Westinghouse

Small Geared Turbines

Type HNC

INSTRUCTION BOOK

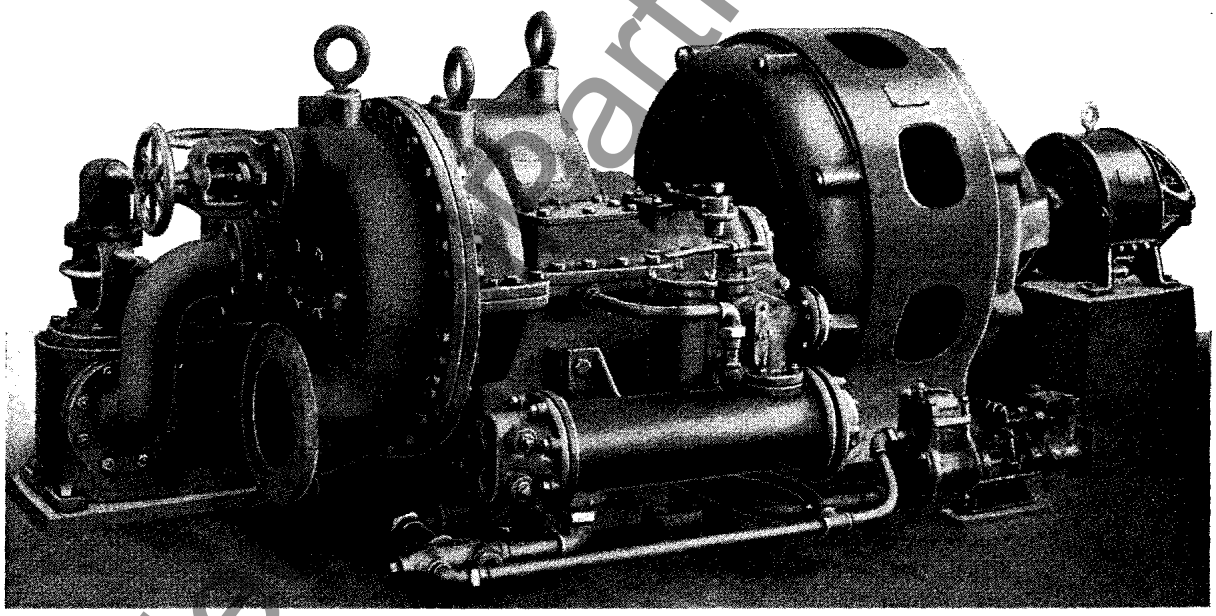

FIG. 1—300 KW. ALTERNATING-CURRENT TURBINE-GENERATOR UNIT WITH EXCITER

Westinghouse Electric & Manufacturing Company

Philadelphia, Pa.

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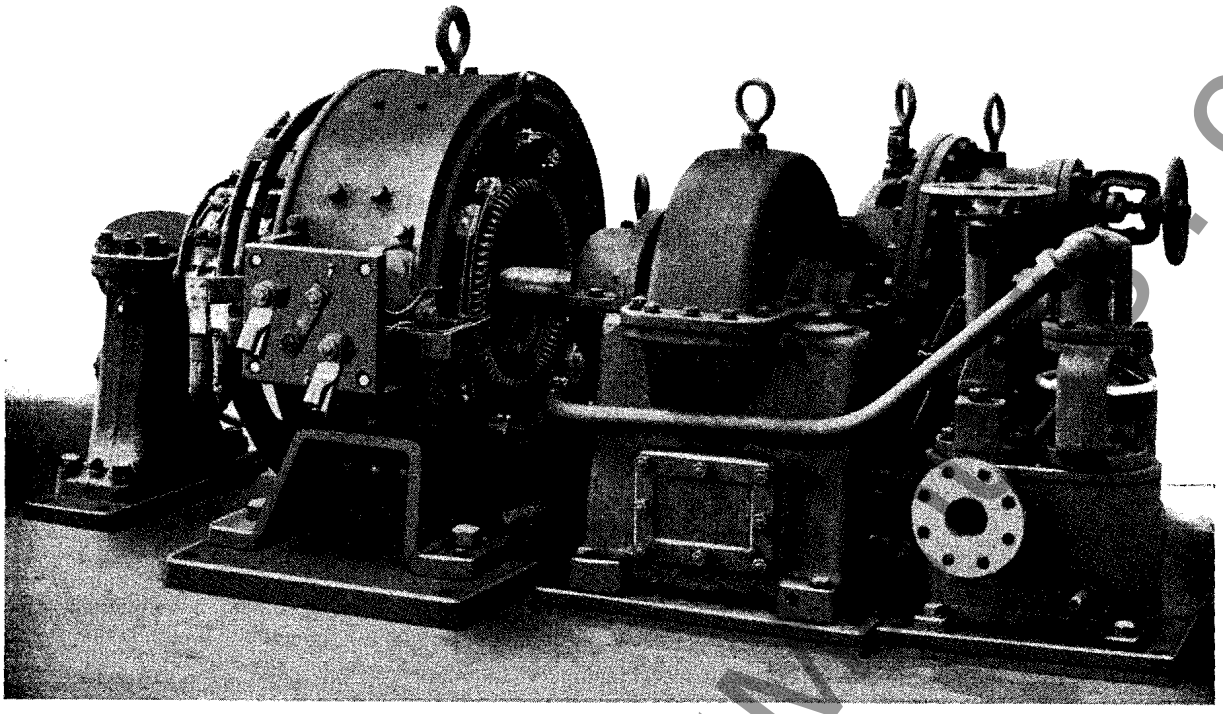

FIG. 2—100 KW. DIRECT-CURRENT TURBINE-GENERATOR UNIT

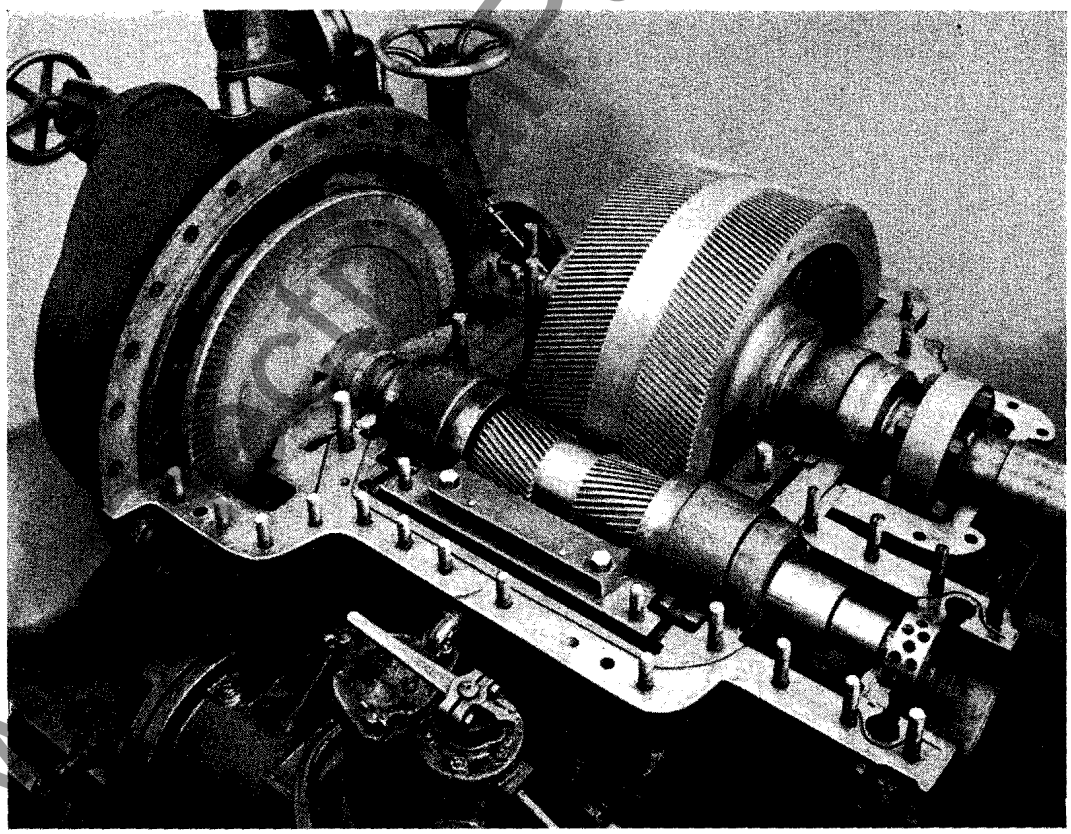

FIG. 3—TURBINE AND GEAR, WITH COVER REMOVED

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Introduction

The steam turbine is now in universal use for the operation of small boiler room and engine room auxiliaries as well as for the large generating units. Development has taken place at such a rate that at the present time the most reliable and economical drive for exciter sets in central stations, and source of power in industrial and marine plants is found in the small turbine, either direct-connected or geared.

Several advantages of the turbine over the reciprocating engine are to be noted, among which the following may be said to be outstanding: The steam in passing from the inlet to the exhaust of the turbine follows more closely the curve of adiabatic expansion, which gives more nearly ideal performance; cylinder condensation is reduced to a minimum since all parts of the turbine are subjected to practically uniform temperature; there are no reciprocating or rubbing parts, thus decreasing the wear on the component parts and loss of power due to friction; exhaust steam is free from oil; foundations of excessive size are not necessary since the vibration of a turbine unit is negligible; and the floor space required is much less than that required for a reciprocating engine of the same power.

Though the turbine is simple in construction and reliable in operation, and does not have parts that require constant care and manipulation by the operator, it is like any other piece of high grade machinery in that intelligent and careful attention must be given it by its operators. All working parts should be given a periodic inspection. It is for the purpose of giving the turbine operator a better opportunity to familiarize himself with the mechanical details of the unit of which he is in charge, and also to furnish a convenient reference for the ordering of repair parts, that this instruction book has been prepared.

The turbine described herein is of the re-entry type and consists essentially of a single wheel carrying one row of impulse blading and overhung on an extension of the pinion shaft. Steam enters 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 instantly if the turbine overspeeds a predetermined amount. The steam then passes through the governor valve and enters the bowl of the nozzle block. It expands through the nozzles to the exhaust pressure and acquires a high velocity with which it impinges upon the blades on 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 two times, practically all of the velocity caused by the expansion of the steam through the nozzles has been transferred to the turbine wheel in the form of mechanical work and the steam finds its way into the turbine casing, passing out through the exhaust line.

Figures 1, 2, 3 and 4 will give the reader a general idea of the construction of turbines of this type. The unit will be described in detail in another part of this book.

Installation

Foundation

It is deemed advisable to provide a concrete foundation, though this is not absolutely necessary. Extensive foundations are not necessary since the weight of the unit is not great. It is

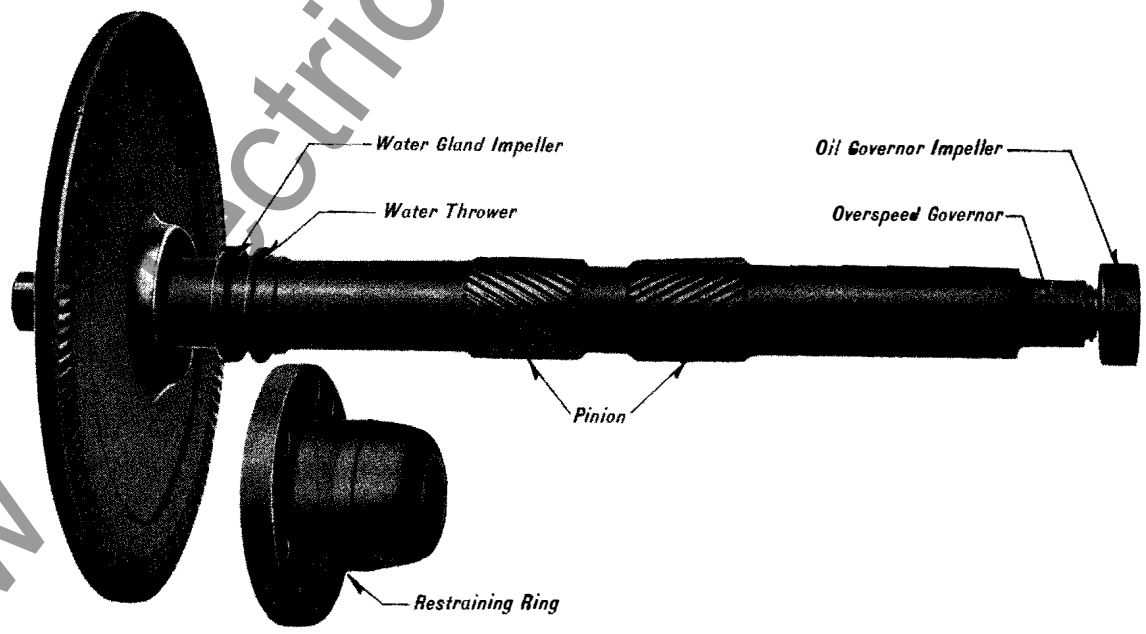


FIG. 4—COMPLETE ROTOR, WITH RESTRAINING RING

desirable that the foundation be built independently of the building, or at least of such parts of the building as may transmit vibration. The top of the foundation should not be finished until after erection of the unit, leaving about one inch for grout. The foundation bolt sleeves should have an inside diameter about $\frac{3}{8}$" larger than the bolt to allow for minor discrepancies. The size of bolts may be obtained from the official outline drawing.

Erection

Handling

The unit is shipped mounted on skids and boxed. The skids should be left in place until the final operation of setting the unit on the foundation is reached. Eye bolts are furnished for lifting the cylinder and gear cover only and should not be used for lifting the assembled unit. When handling the complete machine care should be taken to distribute the load properly upon slings so as not to put undue strain on any one part of the unit.

Soleplates made of steel and finished on one side are furnished to be grouted to the foundation, thus acting as seating plates for the unit. Turbine and gear, generator and outboard pedestal are separately doweled to these steel plates so that they may be removed and replaced in the same position. After the complete unit has been levelled on the foundation the grout may be poured. The grout should consist of a thin one to one mixture of high grade Portland Cement and clean, sharp sand. It must be well worked in under the seating plates.

The grout must be allowed to dry thoroughly before tightening up the foundation bolts. In tightening the bolts care must again be exercised to see that no part of the unit is being subjected to undue strains.

If a steel foundation is used the unit should be levelled carefully by means of shims under the gear and generator feet. The steam chest must also be levelled with care so that no strain will be imposed on the piping.

Piping

Steam and exhaust pipes should be very carefully installed, in order that no strains may be imposed on the turbine proper with consequent misalignment. In connecting the turbine to the steam and exhaust lines, begin the piping from the connecting line and end at the turbine, making the turbine connections the last in the line. Never start piping from the turbine, for doing so will undoubtedly distort the casing or spring the turbine out of line, inasmuch as the weight of the piping will hang directly on the turbine.

If screwed fittings are used, the line should be provided with swinging joints. If flanged fittings are used, long radius bends should be placed in the piping to take care of the expansion of the steam line. Support the piping at a point near the turbine in such a manner that the weight is taken by the support. It should be arranged so that the expansion will not have to be resisted by the turbine. Make sure that the flanges are parallel and that no force is necessary to bring them together or to match up the bolt holes. After installing the piping, heat up to full working temperature, break joints and check.

The exhaust piping should be provided with an expansion joint located next to the turbine exhaust flange. A suitable expansion joint can be purchased from the turbine manufacturer if desired. Even though an expansion joint is used, the same caution in connecting up should be exercised. Be sure that the expansion joint is light enough to be flexible.

In piping up a turbine, make all pipe supports permanent. Do not expect a block of wood, driven under a pipe, to take the strain from the turbine. The best method of supporting the piping is to use an adjustable foot under it as near to the turbine as possible. Another method is to hang it from the building by tie rods which connect to the piping near the turbine. These rods, however, to be satisfactory, must be short. Always put in the supports before actually making the connection to the turbine.

In all cases where the turbine unit is to be realigned, disconnect the steam and exhaust piping, and in re-connecting, be sure that the flanges line up without putting a strain upon the turbine when either hot or cold. If they do not, change the piping.

When laying out the piping a stop valve should be placed in the steam line between the boiler and the turbine. This valve is not necessary for the operation of the turbine but is for use when it is desired to inspect or make repairs on the turbine throttle valve.

If exhausting to the atmosphere, no valve is needed in the exhaust line unless the exhaust pipe is common with that of other units, in which case a stop valve should be supplied to prevent backing up of steam when the turbine is idle. If exhausting to a heater of any kind or to a condenser, a stop valve is required; likewise when condenser also serves another unit.

Small pipes are required to convey water to and from the oil cooling coil and the gland; to carry away the leak-off steam from the governor valve stem packing, and to connect the cavity outside the gland to an open drain. These pipes are so small that no special precautions need be taken against imposing strains on the unit. The connections for these pipes are shown on the outline drawing, which gives sufficient information concerning their installation. Water pressure should be five pounds greater than exhaust pressure but should not exceed twenty-five pounds.

The oil cooler should be supplied with water through a half or three-quarter inch pipe line at a pressure of from fifteen to sixty pounds. This water may be obtained from any convenient source and should be as cold as possible. It may also be used for the gland.

Checking Installation

These units are carefully set up and inspected in the shop, all adjustments made, and are operated under contract conditions as nearly as possible. Usually no further adjustments are required.

Detailed Description and Operation

Cylinder

The cylinder of this type turbine is of rather unusual construction in that it is split vertically in a plane normal to its centerline, the outer part being a single casting bolted to a machined surface on the ends of the upper and lower halves of the gear case. The gear case is split on the horizontal centerline forming the gear and cylinder cover and base respectively. The upper half of the combined turbine and gear housing can be removed without disturbing the steam or exhaust connections. The cylinder end cover is attached to the other part of the cylinder in such a way that the cylinder and gear case cover can be taken off without removing the end cover. In raising the gear cover, the

bolts securing it to the cylinder end cover and the gland must be removed and the cover lifted straight up so that the reversing chamber will clear the turbine rotor. Before replacing, scrape joints clean, and make up with shellac. Be sure to pull the bolts up tight before the shellac hardens.

Both the steam inlet and exhaust outlet are connected to the cylinder end cover. This cover also carries the nozzles and the nozzle control valve.

Rotating Element

The rotating element, shown in Figure 4, consists of the pinion shaft, which carries the rotor, auto-stop governor and oil impeller, supported by the two pinion bearings. The rotor is pressed on the shaft with a tapered press fit and is held in place by a nut which is in turn held in place by a lock washer. A loose rotor may result from overspeeding of the turbine and is evidenced by vibration. If a loose rotor is suspected, it should be pressed off and the fit examined. In putting on a new rotor be sure that a good fit is obtained. The rotor should slide on the shaft until it is one inch from the hub and must be pressed on the remainder of the distance.

When the rotating element is to be removed from the cylinder without disturbing the cylinder end cover, the restraining ring forging must first be unbolted and removed from the end cover. Since the restraining ring surrounds the rotor shaft extension, it would otherwise be impossible to lift the rotor out of the cylinder.

Throttle Valve, Governor and Governor Valve

The governor, throttle valve and governor valves used on this type unit for capacities of from 75 to 100 kw. are shown in Figure 5; and those used on units for capacities of from 100 to 500 kw. are shown in Figure 6. They are of the same type and operate in the same manner, but both illustrations are given in order to facilitate the ordering of repair parts for units of different capacities.

The throttle valve and governor valve are both carried in the steam chest body Item No. 108.

The **throttle valve** is of the automatic quick closing type. Referring to Figure 6, with the valve closed steam from the boiler completely surrounds the main valve "113". By leakage past the packing ring "75" full pressure is established above the valve, thus greatly unbalancing it and holding it firmly on its seat. The valve stem "87" is connected to the by-pass valve "114". Consequently as the stem moves upward to open the valve, this small by-pass valve is lifted off its seat first, relieving the pressure in the cylinder above. The main valve then becomes practically balanced and very little force is required to lift it through its full travel. The valve stem gland "95" contains standard "U.P." commercial packing.

The stem "87" is threaded in the sliding nut "91" which is kept from turning by the pin "98". The hardened steel latch plate "92" on the bottom of the nut engages the trip latch "69" to hold the nut in its uppermost position. With the nut "91" latched in its upper position, the valve can be opened or closed by the handwheel as any ordinary valve. When the nut is released by the latch plate, it is free to drop and the closing spring "76" therefore moves the nut, stem and valve downward shutting off all steam to the turbine. Resetting is accomplished by turning the handwheel in the closing direction which screws the nut "91" upward until it is again engaged by the latch "69". The valve can then be opened in the usual manner.

In normal operation, the latch "69" is held in the position shown by the spring "71". The latch lever "66" is connected to the auto-stop governor by the linkage shown in Figure 13. Therefore when the auto-stop governor operates, the latch "66" is pulled outward thus disengaging the latch plates "69" and "92" and allowing the valve to close as described above.

The **governor** is of the oil type, operated by oil from the main impeller on the pinion shaft. It consists primarily of an oil cylinder "6" in which the spring opposed piston "19" operates. The piston is connected to the governor valve "182" by the rod "24", stem "43" and couplings "25" and "46". Oil discharged from the impeller, the pressure of which varies as the square of the speed, acts against this position to compress the spring "22" and close the governor valve. Therefore, if the speed decreases, the oil pressure above the piston "19" decreases, thus allowing the spring "22" to raise the piston and open the steam valve. If the speed increases, the oil pressure increases, thus moving the piston downward against the spring compression and closing the steam valve.

The speed at which the governor holds the turbine can be varied while the unit is operating by means of the handwheel "17". This handwheel rotates the screw "20" which raises or lowers the spring seat "23" and thus increases or decreases the compression of the spring. Increasing the spring compression increases the speed, while decreasing the compression decreases the speed.

The **governor valve** "182" is of the double seated, poppet type. It operates within the cage "183" which is pressed into the steam chest body.

Steam is kept from leaking by the throttle valve stem by means of the packing Item No. 93. This forms a very effective means for sealing against leakage. There is no metallic packing used on the governor valve stem, leakage being prevented by serrations or grooves cut in the governor valve stem Item No. 43 where the stem passes through the governor cylinder support gland Item No. 8. This forms a series of labyrinth packing strips and the steam which may leak by is carried off through the drain in the packing gland Item No. 8. This leak-off should be led to an open drain or other point without back pressure, such as an open feed water heater.

The lists which follow the description of the component parts of the unit have been compiled to facilitate the ordering of repair parts by name and number together with the serial number of the turbine.

Spindle Gland

Since the turbine rotor is overhung from the pinion shaft, there being no turbine bearings, only one sealing gland is required. It is of the combined water sealed and labyrinth type and is shown in Figure 7.

This gland consists of a bronze impeller which is mounted on the spindle and rotates within a bronze casing bolted to the turbine cylinder. Water under a head, depending on the back pressure, is introduced into the casing. The rotation of the runner tends to pump the water out of the casing, but due to the restricted discharge there results an annular ring of water around the interior of the gland, which prevents the passage of steam out of, or of air into the cylinder. This gland will seal

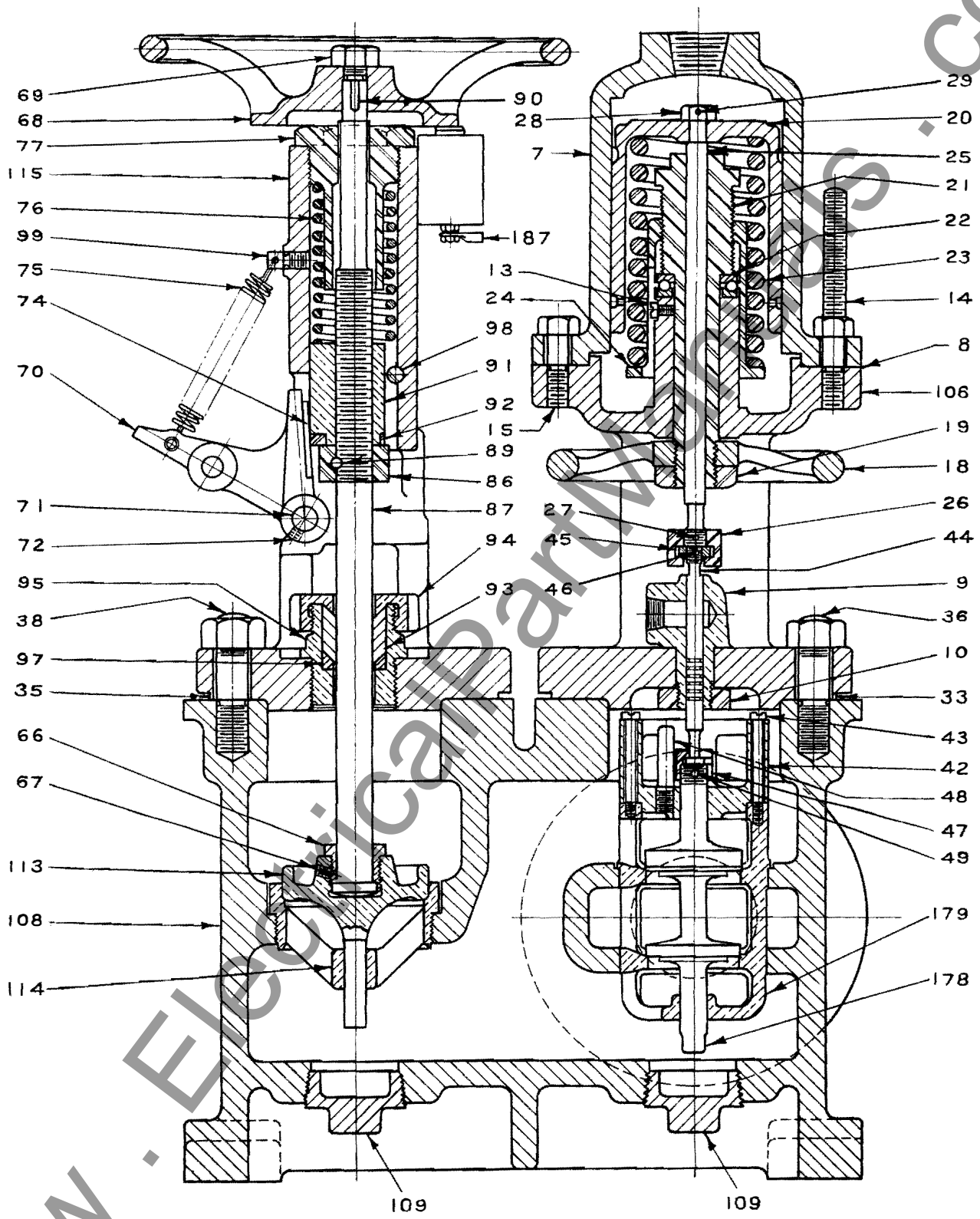


FIG. 5 —THROTTLE VALVE, GOVERNOR AND GOVERNOR VALVE

equally well when the turbine is operating condensing or non-condensing. The labyrinth packing is placed inside of the gland runner so that when operating against back pressures in excess of fifteen pounds, an effective seal may be had. This packing should be fitted very carefully. Each ring consists of four segments. A small spring is used back of each segment to hold the segment toward the shaft so that the shoulder on the segment is, at all times, against the corresponding shoulder in its groove. The rings should have approximately .003" clearance sidewise in the grooves. The springs should press the segments firmly against their shoulders and, with the gland assembled, the ends of the segments should just touch. When inserting new rings, their inside diameter 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 outlet valve should be adjusted so that the flow of water through the gland will be enough to maintain a temperature slightly below the boiling point.

Excessive water leakage from the gland may indicate that the head of water supplied to the gland is too high and should be reduced. It may also indicate that the gland is set up so that the horizontal flanges inside the gland cavity do not match up, thus forming a sharp projection, which breaks up the flow of the water. Too close a clearance on either side of the gland runner may also cause a considerable leakage of water.

In making an inspection of the gland, the horizontal flange bolts should be removed and the gear case cover lifted. The gland may then be taken apart.

The following list is for the Governor, Steam Chest and Throttle Valve shown in Figure 5, and applies to units of from 75 to 100 kw. inclusive.

Item	Name
7	Governor Cylinder.
8	Governor Cylinder Support Gasket.
9	Governor Cylinder Support Gland.
10	Governor Cylinder Support Gland Lock Nut.
13	Governor Cylinder Support Screw.
14	Governor Cylinder Support Stud (To Cylinder).
15	Governor Cylinder Support Stud (To Cylinder).
18	Governor Handwheel.
19	Governor Handwheel Lock Nut.
20	Governor Operating Piston.
21	Governor Operating Screw.
22	Governor Operating Screw Thrust Bearing.
23	Governor Operating Spring.
24	Governor Operating Spring Seat.
25	Governor Operating Stem.
26	Governor Operating Stem Coupling.
27	Governor Operating Stem Coupling Straight Pin.
28	Governor Operating Stem Nut.
29	Governor Operating Stem Nut Spring Cotter.
33	Steam Chest Body Gasket (Gov. Support).
35	Steam Chest Body Gasket (Throttle Valve Yoke).
36	Steam Chest Body Stud (Governor Support).
38	Steam Chest Body Stud (Throttle Valve Yoke).
42	Governor Valve Cage Cover.
43	Governor Valve Cage Cover Screw.
44	Governor Valve Stem.
45	Governor Valve Stem Caps.
46	Governor Valve Stem Caps Straight Pin.
47	Governor Valve Stem Coupling.
48	Governor Valve Stem Coupling Guide.
49	Governor Valve Stem Coupling Pin.
66	Throttle Valve Disc Nut.
67	Throttle Valve Disc Nut Headless Set Screw.
68	Throttle Valve Handwheel.
69	Throttle Valve Handwheel Nut.
70	Throttle Valve Latch.
71	Throttle Valve Latch Fulcrum Pin.
72	Throttle Valve Latch Fulcrum Pin Headless Set Screw.
73	Throttle Valve Latch Plate.
74	Throttle Valve Latch Plate Screw.
75	Throttle Valve Latch Spring.
76	Throttle Valve Spring.
77	Throttle Valve Spring Retainer.
87	Throttle Valve Stem.
88	Throttle Valve Stem Collar.
89	Throttle Valve Stem Collar Pin.
90	Throttle Valve Stem Key.
91	Throttle Valve Stem Nut.
92	Throttle Valve Stem Nut Latch Plate.
93	Throttle Valve Stem Packing.
94	Throttle Valve Stem Packing Gland.
95	Throttle Valve Stem Packing Gland Box.
97	Throttle Valve Stem Packing Seat.
98	Throttle Valve Yoke Pin.
99	Throttle Valve Yoke Stud (Latch Spring).
106	Governor Cylinder Support.
108	Steam Chest Body.
109	Steam Chest Body Pipe Plug.
113	Throttle Valve Disc.
114	Throttle Valve Disc Seat.
115	Throttle Valve Yoke.
178	Governor Valve.
179	Governor Valve Cage.
187	Circuit-Breaker Tripping Switch (Complete).

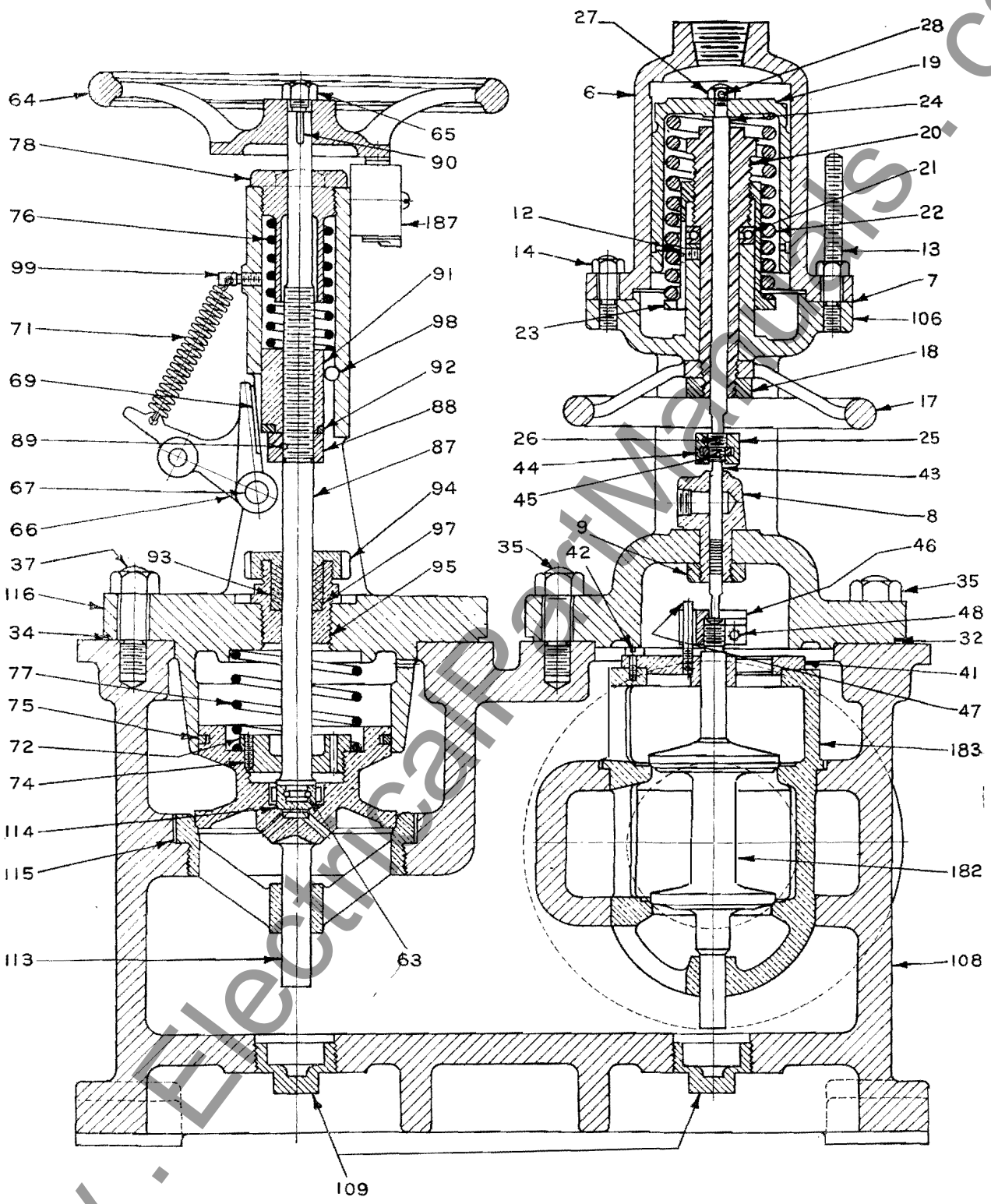


FIG. 6—THROTTLE VALVE, GOVERNOR AND GOVERNOR VALVE

The following list is for the Governor, Steam Chest and Throttle Valve shown in Figure 6, and applies to units of from 100 up to and including 500 kw.:

Item	Name
6	Governor Cylinder.
7	Governor Cylinder Support Gasket.
8	Governor Cylinder Support Gland.
9	Governor Cylinder Support Gland Lock Nut.
12	Governor Cylinder Support Screw.
13	Governor Cylinder Support Stud.
14	Governor Cylinder Support Stud.
17	Governor Handwheel.
18	Governor Handwheel Lock Nut.
19	Governor Operating Piston.
20	Governor Operating Screw.
21	Governor Operating Screw Thrust Bearing.
22	Governor Operating Spring.
23	Governor Operating Spring Seat.
24	Governor Operating Stem.
25	Governor Operating Stem Coupling.
26	Governor Operating Stem Coupling Straight Pin.
27	Governor Operating Stem Nut.
28	Governor Operating Stem Nut Spring Cotter.
32	Steam Chest Body Gasket (Cover)
34	Steam Chest Body Gasket (Throttle Valve Yoke).
35	Steam Chest Body Stud.
37	Steam Chest Body Stud (Throttle Valve Yoke).
41	Governor Valve Cage Cover.
42	Governor Valve Cage Cover Screw.
43	Governor Valve Stem.
44	Governor Valve Stem Cap.
45	Governor Valve Stem Cap Straight Pin.
46	Governor Valve Stem Coupling.
47	Governor Valve Stem Coupling Guide Stud.
48	Governor Valve Stem Coupling Tap Bolt
63	Throttle Valve By-pass Valve Pin.
64	Throttle Valve Handwheel.
65	Throttle Valve Handwheel Nut.
66	Throttle Valve Latch.
67	Throttle Valve Latch Fulcrum Pin.
69	Throttle Valve Latch Plate.
71	Throttle Valve Latch Spring.
72	Throttle Valve Nut.
74	Throttle Valve Nut Headless Set Screw.
75	Throttle Valve Packing Ring.
76	Throttle Valve Spring (Upper).
77	Throttle Valve Spring (Lower).
78	Throttle Valve Spring Retainer.
87	Throttle Valve Stem.
88	Throttle Valve Stem Collar.
89	Throttle Valve Stem Collar Pin.
90	Throttle Valve Stem Feather Key.
91	Throttle Valve Stem Nut.
92	Throttle Valve Stem Nut Latch Plate.
93	Throttle Valve Stem Packing.
94	Throttle Valve Stem Packing Gland.
95	Throttle Valve Stem Packing Gland Box.
97	Throttle Valve Stem Packing Seat.
98	Throttle Valve Yoke Pin.
99	Throttle Valve Yoke Stud (Latch Spring).
106	Governor Cylinder Support.
108	Steam Chest Body.
109	Steam Chest Body Pipe Plug.
113	Throttle Valve.
114	Throttle Valve By-pass Valve.
115	Throttle Valve Seat.
116	Throttle Valve Yoke.
182	Governor Valve.
183	Governor Valve Cage.
187	Circuit-Breaker Tripping Switch (Complete).

In replacing, the joint should be made up with shellac and should be pulled tight before the shellac hardens.

The following list refers to Figure 7:

Item	Name
1	Rotor Gland Case (Upper Half)
2	Rotor Gland Case (Lower Half)
3	Rotor Gland Case Tap Bolt (Upper)
4	Rotor Gland Case Tap Bolt (Lower)
6	Rotor Gland Case Stud.
11	Rotor Gland Packing Ring Segment.
14	Rotor Gland Packing Ring Spring.

Bearings

The bearings are horizontally split cast iron shells lined with genuine babbitt. The pinion bearing is shown in Figure 8, while the thrust bearing is shown in Figure 9. The inboard gear bearing is the same as the thrust bearing with the exception of the babbitted ends.

The shells are closely fitted into circular seats bored to receive them in the gear case and cover. Rotation is prevented by lugs on the bottom halves bearing against the cover. If it becomes necessary to re-babbitt a bearing, the lining used should be of the composition known as "genuine babbitt" to insure satisfactory service. Care must be taken to re-bore concentrically with the turned outside diameters of the bearing shells. If it is necessary to scrape the bearing, scrape to a mandrel the size of the bearing; do not scrape to the journal. If new bearings are fitted in the machine make sure they fit snugly in the gear case housing.

The bearings are supplied with oil through openings at each side feeding the single oil groove running lengthwise above the journal. They are relieved at the horizontal joint to insure formation of the oil film necessary for efficient lubrication. From the bearings the oil drains into the gear casing which serves as a reservoir.

Thrust Bearings

The rotating elements are restrained from axial movement by making one of the slow speed gear bearings a combination main and thrust bearing.

The following list refers to Figure 8:

Item	Name
1	Pinion Bearing (Upper Half)
2	Pinion Bearing (Lower Half)

The following list refers to Figure 9:

Item	Name
3	Thrust Bearing (Upper Half)
4	Thrust Bearing (Lower Half)
6	Thrust Bearing Ring.
7	Thrust Bearing Ring Screw.
9	Thrust Bearing Liner.
10	Thrust Bearing Liner.
11	Thrust Bearing Liner.

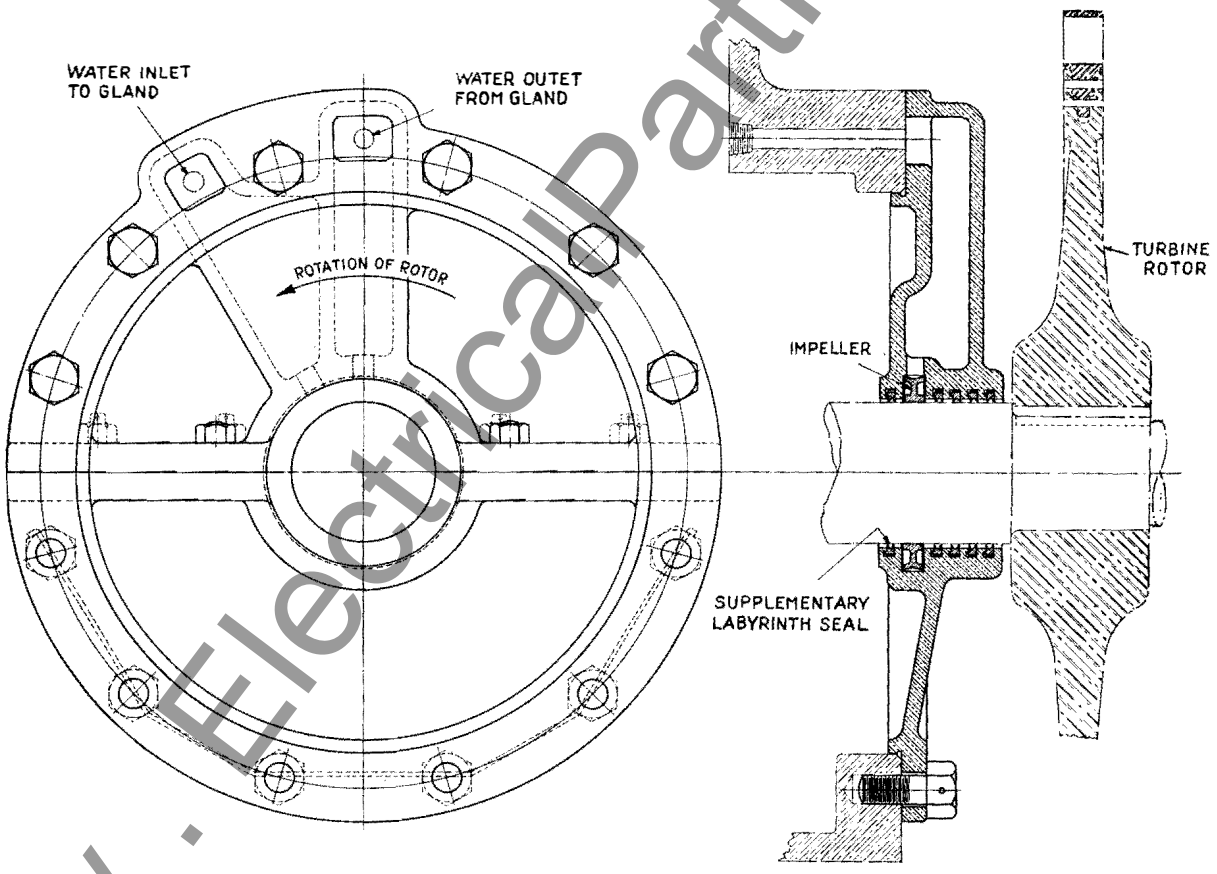


FIG. 7 —ROTOR GLAND

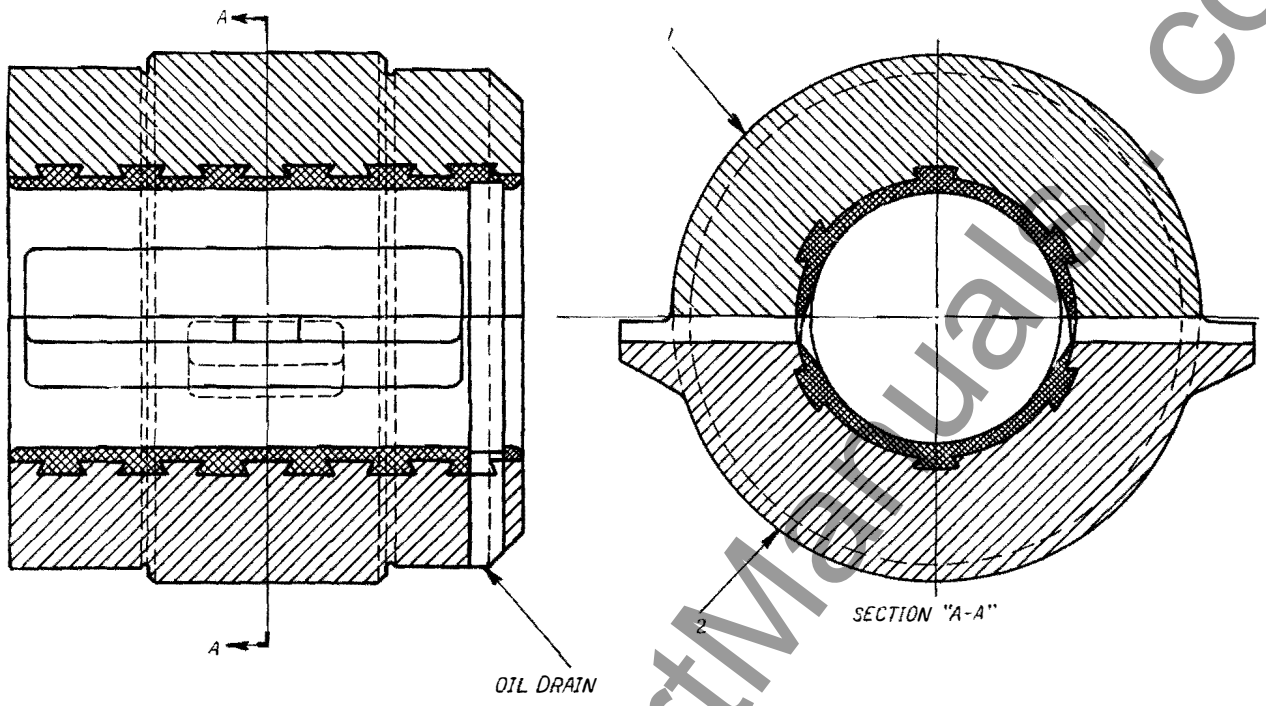


FIG. 8—PINION BEARING

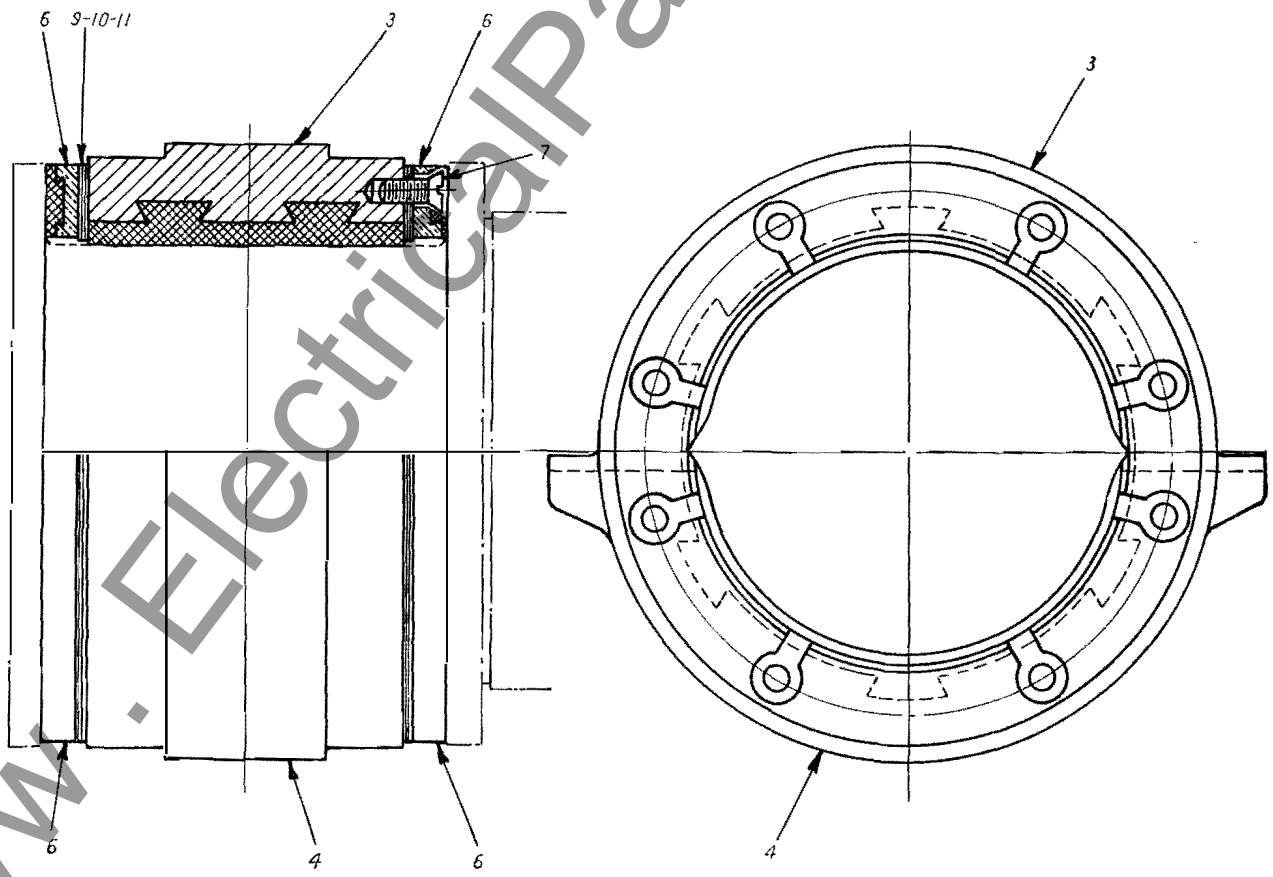


FIG. 9—THRUST BEARING

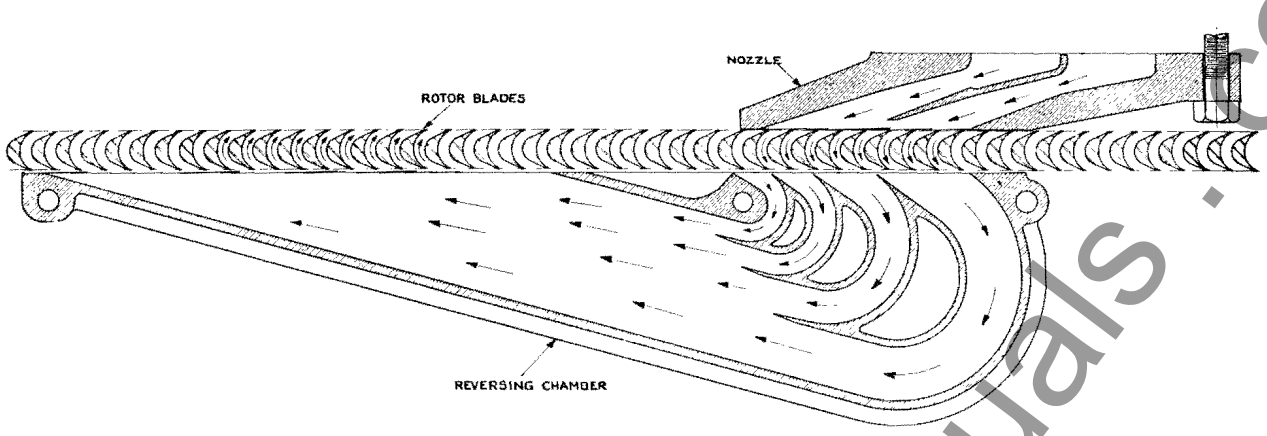


FIG. 10—DEVELOPED SECTION THROUGH NOZZLE BLOCK AND REVERSING CHAMBER, SHOWING PATH OF STEAM

There are two collars turned integral with the gear shaft which bear against the end facings of the thrust bearing. The oil grooves for these faces are fed from the relieved spaces at the horizontal joint. Adjustment is made by means of liners Item Nos. 9, 10, and 11 behind the thrust rings Item No. 6 of the bearing. To adjust: Lift gear wheel from its bearings, remove screws Item No. 7 holding thrust rings, and change liners as desired. There should be .005 to .010 inch axial clearance in this bearing. The axial play or freedom of the pinion shaft relative to the gear may be from .009 to .016 inch.

Nozzles and Reversing Chamber

The steam nozzle, Item No. 40, Figure 14, is located in the cylinder end cover, while the reversing chamber Item No. 41 is bolted to the cylinder and gear case cover. A developed section of the nozzles and reversing chamber is shown in Fig. 10.

When making any setting on the turbine, adjust the rotor so that there will be one-sixteenth of an inch clearance between the blades and the nozzles and one-sixteenth of an inch between the blades and the reversing chamber. After setting the rotor centrally, check the position of the gland runner to see that it has a clearance of approximately one thirty-second of an inch on either side of the gland casing. The gland runner position may be changed on the shaft by removing headless set screw and heating carefully with a gas torch. When in the position desired, replace the set screw. With these clearances correct, adjust the thrust bearing to hold the rotor in this position.

In setting new nozzles and reversing chambers, refer to Figure 14 and note that the reversing chamber should be set flush with the nozzle. It is important that the reversing chamber be set correctly so as to catch all steam emerging from the blades.

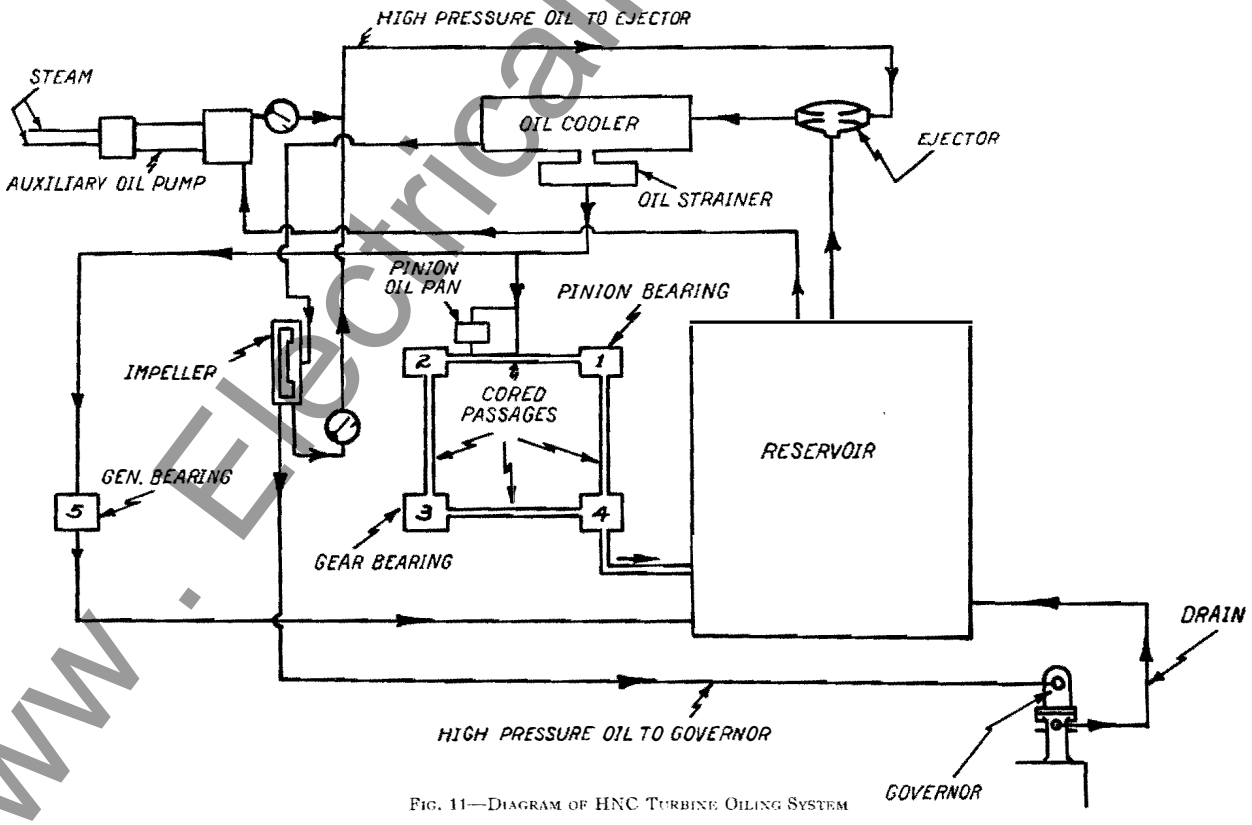


FIG. 11—DIAGRAM OF HNC TURBINE OILING SYSTEM

Oiling System

The base of the gear case serves as a reservoir for the lubricating oil. On one side of this reservoir there is a large cover to permit ready access for cleaning out any dirt or sludge which may deposit from the oil. To circulate the oil for lubrication and the supply to the impeller, an ejector is mounted on the gear case or reservoir below the oil level and a portion of the high pressure oil from the governor impeller is passed through this ejector so as to entrain a much greater quantity of low pressure oil. This oil then passes through a cooler after which part of it goes directly to the impeller and the remainder to the strainer from which it is discharged to the bearings at a pressure of five to ten pounds and to the gear and pinion teeth as they roll into contact. The oil level in the reservoir should be maintained near the center of the sight glass. The oil should in no case be so low that it cannot be seen in the glass, nor should it be above the glass, for the oil will be overheated by coming in contact with the gear wheel. Oil from all bearings except the outboard generator bearing falls directly into the reservoir. Where pedestal type bearing generators are furnished, the oil from the bearing is piped back to the reservoir. Bracket type generators have ring oiled bearings.

The oiling system diagram shown in Figure 11, by means of which the path of the oil may be traced throughout its cycle of circulation, is for machines having pedestal type generators. Oil pressure is built up before starting the unit by means of the auxiliary oil pump, which draws oil from the reservoir and primes the impeller. This pump should be shut down when the turbine speed is such that the impeller is delivering oil at about forty pounds pressure.

When assembling the turbine, care must be taken to see that the cored passages are thoroughly cleaned, and thus insure a plentiful supply of clean oil to the bearings when the unit is in operation. Do not use waste or steel wool anywhere around the unit at any time.

Oil Impeller and Automatic Stop Governor

The impeller, Item No. 14, Figure 12, is actually a small centrifugal pump and is mounted on the end of the pinion shaft. Oil from the ejector at about five pounds pressure enters the impeller at the center and is discharged at its periphery, at eighty to one hundred pounds pressure. The pressure at the impeller periphery varies as the square of the speed of the unit just as the centrifugal force acting on the weights of an ordinary flyball governor varies as the square of the speed. Thus the oil, discharged by the impeller, furnishes a suitable working force for the valve mechanism in the same way and with the same speed characteristics as the weights of the flyball type governor.

The clearance between the impeller and the impeller guide Item No. 17 should be approximately $\frac{5}{64}$" axially and $\frac{1}{8}$" radially.

The automatic stop governor is attached directly to the pinion shaft. It consists of a weight Item No. 11, Figure 12, which operates against a spring Item No. 3 held in place by a retaining nut Item No. 4.

The function of the auto-stop is to shut the turbine down, if for any reason, the main governor should fail to operate and allow the turbine to overspeed.

The auto-stop is set to operate at about 10% overspeed and should not require any adjustment after the turbine is put into service.

When the turbine overspeeds the auto-stop weight is forced out by centrifugal force, compresses the spring, and comes into contact with the trip lever Item No. 3, Figure 13. This movement, through the series of links shown in Figure 13, closes the throttle valve, thus stopping the flow of steam to the turbine.

The clearance between the auto-stop weight and trip lever, with trip gear set, should be from $\frac{1}{32}$" to $\frac{1}{16}$".

Operation

To Start

Start auxiliary oil pump to furnish bearing oil, motive oil for ejector and priming oil for impeller. Open drains on steam and exhaust lines. Open exhaust valve. Crack the steam valve and when live steam appears at the drains, close them. Bring the turbine up to speed slowly, and when it is under control of the governor, open throttle valve wide. Turn on gland water. Stop auxiliary oil pump.

With the unit under way, the speed may be checked by means of the tachometer furnished on the turbine. If the speed is not correct it should be made so at this time. To decrease the speed, turn the governor handwheel counter-clockwise so as to decrease the compression on the governor spring and vice versa to increase the speed. The normal speed is approximately the speed at full load. The no-load speed will be about 4% higher.

To Shut Down

Shut off gland water. Strike hand trip lever sharply, which will close the throttle valve and indicate that the automatic trip mechanism is working properly. Close throttle valve with the handwheel and reset automatic trip. Open steam and exhaust drains. Close exhaust valve.

Maintenance

Care of the Turbine

1. Keep machine clean.
2. Keep the proper amount of good quality, clean oil in the reservoir.
3. If steam is contaminated with boiler compound or sludge, clean off governor valve stem as often as necessary to keep it working freely.
4. Before starting a unit that has been idle for some months, dismantle governor operating mechanism and steam chest governor valve to see that all parts are free and in good working condition.
5. The automatic stop should be tripped periodically; say once a month, by actual overspeeding of machine to see that it is in proper working condition. See that it shuts machine down.

Operating Trouble

Governor Hunting

1. Sticking of governor valve in guides or stem gland or oil operating parts.

Turbine Fails to Come Up to Speed

1. Low boiler pressure.
2. Steam line clogged.
3. Dirty steam strainer.
4. Nozzle throat plugged by foreign matter.
5. Governor speed set too low.
6. Wet steam.

Gland Leaking Steam

1. Packing rings stuck in gland.
2. Water passages clogged with dirt or scale.
3. Recesses in gland runner clogged with scale.

4. No water in gland.
5. Gland joint made up improperly.

Gland Leaking Water

1. Too high a head of water on gland.
2. Obstruction or burrs in gland runner passage.
3. Gland runner rubbing on side of casing.

Inspection

A thorough inspection of all parts of the turbine should be made once a year, renewing such parts as may show undue wear. If heavy wear of any part is evidenced, the cause of the wear should be ascertained if possible, and in any case replacement of the part should be made before failure, as this will be cheaper than a future shut down.

Renewal Parts

Repairing

Repair work can be done most satisfactorily at our nearest Service Shop. However, interchangeable renewal parts can be furnished to customers, who are equipped for doing repair work.

Ordering Instructions

When ordering renewal parts, give the name plate information. Always give the name of the part wanted, also the serial number of the apparatus on which the part is to be used. Refer to the back of this book for the nearest Sales Office from which to order parts.

For sectional views and lists of parts, refer to the following pages

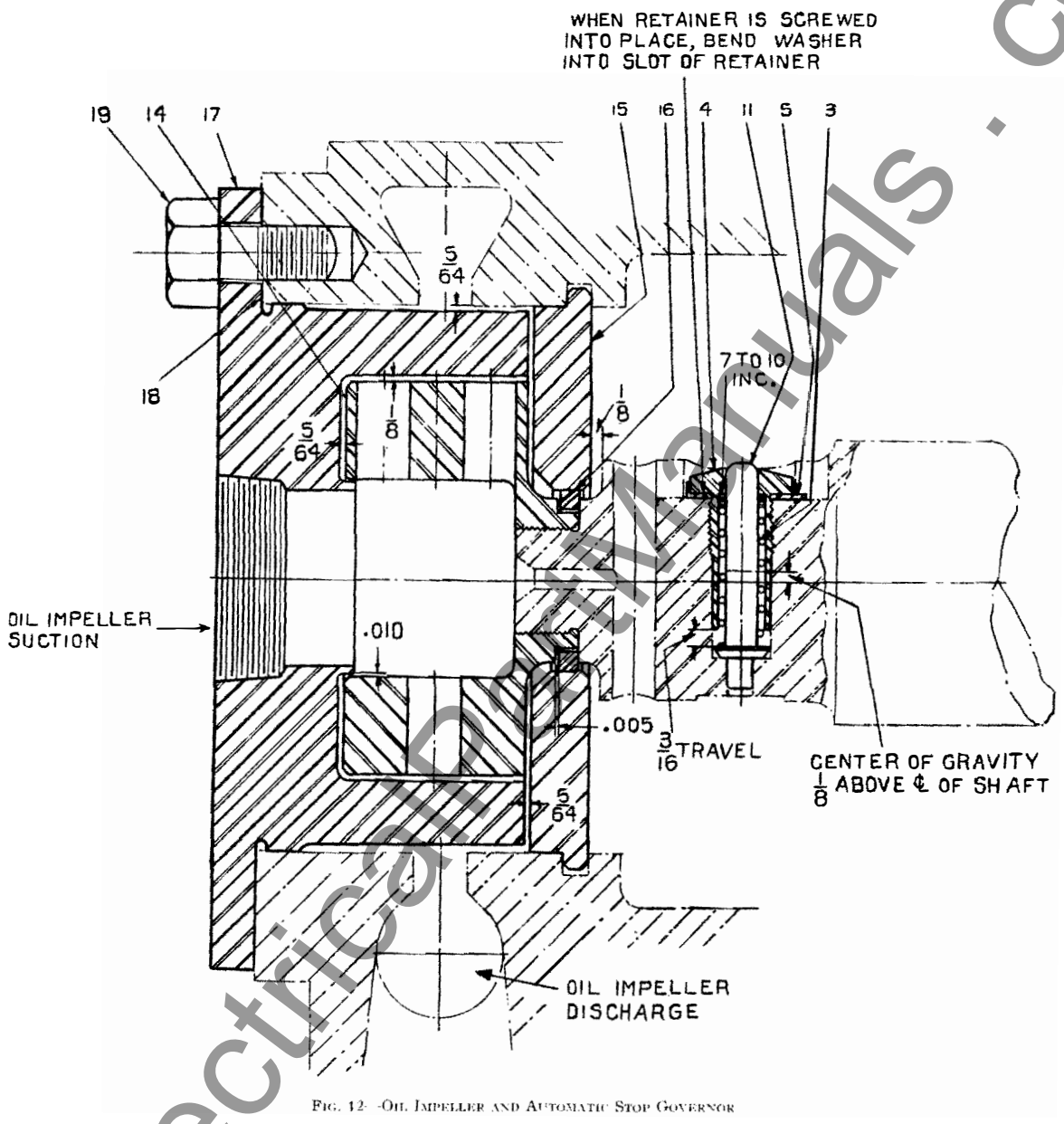


FIG. 12.—OIL IMPELLER AND AUTOMATIC STOP GOVERNOR

The following list refers to Figure 12:

Item	Name
3	Auto Stop Governor Spring.
4	Auto Stop Governor Spring Retainer.
5	Auto Stop Governor Spring Retainer Lock Washer.
7-10	Auto Stop Governor Spring Adjusting Liners.
11	Auto Stop Governor Weight.
14	Oil Governor Impeller.
15	Oil Governor Impeller Baffle.
16	Oil Governor Impeller Baffle Ring.
17	Oil Governor Impeller Guide.
18	Oil Governor Impeller Guide Gasket.
19	Oil Governor Impeller Flange Tap Bolt.
20	Oil Governor Impeller Flange Gasket.

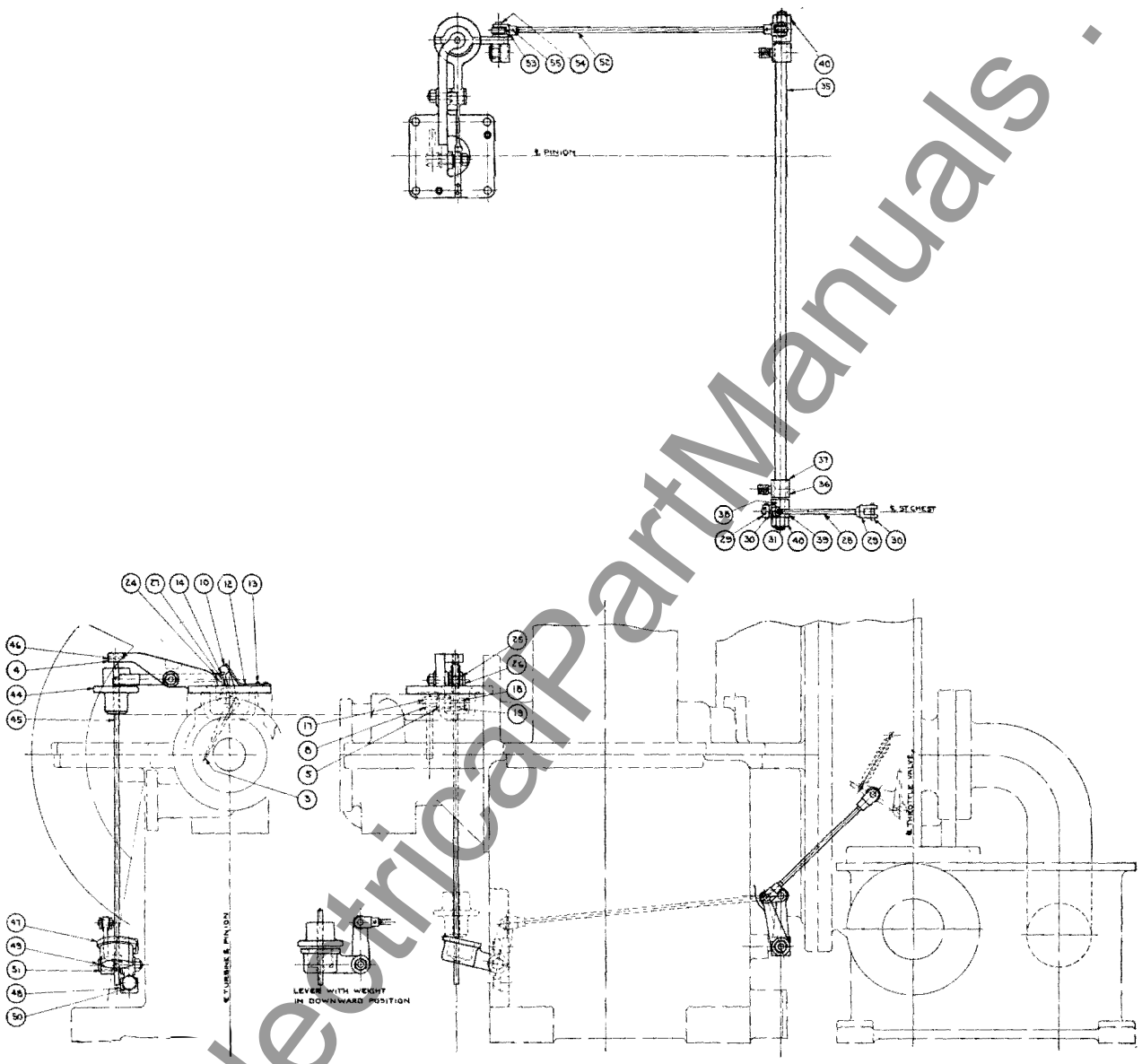


FIG. 13—AUTOMATIC STOP GOVERNOR TRIP LINKAGE

The following list refers to Figure 13:

Item	Name
3	Auto Stop Governor Trip Lever.
4	Auto Stop Governor Trip Lever Bracket.
5	Auto Stop Governor Trip Lever Bracket Bushing.
6	Auto Stop Governor Trip Lever Bracket Taper Dowel.
7	Auto Stop Governor Trip Lever Bracket Tap Bolt.
8	Auto Stop Governor Trip Lever Feather Key.
10	Auto Stop Governor Trip Lever Extension.
11	Auto Stop Governor Trip Lever Extension Feather Key.
12	Auto Stop Governor Trip Lever Extension Feather Key Spring.
13	Auto Stop Governor Trip Lever Extension Feather Key Spring Screw.
14	Auto Stop Governor Trip Lever Extension Tip.
17	Auto Stop Governor Trip Lever Fulcrum Pin.
18	Auto Stop Governor Trip Lever Fulcrum Pin Nut.
19	Auto Stop Governor Trip Lever Fulcrum Lock Washer.
24	Auto Stop Governor Trip Release Lever.
25	Auto Stop Governor Trip Release Lever Bushing.
26	Auto Stop Governor Trip Release Lever Round Head Shoulder Pin.
27	Auto Stop Governor Trip Release Lever Tip.
28	Auto Stop Governor Trip Rod (Throttle Valve).
29	Auto Stop Governor Trip Rod Head.
30	Auto Stop Governor Trip Rod Head Fulcrum Pin.
31	Auto Stop Governor Trip Rod Head Pin.
35	Auto Stop Governor Trip Shaft.
36	Auto Stop Governor Trip Shaft Fulcrum.
37	Auto Stop Governor Trip Shaft Fulcrum Bushing.
38	Auto Stop Governor Trip Shaft Feather Key.
39	Auto Stop Governor Trip Shaft Lever.
40	Auto Stop Governor Trip Shaft Nut.
44	Auto Stop Governor Trip Weight.
45	Auto Stop Governor Trip Weight Rod.
46	Auto Stop Governor Trip Weight Rod Finish Pin.
47	Auto Stop Governor Trip Weight Strike Lever.
48	Auto Stop Governor Trip Weight Strike Lever Bracket.
49	Auto Stop Governor Trip Weight Strike Lever Bracket Shoulder Pin.
50	Auto Stop Governor Trip Weight Strike Lever Bracket Tap Bolt.
51	Auto Stop Governor Trip Weight Strike Lever Bushing.
52	Auto Stop Governor Trip Weight Strike Lever Rod.
53	Auto Stop Governor Trip Weight Strike Lever Rod Head.
54	Auto Stop Governor Trip Weight Strike Lever Rod Head Fulcrum Pin.
55	Auto Stop Governor Trip Weight Strike Lever Rod Head Pin.

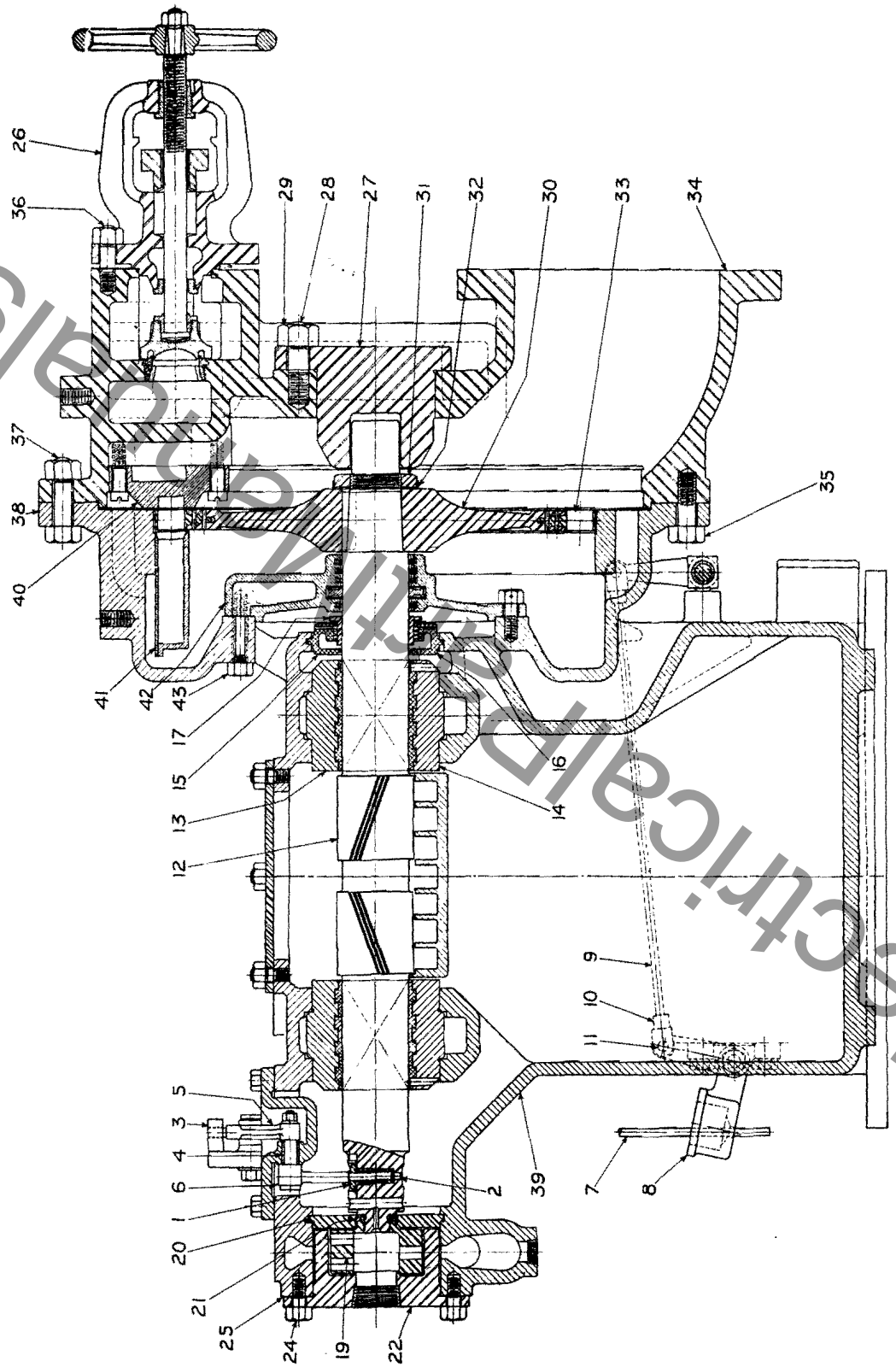
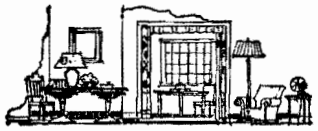


FIG. 14—LONGITUDINAL SECTION OF TURBINE AND GEAR

The following list refers to Figure 14:

Item	Name
1	Auto Stop Governor Spring Retainer.
2	Auto Stop Governor Weight.
3	Auto Stop Governor Trip Lever Bracket.
4	Auto Stop Governor Trip Lever Bracket Bushing.
5	Auto Stop Governor Trip Lever Extension.
6	Auto Stop Governor Trip Lever.
7	Auto Stop Governor Trip Weight Rod.
8	Auto Stop Governor Trip Weight Strike Lever.
9	Auto Stop Governor Trip Weight Strike Lever Rod.
10	Auto Stop Governor Trip Weight Strike Lever Rod Head.
11	Auto Stop Governor Trip Weight Strike Lever Rod Head Pin.
12	Gear Pinion Shaft.
13	Gear Pinion Shaft Bearing (Upper Half).
14	Gear Pinion Shaft Bearing (Lower Half).
15	Gear Pinion Shaft Bearing Oil Ring (Upper Half).
16	Gear Pinion Shaft Bearing Oil Ring (Lower Half).
17	Gear Pinion Shaft Oil Thrower.
19	Oil Governor Impeller.
20	Oil Governor Impeller Baffle.
21	Oil Governor Impeller Baffle Ring.
22	Oil Governor Impeller Guide.
24	Oil Governor Impeller Flange Tap Bolt.
25	Oil Governor Impeller Flange Gasket.
26	Turbine Auxiliary Valve (Complete).
27	Turbine Restraining Ring.
28	Turbine Restraining Ring Stud.
29	Turbine Restraining Ring Stud Nut.
30	Turbine Rotor.
31	Turbine Rotor Nut.
32	Turbine Rotor Nut Lock Washer.
33	Turbine Rotor Blade.
34	Turbine End Cover.
35	Turbine End Cover Stud (Base).
36	Turbine End Cover Stud (Auxiliary Valve).
37	Turbine End Cover Stud Through Bolt.
38	Turbine and Gear Case Cover.
39	Turbine and Gear Case Base.
40	Turbine Nozzle Block.
41	Turbine Reversing Chamber.
42	Turbine Gland Casing.
43	Turbine Water Gland Casing Tap Bolt.

Westinghouse Products



Homes—Farms

Air Heaters
Auto Engine Heaters
Automatic Irons
Automatic Percolators
Automatic Ranges
Cozy Glow Heaters
Curling Irons
Fans
Hot Plates
Light and Power Plants
Lighting Equipment
Mazda Lamps
Motors for
  Buffers and Grinders
  Ice Cream Freezers
  Ironers and Washers
  Refrigerators
  Sewing Machines
  Vacuum Cleaners
Newel Posts
Panelboards
Radio Equipment
Rectigon Chargers for Automobiles and Radio Batteries
Rectox Trickle Charger
Refrigerators, Electrical
Safety Switches
Sollaire Luminaires
Sol-Lux Luminaires
Solar Glow Heaters
Table Stoves
Tumbler Water Heaters
Turnover Toasters
Vacuum Cleaners
Wall-Type Heaters
Waffle Irons
Warming Pads
Water Heaters

Buildings

Arc Welding Equip.
Circuit-Breakers
Elevators and Control
Glue and Solder Pots
Instruments and Relays
Kitchen Equipment
  Bake Ovens
  Hot Plates, Ranges
Lighting Equipment
  Brackets, Newels and Lanterns
  Reflectors & Lamps
  Sol-Lux Luminaires
Lightning Arresters
Micarta Trays
Meters
Meter Service Switches
Motor Generators
Motors and Control for:
  Coal and Ash-Handling Equipment
  Compressors
  Elevators
  Fans and Blowers
  Laundry Equipment
  Refrigerating Equip.
  Vacuum Cleaners
  Water & Sump Pumps
Panelboards
Radio Equipment
Synchronous Converters
Safety Switches
Solar Glow Heaters
Stokers
Switchgear
Transformers

City Improvements

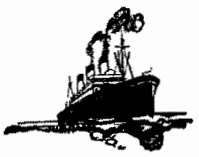
Airport Floodlights
Automatic Substations
Constant Current Regulators
Control Apparatus
Elec. Railway Equip.
Ligbting Units
Mazda Lamps
Ornamental Standards
Parkway Cables
Street Brackets
Streethoods

Offices and Stores

Air Heaters
Bread-baking Oven
Elevators and Control
Fans, Desk and Exhaust
Fuses
Lighting Equipment
Mazda Lamps
Meters
Micarta Desk Tops
Motors for
  Adding Machines
  Addressing Machines
Motors for
  Coffee and Meat Grinders, etc.
  Dictaphones
  Envelope Sealers
  Fans and Blowers
  Pumps
  Refrigerating Machines
Panelboards
Safety Switches
Swirches
Tumbler Water Heaters

Aviation

Approach, Boundary, Hangar, and Obstruction Lights
Arc Welding Equip.
Floodlight Projectors
Motor-Generators
Reflectors
Transformers
Mazda Lamps
Micarta
  Cabin-lining Plate
  Fairleads
  Hinge Bearings
  Propellers
  Pulleys
  Tailwheels
Radio Equipment

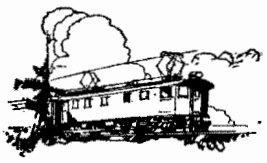


Ships

Circuit-Breakers
Condensing Equipment
Deck Winch Motors
Elec. Heating Appar.
Eng. Room Auxiliaries
Fans and Blowers
Fuses
Generating Equipment
Instruments
Light and Power Plants
Lighting Equipment
Micarta Trays
Motors and Controllers
Ovens, Ranges and Galley Equipment
Panelboards
Propulsion Equipment
  Diesel-Electric
  Geared Turbine
  Turbine Electric
Radio Equipment
Safety Switches
Switchgear

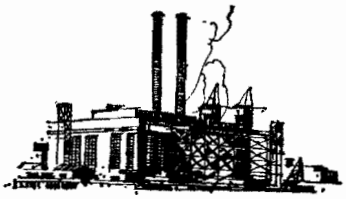
Electric Railways

Arc Welding Equip.
Automatic Substations
Babbitt, Solder & Pots
Baking Ovens
Circuit-Breakers
Elec. Trolley Coaches
Fans
Gas Electric Coaches
Gears and Pinions
Generators
Insulating Material
Insulators
Lighting Fixtures
Lightning Arresters
Line Material
Manual Substations
Mazda Lamps
Meters
Motors and Control
Panelboards
Portable Substations
Relays
Signal Equipment
Supervisory Control
Switchgear
Synchronous Convert's
Transformers
Trolley Poles



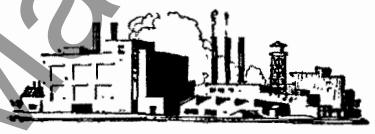
Railroads

Arc Welding Equipment
Automatic Substations
Babbitt, Solder & Pots
Baking Ovens
Battery Charging Equip.
Cars—Multiple-Unit, Gas-Elec., Oil-Elec.
Circuit-Breakers
Control Apparatus
Elec. Heating Apparatus
Fans
Gears and Pinions
Generators
Headlight Equipment
Instruments
Insulating Materials
Insulators
Lighting Equipment
Lightning Arresters
Line Material
Locomotives—Electric Gas-Elec., Oil-Elec.
Manual Substations
Mazda Lamps
Micarta Gears
Motors and Control
Outdoor Substations
Panelboards
Power House Apparatus
Radio Equipment
Safety Switches
Signal Equipment
Stokers
Supervisory Control
Switchgear
Transformers
Yard Lighting Equip.



Electric Service Companies

Automatic Switching Equipment
Circuit-breakers
Condensers
Cutouts
Fans
Frequency-converters
Fuses
Generators
Instruments & Meters
Insulating Material
Insulators
Line Material
Lighting Equipment
Lightning Arresters
Micarta
Motors and Control
Motor-Generators
Network Protectors
Network Transformers
Oil Testing and Purifying Equipment
Outdoor Substations
Panelboards
Porcelain Insulators
Relays
Safety Switches
Steam Turbines
Stokers
Supervisory Control
Switchgear
Synchronous Conden'rs
Synchronous Conv'ters
Transformers
Turbine Generators
Voltage Regulators

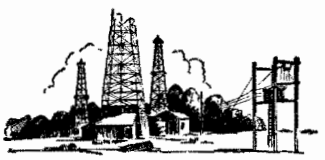


Mills and Factories

Arc Welding Equip.
Automatic Starters and Controllers
Babbitt & Babbitt Pots
Capacitors
Circuit-Breakers
Condensers
Fans, Desk and Exhaust
Furnaces and Ovens
Fuses
Generating Equipment
Insulating Materials
Knife Switches
Larry Car Equipment
Lighting Equipment
Lightning Arresters
Locomotives—Electric Gas-Elec., Oil Elec.
Mazda Lamps
Meters and Relays
Micarta Gears
Motors and Controllers
Panelboards
Pipe Fittings (Struct'al)
Power House Apparatus
Safety Switches
Solder & Glue Pots
Space Heaters
Stokers
Switchgear
Transformers
Turbines

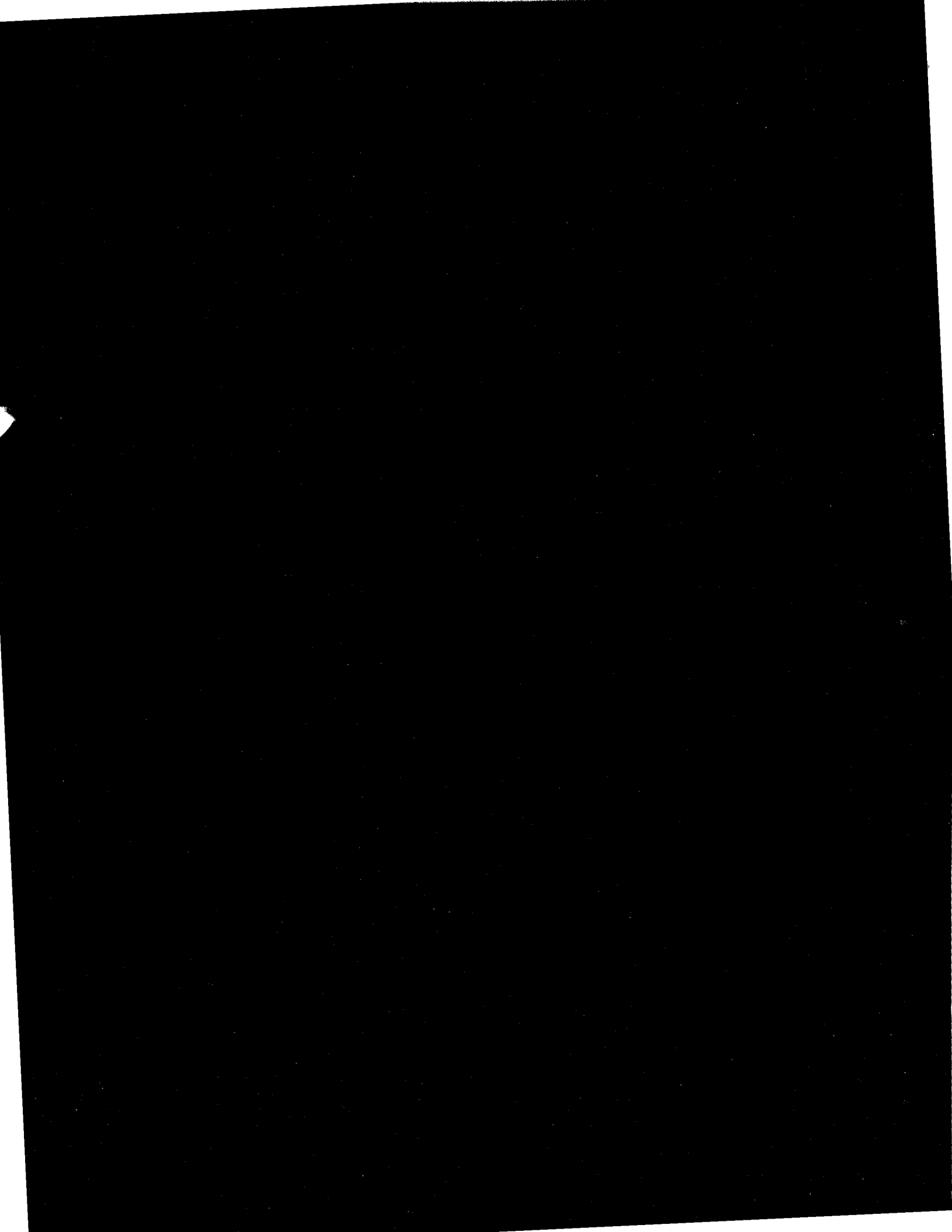
Mines

Arc Welding Equip.
Auto. Feeder Equip.
Automatic Starters and Controllers
Automatic Substations
Battery Charging Equip.
Circuit-Breakers
Clamps
Elec. Heating Apparatus
Fans
Gears and Pinions
Headlights
Insulating Materials
Insulators
Larry Car Equipment
Lightning Arresters
Line Material
Locomotives
Manual Substations
Mazda Lamps
Meters & Instruments
Micarta
Motor Generators
Motors for Hoists, Pumps, Tipples, and Breakers
Panelboards
Portable Substations
Relays
Safety Switches
Switchgear
Synchronous Conv'ters
Transformers
Ventilating Outfits



Oil Fields

Arc Welding Equip.
Change House Heaters
Floodlight Projectors
Gear Units
Insulators
Mazda Lamps
Motors and Control
Panelboards
Reflectors
Rig Lighters
Safety Switches
Small Light Plants
Transformers
Vapor Proof Fixtures



Westinghouse

Small Geared Turbines

Type HNC

INSTRUCTION BOOK

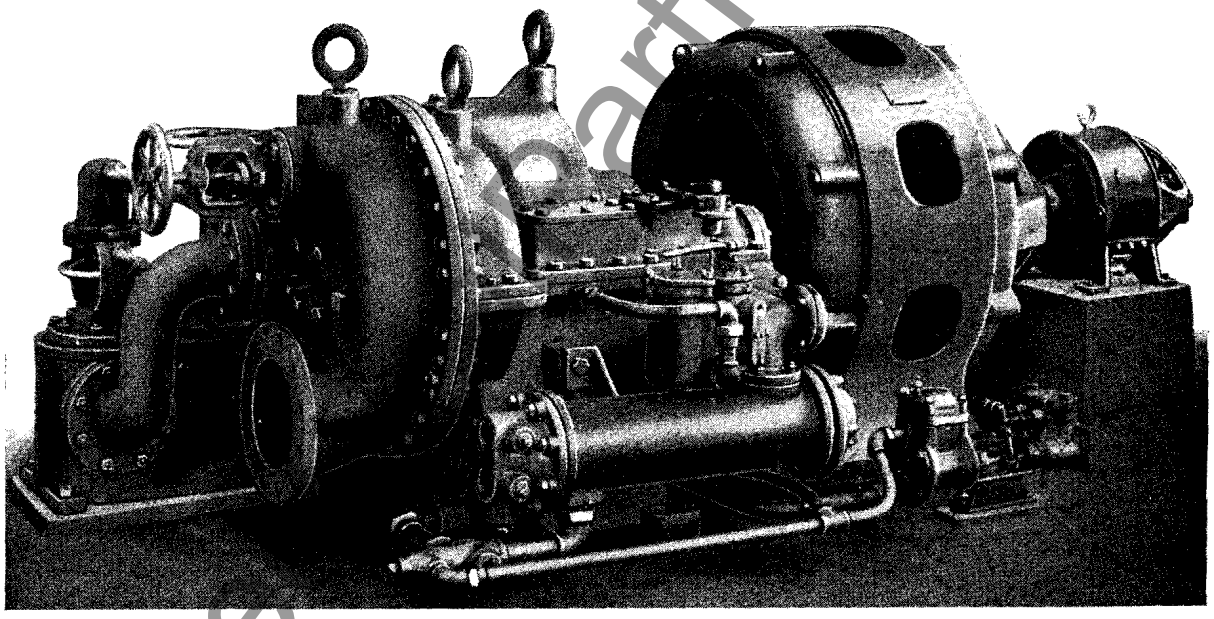


FIG. 1—300 KW. ALTERNATING-CURRENT TURBINE-GENERATOR UNIT WITH EXCITER

Westinghouse Electric & Manufacturing Company

South Philadelphia Works

Philadelphia, Pa.

I. B. 5416

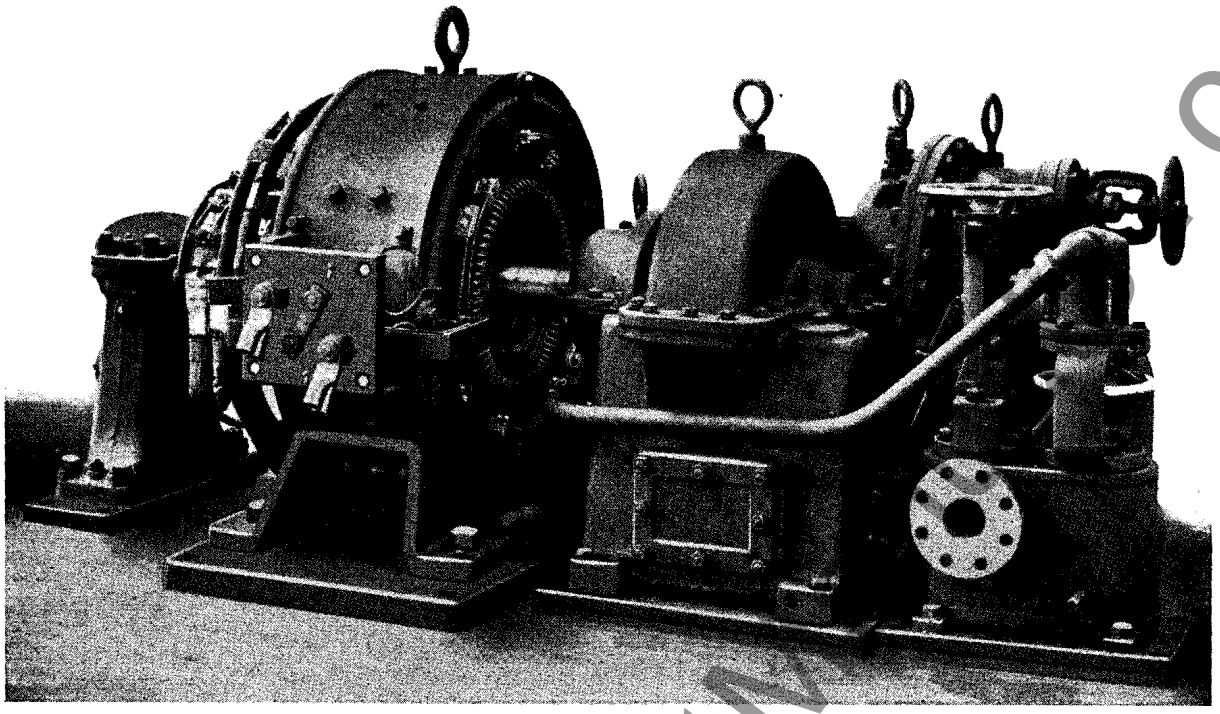


FIG. 2—100 KW. DIRECT-CURRENT TURBINE GENERATOR UNIT

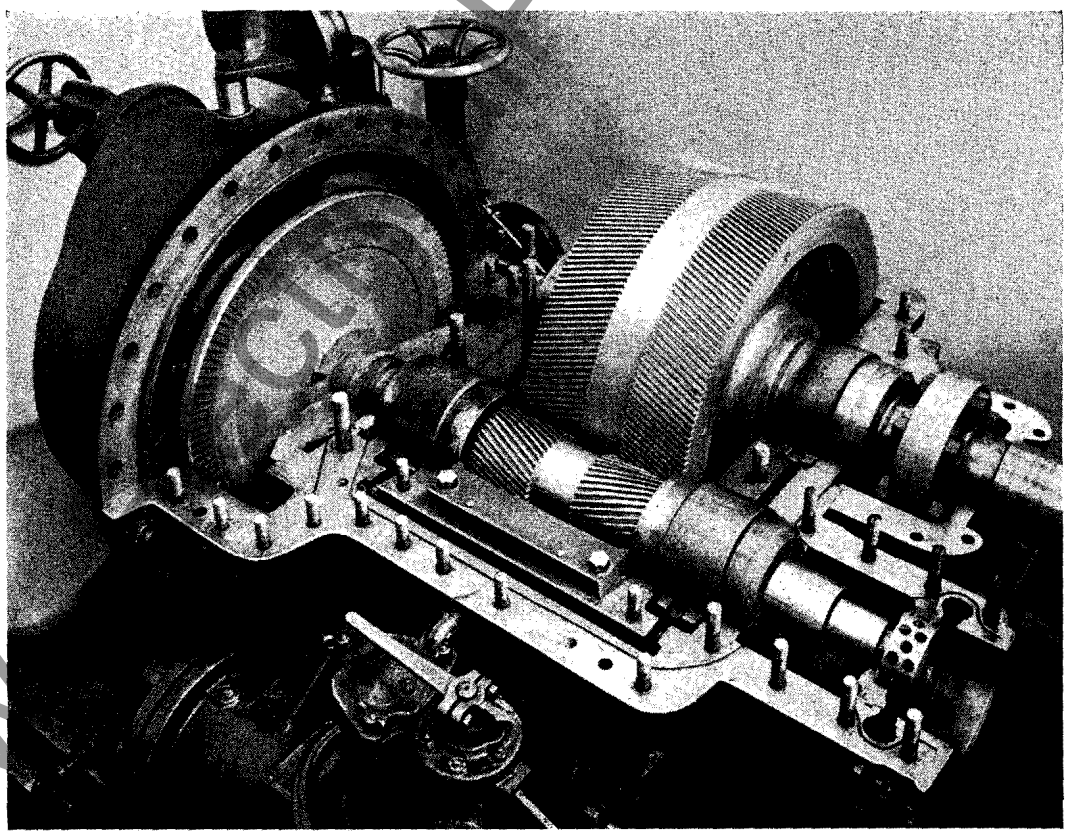


FIG. 3—TURBINE AND GEAR, WITH COVER REMOVED

Westinghouse
Small Geared Turbines
Type HNC

Introduction

The steam turbine is now in universal use for the operation of small boiler room and engine room auxiliaries as well as for the large generating units. Development has taken place at such a rate that at the present time the most reliable and economical drive for exciter sets in central stations, and source of power in industrial and marine plants is found in the small turbine, either direct-connected or geared.

Several advantages of the turbine over the reciprocating engine are to be noted, among which the following may be said to be outstanding: The steam in passing from the inlet to the exhaust of the turbine follows more closely the curve of adiabatic expansion, which gives more nearly ideal performance; cylinder condensation is reduced to a minimum since all parts of the turbine are subjected to practically uniform temperature; there are no reciprocating or rubbing parts, thus decreasing the wear on the component parts and loss of power due to friction; exhaust steam is free from oil; foundations of excessive size are not necessary since the vibration of a turbine unit is negligible; and the floor space required is much less than that required for a reciprocating engine of the same power.

Though the turbine is simple in construction and reliable in operation, and does not have parts that require constant care and manipulation by the operator, it is like any other piece of high grade machinery in that intelligent and careful attention must be given it by its operators. All working parts that are not at all times visible should be given a periodic inspection. It is for the purpose of giving the turbine operator a better opportunity to familiarize himself with the mechanical details of the unit of which he is in charge, and also to furnish a convenient reference for the ordering of repair parts, that this instruction book has been prepared.

The turbine described herein is of the re-entry type and consists essentially of a single wheel carrying one row of impulse blading and overhung on an extension of the pinion shaft. Steam enters 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 instantly if the turbine overspeeds a predetermined amount. The steam then passes through the governor valve and enters the bowl of the nozzle block. It expands through the nozzles to the exhaust pressure and acquires a high velocity with which it impinges upon the blades on 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 two times, practically all of the velocity caused by the expansion of the steam through the nozzles has been transferred to the turbine wheel in the form of mechanical work and the steam finds its way into the turbine casing, passing out through the exhaust line.

Figures 1, 2, 3 and 4 will give the reader a general idea of the construction of turbines of this type. The unit will be described in detail in another part of this book.

Installation

Foundation

It is deemed advisable to provide a concrete foundation, though this is not absolutely necessary. Extensive foundations are not necessary since the weight of the unit is not great. It is

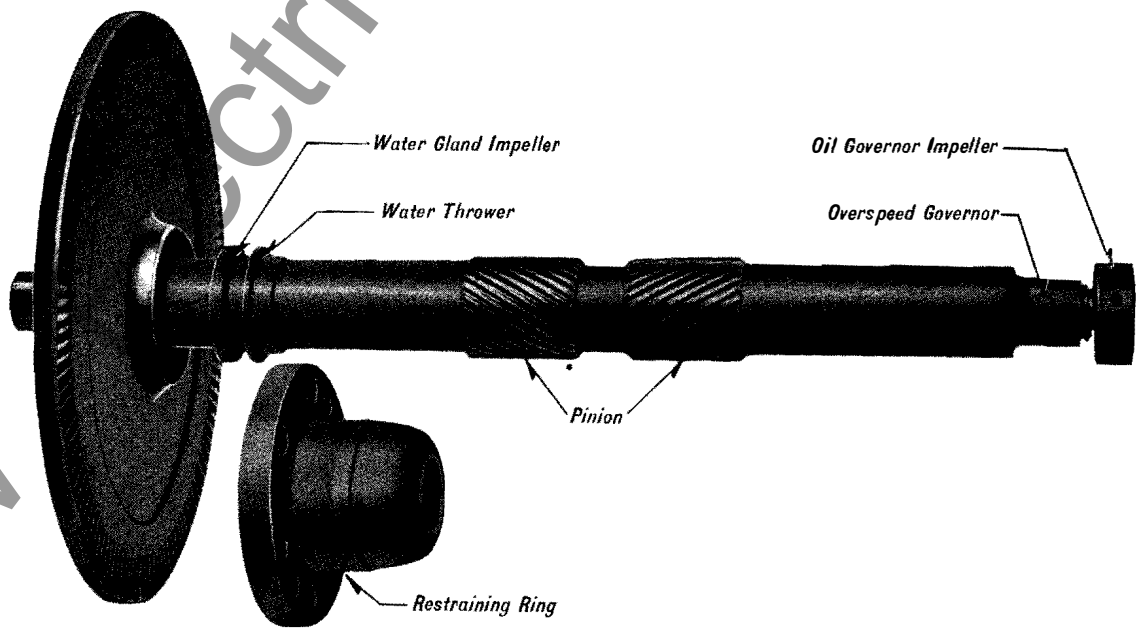


FIG. 4—COMPLETE ROTOR, WITH RESTRAINING RING

desirable that the foundation be built independently of the building, or at least of such parts of the building as may transmit vibration. The top of the foundation should not be finished until after erection of the unit, leaving about one inch for grout. The foundation bolt sleeves should have an inside diameter about 3/8" larger than the bolt to allow for minor discrepancies. The size of bolts may be obtained from the official outline drawing.

Erection

Handling

The unit is shipped mounted on skids and boxed. The skids should be left in place until the final operation of setting the unit on the foundation is reached. Eye bolts are furnished for lifting the cylinder and gear cover only and should not be used for lifting the assembled unit. When handling the complete machine care should be taken to distribute the load properly upon slings so as not to put undue strain on any one part of the unit.

Soleplates made of steel and finished on one side are furnished to be grouted to the foundation, thus acting as seating plates for the unit. Turbine and gear, generator and outboard pedestal are separately doweled to these steel plates so that they may be removed and replaced in the same position. After the complete unit has been levelled on the foundation the grout may be poured. The grout should consist of a thin one to one mixture of high grade Portland Cement and clean, sharp sand. It must be well worked in under the seating plates.

The grout must be allowed to dry thoroughly before tightening up the foundation bolts. In tightening the bolts care must again be exercised to see that no part of the unit is being subjected to undue strains.

If a steel foundation is used the unit should be carefully levelled by means of shims under the gear and generator feet. The steam chest must also be levelled up with care so that no strain will be imposed on the piping.

Piping

Steam and exhaust pipes should be very carefully installed, in order that no strains may be imposed on the turbine proper with consequent misalignment. In connecting the turbine to the steam and exhaust lines, begin the piping from the connecting line and end at the turbine, making the turbine connections the last in the line. Never start piping from the turbine, for doing so will undoubtedly distort the casing or spring the turbine out of line, inasmuch as the weight of the piping will hang directly on the turbine.

If screwed fittings are used, the line should be provided with swinging joints. If flanged fittings are used, long radius bends should be placed in the piping to take care of the expansion of the steam line. Support the piping at a point near the turbine in such a manner that the weight is taken by the support. It should be so arranged that the expansion will not have to be resisted by the turbine. Make sure that the flanges are parallel and that no force is necessary to bring them together or to match up the bolt holes. After installing the piping, heat up to full working temperature, break joints and check.

The exhaust piping should be provided with an expansion joint located next to the turbine exhaust flange. A suitable expansion joint can be purchased from the turbine manufacturer if desired. Even though an expansion joint is used, the same caution in connecting up should be exercised. Be sure that the expansion joint is light enough to be flexible.

In piping up a turbine, make all pipe supports permanent. Do not expect a block of wood, driven under a pipe, to take the strain from the turbine. The best method of supporting the piping is to use an adjustable foot under it as near to the turbine as possible. Another method is to hang it from the building by tie rods which connect to the piping near the turbine. These rods, however, to be satisfactory, must be short. Always put in the supports before actually making the connection to the turbine.

In all cases where the turbine unit is to be realigned, disconnect the steam and exhaust piping, and in re-connecting, be sure that the flanges line up without putting a strain upon the turbine when either hot or cold. If they do not, change the piping.

When laying out the piping a stop valve should be placed in the steam line between the boiler and the turbine. This valve is not necessary for the operation of the turbine but is for use when it is desired to inspect or make repairs on the turbine throttle valve.

If exhausting to the atmosphere, no valve is needed in the exhaust line unless the exhaust pipe is common with that of other units, in which case a stop valve should be supplied to prevent backing up of steam when the turbine is idle. If exhausting to a heater of any kind or to a condenser, a stop valve is required; likewise when condenser also serves another unit.

Small pipes are required to convey water to and from the cooling coil and the gland; to carry away the leak-off steam from the governor valve stem packing, and to connect the cavity outside the gland to an open drain. These pipes are so small that no special precautions need be taken against imposing strains on the unit. The connections for these pipes are shown on the outline drawing, which gives sufficient information concerning their installation. Water pressure should be five pounds greater than exhaust pressure but should not exceed twenty-five pounds.

The oil cooler should be supplied with water through a half or three-quarter inch pipe line at a pressure of from fifteen to sixty pounds. This water may be obtained from any convenient source and should be as cold as possible. It may also be used for the gland.

Checking Installation

These units are carefully set up and inspected in the shop, all adjustments made, and are operated under contract conditions as nearly as possible. As a usual case the unit requires no further adjustments.

Detailed Description and Operation

Cylinder

The cylinder of this type turbine is of rather unusual construction in that it is split vertically in a plane normal to its centerline, the outer part being a single casting bolted to a machined surface on the ends of the upper and lower halves of the gear case. The gear case is split on the horizontal centerline forming the gear and cylinder cover and base respectively. The upper half of the combined turbine and gear housing can be removed without disturbing the steam or exhaust connections. The cylinder end cover is attached to the other part of the cylinder in such a way that the cylinder and gear case cover can be taken off without removing the end

cover. In raising the gear cover, the bolts securing it to the cylinder end cover and the gland must be removed and the cover lifted straight up so that the reversing chamber will clear the turbine rotor. Before replacing, scrape joints clean, and make up with shellac. When high back pressures are used, place a fine linen thread around the flange inside of bolts. Be sure to pull the bolts up tight before the shellac hardens.

Both the steam inlet and exhaust outlet are connected to the cylinder end cover. This cover also carries the nozzles and the nozzle control valve.

Rotating Element

The rotating element, shown in Figure 4, consists of the pinion shaft, which carries the rotor, auto-stop governor and oil impeller, supported by the two pinion bearings. The rotor is pressed on the shaft with a tapered press fit and is held in place by a nut which is in turn held in place by a lock washer. A loose rotor may result from overspeeding of the turbine and is evidenced by vibration. If a loose rotor is suspected, it should be pressed off and the fit examined. In putting on a new rotor be sure that a good fit is obtained. The rotor should slide on the shaft until it is one inch from the hub and must be pressed on the remainder of the distance.

When the rotating element is to be removed from the cylinder without disturbing the cylinder end cover, the restraining ring forging must first be unbolted and removed from the end cover. Since the restraining ring surrounds the rotor shaft extension, it would otherwise be impossible to lift the rotor out of the cylinder.

Governor, Throttle Valve and Steam Chest

The governor, throttle valve and steam chest used on this type unit for capacities of from 75 to 100 kw. is shown in Figure 5; and that used on units for capacities of from 100 to 500 kw. is shown in Figure 6. They are of the same type and operate in the same manner, but both illustrations are given in order to facilitate the ordering of repair parts for units of different capacities.

The governor is of the oil operated type, receiving its oil from the impeller described herein, and consists of an oil cylinder Item No. 6 (Figure 6) in which there is mounted a spring opposed piston Item No. 19 direct-connected to the governor valve Item No. 182. Oil discharged from the impeller, the pressure of which varies as the square of the change in speed, acts against this piston to compress the spring and put the governor valve in the position to admit the amount of steam necessary to maintain the turbine at the desired speed for the load it is then carrying.

The speed of the turbine can be changed by increasing or decreasing the compression on the governor spring Item No. 22 by means of the handwheel Item No. 17 furnished for the purpose.

After the governor has been adjusted on the factory test floor it does not require any further adjustment by the operator.

The throttle valve and steam chest are contained in a common casting, the steam chest consisting of a nickel bronze valve cage mounted within the casing and carrying the governor valve; the throttle valve occupying the opposite end of the casting. The throttle valve is of the automatic type, being connected to the auto-stop governor through the linkage shown in Figure 13, and having a nickel bronze valve disc attached to the lower end of the valve stem. Both disc and seat are made of nickel bronze except in cases where the initial temperature is exceedingly high, in which case they are made of monel metal.

Steam is kept from leaking by the throttle valve stem by means of the packing Item No. 93. This forms a very effective means for sealing against leakage. There is no metallic packing used on the governor valve stem, leakage being prevented by serrations or grooves cut in the governor valve stem Item No. 43 where the stem passes through the governor cylinder support gland Item No. 8. This forms a series of labyrinth packing strips and the steam which may leak by is carried off through the drain in the packing gland Item No. 8. This leak-off should be led to an open drain or other point without back pressure, such as an open feed water heater.

The lists which follow the description of the component parts of the unit are compiled to facilitate the ordering of repair parts by name and number together with the serial number of the turbine.

Spindle Gland

Since the turbine rotor is overhung from the pinion shaft, there being no turbine bearings, only one sealing gland is required. It is of the combined water sealed and labyrinth type and is shown in Figure 7.

This gland consists of a bronze impeller which is mounted on the spindle and rotates within a bronze casing bolted to the turbine cylinder. Water under a head, depending on the back pressure, is introduced into the casing. The rotation of the runner tends to pump the water out of the casing, but due to the restricted discharge there results an annular ring of water around the interior of the gland, which prevents the passage of steam out of, or of air into the cylinder. This gland will seal equally well when the turbine is operating condensing or non-condensing. The labyrinth packing is placed inside of the gland runner so that for cases of operation at back pressures in excess of fifteen pounds, an effective seal may be had. This packing should be fitted very carefully in the gland, allowing it to have about three-thousandths of an inch side clearance in its groove so that it may be free to move forward and backward under the action of the shaft and the packing ring springs. The ends of packing pieces should come together when they shoulder in the gland casing. The inside diameter of the packing ring should be slightly smaller than shaft to allow for wearing in. When first fitted up they may cause the turbine to run rough by bearing hard, in which case they will have to be scraped.

The water outlet valve should be so adjusted that the flow of water through the gland will be enough to maintain a temperature slightly below that of the boiling point.

Excessive water leakage from the gland may indicate that the head of water supplied to the gland is too high and should be reduced. It may also indicate that the gland is set up so that the horizontal flanges inside of the gland cavity do not match up, thus forming a sharp projection, which breaks up the flow of the water. Too close clearance on either side of the gland runner may also cause a considerable leakage of water.

In making an inspection of the gland, the horizontal flange bolts should be removed and the gear case cover lifted. The gland may then be taken apart.

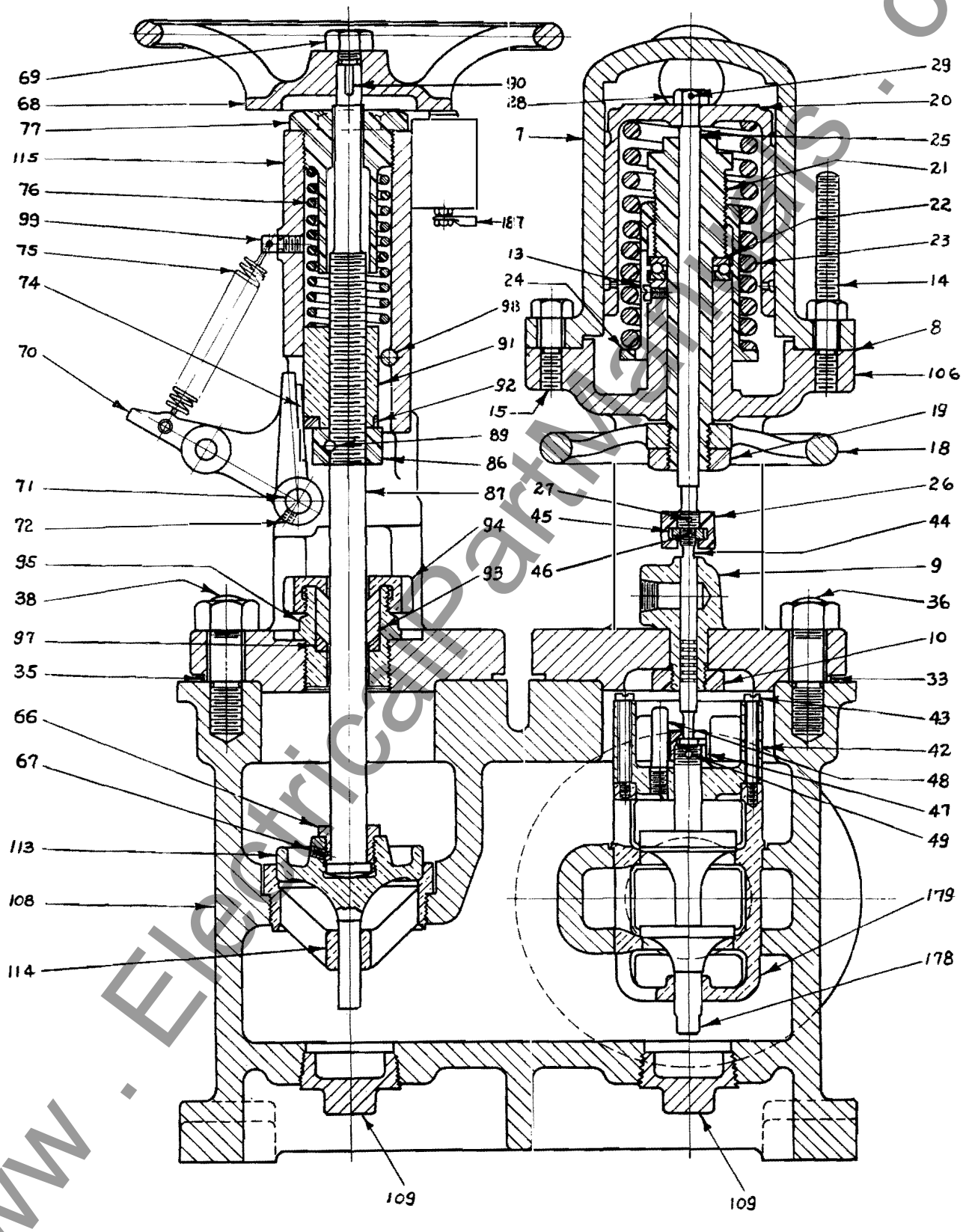


FIG. 5—GOVERNOR, STEAM CHEST AND THROTTLE VALVE

The following list is for the Governor, Steam Chest and Throttle Valve shown in Figure 5, and applies to units of from 75 to 100 kw. inclusive:

Item	Name
7	Governor Cylinder.
8	Governor Cylinder Support Gasket.
9	Governor Cylinder Support Gland.
10	Governor Cylinder Support Gland Lock Nut.
13	Governor Cylinder Support Screw.
14	Governor Cylinder Support Stud (To Cylinder)
15	Governor Cylinder Support Stud (To Cylinder)
18	Governor Handwheel.
19	Governor Handwheel Lock Nut.
20	Governor Operating Piston.
21	Governor Operating Screw.
22	Governor Operating Screw Thrust Bearing.
23	Governor Operating Spring.
24	Governor Operating Spring Seat.
25	Governor Operating Stem.
26	Governor Operating Stem Coupling.
27	Governor Operating Stem Coupling Straight Pin.
28	Governor Operating Stem Nut.
29	Governor Operating Stem Nut Spring Cotter.
33	Steam Chest Body Gasket (Gov. Support)
35	Steam Chest Body Gasket (Throttle Valve Yoke)
36	Steam Chest Body Stud (Governor Support)
38	Steam Chest Body Stud (Throttle Valve Yoke)
42	Steam Chest Governor Valve Cage Cover.
43	Steam Chest Governor Valve Cage Cover Screw.
44	Steam Chest Governor Valve Stem.
45	Steam Chest Governor Valve Stem Caps.
46	Steam Chest Governor Valve Stem Caps Straight Pin.
47	Steam Chest Governor Valve Stem Coupling.
48	Steam Chest Governor Valve Stem Coupling Guide.
49	Steam Chest Governor Valve Stem Coupling Pin.
66	Steam Chest Throttle Valve Disc Nut.
67	Steam Chest Throttle Valve Disc Nut Headless Set Screw.
68	Steam Chest Throttle Valve Handwheel.
69	Steam Chest Throttle Valve Handwheel Nut.
70	Steam Chest Throttle Valve Latch.
71	Steam Chest Throttle Valve Latch Fulcrum Pin.
72	Steam Chest Throttle Valve Latch Fulcrum Pin Headless Set Screw.
73	Steam Chest Throttle Valve Latch Plate
74	Steam Chest Throttle Valve Latch Plate Screw.
75	Steam Chest Throttle Valve Latch Spring.
76	Steam Chest Throttle Valve Spring.
77	Steam Chest Throttle Valve Spring Retainer.
87	Steam Chest Throttle Valve Stem.
88	Steam Chest Throttle Valve Stem Collar.
89	Steam Chest Throttle Valve Stem Collar Pin.
90	Steam Chest Throttle Valve Stem Key.
91	Steam Chest Throttle Valve Stem Nut.
92	Steam Chest Throttle Valve Stem Nut Latch Plate.
93	Steam Chest Throttle Valve Stem Packing.
94	Steam Chest Throttle Valve Stem Packing Gland.
95	Steam Chest Throttle Valve Stem Packing Gland Box.
97	Steam Chest Throttle Valve Stem Packing Seat.
98	Steam Chest Throttle Valve Yoke Pin.
99	Steam Chest Throttle Valve Yoke Stud (Latch Spring)
106	Governor Cylinder Support.
108	Steam Chest Body.
109	Steam Chest Body Pipe Plug.
113	Steam Chest Throttle Valve Disc.
114	Steam Chest Throttle Valve Disc Seat.
115	Steam Chest Throttle Valve Yoke.
178	Steam Chest Governor Valve.
179	Steam Chest Governor Valve Cage.
187	Circuit Breaker Tripping Switch (Complete)

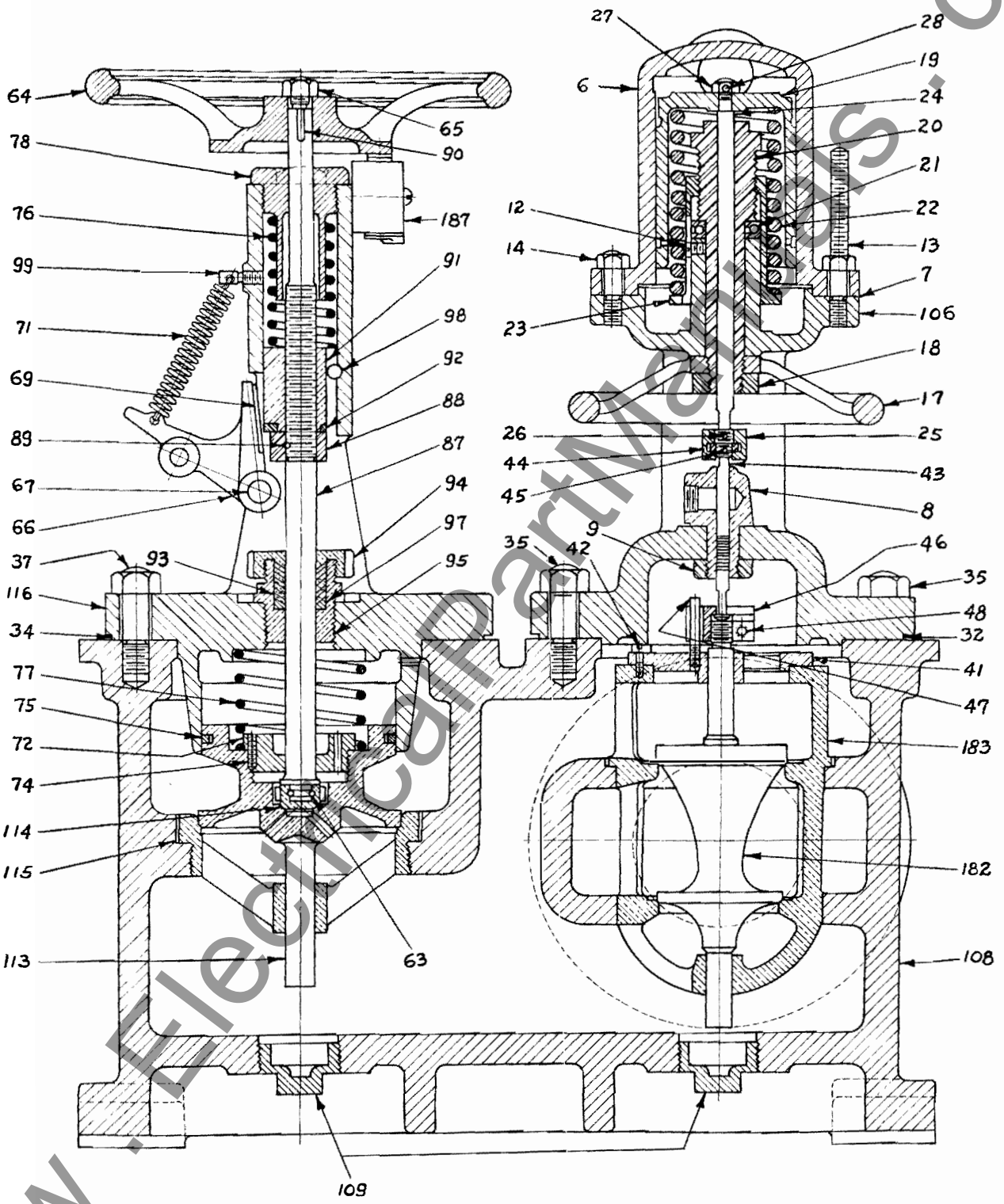


FIG. 6—GOVERNOR, STEAM CHEST AND THROTTLE VALVE

The following list is for the Governor, Steam Chest and Throttle Valve shown in Figure 6, and applies to units of from 100 up to and including 500 kw.:

Item	Name
6	Governor Cylinder.
7	Governor Cylinder Support Gasket.
8	Governor Cylinder Support Gland.
9	Governor Cylinder Support Gland Lock Nut.
12	Governor Cylinder Support Screw.
13	Governor Cylinder Support Stud.
14	Governor Cylinder Support Stud.
17	Governor Handwheel.
18	Governor Handwheel Lock Nut.
19	Governor Operating Piston.
20	Governor Operating Screw.
21	Governor Operating Screw Thrust Bearing.
22	Governor Operating Spring.
23	Governor Operating Spring Seat.
24	Governor Operating Stem.
25	Governor Operating Stem Coupling.
26	Governor Operating Stem Coupling Straight Pin.
27	Governor Operating Stem Nut.
28	Governor Operating Stem Nut Spring Cotter.
32	Steam Chest Body Gasket (Cover)
34	Steam Chest Body Gasket (Throttle Valve Yoke)
35	Steam Chest Body Stud.
37	Steam Chest Body Stud (Throttle Valve Yoke)
41	Steam Chest Governor Valve Cage Cover.
42	Steam Chest Governor Valve Cage Cover Screw.
43	Steam Chest Governor Valve Stem.
44	Steam Chest Governor Valve Stem Cap.
45	Steam Chest Governor Valve Stem Cap Straight Pin.
46	Steam Chest Governor Valve Stem Coupling.
47	Steam Chest Governor Valve Stem Coupling Guide Stud.
48	Steam Chest Governor Valve Stem Coupling Tap Bolt.
63	Steam Chest Throttle Valve By-pass Valve Pin.
64	Steam Chest Throttle Valve Handwheel.
65	Steam Chest Throttle Valve Handwheel Nut.
66	Steam Chest Throttle Valve Latch.
67	Steam Chest Throttle Valve Latch Fulcrum Pin.
69	Steam Chest Throttle Valve Latch Plate.
71	Steam Chest Throttle Valve Latch Spring.
72	Steam Chest Throttle Valve Nut.
74	Steam Chest Throttle Valve Nut Headless Set Screw.
75	Steam Chest Throttle Valve Packing Ring.
76	Steam Chest Throttle Valve Spring (Upper).
77	Steam Chest Throttle Valve Spring (Lower)
78	Steam Chest Throttle Valve Spring Retainer.
87	Steam Chest Throttle Valve Stem.
88	Steam Chest Throttle Valve Stem Collar.
89	Steam Chest Throttle Valve Stem Collar Pin.
90	Steam Chest Throttle Valve Stem Feather Key
91	Steam Chest Throttle Valve Stem Nut.
92	Steam Chest Throttle Valve Stem Nut Latch Plate.
93	Steam Chest Throttle Valve Stem Packing.
94	Steam Chest Throttle Valve Stem Packing Gland.
95	Steam Chest Throttle Valve Stem Packing Gland Box.
97	Steam Chest Throttle Valve Stem Packing Seat.
98	Steam Chest Throttle Valve Yoke Pin.
99	Steam Chest Throttle Valve Yoke Stud (Latch Spring)
106	Governor Cylinder Support.
108	Steam Chest Body
109	Steam Chest Body Pipe Plug.
113	Steam Chest Throttle Valve.
114	Steam Chest Throttle Valve By-pass Valve.
115	Steam Chest Throttle Valve Seat.
116	Steam Chest Throttle Valve Yoke.
182	Steam Chest Governor Valve.
183	Steam Chest Governor Valve Cage.
187	Circuit Breaker Tripping Switch (Complete)

In replacing, the joint should be made up with shellac and a fine linen thread placed on the outside of the gland runner and the packing rings, and the joint should be made before the shellac hardens.

The following list refers to Figure 7:

Item	Name
1	Rotor Gland Case (Upper Half)
2	Rotor Gland Case (Lower Half)
3	Rotor Gland Case Tap Bolt (Upper)
4	Rotor Gland Case Tap Bolt (Lower)
6	Rotor Gland Case Stud.
11	Rotor Gland Packing Ring Segment.
14	Rotor Gland Packing Ring Spring.

Bearings

The bearings are horizontally split cast iron shells lined with genuine babbitt. The pinion bearing is shown in Figure 8, while the thrust bearing is shown in Figure 9. The inboard gear bearing is the same as the thrust bearing with the exception of the babbitted ends.

The shells are closely fitted into circular seats bored to receive them in the gear case and cover. Rotation is prevented by lugs on the bottom halves, bearing against the cover. If it becomes necessary to re-babbitt a bearing, the lining used should be of the composition known as "genuine babbitt" to insure satisfactory service. Care must be taken to re-bore concentrically with the turned outside diameters of the bearing shells. If it is necessary to scrape the bearing, scrape to a mandrel the size of the bearing; do not scrape to the journal. If new bearings are fitted in the machine make sure they fit snug in the gear case housing.

The bearings are supplied with oil through openings at each side feeding the single oil groove running lengthwise above the journal. They are relieved at the horizontal joint to allow formation of the oil film necessary for efficient lubrication. Used oil drains into the gear casing which serves as a reservoir.

Thrust Bearing

The rotating elements are restrained from axial movement by making one of the slow speed gear bearings a combination main and thrust bearing.

The following list refers to Figure 8:

Item	Name
1	Pinion Bearing (Upper Half)
2	Pinion Bearing (Lower Half)

The following list refers to Figure 9:

Item	Name
3	Thrust Bearing (Upper Half)
4	Thrust Bearing (Lower Half)
6	Thrust Bearing Ring.
7	Thrust Bearing Ring Screw.
9	Thrust Bearing Liner.
10	Thrust Bearing Liner
11	Thrust Bearing Liner.

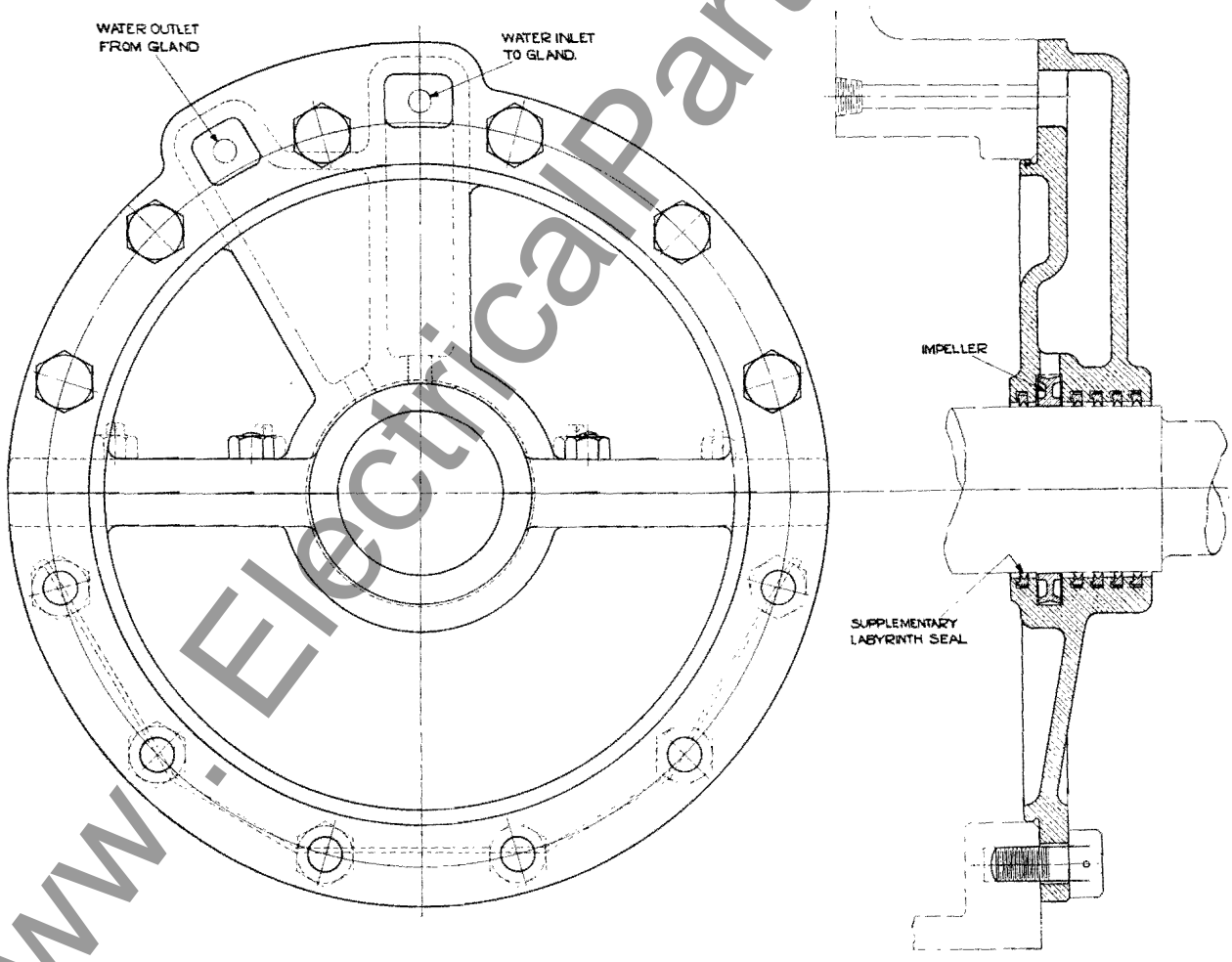


FIG. 7—ROTOR GLAND

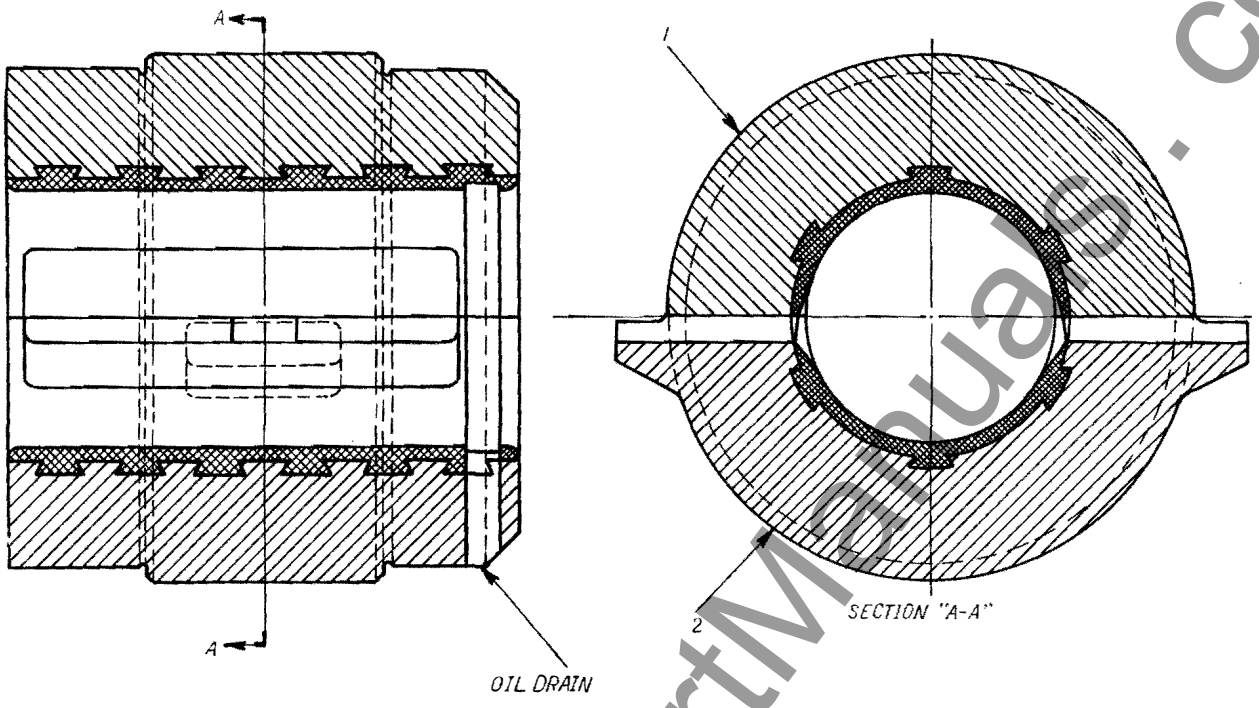


FIG. 8—PINION BEARING

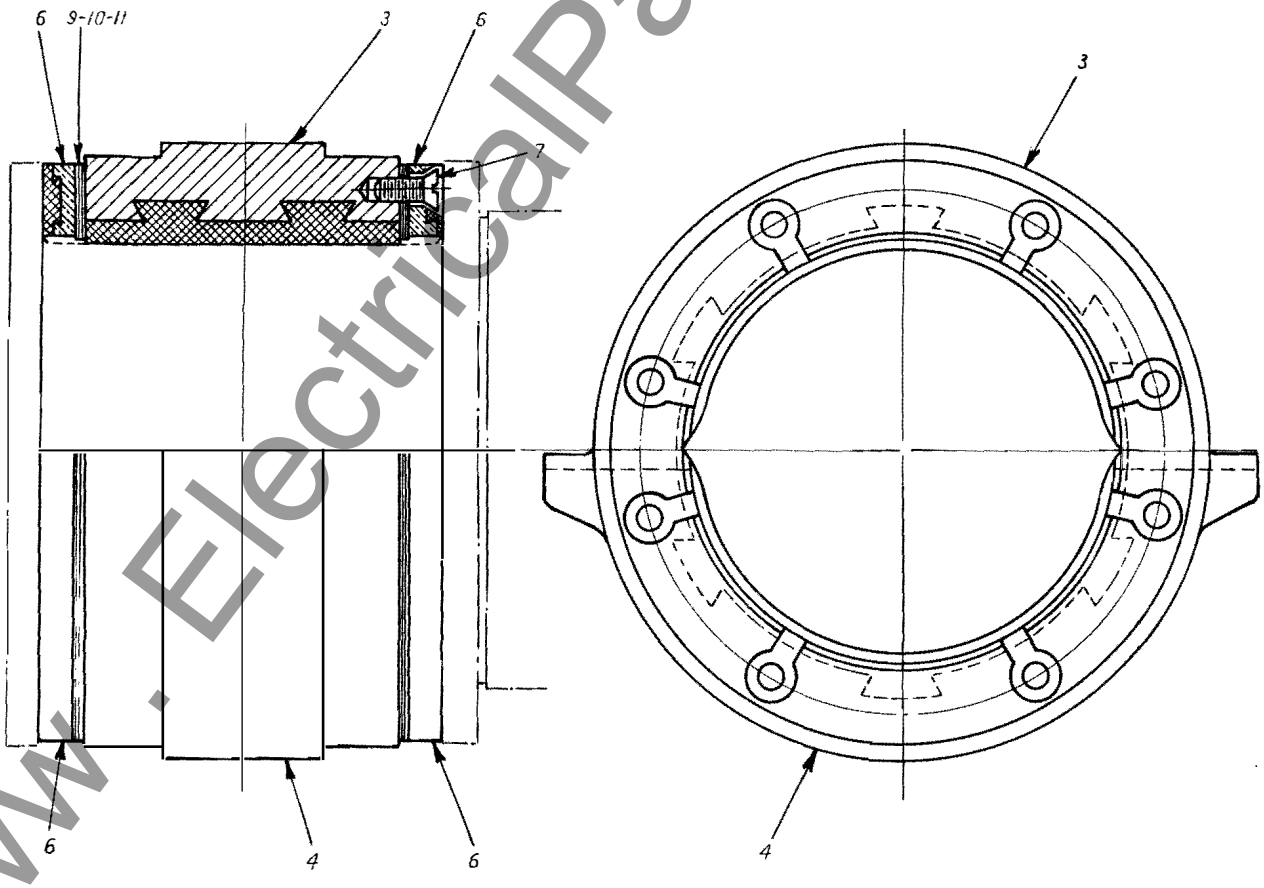


FIG. 9—THRUST BEARING

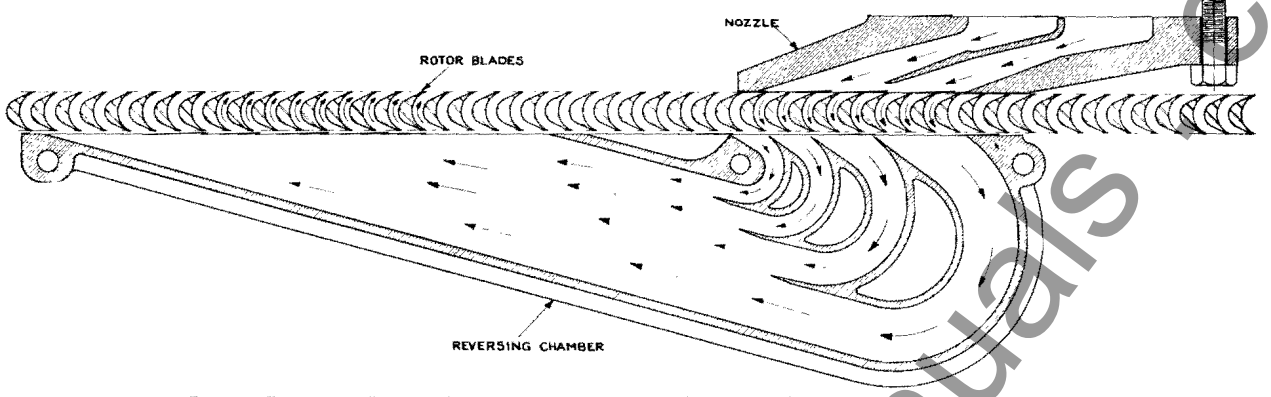


FIG. 10—DEVELOPED SECTION THROUGH NOZZLE BLOCK AND REVERSING CHAMBER, SHOWING PATH OF STEAM

There are two circular collar plates turned integral with the gear shaft which bear against the end facings of the bearing. The oil grooves for these faces are fed from the relieved spaces at the horizontal joint. Adjustment is made by means of liners Item Nos. 9, 10, 11 behind the thrust rings Item No. 6 of the bearing. To adjust: Lift gear wheel from its bearings, remove screws Item No. 7 holding thrust rings, and change liners as desired. There should be .005 to .010 inch axial clearance in this bearing. The axial play or freedom of the pinion shaft relative to the gear may be from .009 to .016 inches.

Nozzles and Reversing Chamber

The steam nozzle, Item No. 40, Figure 14, is located in the cylinder end cover, while the reversing chamber Item No. 41 is bolted to the cylinder and gear case cover. A developed section of the nozzles and reversing chamber is shown in Fig. 10.

When making any setting on the turbine, adjust the rotor so that there will be one-sixteenth of an inch clearance between the blades and the nozzles and one-sixteenth of an inch between the blades and the reversing chamber. After setting the rotor centrally, check the position of the gland runner to see that it has a clearance of approximately one thirty-second of an inch on either side of the gland casing. The gland runner position may be changed on the shaft by removing headless set screw and heating carefully with a gas torch. When in the position desired, replace the set screw. With these clearances correct, adjust the thrust bearing to hold the rotor in this position.

In setting new nozzles and reversing chambers, refer to Figure 14 and note that the reversing chamber should be set flush with the nozzle. It is important that the reversing chamber be set correctly so as to catch all steam emerging from the blades.

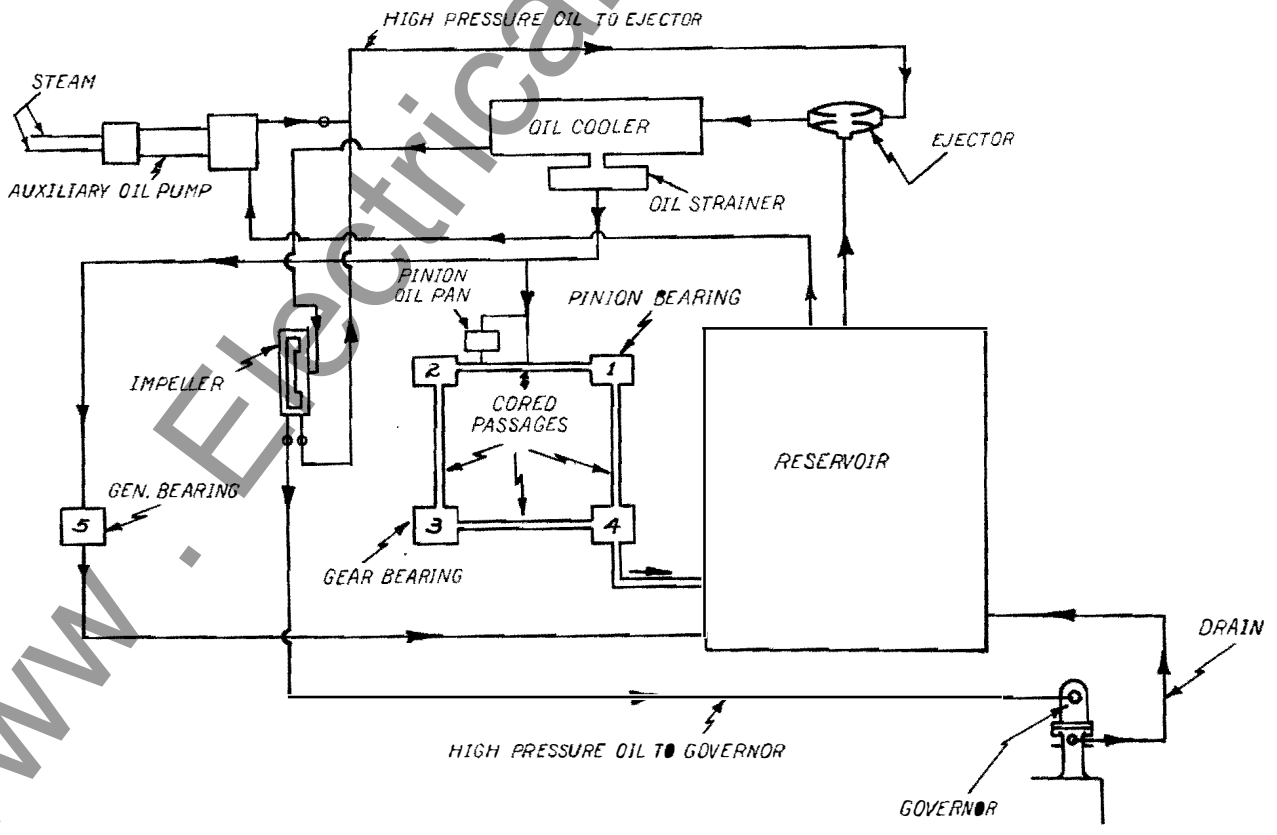


FIG. 11—DIAGRAM OF HNC TURBINE OILING SYSTEM

Oiling System

The base of the gear case serves as a reservoir for the lubricating oil. On one side of this reservoir there is a large cover to permit ready access for cleaning out any dirt or sludge which may deposit from the oil. To circulate the oil for lubrication and the supply to the impeller, an ejector is mounted on the gear case or reservoir below the oil level and a portion of the high pressure oil from the governor impeller is passed through this ejector so as to entrain a much greater quantity of low pressure oil. This oil then passes through a cooler after which part of it goes directly to the impeller and the remainder to the strainer from which it is discharged to the bearings at a pressure of five to ten pounds and to the gear and pinion teeth as they roll into contact. The oil level in the reservoir should be maintained near the center of the sight glass. The oil should in no case be so low that it cannot be seen in the glass, nor should it be above the glass, for the oil will be overheated by coming in contact with the gear wheel. Oil from all bearings except the outboard generator bearing falls directly into the reservoir. Where pedestal type bearing generators are furnished, the oil from the bearing is piped back to the reservoir. Bracket type generators have ring oiled bearings.

The oiling system diagram shown in Figure 11, by means of which the path of the oil may be traced throughout its cycle of circulation, is for machines having pedestal type generators. Oil pressure is built up before starting the unit by means of the auxiliary oil pump, which draws oil from the reservoir and primes the impeller. This pump should be shut down when the turbine speed is such that the impeller is delivering oil at about forty pounds pressure.

When assembling the turbine, care must be taken to see that the cored passages are thoroughly cleaned out, and thus insure a plentiful supply of clean oil to the bearings when the unit is in operation. Do not use waste or steel wool anywhere around the unit at any time.

Oil Impeller and Automatic Stop Governor

The impeller, Item No. 14, Figure 12, is actually a small centrifugal pump and is mounted on the end of the pinion shaft. Oil from the ejector at about five pounds pressure enters the impeller at the center and is discharged at its periphery, through holes drilled in the impeller, at eighty to one hundred pounds pressure. The pressure at the impeller periphery varies as the square of the change in speed of the unit just as the centrifugal force acting on the weights of an ordinary flyball governor varies as the square of the change in speed. Thus the oil, discharged by the impeller, furnishes suitable working force to the valve mechanism in the same way and with the same speed characteristics as the weights of the flyball type governor.

The clearance between the impeller and the impeller guide Item No. 17 should be approximately $\frac{5}{64}$" axially and $\frac{1}{8}$" radially.

The automatic stop governor is attached directly to the pinion shaft, and consists of a weight Item No. 11, Figure 12, which operates against a spring Item No. 3 held in place by a retaining nut Item No. 4.

The function of the auto-stop is to shut the turbine down, if for any reason, the main governor should fail to operate and allow the turbine to overspeed.

The auto-stop is set to operate at about 10% overspeed and should not require any adjustment after the turbine is put into service.

When the turbine overspeeds the auto-stop weight is forced out by centrifugal force, compresses the spring, and comes into contact with the trip lever Item No. 3, Figure 13. This movement, through the series of links shown in Figure 13, closes the throttle valve, thus stopping the flow of steam to the turbine.

The clearance between the auto-stop weight and trip lever, with trip gear set, should be from $\frac{1}{32}$" to $\frac{1}{16}$".

Operation

To Start

Start auxiliary oil pump to furnish bearing oil, motive oil for ejector and priming oil for impeller. Open drains on steam and exhaust lines. Open exhaust valve. Crack the steam valve and when live steam appears at the drains, close them. Bring the turbine slowly up to speed, and when it is under control of the governor, open throttle valve wide; turn on gland water; stop auxiliary oil pump.

With the unit under way, the speed may be checked by means of the tachometer furnished on the turbine. If the speed is not correct it should be made so at this time. To decrease the speed, turn the governor handwheel counter-clockwise so as to decrease the compression on the governor spring and vice versa to increase the speed. The normal speed is approximately the speed at full load. The no-load speed will be about 4% higher.

To Shut Down

Shut off gland water. Strike hand trip lever sharply, which will close the throttle valve and indicate that the auto-stop mechanism is working properly. Close throttle valve with the handwheel and re-set automatic trip. Open steam and exhaust drains; close exhaust valve.

Maintenance

Care of the Turbine

1. Keep machine clean.
2. Keep the proper amount of good quality, clean oil in the reservoir.
3. If steam is contaminated with boiler compound or sludge, clean off governor valve stem as often as necessary to keep it working freely.
4. Before starting a unit that has been idle for some months, dismantle governor operating mechanism and steam chest governor valve to see that all parts are free and in good working condition.
5. The automatic stop should be tripped periodically; say once a month, by actual overspeeding of machine to see that it is in proper working condition. See that it shuts machine down.

Operating Trouble Governor Hunting

1. Sticking of governor valve in guides or stem gland or oil operating parts.

Turbine Fails to Come up to Speed

1. Low boiler pressure.
2. Steam line clogged.
3. Dirty steam strainer.
4. Nozzle throat plugged by foreign matter.
5. Governor speed set too low.
6. Wet steam.

Gland Leaking Steam

1. Packing rings stuck in gland.
2. Water passages clogged with dirt or scale.
3. Recesses in gland runner clogged with scale.

4. No water in gland.
5. Gland joint made up improperly.

Gland Leaking Water

1. Too high a head of water on gland.
2. Obstruction or burrs in gland runner passage.
3. Gland runner rubbing on side of casing.

Inspection

A thorough inspection of all parts of the turbine should be made once a year, renewing such parts as may show undue wear. If heavy wear of any part is evidenced, the cause of the wear should be ascertained if possible, and in any case replacement of the part should be made before failure, as this will be cheaper than a future shut down.

Renewal Parts

Repairing

Repair work can be done most satisfactorily at our nearest Service Shop. However, interchangeable renewal parts can be furnished to customers, who are equipped for doing repair work.

Ordering Instructions

When ordering renewal parts, give the name plate information. Always give the name of the part wanted, also the serial order number of the apparatus on which the part is to be used. Refer to the back of this book for the nearest District Office from which to order parts.

For sectional views and lists of parts, refer to the following pages:

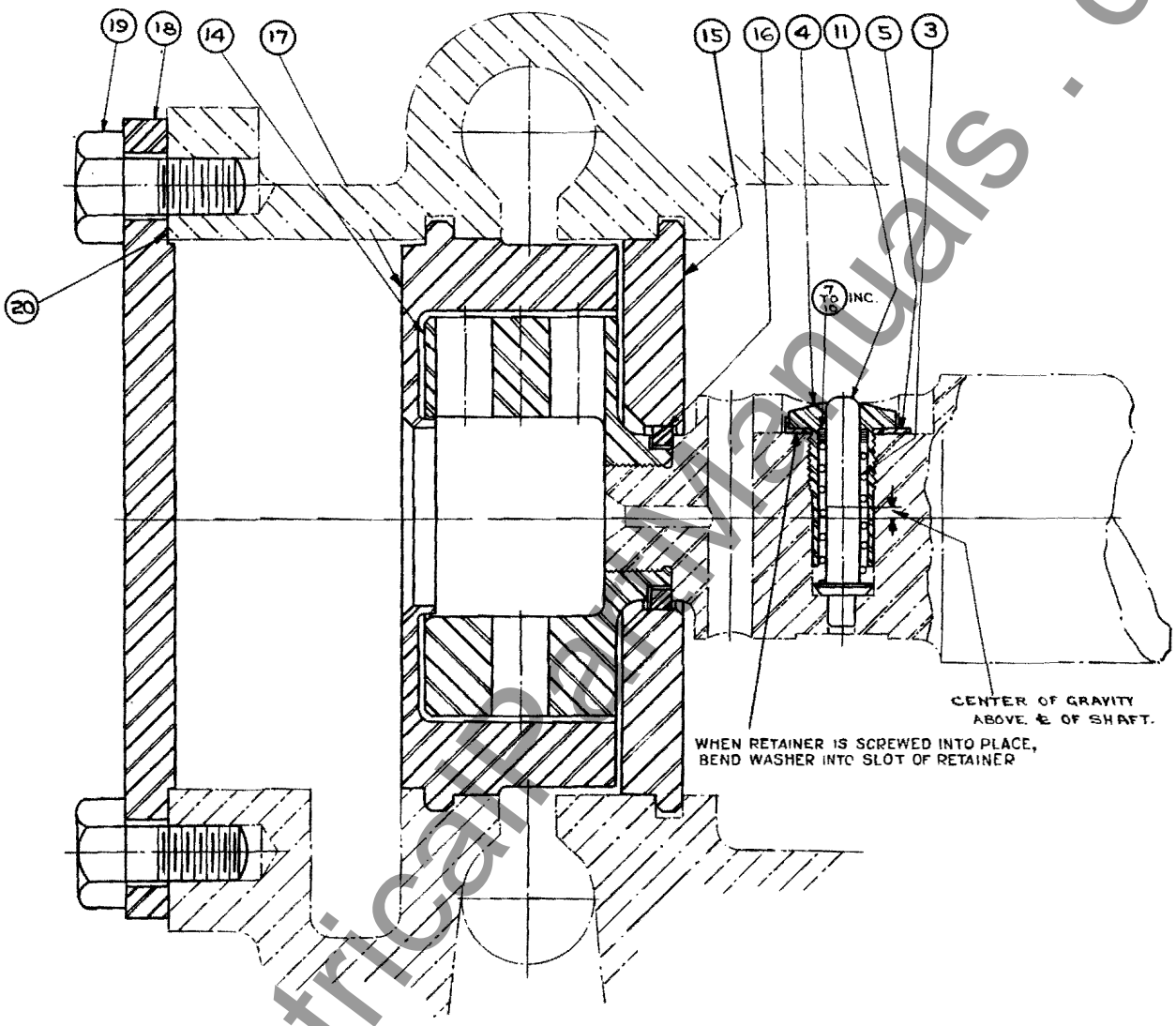


FIG. 12—OIL IMPELLER AND AUTOMATIC STOP GOVERNOR

The following list refers to Figure 12:

Item	Name
3	Auto Stop Governor Spring.
4	Auto Stop Governor Spring Retainer.
5	Auto Stop Governor Spring Retainer Lock Washer.
11	Auto Stop Governor Weight.
14	Oil Governor Impeller.
15	Oil Governor Impeller Baffle.
16	Oil Governor Impeller Baffle Ring.
17	Oil Governor Impeller Guide.
18	Oil Governor Impeller Flange.
19	Oil Governor Impeller Flange Tap Bolt.
20	Oil Governor Impeller Flange Gasket.

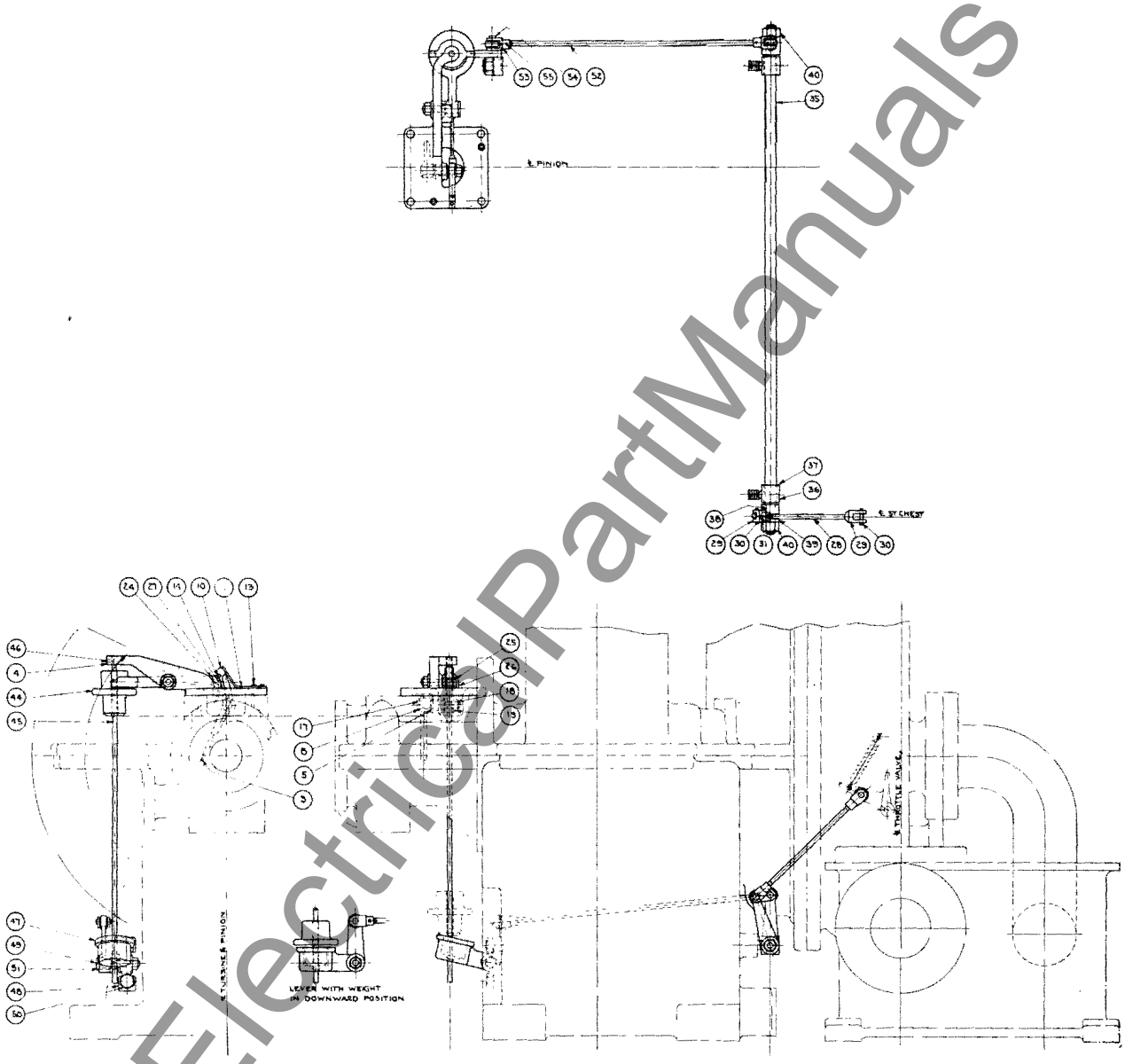


FIG. 13—AUTOMATIC STOP GOVERNOR TRIP LINKAGE

The following list refers to Figure 13:

Item	Name
3	Auto Stop Governor Trip Lever.
4	Auto Stop Governor Trip Lever Bracket.
5	Auto Stop Governor Trip Lever Bracket Bushing.
6	Auto Stop Governor Trip Lever Bracket Taper Dowel.
7	Auto Stop Governor Trip Lever Bracket Tap Bolt.
8	Auto Stop Governor Trip Lever Feather Key.
10	Auto Stop Governor Trip Lever Extension.
11	Auto Stop Governor Trip Lever Extension Feather Key.
12	Auto Stop Governor Trip Lever Extension Feather Key Spring.
13	Auto Stop Governor Trip Lever Extension Feather Key Spring Screw.
14	Auto Stop Governor Trip Lever Extension Tip.
17	Auto Stop Governor Trip Lever Fulcrum Pin.
18	Auto Stop Governor Trip Lever Fulcrum Pin Nut.
19	Auto Stop Governor Trip Lever Fulcrum Lock Washer.
24	Auto Stop Governor Trip Release Lever.
25	Auto Stop Governor Trip Release Lever Bushing.
26	Auto Stop Governor Trip Release Lever Round Head Shoulder Pin.
27	Auto Stop Governor Trip Release Lever Tip.
28	Auto Stop Governor Trip Rod (Throttle Valve)
29	Auto Stop Governor Trip Rod Head.
30	Auto Stop Governor Trip Rod Head Fulcrum Pin.
31	Auto Stop Governor Trip Rod Head Pin.
35	Auto Stop Governor Trip Shaft.
36	Auto Stop Governor Trip Shaft Fulcrum.
37	Auto Stop Governor Trip Shaft Fulcrum Bushing.
38	Auto Stop Governor Trip Shaft Feather Key.
39	Auto Stop Governor Trip Shaft Lever.
40	Auto Stop Governor Trip Shaft Nut.
44	Auto Stop Governor Trip Weight.
45	Auto Stop Governor Trip Weight Rod.
46	Auto Stop Governor Trip Weight Rod Finish Pin.
47	Auto Stop Governor Trip Weight Strike Lever.
48	Auto Stop Governor Trip Weight Strike Lever Bracket.
49	Auto Stop Governor Trip Weight Strike Lever Bracket Shoulder Pin.
50	Auto Stop Governor Trip Weight Strike Lever Bracket Tap Bolt.
51	Auto Stop Governor Trip Weight Strike Lever Bushing.
52	Auto Stop Governor Trip Weight Strike Lever Rod.
53	Auto Stop Governor Trip Weight Strike Lever Rod Head.
54	Auto Stop Governor Trip Weight Strike Lever Rod Head Fulcrum Pin.
55	Auto Stop Governor Trip Weight Strike Lever Rod Head Pin.

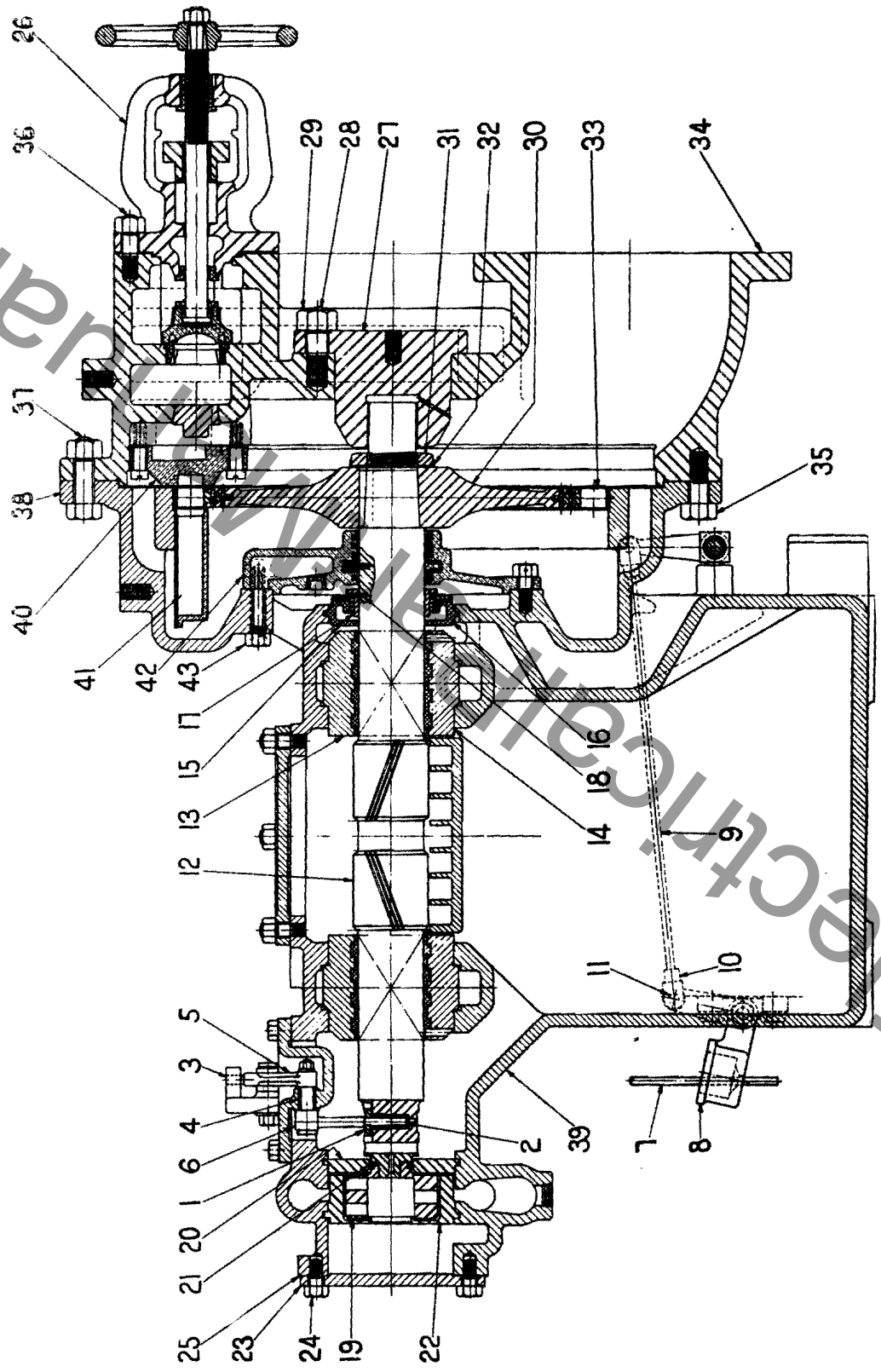
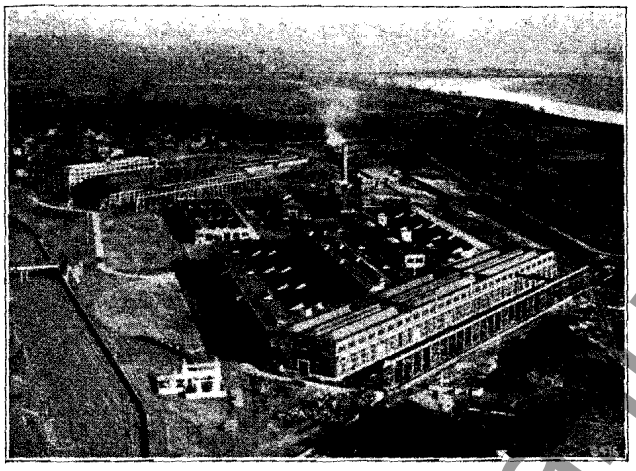


FIG. 14—LONGITUDINAL SECTION OF TURBINE AND GEAR

The following list refers to Figure 14:

Item	Name
1	Auto Stop Governor Spring Retainer.
2	Auto Stop Governor Weight.
3	Auto Stop Governor Trip Lever Bracket.
4	Auto Stop Governor Trip Lever Bracket Bushing.
5	Auto Stop Governor Trip Lever Extension.
6	Auto Stop Governor Trip Lever.
7	Auto Stop Governor Trip Weight Rod.
8	Auto Stop Governor Trip Weight Strike Lever.
9	Auto Stop Governor Trip Weight Strike Lever Rod.
10	Auto Stop Governor Trip Weight Strike Lever Rod Head.
11	Auto Stop Governor Trip Weight Strike Lever Rod Head Pin.
12	Gear Pinion Shaft.
13	Gear Pinion Shaft Bearing (Upper Half)
14	Gear Pinion Shaft Bearing (Lower Half)
15	Gear Pinion Shaft Bearing Oil Ring (Upper Half)
16	Gear Pinion Shaft Bearing Oil Ring (Lower Half)
17	Gear Pinion Shaft Oil Thrower.
18	Gear Pinion Shaft Oil Thrower Headless Set Screw.
19	Oil Governor Impeller.
20	Oil Governor Impeller Baffle.
21	Oil Governor Impeller Baffle Ring.
22	Oil Governor Impeller Guide.
23	Oil Governor Impeller Flange.
24	Oil Governor Impeller Flange Tap Bolt.
25	Oil Governor Impeller Flange Gasket.
26	Turbine Auxiliary Valve (Complete)
27	Turbine Restraining Ring.
28	Turbine Restraining Ring Stud.
29	Turbine Restraining Ring Stud Nut.
30	Turbine Rotor.
31	Turbine Rotor Nut.
32	Turbine Rotor Nut Lock Washer.
33	Turbine Rotor Blade.
34	Turbine End Cover.
35	Turbine End Cover Stud (Base)
36	Turbine End Cover Stud (Auxiliary Valve)
37	Turbine End Cover Stud Through Bolt.
38	Turbine and Gear Case Cover.
39	Turbine and Gear Case Base.
40	Turbine Nozzle Block.
41	Turbine Reversing Chamber.
42	Turbine Gland Casing.
43	Turbine Water Gland Casing Tap Bolt.



South Philadelphia Works

Westinghouse Products

A few of the Westinghouse Products are listed below and will furnish some idea of the great variety of electrical apparatus manufactured by the Company and the many extensive fields for their use.

For Industrial Use

Instruments
Motors and controllers for every application, the more important of which are: Machine shops, woodworking plants, textile mills, steel mills, flour mills, cement mills, brick and clay plants, printing plants, bakeries, laundries, irrigation, elevators and pumps.
Welding outfits
Gears
Industrial heating devices, such as: Glue pots, immersion heaters, solder pots, hat-making machinery and electric ovens.
Lighting systems
Safety switches

For Power Plants and Transmission Lines

Carrier current equipment
Circuit-breakers and switches
Condensers
Controllers
Control switches
Frequency changers
Fuses and fuse blocks
Generators
Insulating material
Instruments
Lamps, incandescent and arc
Lightning arresters
Line material
Locomotives
Meters
Motors
Motor-generators
Portable Power Stands, 110 volts
Rectifiers
Regulators
Relays
Solder and soldering fluids
Stokers
Substations, portable and automatic
Switchboards
Synchronous converters
Transformers
Turbine-generators

For Transportation

Locomotives
Railway equipment
Marine equipment

For Mines

Automatic substations
Lamps
Locomotives
Motors for hoists and pumps
Motor-generators
Portable substations
Switchboards
Line material
Ventilating outfits

For Farms

Fans
Household appliances
Motors for driving churns, cream separators, corn shellers, feed grinders, pumps, air compressors, grindstones, fruit cleaning machines and sorting machines.
Generators for light, power and heating apparatus.
Portable Power Stands, 32 Volts
Radio Apparatus
Transformers

For Office and Store

Electric radiators
Fans
Arc lamps
Incandescent lamps
Sol-Lux lighting fixtures
Small motors for driving addressing machines, dictaphones, adding machines, cash carriers, moving window displays, signs, flashers, envelope sealers, duplicators, etc.
Ventilating outfits

For Electric and Gasoline Automobiles and the Garage

Battery charging outfits
Charging plugs and receptacles
Lamps
Instruments
Motors and controllers
Small motors for driving lathes, tire pumps, machine tools, polishing and grinding lathes.
Solder and soldering fluids
Tire vulcanizers

For the Home

Electric ware, including: Table stoves, toasters, irons, warming pads, curling irons, coffee percolators, chafing dishes, disc stoves, radiators and sterilizers.
Automatic electric ranges
Fans
Incandescent lamps
Radio apparatus
Sol-Lux lighting fixtures
Small motors for driving coffee grinders, ice cream freezers, ironing machines, washing machines, vacuum cleaners, sewing machines, small lathes, polishing and grinding wheels, pumps and piano players.
Sew-motors.