Instruction Book

600 KW TURBINE GENERATOR UNITS
Turbine, Reduction Gear, Generator, Exciter and Regulator

for

HULLS 1053 & 1054

THE INGALLS SHIPBUILDING CORPORATION
Pascagoula, Mississippi

Ingalls Hull No. 1053
Customers Order No. CCY-2
Westinghouse Order No. BH-69181-T2

Ingalls Hull No. 1054
Customers Order No. CDE-2
Westinghouse Order No. BH-71041-T2

January, 1959

IN RE: ABRAMS November 1992

WESTINGHOUSE ELECTRIC CORPORATION

South Philadelphia Works - Steam Division - Essington, Pa.

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MH-729-B

INSTRUCTION BOOK 1430-C95

Printed in U.S.A.

Serial Number Assignments

INGALLS HULL NO. 1053

S/S ______________

	Turbine	Generator	Exciter
Unit No. 1	15-A-1404-1	1-S-58-P-316	1-S-58-P-317
Unit No. 2	15-A-1404-2	2-S-58-P-316	2-S-58-P-317

INGALLS HULL NO. 1054

S/S ______________

	Turbine	Generator	Exciter
Unit No. 1	15-A-1404-3	1-S-57-P-994	1-S-57-P-995
Unit No. 2	15-A-1404-4	2-S-57-P-994	2-S-57-P-995

NOTE: The letter "S" in Generator or Exciter Serial Number, means "Stator". The rotor bears the same Serial Number with the letter "R" in place of "S".

Communications

Should communications be desirable or necessary regarding the unit installation covered by this instruction book, or an individual device included in the installation, replies will be greatly facilitated by citing the Westinghouse General Order Number for the complete equipment and the nameplate readings for the detail apparatus involved.

Do not fail to give the turbine and/or generator stator and rotor serial number and the complete nameplate reading, when information is desired. The turbine data and serial number are stamped on the nameplate, mounted on the turbine exhaust end cover. The generator stator serial number is stamped on the generator nameplate, and also on the metal under the nameplate and on the machine foot. The generator rotor serial number is stamped on the end of the shaft.

Should any particular information be desired, please be very careful to state clearly and fully the question for consideration, and the associated conditions.

Communications should be addressed to the nearest Westinghouse Electric Corporation Sales Office. Local sales, engineering or service representatives are usually available for quick consultation.

Ordering Repair or Renewal Parts

When ordering repair or renewal parts, give the name of the parts, the illustration or drawing and item numbers which apply and the nameplate reading of the machine, including the serial number.

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S/S ______________

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CHAPTER 1 - TURBINE AND REDUCTION GEAR

Section 1.1. Turbine Details

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 reduces the high speed required for efficiency in the turbine to the lower practicable generator speed. The turbine, gear and generator are mounted on a common bedplate, to which is secured also the oil cooler, etc. An outline arrangement plan of the unit is shown in Figure T-1.

2. Two identical units are supplied for each ship. The nominal rating of each unit is 600 kw, on a 750 kva, 80% power factor, 3 phase, 60 cycle, 450 volt, a-c generator; and a 120 volt, d-c exciter.

3. The turbine is designed and tested to operate with steam at a throttle pressure of 585 psig, with 845° FTT. The turbine is also capable of delivering rated load with satisfactory operation in all respects when subjected to pressure and temperature variations as defined in the NEMA Standards for Marine Propulsion Steam Turbines and Gears. The turbine will also operate satisfactorily at reduced capacity when exhausting to the atmosphere.

GUARANTEED PERFORMANCE

Load Percent	Load KW	Throttle Steam Flow Lb/hr	Rate Lb/kw/hr.	Vacuum In. Hg. Abs.
125	750	7868	10.40	1.5
100	600	6294	10.40	1.5
75	450	4892	10.87	1.5
50	300	3501	11.67	1.5

4. The turbine exhausts into an auxiliary condenser at 1.5 inches Hg exhaust pressure.

5. The normal operating speed of the turbine is 9,018 rpm and that of the generator is 1,200 rpm.

6. The pinion and gear are of the double-helical type, and the gear is designed to transmit a normal load of 888 brake horsepower with the pinion operating at 9,018 rpm and the gear at 1,200 rpm. Under these conditions the gear bearing pressure is 80.0 pounds per square inch of projected area, the pinion bearing pressure is 190 pounds per square inch of projected area, and the tooth pressure is 89 pounds per inch face, per inch pitch circle diameter.

7. The turbine bearing pressures are 90.0 and 72.4 pounds per square inch of projected area, and the turbine and pinion journal speeds are 78.7 and 108 feet per second, respectively. The gear journal velocity is 21.0 feet per second.

8. The oil system capacity--at high level is 80 gallons; normal level 76 gallons, and at low level 72 gallons.

GENERAL DESCRIPTION

1. 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. The Curtis stage is followed by six Rateau stages.

2. 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.

3. 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 two transverse plates which are bolted to the cylinder and the bedplate. The web of the transverse plates provide the necessary flexibility for longitudinal expansion and contraction of the cylinder.

CYLINDER

1. The turbine cylinder consists of a base and cover, bolted together on the horizontal joint, and each made in two pieces. The horizontal and vertical joint flanges are carefully machined to a full bearing surface which provides a true metal to metal joint. These four pieces are made from a high grade of cast steel, the steam chest being cast integral with the cylinder cover, high pressure end.

ROTOR

1. The turbine rotor is machined from a solid alloy-steel forging. The auto-stop body is screwed onto one end and the other end is coupled to the reduction-gear pinion through a flexible coupling. After the blades are installed, the entire rotating assembly is dynamically balanced.

CURTIS BLADING

1. The Curtis blading is shown in detail in Figure T-3. 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 forged corrosion resistant steel, and is secured to the turbine cylinder by means of caulked wedges and screws. The steam is expanded through round passages in the block to the pressure existing in the Curtis wheel chamber. The blades are milled from bar stock of corrosion resistant steel and are provided with shrouds, riveted over tenons on the ends of the blades, thus forming a closed passage for the steam flow.

2. The rotating blades are secured to the turbine rotor by a type of fastening consisting of a "T"-root with lugs machined on the blade shank which straddle and hold in the sides of the groove, thus resisting the tendency of the blade-pull to spread the side of the blade-groove. The blades are held against the top of 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.

3. 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

1. The Curtis element is followed by six Rateau stages, divided from the former and from each other by interstage diaphragms. The Rateau blading is illustrated in Fig. T-3. The nozzles for the Rateau stages are machined

units welded into inner and outer rings to make a complete diaphragm assembly. The latter are made in halves and extend completely around the rotor. The second, third, and fourth stage nozzles, 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.

INTERSTAGE SEALS

1. Steam leakage from stage to stage between the stationary diaphragms and the rotating shaft is minimized by means of interstage seals. These consist of stepped-tooth labyrinth strips machined integrally in rings, made in four segments, and mounted in "L" shaped grooves in the diaphragms. The rings are held in position of minimum clearance by means of garter springs as indicated in the illustration, Figure T-4 and are prevented from rotating by means of the pins.

2. The radial clearances between the rotor and the interstage seals are indicated in the illustration Figure T-24. These radial clearances are the designed "cold" clearance and in addition, the seal rings have small gaps between the segments as shown in the illustration Figure T-4, to provide for expansion. The seal rings are matched marked so that they may be reassembled correctly.

CURTIS WHEEL CHAMBER LABYRINTH SEAL

1. In order to minimize leakage of high pressure steam from the Curtis wheel chamber and to lighten the load on the gland at the high pressure end of the turbine, a group of three seals, mounted in the cylinder base and cover is provided between the Curtis wheel chamber and the inlet end gland, as shown in Fig. T-6.

2. Each of these three seals is fitted with twelve rows of integrally machined labyrinth strips by which the steam escaping outward along the shaft is throttled to a much lower pressure. The leakage is carried away through the "dummy leakoff pipe", and re-enters the turbine cylinder at the fifth stage of blading and it, therefore, gives up most of its available energy in the low pressure end of turbine before passing to the condenser.

TURBINE GLANDS

1. At the point where the turbine rotor shaft extends through the ends of the cylinder, leakage of steam from, or air into cylinder is prevented by means of glands of the stepped-tooth labyrinth type. These glands consist of a group of three rings, each fitted with ten rows of integrally machined labyrinth strips, made in four segments, set in "L" shaped grooves in the gland cases, and held against the shoulder of the "L" by means of flat springs. As shown in the illustration Figure T-6, the rings are prevented from turning by the pins.

2. The radial clearance between the rotor and the gland seal rings are indicated in the illustration, Figure T-24. These radial clearances are the designed "cold" clearances. In addition to the radial clearances, the alloy metal seal rings have small gaps between the segments, when cold, to provide for expansion and the segments are matched marked so they may be re-assembled correctly.

BEARINGS

1. The rotating element consists of the turbine rotor, flexible coupling and pinion carried in four bearings which are similar in general design. The turbine bearings are illustrated in Figure T-5. 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 on the vertical centerline at the top, the babbitt being relieved to provide ample space for the distribution of oil along the journal surface. On the inner end of the turbine bearings, the shell is grooved into

which an oil baffle is installed, forming an oil pocket. A slot is cut at the bottom of this pocket on the vertical centerline, by means of which oil bleeding from this end of the bearing is permitted to flow to drain. The turbine bearings have a normal clearance of .005 to .007 inch with a maximum clearance before rebabbitting of .015 inch.

2. The turbine bearings, if removed, may be measured for wear by checking the crown thickness in four specific longitudinal planes, 3/8 inch in from the end of the bearing. Radial lines scribed on the bearing end, as shown in Fig. T-5, designate the measuring planes. The value of these dimensions at the time of manufacture is stamped on the end of each bearing. Any change in these measurements indicates wear and if excessive, the cause should be investigated.

OIL SEAL RINGS

1. The grooved 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 brass baffle plates also made in halves. Any oil which creeps along the shaft is caught in the grooves in the oil ring and flows through a series of radial drain holes in 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 sufficient height to maintain an oil level in the pocket, thus preventing the escape of oil vapor through the drain hole. The oil rings may be seen in Figure T-2.

STEAM DRAIN AND GLAND PIPING

1. The diagram of the steam drain and gland piping is shown in Figure T-7. Sealing steam for the glands is supplied from a separate source at approximately 10 psig and a valve and gauge are supplied for controlling the sealing steam. Approximately 80 pounds per hour of steam will be required at no load to seal the turbine, above 125 Kw the turbine is self sealing. The steam pressure at the L.P. gland should be maintained at not more than 2 psig. It will be noted that the main steam inlet line, and the impulse chamber of the cylinder have drains, controlled by valves. These valves should be opened during the starting periods in order to remove the condensation resulting from heating of the turbine parts. Further reference to these drains and this illustration will be found under "Operation".

THRUST BEARING

1. The portion of the end thrust on the rotor, which is not counter-balanced by the steam pressure acting against the Curtis Wheel Labyrinth Seals, is transmitted to the stationary parts by means of a thrust bearing of the "Kingsbury" type, illustrated in Figure T-8. It is located on the exhaust end of the turbine shaft and is also shown in Figure T-2.

2. The bearing is of the single thrust type, having babbitted thrust shoes on one side of the collar, which is a separate piece mounted on the shaft. As the thrust is in the direction of the steam flow, this side of the bearing is provided with four shoes, while a thrust ring secured to the end of the journal bearing is used on the opposite side of the collar to locate the rotor axially.

3. On the thrust side, the shoes (8) are supported on the leveling blocks (or plates) (6) and (11), which by rocking upon each other allow the shoes to move relatively to one another so that the babbitted faces are all pressed against the collar with equal force. Hence, each shoe takes an equal share of the load. The upper leveling plates (11) rest upon the lower leveling plates (6) which in turn are carried in the base ring (5) which is made in halves.

4. As may be seen in Figure T-2 the base ring is supported in the housing. It is centered by the key (4) shown in Section A-A of Figure T-8. The thrust ring is located by a liner between it and the journal bearing.

5. The correct axial position of the thrust bearing, and hence the correct axial location of the rotor, is determined by the thickness of the filler piece, shown in Figure T-2, and

in Figure T-8 between the base ring (5) and the housing. The thickness of this filler piece 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-24.

6. The actual internal clearance of the bearing should be between .008 and .012 inch in order to permit establishment of a proper oil film between the collar and the shoes. After the filler piece of correct thickness (as described previously) has been installed, the proper running clearance is obtained by adjusting the thickness of the liner which is located between the thrust ring and the turbine bearing. This clearance should be checked by rolling the rotor and barring it from one extreme axial position to the other, and then measuring the end travel with a dial type indicator.

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

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

9. All bearing parts are to be assembled radially with the housing cover removed. See Figure T-8; with the shaft in position, first rotate lower half of brass oil control ring (14), into place under collar.

10. Place the leveling plates (6) and (11) and four shoes in position on the split halves of the base ring (5), and secure by screws, (12) and cotter pins as shown. Rotate the lower half of the base ring into place on inner side of collar, with parts attached and follow with upper half and its key (4).

11. Bolt under half (1) of oil control rings to lower half (14), the halves of the thrust ring (16) and (17) are secured to the upper and lower halves of the journal bearing. Assemble end cover.

12. Turn base ring (5) to bring joint vertical, and test end-play by jacking shaft end-wise and measuring the amount of movement with feelers. Adjust thickness of one or both end filler pieces, by shimming or machining, to make total end-play between .008 and .012 inch maintaining Curtis blade clearance as noted above. When found to be correct, turn base ring to bring key (4), to top center, and bolt housing cover down.

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

ROTOR POSITION INDICATOR

1. The rotor position indicator which is bolted to the end of the thrust bearing housing is shown in Figure T-9. A reading is taken by pushing lightly on the pad "A" on the pointer (10), until the ball (4) makes contact with the end of the rotor. Immediately after installation, the rotor should be barred toward the exhaust end and while in this position, the pointer should be set at zero, loosening the clamp screw in the pointer to adjust it and then tightening up securely, and pinning. Thereafter when a reading is taken, the displacement of the pointer from zero, will indicate an axial displacement of the rotor, one division on the graduated scale (13) representing a displacement of the rotor of .002 inch. A small spring (6) holds the ball out of contact with the turbine rotor when the indicator is not being used. It is obvious that readings should be taken, either with the unit carrying load or with the rotor barred toward the exhaust end. Otherwise the clearance in the thrust bearing may give an erroneous reading.

COUPLING

1. The turbine rotor and the reduction gear pinion are connected by means of a coupling of the Sier-Bath type, illustrated in Figure T-10.

2. As may be seen in 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.

3. Lubrication is supplied by means of sprays of oil directed into the lip of the sleeve, from nipples in the pinion and turbine 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 sleeve flange. Additional information will be found under "Installation" and under "Maintenance".

THROTTLE VALVE

1. Steam is admitted to the turbine by a horizontally disposed throttle valve which is shown in Figure T-11. This valve is manually operated by a handwheel, but can be closed automatically by a compression spring, when the trip release latch is tripped by the overspeed trip mechanism.

2. The valve is of the unbalanced, single seat type. It is guided in a cylindrical recess in the bonnet (10), and secured to the spindle (19), by means of the stem (7) and a slotted coupling (15). Thrust washers (13) and (14) serve to eliminate clearance in the coupling.

3. The handwheel spindle (19) is threaded through a sliding valve stem nut (17), subjected to compression of the spring (18), and prevented from turning by the guide (16), which is welded to the yoke (20). The nut (17), is normally held out against the spring force by the trigger shaft (30), which is connected to the overspeed trip device.

4. When the overspeed trip functions, the trigger shaft is rotated, thus freeing nut (17) and permitting the spring to push the valve stem in the closing direction, thus closing the valve.

5. To reset the device, it is necessary first to turn the wheel all the way in the closing direction, thus forcing the sliding nut (17), outward until the trigger shaft (30), is reengaged through the tension of the relatch spring (35).

6. The valve disc (3), and seat (2), are provided with cobalt-chromium contact surfaces to prevent erosion and the valve is held on the stem (7), by the disc flange (5). Leakage along the valve stem is minimized by the leak-off bushing (8).

7. The steam strainer basket (42), is carried in the body which is welded to the throttle valve body (1). It is made of corrosion-resistant steel and is held in place by the bonnet (40).

STEAM CHEST

1. The governor and servo-motor operating mechanism is shown in Figures T-12 and T-13, the latter showing the connections for the arrangement of the steam chest linkage. The steam chest body is an integral part of the turbine cylinder, and the cover serves also as a linkage support. The turbine is provided with four valves, which are arranged in parallel within the steam chest; that is all valves are surrounded with steam at approximately throttle pressure. The valves are numbered, 1, 3, 2, and 4 beginning at the stud and continuing in a clockwise direction, looking from the top of the valve stems. The steam chest is shown in Figure T-14.

2. These valves are of the single seated, plug type. The seating surfaces are spherical and the seats are of the diffuser type. The seats are pressed in the steam chest body and seal welded, but can be renewed if necessary. As shown in the illustration, the valves are carried by a flange formed on the end of the valve lifting rod. This lifting rod is connected to the operating mechanism by the trunnion and the links. It is guided in the steam chest cover by the bushings, and is held against rotation by the stud. As the operating mechanism raises and lowers the lifting rod, the rod in turn raises the valves by engaging the adjusting nuts. 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

lifting-rod flange, engaging the lower shoulder on each valve.

3. For establishing the proper lifts for the several valves a special fixture is provided, the application of which is shown on the tool illustration, Figure T-28. It comprises a temporary cover to be bolted in place on the steam chest instead of the steam chest cover; an indicator mounting rod; and a rod to be set up on the valve stem.

4. To use this fixture proceed as follows:

Disconnect the governor linkage and remove the steam chest cover. Bolt in its place, the valve setting fixture assembly as shown in Figure T-28, setting it so that four holes in the cover come over the four valves, and set up the rod (8). Drop the rod (6) through the proper hole in cover plate (7), so that it rests on top of No. 1 valve. Clamp two dial indicators to the rod and set one against the top of the valve lifting stem, and the other against the top of the rod (6) compressing them sufficiently to insure positive response when the stem is lifted.

5. Set both indicator dials at zero. Lift the valve lifting stem until a reading shows on each of the indicators. The difference of the two readings will be the clearance for No. 1 valve. Three or four check readings should be taken and the differences should be the same in every instance.

6. Next shift the rod (6) to No. 2 valve and repeat the above process. Do this with each of the four valves. We will then have a series of differences, thus for example:-

Reading	No. 1	No. 2	No. 3	No. 4
Stem	0.022"	0.110"	0.181"	0.205"
Valve Rod	0.009"	0.018"	0.055"	0.050"
Difference	0.013"	0.092"	0.126"	0.155"

7. These differences are the clearances of the several valves between the valve lifting plate and the valve nuts and should be the same as listed in the tabulation of valve settings under the serial number of the unit in question.

8. The amount the valve lifting stem is raised in the above operation is immaterial as long as it is enough to obtain readings on both indicators, and that successive trials show the same difference between the stem and valve readings.

FACTORY VALVE SETTINGS

1. This is the clearance between the valve stem nut and valve lifting plate with the turbine in a static condition.

2. The actual values determined during factory tests will be found stamped on the plate (11) located on the governor lever (10) of Figure T-14. The actual values may vary slightly from the design values shown in Fig. T-14.

3. The opening, through which valve lifting rod (41) extends into the steam chest is sealed against escape of steam to atmosphere by the provision of close fitting bushings (18) and (22) and two leakoffs, one between the two bushings and one near the top of the outer bushing, whence the leakage is carried away. The steam from the inner leakoff is led to a zone of lower pressure in the cylinder, while the outer leakoff is connected to the gland condenser.

GOVERNOR

1. The governor as shown in the illustration Figure T-12 is of the vertical shaft flyball type, in which the revolving weights move radially in response to changes in centrifugal force, resulting from changes in turbine speeds. The changes in centrifugal force and thus the position of the weights, are transmitted to a cup valve, in the sub-assembly (10), the position of which determines the amount of H.P. oil that is permitted to pass through the variable orifice to drain, the balance of the H.P. oil being directed to the operating servo-motor mechanism as "control oil".

2. H.P. oil from the main pump discharge (or from the auxiliary hand pump) is directed through passages in the governor housing, to the filter inlet, item (16) of Figure T-12;

and through external piping to the relay, item (2) of Figure T-13 entering the servomotor at the flanged inlet as shown.

3. The H.P. oil passing through the filter, Figure T-12, is directed by internal passages to the space just above the cup valve (10), which forms a variable orifice permitting the portion of oil that passes through the cup valve to drain back to the oil reservoir, and as mentioned earlier the balance passes to the servo-motor mechanism in the capacity of "control oil".

4. The portion of the H.P. oil that is piped to the servo-motor operating mechanism from the pump discharge, enters the servo-motor housing to a neutral position of the relay (2). Examination of the Figure T-13 shows that this relay, seated on a spring (1), is forced upward, but restrained through linkage from moving except as permitted by a movement of the bellows and stem assembly. Thus, the control oil leaving the governor and entering the servo-motor housing as shown, acts upon this bellows and stem assembly; closing the bellows and moving the stem upwards against the action of the spring (38) with an increase in the pressure; and allowing the bellows to expand with the spring action and moving the stem downward with a decrease in oil pressure.

5. The movement of the stem and bellows assembly permits the movement of the relay (2) in a similar direction. The movement of the relay allows the H.P. oil to flow through passages to either the upper or lower surface of the piston (7) causing the piston and piston rod (13) to move.

6. The piston rod (13), is connected by linkage to the steam chest valves.

7. Referring to Figure T-12, the governor hub which holds the weights assembly, is driven from the end of the main gear wheel shaft by means of spiral gears. The governor weights are secured to a strap of spring steel, mounted across the diameter of the hub, that is in the form of a ring. The spring is formed into a "U" at the center and the forces acting upon the weights, flex the strap spring, thus transmitting the forces through the spring seat to the cup valve (10). When the governor is at rest, the strap spring holds the governor weights (8), in their innermost position.

8. The entire rotating element is carried in four bearings. The governor bearings (4) and (42) (Figure T-12) are combined journal and thrust bearings. The main oil pump bearings (bushings) shown in Figure T-18 are journal wear and all are mounted in the bearing bracket and main oil pump housing. This bearing bracket is located on, and bolted to the oil reservoir base. The vertical position of the governor hub (8) and thereby the proper position of the follower gear (2), can be adjusted by the final machining of the liner (40) so that the designed clearances can be obtained between the governor hub and the sleeve (43), at the thrust bearings (4) and (42).

9. The cup valve rests upon a button supported in the center of the governor weight strap.

10. The space within the cup valve seat is supplied with H.P. oil as described above in paragraph 3 and the cup valve proportions the amount of oil permitted to drain, to the centrifugal force of the governor weights, and thus controls the oil pressure acting under the cup valve seat, and hence the pressure of the "control oil".

11. The balance of forces for any given operating condition, consists of the centrifugal force of the governor weights acting upward, through the strap, button 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 annular area of the variable cup valve orifice and the part of the centrifugal force of the governor weights not balanced by the force of the spring; hence, every turbine speed (and consequent value of centrifugal force on the governor weights) determines a definite value of governor oil pressure.

12. The operation of the governor and steam chest is as follows:

With the turbine at rest, the governor weights (8) of Figure T-12 are held in their innermost position by the strap spring, and the steam chest valves (26) and (27), of Figure T-14, are held closed through linkage connected to the operating piston (7), of Figure T-13, which is held in its uppermost position when no oil pressure is available, by the action of the spring (38) pressing downward in stem and bellows assembly, and by the action of the spring (13) of Fig. T-14 against the lever (10). The Figure T-13 shows the steam chest servo-motor operating mechanism in a position with the turbine at rest. The spring (38) in the stem and bellows assembly has expanded the bellows to the maximum with the stop nut (33) seating on the cover (36). The operating piston (7) is held in the uppermost position and the relay (2), is in a position just past neutral, with the relay closing the upper ported passage leading to the upper surface of the piston (7). The lower ported passage leading to the lower surface of the piston is open.

13. In order to start the unit, it is first necessary to start the auxiliary hand oil pump to insure turbine journal bearing lubrication. This auxiliary oil pump, not being designed to operate the governor and servo-motor mechanism should be operated until the main oil pump can take over. The cam lever items (19), (23) of Figure T-14 should be raised to the horizontal position, which will raise No. 1 steam chest valve (26) approximately .060 inch, sufficiently to allow steam to be admitted to the turbine. With the auxiliary oil pump operating, the cam lever in the horizontal position, the throttle valve hand wheel can be slowly opened until the unit starts to rotate.

14. As the turbine speed increases to approximately 25% of the no-load value, the main oil pump discharge oil pressure exceeds the pressure of the auxiliary pump which may be then shut down. As the main oil pump pressure increases, supplying the governor and servo-motor mechanism with H.P. oil, the oil pressure builds up in the space above the cup valve (10) of Figure T-12; and in the center of the relay (2) of Figure T-13. The H.P. oil leaving the governor as "control oil" directed to the servo-motor, surrounds the stem and bellows assembly and as the oil pressure increases the bellows closes against the action of the spring (38). The H.P. oil that has entered the relay cavity bleeds to the lower side of the piston (7), but as the bellows and stem move upward, permitting the relay (2) to also move upward, the lower ported passage closes and the upper ported passage is opened allowing H.P. oil to flow to the upper side of the piston (7). As the H.P. oil pressure increases, the bellows and stem assembly move upward, the relay (2) also moves upward and the piston (7) moves downward.

15. The action of the piston (7) moving downward results in the steam chest valves being opened by means of the connecting linkage. After the unit has been checked for satisfactory operation, the speed may be increased by further opening of the throttle valve. As the turbine approaches normal speed, the centrifugal forces will begin to move the governor weights outward. The unit is now coming under control of the governor as it approaches full, no load speed, the cam lever item (19) of Figure T-14, will then drop to the lower position, clear of the steam chest operating linkage.

16. As load is applied to the unit, the turbine speed decreases, and the centrifugal force acting on the governor weights is reduced. The governor spring force being constant, the reduction in centrifugal force is balanced by an increase in governor oil pressure. This results in an upward movement of the cup valve (10), reducing the annular opening of this variable orifice and increasing the pressure of the "control oil" to the servo-motor mechanism. The increase in "control oil" pressure acts upon the bellows and stem assembly (39), moving them upward, the relay (2) following in a similar direction in proportional amount and opens the upper ported passage permitting the H.P. oil to flow to the upper surface of the piston (7), the movement of which in a downward direction, opens the steam chest valves (by means of connecting linkage) sufficiently to maintain the required speed.

17. If the load decreases, the turbine speed accelerates, increasing the centrifugal force on the governor weights, and thus increases the annular opening of the cup valve (10),

which permits a greater amount of H.P. governing oil allowed to drain and hence a reduction in the "control oil" pressure. The reduction in control oil pressure, reducing the pressure upon the stem and bellows assembly (39); permits the bellows to expand by the action of the spring (38). Examination of Figure T-13 shows that the relay (2), would then be moved in a downward direction closing the upper ported passage and opening the lower port, permitting H.P. oil to flow to the lower surface of the piston (7), the movement of which in an upward direction closes the steam chest valves (by means of connecting linkage) sufficiently to maintain the required speed.

18. Thus it can be seen by examination of Figures T-12 and T-13 that the governor is capable of closing the steam chest valves in minimum time, in the event of total loss of load. In the event of total loss of oil pressure, the action of the stem and bellows assembly (39), moving downward under forces from the spring (38), and the action of the spring (13) of Fig. T-14 upon the lever (10), would also close the steam chest valves, by means of the connecting linkage in minimum time.

SPEED CHANGER

1. The hand and motor-operated speed changer, by means of which the speed or load of the unit can be varied is shown in Figure T-12. The principal parts of the electrically operated portion are:--The motor shafts, worms, and worm wheels. The principal parts of the hand operated portion are:--The hand-wheel and shaft. Both the electrically operated and hand operated portions act to regulate the turbine speed by means of changing the position of the valve seat (37).

2. The electric motor, connected to the shaft (53) drives the worm (54) which in turn drives the worm gear (46) and worm gear (31). The worm gear (31) drives the collar (27) by friction caused by the spring (33) acting against spring seat (34). The collar (27) is secured to the shaft (21) which is threaded in the bushing (25) in the top of the speed changer housing (18). Since the bushing (25) is stationary, rotation of the shaft (21) by the worm gear (31) screws the shaft either upward or downward through the bushing (25) and housing (18); thus changing the position of the valve seat (37), and hence the speed or load corresponding to a given governor weight position.

3. For hand operation, rotation of the hand knob is transmitted directly through the shaft (21) in the manner described above to the cup valve seat (37) moving it upward or downward. The clutch collar (27) with spring (33), and washer (32) form a friction type clutch which is held in engagement by the spring (33). 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.

4. The hand adjustment knob, (20) mounted on the shaft (21) has an indicating arrow directing counterclockwise rotation for an increase in turbine speed or load and hence clockwise rotation for a decrease in turbine speed or load. The adjustment of the shaft (21) by the hand knob or speed changer motor is not identical with the adjustment (or change in position) of the valve seat (37). The shaft (21) is threaded with R.H. threads 11-1/2 threads per inch at the bushing (25) and 11 threads per inch at the cup valve seat (37). Hence, one revolution of the hand knob in a counterclockwise direction causes the shaft to travel upward approximately .087 inch through the bushing (25). ($1.000 \div 11.5'' = .087$ inch). The cup valve seat being prevented from turning by the screw (12) will move in a downward direction, with shaft movement, approximately .091 inch. Thus the new position of the cup valve seat is the difference between the two or a movement of .004 inch in the downward direction. The same figures apply to the adjustment of the knob in the opposite direction causing the cup valve seat to move in the upward direction. The amount of the cup valve seat travel is identical per revolution of the shaft (21) for the hand adjustment knob or for the speed changer motor by remote control from the control panelboard.

Section 1.2 Reduction Gear

GENERAL DESCRIPTION

1. 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-15. The gear wheel is pressed and keyed onto the gear shaft. The shaft is carried in the gear bearings (Figure T-16) 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.

2. 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 spiral gears, takes its suction from the reservoir as shown.

3. Between the generator-end gear bearing and the coupling, there is an oil thrower collar on the shaft and an oil-ring, the labyrinths of which drain back into the gear housing. Mounted on the coupling flange there is a second oil-ring, the labyrinths of which also drain back into the gear housing, to prevent the possibility of oil vapor escaping into the engine room.

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

PINION AND GEAR BEARINGS

1. The pinion and gear bearings, shown in Figure T-16, consist of steel shells, babbitt-lined, similar in general design to the turbine bearings described in paragraph 10 except that the pinion bearings, being enclosed by the gear housing do not require oil baffles, as do the turbine bearings.

2. The pinion bearings have normal clearance of .007 to .009 inch with maximum of .015 inch before rebabbitting. The gear bearings have .006 to .008-inch normal with maximum of .015 inch before rebabbitting. The turbine-end main gear bearing is provided with bolted-on thrust rings at either end.

3. 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 shell 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.

4. The pinion and gear bearings, if removed, may be measured for wear by checking the crown thickness in four specific longitudinal planes, 5/8 inch in from the end for the pinion bearings and one inch in from the end for the gear bearings. Radial lines scribed on the bearing end, as shown in Fig. T-16, designate the measuring planes. The value of these dimensions at the time of manufacture is stamped on the end of each bearing. Any change in these measurements indicates wear and if excessive, the cause should be investigated.

ALIGNMENT OF PINION AND GEAR

1. For proper operation of the unit, the pinion and gear shafts should be parallel. This condition exists when the pinion and gear shaft centerlines lie in the same plane and are equidistant at both ends. The criterion of proper alignment is uniform tooth contact to ensure a balanced pinion-gear tooth loading. This condition may be checked by clamping the pinion journals so that they will ride hard down on the bottom half of the bearings. The pinion teeth should be coated with Prussion Blue and the pinion and gear rotated together. The resultant marking on the gear teeth will indicate any adjustment that is necessary to produce a uniform tooth contact which may be made by carefully scraping one or more of the babbitt faced journal bearings. This scraping should be limited to the tolerance of the bearing bore.

MAIN OIL PUMP

1. The main oil pump, which is shown in Fig. T-18 and in the reduction gear assembly, Figure T-15, 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.

2. 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. 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 metal.

3. The pump takes oil from the reservoir and discharges into a line leading to the duplex strainer and thence to the oil cooler.

OIL SYSTEM

1. The arrangement of the oil system is shown diagrammatically in Figure T-17. 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.

2. The level of the oil in the reservoir is shown by the bayonet type 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.

3. In normal operation, the main pump discharges at approximately 70 pounds per square inch gage pressure. A part of this oil is led through cored passages to the governor and servo-motor mechanisms to operate the steam-chest valves. The remainder is led through external piping through the strainer and cooler to lubricate the bearings 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.

4. The flow of the oil through the bearings is regulated by orifices installed in each of the bearing oil supply passages in the housing.

5. A relief valve, connected to the bearing oil supply line, is set to discharge a part of the oil directly to the reservoir if the pressure at the bearings exceeds 10 psig. A by-pass valve, Figure T-21, around the cooler, is provided so that the cooler can be temporarily taken out of service for cleaning or repair while the unit is still running. CAUTION - THE VALVE IN THE OIL COOLER LINE MUST BE OPEN WHEN THE BY-PASS VALVE IS IN OIL-TO-COOLER POSITION, SEE FIGURE T-17, OR OIL CANNOT CIRCULATE THROUGH THE SYSTEM. The cooler is normally by-passed when starting the unit, until the normal lube oil temperature has been established.

6. 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.

AUXILIARY OIL PUMP

1. The manually operated auxiliary oil pump which is used to supply oil for the system when starting up is manufactured by the Blackmer Pump Company of Grand Rapids, Michigan. The pump is operated by turning the hand crank in a clockwise direction and will deliver 10 gpm when operated at 115 rpm.

2. The crank is connected to a shaft upon which is mounted a rotor enclosed within the

pump cylinder. The rotor, which is eccentric to the pump cylinder bore contains three spring positioned, self-adjusting vanes which operate with small axial clearance and follow the inner surface of the pump cylinder, the vanes being pressed radially outward by springs. Oil entering from the suction side is imprisoned between consecutive vanes and is carried around to the discharge side. The small axial clearance between the vanes and the pump cylinder prevent oil from returning to the suction side except for a very small amount of leakage.

OIL STRAINER

1. The oil strainer is shown in Figure T-19. It is of the duplex type and the basket, through which the oil must flow, is made with sides of wire mesh and perforated sheet.

2. The flow of oil to the strainers is controlled by the valve plug which is so designed that when turned on its seat by means of the changeover lever it will direct the oil to either strainer, but will prevent the oil from being completely cutoff during changeover from one strainer to the other. The indicator on the changeover lever points toward the side of the strainer which is in use.

3. In order to clean a strainer it is only necessary to swing the changeover lever to the opposite side, back off the handle, remove the cover, and lift out the strainer basket.

OIL COOLER

1. Figure T-20 shows the oil cooler with its pipe connections. The oil enters the cooler shell at the bottom 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 shell. 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.

2. Provision is made in the shell, by means of a "floating" reverse end tube plate for relative expansion of the shell and tube bundle, the reverse end tube plate being sealed against leakage by twin "O" ring seals and a gland spacer. The gland spacer is fitted with an annular groove and radial drain passages, hence any minute amount of oil or water which might bleed past the "O" ring seals is permitted to drain off rather than mix one with the other. Both water chambers are provided with zinc pencils attached to pipe plugs. These zinc pencil electrodes should be examined at least once each month and cleaned and replaced if their condition so warrants. Removal of the zinc pencil from the reverse end chamber cover permits full drainage from the tube side.

3. The dry weight of the complete cooler is 405 pounds. The cooler has 56 tubes and is designed to cool 24 gallons per minute of oil from 143.3 to 130°F with 5.5 psi pressure drop when supplied with 33 gallons per minute of water at 85°F with 0.5 psi water-pressure drop.

LUBRICATING OIL

1. A suitable lubricating oil is of utmost importance and its selection should be given very careful consideration. Oils conforming to the requirements of the following Specification may be purchased in the open market and have been found to perform satisfactorily.

QUALITY OF OIL

1. The oil shall be a refined mineral oil of highest quality and uniformity. It shall contain no grit, inorganic acid, alkali, water, soap, asphaltum, pitch, resinous substances, or any other substance which will interfere with the lubricating properties of the oil, or that will be detrimental to the oil, or to the metals with which the oil will come in contact, in service.

2. The oil shall be capable of preventing the formation of rust on steel parts bathed with oil, should small quantities of water enter the oil during service. (See paragraph III, following, "Corrosion in Lubrication Systems").

I. For Circulation Systems (See Table)

NOTE 1: The values shown in the table below are based on tests made in accordance with the latest approved standards of the American Society for Testing Materials:

Sampling	ASTM D270
Flash Point	ASTM D92
Viscosity	ASTM D88
Carbon Residue	ASTM D189
Neutralization No.	ASTM D663
Sulphur Content	ASTM D129
Corrosion Resistance	ASTM D665

NOTE 2: There is a present trend on the part of various interests in marine propulsion geared units to specify viscosity at 130°F as 171 to 189, with a Dean & Davis Viscosity Index of 50 minimum. Such oils are quite satisfactory for this service.

NOTE 3: The recommended values in the table apply, of course, to new oil only.

NOTE 4: Some Merchant Marine Interests specify that the oil shall pass the corrosion test with a synthetic sea water instead of the distilled water normally used in this test.

II. Physical and Chemical Properties

(See Table at bottom of page)

III. Corrosion in Lubrication Systems

In the operation of a steam turbine it is impossible to entirely exclude moisture from lubricating oil systems. The presence of very small quantities of moisture, in a system using unsuitable oil, has been found responsible for serious corrosion, which interferes with governor system operation and jeopardizes bearings. The ASTM has developed and published the ASTM Specification D-665 (latest revision or issue) entitled "Rust Preventing Characteristics of Steam Turbine Oil in the Presence of Water, Test for". It is recommended that turbine lubricating oil be purchased to successfully pass this test, and that the purchaser verify the oil prior to its use.

IV. Inhibited Oils; Purification Systems

It is known that some types of oil purification systems using fuller's earth or similar filter materials may remove the corrosion or oxidation inhibitors that were added to the oils by the supplier. It is reccamended that before such systems are applied, the oil supplier be consulted on this point.

APPARATUS	DIRECT-CONNECTED TURBINE UNITS	SINGLE REDUCT. GEARS TO 3000 HP (2250 KW)	LARGE GEAR UNITS MARINE PROPULSION UNITS
Flash Point, °F	330 Min.	350 Min.	350 Min.
Saybolt Viscosity Seconds at:			(See Note 2)
100°F	140-to 250	250 to 350	350 to 550
210°F	40 to 50	47 to 60	52 to 66
Carbon Residue	0.10% Max.	1.0% Max.	1.0% Max.
Neutralization Number	0.10 Max.	0.10 Max.	0.10 Max.
Sulphur Content	---------	---------	0.50 Max.
Corrosion Resistance Test	Shall Pass	Shall Pass	(See Note 4) Shall Pass

V. Replace Parts

Some of the corrosion inhibitors added by the suppliers are of the plating type, that is they "plate out" from the oil to the metal surfaces to form a protective coating. It is quite possible, then, to find that an oil which passes the rusting test before being placed in the turbine, may after a short time in service fail to pass the test due to its loss of the inhibitor. Under such conditions, should a new part be installed, for instance, in the governor system, this part may rust if water is present, due to the lack of proper protection. It is recommended that new parts be treated by immersion in new inhibited oil at a temperature of 140-150°F. for several hours before installing in order to start the development of a protective coating.

VI. For Ball Bearings

Lubricate ball bearings on pumps and similar equipment with the same oil as used in the main lubricating system.

Section 1.3 Description of Safety Devices

OVERSPEED TRIP

1. The overspeed-trip mechanism which trips the throttle valve and thus shuts down the turbine in case it overspeeds is shown in Figure T-22. The actuating device consists of a weight located transversely in a hole in the body which is screwed onto 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 screw. As the speed of the rotor increases the centrifugal force of the eccentric weight becomes greater until at a pre-determined 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 the hardened plates. 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 shoulder 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 the liners. Increasing the thickness of the liners increases the tripping speed. Decreasing the thickness of the liners decreases the tripping speed.

2. A limit switch, (item (32) of Figure T-11), mounted on a switch bracket, (Item (33) of Figure T-11) is actuated by the operation of the throttle valve. The closing of the throttle valve, either manually or by overspeed tripping, results in the closing of the limit switch which in turn is connected to a tripping device for the main generator circuit breakers. Thus the limit switch circuit is open when the throttle valve is open and closed when the throttle valve is closed.

3. When this mechanism has operated it must be reset by hand. This is accomplished by returning the reset handle to the horizontal 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 1,000 rpm of generator).

4. A special wrench (5) is furnished, as shown in Figure T-28, by means of which the overspeed-trip retainer may be removed when making a change in the setting or overhauling of these parts.

LOW OIL PRESSURE TRIP

1. The function of this mechanism (shown in Figure T-23) is to shut down the turbine if, for any reason, the oil pressure drops below a predetermined minimum. It operates in conjunction with the overspeed trip linkage which is described previously.

2. As shown in the illustration, the mechanism is in its latched (or starting) position, with no oil pressure established. The latch pin (3) and latch (1) are engaged to hold the piston (7) in its inner position, compressing the spring (8).

3. The chamber in front of the piston (7) is connected to the bearing oil supply line by drilled passages as shown. As pressure is established in this chamber the piston moves inward, further compressing the spring (8). This piston movement also moves the latch (1) inward and the pin (3) is moved upward by the spring (2) thus disengaging the latch completely. The oil pressure now holds the piston (7) and latch (1) in the extreme inner position.

4. If the bearing oil pressure drops to the point at which the mechanism is set to operate, the oil pressure against the piston drops and the spring (8) moves the piston and rod outward, causing the latch (1) to strike the

overspeed trip lever. Movement of this trip lever shuts down the turbine as described under "Overspeed Trip Mechanism".

5. After this mechanism has tripped, the oil trip latch and also the overspeed trip linkage, must be reset by hand.

STEP 1 Push the latch (1) inward and push the pin (3) downward until the pin engages the latch to hold it in its inner position.

STEP 2 Reset the overspeed trip linkage as described previously.

ATMOSPHERE RELIEF VALVE

1. The atmosphere relief valve shown in Figure T-25 is mounted on the cylinder cover at the exhaust end, as shown in Fig. T-2. This valve, when operating, permits excess pressure within the turbine cylinder to be discharged to the atmosphere. The valve is water sealed and spring loaded, and is adjusted to start opening when a pressure of 10 psig exists within the turbine cylinder exhaust end. It will be wide open and release full throttle flow at 30 lbs. gage.

2. The spring loading of the valve is preset at the factory and cannot be adjusted externally.

3. The handwheel (11) is provided to manually check the operation of the valve. Remove the locking pin (16) from stem lock (8) and the valve stem (10) before turning the handwheel. After the manual operation check has been performed; replace the locking pin in its proper position.

TESTING OF SAFETY DEVICES

1. 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 is 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. Periodically, about once each month, the operation of the safety devices should be checked as follows: (with generator disconnected from the line and meters).

2. The operation of the overspeed trip should be tested as follows:

Referring the Figure T-14 (Steam Chest) disconnect the steam-chest valve-lifting rod link from the lever by removing pin, and block the valves in the open position by inserting a suitable block between crosshead and bushing. Then start the turbine and gradually increase the speed to the tripping point. The overspeed trip should function at 10 to 12% above normal generator speed (1,320 to 1,350 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 in case the overspeed governor does not trip at the proper speed.

3. The low oil pressure trip mechanism shown in Figure T-23, may also be checked when shutting down the unit by noting the movement of the latch (1) when it moves outward under the influence of the spring (8) and at the same time observing the reading of the bearing oil pressure gage. The low oil pressure trip mechanism has been adjusted at the factory, to operate when the decreasing bearing supply oil pressure reaches a value of 3 psig.

4. The spring loading of the atmosphere relief valve can be tested with compressed air when the unit is shut down. However, this procedure requires that the valve be removed from the turbine cylinder. A more desirable arrangement is to test the valve with the unit operating at no load and a built up back pressure. The unit can be started without the condensing equipment in operation which allows the back pressure to build up. Watch the exhaust pressure gage to see at what pressure the relief valve starts to open.

Section 1.4 Installation of Turbine

ALIGNMENT OF UNIT AND SETTING OF TURBINE ROTOR

1. The bedplate of the unit is supported on, and secured to, longitudinal seating pads that are bolted to the ship's structure by the shipbuilder.

2. When erecting the unit at the factory, the bedplate is set level and the gear-housing base is set in place and supported on chocks. The pinion and gear bearings are checked for plane and parallelism by using mandrels. The generator stator is then set up and the generator outboard bearing is brought into alignment with the gear bearings. Next the turbine-cylinder base is set up and the turbine bearing is aligned with the pinion bearings, using liners under the turbine supports as necessary.

3. The turbine rotor is then placed in the turbine cylinder cover and is 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-24. The distance from the low-pressure end of the cylinder cover (inside gland face), to the face of the turbine rotor, is then measured. This dimension is recorded and is also stamped on the turbine cylinder-base horizontal-joint flange at the low-pressure end. The turbine rotor is then placed in the cylinder base. The thrust bearing cover and the upper half of the turbine bearing (pinion end) and the bearing cover are assembled and bolted in place. The rotor is then moved as may be necessary to obtain the 1/8-inch dimension between the coupling faces as shown in Figure T-24 and the cylinder base is adjusted in an axial direction, until the dimension from the face of turbine rotor to the cylinder end is in agreement with that stamped on the cylinder-base horizontal flange. The cylinder base is then doweled and keyed to the bedplate in this position. The thickness of the thrust bearing filler piece (9) Fig. T-2 and also shown in Fig. T-8, is machined to suit and assembled. Then the thickness of the bearing thrust ring liners shown in Figs. T-5 and T-8 is adjusted to maintain the clearance shown in the diagram, Fig. T-24. The gear and pinion are adjusted to drawing clearances by shifting the liners (see Figure T-15) in back of the gear bearing-thrust faces as necessary.

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

5. With the new rotor placed in the cylinder cover, the dimension from the face of the rotor to the cylinder-cover end should be determined as described above. Then install the new rotor in the cylinder base and locate it axially to agree with the dimension from the cylinder end to the face of the rotor, as found in the cylinder cover. Then measure the axial clearance at the outboard end of the thrust bearing in order to obtain the proper thickness for the rotor-locating filler piece, shown in Figure T-2 and T-8. With this filler piece installed, the turbine rotor will be in its proper running position. Then measure the thrust-bearing clearance and if this is not found to be within the prescribed limits, change the thickness of the liners behind the thrust ring to provide the proper clearance.

6. With the rotor in place, check the alignment as outlined above.

7. 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.

8. Check the alignment of the gear and generator. To do this, roll out the bottom half of the turbine-end gear bearing and measure the amount that the gear shaft journal drops

when not supported. This drop should be .0040 inch, measured on the shoulder just outside the journal. Replace the turbine-end bearing and roll out the generator-end gear bearing. This journal should drop .0025 inch, measured on the shoulder adjacent to this journal on the generator side. Recheck these readings by rolling the gear-shaft and generator rotor over 180 degrees and repeating the operation. Note: It is more important to obtain a correct ratio of these deflections rather than a specific value of either because the above values are subject to a tolerance of plus or minus .001 inch. The deflection of the generator-end gear shaft bearing, should be 61% of the turbine-end gear shaft bearing deflection. If the proper values are not obtained, the outboard generator bearing pedestal should be adjusted upward or downward as necessary to produce the desired value.

PIPE CONNECTIONS

1. 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 should be supported at a point near the turbine. In making this condition, the pipe should never be sprung into place. The connection should be made so that the joints match properly.

2. 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 the 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.

3. 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 compounds, etc., which if carried into the turbine, might prevent the closing of the steam chest valves and cause over-speeding or plug up part of the nozzle throat, thus reducing the capacity and efficiency of the unit.

4. 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 causes 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.

Section 1.5 Instructions for Operation of Turbine

TO START

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 make certain the valve in the oil cooler line is OPEN if the by-pass valve is in oil-to-cooler position.

STEP 5 Drain the steam and exhaust piping.

STEP 6 Open the throttle valve, steam strainer, gland seal manifold and cylinder drains. These drains are shown in Figure T-7.

STEP 7 Turn steam on glands, using not more than 3 pounds pressure.

STEP 8 Start the circulating pump and the condensate pump.

STEP 9 Prime the unit thoroughly, with the auxiliary oil pump before attempting to start the turbine.

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 1,000 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 the steam-inlet gauge, as the inlet pressure will drop when the governor throttles steam to the turbine. See that bearing oil pressure is maintained between 8 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

1. 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.

STEP 6 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, if work is to be done on the generator.

STEP 3 Close the turbine throttle valve. This can be done by striking the overspeed-trip latch shown in Figure T-22.

STEP 4 Operate the auxiliary oil pump when slowing down until 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

STEP 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.

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

STEP 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.

STEP 4 Keep the throttle stem and the steam-chest valve-lifting rod clean, free of erosion or corrosion. (Do not paint these stems.)

STEP 5 Keep the bearing oil pressure between 8 pounds and 10 pounds gauge.

STEP 6 Keep the oil level in the reservoir between the limits indicated on the "Oil-Level Gauge".

STEP 7 Keep the oil strainer clean.

STEP 8 Keep the oil cooler clean. Note - The valve in the oil cooler line must be open when the by-pass valve is in oil-to-cooler position, or oil cannot circulate through the system.

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

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

Section 1.6 Care and Maintenance of Turbine

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 removed 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 (APPROXIMATE)

1. The approximate weights of the principal parts of the units, which may require handling are as given in the table below:

Name of Part	Pounds
One Unit (Assembled Complete)	18,028
A-C Generator and Exciter (Complete)	8,625
Turbine (Complete)	4,280
Turbine Rotor (Bladed)	640
Cylinder Cover	1,100
Cylinder Base	1,090
Gear-Housing Base and Bedplate	2,610
Gear-Case Cover	285
Gear-Wheel and Shaft	675
Gen. and Exciter Rotors (inc. Shaft)	3,310
Gen. and Exciter Stators	5,318
Governor	131
Throttle Valve	240
Oil Cooler	405
Oil Strainer	87.5

2. The approximate weight of one complete set of tools is 70 pounds.

3. 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

1. Figure T-24 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.

ROTOR-LIFTING GEAR

1. Figure T-26 shows the arrangement of the rotor-lifting gear. 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)

1. In order that the turbine bearings may be removed for examination or replacement without the necessity of lifting the turbine cylinder cover, two rotor lifting jacks are furnished as shown in Figure T-27. By slipping these jacks into place as indicated in the figure and setting up on the nuts, the rotor may be raised sufficiently so that the lower halves of the bearings may be rolled out. 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 with the use of these jacks, the rotor might be lifted sufficiently to damage the thin seal strips around the blading and dummy seals.

TOOLS AND WRENCHES

1. Figure T-28 is shown for the purpose of enabling the operator to familiarize himself with the special wrenches and tools and the purposes 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.

REPAIR PARTS

1. The lists, which face the several turbine illustrations 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.

Section 7 -- Appendix

INDEX

List of Repair Parts
(Use Group 7)

WESTINGHOUSE ELECTRIC CORP. SOUTH PHILA. WORKS, PHILA., PA. — MARINE DIVISION

FRAME TURBINE GENERATOR SET — DWG NOT TO SCALE

TITLE SPARE PARTS LIST SHEET 1 — SUB. — DWG. 640 D 366

EST FIN. WT — GR.1 — GR.2 — GR.3 — GR.4 — GR.5 — ASSY

ITEM	NAME	REFERENCE DRAWING	REFERENCE ITEM	REFERENCE PATTERN OR STYLE NO.	MATL SPEC.	REQ'D FOR 1 SHIP GR.1	GR.2	GR.3	GR.4	GR.5	GR.6	GR.7	GR.8
1	AUTO STOP GOVERNOR												
2	SPRING	16-H-597	1		—	1	1	1	1	1	1	1	1
3	SPRING	90-J-28	50		—	1	1	1	1	1	1	1	1
4	SPRING	90-J-28	51		—	1	1	1	1	1	1	1	1
5	SPRING	90-J-29	15		—	–	1	1	1	–	–	1	1
6													
7													
8	BEARING - THRUST (KINGSBURY)												
9	COLLAR (ASSEMBLED AS ONE UNIT)	90-J-32	1		—	1	1	1	1	1	1	1	1
10	SHOE (ASSEMBLED AS ONE UNIT)		2		—	4	4	4	4	4	4	4	4
11	SHOE BABBITT (ASSEMBLED AS ONE UNIT)		3		—	2 OZ.	2 OZ.	2 OZ.	2 OZ.	2 OZ.	2 OZ.	2 OZ.	2 OZ.
12	SHOE SUPPORT (ASSEMBLED AS ONE UNIT)	90-J-32	4		—	4	4	4	4	4	4	4	4
13													
14													
15	BEARING - TURBINE (THRUST END)												
16	TURBINE BEARING COMPLETE	629J453	1		—	1	1	1	1	1	1	1	1
17													
18	BEARING - TURBINE (COUPLING END)												
19	TURBINE BEARING COMPLETE	629J453	14		—	1	1	1	1	1	1	1	1
20													
21	BEARING - PINION (COUPLING END)												
22	PINION BEARING COMPLETE	629J453	20		—	1	1	1	1	1	1	1	1
23													
24	BEARING - PINION (GENERATOR END)												
25	PINION BEARING COMPLETE	629J453	25		—	1	1	1	1	1	1	1	1
26													
27	BEARING - GEAR (TURBINE END)												
28	GEAR BEARING COMPLETE	629J453	28		—	1	1	1	1	1	1	1	1
29													
30	BEARING - GEAR (GENERATOR END)												
31	GEAR BEARING COMPLETE	629J453	36		—	1	1	1	1	1	1	1	1
32													

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List of Repair Parts (con't)
(Use Group 7)

TITLE SPARE PARTS LIST SHEET 2		SUB.				DWG. 640D366								
ITEM	NAME	REFERENCE			MATL SPEC.	REQ'D FOR 1 SHIP								
		DRAWING	ITEM	PATTERN OR STYLE NO.		GR1	GR2	GR3	GR4	GR5	GR6	GR7	GR8	
33	COUPLING													
34	SHOULDER SCREW	SIER-BATH	6		——	16	10	10	10	10	10	10	10	
35	FLEX-NUT	C-26081	7		——	10	10	10	10	10	10	1C	10	
36														
37														
38														
39														
40	GEAR HOUSING HORIZONTAL JOINT													
41	TAPER DOWEL - 3/8	750104	3		1556-1	1	1	1	1	1	1	1	1	
42	BOLT - 5/8 X 2 3/8 LG	16462	-		5115	2	2	2	2	2	2	2	2	
43	BOLT - 5/8 X 4 5/8 LG.	16462	-		5115	1	1	1	1	1	1	1	1	
44	BOLT - 5/8 X 2 3/4 LG.	16462	-		5115	1	1	1	1	1	1	1	1	
45	CAP SCREW (SOC. HD.) 5/8 X 1 1/2 LG.	10-H-452	-		6553-1	1	1	1	1	1	1	1	1	
46	NUT - HEX. - 5/8	16534	-		7609-0	2	2	2	2	2	2	2	2	
47	NUT - HEX. - 3/8	751459	-		7609-0	1	1	1	1	1	1	1	1	
48														
49														
50														
51	GEAR WHEEL SHAFT COUPLING													
52	BOLT FITTED 1" X 3 1/2 LG.	751503	-		5115	6	6	6	6	6	6	6	6	
53	NUT HEX. 1"	751459	-		7609-0	6	6	6	6	6	6	6	6	
54	LOCKWASHER 1"	74750	-		2052-2	6	6	6	6	6	6	6	6	
55														
56														
57														
58														
59														
60	GLANDS - SPINDLE (THRUST END)													
61	GLAND ASSEMBLY	38-F-167	GR. 1		——	1	1	1	1	1	1	1	1	
62														
63														
64	GLANDS - SPINDLE (COUPLING END)													
65	GLAND ASSEMBLY	38-F-167	GR 2		——	1	1	1	1	1	1	1	1	
66														
67														

List of Repair Parts (con't)
(Use Group 7)

TITLE SPARE PARTS LIST SHEET 3 | SUB | DWG 640D366

ITEM	NAME	REFERENCE: DRAWING	REFERENCE: ITEM	REFERENCE: PATTERN OR STYLE NO.	MAT'L SPEC	REQ'D FOR 1 SHIP: GR1	GR2	GR3	GR4	GR5	GR6	GR7	GR8
68	GOVERNOR & SPEED CHANGER												
69	SPRING	16-H-921	-		—	1	1	1	1	1	1	1	1
70	SPRING	22-H-118	-		—	2	2	2	2	2	2	2	2
71	MOTOR	[illegible] 60-J-260	-		—	-	-	-	-	1	1	-	-
72													
73													
74													
75	OIL FAILURE TRIP												
76	SPRING (OIL FAILURE TRIP)	11-H-166	-		—	1	1	1	1	1	1	1	1
77	SPRING	4-H-896	-		—	1	1	1	1	1	1	1	1
78													
79													
80													
81	OPERATING MECHANISM (SERVO MOTOR)												
82	SPRING - RELAY	24-H-466	-		—	1	1	1	1	1	1	1	1
83	SPRING - BELLOWS	24-H-467	-		—	1	1	1	1	1	1	1	1
84	BELLOWS - COMPLETE	98-J-150	66		—	1	1	1	1	1	1	1	1
85													
86													
87													
88	RELIEF VALVE (ATMOSPHERIC)												
89	SPRING	GIMPEL M-1386	11			-	-	-	1	-	-	1	-
90	SIGHT GAGE		12			-	-	-	1	-	-	1	-
91													
92													
93	SPINDLE POSITION INDICATOR												
94	SPRING - RETAINER	98-J-76	6		[illegible]	1	1	1	1	1	1	1	1
95													
96													
97	STEAM CHEST COVER & LINKAGE (CONT'D AT ITEM-175)												
98	SPRING	24-H-449	-		—	1	1	1	1	1	1	1	1
99	NUT HEX - 1 IN.	16534	-		7609-4	1	1	1	1	1	1	1	1
100	STUD - 1 IN. x 4¾ LG.	9-H-209	-		8337	1	1	1	1	1	1	1	1
101													
102													
103													

List of Repair Parts (con't)
(Use Group 7)

TITLE SPARE PARTS LIST SHEET 4		SUB				DWG 640D366								
ITEM	NAME	REFERENCE			MATL SPEC.	REQ'D FOR 1 SHIP								
		DRAWING	ITEM	PATTERN OR STYLE NO.		GR1	GR2	GR3	GR4	GR5	GR6	GR7	GR8	SEE NOTES
104	TURBINE CYLINDER JOINT													
105	BOLT - 3/4 X 2 3/4 LG.	16462	-		5115	1	1	1	1	1	1	1	1	B
106	BOLT - 7/8 X 3 7/8 LG.	16462	-		5115	1	1	1	1	1	1	1	1	B
107	DOWEL BOLT (A=1", C=1 [illegible], L=4 [illegible])	9-H-306	-		2811	1	1	1	1	1	1	1	1	B
108	STUD - 3/4 X 2 3/4 LG.	16476	-		2811	1	1	1	1	1	1	1	1	B
109	STUD - 1" X 10 1/4 LG.	16476	-		2811	1	1	1	1	1	1	1	1	B
110	DOWEL-STUD - 7/8 X 3 1/2 LG.	9-H-236	-		2811	1	1	1	1	1	1	1	1	B
111	BOLT - 3/4 X 3 1/4	16462	-		5115	1	1	1	1	1	1	1	1	B
112	NUT-HEX - 7/8	16534	-		7609-0	1	1	1	1	1	1	1	1	B
113	NUT-HEX - 3/4	16534	-		7609-0	2	2	2	2	2	2	2	2	B
114	CAP SCREW (SOC. HD) 5/8 X 1 3/8 LG.	10-H-75	-		6553	1	1	1	1	1	1	1	1	A, B
115	EXTENSION NUT - 1" X 2 1/2 LG.	9-H-273	-		1556-1	1	1	1	1	1	1	1	1	B
116	BOLT - 7/8 X 3 7/8 LG.	16462	-		7638	1	1	1	1	1	1	1	1	A
117	DOWEL BOLT - A=1 1/8, C=4 1/8, L=8 1/2	9-H-197	-		8337	1	1	1	1	1	1	1	1	A
118	DOWEL STUD - 1 1/2 X 6" LG.	9-H-244	-		8337	1	1	1	1	1	1	1	1	A
119	STUD BOLT - 1 1/4 X 7 3/4 LG.	9-H-284	-		8337	1	1	1	1	1	1	1	1	A
120	EXTENSION NUT - 1 1/4 X 3 5/8 LG.	10-H-763	-		7714	1	1	1	1	1	1	1	1	A
121	NUT-HEX - 1"	16534	-		7609-4	1	1	1	1	1	1	1	1	A
122	NUT-HEX - 7/8	16534	-		7609-24	1	1	1	1	1	1	1	1	A
123	STUD - 1" X 11 5/8 LG.	9-H-209	-		8337	1	1	1	1	1	1	1	1	A
124	TAPER DOWEL - 3/8	750104	3		1556-1	1	1	1	1	1	1	1	1	A
125	NUT-HEX - 3/8	751459	-		7609-0	1	1	1	1	1	1	1	1	A
126														
127														
128														
129														
130														
131														
132														
133														
134														
135														
136														
137														
138														

List of Repair Parts (con't)
(Use Group 7)

TITLE SPARE PARTS LIST SHEET 5 | SUB. | DWG 640D366

ITEM	NAME	REFERENCE DRAWING	REFERENCE ITEM	REFERENCE PATTERN OR STYLE NO	MAT'L SPEC.	REQ'D FOR 1 SHIP GR1	GR2	GR3	GR4	GR5	GR6	GR7	GR8
139	SENTINEL VALVE												
140	SPRING	CRANE 20097	-		—	1	1	-	-	-	-	-	1
141													
142													
143													
144	THROTTLE VALVE												
146	SPRING	GIMPEL S-422	6		—	1	1	-	1	1	1	1	1
146	SPRING		41		—	1	1	-	1	1	1	1	1
147	BASKET		32		—	-	-	-	-	1	1	-	-
148	SPRING	GIMPEL S-434	6		—	-	-	1	-	-	-	-	-
149	SPRING		41		—	-	-	1	-	-	-	-	-
150	VALVE DISC	GIMPEL S-422	22		—	-	-	-	-	-	-	1	-
151	VALVE SEAT		23		—	-	-	-	-	-	-	1	-
152													
153													
154													
155													
156	OIL PIPING												
157	THERMOMETER-RIGHT SIDE ANGLE 90°	22-H-27	1		—	1	1	1	1	1	1	1	1
158	THERMOMETER-LEFT SIDE ANGLE 90°	22-H-27	1		—	1	1	1	1	1	1	1	1
159	THERMOMETER-STRAIGHT	10-H-71	1		—	1	1	1	1	1	1	1	1
160	SPRING (1 IN. RELIEF VALVE)	21-F-876	6		—	1	1	1	1	1	1	1	1
161	SPRING (3/4 IN. RELIEF VALVE)	LONERGAN [illegible]	6		—	1	1	1	1	1	1	1	1
162	GAUGE (BRG. OIL PRESS.)	360B850	8		—	-	-	-	-	-	-	-	1
163													
164													
165													
166													
167													
168	OIL COOLER (SEE NOTE C)												
169	TUBES-5/8 O.D. x 18 B.W.G. (.049 THK) x 32 3/16 LG				[illegible] 90-10 CU NICKEL	12	12	-	12	12	-	12	12
170	ZINC PENCIL	25G200	20		—	6	6	-	6	6	-	6	6
171	PIPE PLUG	23G200	4		—	6	6	-	6	6	-	6	6
172	TUBES-5/8 O.D. X 18 BWG (.049 THK x 26 15/16 LG.)				[illegible] 90-10 CU NICKEL	-	-	20	-	-	-	-	-
173	ZINC PLATE	97J569	14		—	-	-	2	-	-	-	-	-
174	ZINC PLATE	97J569	32		—	-	-	1	-	-	-	-	-

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List of Repair Parts (con't)
(Use Group 7)

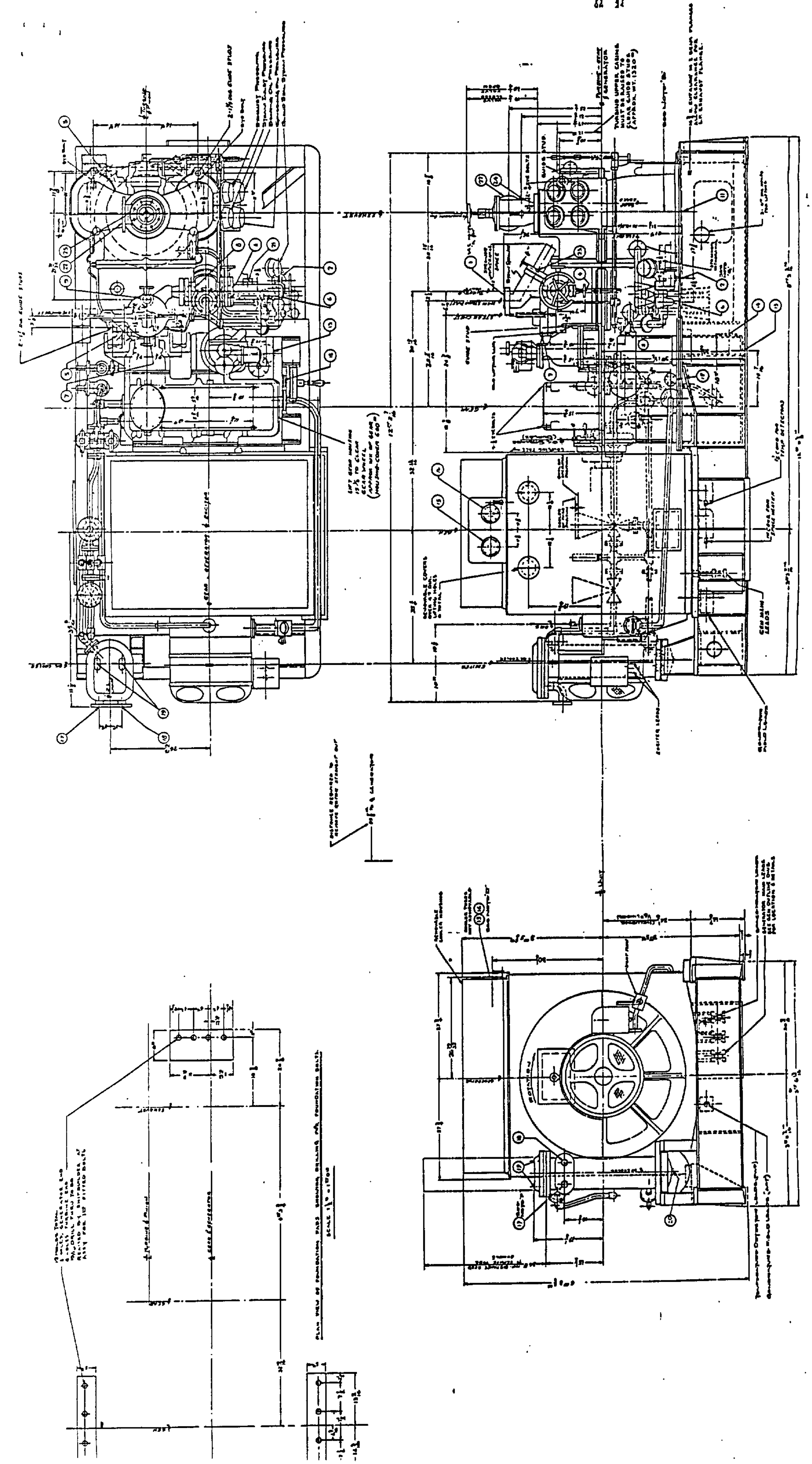
TITLE SPARE PARTS LIST SHEET 6		SUB.				DWG. 640D366								
ITEM	NAME	REFERENCE			MATL SPEC.	REQ'D FOR 1 SHIP								
		DRAWING	ITEM	PATTERN OR STYLE NO.		GR.1	GR.2	GR.3	GR.4	GR.5	GR6	GR7	GR8	
175	STEAM CHEST COVER & LINKAGE	(CONT'D FR ITEM-97)												
176	VALVE	98J178	8		—	-	-	-	-	-	-	2	-	
177	VALVE	98J178	9		—	-	-	-	-	-	-	2	-	
178	VALVE SEAT	98J178	10		—	-	-	-	-	-	-	2	-	
179	VALVE SEAT	98J178	11		—	-	-	-	-	-	-	2	-	

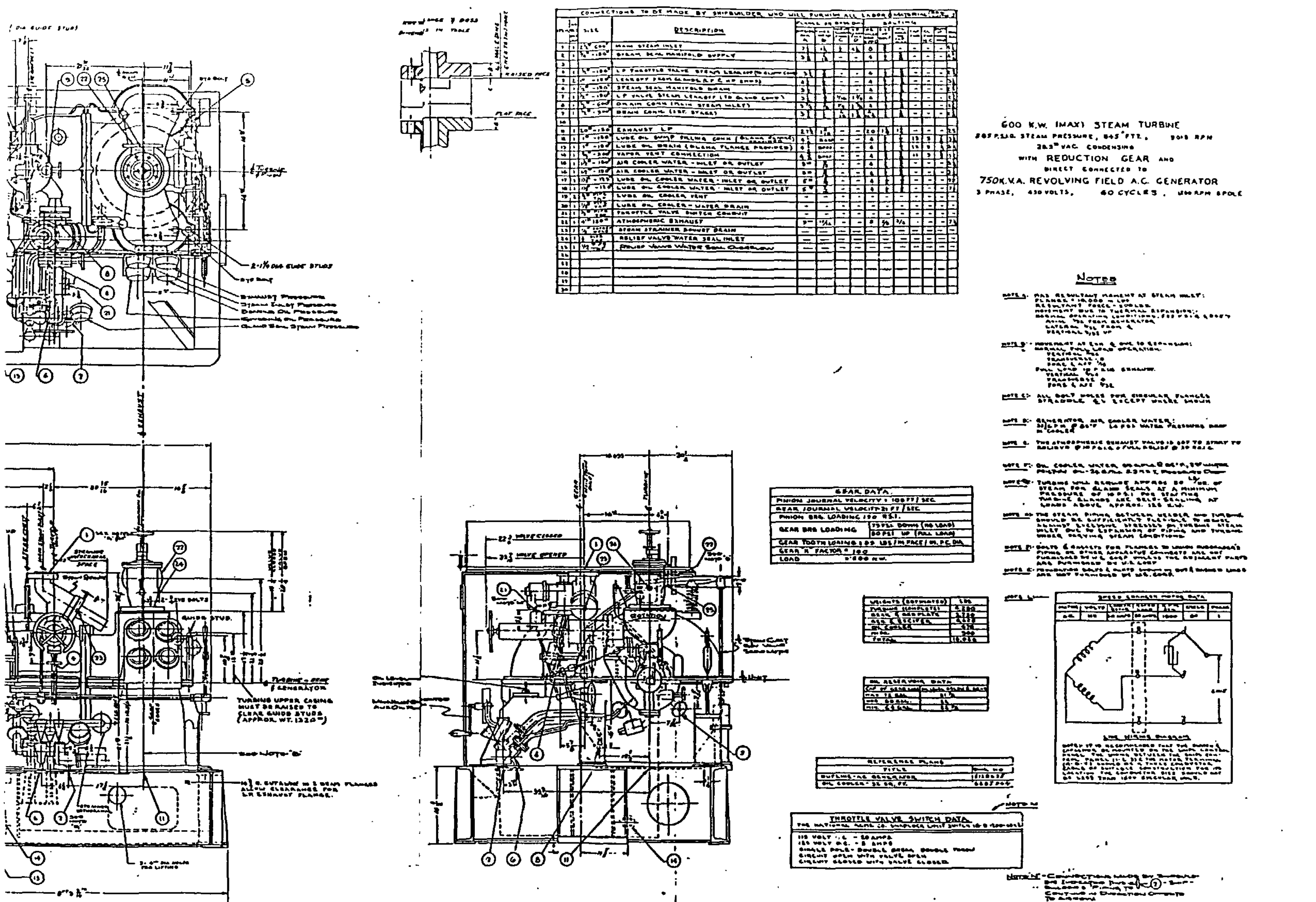
NOTES

NOTE "A": LOCATED IN HORIZONTAL JOINT OF H.P. CYLINDER.

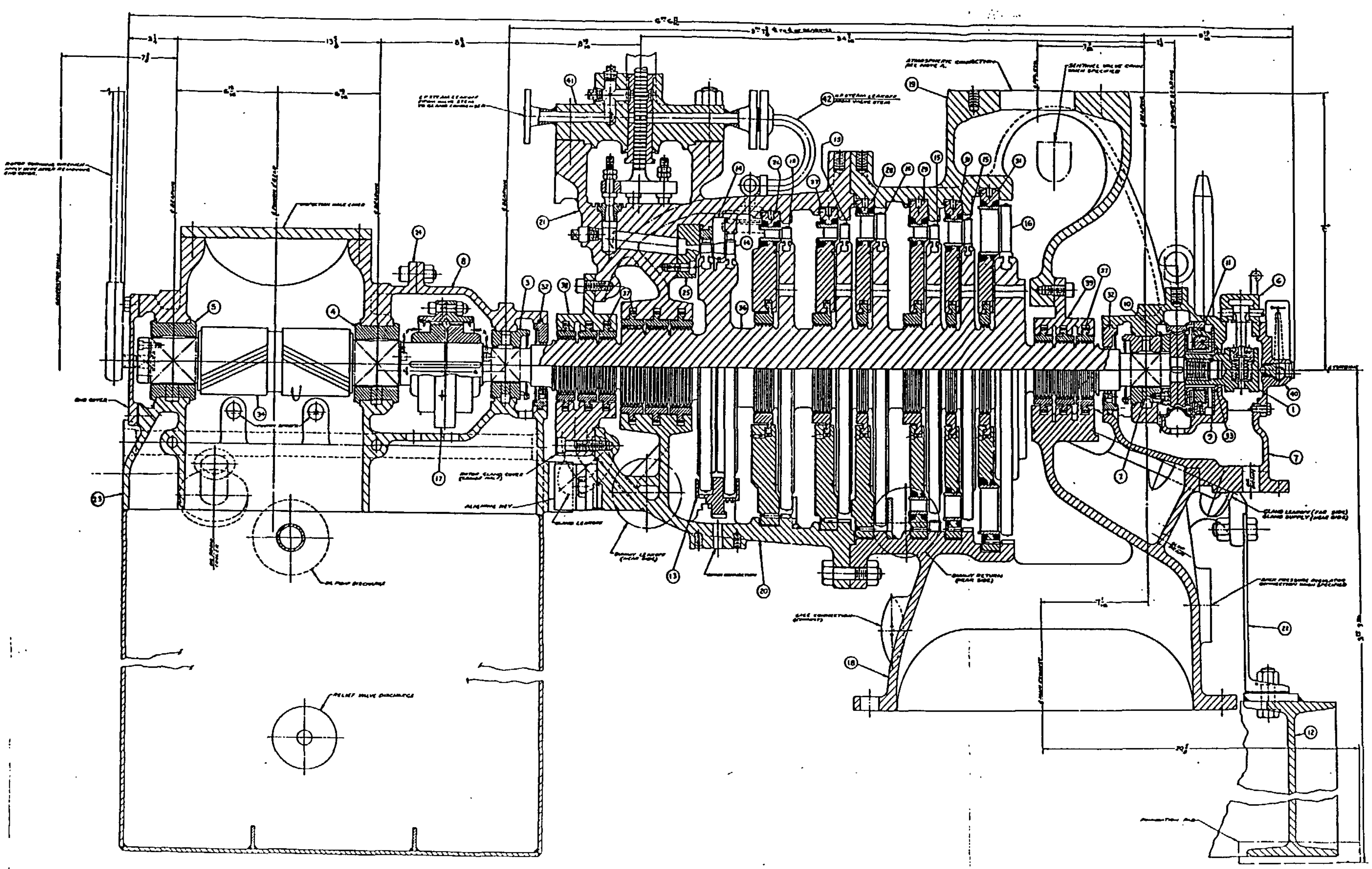
NOTE "B": LOCATED IN HORIZONTAL JOINT OF L.P. CYLINDER.

NOTE "C": THE FOLLOWING ITEMS TO BE ORDERED BY HEAT TRANSFER APPARATUS DIVISION.
169, 170, 171, 172, 173 & 174





Outline of Turbine, Gear and Generator -- FIG. T-1



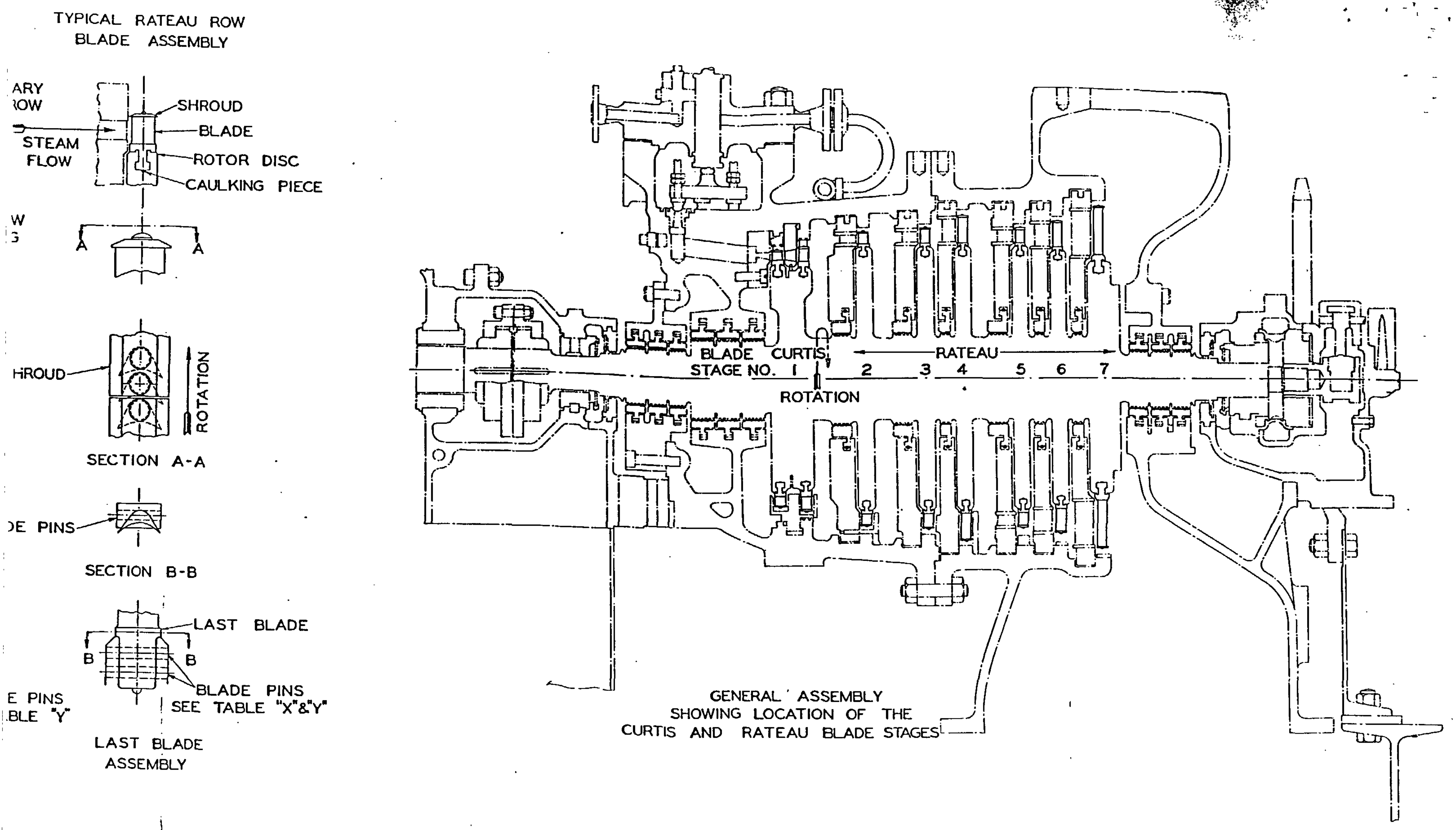
Longitudinal Section Thru Turbine and Pinion -- FIG. T-2

HWB-00038266

FIGURE T-2

LONGITUDINAL SECTION THROUGH TURBINE AND PINION

Item	Name of Part
1	Auto Stop Gov. Body
2	Bearing Turb. (Thrust End)
3	Bearing Turb. (Coupling End)
4	Bearing Pinion (Coupling End)
5	Bearing Pinion (Generator End)
6	Bearing Housing Cover
7	Bearing Housing Base
8	Bearing Cover (Pinion)
9	Filler Plate (Thrust End)
10	Bearing Thrust Ring
11	Bearing (Thrust)
12	Bed Plate
13	Baffle - 1st Stage
14	Blading - 1st Stage
15	Blading - Stages 2 thru 6
16	Blading - 7th Stage
17	Coupling
18	Cylinder Base (L.P. End)
19	Cylinder Cover (L.P. End)
20	Cylinder Base (H.P. End)
21	Cylinder Cover (H.P. End)
22	Turbine Support
23	Gear Housing Base
24	Gear Housing Cover
25	Nozzle Block
26	Nozzle Diaphragm (2nd Stage)
27	Nozzle Diaphragm (3rd Stage)
28	Nozzle Diaphragm (4th Stage)
29	Nozzle Diaphragm (5th Stage)
30	Nozzle Diaphragm (6th Stage)
31	Nozzle Diaphragm (7th Stage)
32	Oil Rings (Turbine)
33	Oil Ring (Thrust Bearing)
34	Pinion
36	Rotor
37	Rotor Glands (H.P. End, L.P. End, & Dummy)
38	Rotor Gland Cover (H.P. End)
39	Rotor Gland Cover (L.P. End)
40	Rotor Position Indicator End Cover
41	Steam Chest Cover
42	Valve Stem Leakoff Pipe
43	Sentinel Valve (When Specified)
44	Blank Flange (When Specified)
45	Atmospheric Relief Valve (When Specified)



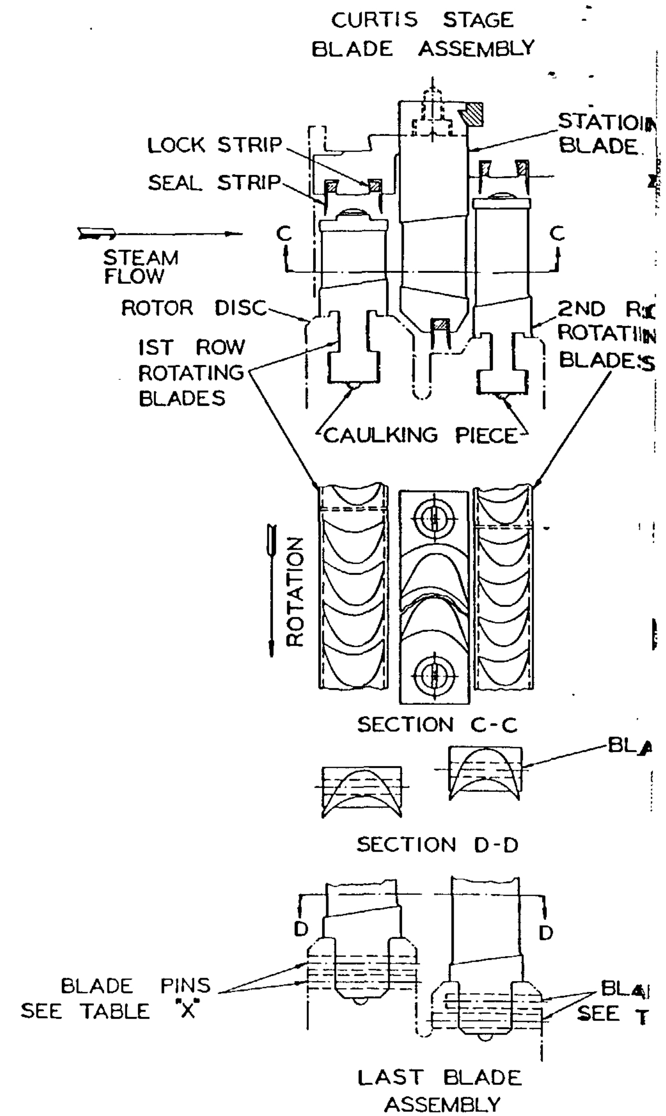
Curtis and Rateau Blading -- FIG. T-3

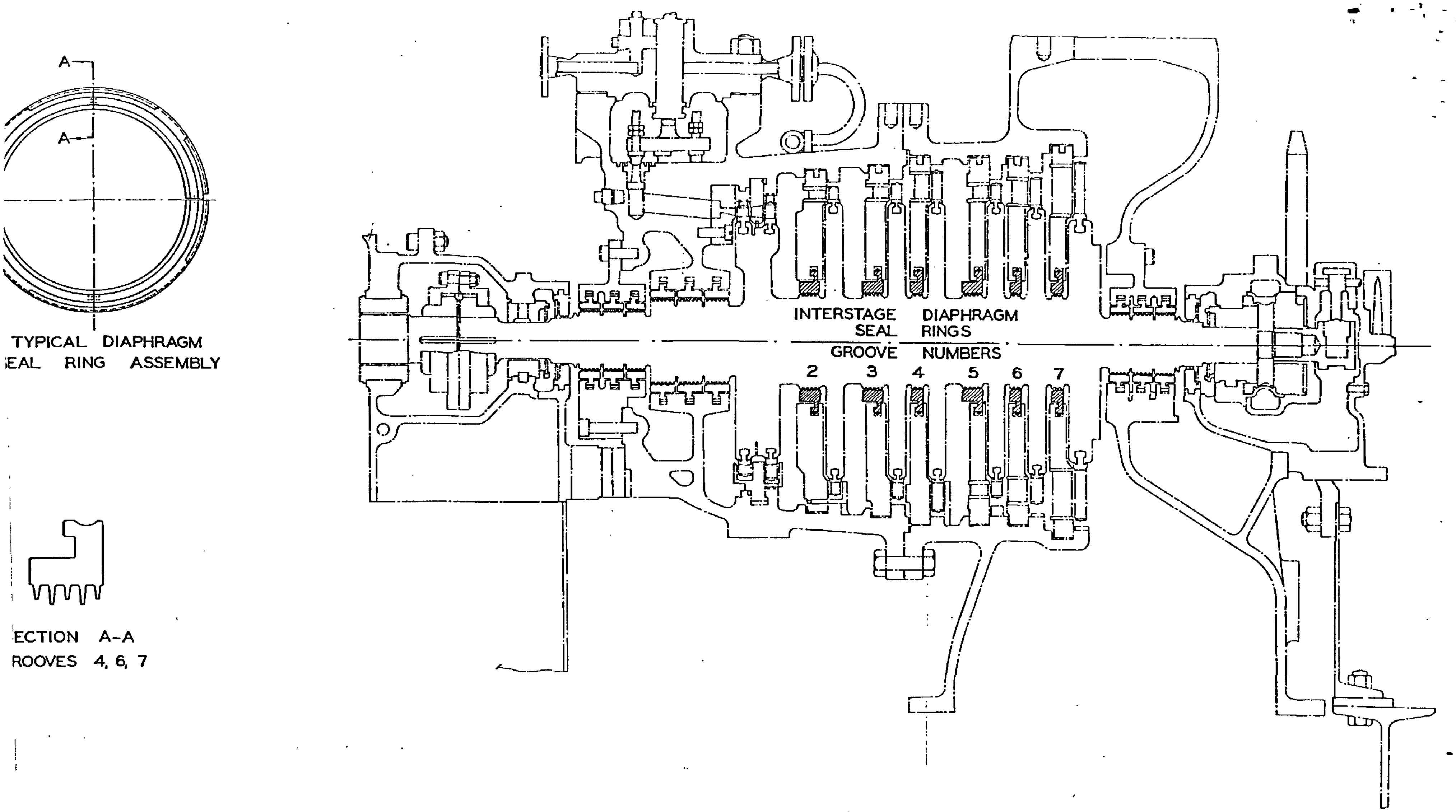
MW2-00039267

BLADE PIN TABLE "X" FOR IST ROT. CURTIS ROW AND 7TH RATEAU ROW			
PIN DIAM.	REAM	DRILL	
		DIAM.	SIZE
.180	.178	.1695	18
.185	.183	.177	16
.190	.188	.182	14
.195	.193	.185	13
.200	.198	.191	11

BLADE PIN TABLE "Y" FOR 2ND ROT. CURTIS ROW AND RATEAU ROWS NO. 2, 3, 4, 5, AND 6			
PIN DIAM.	REAM	DRILL	
		DIAM.	SIZE
.150	.148	.1405	28
.155	.153	.147	26
.160	.158	.152	24
.165	.163	.157	22
.170	.168	.161	20

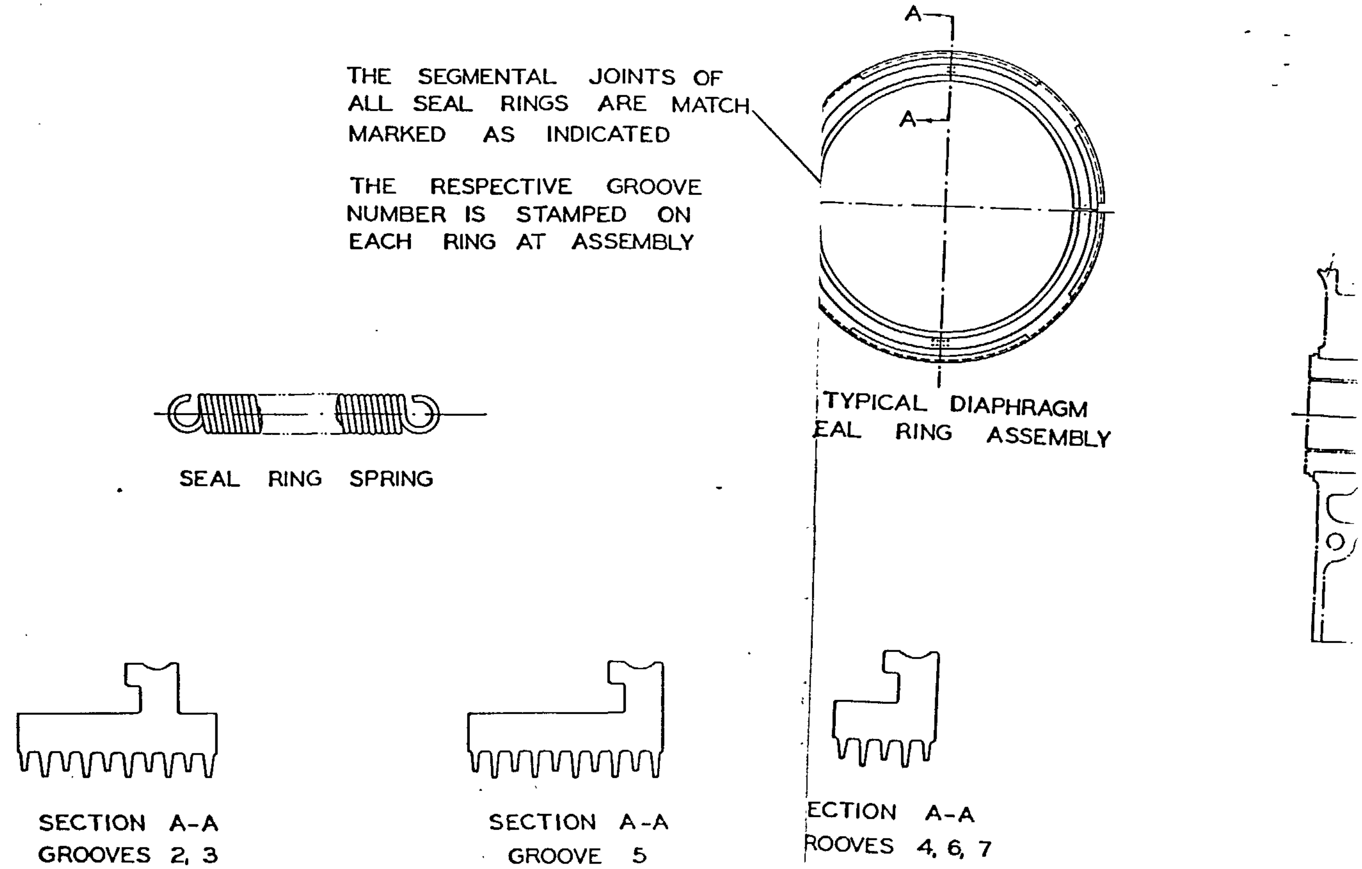
NOTE:- DRILL AND REAM ROTOR AND LAST BLADES FOR BLADE PIN AS SHOWN IN THE TABLES. BEGIN WITH FIRST SIZE LISTED WHEN ROTOR IS MANUFACTURED AND AT EACH REPAIR INCREASE CONSECUTIVELY UNTIL MAXIMUM DIAMETER IS REACHED. IN CASE OF REPAIRS, MEASURE THE DIAMETER OF OLD PINS REMOVED AND SPECIFY THE NEXT LARGER DIAMETER PIN FOR THAT REPAIR AS GIVEN IN THE TABLES.

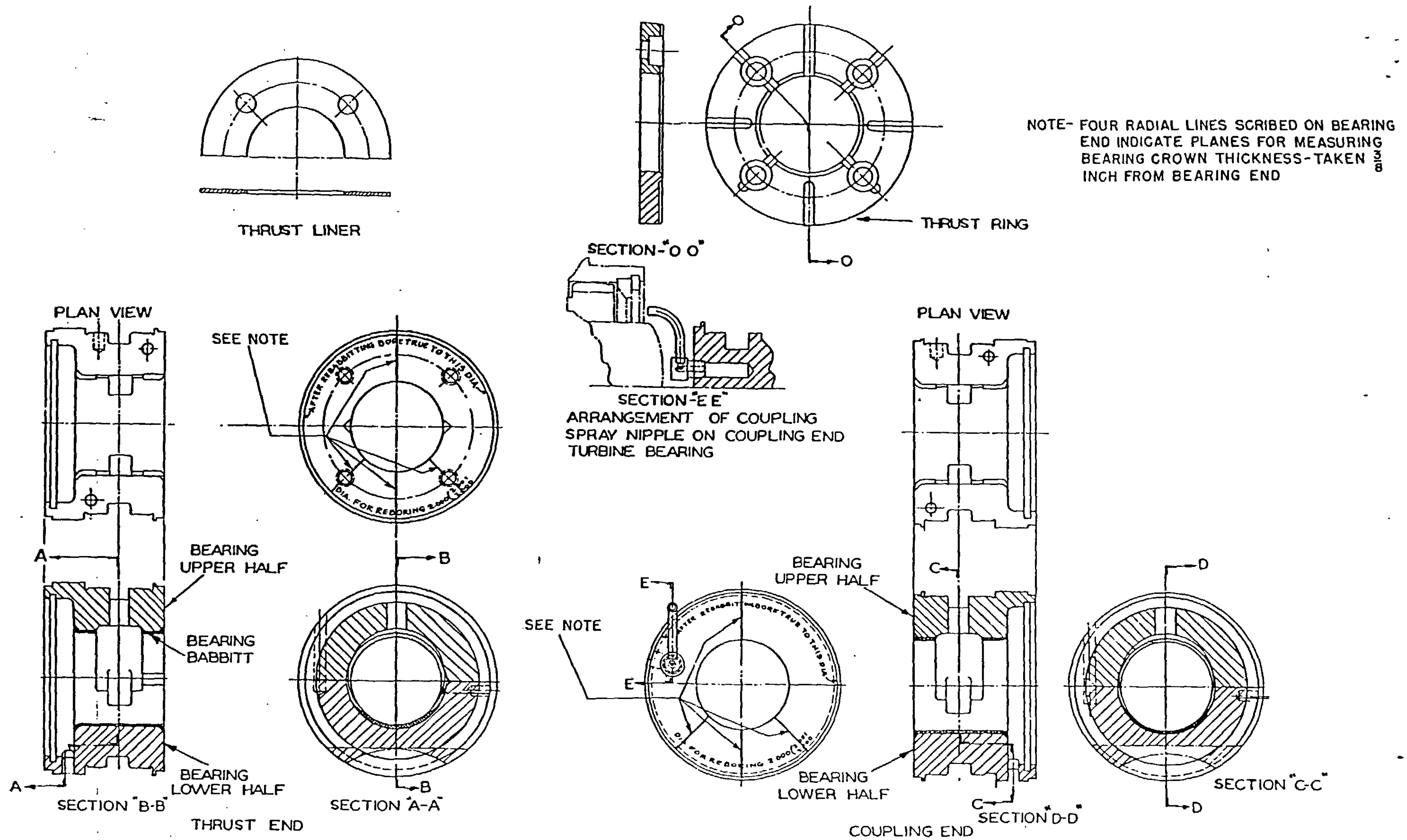




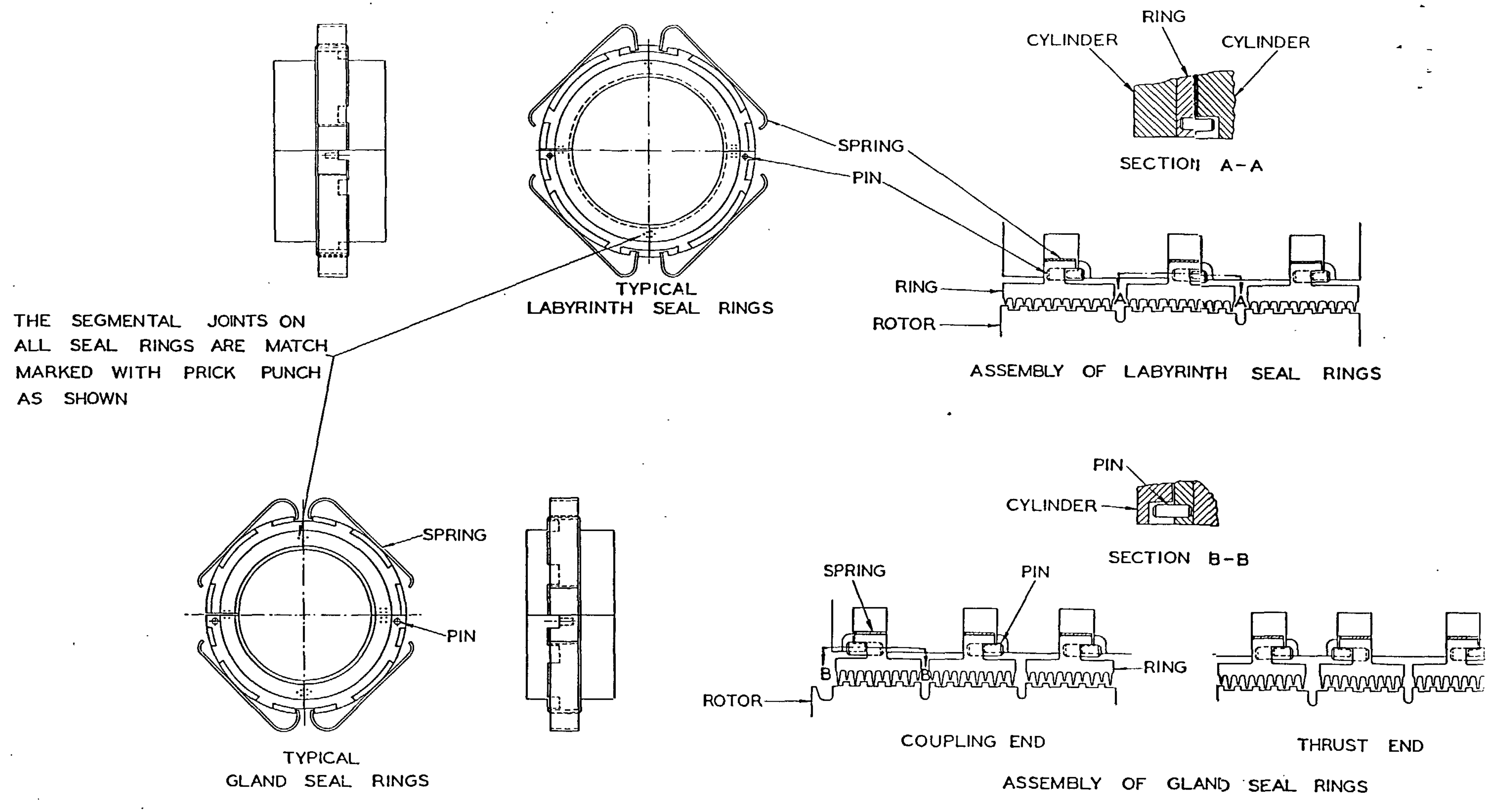
Interstage Diaphragm Seals -- FIG. T-4

MWB-0003524P

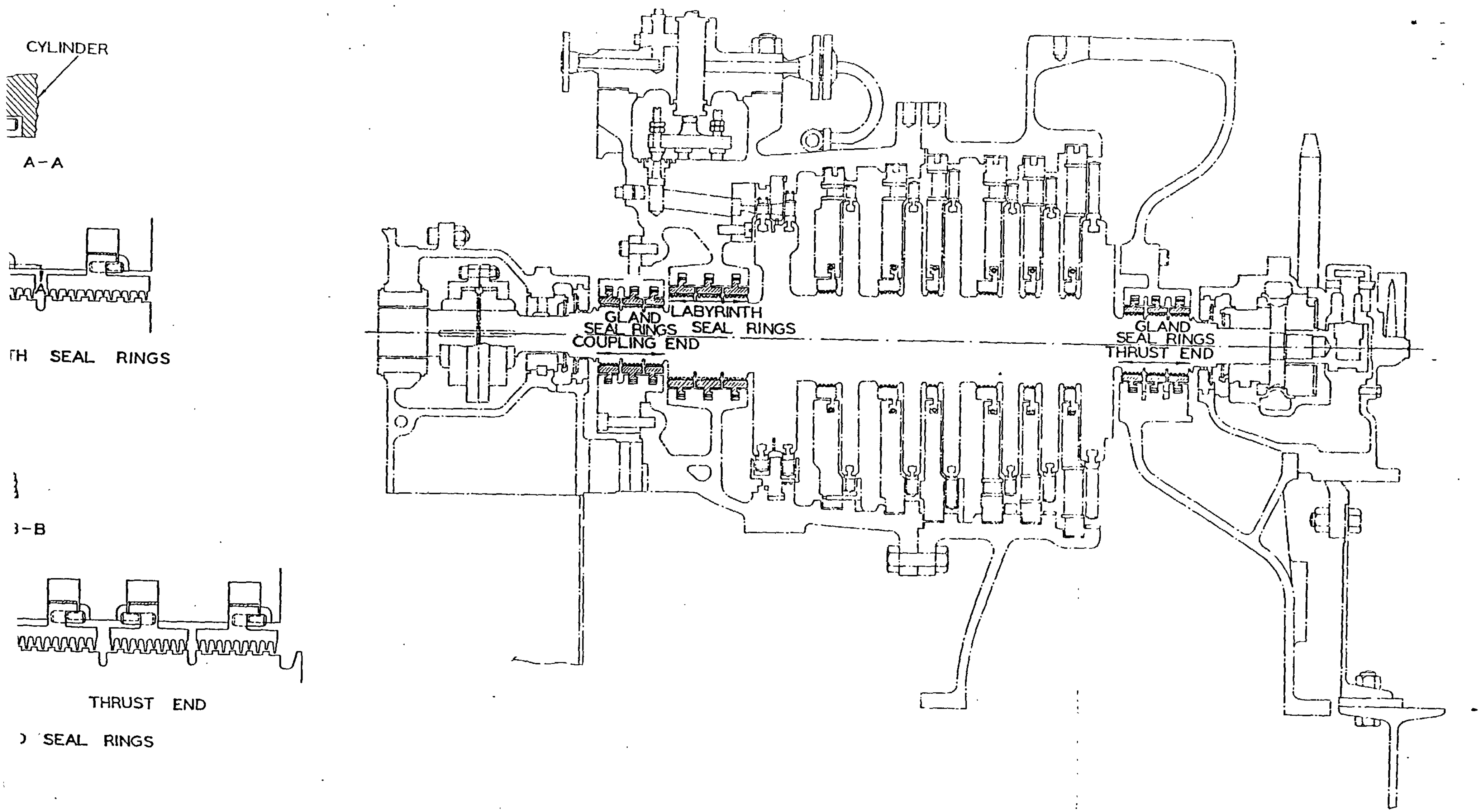

A
A
THE SEGMENTAL JOINTS OF ALL SEAL RINGS ARE MATCH MARKED AS INDICATED
THE RESPECTIVE GROOVE NUMBER IS STAMPED ON EACH RING AT ASSEMBLY
TYPICAL DIAPHRAGM
EAL RING ASSEMBLY
SEAL RING SPRING
SECTION A-A
GROOVES 2, 3
SECTION A-A
GROOVE 5
ECTION A-A
ROOVES 4, 6, 7



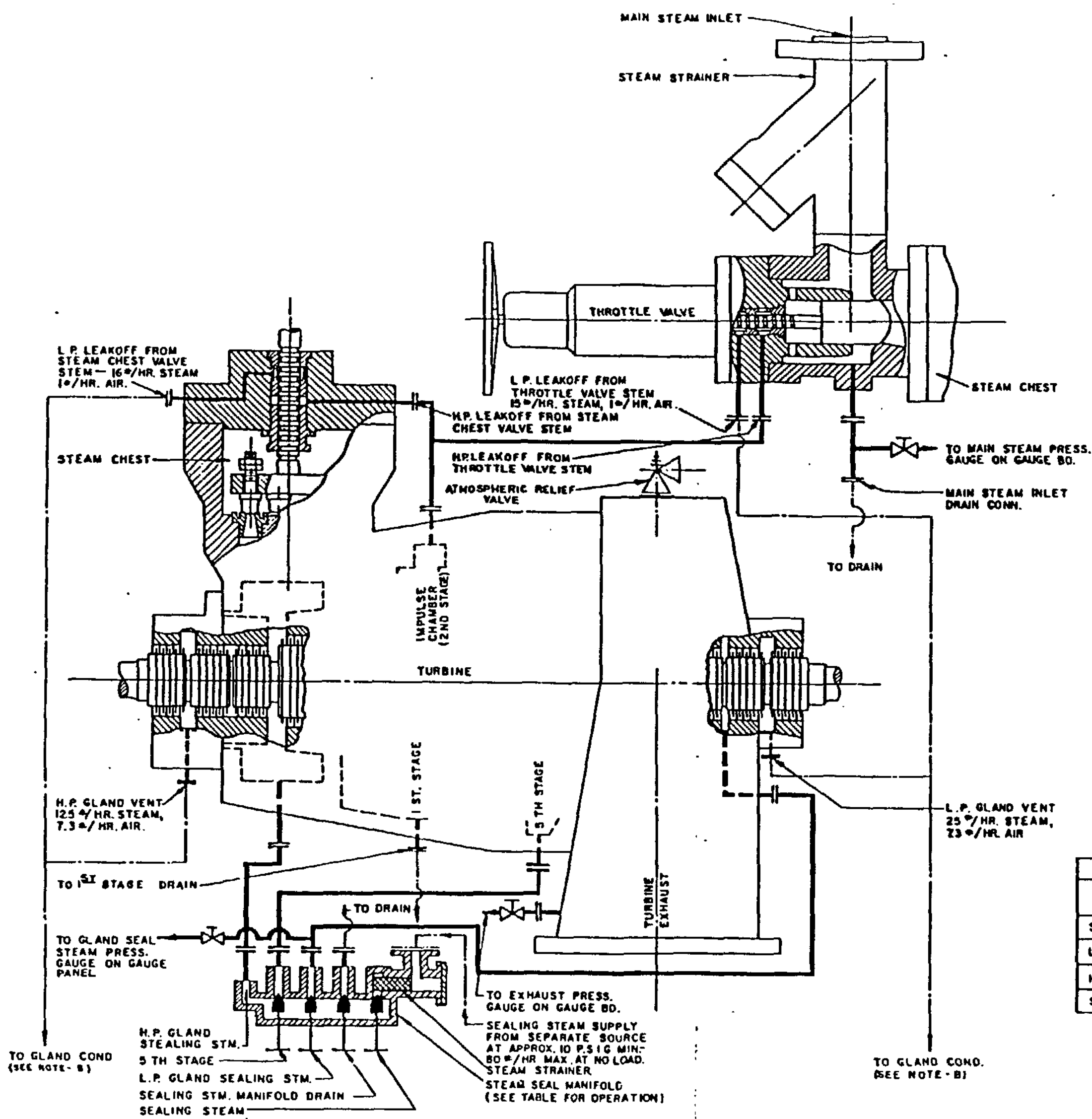
Turbine Bearings -- FIG. T-5



RING
CYLINDER
CYLINDER
SECTION A-A
SPRING
PIN
RING
ROTOR
A
A
ASSEMBLY OF LABYRINTH SEAL RINGS
TYPICAL
LABYRINTH SEAL RINGS
THE SEGMENTAL JOINTS ON
ALL SEAL RINGS ARE MATCH
MARKED WITH PRICK PUNCH
AS SHOWN
PIN
CYLINDER
SECTION B-B
SPRING
PIN
RING
B
B
ROTOR
COUPLING END
THRUST END
ASSEMBLY OF GLAND SEAL RINGS
SPRING
PIN
TYPICAL
GLAND SEAL RINGS



Rotor Glands and Labyrinth Seals -- FIG. T-6



NOTE "A" ALL LINES SHOWN IN DOT AND DASH TO BE SUPPLIED BY SHIPBUILDER.

NOTE "B" PRESSURE IN GLAND CONDENSER SHOULD BE 12 TO 15 INCHES H_2O BELOW ATMOSPHERIC PRESSURE IN ORDER TO MAINTAIN SLIGHT VACUUM AT TURBINE GLANDS.

NOTE "C" ALL LEAKAGES BASED ON 2 X DESIGN CLEARANCES.

OPERATION OF VALVES

VALVE	SEAL	DRAIN	L.P. GLAND	5TH STAGE
STARTING	ADJUST	OPEN	OPEN	CLOSE
LIGHT LOAD	ADJUST	CLOSE	OPEN	CLOSE
HEAVY LOAD	CLOSE	CLOSE	ADJUST	ADJUST
SHUT DOWN	CLOSE	OPEN	OPEN	OPEN

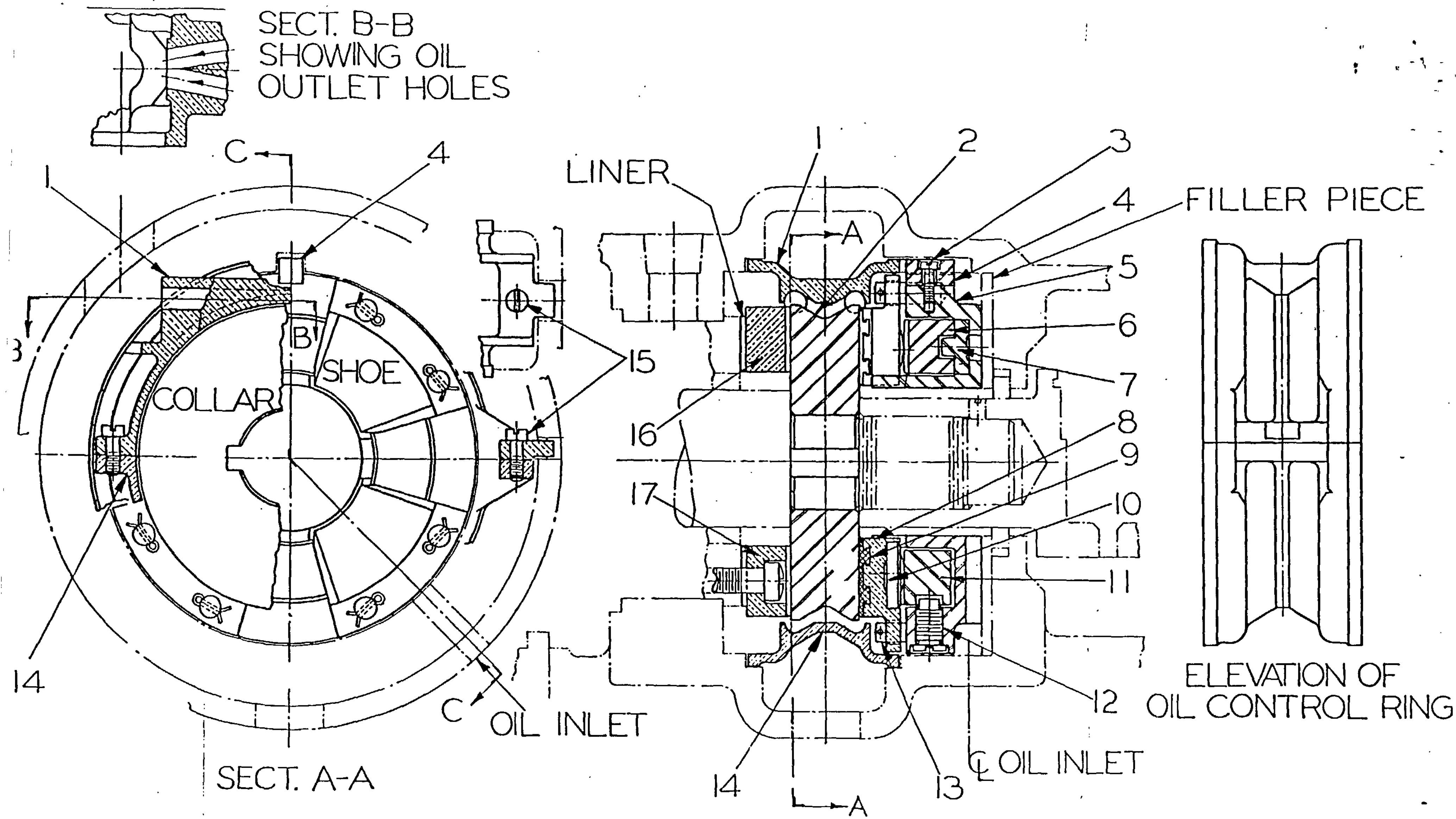
Steam, Drain and Gland Piping Diagram -- FIG. T-7

NWB-00038271

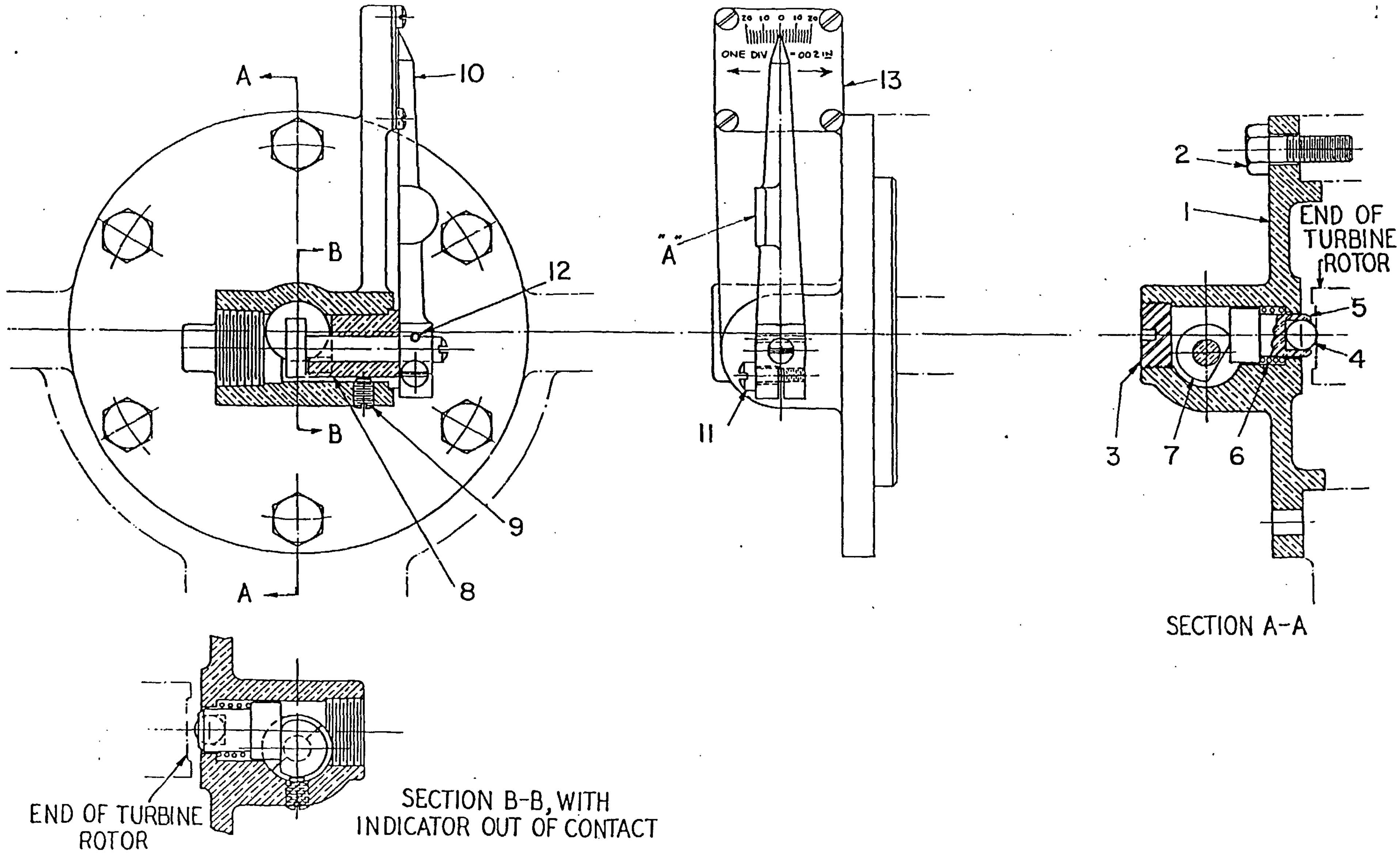
FIGURE T-8

TURBINE THRUST BEARING

Item	Name of Part
1	Oil Control Ring (Upper Half)
2	Collar
3	Base Ring Key Screw
4	Base Ring Key
5	Base Ring (In Halves)
6	Lower Leveling Plate
7	Base Ring Dowel Disc
8	Shoe (Body)
9	Shoe (Babbitt)
10	Shoe (Support)
11	Upper Leveling Plate
12	Leveling Plate Set Screw
13	Base Ring Shoe Dowel
14	Oil Control Ring (Lower Half)
15	Oil Control Ring Screw
16	Thrust Ring (Upper Half)
17	Thrust Ring (Lower Half)



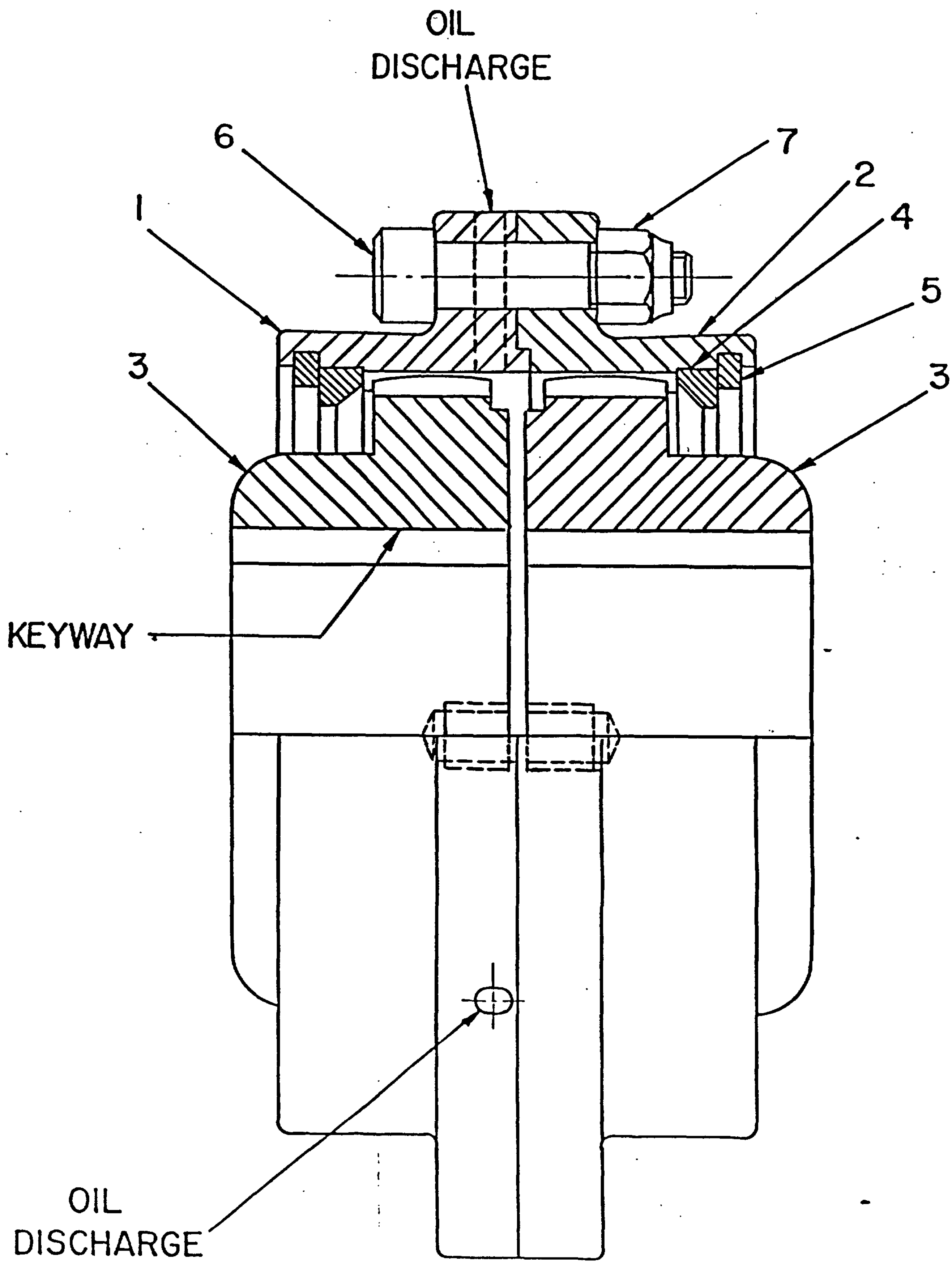
Thrust Bearing -- FIG. T-8
NWS-0003827?



Rotor Position Indicator -- FIG. T-9
MWB-00038273

FIGURE T-9
ROTOR-POSITION INDICATOR

Item	Name of Part
1	End Cover
2	End Cover Bolt
3	End Plug
4	Contact Ball
5	Contact Ball Retainer
6	Contact Ball Retainer Spring
7	Spindle
8	Spindle Bushing
9	Spindle Bushing Set Screw
10	Pointer
11	Pointer Screw
12	Pointer Pin
13	Graduated Scale Plate



Turbine and Pinion Coupling -- FIG. T-

MWB-0003927

FIGURE T-10

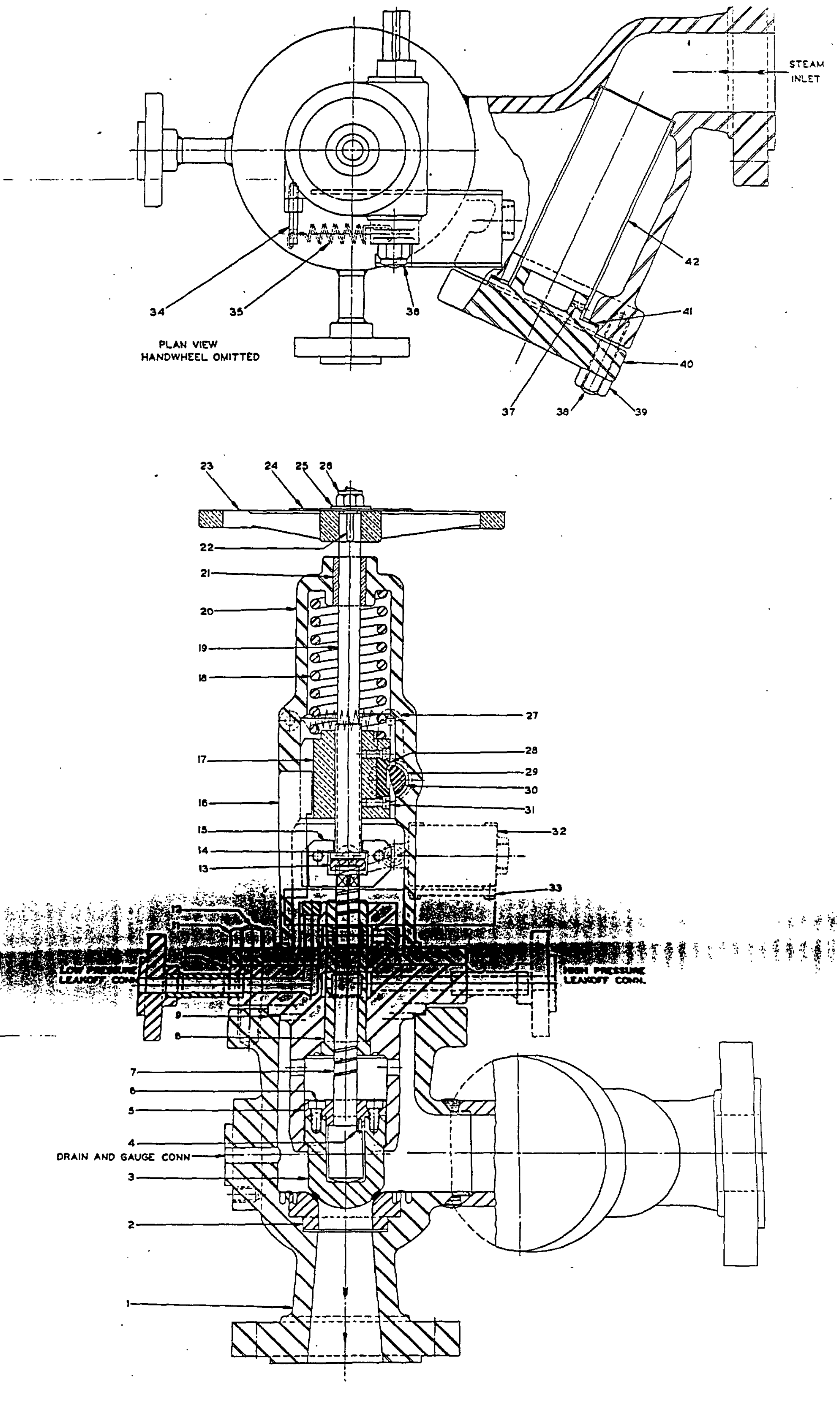
TURBINE - PINION COUPLING

Item	Name of Part
1	Flange Sleeve
2	Flange Sleeve
3	Special Hub
4	Retainer
5	Lock Ring
6	Shoulder Screw
7	Hex Nut

FIGURE T-11

THROTTLE VALVE ASSEMBLY

Item	Name
1	Throttle Valve and Stream Strainer Body
2	Throttle Valve Seat
3	Throttle Valve Disc
4	Throttle Valve Disc Pin
5	Throttle Valve Disc Flange
6	Throttle Valve Disc Cap Screw
7	Throttle Valve Stem
8	Leakoff Bushing
9	Gasket
10	Bonnet
11	Hex Nut
12	Stud
13	Coupling Washer
14	Coupling Thrust Washer
15	Coupling
16	Coupling Guide
17	Sliding Nut
18	Spring
19	Screw Spindle
20	Yoke
21	Yoke Bushing
22	Key
23	Handwheel
24	Reference Plate
25	Washer
26	Hex Nut
27	Tripping Lever
28	Latch Insert
29	Latch Shaft Bushing
30	Latch Shaft
31	Cap Screws
32	Switch
33	Switch Bracket
34	Spring Pin
35	Spring
36	Hex Nut
37	Slotted Machine Screw
38	Stud
39	Hex Nut
40	Strainer Bonnet
41	Gasket
42	Steam Strainer



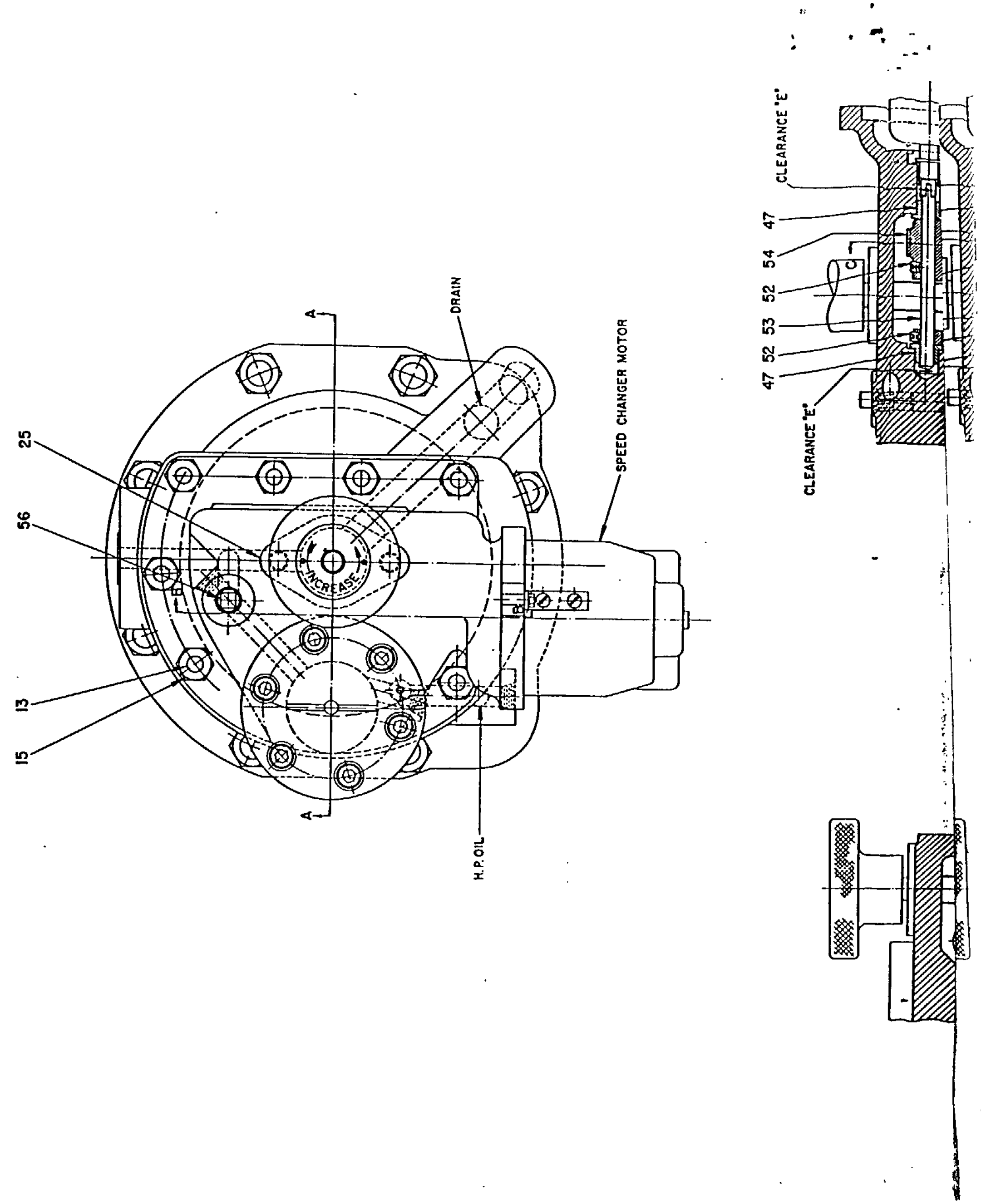
Throttle Valve -- FIG. T-11

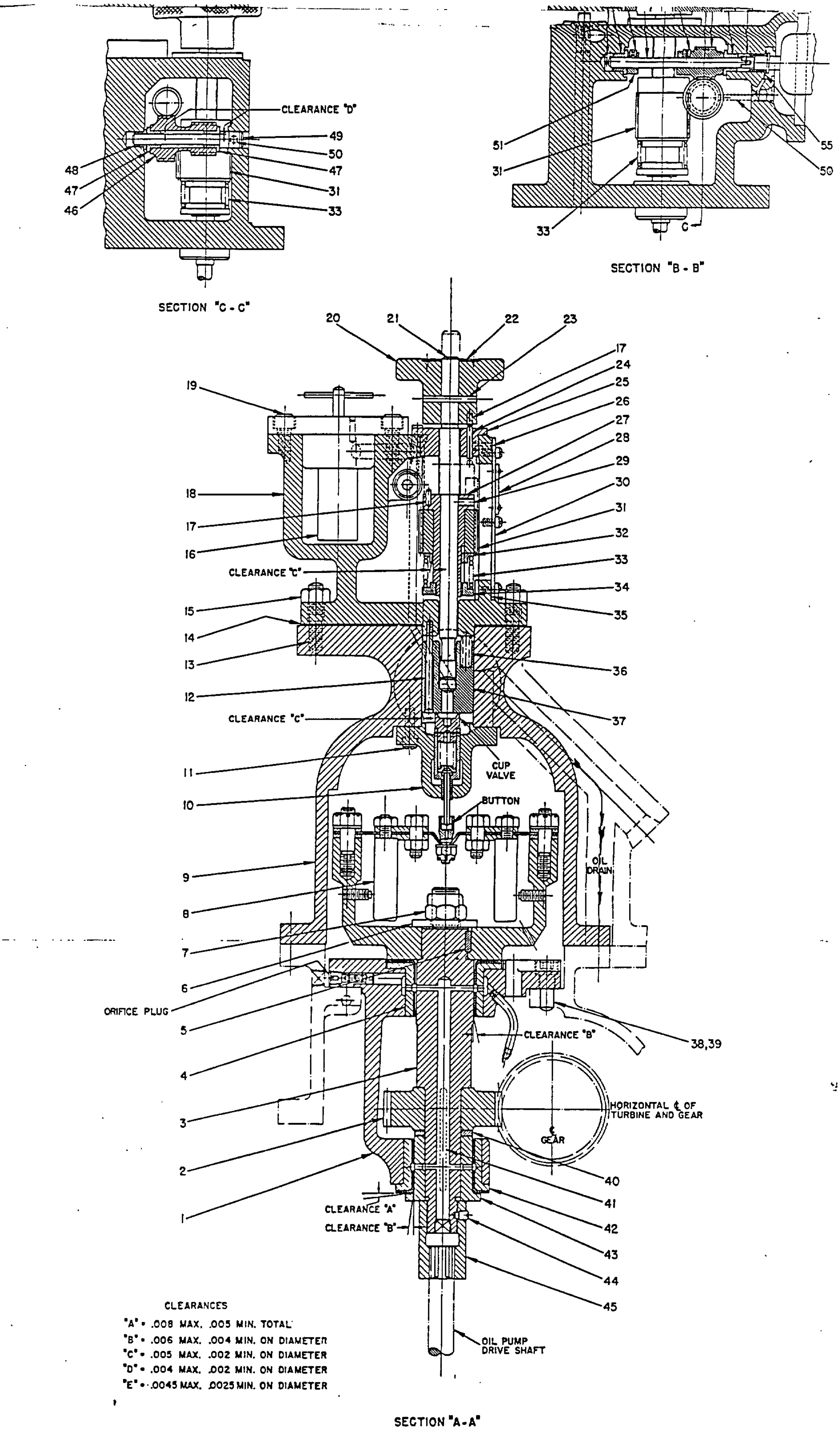
HWB-00038275

FIGURE T-12

GOVERNOR AND SPEED CHANGER

Name of Part	Item	Name of Part
Cover	31	Worm Gear
Spiral Gear, Driven	32	Washer
Shaft	33	Spring
Governor Body Bearing, Upper	34	Spring Seat
Key	35	Gasket
Washer Special	36	Spring
Locknut	37	Valve Seat
Governor Weights Assembly	38	Pin
Governor Housing	39	Socket Head Screw
Cup Valve Assembly	40	Liner
Cap Screw	41	Key
Screw, Special	42	Governor Body Bearing, Lower
Stud		
Gasket	43	Sleeve
Nut	44	Set Screw
	45	Sleeve Nut
Filter		
Pin	46	Worm and Worm Gear
Speed Changer Housing	47	Bushing
Socket Head Cap Screw	48	Bushing
Hand Knob	49	Shaft
	50	Set Screw
Shaft		
Direction Plate	51	Collar
Taper Pin	52	Set Screw
Stop Pin	53	Shaft
Bushing	54	Worm
	55	Bushing
Set Screw		
Clutch Collar	56	Orifice Plug
Caution Plate		
Set Screw		
Cover Plate		



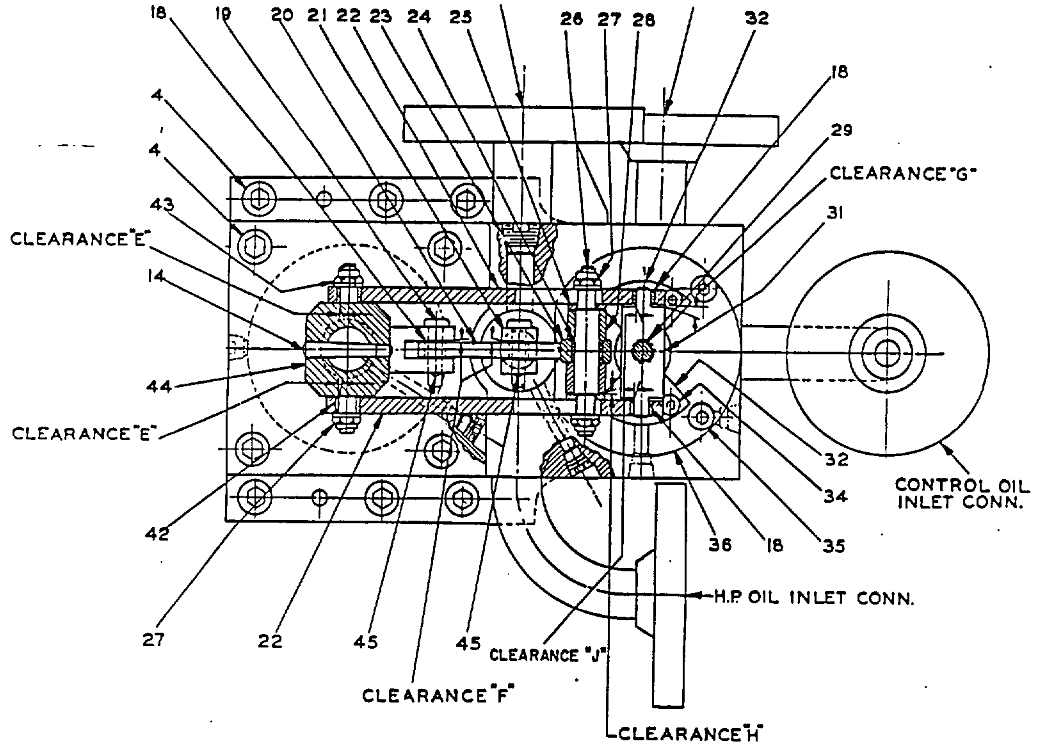


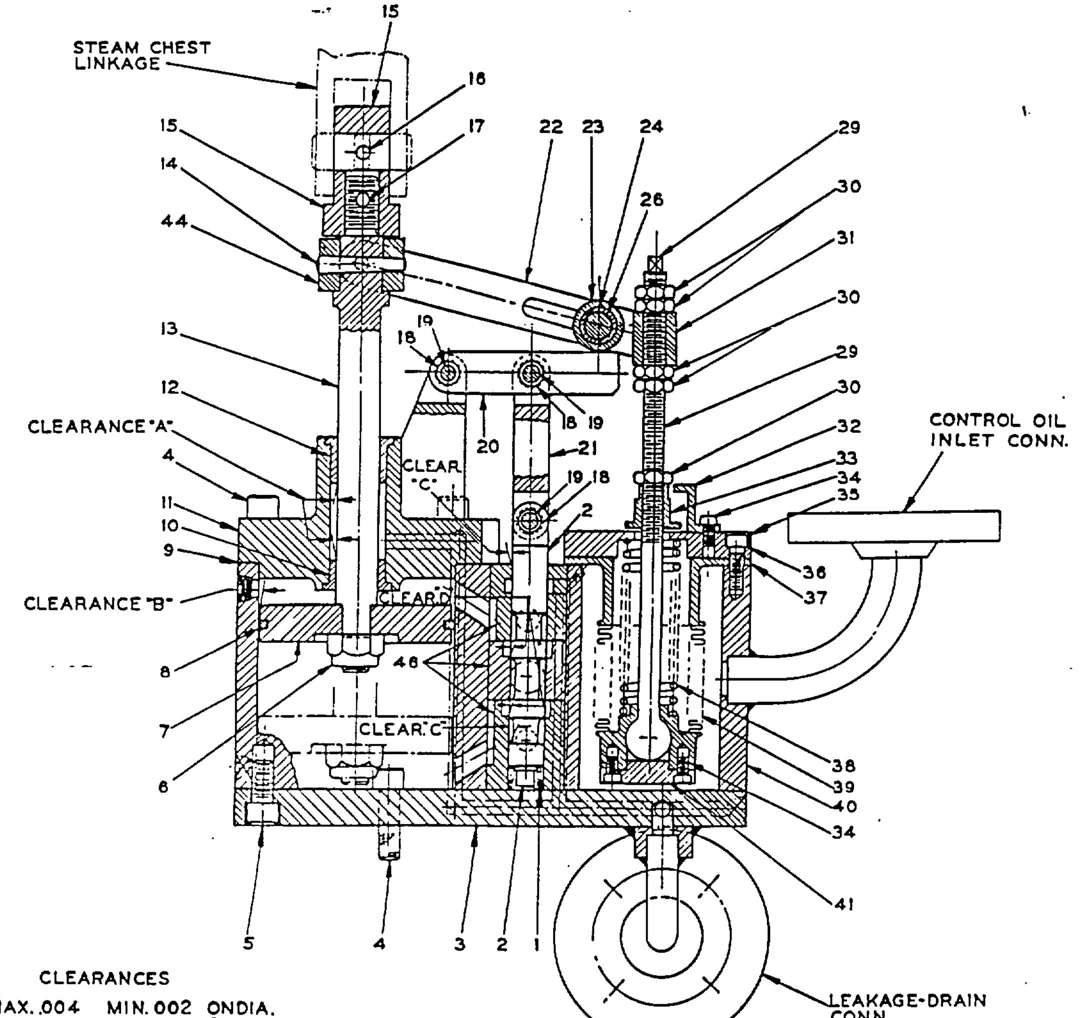
Governor and Speed Changer -- FIG. T-12

FIGURE T-13

GOVERNOR SERVO-MOTOR

Item	Name of Part	Item	Name of Part
1	Spring (Relay)	26	Spacer Bolt
2	Relay	27	Nut
3	Base	28	Spacer
4	Socket Head Screw	29	Stem
5	Socket Head Screw	30	Locknut
6	Elastic Stop Nut, (piston rod)	31	Trunnion
7	Piston	32	Guide Stop
8	Piston Ring	33	Stop Nut
9	Gasket	34	Socket Head Screw
10	Bushing, inner	35	Socket Head Screw
11	Cover, (piston cylinder)	36	Cover, (Bellows Assembly)
12	Bushing, outer	37	Gasket
13	Piston Rod	38	Spring, (Bellows)
14	Taper Pin	39	Bellows Assembly
15	Rod Extension	40	Body
16	Set Screw	41	Flange
17	Taper Pin	42	Bearing
18	Bearing	43	Washer
19	Pin, shouldered	44	Spacer Bolt
20	Link	45	Cotter Pin
21	Link, (relay)	46	Relay Bushing (Assembly of Top, Center and Bottom Bushings)
22	Links, (slotted)		
23	Roller		
24	Bearing		
25	Washer		





CLEARANCES

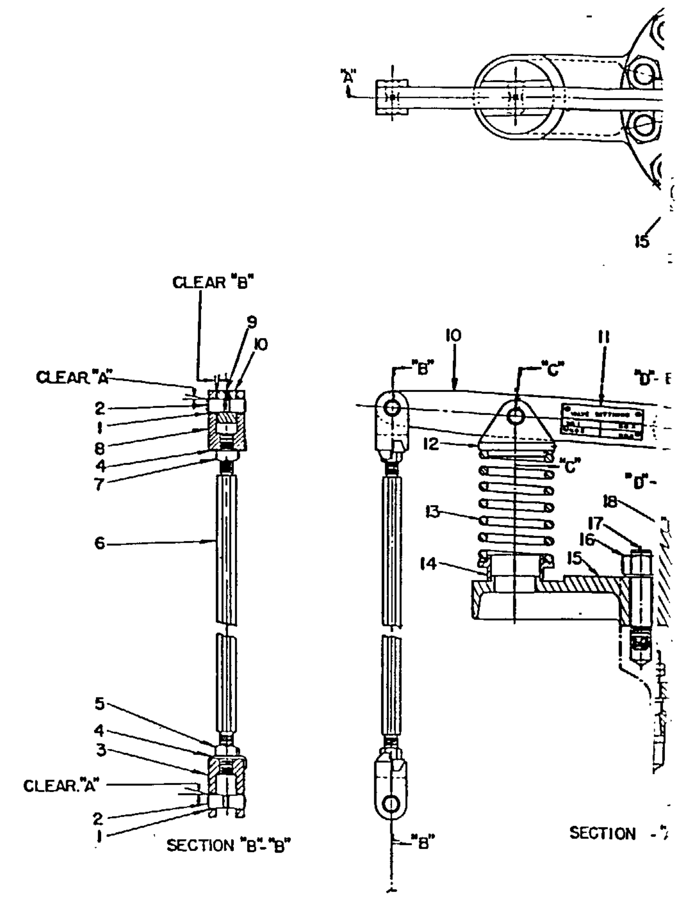
A =	MAX. .004		MIN. .002		ON DIA.
B =	MAX. .033		MIN. .027		ON DIA.
C =	MAX. .0025		MIN. .002		ON DIA.
D =	MAX. .004		MIN. .0035		ON DIA.
E =	MAX. .0035		MIN. .0005		ON DIA.
F =	MAX. .006		MIN. .002		TOTAL
[illegible]	MAX. [illegible]		MIN. [illegible]		TOTAL
[illegible]	MAX. [illegible]		MIN. [illegible]		[illegible]
[illegible]	MAX. [illegible]		MIN. [illegible]		ON DIA.

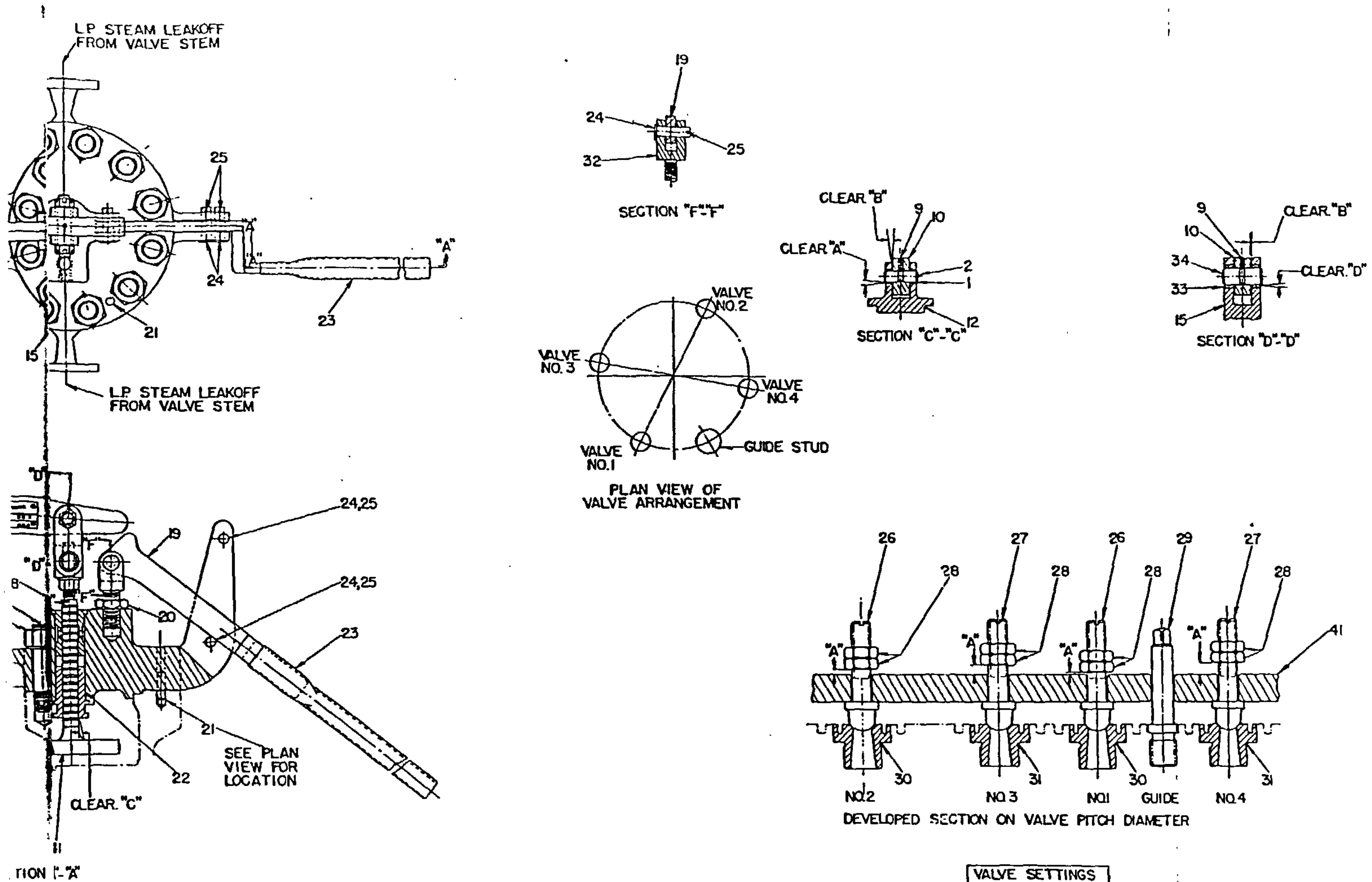
Governor Servo-Hulor -- [illegible]

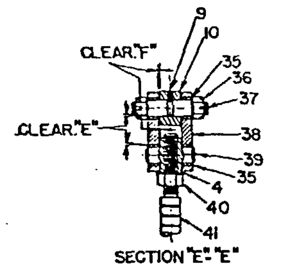
FIGURE T-14

STEAM CHEST

Item	Name of Part
1	Bearing
2	Pin
3	Yoke, lower
4	Lockwasher
5	Nut, left hand threads
6	Rod
7	Nut, right hand threads
8	Yoke, upper
9	Set Screw
10	Lever
11	Valve Setting Plate
12	Spring Cap
13	Spring
14	Spring Seat
15	Steam Chest Cover
16	Nut
17	Stud
18	Bushing, outer
19	Cam Lever
20	Locknut
21	Pin
22	Bushing, inner
23	Handle Extension, for cam lever
24	Pin, shouldered
25	Cotter Pin
26	Steam Chest Valves No. 1 and 2
27	Steam Chest Valves No. 3 and 4
28	Locknut, Steam Chest Valves No. 1,2,3,4
29	Guide Stud
30	Steam Chest Valve Seats No. 1 and 2
31	Steam Chest Valve Seats No. 3 and 4
32	Pivot
33	Bushing
34	Pin
35	Bushing
36	Nut, slotted
37	Pin
38	Link
39	Trunnion
40	Nut
41	Steam and Valve Lifting Plate (integral)







CLEARANCES

A= .003 .004 MAX. .002 MIN. ON DIAMETER
B= .040 MAX. .030 MIN. = TOTAL
C= .005 MAX. .003 MIN. ON DIAMETER
D= .001 .003 MAX. .001 MIN. ON DIAMETER
E= .004 .005 MAX. .003 MIN. ON DIAMETER
F= .050 MAX. .030 MIN. = TOTAL

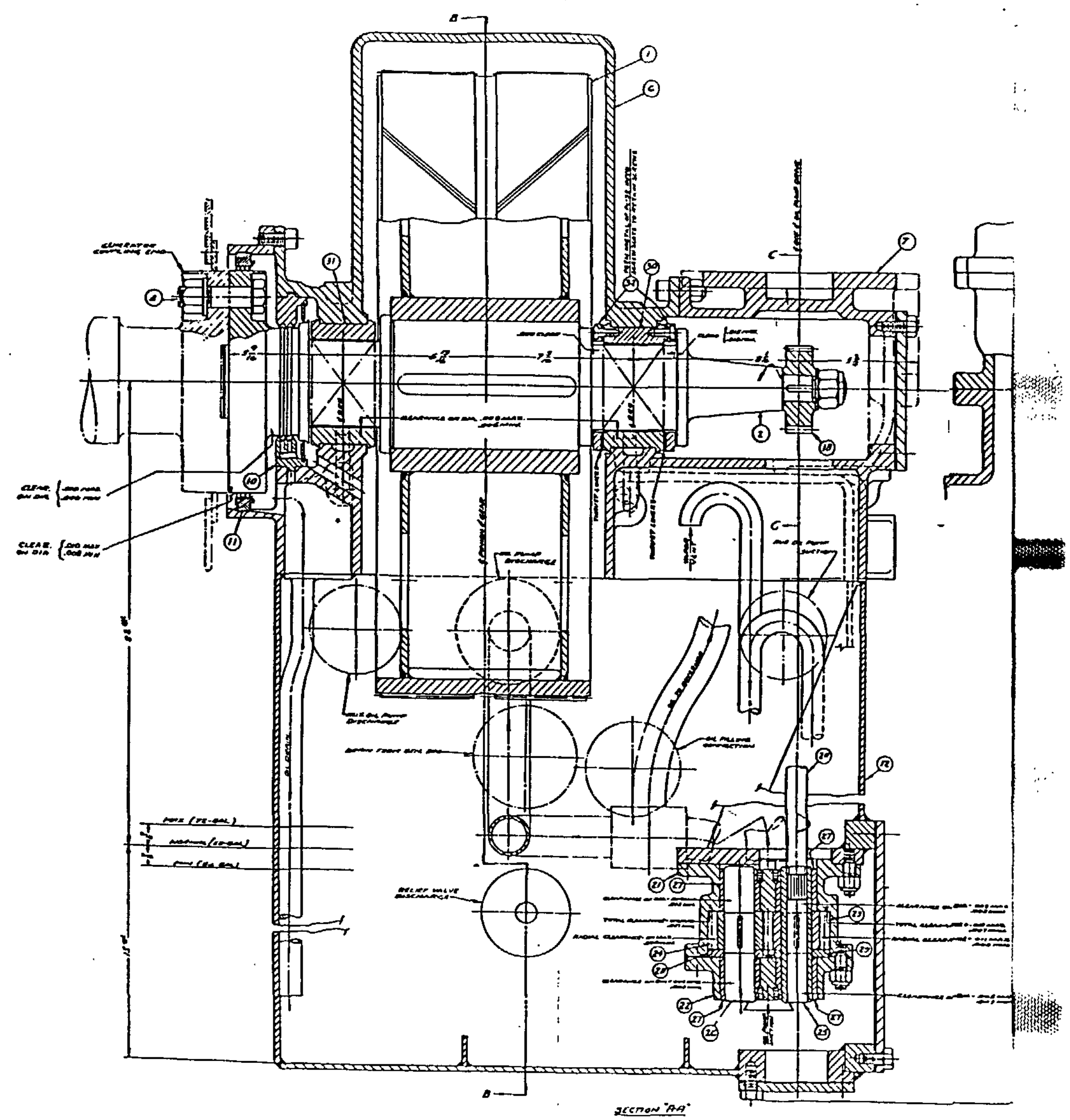
VALVE SETTINGS "A" DIMENSIONS	
VALVE NO.	"A"
1	.040
2	.139
3	.238
4	.299

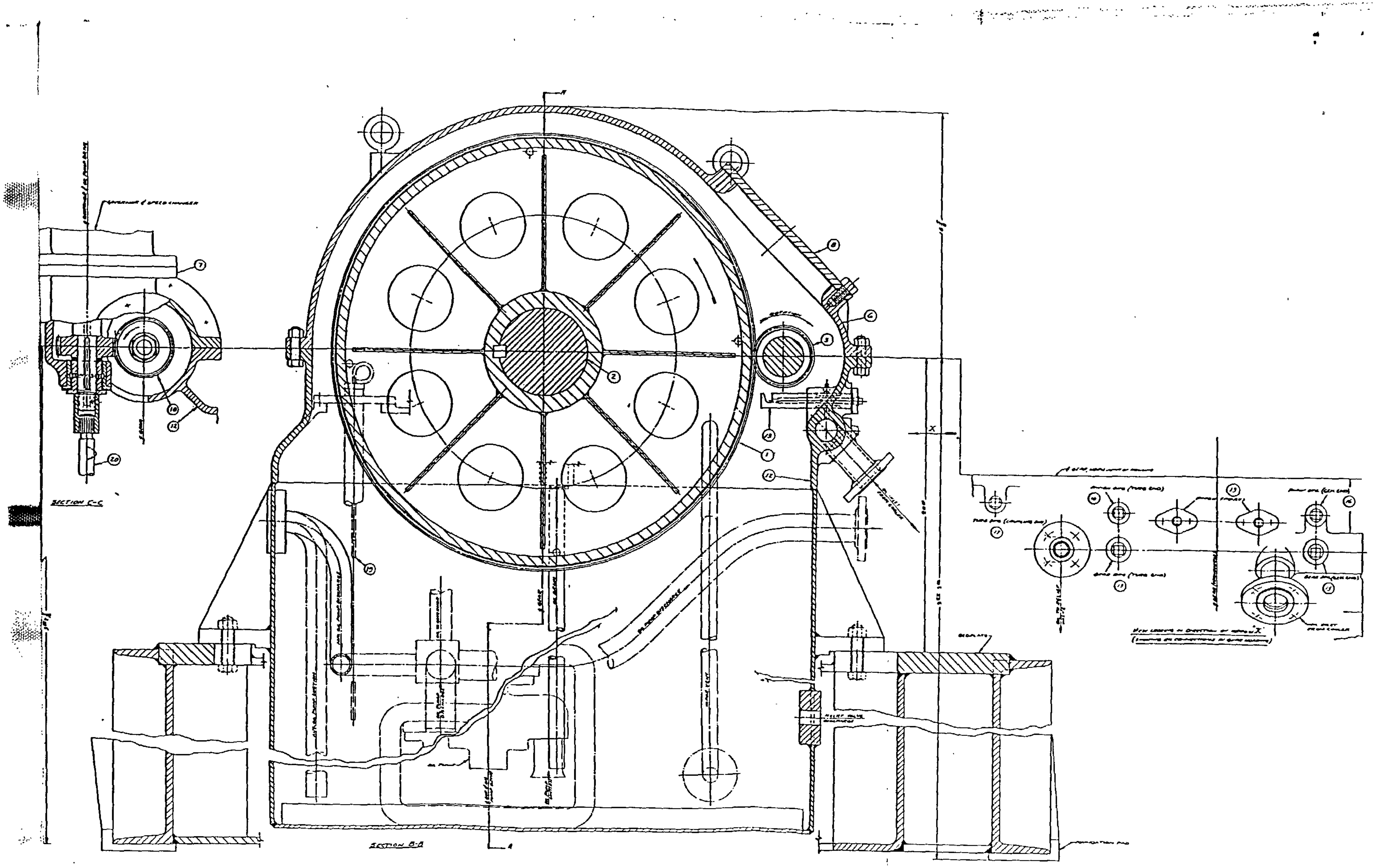
Steam Chest Linkage and Valves -- FIG. T-14

FIGURE T-15

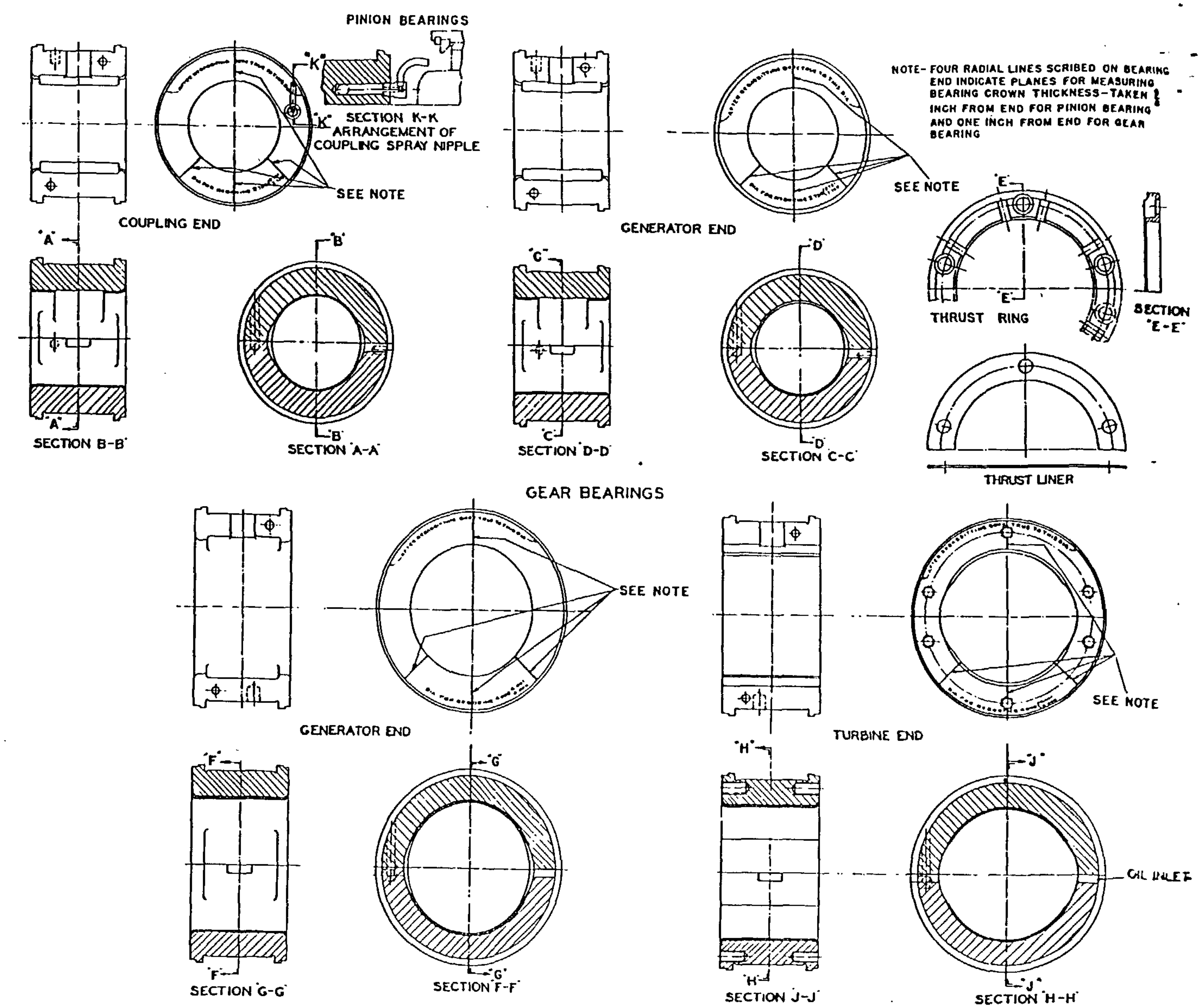
GITUDINAL ASSEMBLY REDUCTION GEAR

Item	Name of Part
1	Gear Wheel
2	Gear Wheel Shaft
3	Pinion
4	Coupling Bolt
6	Gear Housing Cover
7	Oil Pump Drive Cover
8	Inspection Hole Cover
10	Oil Ring (Gear Shaft)
11	Oil Ring (Gear Shaft Coupling)
12	Gear Housing Base
13	Pinion Oil Spray
15	Gear Bearing Orifice
16	Pinion Bearing Orifice
17	Turb. Bearing Orifice
18	Gov. & Pump Drive Gear
19	Oil Level Dipstick
20	Pump Drive Shaft
21	Pump Body
22	Pump Body Cover
23	Pump Gear (Driver)
24	Pump Gear (Driven)
25	Pump Gear Shaft (Driver)
26	Pump Gear Shaft (Driven)
27	Bushing
28	Spacer
29	Spacer
30	Gear Bearing (Thrust End)
31	Gear Bearing
32	Thrust Ring

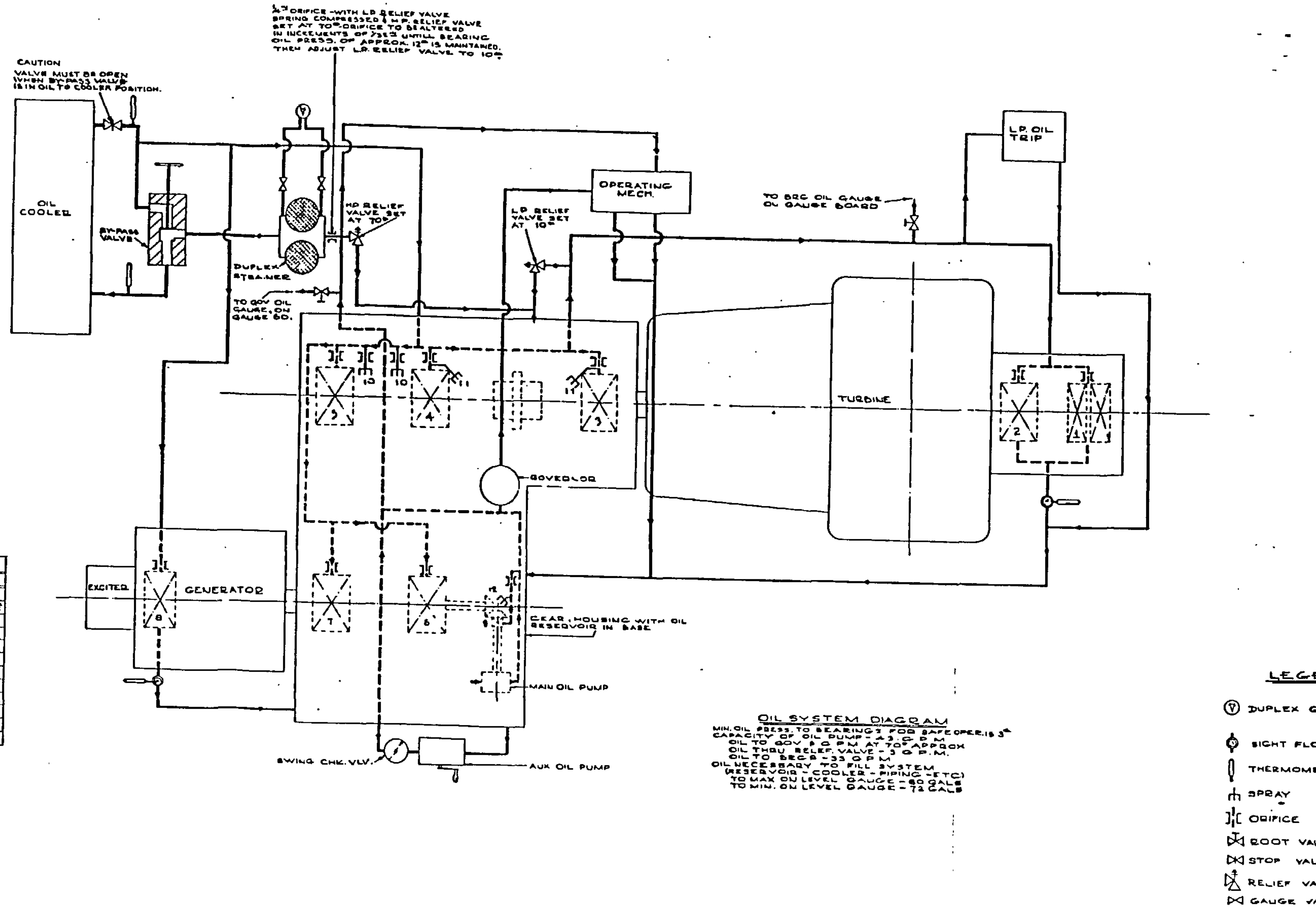




Reduction Gear Longitudinal Assembly -- Fig.



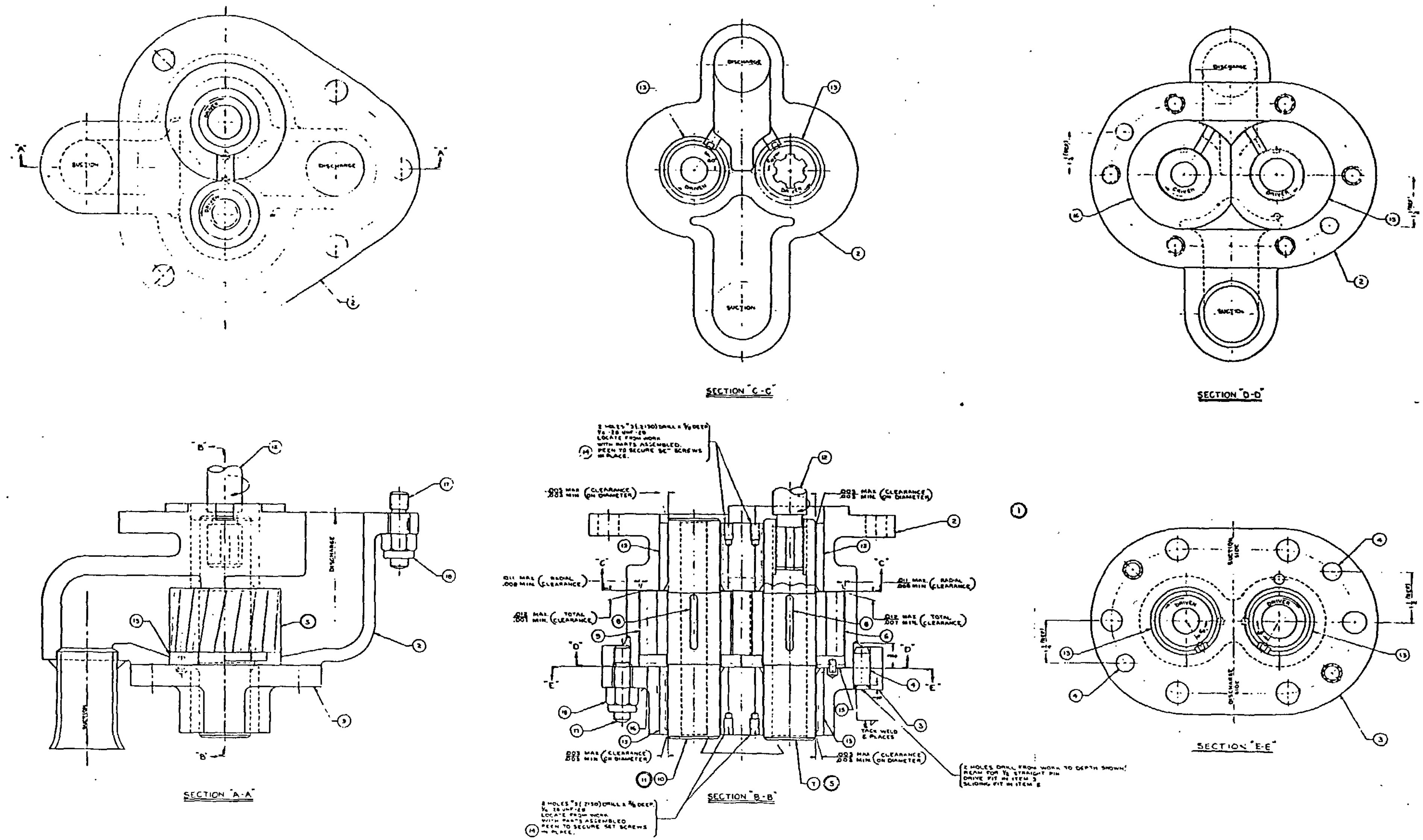
Reduction Gear Bearings -- [illegible]



BEARING AND SPRAY INFORMATION

NO	BEARING AND/OR SPRAY		ORIFICE SIZE
1	THRUST BRG.		1/8 IN
2	TURBINE	(THRUST END)	.031 [illegible]
3	TURBINE	(CPLG. END)	1/4 IN
4	PINION	(CPLG. END)	1/4 IN
5	PINION	(GEN. END)	1/4 IN
6	GEAR	(TURB END)	3/16 IN
7	GEAR	(GEN. END)	3/16 IN
8	GENERATOR BRG.		3/32 IN
9	LUBE OIL PUMP DRIVE SHAFT BRG.		[illegible]
10	GEAR & PINION OIL SPRAYS		1/8 IN
11	COUPLING SPRAYS		[illegible]
12	LUBE OIL PUMP DRIVE SHAFT BEVEL GEAR SPRAYS		[illegible]

Oil System Diagram -- FIG.



Main Oil Pump -- FIG. T-18

NAE-00035222

FIGURE T-18

MAIN OIL PUMPS

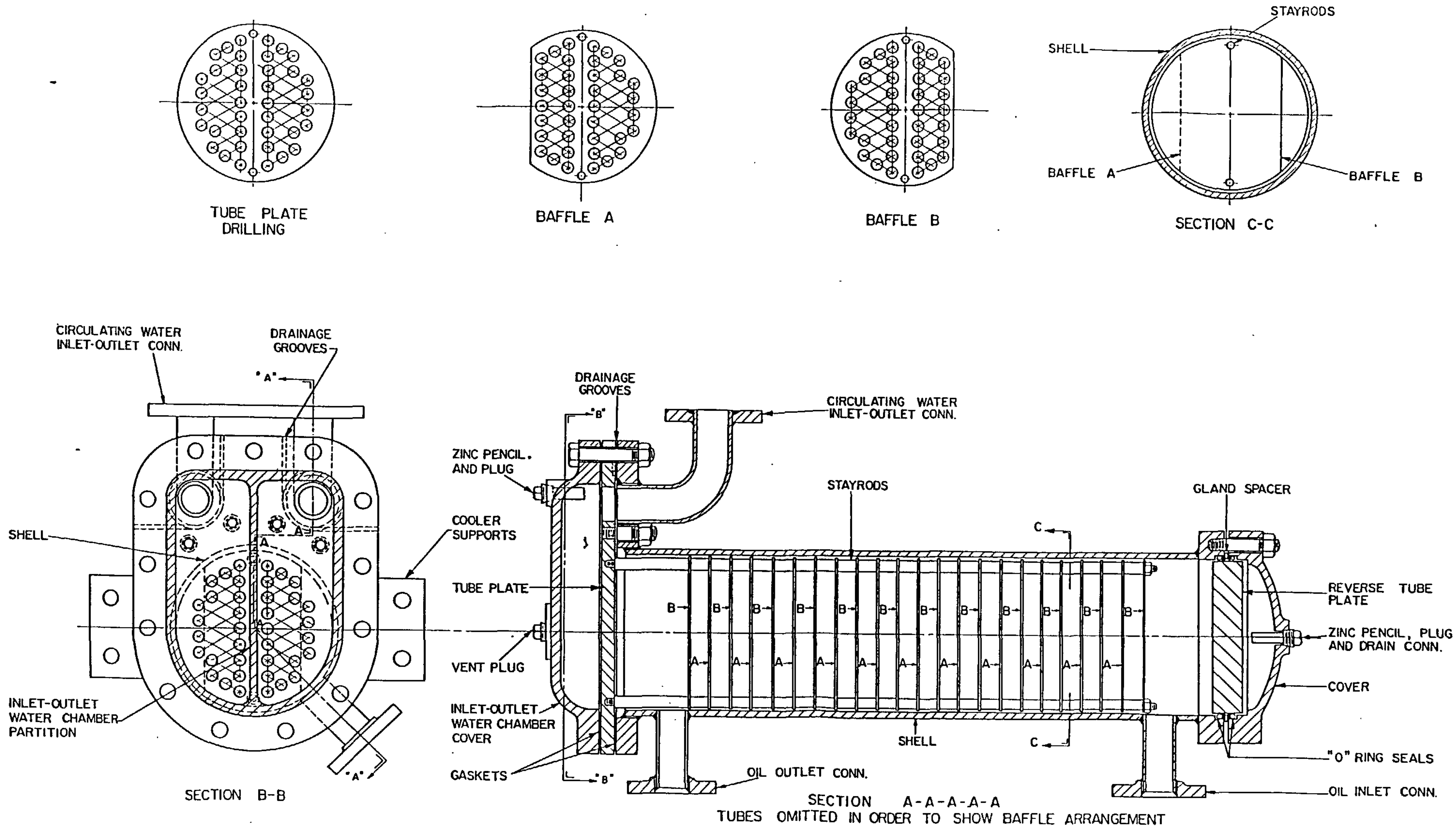
Item	Name of Part
1	Oil Pump Assembly
2	Pump Body Complete
3	Cover
4	Pin
5	Driver Gear and Shaft, Complete
6	Gear, Driver
7	Shaft Driver
8	Key
9	Gear, Driven
10	Shaft, Driven
11	Driven Gear & Shaft, Complete
12	Shaft, Drive
13	Bushing
14	Set Screw
15	Spacer & Pin Complete
16	Spacer
17	Studs
18	Locknuts

FIGURE T-19

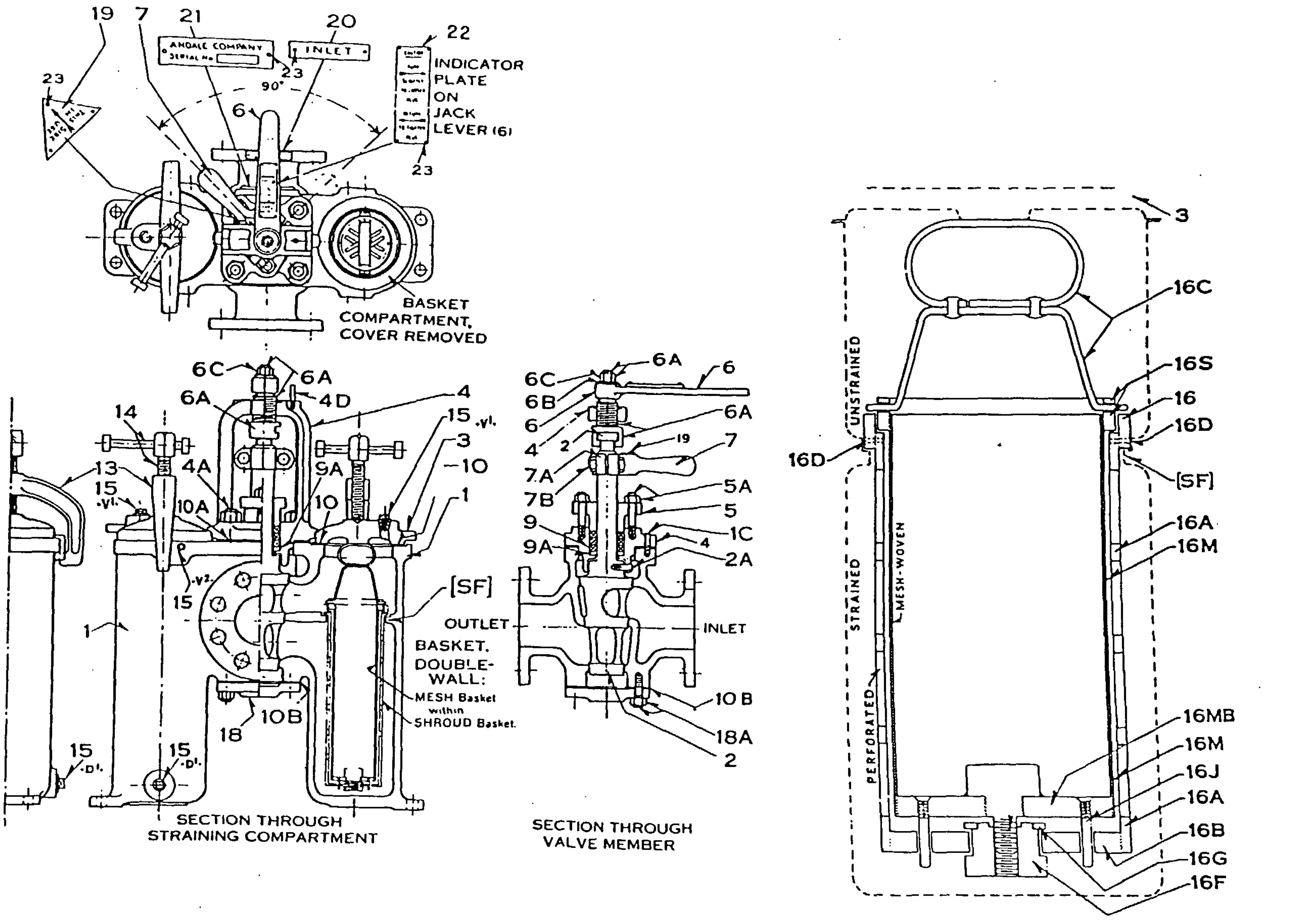
OIL - STRAINER

Item	Name of Part
1	Body
1C	Locating Pin
2	Valve Plug
2A	Stop Pin
3	Straining Compartment Cover
4	Valve Bonnet
4A	Stud and Hex Nut
4D	Stop Pin for Jack Lever
5	Gland
5A	Stud and Hex Nut
6	Jack Lever
6A	Jack Screw
6B	Washer
6C	Hex Nut
7	Plug Turning Lever
7A	Turning Lever Cap
7B	Machine Screw (Hex Head)
9	Packing
9A	Packing Support Ring
10	Gasket
10A	Gasket
10B	Gasket
13	Clamp
14	Set Screw
15 V1	Vent Tap and Plug
15 V2	Vent Tap and Plug
15 D1	Drain Tap and Plug

Item	Name of Part
16	Support Collar
16A	Sidewall (Perforated)
16B	Bottom Plate
16C	Handle Bail and Pressure Spring Bow
16D	Rivets
16F-G	(United) Union Nut
16J	Positioning Pins
16M	Sidewall (Wire Mesh)
16MB	Bottom Plate
16S	Support Collar
18	Bottom Plug Cover
18A	Stud and Hex Nut
19	Indicator Plate
20	Inlet Plate
21	Name Plate
22	Caution Plate
23	Drive Screws
SF	Support Flange

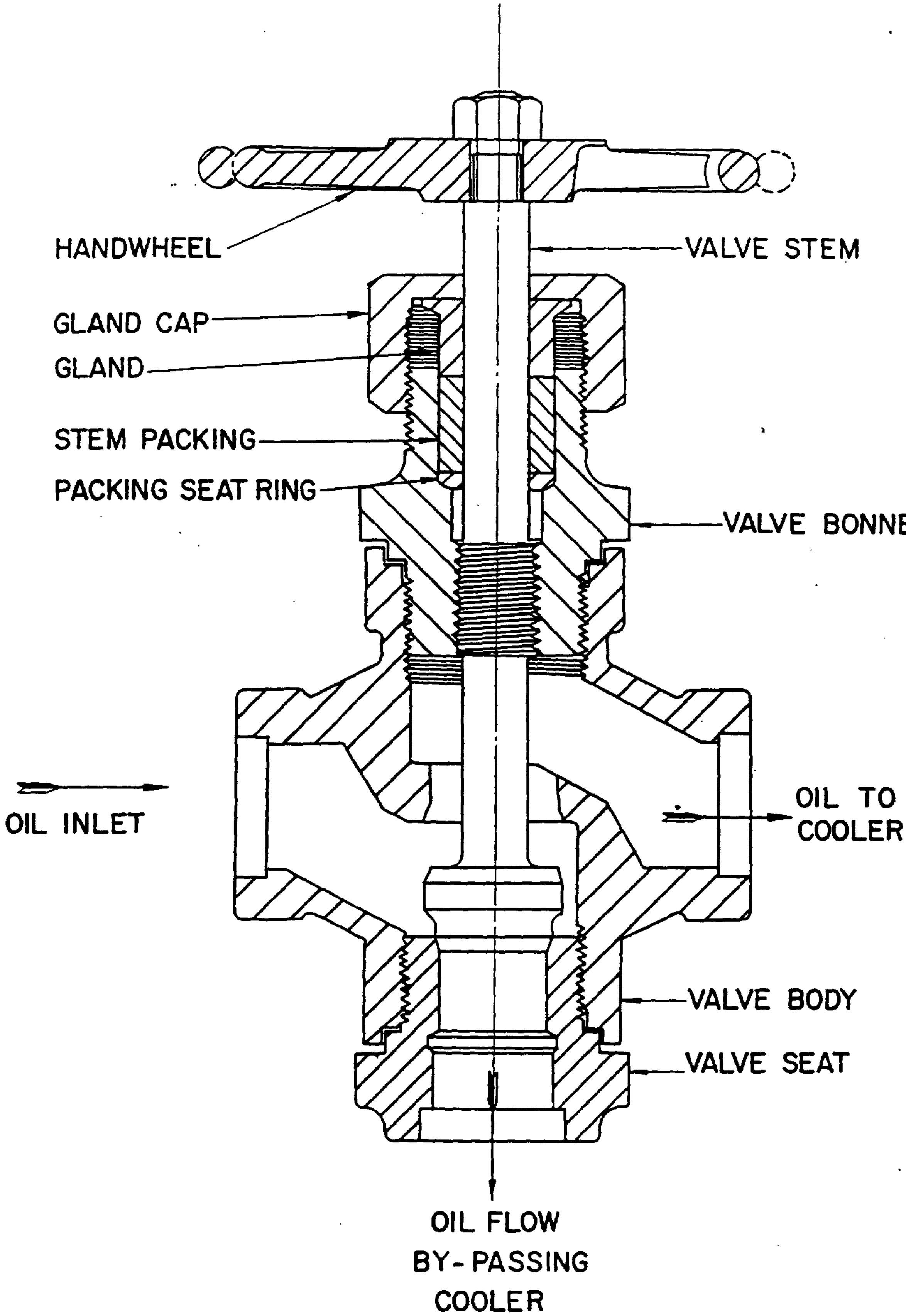


Oil Cooler -- FIG. T-20



Oil Strainer -- FIG. T-19

NWB-00038283

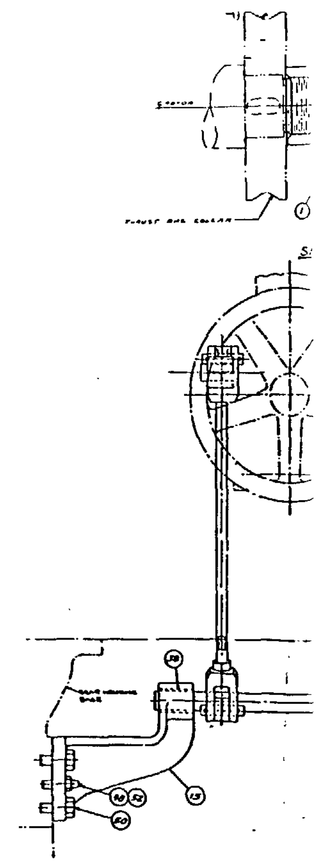


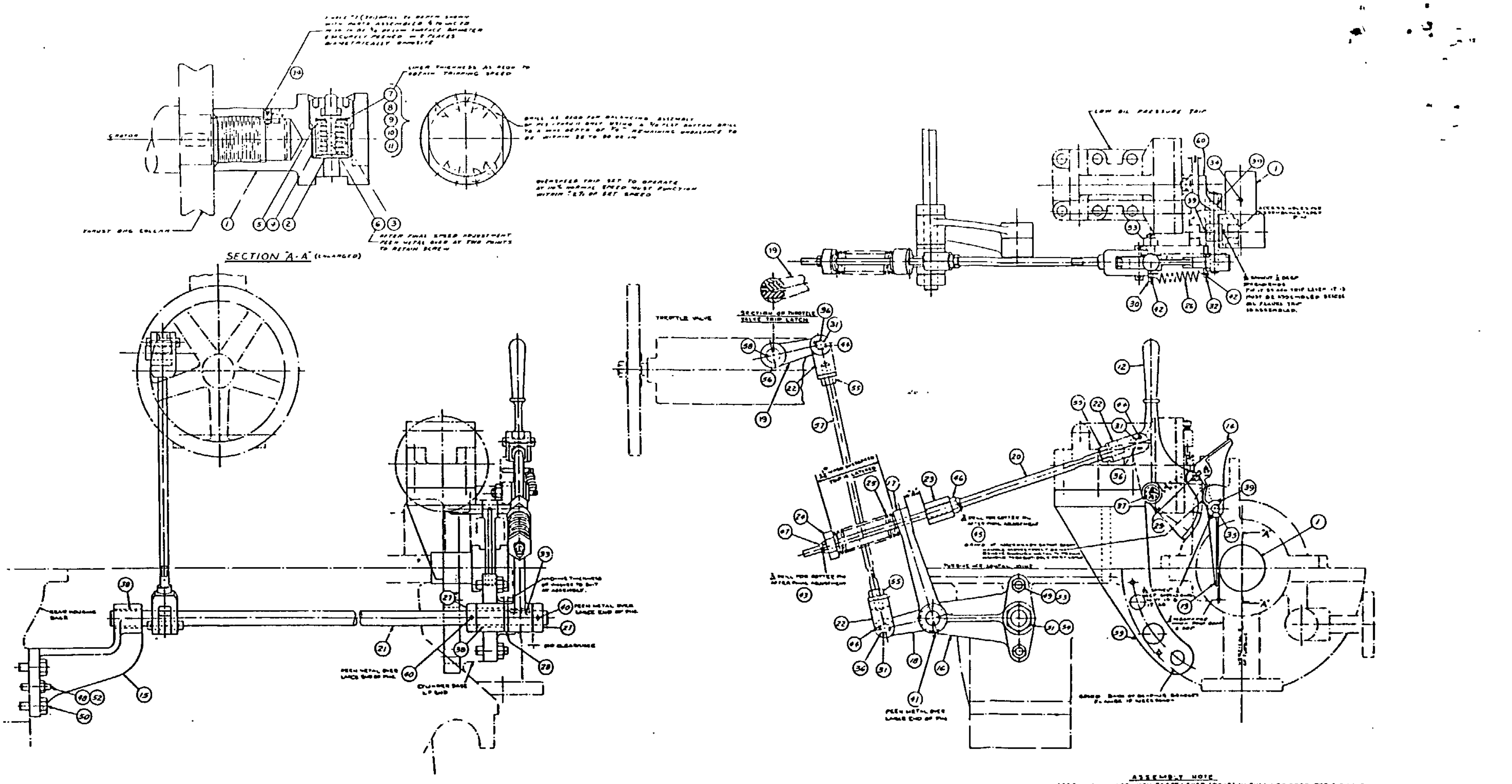
Oil Cooler By-Pass Valve -- FIG. T-21

FIGURE T-22

OVERSPEED TRIP MECHANISM

Item	Name of Part	Item	Name of Part
1	Body - Rotating	31	Clevis Pin
2	Body Weight	32	Latch Pin
3	Spring	33	Key
4	Retainer	34	Set Screw 1/4 x 3/8 Lg. (Half Dog Point)
5	Spring Seat-Fr. 5/16 of 1-1/8 Dia.	35	Trip Lever Shaft
6	Screw-Special (Make Fr. 10-H-75 1/4 x 3/4 Lg. Soc. Hd. Screw)	36	Bushing (See Note 1)
		37	Bushing (See Note 1)
7	Spring Liner	38	Bushing (See Note 1)
8	Spring Liner	39	Taper Pin #2 x 1-1/4 Lg.
9	Spring Liner	40	Taper Pin #4 x 2 In. Lg.
10	Spring Liner	41	Taper Pin #6 x 2 In. Lg.
11	Spring Liner	42	Cotter Pin 3/32 x 1/2 Lg.
12	Reset Handle	43	Cotter Pin 3/32 x 3/4 Lg.
13	Trip Lever	44	Cotter Pin 1/8 x 3/4 Lg.
14	Latch	45	Cotter Pin 1/8 x 1 In. Lg.
15	Bearing Bracket	46	Nut - Castle 1/2-20
16	Bearing Bracket	47	Nut - Castle 3/8-24
17	Lever	48	Taper Dowel 3/8
18	Lever	49	Taper Dowel 1/2
19	Lever	50	Bolt 1/2 x 1-1/4 Lg.
20	Trip Rod	51	Stud 1 In. x 4-1/2 Lg.
21	Rock Shaft	52	Hex. Nut 3/8
22	Clevis	53	Hex. Nut 1/2
23	Hammer Nut	54	Elastic Stop Nut - 1 In.
24	Spring Seat	55	Hex. Nut 1/2
25	Spring	56	Set Screw 5/16 x 5/16 Lg. (Cup Point)
26	Spring	57	Connecting Rod
27	Collar	58	Key 3/16 x 3/16 x 1-1/2 Lg. Fig. 2
28	Spacing Washer	59	Bracket (Low Oil Pressure Trip)
29	Latch Tip	60	Lever (Low Oil Pressure Trip)
30	Fulcrum Pin		





ASSEMBLY NOTE

ASSEMBLE LINKAGE WITH RESET LEVER (PC 12) IN FULLY TRIPPED POSITION AND SPRING (PC 25) PARTIALLY COMPRESSED. ADJUST TRIP ROD (PC 20) AND HAMMER NUT (PC 23) SO THAT "A" = 0 AND FACE OF NUT (PC 23) IS PARALLEL TO STRIKING FACE OF LEVER (PC 17). POSITION LEVER (PC 18) SO THAT CENTER OF HOLE IN PIN END IS APPROX. 1/8 BELOW CENTER OF ROCK SHAFT (PC 21) AND PIN TO SHAFT WITH TAPER PIN (PC. 41) WITH THROTTLE VALVE TRIPPED POSITION LEVER (PC. 19) HORIZONTALLY AND KEY TO THROTTLE VALVE LATCH SHAFT. ADJUST LENGTH OF CONNECTING ROD (PC. 57) TO CONNECT LEVERS (PCS. 18 & 19) IN THIS POSITION. LATCH TRIP MECHANISM AND ADJUST SPRING (PC. 25) TO LENGTH SHOWN. CHECK DIMENSION "A" WHICH SHOULD MEASURE APPROX. 3/4 TO 7/8. WITH THROTTLE VALVE OPEN, TRIP MECHANISM WITH MANUAL TRIP. THROTTLE VALVE MUST TRIP SHUT. CHECK THAT THROTTLE VALVE CANNOT BE REOPENED WITH MECHANISM IN TRIPPED POSITION. ADJUST "A" BY ADJUSTING NUT (PC. 23) TO MAXIMUM VALUE AT WHICH THROTTLE VALVE TRIPS FREELY AND CANNOT BE REOPENED WITH MECHANISM IN TRIPPED POSITION. FINAL SETTING MUST BE SUCH THAT IT IS IMPOSSIBLE TO OPEN THROTTLE VALVE AFTER IT HAS TRIPPED SHUT WITHOUT FIRST RESETTING TRIP MECHANISM.

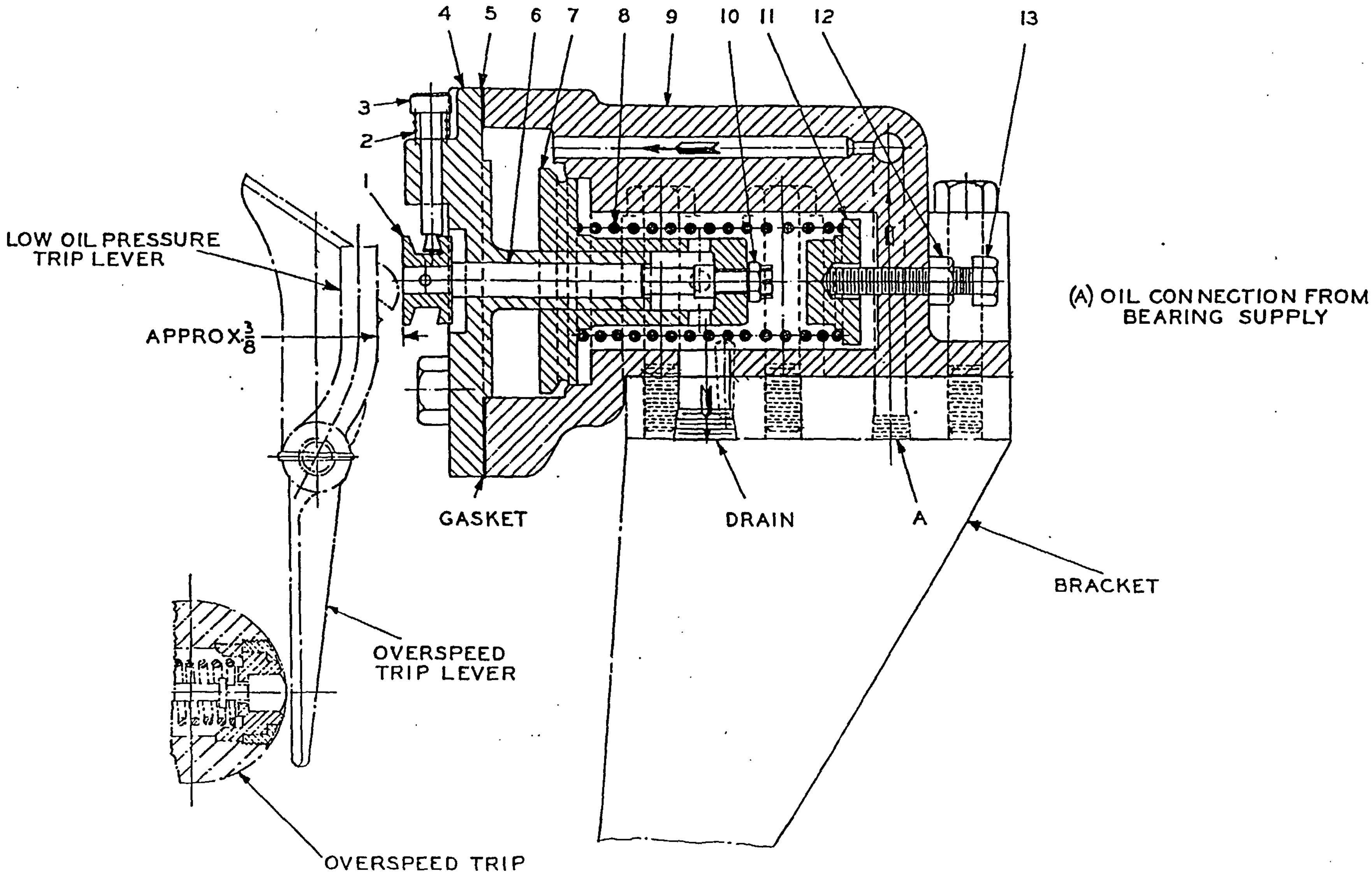
Overspeed Trip -- FIG. T-22

HW3-00038286

FIGURE T-23

LOW-OIL-PRESSURE TRIP

Item	Name of Part
1	Trip Latch
2	Trip Latch Pin Spring
3	Trip Latch Pin
4	Trip Latch Bracket and Cover
5	Gasket
6	Trip Rod
7	Trip Piston
8	Trip Spring
9	Trip Cylinder
10	Trip Rod Nut
11	Trip Spring Seat
12	Trip Spring Adjusting Bolt Locknut
13	Trip Spring Adjusting Bolt



Low Oil Pressure Trip -- FIG. T-23

CLEARANCES

A = .008	.009 MAX .007 MIN	ON DIAMETER
B = .005	.007 MAX .005 MIN	ON DIAMETER
C = .005	.007 MAX .005 MIN	ON DIAMETER
D = .008	.010 MAX .006 MIN	ON DIAMETER
E = .009	.012 MAX .008 MIN	TOTAL
F = .007	.009 MAX .007 MIN	ON DIAMETER

NOTE

AT DYNAMIC BALANCE OF SPINDLE AND PINION THE HUB AND SLEEVE OF THE FLEXIBLE COUPLING ARE MATCH MARKED. ON THE HUB THIS MARK IS ON THE FACE, OVER THE KEYWAY AND EXTENDS OVER THE OUTER PERIPHERY. THE MARK ON THE SLEEVE IS ON THE PERIPHERY ONLY.
AT THE ASSEMBLY THE MARKS ON THE SLEEVE AND HUB OF THE SPINDLE HALF ARE MATCHED, AND THOSE OF THE PINION SIMILARLY MATCHED. HOWEVER, WHEN THE TWO COUPLING HALVES ARE JOINED THE SUPPLIERS MARKS ON THE SLEEVES SHOULD BE MATCHED.

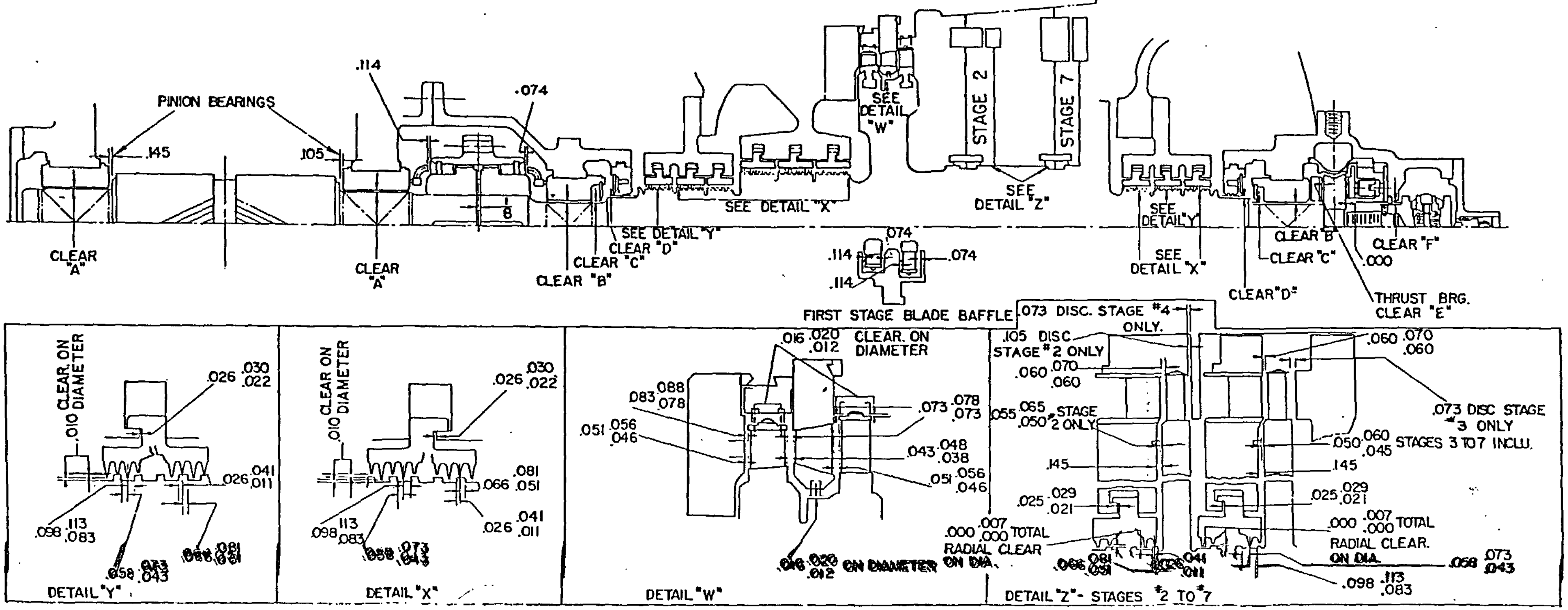
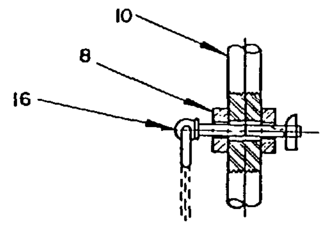


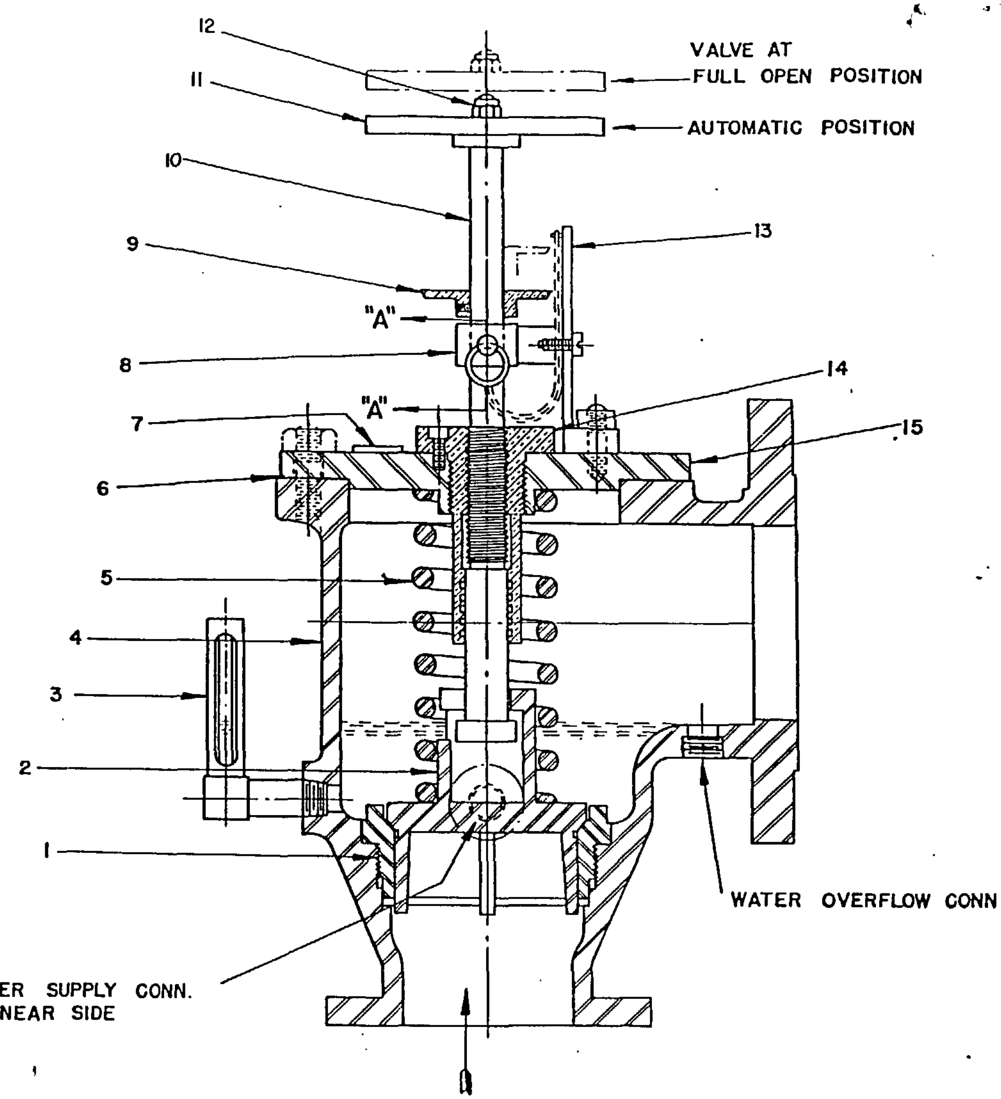
FIGURE T-25

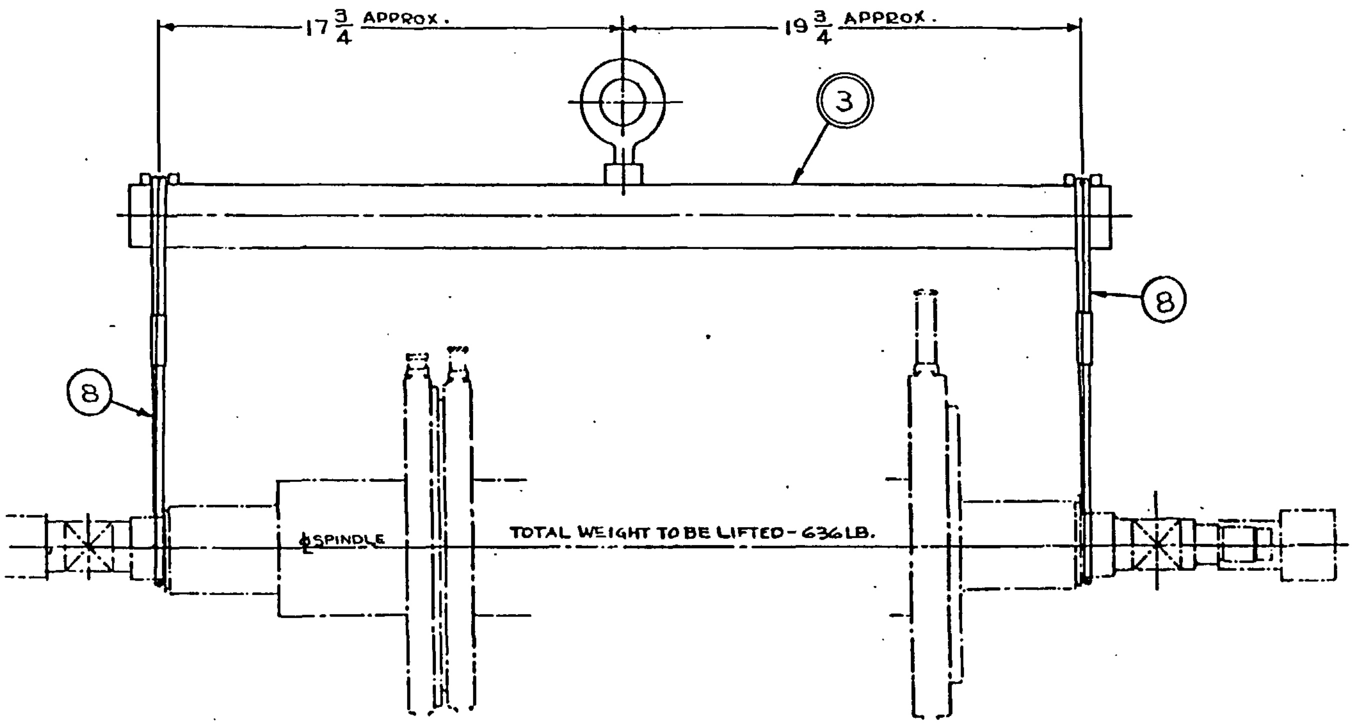
ATMOSPHERE RELIEF VALVE

Item	Name
1	Seat Ring
2	Disc
3	Sight Gage
4	Body
5	Spring
6	Gasket
7	Name and Specification Plate
8	Stem Lock
9	Indicator
10	Valve Stem
11	Handwheel
12	Nut
13	Indicator Plate
14	Stem Bushing
15	Cover
16	Locking Pin

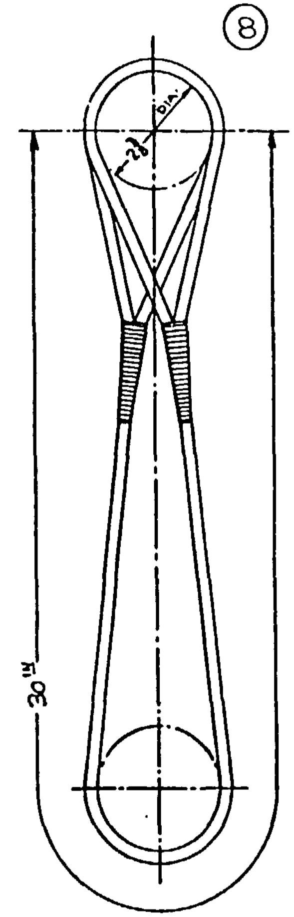


SECTION "A"-"A"





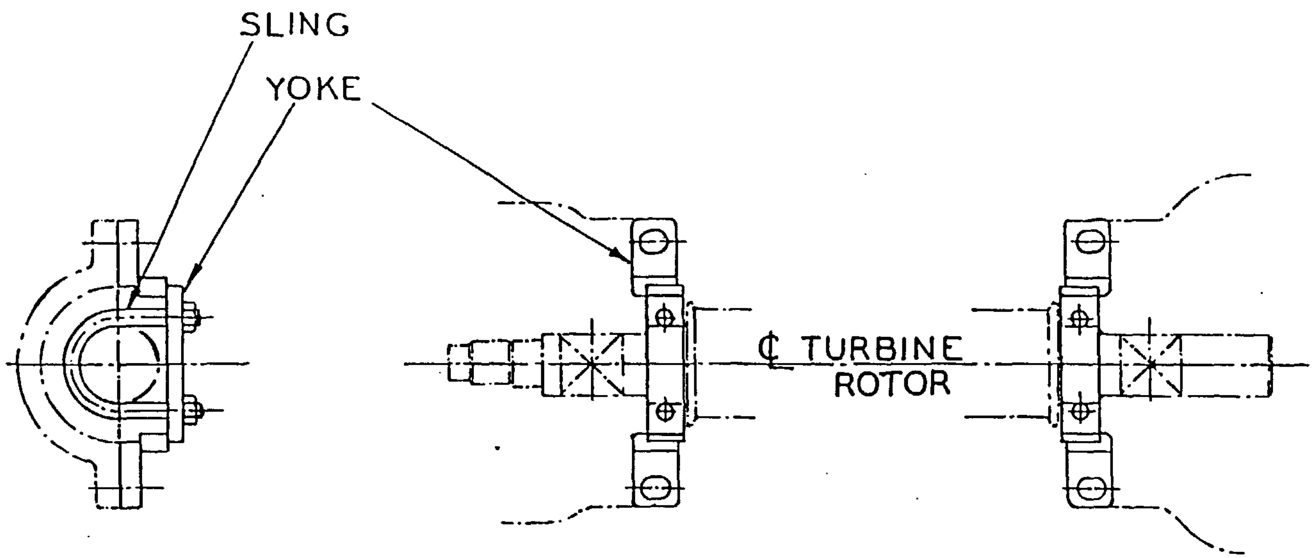
ASSEMBLY OF LIFTING GEAR
ELEVATION VIEW OF LIFTING GEAR
1



1/4 DIA. 6x37 PLOW STEEL WIRE ROPE.

Rotor Lifting Gear -- FIG. T-26

HWB-00038290



ROTOR JACKING DEVICE (FOR REMOVING BEARINGS)

Rotor Lifting Device for Removing Bearings -- FIG. T-27

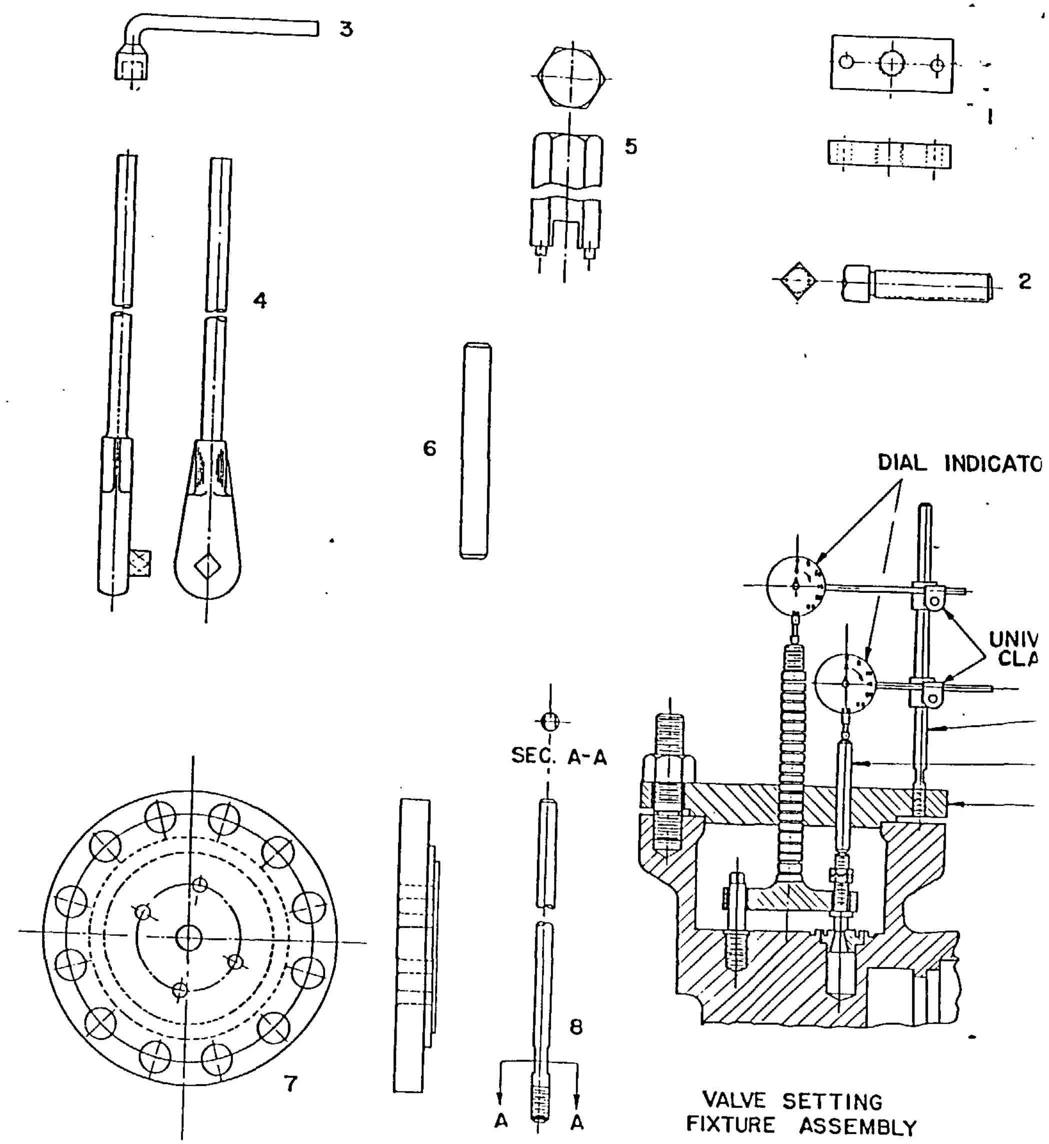
NVB-00038291

FIGURE T-28

TOOLS AND WRENCHES

Item	Name of Part
1	Coupling Hub Puller
2	Jack Screw
3	Generator Coupling Wrench
4	Rotor Turning Wrench
5	Auto Stop Governor Wrench
6	Extension Rod
7	Valve Setting Fixture
8	Indicator Post
9	Tube Expander
10	Tube Flaring Tool
11	Tube Reamer
12	Tube Pusher

Note - Items 9, 10, 11 & 12 (not shown) are used for making repairs to the Oil Cooler Tube Bundle.



(SHIP'S SERVICE A-C GENERATOR ONLY)

IN RE: ABRAMS November 1992

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Illustrations Index
(Ship's Service A-C Generator Only)

CHAPTER 2 - 600 KW, 450 VOLT SHIP'S SERVICE A-C GENERATOR

Section 2.1 Description of Generator

GENERAL INFORMATION

Purpose

1. These instructions are intended to describe the construction and to guide in the installation, operation and maintenance of the ship's service generators.

Machine Identification and Data

RATING

1. These generators are rated 600 KW (750 KVA), 80% power factor; 450 volts, 961 amperes, 3 phase, 60 cycles, 1200 Rpm; Excitation 120 volts, 50.5 amperes d-c; temperature rise per Table I.

Table I

Item	Temperature Rise Degrees Centigrade Thermometer	Resistance
Armature Windings	40	50
Insulated Field Windings	40	50
Collector Rings	55	-
Bearings	35	-
Cores & Mechanical Parts in contact with Insulation	40	-

NAMEPLATE DATA

600 KW (750 KVA)	3 Phase
450 Volts	60 Cycles
961 Amperes	1200 Rpm
80% Power Factor	120 Exciting Volts
	50.5 Exciting Amperes

Stator Serial - 1S - 2S - 58P316
Rotor Serial - 1R - 2R - 58P316

1. It is recommended that the nameplate readings of the new equipment be reviewed and office copies of these readings be made available. This information will be found useful in subsequent correspondence on the equipment.

2. Always refer to the serial number stamped on the nameplate of the machine when corresponding with the manufacturer for this is the number which identifies the machine.

Generator Classification

(a) Reference Ambient Temperature . . . 50°C
(b) Table and Method of Measuring Temperature Rise: . . . . . . Table I
(c) Class of Insulation . . . . . . Class
(d) Degree of Enclosure . . Totally Enclosed
(e) Method of Cooling . . . . . Water Cooler
(f) Manufacturer's Type Designation . . . . . Special 6-39-16
(g) Means of Excitation . . 120 volt, 1200 Rpm, direct current exciter directly connected to generator
(h) Prime Mover . . Steam Turbine South Philadelphia (W)

DESCRIPTION OF APPARATUS

Illustrations

1. Reference to the outline drawing, Fig. G-6, will be found useful in supplementing the following description.

General Arrangement

1. The a-c generator is coupled to the speed reducing gear by a forged flange coupling. The shaft is supported between the generator and exciter by a split sleeve bearing mounted on the bracket of the generator and at the coupling end by the speed reducing gear coupling. The stator frame is mounted on the sub base. The rotor of the exciter is over-

hung on the shaft and the exciter frame is connected to the generator bracket. The exciter has its own shaft which has a pilot fit and threads into the a-c generator shaft.

Frame and End Covers

1. The frame is formed of welded, hot-rolled steel members. Removable covers on the upper side of the stator frame furnisb access to lifting lugs on the inside of the frame and heavy steel feet are welded to the lower portion of the frame. These feet are machined parallel to the shaft and are drilled for foundation bolts, dowels, and jackscrews.

2. The stator core laminations are stamped from special silicon steel. They are stacked on transverse bolts and are clamped by steel end rings bolted together. Ventilating spaces are provided by fingerplate spacers permitting air to circulate through the core. Terminals of the armature are brought out at the bottom of the frame to a conduit box mounted on the bottom of the frame.

3. Air shields and end cover, which are bolted to the frame, enclose and direct the ventilating air, and protect the armature winding. The front cover is split on the horizontal center line. The upper half has a removable window giving access to the brushes. The rear end cover is split along the horizontal centerline. A removable cover is provided around the coupling flange to give access to coupling bolts.

Air Cooler

1. The air cooler for the a-c generator is located at the top of the generator frame. It is a double tube type of cooler furnished by the Harrison Radiator Division of the General Motors Corporation.

2. The purpose of the double-tube construction is to enable leaks in the water tubes to be detected before serious failure of a tube occurs. Each double tube consists of a water carrying tube surrounded by a close-fitting outer tube. Axial grooves in the inside surface of the outer tube extend the full length of the cooler tubes.

3. The grooves in the outer tubes open into a "tell-tale" chamber at each end of the cooler. When a leak occurs in the main water carrying tube, the leakage runs into the grooves in the outer tubes and into the aforementioned "tell-tale" chamber. Tube leakage can be detected only if the lower 1/8" pipe plug is opened permanently to permit the leakage from the "tell-tale" chamber to be observed. The upper 1/8" pipe plug should also be permanently removed to vent the "tell-tale" chamber. Treat the upper and lower 1/4" pipe plugs as conventional tube sheet header chamber vents and drains. Flanged connections are provided on the inlet and outlet for connection to the sea water lines. Either connection may be used as the inlet. Care must be used to install the piping in such a way that the cooler will be full of water at all times during operation. The cooler will not operate properly if all tubes do not contain flowing water.

4. 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 inch screen openings. Strainers or filters are essential if liquids circulated through the cooler contain foreign matter larger than specified.

5. This cooler requires 35 gallon per minute of water at 85°F. This water will cool the air circulated in the cooler to 50°F.

Bearing (Fig. 6-6)

1. The shaft is supported by a bracket-type split sleeve bearing at the collector end. Lubrication is provided by the forced-feed system of the prime mover. A fixed orifice at the bearing inlet supplied by the prime mover limits the oil flow through the bearing to 1/2 gallon per minute.

2. In addition to oil throwers machined on the shaft, front and rear oil seals are provided to prevent leakage of oil from the bearing. The seals consist of 4 semi-circular washers of aluminum which are bolted to the bracket and bearing cap. The small clearance between the shaft and the inner periphery of

the seals prevents leakage of oil along the shaft away from the bearing.

Stator Core

1. The core of the machine is built up of circular segmental laminations of silicon steel stacked on nine transverse studs. Each circular lamination consists of four and one half segments. Ventilating spaces are formed between the frame rings and the ends of the core by finger-plate spacers, and between the packages of punchings by vent-plate spacers at seven positions along the length of the core. This arrangement furnishes a means for dissipating heat from the core by permitting cooling air to enter the inner portion of the core. The laminations are insulated from one another with a surface coating of sodium silicate (water glass). Finger-plates at each end of the core prevent loosening of the teeth. The stator punchings have 72 slots each having a finished size, after stacking, of 0.555 inch wide by 2.585 inches deep.

Terminals

1. The a-c generator stator leads are brought out at the bottom of the frame. The rotor leads are brought out the bottom of the a-c generator frame to a bottom-mounted conduit box.

Armature (Stator) Winding

Tabulation of Winding

Coil Grouping:	4 Coils per group repeated 18 times - 1 Group per pole per phase - 3 Groups per pole - 18 Groups total - 72 Coils
Throw of Coils:	Slots 1 to 12 - 6 Poles - 3 Phase - 6 Parallels - Delta

1. The stationary armature has a bore of 27.5 inches and has 72 slots, each of which has a finished size of 0.555 inches wide by 2.585 inches deep. The armature coil is of the diamond-type and consists of 6 conductors, each of which is two strands wide by two strands deep of double cotton covered copper wire. The strands are .072 inch thick; the width of the strands is .204 inch.

2. Micarta wedges are used to hold the coils in place in the slots. The coils are roped to an insulated steel ring on each end of the winding to prevent distortion in case of short-circuit.

Shaft and Spider

1. The shaft for the a-c generator is machined from a steel forging and is provided with an integral flange on the rear end for coupling to the speed reducing gear. The exciter shaft is threaded to the main shaft at the front end of the machine. The spider which carries the field poles is built up of steel laminations riveted together, the assembly being pressed on and keyed to the shaft. The spider laminations are punched with a dovetail slot for mounting the field poles.

Field (Rotor) Poles

1. The six poles are constructed of laminated steel punchings which are securely bound together by through rivets. Each field pole is fastened to the spider by a dovetail, which is held in place by four tapered keys.

2. Seven 1/2" diameter copper damper bars extend axially just beneath the face of each pole. These bars are brazed at each end of the pole to an end ring. These end rings are all connected between poles.

Blowers and Lower Coil Supports

1. Six, scoop type, unidirectional blowers are mounted on each end of the rotor assembly. These blowers are suitable only for clockwise rotation facing the collector end. Sheet steel, slotted coil supports are mounted under each pole on both ends of the rotor assembly to ensure a tightly fitting field coil.

Field (Rotor) Winding

1. Each field coil consists of one section composed of 177 turns of .162 x .182 inch double cotton covered copper, wound on a mould.

The dimensions of the mould are 5-3/4 inches in width by 17-1/2 inches in length with a radius of 5/8 inch at the corners. As the coil is wound, each layer is brushed with synthetic resin and the coil is pressed in both the turn and layer directions. The inside of the coil is blocked, and clamps are applied during the pressing operations.

2. After the coil is removed from the mould, the coil is insulated from the pole with U-shaped pieces of reinforced mica placed inside the coil and turned out over the top and bottom edges of the coil. The coil is assembled on the pole with Micarta washers; after assembly it is treated three times in moisture and oil-resisting varnish.

3. Each coil is secured in its position on the pole by the upper coil support, wedge washers and the lower coil support. The upper coil support is made from aluminum laminations and is riveted to the pole. The wedge washer is made of fishpaper and is under the Micarta bottom washer. The lower coil support is made of steel and two slotted bolt holes allow it to be pressed tightly against the bottom washer. A Micarta coil brace is held to the spider with 2 insulated bolts between every pole and its neighbor.

Collector

1. The collector assembly is shrunk on the shaft between the rotor assembly and the front journal. It consists of two bronze collector rings shrunk onto a length of steel bushing around which a sleeve of mica has been built up with the entire bushing used as a mandrel. Two brass studs, one threaded into each ring, pass through Micarta insulating tubes connecting the rings to their respective field leads.

Brush Rigging and Brushes

1. The two brushholders are supported on an insulated steel stud mounted on the bracket cap. Each brushholder contains two brushes 1-1/4 inch thick by 3/4 inch wide by 2 inches long. Each generator requires four brushes. For replacement brushes, order by Westinghouse Style No. 1295005.

Mechanical Rotation

1. The blowers on the generator are suitable for clockwise rotation facing collector end.

Phase Rotation

1. When the mechanical rotation of the generator is clockwise as viewed from the collector end, the emf's inducted in the phases will reach positive maximum values in the following order:

$$T_1 - T_2 - T_3$$

Space Heaters

1. Four 250 watt, 115 volt (Style #1215854) space heaters are located in the bottom of the machine frame. These heaters are connected in parallel for 115 volt, single phase operation. The total power requirement is 1000 watts. The leads are brought out to a conduit box located on the bottom of the generator.

Stator Temperature Detectors

1. The temperature detectors consist of ten ohm resistance coils embedded between the upper and lower coil sides in the stator slots. The seven detectors are equally spaced around the circumference of the generator. The leads are brought out to a conduit box located on the bottom of the generator.

Spare Parts

1. The spare parts furnished for the a-c generator are given on the "List of Spare Parts and Tools" which is Fig. G-7 of this Instruction Manual.

Ordering Renewal Parts

1, When ordering renewal parts, give the name of the part, the drawing and item numbers which apply, and the nameplate reading of the machine, including the serial number. The stator serial number will be found stamped on the nameplate, under the nameplate and on the machine foot. The rotor serial is stamped on the end of the shaft.

Communications

1. Should communication be desirable or necessary regarding the installation covered by this Instruction Book, or an individual device included in the installation, replies will be greatly facilitated by citing the General Order (G.O.) number for the complete equipment and the nameplate readings of the detail apparatus involved.

2. Do not fail to give the stator and/or rotor serial number and the complete nameplate reading when information is desired for a rotating machine. The stator serial number is stamped on the machine nameplate and in the metal under the nameplate and on the machine foot. The rotor serial number is stamped on the end of the shaft.

3. Should any particular information be desired, be very careful to state clearly and fully the question for consideration, and the associated conditions.

4. Communications should be addressed to the nearest Westinghouse Electric Corporation Sales Office. Local sales, engineering or service representatives are usually available for quick consultation.

Section 2.2 Installation of Generator

GENERAL INSTALLATION

Storage

1. The generator is shipped with the windings well protected from moisture. At the destination, the rotor and stator should be placed in locations protected from the weather and from mechanical injury. Rain, snow, water or steam from leaking pipes, or condensation from the atmosphere should be excluded. It is particularly important to keep the windings dry for moisture lowers the insulation resistance and increases the likelihood of a breakdown. If the machine is brought from cold surroundings into a warm room, it should be kept covered until its temperature has risen to room temperature in order to prevent the condensation of moisture on the windings and other parts.

2. When storage over a period of time is anticipated, the machine should be completely enclosed by a tarpaulin or a covering of wood, metal or roofing paper unless the machine is in a protected location. Also, the space heaters should be energized.

Handling and Unpacking

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 would be done 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 likely to injure the insulation and result in the burning out of a coil. The generator frame should be lifted by placing hooks in the lifting lugs provided on the side of the generators.

3. In lifting the rotor, it is preferable to use rope slings looped around the shaft. 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 or collector rings.

INSTALLATION AND ERECTION

General

1. The principal external dimensions of the generator set and the provisions for mounting it on the base of the prime mover are shown on the outline drawing, which appears as Fig. G-6 of these instructions.

Examination of Bearing and Journal

1. Before the machine is placed in service, the surfaces of the bearing and journal should be examined for injuries accidentally sustained during or after shipment. Scratches on the surface of the babbitt should be smoothed out, and scratches or rust on the journal should be polished off before the machine is assembled.

Cleaning of Collector Rings

1. Remove the protective compound covering the rings. A cloth dipped in benzine or carbon tetrachloride will be useful in removing this compound.

Alignment of Equipment

1. Once the a-c generator has been approximately located on the turbine sub-base with the coupling loosely fitted, the final alignment should be undertaken. The feet of the generator are provided with jackscrews which permit either side of the stator to be raised so that sheet-metal liners may be inserted between the feet and the sub-base to correct the alignment.

2. The fit at the face of the coupling is the guide for the alignment of the electrical equipment with the prime mover. Liners should be inserted under the stator feet as needed to cause the faces of the coupling to fit together as specified in the instructions for the prime mover. The coupling bolts should then be tightened.

3. The position of the generator should be adjusted so that the following conditions are

met after the frame feet bolts are pulled tight:

a. The proper axial clearances exist at the journal between the journal oil throwers and the bearing. The clearances at the ends of the bearing should be such that they will be approximately equal after the coupling bolts are tightened.

b. The air gaps are equal around the bore within 1/64 inch. It is particularly important that the air gap between the armature core and the pole faces be uniform, for any inequality in the gap will cause unnecessary friction and heating in the bearings as well as unequal heating of the iron in the armature.

During these adjustments, the air gap should be gaged from both ends of the machine at different points around the rotor. Gages for the purpose should extend to the center of the core.

The feeler gage should be inserted along the core between the poles and then moved over into the space between the pole face and the stator core. This procedure reduces the likelihood of reading too small a value for the air gap at a point near the end of the machine where a high punching is most likely to exist.

If accurate readings of the air gap are required, the varnish should be removed from both the rotor and stator punchings at the air-gap surface.

c. The coupling outage is less than .001 inch as measured at the flange with a dial indicator after the coupling bolts have been tightened. The presence of burrs, nicks, or other results of poor handling will be noticed in this check.

d. The rotor should be centered axially in the stator bore. That is, the pole tips on the rotor must extend equal distances beyond the stator core at both ends of the machine.

When the proper alignment of all parts is obtained, ream holes for dowels and install dowels and foundation bolts.

Ventilation and Cooling

1. The generator is ventilated with air circulated through the machine by the blowing action of the field poles and blower vanes on the rotor.

2. Air from the outer end bells is drawn axially into each end of the machine near the shaft. Part of the air ventilates the end turns of the stator and passes through openings through the finger plates, into the space between the stator core and the frame cover. The remainder of the air enters the space between the field poles, crosses the air gap, and flows radially through the stator core. From there, all the air is directed into the cooler through an opening at the top of the generator frame. After passing through the cooler, the air is returned to the generator through ducts which are integral parts of the frame.

Power Connections (Stator Leads)

1. The main generator terminals are brought out to a conduit box located on the bottom of the frame.

Control Wiring and Rotor Leads

1. The leads from the generator field are brought out to a conduit box located on the bottom of the a-c generator frame. From there they can be connected to the leads brought out of the exciter conduit box. The space heater and stator temperature detector leads are brought out to separate conduit boxes located on the bottom of the a-c generator frame.

Lubrication

1. The bearing is connected to the forced-feed lubrication system of the speed reducing gear. An orifice at the bearing inlet reduces the oil pressure at the bearing to a value which permits an oil flow through the bearing of 1/2 gallon per minute.

2. The lubricant recommended is engine oil having a viscosity of 180 to 250 seconds Saybolt at 100°F.

Section 2.3 Operation of Generator

PRELIMINARY STARTING

Brush Adjustment

1. Brushes and brushholders should be examined before the machine is started up to make sure that the brushes are in the proper position, that there is a proper fit between the collector and the brushes, and that the brushes are free in the bolder. If the faces of the brushes do not conform to the curvature of the collector, it is necessary to grind them to shape. This operation is always required when new brushes are installed.

2. When 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 fitting. The sandpaper should be drawn in the direction of rotation under the brushes. Rounding of the brush edges can be avoided by releasing pressure as the paper is drawn back and by being careful to keep the ends of the paper as close to the collector as possible. Each brush should be treated in turn, and it will be found that by this means a satisfactory contact is quickly secured.

3. An initial brush pressure of 2.4 lbs is recommended. Once the machine is in service, the pressure may be altered as necessary.

Initial Check on Insulation Resistance

1. The insulation resistance of an electrical machine gives an indication of whether the machine is in a suitable condition for operation or potential tests. If the insulation resistance of a winding is below the minimum acceptable value for a new machine, the winding should be dried out.

2. Once the windings are in a satisfactory condition for operation, it is recommended that initial readings be taken for both the armature and field windings so as to provide a basis for later comparison.

3. Further information on insulation resistance is given under the Section on "Maintenance of Generator", page 215.

Drying-Out Windings

1. If the insulation resistance indicates that the windings have absorbed moisture during shipment, the generator should be dried out before any high-potential test is made or before the generator is initially run. Once the windings have been dried out, the space heaters should be placed in operation whenever the machine is not running. The windings may be dried either by the use of external heat or by the circulation of current through the winding themselves.

2. When external heat is to be applied, it is advisable to use resistance heaters or steam coils as sources of heat. The space heaters located inside the generator are not of sufficient capacity for use in drying out the machine; so additional heaters are required. The space heaters may be used as supplementary sources of heat. The machine should be covered, and the heaters should be placed near the bottom of the enclosure. Care should be taken to protect the machine against direct radiation from the heaters. Effective drying cannot be accomplished unless means are provided to circulate the air so as to remove the moisture. The circulation of heated air can be improved by the following:

a. Forcing air into the bottom of the enclosure with small fans.

b. Having the enclosure sufficiently close-fitting to cause most of the heated air to pass through the ventilating spaces in the machine.

c. Providing an opening at the top of the enclosure for the escape of moisture-laden air.

3. When the heating is to be accomplished by the circulation of current, a d-c welding set may be used to provide the current. The cur-

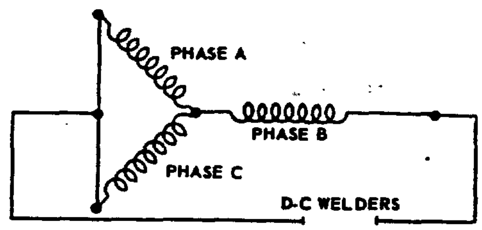

FIG. G-1 -- Connections for Drying-Out Windings With D-c Welder

rent in any part of the winding should not exceed the rated value. Refer to Fig. G-1.

4. Another method of circulating current through the stator winding of the generator without subjecting them to full voltage is to drive the machine at a convenient speed with the stator windings short-circuited and with the proper value of excitation applied to the field to give somewhat less than rated armature current.

5. Regardless of the method of heating used, it is essential that the heat be brought up gradually at first, the aim being to allow the water vapor to find its way out naturally through the insulation. Too rapid heating is likely to develop such steam pressure in local portions that escape passages are forced through the insulation, injuring it permanently. It is generally desirable to consume 15 to 20 hours in bringing the temperature up to the value required.

6. The total temperature of any part of the machine should not exceed 75°C during the early part of the drying-out period. Later, after the insulation resistance has passed its minimum value and has become nearly stable, the temperature may be raised to 125°C or slightly higher. If the windings are heated by passing current through them, the temperature of the stator coils should be determined by thermometers, and the temperature of the field windings may be determined by comparison of the winding resistance with its resistance at a known temperature. Refer to the paragraph on "Temperature" page 215 for the method

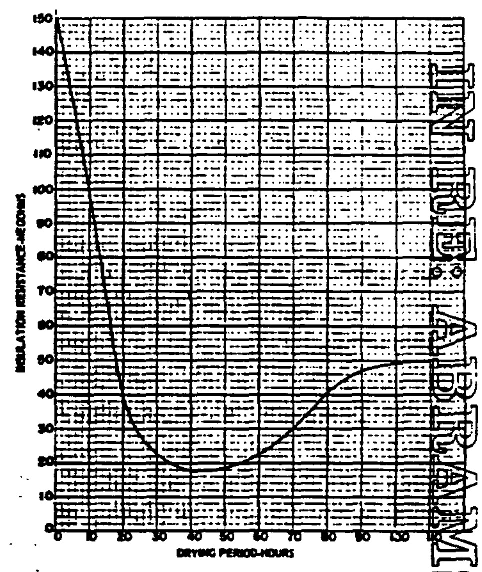

FIG. G-2 -- Typical Behavior of Insulation Resistance During a Dry-Out Run

of measuring temperature by change of resistance.

7. During the drying-out process, measurements of insulation resistance should be taken at regular intervals and it is recommended that the results be plotted in the form of a curve of "Insulation Resistance vs. Time". A typical curve of this kind is shown as Fig. G-2. The initial drop in insulation resistance can be attributed to the effect of rising temperature, and the subsequent rise in resistance is caused by the removal of moisture. The drying-out process should be continued until the insulation resistance becomes approximately constant at a high value.

Final Check Before First Start

1. Before the unit is started, the following checks should be made:

a. Be sure that all necessary work of installation and erection has been completed.

b. Carefully examine the interior of the generator for loose objects such as bolts, nuts, and tools. Such items should be removed from the machine, and care should be taken to prevent their being drawn into it by magnetic attraction.

c. Check to be sure that the brushes are free in their holders and that the brush pressure is about 2-1/2 psi (roughly 2.4 lb per brush for this machine). Once the machine is in service, the pressure may be altered as necessary.

d. Check the wiring and piping to be sure that all connections have been made properly.

e. Check to see that the proper electrical clearances exist between conductors. Do not allow brush shunts to touch each other.

f. Be sure that all moving parts have sufficient clearance with respect to adjacent stationary parts.

g. Check to see that the windings are free from dirt and moisture.

h. Measure the insulation resistance of the windings, and dry out the windings if the test shows this to be necessary.

i. Be sure that all cover plates have been installed over the openings in the frame and end bells.

STARTING GENERATOR

Check During First Start

1. When the unit is first started, the following observations should be made:

a. Before starting the generator, the cooling water valves to the generator air cooler must be opened to give the rated flow (35 GPM of water at 85°F) of cooling water to the generator air cooler. The air cooler will not operate satisfactorily if the flow of cooling water is insufficient. Therefore, any throttling should be done on the cooling water outlet piping only.

b. Watch temperature whenever possible to be sure that none is excessive.

c. Check the brush rigging to be sure that the brushes ride properly on the collector rings.

General

1. When generator units are to be paralleled, the starting of subsequent units is similar to that for a single generator, but additional care is required in order to synchronize the units.

2. In order that synchronous generators may be connected to a system already in operation, the voltage of the incoming machine and that of the system must be approximately the same at each instant. This requires that the two voltages be of the same frequency, have the same magnitude and phase rotation, and be in phase with each other.

3. Voltmeters indicate whether the magnitudes of the voltages are the same, and frequency meters or tachometers indicate whether the frequencies are approximately the same. Whether the voltages are exactly in phase and of exactly the same frequency is indicated by a synchroscope or by a synchronizing lamp circuit.

Explanation of Synchronizing Lamp Circuits

1. Although the indication of synchronism given by a synchronizing lamp circuit is less precise than the indication given by a synchroscope, the frequent use of the lamp circuit justifies an explanation of its operation.

2. Lamps should be connected between the leads which will be joined together when the generators are synchronized. The lamps should be adapted for the highest voltage which they will receive. This voltage will be twice the normal value and will occur when the machine voltages are in phase-opposition. When the voltage of the system is too high for the synchronizing apparatus, it is usual to place voltage transformers between the main circuits and the synchronizing circuits so as to reduce the voltage at the switchboard to a safe

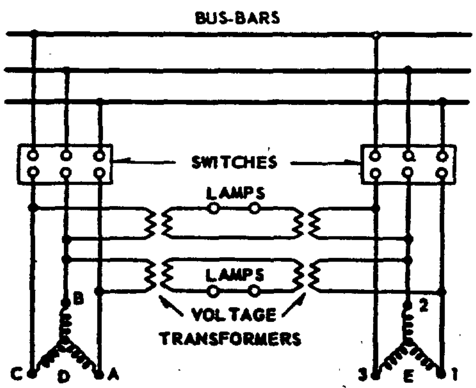

FIG. G-3 -- Connections for Synchronizing A-c Generators Using Lamps

value. Figure G-3 shows such connections between two of the phases of two 3-phase generators. One generator may be considered as representing a system which is already in operation.

3. As the voltage of the incoming generator and the voltage of the system change from a condition of phase-coincidence to one of phase-opposition, the flow of current through the lamps changes from a minimum to a maximum. When the voltages are exactly equal and in phase, the current through the lamps is zero. A phase difference between the voltages causes current to flow through the lamp circuit and illuminate the lamps.

4. If there is a small difference between the frequency of the incoming generator and that of the system, the lamps increase in brilliancy until the voltage of the machine and that of the system are in exact opposition. From this condition, the lamps decrease in brilliancy until they are completely dark (if the voltages are equal in magnitude), indicating that the voltages are again in phase. The frequency with which the lamps alternate between the bright and dim conditions is proportional to the difference between the generator and system frequencies.

5. When the frequencies of the incoming generator and the system are equal and the voltages are equal but out-of-phase, the lamps glow with a steady brilliancy. The degree of brilliancy depends upon the amount of phase displacement between the two voltages.

6. When voltage transformers are required in the lamp circuit because of high line voltages, it is possible for the transformer connections to be made in such a manner that the lamps burn with maximum brilliancy when the two voltages in question are in-phase rather than out-of-phase. It is preferable to use DARK LAMPS TO INDICATE SYNCHRONISM instead.

7. The following check can be used to make certain that the lamps will be dark when the voltages are in phase. Disconnect the main leads of the incoming generator at the generator, and throw in the main switch of this generator so that its bus work will be energized from the system. Both voltage transformers will then be energized from the same voltage source, and the lamps will be dark if the transformer connections are correct. If the lamps burn brightly under these conditions, the two connections to one of the primaries or to one of the secondaries of the voltage transformers should be reversed.

Determining Proper Phase Sequence

1. When a generator is to be synchronized with a system already in operation, the phase sequence of the generator must be the same as that of the system. To check the phase sequence, the following procedure is recommended. Refer to Fig. G-3, and assume that generator "D" is to be synchronized with the system represented by generator "E". Note that synchronizing equipment is required in two phases, when the phase sequence is to be checked. Check the two lamp circuits separately, as described in the preceding section, to be sure that the lamps in each circuit are dark when the voltages being compared are equal and in phase. Once the circuits have been checked, the proper phase sequence for the incoming generator may be determined.

2. To check the phase sequence, observe both sets of lamps when the voltage and frequency

of the incoming generator have been made approximately equal to that of the system. If both sets of lamps become bright and dark in unison when the frequency of the incoming generator is slightly different from that of the system, the phase rotation of the generator is the same as that of the system.

3. If one set of lamps is bright while the other is dark, the phase sequence of the incoming generator is opposite to that of the system. To make the phase sequence of the generator agree with that of the system, interchange any two of the three line connectors between the generator and the bus. It is well to make a confirming check on the phase sequence after changing the connections, but first the lamps should again be checked to be sure that they will be dark when the corresponding voltages are equal and in phase.

FIG. G-4 -- Synchroscope

Synchronizing Generators with Lamps

1. Synchronizing lamps are recommended for use as a check on the operation of the synchroscope and for emergency use in case the synchroscope is inoperative. Separate voltage transformers should be used for the synchroscope and lamps. If the phase sequence of the incoming machine is known to be correct, lamps need to be connected between only one phase of the generator and one phase of the system.

2. The lamps should be connected so as to be dark at synchronism and to be at maximum brilliancy when the generator and system voltages are 180 degrees out-of-phase. Zero potential is applied to the lamps at synchronism. However, an incandescent lamp appears dark even though a considerable potential is applied. For this reason, lamps do not give as definite and accurate an indication of synchronism as is obtained with a synchroscope. Nevertheless, they may be used satisfactorily if proper care is exercised.

3. With the generator frequency slightly greater than that of the system, adjust the speed of the generator so that the bright and dim sequence of the lamps becomes slow and constant. Anticipate the time required for the breaker to close its contacts, and throw the breaker so that its contacts will close at the middle of the dark period.

Synchronizing Generators with a Synchroscope

1. A synchroscope is an instrument which is used to indicate the instantaneous difference in phase between the voltage of the incoming generator and the voltage of the system with which the generator is to be synchronized. Refer to Fig. G-4. The voltage of the system is used as a reference, and its voltage vector can be represented as a stationary pointer in the "12 o'clock" position on the dial of the instrument. The voltage vector of the incoming generator is represented by the movable pointer. The number of mechanical degrees between these "vectors" on the synchroscope dial is the number of electrical degrees by which the generator and system voltages are out of phase.

2. When the pointer is in the left-hand portion of the dial, the voltage of the incoming generator is considered to be lagging the voltage of the system. When the pointer is in the right-hand portion of the dial, the voltage of the incoming generator is considered to be leading the voltage of the system.

3. The speed of rotation of the pointer is proportional to the difference between the frequency of the generator and that of the system. If the generator frequency is higher than the system frequency, the pointer will rotate in the "FAST" (clockwise) direction, indicating that the generator is running too fast. If the generator frequency is less than the system frequency, the pointer will rotate in the "SLOW" (counter clockwise) direction, indicating that the generator is running too slowly.

4. Before the incoming generator is connected to the system, a check should be made on the synchroscope to be sure that the pointer of the instrument rotates when the generator frequency is known to be somewhat different from the system frequency.

5. When the incoming generator and the system are in exact synchronism, the following conditions exist:

a. The voltage of the generator is equal to the voltage of the system. When this condition exists, the generator and system voltmeter readings are equal.

b. The frequency of the generator is equal to the frequency of the system. When this condition exists, the pointer of the synchroscope remains stationary.

c. The voltage of the generator is in phase with the voltage of the system. When this condition exists, the pointer of the synchroscope is in the "12 o'clock" position.

6. In practice, the best results in synchronizing a generator with a system are obtained by closing the line breaker when the pointer is rotating slowly in the "FAST" direction and approaching the "12 o'clock" position. By observing the synchroscope carefully and timing the closing operation properly, the circuit may be completed at the exact point of synchronism, or at least within a very few degrees of it. Faulty synchronizing will cause a disturbance on the power system and may result in automatic tripping of the circuit breakers.

OPERATION OF GENERATORS

Single Generator

1. When a synchronous generator operates alone and is not paralleled with other generators, the field current must be adjusted for each change in load in order to maintain rated voltage. This adjustment can be made through manual control of the regulator, but it is preferable for this to be done with the regulator set for automatic operation to keep the voltage constant even though the load varies rapidly. No change in the power factor of the generator can be affected by changing the field current of the generator, as the power factor for a single generator is determined entirely by the characteristics of the load.

Parallel Generators

REQUIREMENTS FOR SUCCESSFUL PARALLEL OPERATION

1. The following paragraphs give the general requirements for successful parallel operation of synchronous generators.

2. The speed regulation of the prime movers should be alike. That is, the per cent drop in speed for a given percent increase in load should be the same for all units. The drop in speed from no-load to full-load may be only two percent or less, but if it is the same for all of the generators which are in parallel, the total load will be divided between them in proportion to their ratings.

3. The speed governors of the prime movers should be free from "hunting" and should bring the machines quickly to a steady speed. Any oscillation of the governors will result in a transfer of load back and forth between machines and a fluctuation of the voltage.

LOAD DIVISION AND POWER FACTOR CONTROL

1. When synchronous generators are operating in parallel, the power factor of each depends upon the relative excitation and upon the division of the total kilowatt-load between the machines. It is preferable for all the generators to operate at the same power factor.

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C95

2. In the following discussion, let it be assumed that the total load is to be divided between two generators of equal rating. In addition, it will be assumed that the regulator is set for "MANUAL" operation. The kilowatt-load may be divided equally between the generators by adjusting the governor settings of the two prime movers. When the two generators are carrying equal loads, their wattmeter readings will be equal. This redivision of load may be affected without any appreciable change in the frequency of the power system (normally 60 cycles) by making each governor adjustment very slight and by making the adjustments alternately on the two machines.

3. After the load is balanced, the power factor and line current of the two generators may be equalized by properly adjusting the manual control unit of the regulator. This may be accomplished without appreciable change in the ship's service voltage (normally 450 volts) by slight and alternate adjustments of the "MANUAL CONTROL" handles of the two regulators. Refer to the Chapter on "Voltage Regulator".

4. With the kilowatt-load divided equally between the two generators, the machine operating at the lower lagging power factor has the higher line-current ammeter reading. If the "MANUAL CONTROL" handle for the generator having the higher line current is turned slightly toward the "LOWER" position (in order to decrease excitation), the power factor of this machine will increase and the line-current ammeter reading for this machine will decrease.

5. In an extreme condition of improper "MANUAL CONTROL" setting, one generator may be operating at a low lagging power factor while the other generator is operating at unity power factor. Under this condition, the ammeter reading of the lagging-power factor machine will be considerably higher than that of the other machine. This is due to the fact that the one generator is carrying all of the reactive-load whereas the other machine is carrying only its share of the kilowatt-load.

6. When the voltage regulator is set for automatic control, during the power-factor adjustments, the same equalization of current may be obtained. In this case it is necessary to vary the "VOLTAGE ADJUSTING" instead of the "MANUAL CONTROL". The regulators will continue to maintain the proper division of reactive-load by means of cross-current compensators, regardless of changes in load. Refer to Chapter on "Voltage Regulator".

SHUTTING DOWN OF GENERATOR

Removing from Service

1. When a generator is operating in parallel with other generators of a system, and it is desired to remove the generator from service, the operator should reduce the load on the generator. When all the load has been shifted to the other machines, disconnect the generator from the line, and turn on space heaters to keep generator warm and dry.

Extended Shutdown

1. During an extended shutdown, the following protective measures should be taken unless the generator unit can be started periodically and run for a few minutes:

a. Apply slushing compound to the shaft journals to prevent rusting.

b. Remove the brushes from the rings and wipe the rings with paraffin as the machine is coming to a stop with the rings still warm. Be sure that the generator has first been disconnected from the line and that the excitation has been removed before the brushes are raised.

c. Turn on the space heaters.

Section 2.4 Maintenance of Generator

GENERAL MAINTENANCE

Temperature

1. The appearance of excessive temperature in any part of the machine is an indication of trouble. The situation should be investigated immediately and the cause of the trouble removed. Routine checks on temperature are recommended so that such conditions may be discovered before serious damage is done.

2. The bearing thermostat warns of excessive bearing temperature. If the alarm sounds, the oil supply should be checked. Shut down the unit if the temperature cannot be reduced immediately.

3. The temperature of the field windings is measured by the change in resistance of the field winding itself.

4. When the change of resistance of a copper winding is used to measure the average total temperature of the winding, the following equation can be used:

$$t_2 = \frac{R_2\,(234.5 + t_1)}{R_1} - 234.5$$

in which the resistance values (R) are both in the same units, and the total temperatures (t) are in degrees Centigrade. Subscript (1) refers to the known condition. Subscript (2) refers to the condition at which the resistance is known but the temperature is to be calculated. This equation is satisfactory for the range of temperatures normally obtained in electrical machines.

Possible Sources of Collector and Brush Trouble

1. One of the principal indications of improper brush and collector performance is sparking. The following list presents possible causes of brush and collector trouble. USE THIS INFORMATION TO PREVENT TROUBLE as well as to remedy it.

IMPROPER BRUSHHOLDER SPRING TENSION

1. The spring tension should be sufficient to maintain contact between the brush and the collector ring in spite of small vibrations of the brush rigging and collector rings. However, the pressure should not be such as to cause undue mechanical wear. It has been found that a brush pressure of 2-1/2 psi of brush area gives the best brush performance. This is equivalent to approximately 2.4 lb for this machine.

BRUSHES REQUIRING REPLACEMENT

1. As the brushes become shorter from wear the springs should be tightened so as to maintain the proper brush pressure. Brushes should be replaced before they reach the limit of their travel.

UNEQUAL CURRENT DISTRIBUTION AMONG BRUSHES

1. Sparking may result from an unequal distribution of current among the brushes on any one ring. The spring tension should be relieved temporarily on the brush carrying the excessive current. Readjustment of the spring tension may be necessary for all the brushes on the ring to cause each brush to carry its proper share of the current.

Dirty or Oily Collector Rings or Brush Rigging

1. Imperfect contact results when dirt, oil, or particles broken from the brush are present between the brush and the ring. Furthermore, dust between the brush and the holder may conduct sufficient current to fuse the brush to the holder.

2. The collector rings, brushes, and brush holder should be kept clean and free from dirt, carbon dust, and oil. A piece of canvas dipped in a grease solvent is recommended for cleaning these parts.

IMPROPER BRUSHES

1. Brushes of the proper grade are furnished with the machine. Other types may give unsatisfactory performance. See "Brush Rigging and Brushes", page 204.

2. Brushes of the proper size must be used. If the brushes are too small, they may become wedged at an angle in the holders. If they are too large they will stick in the holders, but this can be remedied by rubbing the sides of the brush with fine sandpaper.

IMPROPER ALIGNMENT OF BRUSHHOLDERS

1. The alignment of the brushes on the ring should be checked occasionally to be sure that a brush does not overhang the edge of the ring. If the brush is allowed to overhang, the overhanging part develops a thin edge which chips and breaks off.

VIBRATION OF THE BRUSH RIGGING

1. Any loose parts of the brush rigging should be tightened.

UNBALANCE IN THE ROTOR OR ECCENTRICITY OF THE COLLECTOR RINGS

1. Either of these conditions can cause the brushes to leave the rings and draw an arc once every revolution. This repeated arcing at the same place on the ring in time burns the imprint of the brush on the ring.

2. The "truth" of the rings can be checked with a dial indicator on the back of a brush while the unit is running at low speed. If the rings are eccentric on the shaft, they should be turned, or ground, and polished. These operations must be done when the rotor is turning, for if they are done at standstill or by hand, the eccentricity of the rings may actually be increased.

ROUGH OR MARKED RINGS

1. Any black spots that appear on the surface of the collector should be removed by polishing lightly with fine sandpaper. It is very important that this be done; for while these spots are not serious in themselves, they will lead to pitting of the rings and the necessity for regrinding. However, no harm is done to the rings if the condition is corrected at once. If the rings are very rough, they should be ground and polished with the rotor turning. This should not be done at standstill or by hand, for under these circumstances, the rings may be made eccentric and uneven.

CORRODED RINGS

1. Brush imprints may be burned on the surface of the rings as a result of causes other than unbalance and eccentricity. This burning also occurs when the rings have been left unprotected during an extended shutdown. This usually occurs on a machine which is subjected to corrosive fumes. When the machine is shut down, the fumes act upon the surface of the rings except where they are covered by the brushes. The difference in surface caused by this action produces a slight burning as the rings rotate after the machine has been returned to service. Brush imprints due to corrosive fumes can appear at any point on the rings, depending upon the position in which the rotor happens to stop. Refer to the instructions on "Extended Shutdown", page 214, for protective measures.

2. Corroded rings may require grinding and should always be polished before being returned to service.

UNEVEN HARDNESS OF RING

1. If a ring is not of uniform hardness around the periphery, uneven wear results, and the performance becomes unsatisfactory.

ELECTROLYTIC ACTION

1. Because there is an electrolytic action at the surface of the rings, their performance is improved by reversing their polarity occasionally. In some cases, it has been found useful to do this as often as once a week.

UNUSUAL OPERATING CONDITIONS

Excessive Current Densities Due to Overloads

1. The mechanical contact between the brush and the ring is never absolutely perfect, and high current density at the contact surface can cause sparking with brush fits that would be sufficiently accurate for normal densities.

Extended Operation with a Low Value of Brush Current

1. Brush "chatter", accompanied by sparking, has been found to result from this practice, as when machines are run without load in a standby capacity.

CORRECTIVE MAINTENANCE

Insulation Resistance

GENERAL

1. The insulation resistance of a winding is the resistance of the insulation to a d-c voltage tending to produce leakage current through the insulation and over its creepage surfaces. Although it is not a measure of the dielectric strength of the insulation, the insulation resistance indicates whether the machine is in a suitable condition for operation or for high-potential tests.

2. Insulation resistance is affected by a number of conditions, and often an apparent inconsistency in a group of readings can be attributed to variations in one or more of the test conditions which have been incorrectly assumed as constant.

3. The actual insulation resistance is lowered by the following conditions:

a. Aging of the insulation.

b. Mechanical damage to the insulation.

c. Presence of dirt in the machine.

d. Increased moisture content of the insulation.

e. Increased temperature of the insulation. (The effect of temperature on insulation resistance is great, the resistance at 25°C. being six to fourteen times that at 75°C, depending upon the type of machine.)

4. Measurements of insulation resistance are lowered by the following factors:

a. Increased magnitude of the test voltage used. (Variations of test voltage as small as 2:1 or 3:1 make no appreciable difference).

b. Decreased time of application of test voltage.

SIGNIFICANCE OF TESTS

1. Insulation resistance varies widely among machines of different sizes and voltages. Therefore, measurements of this quantity are useful chiefly for comparison with those made at other times on the same machine. MONTHLY TESTS OF INSULATION RESISTANCE ARE RECOMMENDED for detecting changes in the insulation material or creepage surfaces. In order for these tests to be correlated properly, each test should be made under the same conditions.

2. A trend toward lower insulation resistance is a warning that failure of the insulation is possible. For this reason, the readings obtained at any particular time should be compared with the previous readings in order to be of maximum significance.

3. The behavior of insulation resistance while the windings of a machine are being dried out is discussed in the section on "Drying Out Windings", page 208.

CONDITIONS FOR TEST

1. In order for all the tests to be made under approximately equal conditions of temperature and moisture, it is suggested that the insulation resistance be measured immediately after shutdown while the machine is still hot. It is preferable to use the same method and the same circuit for all tests. In any case, the records of insulation resistance will be more valuable for future reference if the conditions of temperature,

moisture, etc., and the test circuit and voltage are noted along with the insulation resistance.

METHOD OF TEST

1. The insulation resistance of a winding may be measured by using either an instrument called a megger or a d-c test circuit. In either case, one connection is made to the frame (for stator windings) or to the shaft (for rotor windings), and the other connection is made to a common terminal to which all leads of the winding in question are attached.

2. When the d-c circuit is used, readings are taken with a high resistance d-c voltmeter, first with the meter connected directly across a 500 or 600 volt d-c power supply, and next with the unknown insulation resistance in series with the meter and power supply. A recommended test consists of 500 volts d-c applied for 60 seconds. Refer to Fig. G-5.

3. The insulation resistance may be calculated from the following formula when the d-c test circuit has been used:

$$R = \left(\frac{R' \cdot (E-E')}{1{,}000{,}000\ E'}\right) \quad \text{where}$$

R = Insulation resistance in megohms

R'= Resistance of voltmeter in ohms

E = Voltage of d-c power supply

E'= Voltage read on meter when insulation resistance is in series with the voltmeter.

4. If the readings of insulation resistance are low, the leads should be disconnected and the measurement repeated separately on the winding and on the leads in order to determine whether the trouble is in the winding or in the leads.

Annual Inspection

1. It is recommended that after one year of operation, and once a year thereafter, the generator be thoroughly inspected.

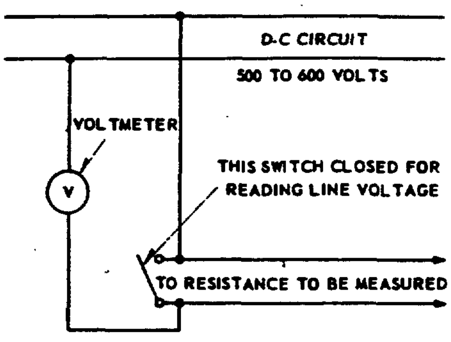


FIG. G-5 -- Diagram of Connections for Measuring Insulation Resistance

2. Remove the end bells and the bearings.

3. Examine the stator core and stator coils for loose wedges, coils, or coil bracing or any other unusual condition. Check the appearance of the coil insulation.

4. Check the rotor for loose damper bars and loose connections. If a field coil is not tight on the pole, the pole and coil should be removed, and Mica plates inserted between the coil and pole to take up space in width. A collar the same size as the bottom coil washer should be used to take up space in depth.

5. Inspect the collector rings, being sure that they are tight. If the rings are rough, marked, or corroded, polish them as described in the section on "Possible Sources of Collector and Brush Trouble", page 215. If rings are loose, the collector must be replaced.

6. Inspect the bearing and smooth out any rough places in the babbitt. Inspect the journal. Its surface MUST be smooth. Polish out scratches which are found.

7. Bring to the attention of a Westinghouse service representative any condition which cannot be repaired by the maintenance crew.

Cleaning Generator

1. At the annual shutdown period, the generator should be cleaned. It is advisable to remove the dirt from all accessible parts of the generator, but particularly from the windings, collector, brush rigging, ventilating spaces, and parts adjacent to the electrical windings and connections.

Cleaning Air Cooler

1. The strainers in the sea-water inlet line should be cleaned as frequently as required to provide unrestricted flow.

2. The inside of the water 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.

3. The cooler is provided with zinc electrodes to centralize electrolysis. These electrodes should be examined regularly at 30 day intervals to see that size of electrode is still adequate.

4. The following procedure should be used in cleaning the air cooler:

Step 1 - Close valves in pipe connections to and from the cooler; drain water, and remove the unit from the piping.

Step 2 - Disconnect inlet and rear covers to expose inside of tubes.

Step 3 - Clean inside of tubes by application of steam jet and use rods where necessary.

Step 4 - Clean outside of tubes by use of steam jet, drying with compressed air.

Step 5 - Clean any foreign matter from inside of inlet and rear covers.

Step 6 - Reassemble in reverse order, using new gaskets where necessary.

Rebabbitting Bearing

1. In case it is necessary to rebabbitt an old bearing on a ship, melt out the old babbitt and prepare a suitable mandrel. Since the bearing is split, each half should be babbitted individually. The mandrel should consist of a half-cylinder with shoulders running along its length so that the sides of the bearing may rest on them and form a close fit. Pieces of felt should be placed around the ends of the bearing shell to prevent the babbitt from running out at the ends. Remove bearing insulation and replace after bearing is rebabbitted.

2. Only a good tin-base babbitt (Westinghouse Alloy No. 46-1) or an approved lead-base babbitt (Westinghouse Alloy No. 25) should be used for such work. The melted babbitt should be poured into the gate until it begins to overflow. Sufficient time should elapse after the pouring and before the mandrel is removed from the bearing to allow the babbitt to become quite hard.

3. The bearing should then be bored or reamed to the proper size. Holes for the introduction and draining of oil from the bearing should be drilled and the proper machining done to provide grooves at the splits and eccentric chambers for the oil in the center of the bearing. The finishing operations may be done with a suitable scraper.

Repair of Air Cooler

1. The Harrison Radiation Division makes the following comment on emergency repair of the air cooler:

2. "Approximately 5% of the tubes may be blocked off and the generator air cooler will still operate efficiently. Thus a leaking tube may be blocked off by inserting plugs into each end".

WESTINGHOUSE ELECTRIC CORPORATION - DIVISION L.R.A. PLANT LOCATION E.PGH.

TITLE SPARE PARTS LIST

DWG 171 A 538 SUB 1

LIST OF SPARE PARTS AND TOOLS

MANUFACTURER - WESTINGHOUSE ELECTRIC CORP.

APPLIANCE - GENERATOR SPARES

APPLICATION -

ITEM NO.	NUMBER OF SETS	NUMBER PER SET	NAME OF PARTS OR TOOL	MANUFACTURERS DATA: CATALOG OR SERIAL ORDERING DATA	MANUFACTURERS DWG & PIECE NO.: PC.	MANUFACTURERS DWG & PIECE NO.: DRAWING NO.
1	1/3	6	FIELD COILS	S#1634311		16 C 4969
2	1	1	BEARING	S# 372P951601		1 B 9175
3	1/2	2	BRUSH HOLDER	S# 1359452-B		8 B1148
4	3/4	4	BRUSH HOLDER SPRING	S# 255910 B		19 D 7411
5	1	1	BRUSH RIGGING INSUL.	ITS. 6, 7, & 12		380 C 678
6	1	4	BRUSH	S#1295005		29 D 284
7	1		ZINCS AND GASKETS (COOLER) FR HARRISON RADIATOR DIV. OF GEN MOTORS E 8519632			

G.O. - BH - 69181 - TP

SPARE PARTS S.O. 58 P 319

SPARE PARTS FOR USE WITH 1 BRG. A.C. TURBINE GENERATOR S.O. ~~58-P-316~~

LEGEND:

S - STYLE NO.

WHEN ORDERING ALWAYS REFER TO MACHINE SERIAL NUMBER

171 A538

List of Spare Parts and Tools -- FIG. G-7

7.5-KW D-C EXCITER

Rating: Type SK 6-83; 7.5 KW; 120 Volts; 62.5 Amps; 1200 RPM

Characteristics

Enclosure	Dripproof Protected
Winding	Shunt
Duty	Continuous
Rotation	CW from Comm. End
Ambient Temperature	50°C
Temperature Rise	40°C 100% 24 hours 55°C 125% 2 hours
Class of Insulation	A
Drive	Direct-Quill Type
Bearings	None
Lubrication	None
Mounting	Horizontal

For Maintenance Instructions See EMS-141 following this page.

Outline Drawing is 21-C-8236 which follows EMS-141.

AC to DC and/or DC to DC MOTOR GENERATOR SETS and DC MOTORS

INDEX

GENERAL

To obtain long satisfactory service from rotating electrical equipment, it is necessary to properly install, operate and maintain such equipment. The following gives the simple precautions and instructions for such care. Properly maintained equipment will require very little care other than periodic inspections and lubrication. The most important factor is to keep the apparatus clean and free of oil, water and other foreign material.

INSTALLATION

UNPACKING

When unpacking, be sure and protect any exposed windings from damage. Never pry against a winding nor strike it a blow with a hammer. Do not allow sharp instruments to come in contact with the coils. Avoid damage to the shaft. Keep it free from bumping which will cause burrs and interfere with the coupling or pulley fit. Do not bend shaft as it will cause misalignment.

INSPECTION

As soon as the apparatus is unpacked give it a thorough inspection. Look especially for any loose field connections, bolts, covers, broken brushes or brushholders and any noticeable damage to coil insulation. Repair immediately any damage found. If machine has been in storage some time or has been exposed to dampness, the insulation resistance should be checked. See instructions under "Maintenance" - Insulation. See that name plate reading agrees with the voltage and frequency provided for the motor.

HANDLING

Electrical equipment can be damaged when dismantled. If the machine is dismantled and the windings are exposed, care is necessary to properly protect these windings from damage. In handling the armature, do not allow the commutator or coil ends to be bumped as this will damage them. Support the rotor or armature by rope slings about the shaft or steel punchings. Use a spreader to keep the ropes from pressing against the coil ends or commutator. Never support it by pressure on the coil ends or on the commutator, either when using a rope sling or when resting on blocks. Never use any sharp instruments on any coils as the insulation may be punctured.

ELECTRICAL CONNECTIONS

AC Motors

Connection of Motor to Power Circuit with Standard Number of Terminals.

Three-Phase (Three Terminals). Connect any lead to any motor terminal. To reverse the direction of the motor, interchange any two leads.

Two-Phase, Four Wire (Four Terminals). Connect the leads from one phase to motor terminals T1 and T3 and the leads from the other phase to motor terminals T2 and T4. To reverse the direction of the motor, interchange the leads of one phase.

Two-Phase, Three Wire (Four Terminals). Connect the two outside leads to motor terminals T1 and T2 and the common lead to T3 and T4. To reverse the rotation of the motor, interchange the two outside leads.

Connection of Motor with more than Standard Number of Terminals.

Refer to the connection plate on the motor or to the connection sheet filed in the instruction envelope.

DC Motors

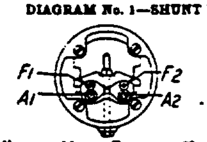
Connect the motor and starter by referring to the diagrams furnished with the starter and as given in diagrams 1, 2, 3 or 4.

DC Generators

Connect the generator and field rheostat by referring to diagrams furnished with the field rheostat as given in diagrams 5 and 6.

Motor Connections—Rotation Facing Commutator End

DIAGRAM No. 1—SHUNT WOUND MOTOR, WITHOUT COMPENSATING COILS

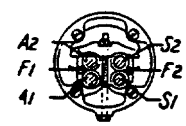


View of Motor Terminals**

CLOCKWISE ROTATION
Connect A1 and F2 to — line
Connect A2 to starting resistance, then to + line
Connect F1 to + line

COUNTER-CLOCKWISE ROTATION
Connect A2 and F2 to — line
Connect A1 to starting resistance, then to + line
Connect F1 to + line

DIAGRAM No. 2—SHUNT WOUND MOTOR, WITH COMPENSATING COILS, AND COMPOUND WOUND

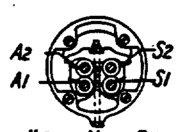


View of Motor Terminals**

CLOCKWISE ROTATION
Connect S2 and F2 to — line
Connect A1 to S1
Connect A2 to starting resistance, thence to + line
Connect F1 to + line

COUNTER-CLOCKWISE ROTATION
Connect S2 and F2 to — line
Connect A2 to S1
Connect A1 to starting resistance, thence to + line
Connect F1 to + line

DIAGRAM No. 3—SERIES WOUND MOTOR

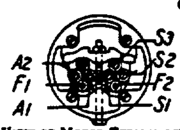


View of Motor Terminals**

CLOCKWISE ROTATION
Connect S2 to — line
Connect A1 to S1
Connect A2 to starting resistance, thence to + line

COUNTER-CLOCKWISE ROTATION
Connect S2 to — line
Connect A2 to S1
Connect A1 to starting resistance, thence to + line

DIAGRAM No. 4—TYPE SK ELEVATOR MOTOR
COMPOUND WOUND—CLASSES II AND III (See note)
(for class I motors use diagram No. 1)



View of Motor Terminals**

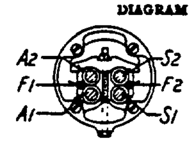
CLOCKWISE ROTATION
Connect S2 and F2 to — line
Connect A1 to S1
Connect A2 to starting resistor, thence to + line
Connect F1 to + line

COUNTER-CLOCKWISE ROTATION
Connect S2 and F2 to — line
Connect A2 to S1
Connect A1 to starting resistor, thence to + line.
Connect F1 to + line

Diagram indicates connection for starting, the full series field being in circuit. Under normal running conditions the series field is short circuited. In classes II and III motors, the series field may be cut out in two steps by short-circuiting S2 and S3, then S1 and S3.

Generator Connections

DIAGRAM No. 5—COMPOUND WOUND GENERATOR

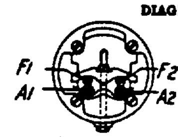


View of Generator Terminals**

CLOCKWISE ROTATION
Connect A2 to + line
Connect A1 and F2 to S2
Connect S1 to — line
Connect F1 to field rheostat, thence to + line.

COUNTER-CLOCKWISE ROTATION
Connect A1 to + line
Connect A2 to F2 to S2
Connect S1 to — line
Connect F1 to field rheostat, thence to + line.

DIAGRAM No. 6—SHUNT WOUND GENERATOR



View of Generator Terminals**

CLOCKWISE ROTATION
Connect A2 to + line
Connect A1 and F2 to — line
Connect F1 to field rheostat, thence to + line

COUNTER-CLOCKWISE ROTATION
Connect A1 to + line
Connect A2 to F2 to — line
Connect F1 to field rheostat, thence to + line.

Above terminal locations are for leads out right hand side looking at commutator end.
When leads are out left hand side looking at commutator end, location and markings will be upside down."

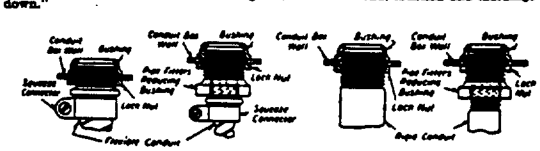


FIG. 1—METHOD OF CONNECTING MOTOR TO LINE

General

Install all wiring and fusing in accordance with the National Electric Code, and local requirements.

A conduit box is supplied, but conduit and conduit fittings are not furnished with the machine. These items may be purchased from any Electrical Dealer, or Plumber's Supply House.

When the machine is mounted on a bedplate, or on slide rails for belt adjustment, flexible metallic conduit should be used to protect the leads. In making this connection a squeeze connector should be used for attaching the flexible conduit to the conduit box, as shown in Fig. 1.

Squeeze connectors may be straight, 45°, or 90°.

In order to connect a squeeze connector to the conduit box first remove the cover of the box. Run a locknut well down the threads of the connector and place the connector in the hole in the bottom of the conduit box. Screw a conduit bushing over the end of connector, swing the connector to the desired position and draw the locknut up tight against the box. Follow the same procedure with rigid conduit or reducing bushing.

OPERATION

BEFORE STARTING

Check to see that all connections are made and all joints are tight. Examine the brushes and brushholders. The brushes should be free to slide in the holders and should be bearing against the surface of the commutator or slip ring. If any broken brushes are found they should be replaced. (See instructions under "Maintenance" - Brushes). The holders should be providing approximately two pounds per square inch pressure and should be located 1/16 to 1/8 inch from commutator surface. If brush rig has been disturbed during installation it should be returned to the correct position as set at the factory and which is marked by means of a dowel bolt. Always keep the rig in this position. Examine air gaps and remove any foreign material found therein. See that rotating members turn freely.

The following instructions cover various types of electrical apparatus. Be sure to know which type you have.

If you have:

D-C Motors use paragraphs 2, 3, 4
D-C Generators use paragraphs 1, 5, 6
A-C to D-C M-G Set use paragraphs 1, 5, 6
D-C to D-C M-G Set use paragraphs 1, 2, 5, 6

(1) On DC Generators

Keep field rheostat turned to the "all in" position (position of minimum voltage) and all line switches should be open.

(2) ON DC MOTORS

Keep field rheostat (if there is one) turned to the "all out" position (position of minimum speed) and all line switches should be open.

(3) Starting Generator and Motor Generator Sets

On initial starting proceed slowly and note especially for any evidence of rubbing. Check for heating in the bearings.

After set is up to speed raise voltage by turning field rheostat. If polarities are right adjust for rated voltage and close main switch. Generator is then ready to be loaded.

After load is applied to d-c generators look for evidence of sparking at the commutator. The generator should carry rated load with little sparking. If severe sparking occurs, see comments under "Maintenance".

(4) STARTING DC MOTORS

On initial starting proceed slowly and note especially for any evidence of rubbing. Check for heating in the bearings.

After motor is up to speed, check speed. If OK, motor is ready to be loaded.

After load is applied to DC motors look for evidence of sparking at the commutator. The motor should carry rated load with little sparking. If severe sparking occurs, see comments under "Maintenance".

(5) Stopping Generator and Motor Generator Sets

When stopping, gradually reduce load on generator as much as possible before tripping circuit breaker. Turn rheostat to minimum voltage and stop prime mover.

(6) STOPPING DC MOTORS

When stopping, gradually reduce load as much as possible before tripping circuit breaker.

MAINTENANCE

INSULATION

Keep machine free of dirt, oil and water at all times. One of the greatest enemies of coil insulation is dirt, and if the equipment is kept clean less trouble will result. The best way to check for excessive dampness in the windings is to make an insulation resistance measurement.

This can be done directly by a "megger". If a megger is not available, the measurement can be made using a 100 to 500 volt direct current (the higher voltage available the more accurate the results) and a direct current voltmeter, of which the resistance in ohms is known (generally marked on label inside the instrument cover).

The method of making a resistance measurement with the voltmeter is to first read the voltage of the line, then connect the resistance to be measured in series with the voltmeter and take a second reading.

The measured resistance is calculated from the formula:

$$R = \frac{r\,(V-v)}{v} \quad \text{or} \quad \frac{r}{v}\,(V-v)$$

V = First voltage reading.
v = Second voltage reading.
R = Resistance of insulation in ohms.
r = Resistance of voltmeter in ohms.

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. The voltmeter should be connected between the windings and the other side of the circuit.

The insulation resistance with the machine cold (at room temperature) should be at least: one megohm (1, 000, 000 ohms). When the windings are hot it should be at least:

$$\frac{3\ (\text{rated voltage})}{KW + 1000} \quad \text{(In megohms)}$$

If the resistance is low, the generator should be dried out before it is started into regular service. It can be done by, (1) using a separate heater (such as a lamp bulb) inside the generator (do not place too near the coils and in general the machine should be partially enclosed for the best results), (2) circulating current through the windings, or (3) dismantling and removing the armature and coils and baking them in an oven (at not over 105°C). This should be done in extreme cases.

If the second method is used, run the generator with a low voltage output, adjusting the load to a current value 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.

Careful attention should be given to the machine during this drying-out process. There is always danger of overheating the windings when drying by circulating current through them. The inner parts which cannot quickly dissipate the heat generated in them may get dangerously hot, while the 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 during the drying-out process, and should not be allowed to exceed 80°C total temperature.

If it is found that the generator is in a very damp condition, it may require several hours or even days to dry it out because the insulation is more easily injured when damp then when it is comparatively dry. In such extreme cases, it is better to bring up the temperature slowly at first, not allowing the maximum temperature to be reached until part of the moisture is expelled.

BRUSH POSITION

The correct brush position has been located at the factory and the rocker ring is locked to the magnet frame to prevent any movement. The brushholder should be adjusted to be approximately 1/16 inch from the face of the commutator.

BRUSHES

The ends of all brushes should be fitted to the commutator so that they make good contact over their entire bearing face. This can best be 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. Be careful to keep the ends of the paper as close to the commutator surface as possible as this will avoid rounding the edges of the brushes. It will be found that by this means a satisfactory contact is quickly secured. Use sandpaper grade 1-1/2 for the roughing out and grade 0 for the final fit.

Make frequent inspection to see that:

1. Brushes are not sticking in holders.
2. Shunts are properly attached to brushes and holders.
3. Tension is changed as brush wears. Maintain approximately two pounds per square inch.

4. Worn out brushes are replaced before they reach their limit of travel and break contact with the commutator.
5. Remove the free copper picked up by the face of the brush.

COMMUTATOR

The commutator is perhaps the most important part of the whole machine because it is most sensitive to abuse. Under normal conditions, it should require very little attention beyond frequent inspection. The surface should always be kept smooth. 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.

Sometimes a little sandpapering is all that is necessary. Emery cloth or paper should never be used for this purpose because of the continued abrasive action of the emery which becomes embedded in the copper bars and brushed. Even when sandpaper is used the brushes should be raised and the commutator wiped clean with a piece of canvas. Cotton waste should never be used.

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 too sever flash or short circuit.

Under normal conditions the commutator should become dark and highly polished after a few weeks' operation, and remain unchanged for years. There should never be any lubricant used on the commutator.

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 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.

Even with the most careful workmanship, high mica sometimes develops and starts 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 one-sixteenth of an inch below the adjacent copper.

SPARKING AT BRUSHES

Sparking at the brushes may be due to any of the following causes:
a. Machines 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. A 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 equally spaced 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.

There are other causes, but localized 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 readily be located, as the bars adjacent to the disconnected bar will be more or less pitted.

FLASHOVER

A flashover happens when arcing occurs between adjacent brushholder brackets. In general, it 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 flashover. Among other causes are the following:

1. Rough or dirty commutator.
2. A drop of water on the commutator from leaky steam pipes or other source.
3. Short circuits on the line producing excessive overload.

BEARINGS, SLEEVE

When machines are installed, put a good grade of light dynamo oil in each bearing housing. Use oil of a viscosity of from 185 to 212 seconds at 40°C. This oil is satisfactory for normal temperature down to 0°C or 32°F. For oils suitable for lower temperature secure special engineering recommendations.

The correct level of the oil is one-eighth inch below top of combination over gauge and filling device. Close down cover when through oiling.

When machines are first started, feel bearing housings occasionally to see that bearings are not overheating.

The frequency of bearing inspection depends on the conditions surrounding your application. Do not add oil unless the oil level has dropped more than one-eighth inch below the top of the combination overflow gauge and filling device.

Do not oil bearings while the motor is running.

Do not flood with oil. Do not spill oil over the housing or the bracket.

Old oil should be drained from the housing once a year and replaced with new oil.

BALL AND ROLLER BEARINGS—OPERATION AND CARE OF

Quietness and life of ball and roller bearings depends largely on cleanliness and proper lubrication.

Inspection

1. When the machine is installed make certain that the rotor turns easily, particularly if the machine is not installed until some months after being shipped.
2. Never open the bearing housing under conditions which would permit entrance of dirt.
3. External inspection of the machine at the time of the first greasing soon after it is put into operation will determine whether the bearings are operating quietly and without undue heating. Further inspection will not be necessary except at frequent intervals, probably at greasing periods.
4. If practicable, it is desirable for the most satisfactory service, to open the bearing housings once a year, or after every 5,000 hours' operation, to check the condition of the bearings and grease. If difficult to inspect the pulley or pinion end bearing, the condition of the bearing at the opposite end will usually be representative of both.
5. If grease deterioration has occurred or if dirt has gained entrance to the housing, the bearing and housing parts should be thoroughly cleaned out and new grease added.

Grease Lubrication

1. Grease is generally used as a lubricant. Ordinary cup greases are not satisfactory because of great tendency to deteriorate under the severe churning action of the bearings. To be suitable for ball or roller bearing lubrication a grease should be compounded from a pure mineral oil and a sodium base soap. It should be free from dirt and fillers, such as powdered mica, flake graphite, etc. It should be free from acid or alkali or from ingredients which will form these compounds. It should not melt at the highest operating temperature of the bearings and it should maintain a fairly uniform consistency over a large temperature range. Westinghouse grease meets these requirements. Keep grease clean by using only closed containers.

Do Not Over Lubricate

2. A small amount of lubricant is essential, sufficient to maintain a film of lubricant over the surface of the balls and races. Too much grease will cause churning, overheating and grease leakage. If grease leakage occurs the bearing has been over filled, or the grease used is not suitable for the particular application.

If high pressure guns are used, great care should be used to avoid over lubrication.

When shipped from the factory, grease lubricated ball and roller bearing machines have sufficient grease of the right grade to last for a limited period. However, a charge of grease should be added soon after the machine is put in operation, and thereafter at suitable intervals, as determined by experience. As a guide, it is suggested that grease should be added every three months of operation in amounts as indicated in the following table. If experience indicates that these quantities result in a surplus of grease in the bearing, the quantity should be reduced or the greasing periods lengthened or both. The ideal condition is that the bearing housing be from 1/3 to 1/2 full of grease.

As the shaft extension diameter is easily determined and is roughly proportional to the bearing size the following table for grease additions is prepared on this basis.

Shaft Extension Diameter	Amount of Grease to be added
3/4 to 1-1/4"	1 cu. in.
Above 1-1/4 to 1-7/8"	1-1/4 cu. in.
Above 1-7/8 to 2-3/8"	2-1/2 cu. in.
Above 2-3/8 to 3"	4 cu. in.
Above 3 to 4"	7 cu. in.
Above 4 to 5"	10 cu. in.

1 oz. = 1-1/4 cu. in.

3. When surplus grease sump below bearing is supplied, this should be kept empty at all times.

Regreasing (not pre-lubricated type)

4. When the bearing housing has been disassembled and the bearing thoroughly cleaned with a suitable solvent it should be immediately regreased with Westinghouse grease after first spraying or flushing with good lubricating oil. Apply the new grease either from a tube or by hand, over and between the balls or rollers. Do not use more than the amount specified in the table.

Westinghouse Grease - Ordering Data

8 oz. tube --- Style No. 1360876
1 lb. can ---- Style No. 1248911
5 lb. can ---- Style No. 1248912
10 lb. can ---- Style No. 1248913
25 lb. can ---- Style No. 1360877

Refer to the nearest district office of the Company for Westinghouse Grease packed in larger containers.

Cleanliness

Ball and roller bearings are especially sensitive to even a small amount of dirt. Hence, they must be protected from it at all times. If necessary to disassemble the bearing housing, first thoroughly remove dirt from all adjacent parts so that dirt will not fall into bearing or interior of housing.

PRELUBRICATED BEARINGS

Some motors are supplied with pre-lubricated bearings which do not require servicing. These motors are identified by a decal near the bearing housing and usually by the omission of grease fittings and drains.

A grease having high stability is permanently sealed in these bearings by the bearing manufacturer. Both laboratory tests and years of actual service have proved that this grease will give long service.

Bearings from several suppliers are used in Life-Line motors; for a given size motor, the bearings of all suppliers are interchangeable. The details of the seal construction vary somewhat depending upon the bearing manufacturer, but each type of seal is equally effective in keeping out foreign material and retaining the lubricant.

CAUSES OF INSUFFICIENT VOLTAGES (GENERATORS)

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 different from that indicated, or the current may be different from that shown by the readings.
c. Part of the shunt field may be reversed or short circuited.
d. The brushes may be incorrectly set.
e. The part of the field rheostat or other unnecessary resistance may be in the field circuit.

CAUSES OF UNDERSPEED (MOTORS)

AC Motors

The switchboard instruments may be incorrect, and the voltage and/or the frequency may be different from that indicated, or the current may be different from that shown by the readings.

DC Motors

a. The switchboard instruments may be incorrect and the voltage may be different from that indicated, or the current may be different from that shown by the readings.

b. If shunt field is separately excited the voltage and field current may be high.

c. The brushes may be incorrectly set.

d. If field rheostat is necessary for rated speed part of rheostat may not be in circuit and as a result the field current is high.

HEATING OF FIELD COILS

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

a. Operating at too low a speed, requiring more than normal field current.

b. Too high voltage.

c. Partial short circuit of one coil.

d. Overload.

HEATING OF ARMATURE OR ROTOR

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 with heating of the two particular coils affected.

c. Short circuits or grounds on armature or commutator.

HEATING OF COMMUTATOR

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 inherent lubrication of brushes.

CLEANLINESS

Particular care should be exercised towards keeping all parts of the machine reasonably clean. High rotative speed draws air into the armatures and the 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 periodically or the machines will ultimately short circuit between commutator necks or break down to ground over insulation surfaces. Stationary windings should be well cleaned for the same reason.

In extreme cases clean machine using carbon-tetracholordie on a cloth. Use sparingly and in a well ventilated place as the fumes are toxic. Do not scrape coils with any instrument.

After several years of operation it is good practice to coat all coils with a coat of good insulating varnish. A baking varnish is much superior to air-drying varnish, and should be used if possible.

DISASSEMBLY OF MACHINES— ON BEDPLATE

If, for any reason, a machine must be removed from a bedplate, the following procedure should be followed:

1. Remove coupling bolts to disengage shaft from other units.

2. Remove dowel in feet of machine to be removed from bedplate by tightening nut on dowel pin until entire dowel can be removed. There should be two dowels per frame located diagonally opposite each other.

3. Remove holding-down bolts in feet, being careful to observe and maintain correct shims under each foot for reassembly.

REASSEMBLY OF MACHINES— ON BEDPLATE

After a machine has been removed from a bedplate, reassemble as follows:

1. Place machine on bedplate with same shims under each foot as when disassembled.

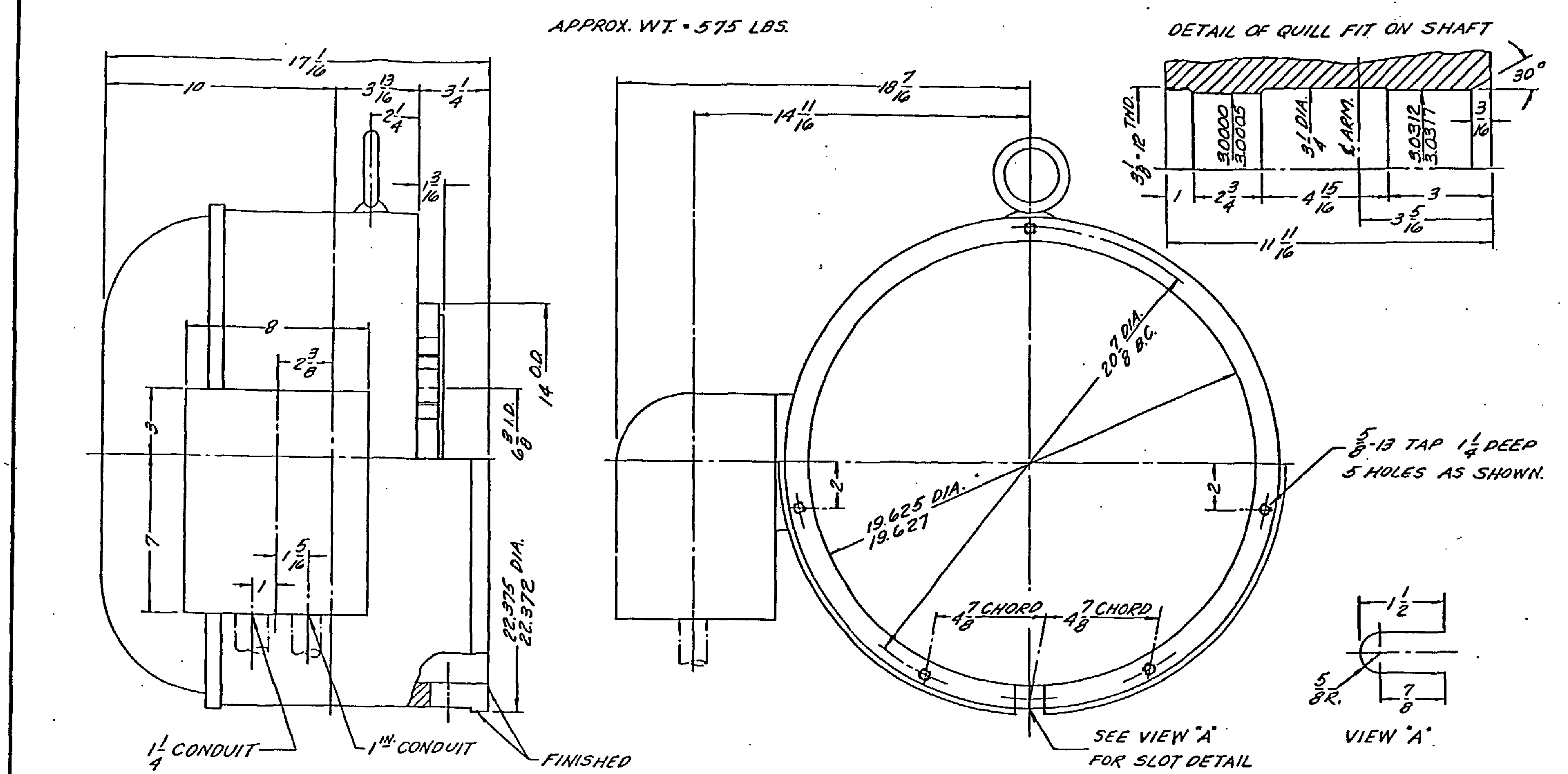
2. Start holding-down bolts, but do not tighten.

3. Install dowel bolts, and drive down as far as possible.

4. Tighten holding-down bolts, and drive dowels all the way in.

5. Install coupling discs and bolts. Machine is ready to run.

6. Observe the rules for starting as given under "Operation".



WESTINGHOUSE ELECTRIC CORPORATION

TITLE GEN. D.C. FRAME #83-6 TYPE SK

OUTLINE

DIMENSIONS IN INCHES—SCALE N.T.S.

DFTM. BRYANT	3-2-54	APPD. [signature]	3/3/54
		APPD.	
CHKD. [signature]	3/3/54	APPD. [signature]	3/3/54

DIV. & PLANT LOCATION MOTOR

TOOL REF. DWG. | ENG. REF. DWG.

21-C-8236

BUFFALO DIVISIONS, BUFFALO, N.Y. U.S.A.

MVB-00038326

GENERAL INFORMATION

1A. FOREWORD

a) Careful reading of these instructions will provide information for the 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.

b) When corresponding regarding the equipment described herein refer to--Type "SRAN-3" Voltage Regulating Equipment. Use Westinghouse identification data given on title page. Complete identification of parts is contained on page II.

c) Address inquiries to the nearest Westinghouse Service Facility--see list at end of this book--or to Westinghouse Electric Corporation; Switchgear and Control Division; East Pittsburgh, Pennsylvania, U.S.A.

1B. DESCRIPTION OF GENERATOR VOLTAGE REGULATING EQUIPMENT

a) The purpose of the automatic voltage regulator is to maintain the terminal voltage of the alternating-current generators at, or very close to, rated volts regardless of load variations.

b) The voltage regulator controls the voltage of the alternating-current generator by varying the resistance in the exciter field circuit. This regulating action is of a semi-static nature and hence the device operates only when a correction in voltage is necessary. Since the regulator acts directly on the exciter field resistance, no intermediate contactors, levers or linkages are necessary.

c) The "SRAN-3" type of voltage regulator has two regulating resistance plates which can be connected in parallel, series-parallel or series. These in turn are connected directly in the exciter field circuit. On some installations it is considered advisable, due to exciter field characteristics, to use an exciter field resistor to limit the range of regulating resistance and improve the sensitivity.

d) The resistance is varied by the value of the current in the coil circuit. Normal operating range of the coil current varies from .125 to .140 ampere d-c from the rectifier.

e) With this value of coil current in the regulator circuit, proper voltage regulation will be obtained.

1C. VOLTAGE REGULATOR CONTROL ELEMENT

a) The regulator coil is wound with 3000 turns of No. 25 enameled copper wire with a resistance of 65 ohms. It is identified by Westinghouse Style No. 1173224.

b) An adjustable resistance is connected in series with the coil of the voltage regulator to set the range covered by the voltage adjusting rheostat, so that rated generator voltage is obtained with the voltage adjusting rheostat in the mid-position. This internally mounted resistance consists of two 750-ohm tubes each identified by Westinghouse Style No. 1115103.

c) The spring-mounted moving arm of the regulator is supported so that the armature passes within the fixed air gap in the magnetic circuit. The pusher pins are located at the outer end of the moving arm and arranged to press against the silver buttons which are mounted at the free end of the leaf springs made of conducting material.

d) The fixed end of each silver-button leaf spring is attached to consecutive steps of the regulating resistance plates. These plates have resistive wire embedded in vitreous to prevent excessive voltage and hunting. When the a-c voltage rises, the regulator operates, due to increasing coil pull, to insert resistance in the exciter field circuit and thereby decrease the exciter field current and armature voltage. The primary of the damping transformer is subject to this change and induces a voltage in the secondary which causes a momentary reduction in the normal regulator coil current. Thus, the coil pull is reduced by this impulse from the damping transformer, and the regulated voltage is not decreased excessively. Conversely, when the a-c voltage falls and the regulator operates, due to decreasing coil pull, to short-out resistance in the exciter field circuit, the impulse from the damping transformer aids the normal coil current. Thus the regulated voltage is not increased excessively.

c) The 3-phase, full wave, Rectox rectifier, rectifies the 3-phase a-c voltage to provide d-c current for the main coil of the voltage regulator control element. The basic element of the Rectox rectifier is a copper disc, on one side of which a layer of cuprous oxide has been formed. This disc allows current to pass freely in the oxide-to-copper direction but with difficulty in the opposite direction. In this installation the discs are assembled on six separate supporting studs. The six stacks of discs each identified by Westinghouse Style No. 1106396, are connected so that all positive half-waves of the impressed alternating-current energy will send current to the regulator coil in one direction through one half of the rectifier stacks; all negative half-waves will return to the potential transformer through the other half-stack which previously opposed passage of the positive half waves. The result is a d-c output from the rectifier to the control element coil. This output depends on the average of the 3-phase voltages.

1E. VOLTAGE ADJUSTING RHEOSTAT

a) Turning the handle of this rheostat raises or lowers the value at which the regulator holds the generator voltage. Changing the resistance varies the current in the coil circuit of the regulator, which changes the position of the regulator moving arm and results in a change in resistance in the exciter field circuit. Hence the regulated value of generator voltage can be adjusted by the position of this rheostat. This rheostat has approximately 203 equal steps of resistance, 225 ohms total.

1F. CROSS-CURRENT COMPENSATOR

a) This piece of apparatus consists of an adjustable auto-transformer connected across a resistor-reactor combination. Two insulating transformers transmit energy in proper phase relation to the potential circuit of the regulator. This causes the regulator to droop the regulated voltage in proportion to the magnitude and phase angle of the reactive load current.

1G. A-C POTENTIAL TRANSFORMER

a) Two potential transformers are used to step down from rated a-c generator voltage to approximately 115 volts, the voltage applied to the regulating equipment.

b) The potential transformers are connected as follows:

PRIMARY - Connected open-delta receives 3-phase, 3-wire, 60-cycle, generator volts.

SECONDARY - Connected open-delta gives 3-phase, 3-wire, 60-cycle, 115 volts.

1H. CURRENT TRANSFORMERS

a) One current transformer is supplied with each a-c generator that operates in parallel with other generators. It is connected in line "B" of the generator and its energy is supplied to the cross-current compensator. The ratio of this current transformer depends upon the kw rating of the generator.

1I. REGULATOR CUTOUT SWITCH

a) The regulator cutout switch is of the rotary type provided with three positions

2A. STORAGE

a) The regulating equipment was carefully inspected and checked and then packed for shipment with the object of providing protection during the necessary handling and storage. The unit will withstand reasonable atmospheric and temperature conditions. A metal case encloses the moving element of the regulator to afford protection against dirt and dust. However it is recommended that the shipment should be checked immediately for loss or damage. If any such shortage or damage is found, it should be reported to the transportation company without delay.

2B. HANDLING AND UNPACKING

a) Care should be taken not to kink or bend the hinge-spring assembly. The moving-arm assembly should not be forced in any direction otherwise the performance of the regulator is likely to be unsatisfactory.

2C. INSTALLATION AND ERECTION

a) When the regulator is placed in position prior to the installation of other large apparatus nearby, the electrical equipment should be protected by box or crate parts, or sections of plywood.

2D. TEMPERATURE AND VENTILATION

a) Provision for cooling has been made by leaving the resistance plates exposed to the atmosphere and yet protected from harm by the use of a metal shield. These resistance plates are vertically mounted which assures rapid removal of heat from the unit. Free movement of air around the unit should be permitted for proper dissipation of the heat developed in the resistance plates.

2E. CONTROL CONNECTIONS

a) Each piece of apparatus has clearly marked terminal blocks or studs for connections. Leads should be connected as shown in the schematic and connection diagram. Due regard should be given to the polarity of the damping transformer otherwise the moving armature of the magnet will swing violently.

2F. ADJUSTING AND TESTING

a) The regulator has been carefully adjusted and tested at the factory and no readjustment should be required other than voltage adjustment by means of the voltage adjusting rheostat.

b) The following precautions are desirable before actually operating the unit. Check for the free operation of the moving armature. The clearances are approximately .013 ± .002 of an inch on each side of the moving armature. This armature must be exactly centered for all its travel in the air gap of the magnet. Sufficient clearance in the hinge spring holes permits centering the armature. If the armature should be out of center, thus causing a binding or rubbing against the bumpers, it is necessary only to loosen the hinge-spring screws, center the armature with a feeler gage to insure proper clearance and then tighten the hinge-spring screw thus locking the armature in position. Check to see that there are no bent or kinked hinge springs, as this will cause the armature to shift out of position. The leaf springs should under no condition be loose or bent.

c) The limit of travel for the moving arm should be just sufficient to permit all silver buttons to open and close. This travel can be adjusted by loosening the stop screws at the bottom of the moving arm, adjusting to permit all buttons to open and close, and then retightening the locknuts.

2G. LUBRICATION

a) Positively no form of oil or lubricating substances are required on this regulator. There are no bearings as all movement is accomplished through springs.

Contents

CONTRACT IDENTIFICATION

Purchaser
INGALLS SHIPBUILDING CORP.

Manufacturer
WESTINGHOUSE ELECTRIC CORP.
G.O. BH-69181-TY and BH-71041-TY
S.O. 23-Y-2533

MACHINE IDENTIFICATION AND RATINGS

A-C GENERATOR - S.O. 57-P-994 and 58-P-316
75 KVA, 450 Volts, 0.8 PF, 3 Phase, 60 Cycle, 1200 RPM

D-C EXCITER - S.O. 57-P-995 and 58-P-317
7.5 KW, 120 Volt, 1200 RPM

IDENTIFICATION AND DRAWINGS

Apparatus	Identification	Tab
SCHEMATIC AND CONNECTION DIAGRAM	18-D-9190	1
TYPE SRAN-4 REGULATOR CONTROL ELEMENT	S# 1584350	
Outline & Drilling Plan	9-D-1805	2
Internal Diagram	13-D-6243	2
DAMPING TRANSFORMER AND RECTIFIER ASSEMBLY	S# 1736122	
Outline and Drilling Plan	7-D-8980	3
VOLTAGE ADJUSTING RHEOSTAT	S# 1736119	
Assembly Dwg. (Assy. No. 1)	97-C-67	4
CROSS CURRENT COMPENSATOR	S# 1114839	
Outline & Drilling Plan	1-D-4638	5
Internal Diag.	1-D-4637	5
REGULATOR CUTOUT SWITCH	S# 1173289	
Outline & Drilling Plan Fig. 3 & 7 Lines 5 & 15	13-B-8976	6
CURRENT TRANSFORMER	S# 1304227	
Outline & Drilling Plan	89-C-763	7
POTENTIAL TRANSFORMER	S# 1304463	
Outline & Drilling Plan	2-C-3864	8
SPARE PARTS LIST	127-A-323	9

GENERAL INFORMATION

1A. FOREWORD

a) Careful reading of these instructions will provide information for the 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.

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c) The "SRAN-4" type of voltage regulator has four regulating resistance plates which can be connected in parallel, series-parallel or series. These in turn are connected directly in the exciter field circuit. On some installations it is considered advisable, due to exciter field characteristics, to use an exciter field resistor to limit the range of regulating resistance and improve the sensitivity.

d) The resistance is varied by the value of the current in the coil circuit. Normal operating range of the coil current varies from 0.145 to 0.165 ampere d-c from the rectifier.

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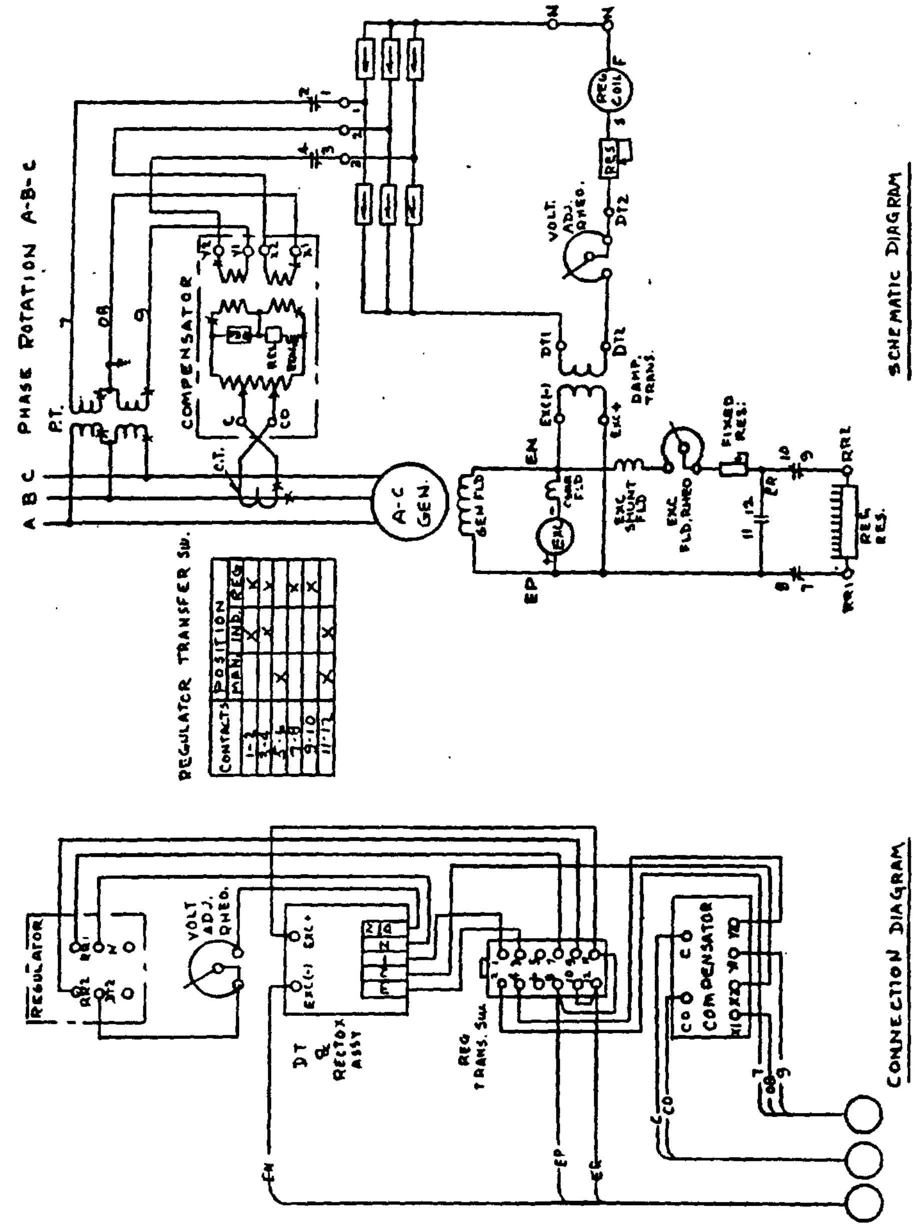
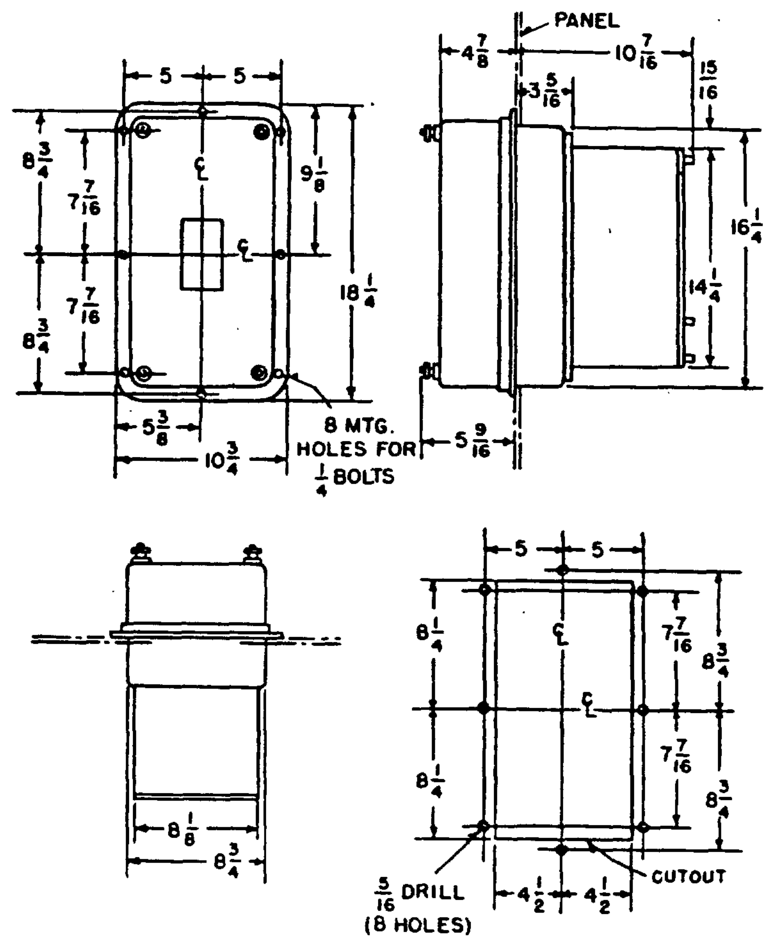
1I. REGULATOR CUTOUT SWITCH

a) The regulator cutout switch is of the rotary type provided with three positions



Schematic and Connection Diagram

Drawing 18-D-9190-3

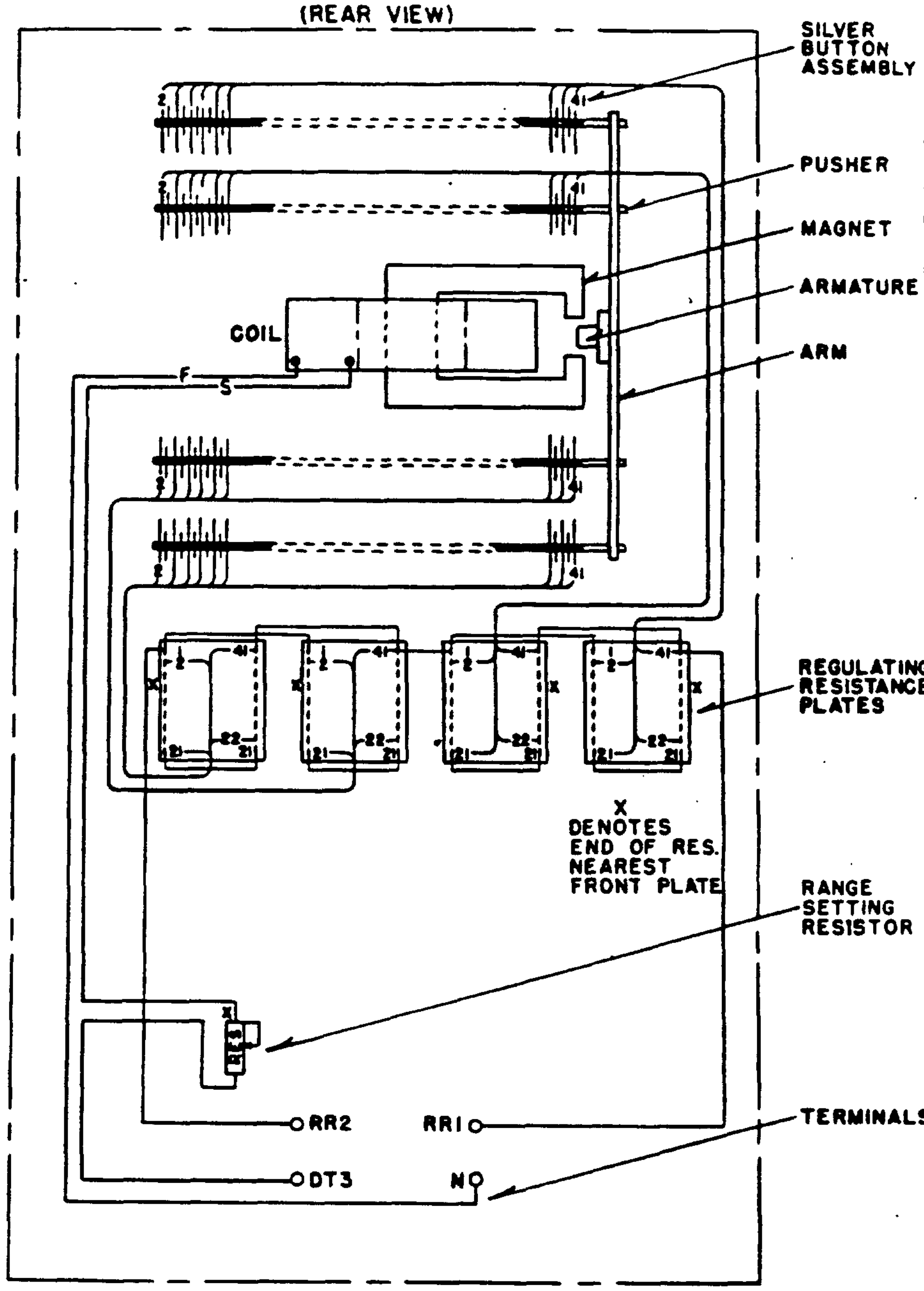


Outline Drawing and Drilling Plan

Drawing 9-D-1805-3

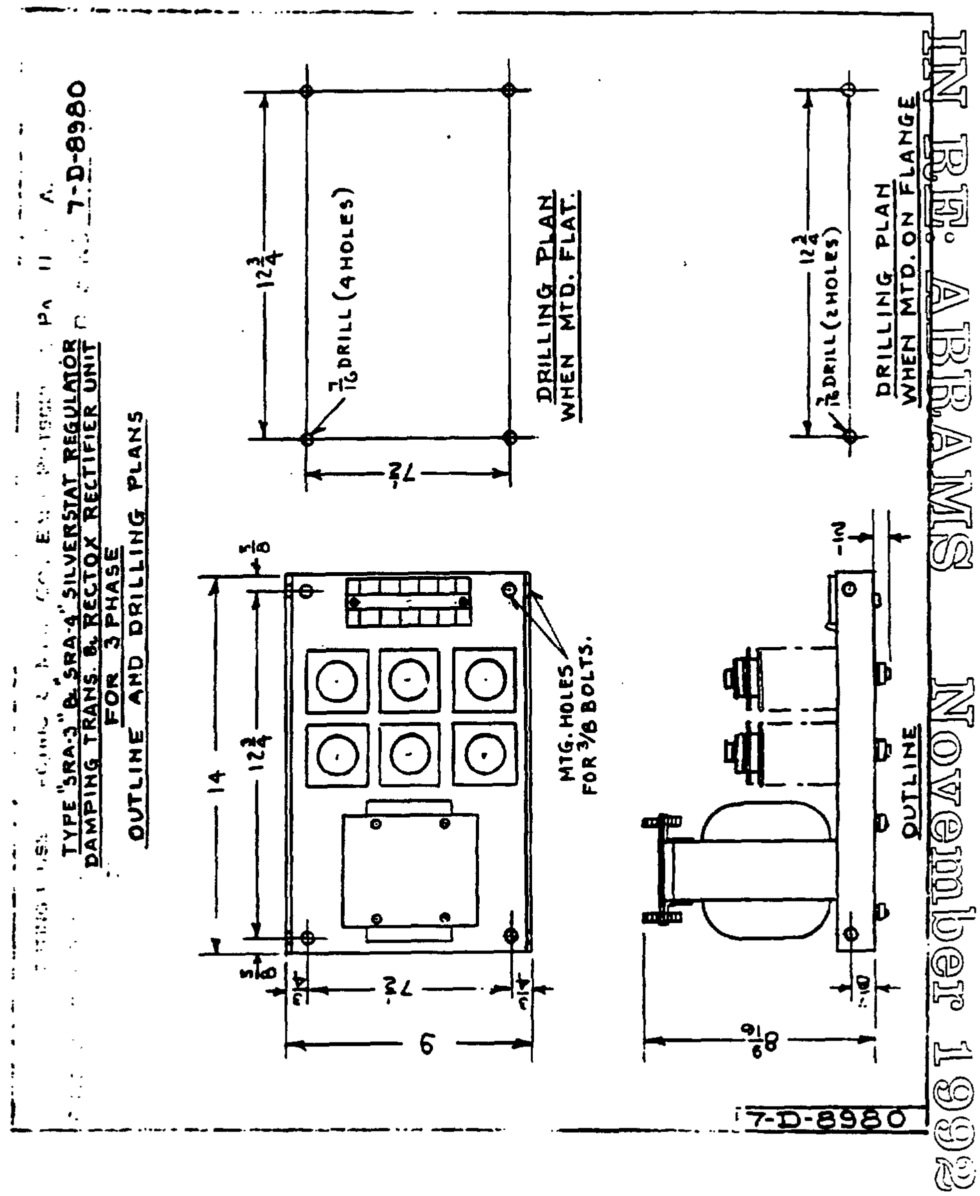
SERIES PARALLEL CONNECTED PLATES

(REAR VIEW)

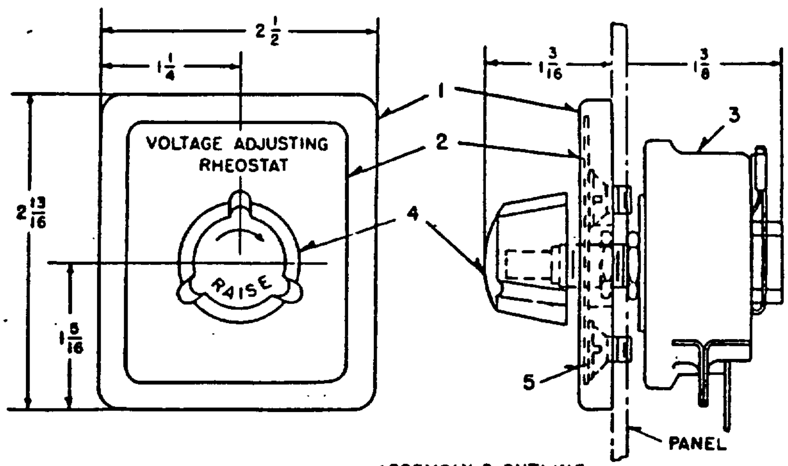


Internal Diagram

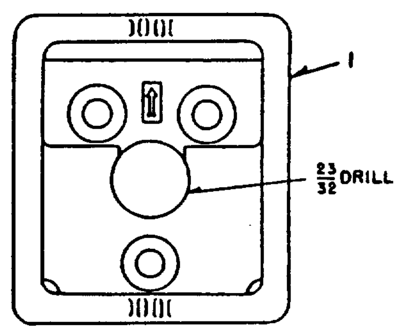
Drawing 13-D-6243-3

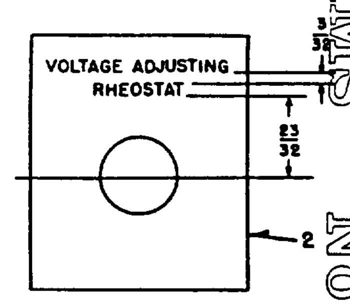


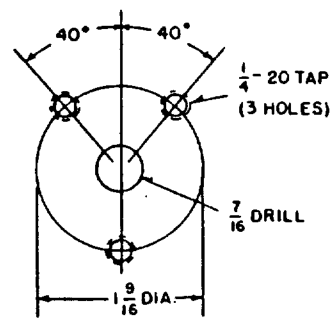
Dwg. 7-D-8980-1 Outline and Drilling Plan



ASSEMBLY & OUTLINE





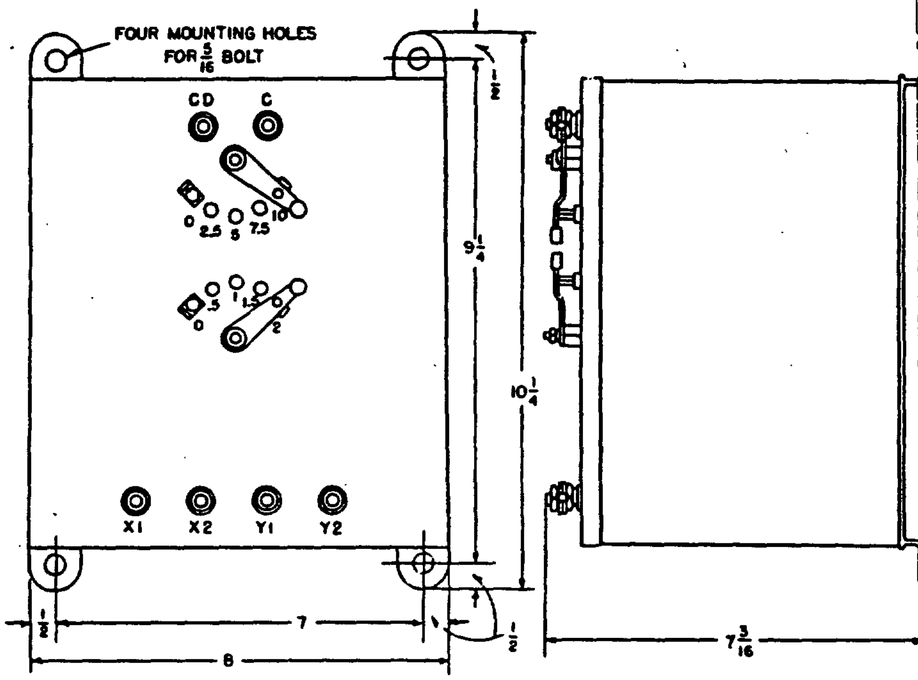


DRILLING PLAN

1	Dial Plate
2	Name Plate
3	Rheostat
4	Rheostat Knob
5	$\frac{1}{4}$ in. - 20 X $\frac{3}{8}$ in. Flat Head Steel Machine Screw

Voltage Adjusting Rheostats --
Assembly Drawing

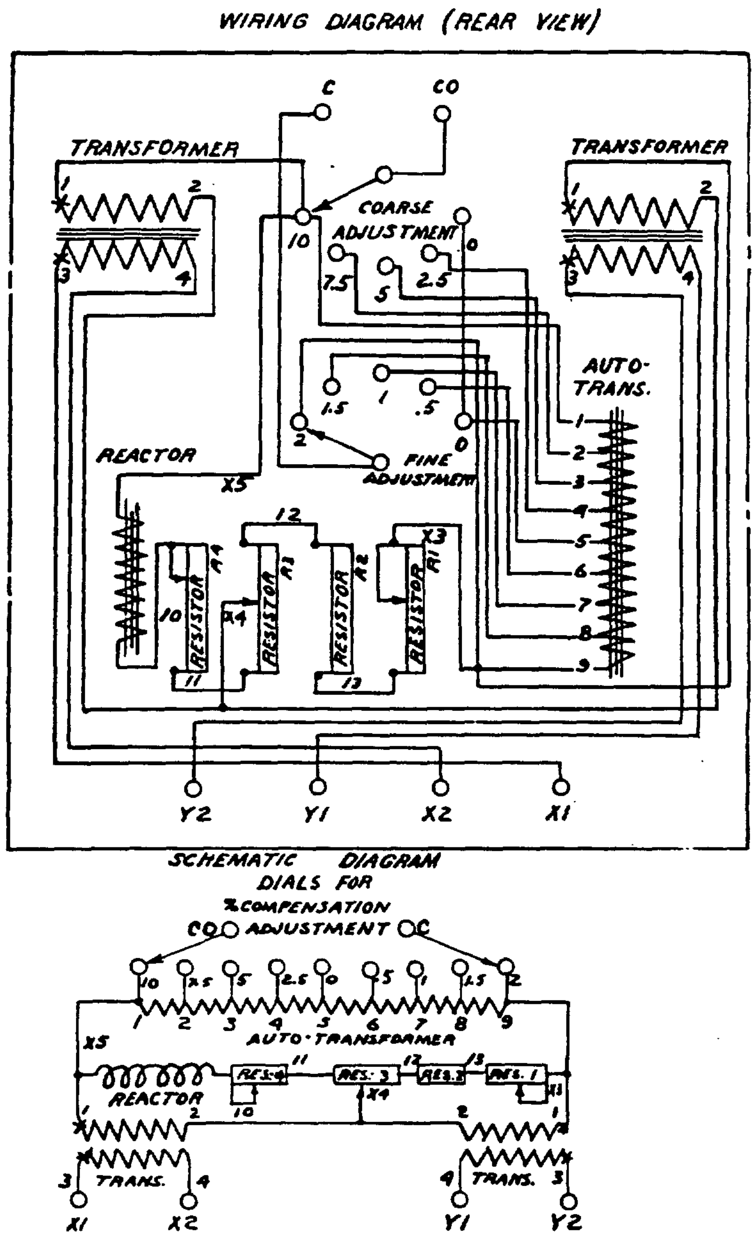
Drawing 97-C-67-2



Cross-Current Compensator --
Outline and Drilling Plan

Drawing 1-D-4638-1

NWB-00038344

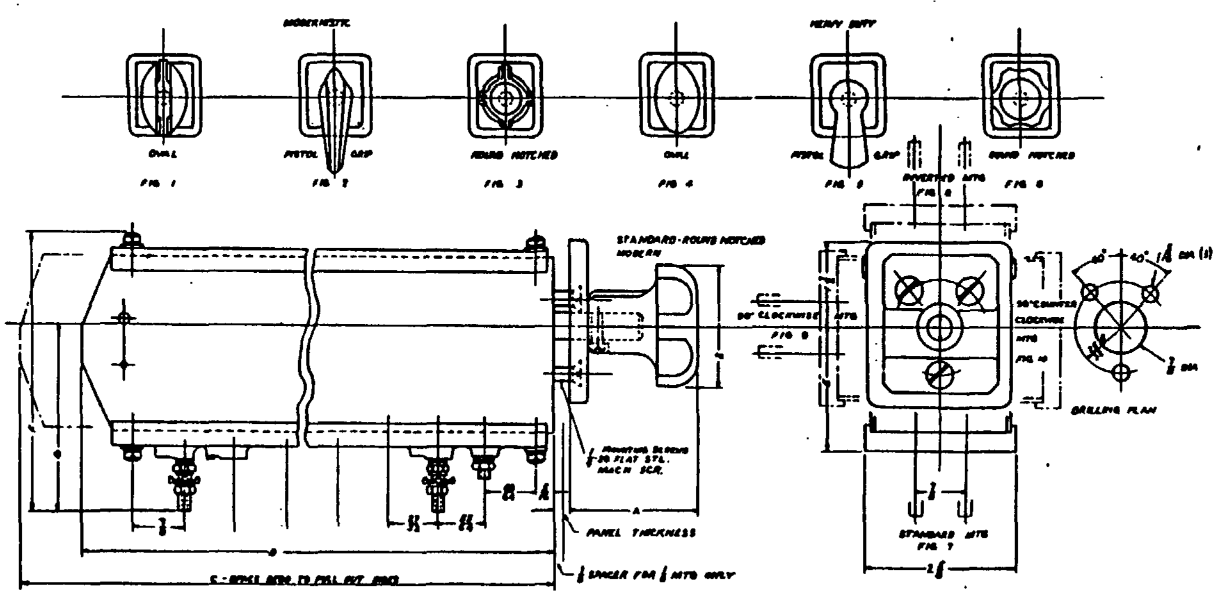


Cross-Current Compensator --
Internal Connection Diagram

Drawing 1-D-4637-7

NWB-00038345

IN RE: ABRAMS November 1992



LINE NO.	NO. POINTS	C	D	E	F	G
1 2	2 3	8-3/8 10-1/16	4-1/4 5-1/8	2-1/32 2-1/32	4-5/8 4-5/8	3-3/16 3-3/16
3 4	4 5	11-3/4 13-7/16	5-15/16 6-13/16	2-1/32 2-1/32	4-5/8 4-5/8	3-3/16 3-3/16
5 6	6 8	15-1/8 18-1/2	7-5/8 9-5/16	2-1/32 2-5/32	4-5/8 4-5/8	3-3/16 3-3/16
7 8	10 11	21-7/8 23-5/8	11 11-7/8	2-5/32 2-5/32	4-5/8 4-5/8	3-3/16 3-3/16

FIG. NO.	A
1 2	2-3/16 2-1/4
3 4	2-3/16 3-1/4
5 6	3-15/16 3-1/16

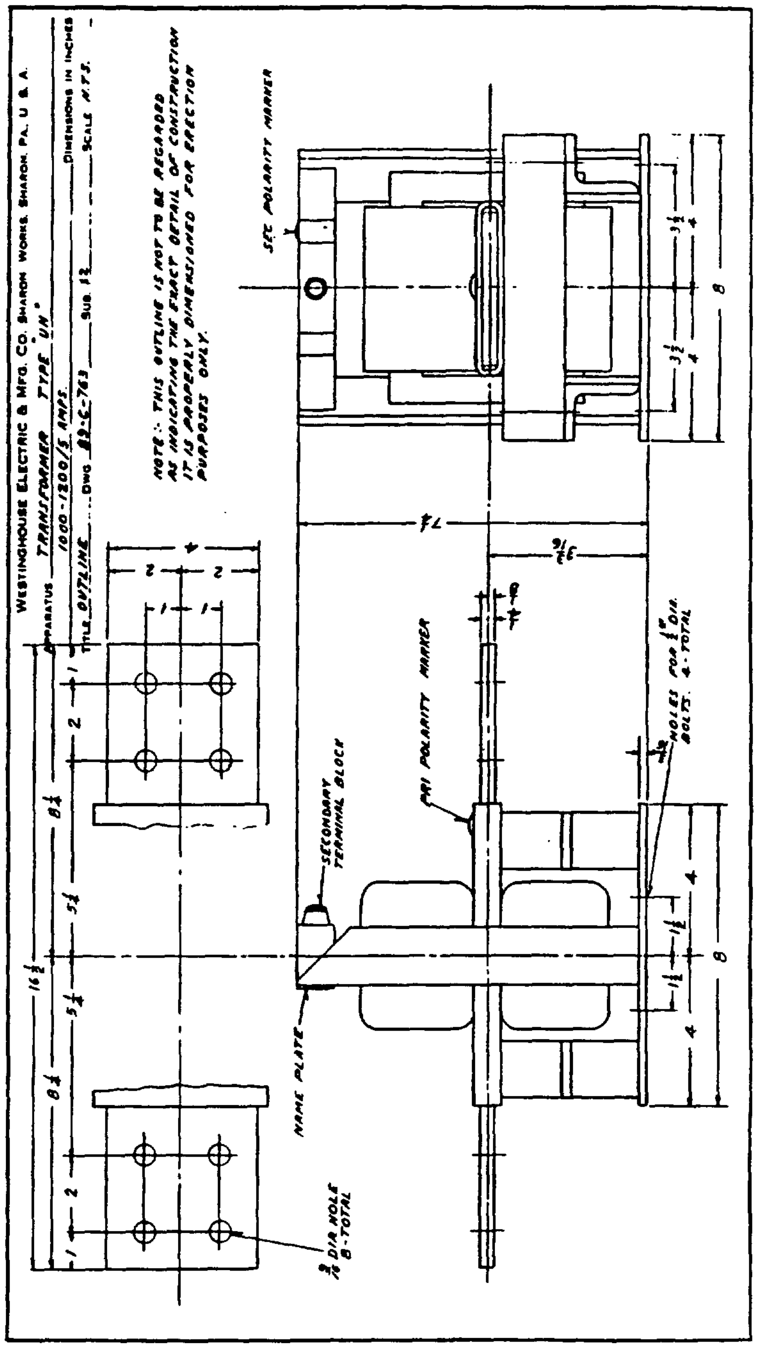
PANEL THICKNESS			
SYM	LINE NO.	PANEL THICK-NESS	"B" LENGTH OF SCREW
A	15 16	1/8-1/4 1	1-1/4 2
	17 18	1-1/2 2	2-1/2 3

A-1/8 THK SPACER IS FURNISHED FOR 1/8 PANEL THICKNESS

Regulator Control Switch -- Outline Drawing and Drilling Plan

Drawing 13-B-8976-6

IN RE: ABRAMS November 1992



Outline and Drilling Plan

Drawing 89-C-763-2

LIST OF REPAIR PARTS

ITEM NO.	NO. OF SETS	NO. PER SET	NAME OF PIECE	MFGR'S DATA STYLE NO.	MFGR'S DATA SHOP ORD.
			TYPE SRAN-4 CONTROL ELEMENT		23Y2534
1	1	4	SILVER BUTTON ASSEMBLY	1313989	
2	1	1	MAIN SPRING	1114610	
3	1	2	SHORT HINGE SPRING	1166944	
4	1	2	LONG HINGE SPRING	1313985	
5	1	1	MAIN COIL	1173224	
6	1	2	RANGE SETTING RESISTOR	1115103	
7	1	4	REGULATING RESISTANCE PLATE	1298910	
			VOLTAGE ADJUSTING RHEOSTAT		
8	1	1	RHEOSTAT	1736119	
			CROSS CURRENT COMPENSATOR		
9	1	1	RESISTOR	1115144	
			TYPE "W" REGULATOR CONTROL SW.		
10	1	3	CONTACT SEGMENT	1041505	
11	1	3	CONTACT SEGMENT	545626	
12	1	2	STOP FINGER	1114883	
13	1	12	CONTACT FINGER	1087205	

REPAIR PARTS LIST FOR TYPE SRAN-4 VOLTAGE REGULATING EQUIPMENT

WHEN REORDERING REFER TO STYLE NUMBER AND SHOP ORDER

WESTINGHOUSE REPRESENTATIVES IN FOREIGN COUNTRIES--Cont'd

Nicaragua	See Mexico
Panama	See Mexico
Paraguay	See Argentina
Peru	Cable Address--WEMCOEXPO Westinghouse Electric International Company, Attention of Regional Representative Casilla 1635, Avenida Wilson 9-90, 7th Floor, Lima, Peru.
Philippine Islands	Cable Address--WEMCOEXPO Westinghouse Electric Company, Ltd. Attention of Regional Engineer 301 Myers Building, Port Area, Manila, Philippine Islands.
Puerto Rico	See Cuba
San Salvador	See Mexico
South Africa	Cable Address--WEMCOEXPO (Johannesburg) Westinghouse Electric Company, Ltd. Attention of Regional Supervisor, P.O. Box 6067, 308 Union Corporation Building 78 Marshall St., Johannesburg, South Africa.
Spain	Cable Address--WEMCOEXPO Westinghouse Electric International Company, Attention of Zone Director, (Avda. Jose Antonio 7), Madrid, Spain.
Surinam	See Venezuela
Sweden	See France
Switzerland	See France
Trinidad	See France
Turkey	Cable Address--WEMCOEXPO Westinghouse Elec. Intl. Co. Attn: Project Representative c/o Tacico, 59 Bayindir Sokak Yenisehir, Ankara.
Uruguay	Cable Address--SERRACAS Westinghouse Elec. Intl. Co. Attn: Regional Supervisor c/o Serratosa & Castells, S. A. 18 de Julio 1110, Montevideo, Uruguay.
Venezuela	Cable Address--WEMCOEXPO Westinghouse Electric Company, S. A., Attention of Zone Director, Apartado 1889, Edeficio la Ceiba 3er Pisa Sociedad a San Francisco 8, Caracas, Venezuela.

DOMESTIC PORTS (Continued)

Port Everglades	Sales Office--731 Ingraham Bldg., Miami, Fla.
Portland, Me.	Sales Office--9 Bowman Street, Augusta, Maine
*Portland, Ore.	PORT ENGINEER--309 S. W. Sixth Avenue, Portland 4, Oregon Sales Office
Providence	Sales Office--51 Empire St., Providence 3, R. I.
San Diego	Sales Office--861 Sixth Avenue, San Diego 1, Calif.
*San Francisco	PORT ENGINEER--1 Montgomery Street, San Francisco 4, California Sales Office
Savannah	Sales Office--1299 Northside Drive, N. W. P.O. Box 4808, Atlanta 2, Georgia
*Seattle	PORT ENGINEER--3451 East Marginal Way, Seattle 4, Wash. Sales Office
Tacoma	PORT ENGINEER--1930 Pacific Avenue, Tacoma 2, Wash.
Tampa	Sales Office--608 Tampa St., Tampa, Fla.
Toledo	Sales Office--245 Summit Street, Toledo 4, Ohio
Wilmington, Cal.	PORT ENGINEER--600 St. Paul Ave., Los Angeles 17, Calif.
Wilmington, Del.	PORT ENGINEER--3001 Walnut Street, Philadelphia 4, Pa.
Wilmington, N. C.	Sales Office--210 E. Sixth Street, Charlotte 1, North Carolina

WESTINGHOUSE REPRESENTATIVES IN FOREIGN COUNTRIES

Africa	See Egypt and South Africa
Argentina	Cable Address--WEMCOEXPO Westinghouse Electric Company, S. A., Attention of Zone Director Paseo Colon 221, Buenos Aires, Argentina.
Australia	Cable Address--WEMCOEXPO (Sydney) Westinghouse Electric International Company, Attention of Zone Director, Box 23, Waterloo, N. S. W., (Joynton Avenue), Sydney, Australia.
Brazil	Cable Address--WEMCOEXOP (Rio De Janeiro) Westinghouse Electric Company of Brazil, Attention of Zone Director, Caixa Postal 1320, (Av. Graca Aranha 182-10^{o} Andar) Rio de Janeiro, Brazil.
	Cable Address--WEMCOEXPO (Sao Paulo) Westinghouse Electric Company of Brazil, Attention of Regional Engineer, Caixa Postal 5156, Rua 15 de Novembro 200-3^{o} Andar - Sala 1 Sao Paulo, Brazil.
British Guiana	See Venezuela
Ceylon	See India
Chile	See Uruguay
China	See Philippine Islands

*Repair Shop

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