. 5

LIST OF SPARE PARTS AND TOOLS

REPRODUCED FROM MFRS. DRAWING NO. 35-J-591 **BUREAU NO.**

NAMES AND NUMBERS OF VESSELS: BB-61 TO BB-66 INCLUSIVE

APPLICATION FOR RHEOSTAT OPERATION

NAVY CONTRACT NO. 70862 **APPLIANCE** RHEOSTAT MOTOR, D-C.

SHIPBUILDER'S ORDER NO. **MANUFACTURER** W. E. & M. CO.

ITEM NO.	NUMBER OF SETS *	NUMBER PER SET	NAME OF PART OR TOOL	MANUFACTURER'S DATA			BUREAU DRAWING AND PIECE NUMBER	
				CATALOG OR SERIAL ORDERING DATA	MFRS. DRAWING AND PIECE NO.			
					PC.	DWG. NO.	PC.	DWG. NO.
1	1	1	Armature Complete	D. 28-B-733 Assembly 43	77	35-J-426	77	10-T-2572-L
2	2	2	Sleeve Bearing	D. 54-D-228 S. 887 867	79	35-J-426	79	10-T-2572-L
3	12	2	Carbon Brushes	D. 847025 S. 840 242	69	35-J-426	69	10-T-2572-L
4	2	1	Brushholder (Complete Rocker Ring Supplied)	D. 34-B-400 S. 840 977	78	35-J-426	78	10-T-2572-L
5	2	3	Brushholder Springs	D. 46-D-507 S. 887 807	66	35-J-426	66	10-T-2572-L
6	2	1	Brush Rigging Insulation (Complete Rocker Ring Supplied)	D. 34-B-400 S. 840 977	78	35-J-426	78	10-T-2572-L
7	4	2	Field Coil Set ø	D. 47-B-684 Assembly 33	42	35-J-426	42	10-T-2572-L
8	17	1	Bearing Housing Cap	D. 47-B-949 S. 858 435	9	35-J-426	9	10-T-2572-L
9	17	1	Rear Dust Ring	D. 38-D-855 S. 887 168	19	35-J-426	19	10-T-2572-L
10	17	1	Front Dust Cap	D. 668562 #20028	18	35-J-426	18	10-T-2572-L

ø - Each Set Contains Complete Coils for One Motor.

* - Quantities Given Are For One Ship.

MOTOR SPARE PARTS STYLE NO. 957 936

FOR USE WITH MOTOR STYLE NO. 957 881

TYPE "FK", FRAME NO. 125E15, 1/12 HP.

HORIZONTAL, 120 VOLTS D-C.,

4150 RPM. 1.05 AMPERES

LEGEND—

S—STYLE NUMBER

D—DRAWING NUMBER

L—ELECTRICAL SPECIFICATION NUMBER

NOTE:—SUFFIX LETTERS IN CONNECTION WITH IDENTIFYING NUMBERS FOR SPARE PARTS ARE FOR THE INFORMATION OF THE MANUFACTURER AND WILL NOT AFFECT THE MATERIAL FURNISHED ON FUTURE ORDERS.

NO. OF SHEETS 6 SHEET NO. 6

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 522)

(These Spares for BB-61 and 62 only. For Spares for BB-63 to 66 See Pages 523 to 527).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
1	Oil Cooler Gasket	16	25-J-266	33	BB61-S61-044	
2	Oil Cooler Gasket	8	25-J-266	34	BB61-S61-044	
3	Oil Cooler Gasket	8	25-J-266	35	BB61-S61-044	
4	Pipe Plug	32	25-J-266	39	BB61-S61-044	
5	Zinc Bar	32	25-J-266	40	BB61-S61-044	
7	Auto-Stop Governor Body	2	25-J-504	1	BB61-S61-05	
8	Weight	2	25-J-504	2	BB61-S61-05	
9	Welding Rod	2	25-J-504	3	BB61-S61-05	
10	Spring	2	25-J-504	4	BB61-S61-05	
11	Retainer Half	4	25-J-504	5	BB61-S61-05	
12	Nut	2	25-J-504	6	BB61-S61-05	
13	Liner	2	25-J-504	7	BB61-S61-05	
14	Liner	4	25-J-504	8	BB61-S61-05	
15	Liner	2	25-J-504	9	BB61-S61-05	
16	Liner	2	25-J-504	10	BB61-S61-05	
17	Liner	2	25-J-504	11	BB61-S61-05	
18	Set Screw	2	25-J-504	12	BB61-S61-05	
19	Trip Lever	2	25-J-504	13	BB61-S61-05	
20	Trip Latch	2	25-J-504	14	BB61-S61-05	
21	Tip	4	25-J-504	15	BB61-S61-05	
22	Lever Shaft	2	25-J-504	16	BB61-S61-05	
23	Latch Pin	2	25-J-504	17	BB61-S61-05	
24	Taper Pin	4	25-J-504	18	BB61-S61-05	
25	Latch Spring	2	25-J-504	19	BB61-S61-05	
26	Reset Bushing	2	25-J-504	21	BB61-S61-05	
27	Fulcrum Pin	2	25-J-504	22	BB61-S61-05	
28	Trip Spring	2	25-J-504	30	BB61-S61-05	
29	Bracket Bushing	4	25-J-504	37	BB61-S61-05	
30	Trip Lever Bushing	4	25-J-504	47	BB61-S61-05	
31	Reset Handle Bushing	2	25-J-504	48	BB61-S61-05	
32	Clevis Pin	4	25-J-504	49	BB61-S61-05	
33	Clevis Pin	2	25-J-504	50	BB61-S61-05	
34	Headless Set Screw	2	25-J-504	57	BB61-S61-05	
38	Back Pressure Safety Stop Diaphragm	2	25-J-505	63	BB61-S61-06	
39	Spring	2	25-J-505	75	BB61-S61-06	
42	Oil Flow Indicator Cover Glass	2	25-J-506	15	BB61-S61-07	
45	Gear Bearing (Upper Half) Generator End	2	25-J-507	1	BB61-S61-08	
46	Gear Bearing (Lower Half) Generator End	2	25-J-507	2	BB61-S61-08	
47	Babbitt	21#	25-J-507	3	BB61-S61-08	
48	Dowel Pin	24	25-J-507	4	BB61-S61-08	
49	Stop Pin	4	25-J-507	5	BB61-S61-08	
50	Gear Bearing (Upper Half) Turbine End	2	25-J-507	6	BB61-S61-08	
51	Gear Bearing (Lower Half) Turbine End	2	25-J-507	7	BB61-S61-08	
52	Babbitt	21#	25-J-507	8	BB61-S61-08	
53	Pinion Bearing (Upper Half) Generator End	2	25-J-507	9	BB61-S61-08	
54	Pinion Bearing (Upper Half) Turbine End	2	25-J-507	10	BB61-S61-08	
55	Pinion Bearing (Lower Half)	4	25-J-507	11	BB61-S61-08	

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 522)

(These Spares for BB-61 and 62 only. For Spares for BB-63 to 66 See Pages 523 to 527).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
56	Babbitt	24#	25-J-507	12	BB61-S61-08	
57	Stop Pin	4	25-J-507	13	BB61-S61-08	
58	Nipple	2	25-J-507	14	BB61-S61-08	
59	Turbine Bearing (Upper Half)	4	25-J-507	15	BB61-S61-08	
60	Turbine Bearing (Lower Half) Thrust End	2	25-J-507	16	BB61-S61-08	
61	Turbine Bearing (Lower Half) Coupling End	2	25-J-507	17	BB61-S61-08	Assembled as One Unit
62	Babbitt	20#	25-J-507	18	BB61-S61-08	
63	Stop Pin	4	25-J-507	19	BB61-S61-08	
64	Bearing Baffle (Half)	8	25-J-507	20	BB61-S61-08	
65	Thrust Ring (Half)	8	25-J-507	21	BB61-S61-08	
66	Screw (Fil. Head)	24	25-J-507	22	BB61-S61-08	
67	Thrust Liner	16	25-J-507	23	BB61-S61-08	
68	Thrust Liner	8	25-J-507	24	BB61-S61-08	
69	Thrust Liner	16	25-J-507	25	BB61-S61-08	
73	Thrust Bearing Collar	2	25-J-508	4	BB61-S61-09	
74	Thrust Bearing Shoe	24	25-J-508	5	BB61-S61-09	Assembled as One Unit
75	Babbitt	2#	25-J-508	6	BB61-S61-09	
76	Support	24	25-J-508	7	BB61-S61-09	
79	Gages (For Gage Board)	(2 ea.)	25-J-523	10-14	BB61-S61-025	
80	Glass for Above Gages	5	25-J-523	15	BB61-S61-025	
83	Gage	2	25-J-525	50	BB61-S61-027	
84	Gage Glass for Piece 50	2	25-J-525		BB61-S61-027	
86	Gear Shaft Oil Ring (L. Half)	2	25-J-526	22	BB61-S61-028	
87	Gear Shaft Oil Ring (U. Half)	2	25-J-526	23	BB61-S61-028	
88	Baffle (Lower Half)	2	25-J-526	24	BB61-S61-028	
89	Baffle (Upper Half)	2	25-J-526	25	BB61-S61-028	
91	Governor Details		25-J-487			
92	Bushing	2	25-J-487	4		
93	Bushing	10	25-J-487	5		
94	Rod	1	25-J-487	6		
95	Bushing	2	25-J-487	24		
96	Adjusting Nut	2	25-J-487	26		
97	Pin	1	25-J-487	27		
99	Governor Relay Bushing	1	25-J-488	1		
100	Piston Rod	1	25-J-488	2		
101	Governor Closing Spring	2	25-J-488	5		
102	Governor Spring	2	25-J-488	6		
103	Spring Seat (Upper)	1	25-J-488	7		
104	Relay Rod	1	25-J-488	8		
105	Spring Seat (Lower)	1	25-J-488	9		
106	Spring Seat (Upper)	1	25-J-488	10		
107	Relay	1	25-J-488	11		
108	Speed Reg. Spring	2	25-J-488	12		
109	Bushing	1	25-J-488	13		
110	Bushing	4	25-J-488	14		
111	Bushing	1	25-J-488	15		
112	Motor Shaft Extension	1	25-J-488	16		
113	Clutch Plate	1	25-J-488	19		
114	Clutch Plate	1	25-J-488	20		
115	Clutch Collar	1	25-J-488	21		
116	Worm Wheel	1	25-J-488	23		
117	Spring	1	25-J-488	24		
118	Worm Gear	1	25-J-488	25		
119	Handwheel Stem	1	25-J-488	26		

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 522)

(These Spares for BB-61 and 62 only. For Spares for BB-63 to 66 See Pages 523 to 527).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau	Ship's	Remarks
120	Worm	1	25-J-488	27			
121	Pin	4	25-J-488	29			
122	Bushing	1	25-J-488	31			
123	Pin	1	25-J-488	36			
124	Piston Ring	2	25-J-488	37			
125	Castle Nut	1	25-J-488	41			
126	Relay (Complete)	1	25-J-488	42			
127	Pin	1	25-J-488	43			
130	Transformer Housing	4	25-J-489	1			See Note C
131	Orifice	1	25-J-489	2			See Note C
132	Bolt	4	25-J-489	3			See Note D
133	Cap Screw	3	25-J-489	4			See Note C
135	Ring	1	25-J-489	6			See Note C
136	Bushing	1	25-J-489	7			See Note C
137	Relay	1	25-J-489	8			See Note C
139	Stop Ring	1	25-J-489	10			See Note C
140	Ring	1	25-J-489	11			See Note C
141	Welding Rod	1	25-J-489	12			See Note C
142	Stop Flange	1	25-J-489	13			See Note C
143	Cap Screw	4	25-J-489	14			See Note C
144	Worm Wheel	1	25-J-489	15			See Note C
145	Set Screw	1	25-J-489	16			See Note C
146	Pipe Plug	3	25-J-489	17			See Note C
147	Cap Screw	2	25-J-489	18			See Note C
148	Cap Ccrew	4	25-J-489	19			
149	Casing	1	25-J-489	20			See Note D
150	Cylinder (Outer)	1	25-J-489	21			See Note D
151	Cylinder (Inner)	1	25-J-489	22			See Note D
152	Hub	2	25-J-489	23			See Note D
153	Contact Ball	2	25-J-489	24			See Note D
154	Spring Guide	20	25-J-489	25			See Notes D & E
155	Spring Retainer	20	25-J-489	26			See Notes D & E
156	Seat	1	25-J-489	27			See Note D
157	Governor Weight	2	25-J-489	28			See Note D
158	Pin Key	1	25-J-489	29			See Note D
159	Governor Stop Screw	2	25-J-489	30			See Note D
160	Spring	10	25-J-489	31			See Notes D & E
161	Spring Seat	1	25-J-489	32			See Note D
162	Clamp Bar	1	25-J-489	33			See Note D
163	Ball Seat	2	25-J-489	34			See Note D
164	Spacer	4	25-J-489	35			See Note D
165	Headless Set Screw	2	25-J-489	36			See Note D
166	Governor Spring	2	25-J-489	37			See Note D
167	Pin	8	25-J-489	38			See Note D
168	Cotter Wire	1	25-J-489	39			See Note D
169	Button Head Rivet	20	25-J-489	40			See Notes D & E
170	Nut	4	25-J-489	41			See Note D
171	Round Hd. Cap Screw	4	25-J-489	42			See Note D
172	Lock Nut	2	25-J-489	43			See Note D
173	Thrust Bearing	5	25-J-489	44			See Note D
174	Elastic Stop Nut	1	25-J-489	45			
175	Stud	1	25-J-489	46			
176	Pipe Plug	1	25-J-489	47			See Note D
177	Pin	1	25-J-489	48			See Note C
178	Screw, Oval Fil. Hd. Machine	2	25-J-489	49			See Note C

For Notes See Page 522

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 522)

(These Spares for BB-61 and 62 only. For Spares for BB-63 to 66 See Pages 523 to 527).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau	Ship's	Remarks
179	Liner	2	25-J-489	50			See Note C
180	Liner	1	25-J-489	51			See Note C
181	Liner	1	25-J-489	52			See Note C
182	Liner	1	25-J-489	53			See Note C
184	Pipe Plug	1	25-J-490	7			
185	Governor Body Bearing	1	25-J-490	3			
186	Sleeve	1	25-J-490	4			
187	Sleeve Nut	1	25-J-490	5			
188	Oil Filter	1	25-J-490	9			
189	Straight Pin	2	25-J-490	14			
190	Spiral Gear (Driven)	2	25-J-490	15			
191	Spiral Gear (Driver)	2	25-J-490	16			
192	Liner	2	25-J-490	17			
193	Set Screw Dog Point	1	25-J-490	18			
194	Governor Body Shaft Key	1	25-J-490	19			
195	Governor Body Bearing	1	25-J-490	20			
196	Babbitt	(2 sets)	25-J-490	21			
197	Valve No. 3	2	25-J-492	6			
198	Valve Seat No. 2 -3 and 5	6	25-J-492	8			
199	Valve Seat No. 1 - 4 and 6	6	25-J-492	9			
200	Valve No. 2 and 5	4	25-J-492	10			
201	Valve No. 1 -4 and 6	6	25-J-492	11			
202	Welding Rod	(1 set)	25-J-492	12			
203	Lifting Rod	4	25-J-492	14			
204	Bushing (Upper)	4	25-J-492	15			
205	Bushing (Lower)	4	25-J-492	16			
206	Bushing	4	25-J-492	24			
207	Bushing	4	25-J-492	25			
208	Bushing	4	25-J-492	26			
209	Bushing	4	25-J-492	27			
212	Steam Piping Gage	2	25-J-565	32	BB61-S61-069		
213	Gage Glass	2	25-J-565	33	BB61-S61-069		
216	Oil Strainer Packing	(3 rows)	25-J-576	9	BB61-S61-049		
217	Basket Support	1	25-J-576	16	BB61-S61-049		
218	Basket (Side)	1	25-J-576	16A	BB61-S61-049		
219	Basket (Bottom)	1	25-J-576	16B	BB61-S61-049		
220	Basket Handle	1	25-J-576	16C	BB61-S61-049		
221	Rivet	6	25-J-576	16D	BB61-S61-049		
222	Union Nut	1	25-J-576	16F	BB61-S61-049		
223	Union Check Nut	1	25-J-576	16G	BB61-S61-049		
224	Pin	1	25-J-576	16J	BB61-S61-049		
225	Basket (Side)	1	25-J-576	16M	BB61-S61-049		
226	Basket (Bottom)	1	25-J-576	16MB	BB61-S61-049		
227	Basket Ring	1	25-J-576	16S	BB61-S61-049		
228	Magnet	6	25-J-576	17	BB61-S61-049		
229	Magnet Rod	1	25-J-576	17A	BB61-S61-049		
230	Magnet Pin	6	25-J-576	17C	BB61-S61-049		
231	St. Jam Hex Nut	2	25-J-576	17D	BB61-S61-049		
232	Nut	1	25-J-576	17E	BB61-S61-049		
233	Pin (For Piece 17E)	1	25-J-576	17F	BB61-S61-049		
236	Governor Speed-Changer Motor Armature Complete	1	31-J-755	54			
237	Ball Bearing No. 6200 SKF	2	31-J-755	3			
238	Brushes	24	31-J-755	13			
239	Brush Springs	6	31-J-755	8			
240	Brush Holder	2	31-J-755	34			

See Page 522

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 522)

(These Spares for BB-61 and 62 only. For Spares for BB-63 to 66 See Pages 523 to 527).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
241	Brush Holder Screw	2	31-J-755	11		
242	Field Coil Set	8	31-J-755	17		
243	Brushholder Insulation	2	31-J-755	34		
244	Felt Wick	17	31-J-755	5		
246	Relief Valve Spring	1	25-J-551	10	BB61-S61-053	
249	Sentinel Valve Spring	1	25-J-579	6	BB61-S61-056	
251	Relief Valve Oil Line Spring	1	25-J-580	6	BB61-S61-054	
253	Throttle Valve Spring	1	25-J-566	68	BB61-S61-073	
255	Oil Piping Thermometer	4	25-J-543	2	BB61-S61-045	
257	Oil Piping Sight Flow Glass	2	25-J-544	67	BB61-S61-046	
259	Oil Pump Body	2	25-J-545	1	BB61-S61-047	
260	Oil Pump Body Casting	2	25-J-545	2	BB61-S61-047	
261	Suction Pipe	2	25-J-545	3	BB61-S61-047	
262	Pump Gear (Driver)	4	25-J-545	4	BB61-S61-047	
263	Pump Gear (Driven)	4	25-J-545	5	BB61-S61-047	
264	Pump Gear Shaft (Driven)	4	25-J-545	6	BB61-S61-047	
265	Pump Gear Shaft (Driver)	4	25-J-545	7	BB61-S61-047	
266	Shaft Sleeve	2	25-J-545	8	BB61-S61-047	
267	Cover	2	25-J-545	9	BB61-S61-047	
268	Drive Shaft	2	25-J-545	10	BB61-S61-047	
269	Bushing	4	25-J-545	11	BB61-S61-047	
270	Pump Gear Key	8	25-J-545	12	BB61-S61-047	
271	Stud	22	25-J-545	13	BB61-S61-047	
272	Elastic Stop Nut	22	25-J-545	14	BB61-S61-047	
273	Straight Pin	4	25-J-545	15	BB61-S61-047	
274	Set Screw	8	25-J-545	16	BB61-S61-047	
275	Bushing	4	25-J-545	17	BB61-S61-047	
277	Oil Pump (Auxiliary) (Hand Operated)	2	25-J-546	1-26 incl.	BB61-S61-048	Assembled as Complete Pump
280	Spindle Gland Packing Ring	8	25-J-558	10	BB61-S61-063	
281	Retainer Ring Segment	64	25-J-558	11	BB61-S61-063	
282	Key	16	25-J-558	12	BB61-S61-063	
283	Spring	16	25-J-558	16	BB61-S61-063	
284	Spindle Gland Packing Ring	8	25-J-558	26	BB61-S61-063	
287	Spindle Position Indicator					
288	Contact Ball	1	25-J-561	4	BB61-S61-066	
289	Retainer	1	25-J-561	5	BB61-S61-066	
290	Spring	2	25-J-561	6	BB61-S61-066	
291	Spindle	1	25-J-561	7	BB61-S61-066	
292	Bushing	1	25-J-561	8	BB61-S61-066	

(Shore Spares—See Note "B", Page 522)

307	Blade (1st Rotating)	83	25-J-510	2	BB61-S61-012	
308	Blade (Last) (1st Rotating)	2	25-J-510	3	BB61-S61-012	
309	Blade Stationary	27	25-J-510	4	BB61-S61-012	
310	Blade (2nd Rotating)	71	25-J-510	5	BB61-S61-012	
311	Blade (Last)(2nd Rotating)	2	25-J-510	6	BB61-S61-012	
312	Pin (1st Rotating)	3	25-J-510	7	BB61-S61-012	
313	Pin (2nd Rotating)	3	25-J-510	8	BB61-S61-012	
314	Shroud Stock	(12 ft.)	25-J-510	11	BB61-S61-012	
315	Blade Start Piece	1	25-J-510	13	BB61-S61-012	
316	Blade Stop Piece	1	25-J-510	14	BB61-S61-012	
317	Screw (Flat Fil. Head)	2	25-J-510	15	BB61-S61-012	
318	Caulking Piece	168	25-J-510	16	BB61-S61-012	
319	Caulking Piece	44	25-J-510	17	BB61-S61-012	
320	Caulking Piece	384	25-J-510	18	BB61-S61-012	

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Shore Spares—See Note "B", Page 522)

(These Spares for BB-61 and 62 only. For Spares for BB-63 to 66 See Pages 527 to 530).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
321	Caulking Piece	88	25-J-510	19	BB61-S61-012	
322	Caulking Piece	28	25-J-510	20	BB61-S61-012	
323	Sealing Strip	2	25-J-510	21	BB61-S61-012	
324	Sealing Strip	1	25-J-510	22	BB61-S61-012	
325	Sealing Strip	1	25-J-510	23	BB61-S61-012	
326	Lock Strip	4	25-J-510	24	BB61-S61-012	
331	Blade (1st Stage)	153	25-J-512	2	BB61-S61-014	
332	Blade (Last)(1st Stage)	2	25-J-512	3	BB61-S61-014	
333	Shroud (1st Stage)	24	25-J-512	4	BB61-S61-014	
334	Shroud (1st Stage)	2	25-J-512	5	BB61-S61-014	
335	Blade (2nd Stage)	153	25-J-512	6	BB61-S61-014	
336	Blade (Last)(2nd Stage)	2	25-J-512	7	BB61-S61-014	
337	Shroud (2nd Stage)	24	25-J-512	8	BB61-S61-014	
338	Shroud (2nd Stage)	2	25-J-512	9	BB61-S61-014	
339	Blade (3rd Stage)	153	25-J-512	10	BB61-S61-014	
340	Blade (Last) (3rd Stage)	2	25-J-512	11	BB61-S61-014	
341	Shroud (3rd Stage)	24	25-J-512	12	BB61-S61-014	
342	Shroud (3rd Stage)	2	25-J-512	13	BB61-S61-014	
343	Blade (4th Stage)	153	25-J-512	14	BB61-S61-014	
344	Blade (Last)(4th Stage)	2	25-J-512	15	BB61-S61-014	
345	Shroud (4th Stage)	24	25-J-512	16	BB61-S61-014	
346	Shroud (4th Stage)	2	25-J-512	17	BB61-S61-014	
347	Blade (5th Stage)	153	25-J-512	18	BB61-S61-014	
348	Blade (Last)(5th Stage)	2	25-J-512	19	BB61-S61-014	
349	Shroud (5th Stage)	24	25-J-512	20	BB61-S61-014	
350	Shroud (5th Stage)	2	25-J-512	21	BB61-S61-014	
351	Blade (6th Stage)	153	25-J-512	22	BB61-S61-014	
352	Blade (Last) (6th Stage)	2	25-J-512	23	BB61-S61-014	
353	Shroud (6th Stage)	24	25-J-512	24	BB61-S61-014	
354	Shroud (6th Stage)	2	25-J-512	25	BB61-S61-014	
355	Blade (7th Stage)	153	25-J-512	26	BB61-S61-014	
356	Blade (Last)(7th Stage)	2	25-J-512	27	BB61-S61-014	
357	Shroud (7th Stage)	24	25-J-512	28	BB61-S61-014	
358	Shroud (7th Stage)	2	25-J-512	29	BB61-S61-014	
359	Blade (8th Stage)	125	25-J-512	30	BB61-S61-014	
360	Blade (Last) (8th Stage)	2	25-J-512	31	BB61-S61-014	
361	Shroud (8th Stage)	16	25-J-512	32	BB61-S61-014	
362	Shroud (8th Stage)	6	25-J-512	33	BB61-S61-014	
363	Caulking Piece	150	25-J-512	34	BB61-S61-014	
364	Caulking Piece	1050	25-J-512	35	BB61-S61-014	
365	Shroud (8th Stage)	2	25-J-512	36	BB61-S62-015	
368	Blade Pin	16	25-J-513	1	BB61-S62-015	
369	Blade Pin	3	25-J-513	2	BB61-S62-015	
372	Low Pressure Oil Alarm Contact-Maker	1 Set	25-J-532	1-35 incl.	BB61-S61-033	Assemble as One Complete Contact-Maker
375	Nozzle Block Welding & Ass'y	2	25-J-534	1	BB61-S61-035	
376	Passage Unit	18	25-J-534	5	BB61-S61-035	
377	Starting Piece	2	25-J-534	6	BB61-S61-035	
378	Ending Piece	2	25-J-534	7	BB61-S61-035	
379	Outer Ring Segment	2	25-J-534	8	BB61-S61-035	
380	Inner Ring Segment	2	25-J-534	9	BB61-S61-035	
381	Filler Piece	2	25-J-534	10	BB61-S61-035	
382	Filler Piece	2	25-J-534	11	BB61-S61-035	
383	End Bridge	2	25-J-534	12	BB61-S61-035	
384	End Bridge	2	25-J-534	13	BB61-S61-035	
385	Intermediate Bridge	8	25-J-534	14	BB61-S61-035	

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Shore Spares—See Note "B", Page 522)

(These Spares for BB-61 and 62 only. For Spares for BB-63 to 66 See Pages 527 to 530).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
386	Filler Ring	2	25-J-534	16	BB61-S61-035	
387	Wedge	60	25-J-534	17	BB61-S61-035	
388	Locking Strip	4	25-J-534	18	BB61-S61-035	
389	Sealing Strip	2	25-J-534	19	BB61-S61-035	
390	Sealing Strip	2	25-J-534	20	BB61-S61-035	
391	Screw	18	25-J-534	22	BB61-S61-035	
392	Screw	4	25-J-534	23	BB61-S61-035	
393	Welding Rod	1	25-J-534	24	BB61-S61-035	
394	Welding Rod	1	25-J-534	25	BB61-S61-035	
395	Welding Rod	1	25-J-534	26	BB61-S61-035	
397	Sealing Strip (Half)	2	25-J-535	11	BB61-S61-036	
398	Locking Strip (Half)	2	25-J-535	12	BB61-S61-036	
400	Sealing Strip (Half)	2	25-J-536	15	BB61-S61-037	
401	Locking Strip (Half)	2	25-J-536	16	BB61-S61-037	
403	Sealing Strip (Half)	2	25-J-537	15	BB61-S61-038	
404	Locking Strip (Half)	2	25-J-537	16	BB61-S61-038	
405	Retaining Screw	2	25-J-537	17	BB61-S61-038	
406	Sealing Strip (Half)	2	25-J-538	15	BB61-S61-039	
407	Locking Strip (Half)	2	25-J-538	16	BB61-S61-039	
409	Sealing Strip (Half)	2	25-J-539	15	BB61-S61-040	
410	Locking Strip (Half)	2	25-J-539	16	BB61-S61-040	
412	Sealing Strip (Half)	2	25-J-540	15	BB61-S61-041	
413	Locking Strip (Half)	2	25-J-540	16	BB61-S61-041	
415	Sealing Strip (Half)	2	25-J-541	15	BB61-S61-042	
416	Locking Strip (Half)	2	25-J-541	16	BB61-S61-042	
418	Sealing Strip (Half)	2	25-J-542	15	BB61-S61-043	
419	Locking Strip (Half)	2	25-J-542	16	BB61-S61-043	
422	Pinion	1	25-J-550	10	BB61-S61-052	
423	Pinion Key	2	25-J-550	11	BB61-S61-052	
426	Relief Valve	1	25-J-551	1-21 incl.	BB61-S61-053	Assemble as Complete Valve
429	Seal Strip Ring	8	25-J-552	2	BB61-S61-055	
430	Seal Strip Ring	8	25-J-552	3	BB61-S61-055	
431	Seal Strip Ring Segment	8	25-J-552	4	BB61-S61-055	
432	Seal Strip Ring Segment	8	25-J-552	5	BB61-S61-055	
433	Seal Strip Ring Segment	8	25-J-552	6	BB61-S61-055	
434	Seal Strip Ring Segment	8	25-J-552	7	BB61-S61-055	
435	Spring	32	25-J-552	9	BB61-S61-055	
436	Seal Strip (Half)	24	25-J-552	10	BB61-S61-055	
437	Seal Strip (Quarter)	48	25-J-552	11	BB61-S61-055	
438	Seal Strip (Half)	24	25-J-552	12	BB61-S61-055	
439	Seal Strip (Quarter)	48	25-J-552	13	BB61-S61-055	
440	Caulking Strip (Half)	24	25-J-552	14	BB61-S61-055	
441	Caulking Strip (Quarter)	48	25-J-552	15	BB61-S61-055	
442	Seal Strip (Ring Segment)	8	25-J-552	16	BB61-S61-055	
443	Seal Strip (Ring Segment)	8	25-J-552	17	BB61-S61-055	
444	Seal Strip (Ring Segment)	8	25-J-552	18	BB61-S61-055	
445	Seal Strip (Ring Segment)	8	25-J-552	19	BB61-S61-055	
448	Throttle Valve Assembly	1 Set	25-J-566	2-7 9-19 21-97	BB61-S61-073	
452	Steam Strainer	2	25-J-571	3	BB61-S61-071	
453	Collar	4	25-J-571	4	BB61-S61-071	
454	Gasket	2	25-J-571	7	BB61-S61-071	
455	Cross Bar	2	25-J-571	8	BB61-S61-071	

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Shore Spares—See Note "B", Page 522)

(These Spares for BB-61 and 62 only. For Spares for BB-63 to 66 See Pages 527 to 530).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
458	Sentinel Valve Body	1	25-J-579	1	BB61-S61-056	
459	Bonnet	1	25-J-579	2	BB61-S61-056	
460	Lever	1	25-J-579	4	BB61-S61-056	
461	Spring	1	25-J-579	6	BB61-S61-056	
462	Disc	1	25-J-579	8	BB61-S61-056	
463	Spring Washer	2	25-J-579	11	BB61-S61-056	
464	Bonnet Bushing	1	25-J-579	12	BB61-S61-056	
465	Adjusting Screw	1	25-J-579	13	BB61-S61-056	
466	Adjusting Screw Locknut	1	25-J-579	16	BB61-S61-056	
467	Stem	1	25-J-579	18	BB61-S61-056	
468	Disc Stem Ring	1	25-J-579	19	BB61-S61-056	
469	Seat Bushing	1	25-J-579	20	BB61-S61-056	
470	Cap	1	25-J-579	23	BB61-S61-056	
471	Stem Nuts	2	25-J-579	24	BB61-S61-056	
472	Lever Pin	1	25-J-579	26	BB61-S61-056	
473	Cap Set Screw	1	25-J-579	40	BB61-S61-056	
474	Cotter Pin	1	25-J-579	43	BB61-S61-056	
475	Liquid Level Indicator	1	25-J-579	50	BB61-S61-056	
478	Relief Valve Oil Line Cap	1	25-J-580	1	BB61-S61-054	
479	Adjusting Screw	1	25-J-580	2	BB61-S61-054	
480	Locknut	1	25-J-580	3	BB61-S61-054	
481	Gasket	1	25-J-580	4	BB61-S61-054	
482	Spring Step	2	25-J-580	5	BB61-S61-054	
483	Spring	1	25-J-580	6	BB61-S61-054	
484	Cover	1	25-J-580	7	BB61-S61-054	
485	Stem	1	25-J-580	8	BB61-S61-054	
486	Name Plate	1	25-J-580	9	BB61-S61-054	
487	Star	1	25-J-580	10	BB61-S61-054	
488	Sleeve	1	25-J-580	11	BB61-S61-054	
489	Body	1	25-J-580	12	BB61-S61-054	
490	Gasket	1	25-J-580	13	BB61-S61-054	
491	Drive Screw	2	25-J-580	14	BB61-S61-054	

NOTE "A" Quantities Indicated In Req. Columns for Ship Spares Are Sufficient For One Set. One Set Furnished Per Ship.

NOTE "B" Quantities Indicated In Req. Columns For Shore Spares Are Sufficient For One Set. 2 Sets Furnished For Contract No. 70862.

NOTE "C" Assemble One Set Of Items 130, 131, 133, 135, 136, 137, 139 to 147 Incl. And 177 to 182 Incl. Per Ship

NOTE "D" Assemble One Set Of Items 132, 149 to 173 And 176 Per Ship.

NOTE "E" Assembly Four (4) Sets of Items 154, 155, 160 And 169 Per Ship

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 530)

(These Spares for BB-63 to 66 only. For Spares for BB-61 and 62 See Pages 515 to 519).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
1	Oil Cooler Gasket	16	25-J-266	33	BB61-S61-044	
2	Oil Cooler Gasket	8	25-J-266	34	BB61-S61-044	
3	Oil Cooler Gasket	8	25-J-266	35	BB61-S61-044	
4	Pipe Plug	32	25-J-266	39	BB61-S61-044	
5	Zinc Bar	32	25-J-266	40	BB61-S61-044	
7	Auto-Stop Governor Body . .	1	25-J-504	1	BB61-S61-05	
8	Weight.	1	25-J-504	2	BB61-S61-05	
9	Welding Rod	1	25-J-504	3	BB61-S61-05	
10	Spring	1	25-J-504	4	BB61-S61-05	
11	Retainer Half	2	25-J-504	5	BB61-S61-05	
12	Nut	1	25-J-504	6	BB61-S61-05	
13	Liner	1	25-J-504	7	BB61-S61-05	
14	Liner	2	25-J-504	8	BB61-S61-05	
15	Liner	1	25-J-504	9	BB61-S61-05	
16	Liner	1	25-J-504	10	BB61-S61-05	
17	Liner	1	25-J-504	11	BB61-S61-05	
18	Set Screw	1	25-J-504	12	BB61-S61-05	
19	Trip Lever	1	25-J-504	13	BB61-S61-05	
20	Trip Latch	1	25-J-504	14	BB61-S61-05	
21	Tip	2	25-J-504	15	BB61-S61-05	
22	Lever Shaft	1	25-J-504	16	BB61-S61-05	
23	Latch Pin	1	25-J-504	17	BB61-S61-05	
24	Taper Pin	2	25-J-504	18	BB61-S61-05	
25	Latch Spring	1	25-J-504	19	BB61-S61-05	
26	Reset Bushing	1	25-J-504	21	BB61-S61-05	
27	Fulcrum Pin	1	25-J-504	22	BB61-S61-05	
28	Trip Spring	1	25-J-504	30	BB61-S61-05	
29	Bracket Bushing	2	25-J-504	37	BB61-S61-05	
30	Trip Lever Bushing	2	25-J-504	47	BB61-S61-05	
31	Reset Handle Bushing . . .	1	25-J-504	48	BB61-S61-05	
32	Clevis Pin	2	25-J-504	49	BB61-S61-05	
33	Clevis Pin	1	25-J-504	50	BB61-S61-05	
34	Headless Set Screw	1	25-J-504	57	BB61-S61-05	
38	Back Pressure Safety Stop Diaphragm	2	25-J-505	63	BB61-S61-06	
39	Spring	2	25-J-505	75	BB61-S61-06	
42	Oil Flow Indicator Cover Glass	2	25-J-506	15	BB61-S61-07	
45	Gear Bearing (Upper Half) Generator End	1	25-J-507	1	BB61-S61-08	
46	Gear Bearing (Lower Half) Generator End	1	25-J-507	2	BB61-S61-08	
47	Babbitt . . . (10-1/2 lb.)		25-J-507	3	BB61-S61-08	
48	Dowel Pin	12	25 J-507	4	BB61-S61-08	
49	Stop Pin	2	25-J-507	5	BB61-S61-08	
50	Gear Bearing (Upper Half) Turbine End	1	25-J-507	6	BB61-S61-08	
51	Gear Bearing (Lower Half) Turbine End	1	25-J-507	7	BB61-S61-08	
52	Babbitt . . . .(10-1/2 lb.)		25-J-507	8	BB61-S61-08	
53	Pinion Bearing (Upper Half) Generator End	1	25-J-507	9	BB61-S61-08	
54	Pinion Bearing (Upper Half) Turbine End	1	25-J-507	10	BB61-S61-08	
55	Pinion Bearing (Lower Half)	2	25-J-507	11	BB61-S61-08	
56	Babbitt . . . . . .(12 lb.)		25-J-507	12	BB61-S61-08	
57	Stop Pin	2	25-J-507	13	BB61-S61-08	

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 530)

(These Spares for BB-63 to 66 only. For Spares for BB-61 and 62 See Pages 515 to 519).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
58	Nipple	1	25-J-507	14	BB61-S61-08	
59	Turbine Bearing (Upper Half)	2	25-J-507	15	BB61-S61-08	
60	Turbine Bearing (Lower Half) Thrust End	1	25-J-507	16	BB61-S61-08	
61	Turbine Bearing (Lower Half) Coupling End	1	25-J-507	17	BB61-S61-08	
62	Babbitt	10#	25-J-507	18	BB61-S61-08	
63	Stop Pin	2	25-J-507	19	BB61-S61-08	Assembled as One Unit
64	Bearing Baffle (Half)	4	25-J-507	20	BB61-S61-08	
65	Thrust Ring (Half)	4	25-J-507	21	BB61-S61-08	
66	Screw (Fil. Head)	12	25-J-507	22	BB61-S61-08	
67	Thrust Liner	8	25-J-507	23	BB61-S61-08	
68	Thrust Liner	4	25-J-507	24	BB61-S61-08	
69	Thrust Liner	8	25-J-507	25	BB61-S61-08	
73	Thrust Bearing Collar	2	25-J-508	4	BB61-S61-09	
74	Thrust Bearing Shoe	24	25-J-508	5	BB61-S61-09	Assembled as One Unit
75	Babbitt	2#	25-J-508	6	BB61-S61-09	
76	Support	24	25-J-508	7	BB61-S61-09	
79	Gages (For Gage Board)	2 ea.	25-J-523	10-14	BB61-S61-025	
80	Gage Glass for Pieces 10-14	10	25-J-523	15	BB61-S61-025	
81	Gage Glass for Piece 50	4	25-J-525		BB61-S61-027	
83	Gage	2	25-J-525	50	BB61-S61-027	
86	Gear Shaft Oil Ring (Lower Half)	1	25-J-526	22	BB61-S61-028	
87	Gear Shaft Oil Ring (Upper Half)	1	25-J-526	23	BB61-S61-028	
88	Baffle (Lower Half)	1	25-J-526	24	BB61-S61-028	
89	Baffle (Upper Half)	1	25-J-526	25	BB61-S61-028	
91	Governor Details		25-J-487			
92	Bushing	2	25-J-487	4		
93	Bushing	10	25-J-487	5		
94	Rod	1	25-J-487	6		
95	Bushing	2	25-J-487	24		
96	Adjusting Nut	2	25-J-487	26		
97	Pin	1	25-J-487	27		
99	Governor Relay Bushing	1	25-J-488	1		
100	Piston Rod	1	25-J-488	2		
101	Governor Closing Spring	2	25-J-488	5		
102	Governor Spring	2	25-J-488	6		
103	Spring Seat (Upper)	1	25-J-488	7		
104	Relay Rod	1	25-J-488	8		
105	Spring Seat (Lower)	1	25-J-488	9		
106	Spring Seat (Upper)	1	25-J-488	10		
107	Relay	1	25-J-488	11		
108	Speed Reg. Spring	2	25-J-488	12		
109	Bushing	1	25-J-488	13		
110	Bushing	4	25-J-488	14		
111	Bushing	1	25-J-488	15		
112	Motor Shaft Extension	1	25-J-488	16		
113	Clutch Plate	1	25-J-488	19		
114	Clutch Plate	1	25-J-488	20		
115	Clutch Collar	1	25-J-488	21		
116	Worm Wheel	1	25-J-488	23		
117	Spring	2	25-J-488	24		
118	Worm Gear	1	25-J-488	25		
119	Handwheel Stem	1	25-J-488	26		

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 530)

(These Spares for BB-63 to 66 only. For Spares for BB-61 and 62 See Pages 515 to 519).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
120	Worm	1	25-J-488	27		
121	Pin	4	25-J-488	29		
122	Bushing	1	25-J-488	31		
123	Pin	1	25-J-488	36		
124	Piston Ring	1	25-J-488	37		
125	Castle Nut	1	25-J-488	41		
126	Relay (Complete)	1	25-J-488	42		
127	Pin	1	25-J-488	43		
130	Transformer Housing	4	25-J-489	1		See Note C
131	Orifice	1	25-J-489	2		See Note C
132	Bolt	4	25-J-489	3		See Note D
133	Cap Screw	3	25-J-489	4		See Note C
135	Ring	1	25-J-489	6		See Note C
136	Bushing	1	25-J-489	7		See Note C
137	Relay	1	25-J-489	8		See Note C
139	Stop Ring	1	25-J-489	10		See Note C
140	Ring	1	25-J-489	11		See Note C
141	Welding Rod	1	25-J-489	12		See Note C
142	Stop Flange	1	25-J-489	13		See Note C
143	Cap Screw	4	25-J-489	14		See Note C
144	Worm Wheel	1	25-J-489	15		See Note C
145	Set Screw	1	25-J-489	16		See Note C
146	Pipe Plug	3	25-J-489	17		See Note C
147	Cap Screw	2	25-J-489	18		See Note C
148	Cap Screw	4	25-J-489	19		
149	Casing	1	25-J-489	20		See Note D
150	Cylinder (Outer)	1	25-J-489	21		See Note D
151	Cylinder (Inner)	1	25-J-489	22		See Note D
152	Hub	1	25-J-489	23		See Note D
153	Contact Ball	5	25-J-489	24		See Note D
154	Spring Guide	18	25-J-489	25		See Notes D & E
155	Spring Retainer	18	25-J-489	26		See Notes D & E
156	Seat	1	25-J-489	27		See Note D
157	Governor Weight	2	25-J-489	28		See Note D
158	Pin Key	1	25-J-489	29		See Note D
159	Governor Stop Screw	2	25-J-489	30		See Note D
160	Spring	9	25-J-489	31		See Notes D & E
161	Spring Seat	1	25-J-489	32		See Note D
162	Clamp Bar	1	25-J-489	33		See Note D
163	Ball Seat	5	25-J-489	34		See Note D
164	Spacer	2	25-J-489	35		See Note D
165	Headless Set Screw	1	25-J-489	36		See Note D
166	Governor Spring	2	25-J-489	37		See Note D
167	Pin	4	25-J-489	38		See Note D
168	Cotter Wire	1	25-J-489	39		See Note D
169	Button Head Rivet	18	25-J-489	40		See Notes D & E
170	Nut	2	25-J-489	41		See Note D
171	Round Hd. Cap Screw	2	25-J-489	42		See Note D
172	Lock Nut	1	25-J-489	43		See Note D
173	Thrust Bearing	5	25-J-489	44		See Note D
174	Elastic Stop Nut	1	25-J-489	45		
175	Stud	1	25-J-489	46		
176	Pipe Plug	1	25-J-489	47		See Note D
177	Pin	1	25-J-489	48		See Note C
178	Screw Oval Fil. Hd. Machine	2	25-J-489	49		See Note C

For Notes See Page 530

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 530)

(These Spares for BB-63 to 66 only. For Spares for BB-61 and 62 See Pages 515 to 519).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
179	Liner	2	25-J-489	50		See Note C
180	Liner	1	25-J-489	51		See Note C
181	Liner	1	25-J-489	52		See Note C
182	Liner	1	25-J-489	53		See Note C
184	Pipe Plug	1	25-J-490	7		
185	Governor Body Bearing	5	25-J-490	3		
186	Sleeve	1	25-J-490	4		
187	Sleeve Nut	1	25-J-490	5		
188	Oil Filter	1	25-J-490	9		
189	Straight Pin	2	25-J-490	14		
190	Spiral Gear (Driven)	2	25-J-490	15		
191	Spiral Gear (Driver)	2	25-J-490	16		
192	Liner	2	25-J-490	17		
193	Set Screw Dog Point	1	25-J-490	18		
194	Gov. Body Shaft Key	1	25-J-490	19		
195	Gov. Body Bearing	5	25-J-490	20		
196	Babbitt (10 sets)		25-J-490	21		
197	Valve No. 3	2	25-J-492	6		
198	Valve Seat No. 2-3 & 5	6	25-J-492	8		
199	Valve Seat No. 1-4 & 6	6	25-J-492	9		
200	Valve No. 2 & 5	4	25-J-492	10		
201	Valve No. 1-4 & 6	6	25-J-492	11		
202	Welding Rod (1 set)		25-J-492	12		
203	Lifting Rod	2	25-J-492	14		
204	Bushing (Upper)	2	25-J-492	15		
205	Bushing (Lower)	2	25-J-492	16		
206	Bushing	2	25-J-492	24		
207	Bushing	2	25-J-492	25		
208	Bushing	2	25-J-492	26		
209	Bushing	2	25-J-492	27		
212	Steam Piping Gage	2	25-J-565	32	BB61-S61-069	
213	Gauge Glass for above Gage.	4	25-J-565	33	BB61-S61-069	
216	Oil Strainer Packing (3rows)		25-J-576	9	BB61-S61-049	
217	Basket Support	1	25-J-576	16	BB61-S61-049	
218	Basket (Side)	1	25-J-576	16-A	BB61-S61-049	
219	Basket (Bottom)	1	25-J-576	16-B	BB61-S61-049	
220	Basket Handle	1	25-J-576	16-C	BB61-S61-049	
221	Rivet	6	25-J-576	16-D	BB61-S61-049	
222	Union Nut	1	25-J-576	16-F	BB61-S61-049	
223	Union Check Nut	1	25-J-576	16-G	BB61-S61-049	
224	Pin	1	25-J-576	16-J	BB61-S61-049	
225	Basket (Side)	1	25-J-576	16-M	BB61-S61-049	
226	Basket (Bottom)	1	25-J-576	16-MB	BB61-S61-049	
227	Basket Ring	1	25-J-576	16-S	BB61-S61-049	
228	Magnet	6	25-J-576	17	BB61-S61-049	
229	Magnet Rod	1	25-J-576	17-A	BB61-S61-049	
230	Magnet Pin	6	25-J-576	17-C	BB61-S61-049	
231	St. Jam Hex Nut	2	25-J-576	17-D	BB61-S61-049	
232	Nut	1	25-J-576	17-E	BB61-S61-049	
233	Pin (For Pc. 17-E)	1	25-J-576	17-F	BB61-S61-049	
236	Gov. Speed Changer Motor Armature Complete	1	31-J-755	54		
237	Ball Bearing No. 6200 SKF	5	31-J-755	3		
238	Brushes	24	31-J-755	13		
239	Brush Springs	6	31-J-755	8		

See Page 530

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Ship's Spares—See Note "A", Page 530)

(These Spares for BB-63 to 66 only. For Spares for BB-61 and 62 See Pages 515 to 519).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
240	Brushholder	2	31-J-755	34		
241	Brushholder Screw	2	31-J-755	11		
242	Field Coil Set.	8	31-J-755	17		
243	Brushholder Insulation	2	31-J-755	34		
244	Felt Wick	17	31-J-755	5		
246	Relief Valve Spring	2	25-J-551	10	BB61-S61-053	
249	Sentinel Valve Spring	2	25-J-579	6	BB61-S61-056	
251	Relief Valve Oil Line Spring	2	25-J-580	6	BB61-S61-054	
253	Throttle Valve Spring	2	25-J-566	68	BB61-S61-073	
255	Oil Piping Thermometer	2	25-J-543	2	BB61-S61-045	
257	Oil Piping Sight Flow Glass	2	25-J-544	67	BB61-S61-046	
260	Oil Pump Details					
261	Pump Gear (Driver).	2	25-J-545	4	BB61-S61-047	
262	Pump Gear Shaft (Driver)	2	25-J-545	5	BB61-S61-047	
263	Pump Gear (Driven)	2	25-J-545	6	BB61-S61-047	
264	Pump Gear Shaft (Driven)	2	25-J-545	7	BB61-S61-047	
265	Shaft Sleeve	2	25-J-545	8	BB61-S61-047	
266	Drive Shaft	2	25-J-545	10	BB61-S61-047	
267	Bushing	4	25-J-545	11	BB61-S61-047	
268	Set Screw	8	25-J-545	16	BB61-S61-047	
269	Bushing	4	25-J-545	17	BB61-S61-047	
271	Crank Shaft Gear	2	25-J-546	4	BB61-S61-45	
272	Pump Shaft Gear	2	25-J-546	5	BB61-S61-45	
273	Pump Gear (Driver)	2	25-J-546	6	BB61-S61-45	
274	Pump Gear (Driven)	2	25-J-546	7	BB61-S61-048	
278	Spindle Gland Packing Ring.	12	25-J-558	10	BB61-S61-063	
279	Retainer Ring Segment	96	25-J-558	11	BB61-S61-063	
280	Key	24	25-J-558	12	BB61-S61-063	
281	Spring	24	25-J-558	16	BB61-S61-063	
282	Spindle Gland Packing Ring.	12	25-J-558	26	BB61-S61-063	
285	Spindle Position Indicator					
286	Contact Ball	1	25-J-561	4	BB61-S61-066	
287	Retainer	1	25-J-561	5	BB61-S61-066	
288	Spring	2	25-J-561	6	BB61-S61-066	
289	Spindle	1	25-J-561	7	BB61-S61-066	
290	Bushing	1	25-J-561	8	BB61-S61-066	

(Shore Spares—See Note "B", Page 530)

307	Blade (1st Rotating)	83	25-J-510	2	BB61-S61-012	
308	Blade (Last)(1st Rotating).	2	25-J-510	3	BB61-S61-012	
309	Blade Stationary	27	25-J-510	4	BB61-S61-012	
310	Blade (2nd Rotating)	71	25-J-510	5	BB61-S61-012	
311	Blade (Last)(2nd Rotating).	2	25-J-510	6	BB61-S61-012	
312	Pin (1st Rotating)	3	25-J-510	7	BB61-S61-012	
313	Pin (2nd Rotating)	3	25-J-510	8	BB61-S61-012	
314	Shroud Stock	12 Ft.	25-J-510	11	BB61-S61-012	
315	Blade Start Piece	1	25-J-510	13	BB61-S61-012	
316	Blade Stop Piece	1	25-J-510	14	BB61-S61-012	
317	Screw (Flat Fil. Head)	2	25-J-510	15	BB61-S61-012	
318	Caulking Piece	168	25-J-510	16	BB61-S61-012	
319	Caulking Piece	44	25-J-510	17	BB61-S61-012	
320	Caulking Piece	384	25-J-510	18	BB61-S61-012	
321	Caulking Piece	88	25-J-510	19	BB61-S61-012	
322	Caulking Piece	28	25-J-510	20	BB61-S61-012	
323	Sealing Strip	2	25-J-510	21	BB61-S61-012	

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Shore Spares—See Note "B", Page 530)

(These Spares for BB-63 to 66 only. For Spares for BB-61 and 62 See Pages 519 to 522).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
324	Sealing Strip	1	25-J-510	22	BB61-S61-012	
325	Sealing Strip	1	25-J-510	23	BB61-S61-012	
326	Lock Strip	4	25-J-510	24	BB61-S61-012	
331	Blade (1st Stage)	153	25-J-512	2	BB61-S61-014	
332	Blade (Last)(1st Stage)	2	25-J-512	3	BB61-S61-014	
333	Shroud (1st Stage)	24	25-J-512	4	BB61-S61-014	
334	Shroud (1st Stage)	2	25-J-512	5	BB61-S61-014	
335	Blade (2nd Stage)	153	25-J-512	6	BB61-S61-014	
336	Blade (Last) (2nd Stage)	2	25-J-512	7	BB61-S61-014	
337	Shroud (2nd Stage)	24	25-J-512	8	BB61-S61-014	
338	Shroud (2nd Stage)	2	25-J-512	9	BB61-S61-014	
339	Blade (3rd Stage)	153	25-J-512	10	BB61-S61-014	
340	Blade (Last)(3rd Stage)	2	25-J-512	11	BB61-S61-014	
341	Shroud (3rd Stage)	24	25-J-512	12	BB61-S61-014	
342	Shroud (3rd Stage)	2	25-J-512	13	BB61-S61-014	
343	Blade (4th Stage)	153	25-J-512	14	BB61-S61-014	
344	Blade (Last)(4th Stage)	2	25-J-512	15	BB61-S61-014	
345	Shroud (4th Stage)	24	25-J-512	16	BB61-S61-014	
346	Shroud (4th Stage)	2	25-J-512	17	BB61-S61-014	
347	Blade (5th Stage)	153	25-J-512	18	BB61-S61-014	
348	Blade (Last)(5th Stage)	2	25-J-512	19	BB61-S61-014	
349	Shroud (5th Stage)	24	25-J-512	20	BB61-S61-014	
350	Shroud (5th Stage)	2	25-J-512	21	BB61-S61-014	
351	Blade (6th Stage)	153	25-J-512	22	BB61-S61-014	
352	Blade (Last) (6th Stage)	2	25-J-512	23	BB61-S61-014	
353	Shroud (6th Stage)	24	25-J-512	24	BB61-S61-014	
354	Shroud (6th Stage)	2	25-J-512	25	BB61-S61-014	
355	Blade (7th Stage)	153	25-J-512	26	BB61-S61-014	
356	Blade (Last)(7th Stage)	2	25-J-512	27	BB61-S61-014	
357	Shroud (7th Stage)	24	25-J-512	28	BB61-S61-014	
358	Shroud (7th Stage)	2	25-J-512	29	BB61-S61-014	
359	Blade (8th Stage)	125	25-J-512	30	BB61-S61-014	
360	Blade (Last)(8th Stage)	2	25-J-512	31	BB61-S61-014	
361	Shroud (8th Stage)	16	25-J-512	32	BB61-S61-014	
362	Shroud (8th Stage)	6	25-J-512	33	BB61-S61-014	
363	Caulking Piece	150	25-J-512	34	BB61-S61-014	
364	Caulking Piece	1050	25-J-512	35	BB61-S61-014	
365	Shroud (8th Stage)	2	25-J-512	36	BB61-S61-014	
368	Blade Pin	16	25-J-513	1	BB61-S61-015	
369	Blade Pin	3	25-J-513	2	BB61-S61-015	
372	Low Pressure Oil Alarm Contact-Maker	1 set	25-J-532	1-35 Incl.	BB61-S61-033	Assemble as One Complete Contact Maker
375	Nozzle Block Welding & Ass'y	2	25-J-534	1	BB61-S61-035	
376	Passage Unit	18	25-J-534	5	BB61-S61-035	
377	Starting Piece	2	25-J-534	6	BB61-S61-035	
378	Ending Piece	2	25-J-534	7	BB61-S61-035	
379	Outer Ring Segment	2	25-J-534	8	BB61-S61-035	
380	Inner Ring Segment	2	25-J-534	9	BB61-S61-035	
381	Filler Piece	2	25-J-534	10	BB61-S61-035	
382	Filler Piece	2	25-J-534	11	BB61-S61-035	
383	End Bridge	2	25-J-534	12	BB61-S61-035	
384	End Bridge	2	25-J-534	13	BB61-S61-035	
385	Intermediate Bridge	8	25-J-534	14	BB61-S61-035	
386	Filler Ring	2	25-J-534	16	BB61-S61-035	
387	Wedge	60	25-J-534	17	BB61-S61-035	

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Shore Spares—See Note "B", Page 530)

(These Spares for BB-63 to 66 only. For Spares for BB-61 and 62 See Pages 519 to 522).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
388	Locking Strip	4	25-J-534	18	BB61-S61-035	
389	Sealing Strip	2	25-J-534	19	BB61-S61-035	
390	Sealing Strip	2	25-J-534	20	BB61-S61-035	
391	Screw	18	25-J-534	22	BB61-S61-035	
392	Screw	4	25-J-534	23	BB61-S61-035	
393	Welding Rod	1	25-J-534	24	BB61-S61-035	
394	Welding Rod	1	25-J-534	25	BB61-S61-035	
395	Welding Rod	1	25-J-534	26	BB61-S61-035	
397	Sealing Strip (Half)	2	25-J-535	11	BB61-S61-036	
398	Locking Strip (Half)	2	25-J-535	12	BB61-S61-036	
400	Sealing Strip (Half)	2	25-J-536	15	BB61-S61-037	
401	Locking Strip (Half)	2	25-J-536	16	BB61-S61-037	
403	Sealing Strip (Half)	2	25-J-537	15	BB61-S61-038	
404	Locking Strip (Half)	2	25-J-537	16	BB61-S61-038	
405	Retainer Screw	2	25-J-537	17	BB61-S61-038	
406	Sealing Strip (Half)	2	25-J-538	15	BB61-S61-039	
407	Locking Strip (Half)	2	25-J-538	16	BB61-S61-039	
409	Sealing Strip (Half)	2	25-J-539	15	BB61-S61-040	
410	Locking Strip (Half)	2	25-J-539	16	BB61-S61-040	
412	Sealing Strip (Half)	2	25-J-540	15	BB61-S61-041	
413	Locking Strip (Half)	2	25-J-540	16	BB61-S61-041	
415	Sealing Strip (Half)	2	25-J-541	15	BB61-S61-042	
416	Locking Strip (Half)	2	25-J-541	16	BB61-S61-042	
418	Sealing Strip (Half)	2	25-J-542	15	BB61-S61-043	
419	Locking Strip (Half)	2	25-J-542	16	BB61-S61-043	
422	Pinion	1	25-J-550	10	BB61-S61-052	
423	Pinion Key	2	25-J-550	11	BB61-S61-052	
426	Relief Valve	1	25-J-551	1-21 incl.	BB61-S61-053	Assemble as Complete Valve
429	Seal Strip Ring	8	25-J-552	2	BB61-S61-055	
430	Seal Strip Ring	8	25-J-552	3	BB61-S61-055	
431	Seal Strip Ring Segment	8	25-J-552	4	BB61-S61-055	
432	Seal Strip Ring Segment	8	25-J-552	5	BB61-S61-055	
433	Seal Strip Ring Segment	8	25-J-552	6	BB61-S61-055	
434	Seal Strip Ring Segment	8	25-J-552	7	BB61-S61-055	
435	Spring	32	25-J-552	9	BB61-S61-055	
436	Seal Strip (Half)	24	25-J-552	10	BB61-S61-055	
437	Seal Strip (Quarter)	48	25-J-552	11	BB61-S61-055	
438	Seal Strip (Half)	24	25-J-552	12	BB61-S61-055	
439	Seal Strip (Quarter)	48	25-J-552	13	BB61-S61-055	
440	Caulking Strip (Half)	24	25-J-552	14	BB61-S61-055	
441	Caulking Strip (Quarter)	48	25-J-552	15	BB61-S61-055	
442	Seal Strip (Ring Segment)	8	25-J-552	16	BB61-S61-055	
443	Seal Strip (Ring Segment)	8	25-J-552	17	BB61-S61-055	
444	Seal Strip (Ring Segment)	8	25-J-552	18	BB61-S61-055	
445	Seal Strip (Ring Segment)	8	25-J-552	19	BB61-S61-055	
448	Throttle Valve Assembly	1 set	25-J-566	2-7 9-19 21-97	BB61-S61-073	
452	Steam Strainer	2	25-J-571	3	BB61-S61-071	
453	Collar	4	25-J-571	4	BB61-S61-071	
454	Gasket	2	25-J-571	7	BB61-S61-071	
455	Cross Bar	2	25-J-571	8	BB61-S71-071	
458	Sentinel Valve Body	1	25-J-579	1	BB61-S61-056	
459	Bonnet	1	25-J-579	2	BB61-S61-056	
460	Lever	1	25-J-579	4	BB61-S61-056	

SPARE PARTS LIST FOR TURBINE AND REDUCTION GEAR

(Shore Spares—See Note "B", Page 530)

(These Spares for BB-63 to 66 only. For Spares for BB-61 and 62 See Pages 519 to 522).

Item No.	Name of Piece	No. Req.	DRAWING NUMBER Contractor	Pc.	Bureau Ship's	Remarks
461	Spring	1	25-J-579	6	BB61-S61-056	
462	Disc	1	25-J-579	8	BB61-S61-056	
463	Spring Washer	2	25-J-579	11	BB61-S61-056	
464	Bonnet Bushing	1	25-J-579	12	BB61-S61-056	
465	Adjusting Screw	1	25-J-579	13	BB61-S61-056	
466	Adjusting Screw Locknut	1	25-J-579	16	BB61-S61-056	
467	Stem	1	25-J-579	18	BB61-S61-056	
468	Disc Stem Ring	1	25-J-579	19	BB61-S61-056	
469	Seat Bushing	1	25-J-579	20	BB61-S61-056	
470	Cap	1	25-J-579	23	BB61-S61-056	
471	Stem Nuts	2	25-J-579	24	BB61-S61-056	
472	Lever Pin	1	25-J-579	26	BB61-S61-056	
473	Cap Set Screw	1	25-J-579	40	BB61-S61-056	
474	Cotter Pin	1	25-J-579	43	BB61-S61-056	
475	Liquid Level Indicator	1	25-J-579	50	BB61-S61-056	
478	Relief Valve Oil Line Cap	1	25-J-580	1	BB61-S61-054	
479	Adjusting Screw	1	25-J-580	2	BB61-S61-054	
480	Locknut	1	25-J-580	3	BB61-S61-054	
481	Gasket	1	25-J-580	4	BB61-S61-054	
482	Spring Step	2	25-J-580	5	BB61-S61-054	
483	Spring	1	25-J-580	6	BB61-S61-054	
484	Cover	1	25-J-580	7	BB61-S61-054	
485	Stem	1	25-J-580	8	BB61-S61-054	
486	Name Plate	1	25-J-580	9	BB61-S61-054	
487	Star	1	25-J-580	10	BB61-S61-054	
488	Sleeve	1	25-J-580	11	BB61-S61-054	
489	Body	1	25-J-580	12	BB61-S61-054	
490	Gasket	1	25-J-580	13	BB61-S61-054	
491	Drive Screw	2	25-J-580	14	BB61-S61-054	

NOTE "A" Quantities Indicated In Required Columns For Ship Spares Are Sufficient For One Set. One Set Furnished Per Ship.

NOTE "B" Quantities Indicated In Required Columns For Shore Spares Are Sufficient For One Set. 2 Sets Furnished For Contract No. 70862.

NOTE "C" Assemble One Set of Items 130, 131, 133, 135, 136, 137, 139 to 147 Incl. And 177 to 182 Incl. Per Ship.

NOTE "D" Assemble One Set of Items 132, 149 to 173 And 176 Per Ship.

NOTE "E" Assemble Four Sets of Items 154, 155, 160 And 169 Per Ship.

PART VI

LIST OF ILLUSTRATIONS, DRAWINGS AND DIAGRAMS

OVERBLOWN DOCUMENTS

WITHIN THE CONTENT OF THIS EXHIBIT ARE NOT IMAGED