Westinghouse

Turbine-Generator Units

INSTRUCTION BOOK

for

The Care and Operation

of

05 EHNC Turbine

Westinghouse Electric & Manufacturing Company

South Philadelphia Works

Philadelphia, Pa.

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Index

Westinghouse

TURBINE-GENERATOR UNITS

25 to 50 Kw.

Instructions for the Care and Operation

of

05-EHNC Turbine

General Description

The unit described herein consists of a turbine of the Westinghouse impulse re-entry type and a gear connected to a direct-current or alternating-current generator, the turbine rotor being mounted on the pinion shaft.

Steam enters the turbine through the throttle valve, which is of the quick closing type and is controlled by the automatic stop governor in such a manner that it will close instantaneously if the turbine overspeeds a predetermined amount. The steam next passes through the governor valve into the nozzle chamber from which it expands through the nozzles to the exhaust pressure and impinges upon the blades which are mounted around the periphery of the turbine wheel. After passing through the blades, the steam is received in a reversing chamber which changes its direction of flow and again directs it upon the turbine blades. After having passed through the blades twice practically all of the energy obtained by the expansion of the steam through the nozzles has been transformed by the turbine wheel into mechanical work and the steam flows into the turbine casing and passes out through the exhaust line.

Dismantling:

This unit was designed with the purpose of obtaining a compact unit, and facility of dismantling and assembling was sacrificed somewhat in order to shorten the overall length of the unit.

To inspect the reduction gear and the turbine rotor, first remove the upper half of the generator distance piece "83" Figure 2. Next disconnect the governor lever "107" from the lever connecting link "108" Fig. 3. Remove the governor case cover "94" and reach down and remove the two trunnion bolts "106" which are held in place by cotter wire. Remove the governor lever rock shaft bracket "112" with the levers "104" and "107" and connecting mechanism. After disconnecting the oil pipe to the strainer, the gear housing cover may be lifted. Care should be taken not to bend the governor spindle in this operation.

The turbine cylinder cover "52" may be removed after the gear housing cover has been removed.

Upon removal of the gear housing cover, the governor bracket may be unbolted and the governor, bracket and oil pump, lifted out as a unit.

With the turbine cylinder, gear housing, turbine bearing covers, and the governor removed, the turbine and pinion shaft may be lifted out with its bearings. The bearings may then be slipped off the ends, or they can be removed without displacement of the shaft by removing the end cover plates and rotating the bearings in the housings until the dowels are free of their grooves. This should always be done before removal of generator with gear, as subsequently described under "Removal of Armature", in order not to injure the gear teeth. If the gear teeth are jammed, they should be re-dressed carefully by scraping to remove any high spots.

If the governor valve stem is to be disconnected, markings or measurements should be made previously in order to preserve the setting.

Assembling:

Before replacing turbine or gear case covers, thoroughly clean all interior parts and surfaces using gasoline and cloths (not waste) freely to remove all dirt. Clean the flange joint and paint with shellac, bolting the covers in place before the shellac hardens. A very light cotton thread used as a gasket with shellac makes a good joint. No other gasket should be used.

Maintenance

Adjustments:

All alignments, adjustments, settings, etc., are properly made before shipping and should not under any ordinary circumstances be changed.

Clearances as shown on the Figures contained in this book should be maintained. Pinion and turbine bearings should have between .008 and .012 inch, gear and generator bearings between .008 and .012 inch and gear thrust between .005 and .010 inch. This latter may be adjusted by changing the number of liners behind the thrust collars.

If it is necessary to change the speed slightly, the governor spring adjusting nut "120" (Figure 3) may be screwed down to increase the speed or in the opposite direction to decrease the speed. The location of this nut is evident upon removal of the small cap "95" on top of the governor case. DO NOT ATTEMPT SPEED ADJUSTMENTS BY MANIPULATION OF THE GOVERNOR VALVE STEM LINK.

The sensitiveness of the governor may be increased, that is, the percentage regulation decreased, by screwing the nut "122", which holds the upper coils of the governor spring, out of the coils a turn or so and thus weakening the spring scale by adding to the number of active coils. When this is done care must be taken so as not to get too great a degree of sensitiveness, thus approaching isochronism, a condition which will cause the governor to "hunt".

One of the most important adjustments on the unit is the proper setting of the governor valve in order that the valve will be on its seat before the governor sleeve has reached the end of its travel. To obtain this setting, remove the governor housing, mark the posit on of the governor spring nut so as to return it to its original position, and slack up on the nut until the weights can be pulled outward by hand. Insert a piece of steel or any handy object, at least 3/8" thick, between the governor sleeve "115" (Figure 3) and the thrust ring "128" holding or wedging the weights outward. Now adjust the gov-

ernor valve stem in its head "145" until the valve is just on its seat and tighten the lock nut in this position. This same setting may be checked in a simpler manner by merely removing the valve stem pin and measuring the distance the valve drops to its seat. This should not be more than $1\frac{1}{32}$". This simple method of checking the governor setting can be tried occasionally to insure that nothing has disturbed the setting. In connection with the valve setting, any excessive lost motion of the governor levers and links should be noted and eliminated. The evers must be a tight fit with their keys on the rock shaft and if looseness is evident new keys should be fitted.

If the governor valve is replaced be very careful to see that the new valve is properly pinned to the stem, and that the setting is as given in the preceding paragraph.

If any unsteadiness of voltage is noticed during the operation of the unit, it may indicate that the governor valve stem is sticking. The unit should be shut down at the first opportunity and the trouble corrected by moving this valve stem up and down by hand until free.

When any change is made in the adjustment of the throttle valve stem packing, the valve should be opened and tripped by hand to be sure that it will be closed quickly by the pressure of the spring.

When overhauling the gear, it is well to check the alignment of the gear and pinion in the horizontal plane (center distance) by means of the gauges furnished. These gauges should just fit between the aligning collars at the ends of the pinion and gear shafts. Be sure to place the gauge properly, as stamped upon it. The axial play or freedom of the pinion shaft relative to the gear should be from .012 to .020 inch when set to the gauge. The alignment in the vertical plane is indicated by the contact marks on the teeth. These marks should be distributed over the length of the teeth, and not concentrated at the ends. The setting of the pinion shaft has been done in the shop by experienced men, and a change is warranted only in case the operation of the unit has been seriously affected by extraordinary circumstances. If it is necessary to change the setting of the pinion shaft, it may be done by shifting the liners under the bearing pads. The total number of liners under opposite pads should not be altered, but the liners shifted from one pad to the opposite one. Care must be taken not to interchange the pinion and turbine bearings, and to replace them in their proper positions, making sure that the oil hole in the top is unobstructed.

Nozzle and Reversing Chamber:

These parts require practically no attention unless it is necessary to renew the nozzle after considerable use on account of erosion which is due to the use of very wet steam. In setting a new nozzle, care must be taken in making the joint. Anneal the copper liner by heating to a red color and quenching in water. All surfaces entering into the joint must be cleaned carefully and should be given a light coat of thin shellac just before bolting the nozzle down. Inasmuch as leakage through this joint is wasted steam, care cannot be over-emphasized in properly replacing the nozzle.

The reversing chamber does not require a joint of this kind since there is no change in pressure between the inside and the outside. The clearance between the nozzle and the blades, and between the reversing chamber and the blades should be nominally $\frac{1}{32}$" and should not be less than .020 or more than .050 inch. This clearance can be determined by the use of a feeler gauge with the rotor in its central position, as determined by the mesh of pinion teeth.

Bearings:

The pinion and turbine bearings consist of solid shells lined with babbitt. One bearing or both may have pads with liners underneath for adjustment of the pinion relative to the gear, as covered in another part of this book. The screws holding the pads in place should be set up tight and the shell with its pads should fit nicely in its housing. The clearance between the journal and bearing should be .008 or .012 of an inch. More than .014 is excessive. The bearing contains but one oil groove, which is located lengthwise on the top, oil being admitted to the center of the groove. If it is necessary to rebabbitt a bearing, the utmost care should be exercised to re-bore or ream centrally and parallel with the surface of the pads.

The gear bearing is made in halves, obtaining its oil along the horizontal centerline on either side, through the oil grooves cut lengthwise in the shell. The clearance of this bearing should be between .008 and .012 of an inch. More than .014 is excessive and should be corrected. In re-babbitting this bearing, care must also be taken to bore it centrally. This bearing also serves as a thrust bearing to limit the axial play of both the gear and pinion shafts. The thrust clearance should be from .005 to .010 of an inch. In re-babbitting care must be taken to chamfer and groove the thrust faces properly. The axial position of both shafts may be adjusted by changing the number of liners behind the thrust collars.

Turbine Wheel and Pinion:

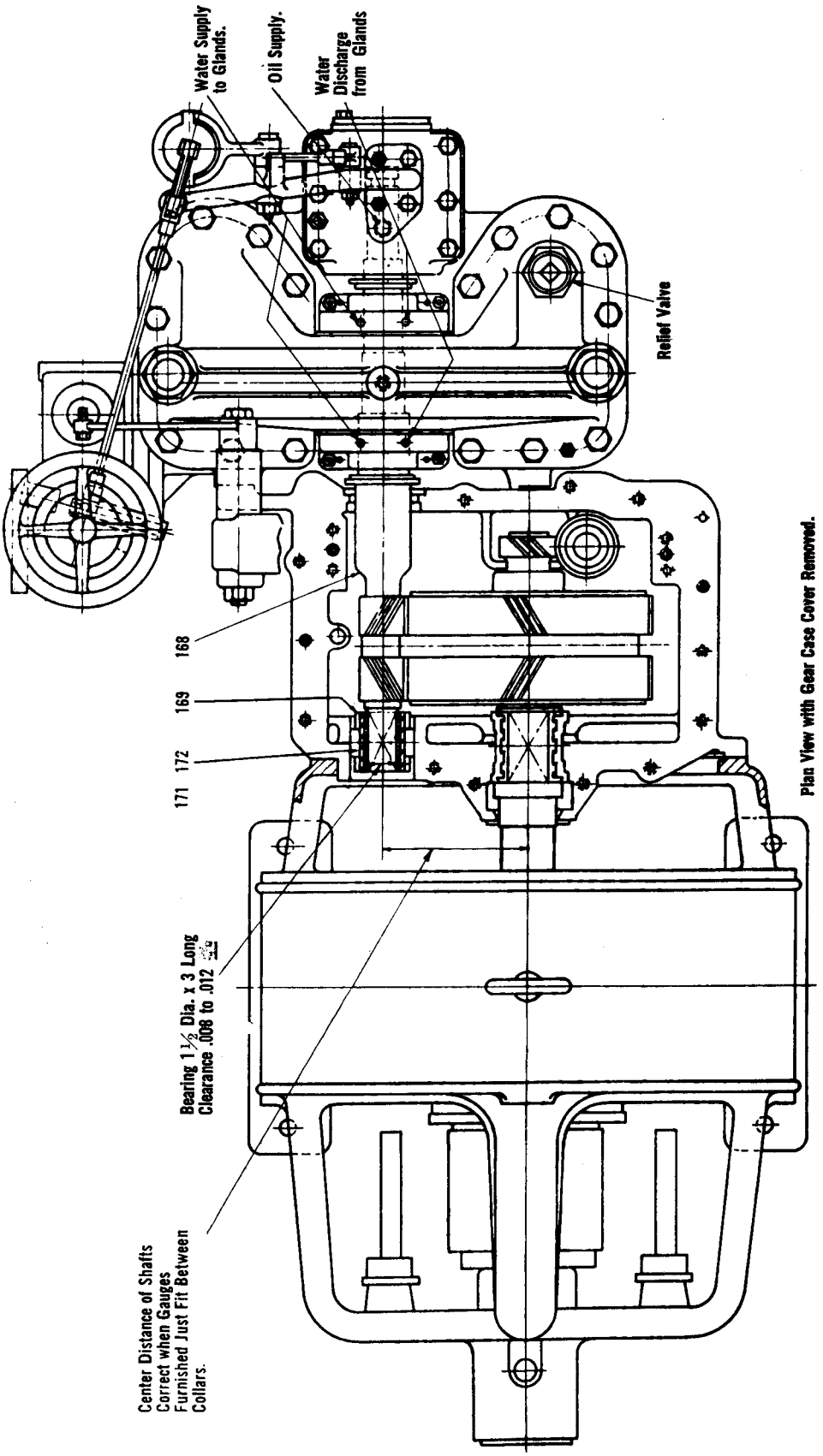
The turbine wheel is pressed and keyed on the pinion shaft along with the gland runners and collars. The wheel should not be removed from the shaft except in very special cases. If this is done, the utmost care must be exercised to prevent springing of the shaft and injury of the fit. The shaft and rotor must run true within .002 of an inch. In adjusting the thrust bearing for proper position of the rotor, attention must also be given to the proper position of the gland runners. The proper clearance between the blades and the nozzles is given under the heading "Nozzle and Reversing Chamber." The clearance on each side of the gland runners is normally $\frac{1}{32}$ inch and should be between .015 and .045 of an inch.

The rotor must be in balance for smooth operation. If unbalance is indicated by vibration, check rotor and shaft on parallels. A good static balance is sufficient. Balancing can be best effected by chipping metal off both sides of the rotor equally at the inner shoulder of the rim. Do not chip further back than $\frac{3}{8}$ of an inch and take off the edge by bevelling. Vibration is not necessarily caused by unbalance, but may be due to parts rubbing or misalignment.

Gear Wheel:

The gear wheel, shown in Figures 1 and 2, consists of a cast iron center upon which is shrunk a steel ring in which the gear teeth are cut. This rim should never be removed, unless it is necessary to have a new gear, in which case the old one should be sent to the factory for repair.

To determine the proper relative location of the pinion to the gear in the horizontal plane, two aligning gauges properly marked are furnished with the unit. These gauges should fit nicely between the aligning collars at the ends of the gear and pinion teeth, as indicated on the plan view in Figure 1. The pinion and turbine bearings may be adjusted to secure this fit. The object of



Plan View with Gear Case Cover Removed.

Fig. 1

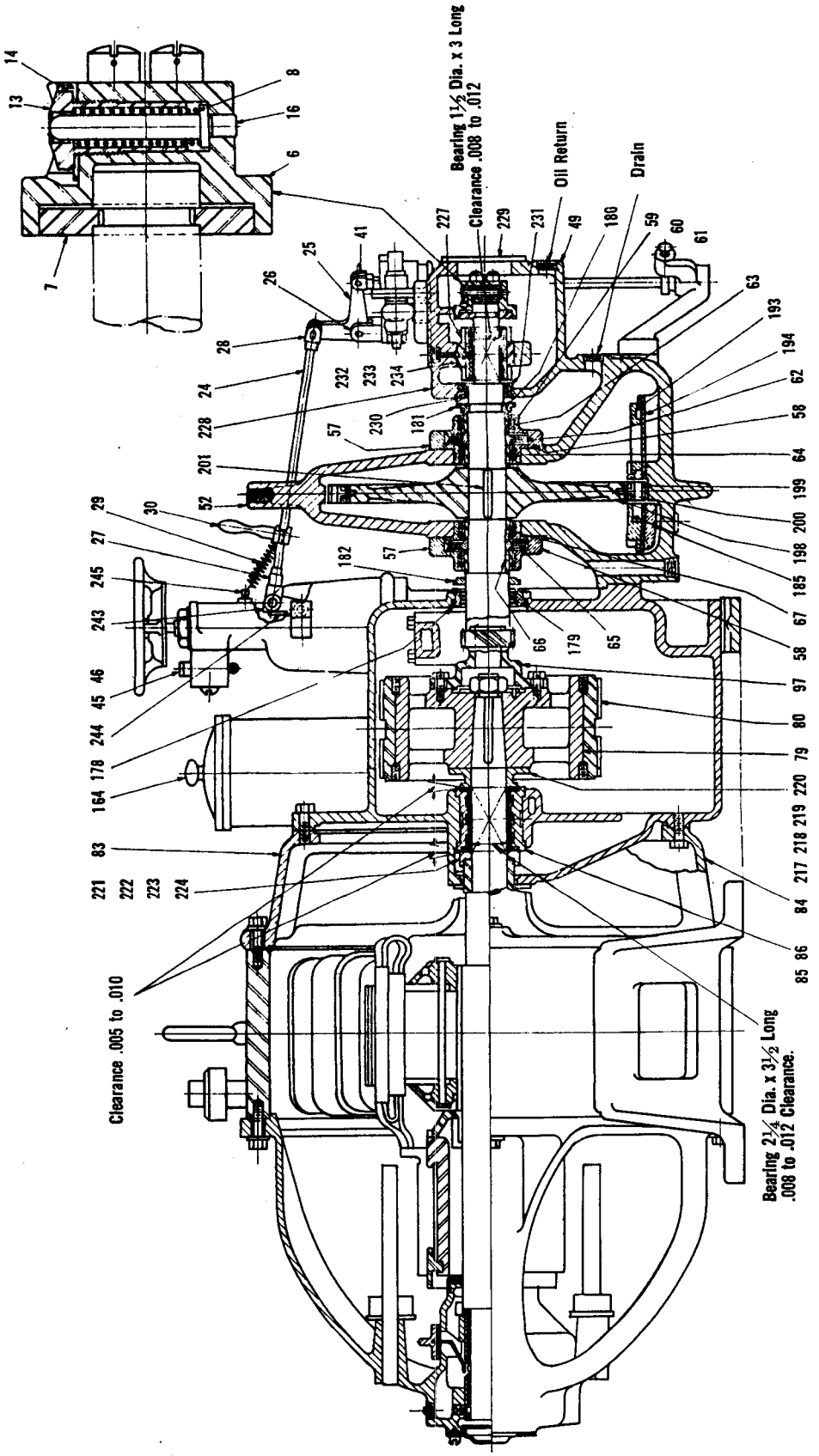

Bearing 1½ Dia. x 3 Long
Clearance .008 to .012
Oil Return
Drain
Clearance .005 to .010
Bearing 2¼ Dia. x 3½ Long
.008 to .012 Clearance.

Fig. 2

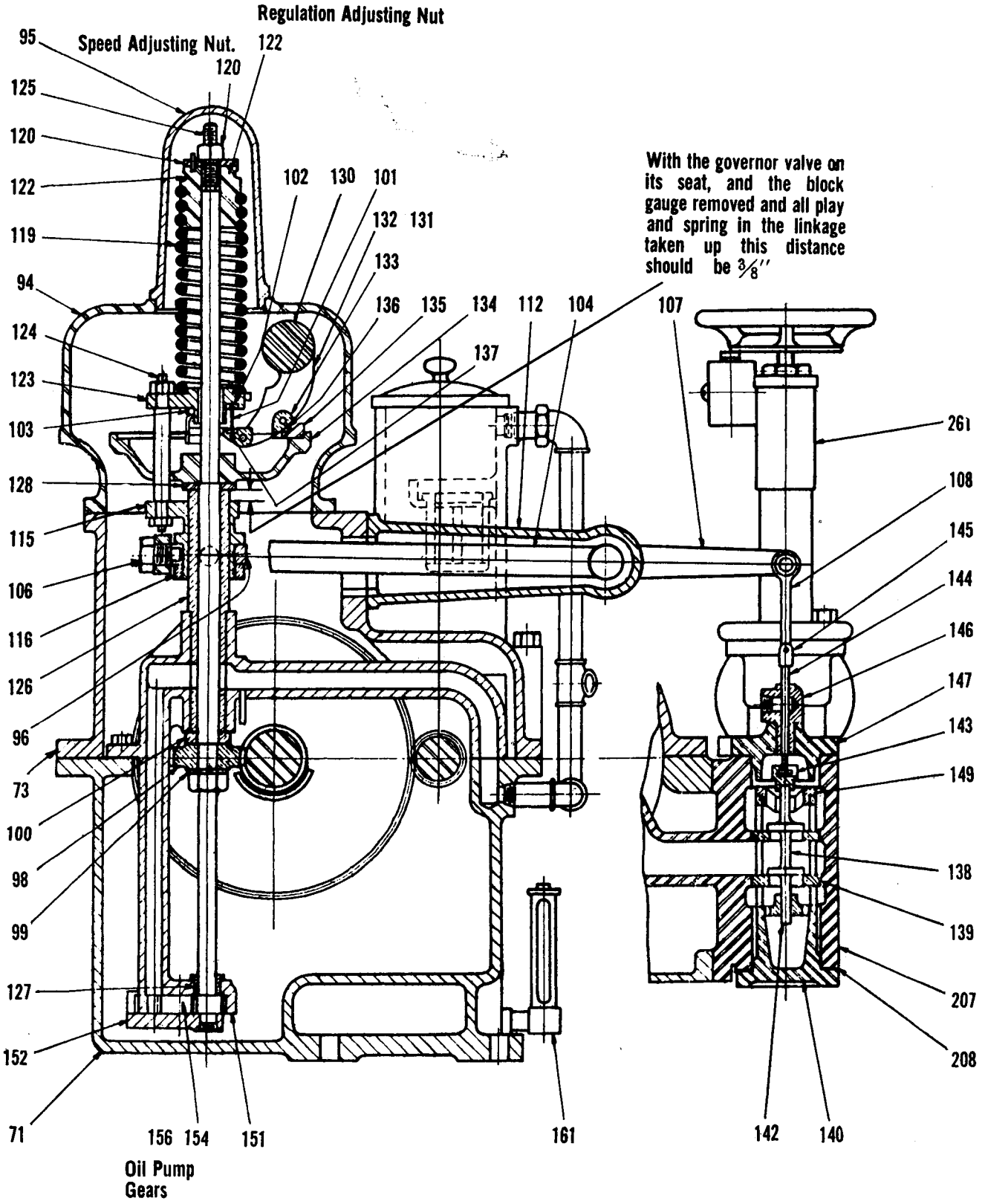

Regulation Adjusting Nut
Speed Adjusting Nut.
95
122
120
125
120
122
119
94
124
123
103
128
115
106
116
126
96
73
100
98
99
127
152
71
102
130
101
132
131
133
136
135
134
112
104
137
With the governor valve on its seat, and the block gauge removed and all play and spring in the linkage taken up this distance should be 3/8"
107
261
108
145
144
146
147
143
149
138
139
207
208
142
140
161
156
154
151
Oil Pump Gears

Fig. 3

these gauges is to make the pinion shaft parallel to the gear shaft and in case of loss of the gauges this may be done by such other means as may be devised. The proper center distance is such as will allow the pinion to be moved axially relative to the gear wheel between .012 and .020 of an inch. In determining this it is well to wedge the gear wheel over against one face of the thrust bearing and use a feeler gauge at any convenient place on the pinion shaft, as for instance, between a gland runner and case. Care must be taken in determining this movement to see that the rotor or glands do not rub against their adjacent parts. If this is the case, the thrust bearing should be adjusted so that the rotor or gland runner will not touch at either limit of the axial movement, as determined by the meshing of the teeth.

The alignment in the vertical plane can be properly determined only by the operation of the machine under approximately full load and examination of the teeth for distribution of contact marks.

The gear and pinion teeth should show no signs of wear over a long period. Slight pitting about the pitch line may occur but is not serious. Cutting or flaking of the teeth indicates poor alignment or poor lubrication. Check the alignment and examine the oil pan under the pinion to make sure that the pinion is dipping in oil.

Governor:

The construction of the governor is shown in Figure 3. Any troubles that occur with this mechanism can usually be traced to improper seating of the knife edges, a sprung spindle, or incorrect alignment of the sleeve "115" with the spring sleeve "123" so that the sleeve binds on the bushing.

In assembling the trunnion bolts "106" care must be taken to see that they are properly replaced according to marking and that they enter the clutch freely and without binding, also that the clutch does not bear upon the spindle or bind. These trunnion bolts must be thoroughly wired to the lever. See that the knife edges "101" and fulcrum knife edges "136" are in the proper position in their blocks and that the spring is over its spigot on the sleeve.

Governor Valve:

The governor valve is shown in Figure 3 and consists of a spool dowelled on the stem and working within a cage, which is pressed into the steam chest. The valve should be tested occasionally to insure against excessive leakage. The leakage is only excessive when, with the valve pressed on its seat and a full head of steam upon it, the turbine will continue to rotate. This valve is not susceptible to grinding on its seat, since this results in unbalancing the valve, causing irregular governing. The cage should be tight in the steam chest when hot.

Reseating Governor Valve:

If this is necessary, face off the lower disc in a lathe, facing back the level on the upper disc the same amount. Bore the cage in the same manner, facing off the upper seat and turning back the bevel on the lower seat. The object of reseating can plainly be seen from the fact that the contact between the two parts must be a line rather than a surface, in order to keep the two diameters to practically the same dimension and maintain the balance.

Automatic Stop Governor:

The automatic overspeed stop is shown in Figure 2. It consists of a plunger or weight "16" set transversely in the pinion shaft and held in place by the spring "8" and retainer "13". At the proper speed, between 8 and 12% above normal, for which it is set, the centrifugal force of the plunger overcomes the resistance of the spring and flies outward about $\frac{3}{16}$ of an inch, striking the lever "20" (Figure 6). The movement of this lever releases the engagement of the release lever "31" allowing, through the connecting linkage, the weight "35" to fall. This weight is guided by the rod "40" so as to strike the collar at the lower end, the blow tripping the throttle valve latch whereupon the throttle valve is forced to its seat by a heavy spring "249" (Figure 4). The stop may be reset by turning the throttle valve handwheel in the closing direction to its stop and returning the weight "35" to its upper position.

To change the setting of the auto stop, that is, the tripping speed, insert thin liners or washers (.005 or .010 thick) between the spring retainer "13" (Figure 2) and the end of the spring so as to increase the spring compression and hence the tripping speed or remove washers to reduce the tripping speed. In case no washers are present grind the end of the spring off squarely. Be very careful to place the liners between the retainer and the spring and not between the spring and the collar on the end of the plunger.

There is only one other important adjustment to the stop linkage; that being the clearance between the cam lever and the shaft. This clearance should be between $\frac{1}{32}$ and $\frac{1}{16}$ of an inch.

The plunger must work freely. It may be pushed outward with a rod in order to determine whether or not it is free. There should be ample clearance in the pins and shafts comprising the linkage since there is no call for close fitting and inasmuch as looseness, guards against sticking. A few drops of oil occasionally will help to prevent rust and consequent sticking.

The action of this governor should be checked occasionally, to make sure that the weight flies out and trips the valve at the proper speed. This can be done most conveniently by disconnecting the link "108" (Fig. 3) from the governor lever "107" and holding the valve up off its seat while the turbine is overspeeded by slowly opening the throttle valve. Another method is to mark the position of the governor spring nut "120" (Fig. 3) so that it can be reset to its original position, and then screwing it down sufficiently to permit the turbine speed to be increased to the tripping point by opening the throttle valve. In either case, a direct reading tachometer should be used to guard against excessive speed in case the automatic stop governor should fail to function.

Do not overspeed the turbine by pulling up on the governor lever "107" (Fig. 3). Such procedure is apt to damage the keys in the inner and outer governor levers "104" and "107", after which the governor may fail to control the speed properly.

Throttle Valve:

The construction of this valve is shown in Figure 4. The stem screws through a nut "246" which is kept from turning by a pin. A hardened steel washer "247" on the bottom of the nut engages the latch "243" (Figure 2) to hold the nut in its uppermost position. When this latch is tripped out by the auto-stop or by hand, the spring "249" forces the valve to its seat. Resetting is accomplished by turning the handwheel in the closing direction, which screws the nut upward, until engagement of the latch "243" and plate "244" is effected.

No special attention is required other than, after tightening the gland nut "258", to test the free working of the stem by tripping the auto stop by hand.

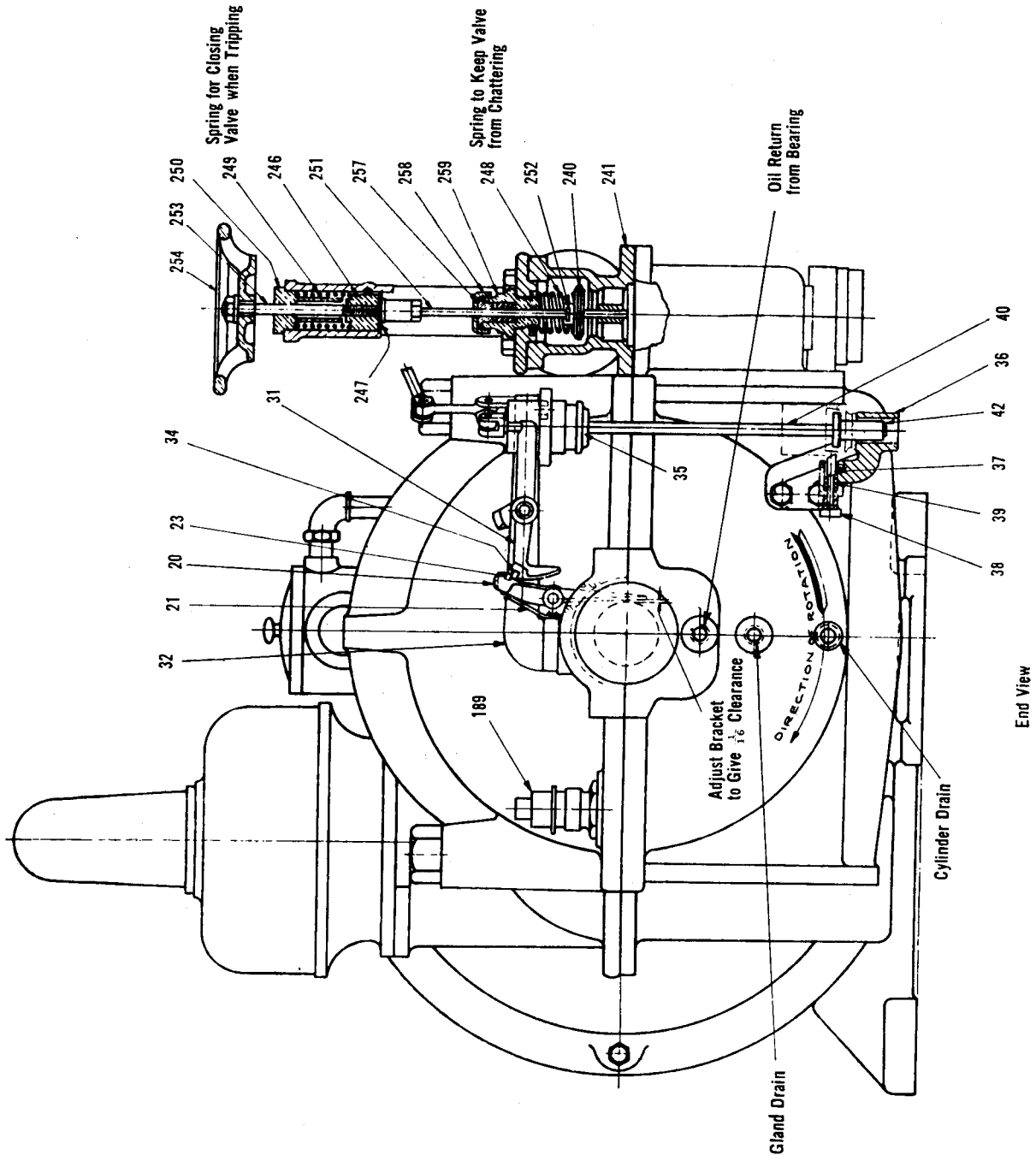

Spring for Closing Valve when Tripping
Spring to Keep Valve from Chattering
Oil Return from Bearing
250
249
246
251
257
258
259
248
252
240
241
253
254
247
31
34
23
20
21
32
189
35
40
36
42
37
39
38
Adjust Bracket to Give 1/16 Clearance
Gland Drain
Cylinder Drain
DIRECTION OF ROTATION
End View

Fig. 4

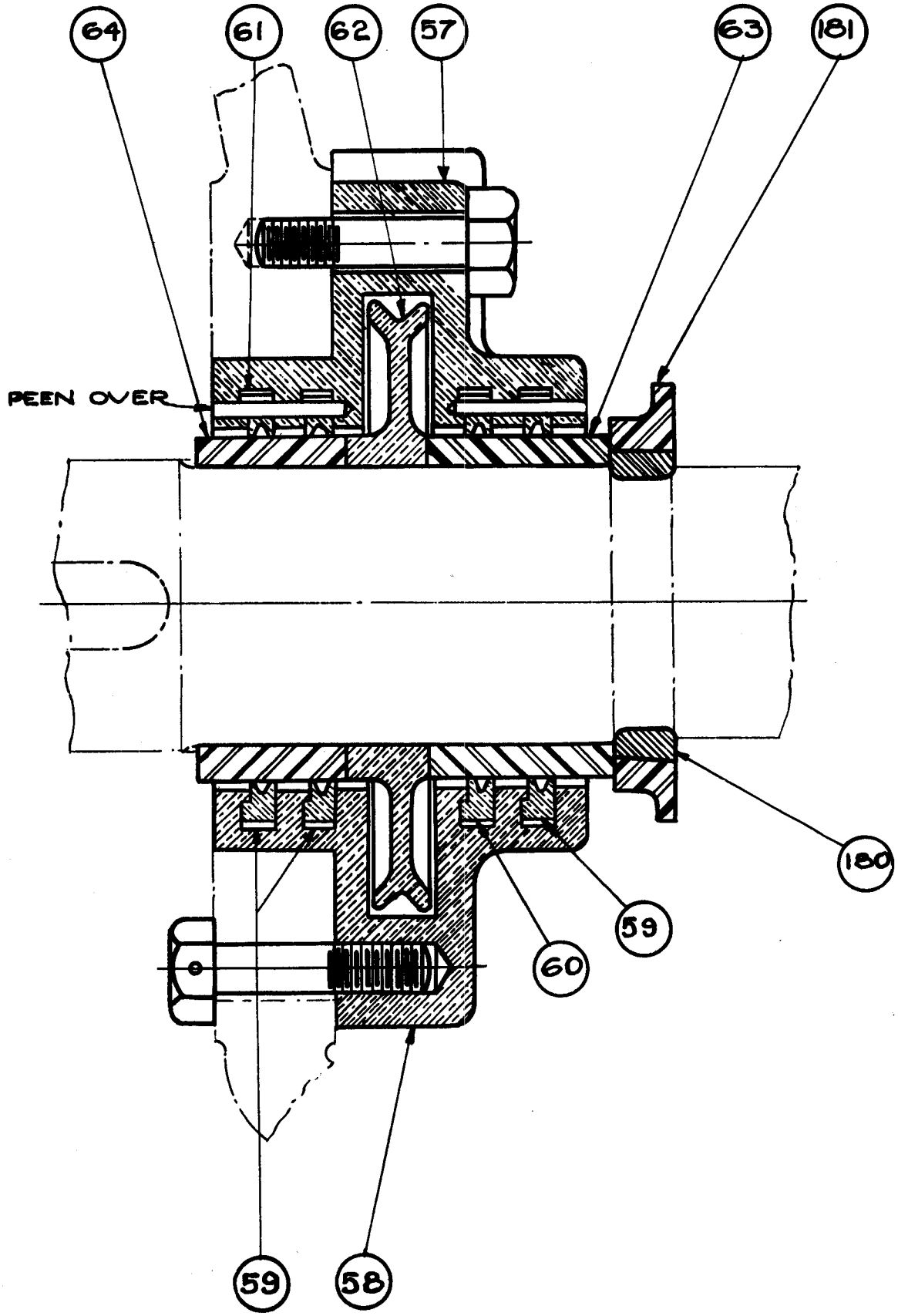


Fig. 5

The valve disc may be ground on its seat after removing the bonnet and stem.

Spindle Glands:

The glands used on this turbine to prevent the leakage of steam out of, or air into the turbine cylinder, are of the water seal type. The gland is shown in Figure 5. A runner shrunk on the shaft acts as a centrifugal pump impeller, building up an annulus of water at its periphery having sufficient pressure to prevent steam forcing its way past. The pressure built up by the gland runner is dependent upon the pressure of the sealing water supplied, which should be three or four pounds in excess of the back pressure sealed against. It is necessary to circulate water through the gland in order to prevent boiling, except when the turbine is operating condensing. The water outlet should, therefore, always be open when operating non-condensing. It should be noted that the water seal is not effective when the runner is stationary or rotating at low speeds. Therefore, if the turbine exhausts into a high vacuum, it is necessary to provide a steam connection so that steam can be admitted to the glands for sealing during the starting periods. Both openings in the gland case connect into the water chamber at the periphery of the runner. The relative position of these connections is shown in Figure 1 for a clock-wise rotation of the rotor, viewed from the auto-stop governor end of the turbine.

These glands are also equipped with an auxiliary packing of the labyrinth type. The packing ring is made up of four segments, each of which is held in place against the shoulder of the groove in the gland case with its ends just touching those of the adjacent segments, and its thinned edges barely touching the rotating shaft.

The glands require no adjustments. The proper clearances of the runners are given under "Turbine Wheel and Pinion" as $\frac{1}{32}$ of an inch or from .015 to .045 of an inch. The labyrinth packing rings should have a sidewise clearance in the grooves of from .004 to .007 of an inch. The springs should press the strips firmly against their shoulders and the ends of the segments should just touch. Bear this in mind when inserting new strips. The inside diameter of the new strips should be about .010 less than the shaft diameter, this amount being left to wear off during the first few minutes of operation.

The water chambers may become filled with scale or other deposits if impure water is used. This will result in rubbing, vibration and wear. If it is impossible to obtain pure water for use in the glands it will be necessary to open and clean them periodically. If leakage from the glands seems excessive examine the horizontal joint, scraping the halves together if necessary, taking especial care to have a fit all around the water chamber. See that the halves of the gland fit properly and that there is no roughness or irregularity in the water passage, such as would be caused by the water outlet or inlet pipe extending downward into the passage or by a formation of scale. See that the water pressure on the glands is steady and does not exceed 20 pounds gauge. Runner clearances beyond the limits given will result in excessive leakage.

Oil Pump:

The oil pump is located in the base of the governor bracket and is shown in Figure 3. This pump must be nicely fitted in order to pump sufficient oil. If the amount of oil pumped is insufficient, as indicated by the level falling too near the bottom of the oil strainer case, the pump should be re-fitted by scraping the joint to reduce the clearance of the gear faces which should be .002 to .006 of an inch. Likewise the clearance at the tooth ends should not exceed these figures.

Oiling System:

The oil level in the reservoir should be maintained near the center of the sight glass. The oil level should, of course, in no case be so low as to prohibit its being seen in the glass, nor should it be above the glass (that is, within 7 inches of the horizontal centerline), for if it is, the gear wheel will dip in the oil, causing a loss of power and heating of the oil. The reservoir may be drained through the cock, and filled through the oil strainer. In so doing, only the oil necessary to fill the passages to the bearings will pass through the strainer, the bulk flowing to the reservoir through the overflow. The oil should be kept clean and renewed when necessary. The oil strainer should be cleaned occasionally. It may be removed while the unit is in operation. The cooling water should be in circulation whenever the turbine is in operation.

The oiling system should be filled with a pure mineral oil having about 130 seconds Saybolt viscosity at 130 degrees F. The importance of using high grade oil, free from animal or vegetable oil compounds, cannot be over-emphasized.

Repairs

Re-blading the rotor is the main point in repairing the turbine. To replace a few blades, not over 6 or 8 consecutive ones, drive out old pins and insert blades, fitting the last one so that all blades will press together tightly.

The holes for blade pins should be drilled with the blades in place. Diameter of pins and reamer sizes are given below. In place of a reamer a **new** drill of the reamer size indicated may be used.

Pin Dia.	Reamer Dia.
.1875	.1850
.1910	.1890
.1935	.1910
.1990	.1960
.2031	.2010
.2188	.2165
.2344	.2323
.2420	.2401
.2500	.2480

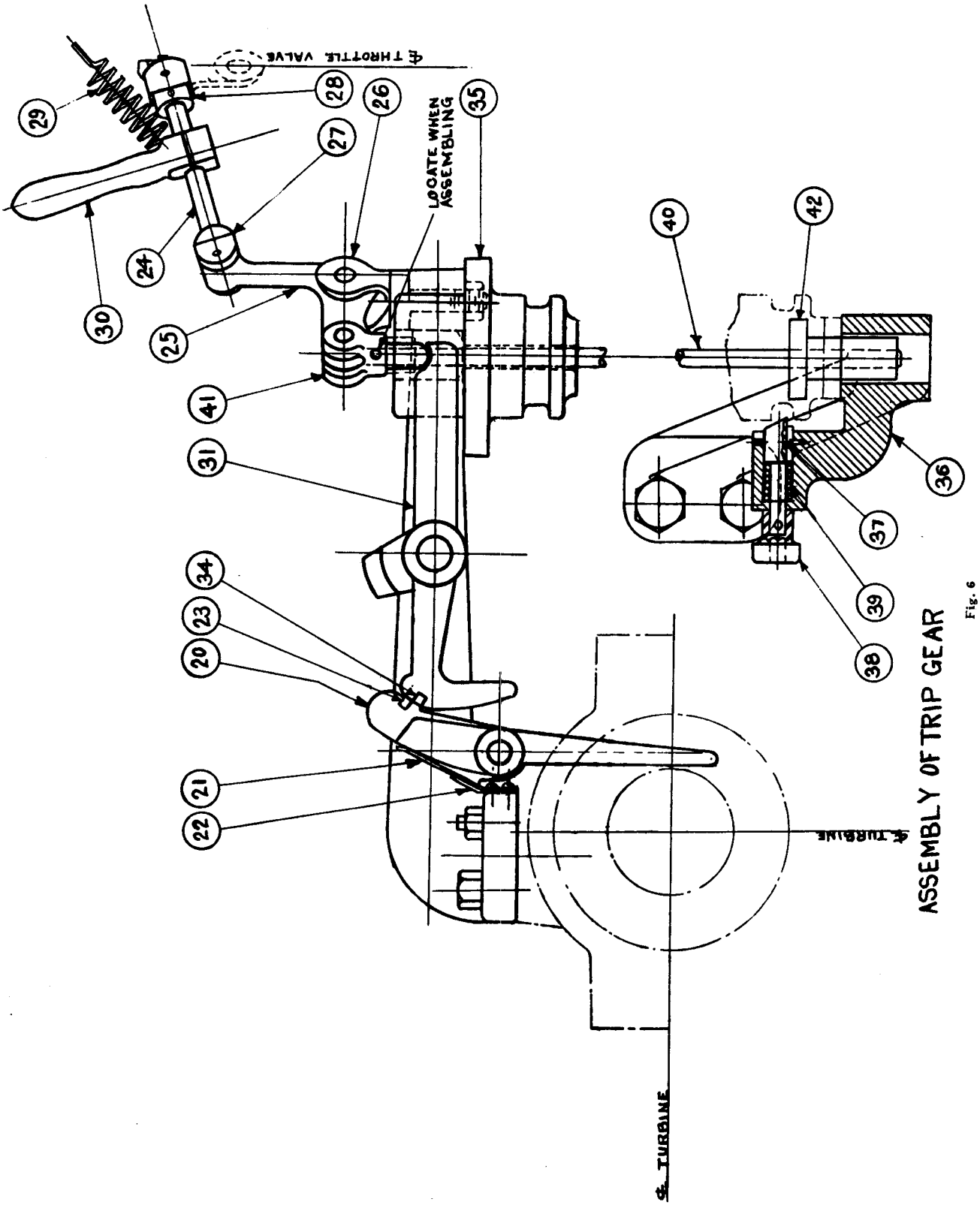
In selecting the new size of pin, take the smallest one for which the proper reamer or reaming drill cleans up the holes. Turn shroud and pins off flush. If the rotor is to be completely bladed extreme care must be taken to drill the holes in the shanks of the blades in the proper position. To have these pins incorrectly located results in a dangerous condition. Pin 12 blades equally distant, making sure that pins are correctly located in the shanks of the blades. From each of these, work either way, fitting last blades so that all blades will be tight against each other. Pin as before. Turn shrouds and pin ends flush. The diameter of the wheel with blades in place must be 17¾ inches.

Operation

Turbine:

To Start:

1. Drain the steam inlet and exhaust pipes.
2. After making sure that the exhaust is free, open throttle valve slightly, bringing the turbine up to speed and be sure that the speed is being controlled by the governor before further opening of the throttle valve.
3. Close drains.
4. Open the gland water inlet valve.



ASSEMBLY OF TRIP GEAR

Fig. 6

5. Open gland water outlets, adjusting the valves to pass just sufficient water to keep the temperature of the water in the glands below the vaporization point. This point will be reached when no vapor can be observed coming from the glands.
6. Test action of the overspeed stop linkage and throttle valve by releasing the auto-stop governor trip lever "20" by hand, which will allow the weight to fall and close the throttle valve.
7. To reset the throttle valve the handwheel should be turned in the closing direction to its stop, the hammer weight "35" lifted, and its supporting lever "31" replaced in position. Then the valve can be re-opened as before.
8. The gland water pressure should be about 5 pounds plus the pressure of the exhaust. It must never exceed 20 pounds.
9. When operating condensing or exhausting to the atmosphere the gland water pressure may be reduced to 5 pounds. Circulation is unnecessary if running condensing.

To Shut Down:

1. Close throttle valve.
2. Open steam and exhaust drains.
3. Close exhaust valve.
4. Turn off gland water.

Generator:

To Start:

1. Cut in all resistance in the field rheostat.
2. Start up steam end as previously described.
3. Adjust rheostat for normal voltage, bringing voltage up slowly.

To Parallel:

1. To parallel one generator with another generator, bring it up to normal speed.
2. With a voltmeter connected to its terminals, gradually bring up the voltage by cutting out resistance in the rheostat until approximately the voltage of the other generator is reached.
3. Throw in equalizer switch.
4. Throw in main switches.
5. Adjust rheostat until generator takes its proportion of the load.

To Shut Down:

1. Reduce the load on the generator as much as possible by throwing in the resistance in the shunt field rheostat.
2. Throw off load by opening the machine circuit-breaker.
3. Open equalizer switch.
4. Open main line switch.
5. Shut down steam end as described previously.
6. Wipe off all the oil and dirt and clean the machine thoroughly, thus putting it in good order for the next run.

Care:

1. The generator should be kept clean by blowing out with compressed air, or by some other means, if compressed air is not available.
2. Care should be taken not to destroy the balance of the rotor by bending shaft or by any other means.
3. Keep small pieces of iron, bolts, and any other material of that nature away from the frame. Any such fragment attached to the field magnet of a machine may jam between the armature and pole, thus causing damage.

Removal of Armature:

1. Remove turbine rotor, pinion shaft and governor bracket as described under "Dismantling".
2. Take out bolts which fasten lower half of generator frame extension or distance piece to gear casing after blocking up end of gear case to secure it against tilting.
3. Slide complete frame and bracket away from steam end about 3 inches (or just enough so that the frame extension clears the gear casing when the frame is raised) so that the gear can be taken out of the case. Frame and bracket should not be shifted far enough so that the shaft will come out of the bearing at the commutator end.
4. Generator should then be raised as a whole, allowing armature to rest on the poles at the rear end. It should be raised just high enough for the reduction gear to be lifted out of the case.
5. The complete generator should be swung around and placed on the floor.
6. The armature can then be removed from the frame by sliding it out at the rear end. When replacing, lift the oil ring in bearing, to clear the shaft.
7. Extreme care should be taken not to injure the commutator or the gear by supporting the armature on them, either when blocking or using a rope sling.

Removal of Poles:

1. Disconnect field winding.
2. Remove the two bolts which hold the pole to the frame.
3. Slide out the pole with its winding.
4. Poles can then be removed without removing the armature.
5. When the pole is replaced, care should be taken that the same thickness of liners or shims is placed under the pole as were there when the pole was removed.
6. The air gap should be the same at all four main poles and at the auxiliary poles. The gap is not necessarily the same for the main poles as for the auxiliary poles.
7. The air gap under main and auxiliary poles should be checked carefully with a feeler gauge before removal and again after assembly in order to be sure that the same length of air gap is obtained.

General Precautions:

1. Be sure that all parts are clean, noting the condition of the oil and any deposits indicating deterioration or breaking down of the lubricant.
2. Examine for strains from piping or holding down bolts, also for even support of feet.
3. When unit is open, observe conditions of blades, nozzles and valves with respect to steam erosion or other wear.
4. Examine blades carefully to see that they are tight and down in place. If any indication of loose blades is observed, repair as noted under "Repairs", or replace previous to further operation.
5. Observe wear or deterioration in bearings, governor knife edges, bushings and sleeves, main governor and oil pump gears, auto-stop cam lever and plunger, etc.
6. Note any considerable lost motion in governor linkage due to wear or poor adjustments.
7. Examine glands for scale deposits, leaks at flanges, condition of labyrinth rings and springs.

If any discrepancies are found they should be corrected in order to prolong the life of the unit. Continuous operation for years without replacement of any major parts at least, is to be expected if the unit is properly installed and given the proper care as set forth herein.

Cylinder Drainage

Water standing in any part of the turbine causes rapid deterioration and it is, therefore, of utmost importance that the cylinder be kept clear of water while the unit is shut down. As stated above, the cylinder drains into the exhaust chamber and this chamber should be drained, through an open funnel if possible, so that the operator can observe that the drain is functioning properly.

This drain should be opened immediately after shutting down and remain open throughout the shut-down period. Daily inspections should be made to be assured that the drain is free and that water is not accumulating in the cylinder.

Before starting up, the steam inlet line should be drained and both drains left open until steam blows freely indicating that all parts are clear of water.

The following list has been compiled to facilitate ordering repair parts by name and number together with the serial number of the turbine:

Item	Name	Fig.
6	Auto stop governor body	2
7	Auto stop governor retainer	2
8	Auto stop governor spring	2
13	Auto stop governor spring retainer	2
14	Auto stop governor spring retainer lock washer	2
16	Auto stop governor spring weight	2
20	Auto stop governor trip lever	4–6
21	Auto stop governor trip lever spring	4–6
22	Auto stop governor trip lever spring leaf	6
23	Auto stop governor trip lever tip	2–6
24	Auto stop governor trip latch rod	2–6
25	Auto stop governor trip latch rod bell crank	2–6
26	Auto stop governor trip latch rod bell crank clevis	2–6
27	Auto stop governor trip latch rod end	2–6
28	Auto stop governor trip latch rod end	2–6
29	Auto stop governor trip latch rod spring	2–6
30	Auto stop governor trip latch rod spring block	2–6
31	Auto stop governor trip release lever	4–6
32	Auto stop governor trip release lever bracket	4
34	Auto stop governor trip release lever tip	4–6
35	Auto stop governor trip weight	4–6
36	Auto stop governor trip weight bracket	4–6
37	Auto stop governor body weight latch	4–6
38	Auto stop governor trip weight latch handle	4–6
39	Auto stop governor trip weight latch spring	4–6
40	Auto stop governor trip weight rod	4–6
41	Auto stop governor weight rod end	2–6
42	Auto stop governor trip weight sleeve	4–6
49	Cylinder base	2
52	Cylinder cover	2
57	Gland case (upper half)	2–5
58	Gland case (lower half)	2–5
59	Gland packing ring	2–5
60	Gland packing ring	2–5
61	Gland packing ring spring	2–5
62	Gland runner (bearing end)	2–5
63	Gland runner (bearing end) sleeve	2–5
64	Gland runner (bearing end) sleeve	2–5
65	Gland runner (gear end)	2
66	Gland runner (gear end) sleeve	2
67	Gland runner (gear end) sleeve	2
71	Gear case base	3
73	Gear case cover	3
79	Gear wheel center	2
80	Gear wheel rim	2
83	Generator distance piece (upper)	2
84	Generator distance piece (lower)	2
85	Generator shaft bearing (upper half)	2
86	Generator shaft bearing (lower half)	2
94	Governor case cover	3
95	Governor case cover cap	3
96	Governor clutch	3
97	Governor gear (driver)	2
98	Governor gear (driven)	3
99	Governor gear lock washer	3
100	Governor gear thrust washer	3
101	Governor knife edge	3
102	Governor knife edge block	3
103	Governor knife edge retainer	3
104	Governor lever (inner)	3
106	Governor lever trunnion bolt	3
107	Governor lever (outer)	3
108	Governor lever connecting link	3
112	Governor lever rock shaft bracket	3
115	Governor sleeve	3
116	Governor sleeve nut	3
119	Governor spring	3
120	Governor spring adjusting nut	3
122	Governor spring nut	3
123	Governor spring sleeve	3
124	Governor spring sleeve bolt	3
125	Governor spindle	3
126	Governor spindle bushing	3
127	Governor spindle bushing (oil pump gear)	3
128	Governor spindle thrust collar	3
130	Governor weight	3
131	Governor weight arm (l. h.)	3
132	Governor weight arm (r. h.)	3
133	Governor weight arm block	3
134	Governor weight disc	3
135	Governor weight disc fulcrum block	3
136	Governor weight disc fulcrum knife edge	3
137	Governor weight knife edge block	3
138	Governor valve	3
139	Governor valve cage	3
140	Governor valve cage cover (bottom)	3
142	Governor valve stem	3
143	Governor valve stem coupling	3
144	Governor valve stem extension	3
145	Governor valve stem extension head	3
146	Governor valve stem gland	3
147	Governor valve stem stuffing box	3
149	Governor valve stem cage cover (upper)	3
151	Oil pump body	3
152	Oil pump body cover (bottom)	3
154	Oil pump gear (driver)	3
156	Oil pump gear (driver)	3
161	Oil reservoir oil level gauge	3
164	Oil strainer cover	2
168	Pinion shaft and rotor shaft	1
169	Pinion shaft bearing	1
171	Pinion shaft bearing key	1
172	Pinion shaft bearing key	1
178	Pinion shaft oil ring (upper half)	2
179	Pinion shaft oil ring (lower half)	2
180	Pinion shaft split collar	2–5
181	Pinion shaft shrink collar (bearing end)	2–5
182	Pinion shaft shrink collar (gear end)	2
185	Nozzle block	2
189	Relief valve	4
193	Reversing chamber	2
194	Reversing chamber liner	2
198	Rotor	2
199	Rotor blade	2
200	Rotor blade pin	2
201	Rotor key	3
207	Steam chest body	3
208	Steam chest body gasket	3
217	Thrust bearing collar (gear end)	2
218	Thrust bearing liner	2
219	Thrust bearing liner	2
220	Thrust bearing liner	2
221	Thrust bearing collar (gen. end)	2
222	Thrust bearing liner	2
223	Thrust bearing liner	2
224	Thrust bearing liner	2
227	Turbine bearing	2
228	Turbine bearing cover	2
229	Turbine bearing cover end plate	2
230	Turbine bearing cover oil ring (upper half)	2
231	Turbine bearing cover oil ring (lower half)	2
232	Turbine bearing key	2
233	Turbine bearing key	2
234	Turbine bearing key	2
240	Throttle valve	4
241	Throttle valve body	4
243	Throttle valve latch	2
244	Throttle valve latch plate	2
245	Throttle valve latch spring stud	2
246	Throttle valve nut	4
247	Throttle valve nut washer	4
248	Throttle valve spring (lower)	4
249	Throttle valve spring (upper)	4
250	Throttle valve spring retainer	4
251	Throttle valve stem (lower)	4
252	Throttle valve stem (lower) collar	4
253	Throttle valve stem (upper)	4
254	Throttle valve stem handwheel	4
257	Throttle valve stem packing gland	4
258	Throttle valve stem packing nut	4
259	Throttle valve stem stuffing box	4
261	Throttle valve yoke	3

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