Westinghouse

Turbines

for

Mechanical Drive—Type AMD

INSTRUCTION BOOK 5488 (Rev. 1)

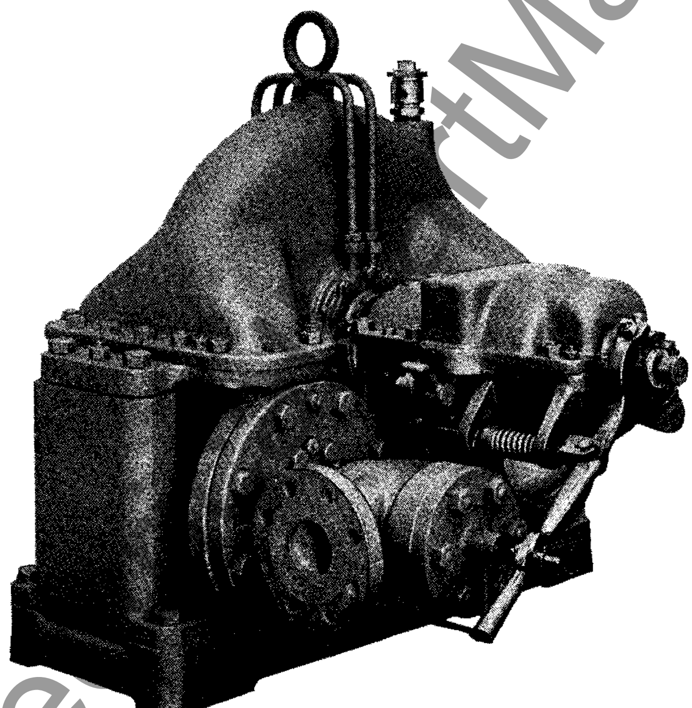

FIG. 1—SIDE VIEW OF MECHANICAL DRIVE TURBINE ILLUSTRATING CENTER-SUPPORT FEATURE

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

Westinghouse Electric & Manufacturing Company

South Philadelphia Works **Philadelphia, Pa.**

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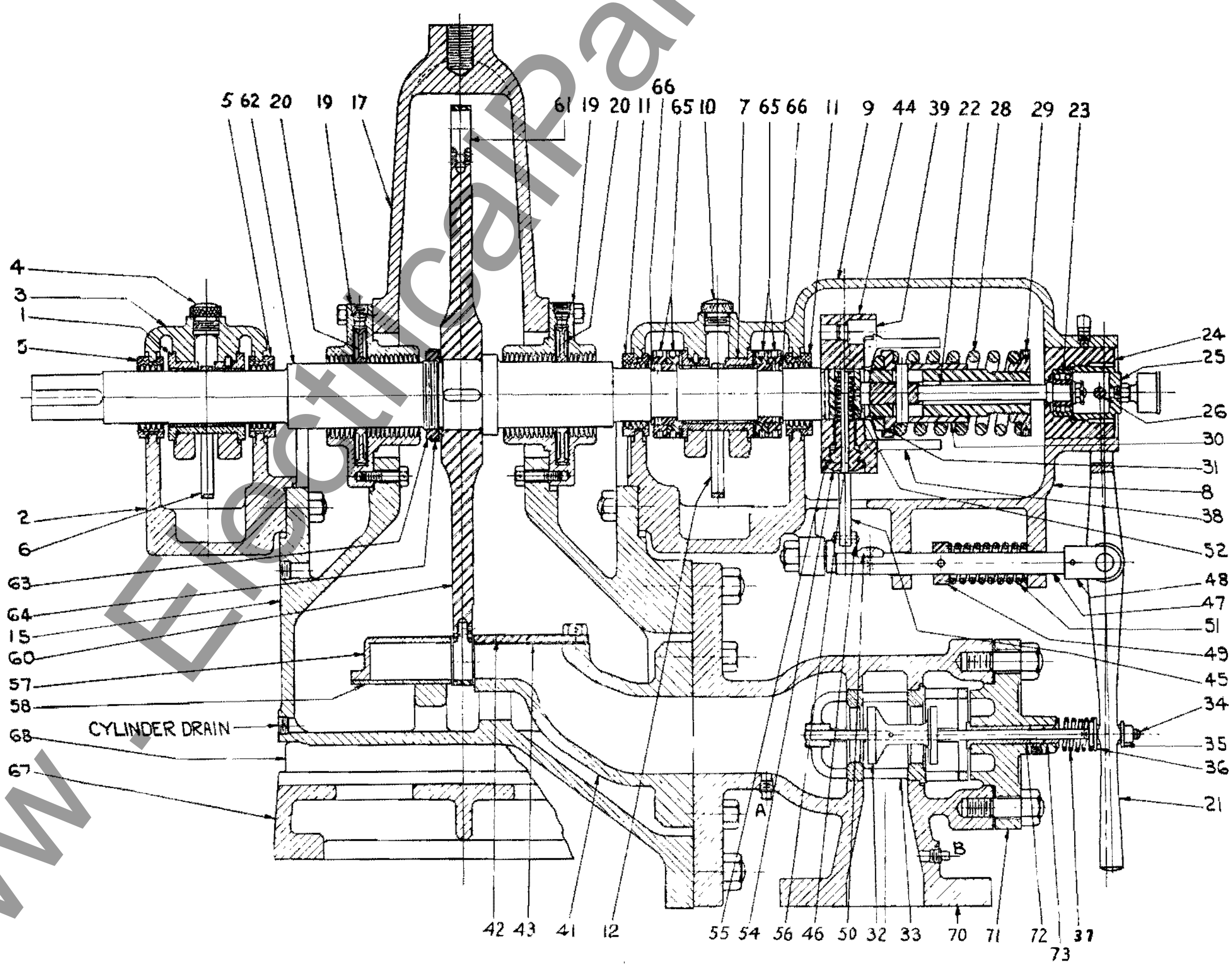

Fig. 2—Longitudinal Section, 2-AMD[Turbine

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General Description

The Westinghouse steam turbine of the mechanical drive type is essentially a single wheel with blades mounted on its periphery. Refer to Figure 2. Steam enters the steam chest and passes through a governor valve to the nozzle chamber which is bolted to the steam chest. Expansion of the steam takes place in the nozzle, thus transforming the heat energy into velocity. The steam acquiring its maximum velocity at the nozzle mouth impinges upon the blades, which causes them to move forward, thus revolving the turbine wheel. The rotation of the wheel converts the velocity of the steam into work at the turbine coupling.

The velocity of the steam at the nozzle mouth is so much greater than that of the blades, that it is advantageous to collect the steam in a reversing chamber and direct it against the wheel a second time. The energy of a second impingement on the blades is added to the turbine shaft instead of passing directly into the exhaust casing unutilized.

If the steam conditions and the turbine speed are such that the velocity of the steam leaving the blades, after having passed through one reversing chamber, is still much higher than the speed of the blades, it is economical to use a second reversing chamber and utilize this available energy before the steam flows into the exhaust casing.

Turbine Support

The entire turbine unit is suspended from two arms cast integral with the cylinder base, one on either side of the cylinder at the horizontal joint. These arms are bolted to the supporting members which usually consist of two soleplate supports bolted to the soleplate. In some installations the soleplate may be omitted and the supports may be bolted directly to the bedplate, or the soleplate may be used without a bedplate. In special cases the turbine may be installed without either supports or soleplate by using a specially designed or built up bedplate to support the turbine at the centerline.

With the cylinder supported at the center line, it is free to expand upward or downward while the shaft remains in its original position. The position of the coupling, therefore, does not change in going from hot to cold, or vice versa, with the result that misalignment and troubles are brought to a minimum.

The centerline support is a distinctive feature which makes a three bearing unit possible when the turbine is connected to a reduction gear. With this type of support the turbine shaft is rigidly connected to the pinion shaft by a solid flange coupling and the bearing between the gear and the turbine omitted. See Fig. 16. The two bearings on the pinion shaft and the one turbine bearing constitute the three bearing unit. The thrust is taken by the double helical pinion gear and the thrust collars on the turbine bearing are omitted.

Turbine Casing

The turbine casing is split horizontally with all pipe connections attached to the base so that a complete inspection may be made by raising the cylinder cover. In raising the cylinder cover it should be lifted straight up to 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 flange inside of bolts. Be sure to pull the joint down tight before shellac hardens.

Rotating Element

The rotating element consists of a shaft, carrying the rotor, supported by two ring oiled bearings. The rotor is pressed on the shaft with a press fit and is held in place by nut "63" (Fig. 2) which in turn is locked by washer "64". 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 the shaft and the fit examined. In putting on a new rotor, be sure that a good fit is obtained.

One end of the shaft supports the coupling. The coupling is pressed on and keyed to the shaft and is true and square to the axis of rotation. The key should be well fitted to avoid distortion of the coupling face. If the coupling runs out of true, it should be lightly faced off.

The automatic trip and the governor are supported on the other end of the shaft overhanging the governor end bearing.

Auto-Stop

The auto-stop is located in the overspeed stop housing "44" Fig. 2, and consists of a weight "56" which operates against spring "52" held in place by retaining nut "54" which is secured by lock "55".

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

The auto-stop should be set to operate at about 10 percent above normal speed. If it operates below this speed, spring compression should be increased by adding washers between the retainer "54" and spring "52". The adjustment must be determined by trial. Be sure to lock retainer by means of lock washer after final adjustment is made

The operation of the auto-stop is as follows:

The weight "56" (Fig. 2) is forced out by centrifugal force compressing the spring "52" and comes in contact with the knock-off lever "45" disengaging the latch plates "46" and "50" and allowing the spring "51" which is under compression to pull the fulcrum of the governor linkage inward, forcing the governor valve "32" hard on its seat "33".

When the turbine slows down, the weight "56" returns to its former position and the governor poppet valve may be opened and the auto-stop reset by pulling outward on lever "21" which allows the latch plates "46" and "50" to engage and hold the governor linkage in its running position.

The auto-stop may be operated by hand by striking the knock-off lever "45" which will disengage the latch plates as in the other operation.

Governor

The governor is of the horizontal centrifugal type. The overspeed stop housing "44" fits on the rotor shaft "62" with a metal to metal fit and is secured by the auto-stop retainer "54". The overspeed stop housing "44" is made in one piece and supports the fulcrum blocks "39" as shown. Each governor weight is made in one piece thus eliminating the possibility of dislocation of separate knife edges. The lower toe of the governor weight "38" has the shape of a gear tooth. It is pivoted on the knife edge machined integral with the weight. Both the toe and knife edge are case hardened. The toe block "31" is also hardened and is held against the toe of the governor weight by the pressure of the spring "28". This pressure is adjusted by means of the adjusting nut "29".

An elongated slot is machined in the rotor shaft "62" allowing forward and backward motion of the governor spindle pin "8" which passes through this slot and fits in a carefully reamed hole in the spring seat "30". This pin is held in place by the governor spring.

As the governor revolves, the ends of the governor weights fly outward, the force of which is transmitted through the knife edges and the toe of the weight to the spring seat compressing the governor spring. The movement of the spring seat is transmitted through the spring seat pin to the governor spindle "22" which through suitable linkage described later, acts upon the governor poppet valve thus giving the proper speed.

To increase the speed of the turbine, increase the compression of the governor spring "28" by means of the adjusting nut "29". One full turn of the nut either way should change the speed about 100 R.P.M.

All moving parts of the governor proper are hardened and require no lubrication.

If hunting occurs, the governor thrust bearing housing may be sticking. To remedy, clean thoroughly and if necessary dress down the parts slightly with fine emery cloth. An unstable

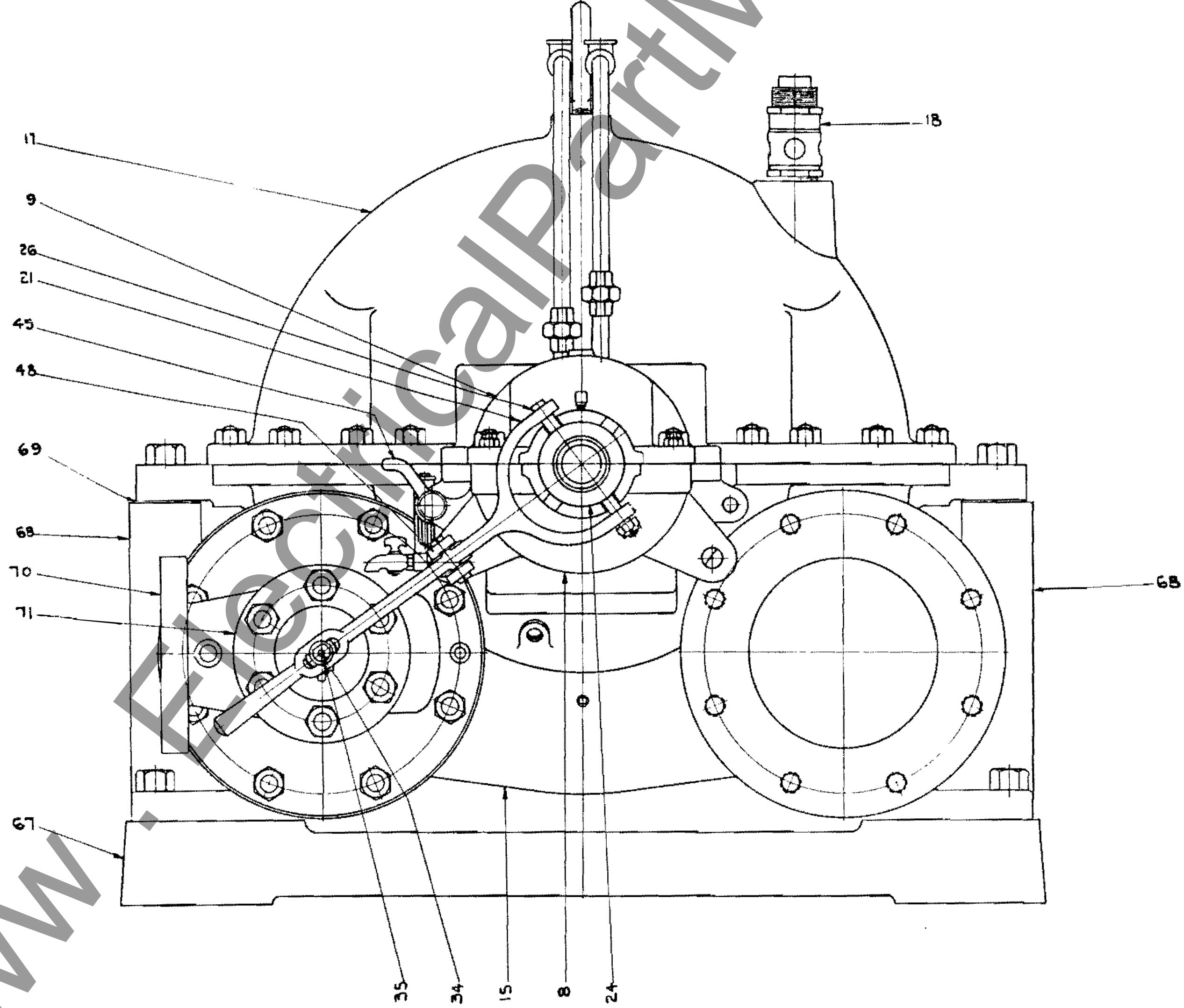


FIG. 3—END VIEW, 2-AMD TURBINE

action of the governor may result from lost motion due to an improper fit between the governor spindle and the pin or the pin and seat. This lost motion can only be taken up by replacement of parts.

To see if the governor operates freely, remove governor spring as explained under "Governor Linkage" and press inward on governor spindle at the same time, pulling one weight outward. Release weight suddenly still maintaining pressure on governor spindle. If weight snaps back into place freely it is correct. If rub occurs, it can be felt. Repeat process for other weight and then for both weights. When governor weights are removed, be sure to replace them in their original position.

Governor Linkage

The governor linkage is the means of transferring the motion of the governor weights to the poppet valve. Inasmuch as the motion of the governor weights must be quickly and accurately transmitted to this valve, it is necessary that there be very little lost motion in all the connecting linkage.

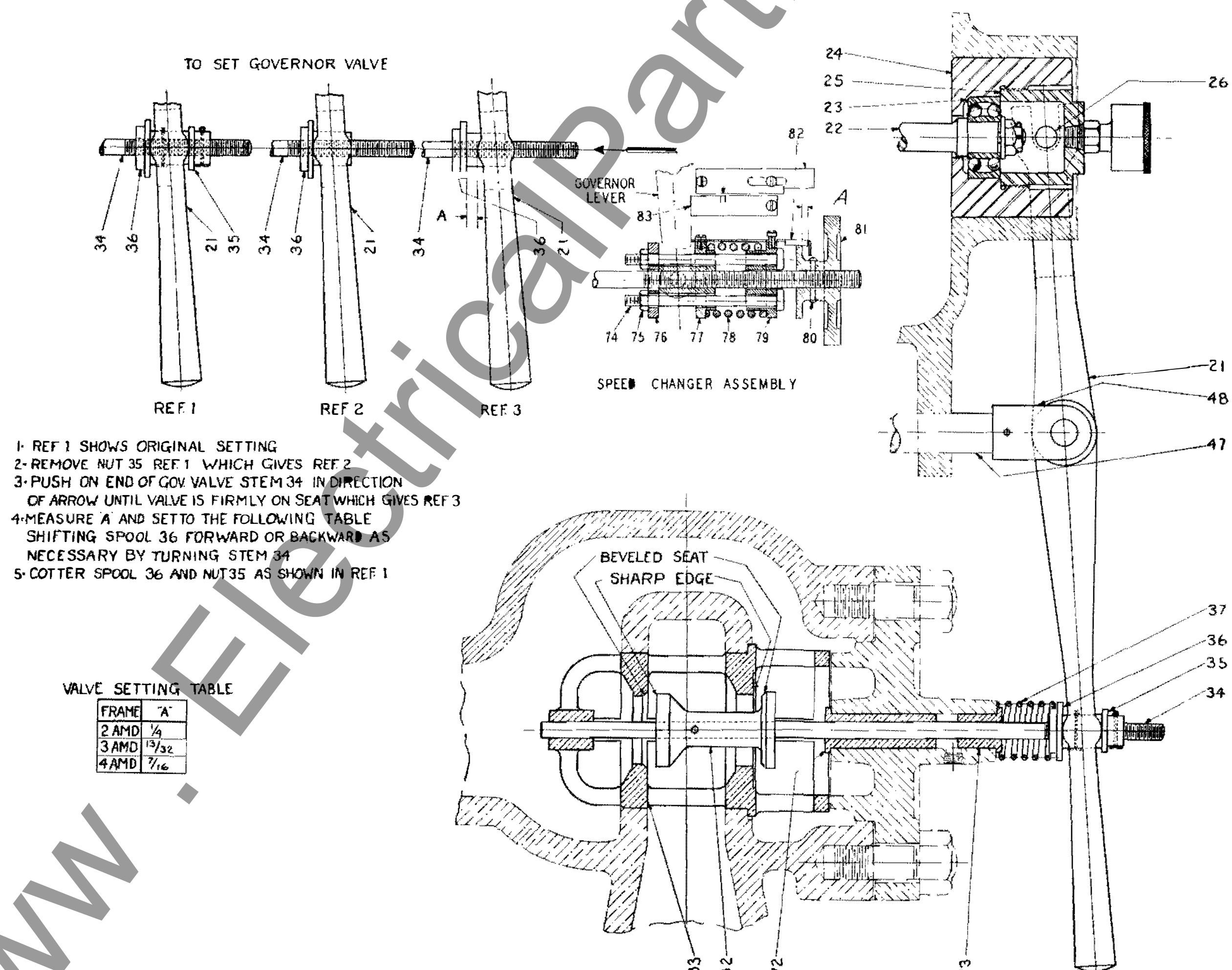
The motion of the governor weights is transmitted through the governor spindle pin Fig. 2 to the governor spindle "22" Figs. 2 and 4. This spindle is in turn connected to a self aligning ball bearing "23" located in the governor spindle thrust bearing housing "24" and held in place by the retainer "25". The motion of the thrust bearing housing and retainer is transmitted to the governor lever through the retainer bolt "26". The governor lever "21" is pivoted at the fulcrum pin. The lower portion of the governor lever connects to the governor valve through a yoke in which a spool "36" is carried which is screwed on the governor valve stem "34". Below this yoke on the lever "21" is a handle for resetting the lever after the overspeed trip has functioned.

The thrust bearing "23" is lubricated by the grease cup. This bearing should receive an ample supply of grease and the small oil hole on top of the supporting case should be oiled occasionally.

It will be noted that the governor valve stem spring "37" tends to eliminaet lost motion by the constant application of a force in one direction.

To Take Apart Governor Linkage

To take apart the governor linkage, block the knock off lever rod "47" in its normal operating position and drive out the governor lever fulcrum pin. Take off the nut and bushing and drive the thrust bearing retainer bolt "26" out of the housing. Move the governor lever "21" to one side being careful not to bend the valve stem "34". Lift off the turbine bearing cover "9" and loosen governor spring nut "29" to its fullest extent so that the governor weights may be taken out. Pull the



FRAME	"A"
2 AMD	1/4
3 AMD	13/32
4 AMD	7/16

Fig. 4—Governor Linkage and Speed Changer

spring "28" toward the governor thrust bearing and take out the governor spindle pin. Unscrew valve stem spool nut and pull governor linkage straight back.

In replacing the linkage, the governor valve travel should be checked as indicated in the paragraph on setting the governor poppet valve.

Steam Chest

The steam chest "70" is located below and to one side of the governor housing and is bolted to the cylinder base. The steam chest also holds the governor poppet valve cage "33" in place and likewise centers it. The steam chest cover "71" is bolted directly on the end of the steam chest and forms a support for the valve stem "34". This cover is bushed by brass bushings "72" and "73" which have a small clearance between themselves and the poppet valve stem. At the center a space is left between the two bushings which forms a steam leak-off to assist in sealing the steam so that it does not pass out along the poppet valve stem. This passage is tapped with a pipe connection so that a slight leak at this point may be conducted to a point which is not objectionable. There is no stuffing box on the poppet valve stem, and severe leakage must be taken care of by the renewal of the bushings. Should the poppet valve stem stick in the bushing, it should be taken out and a reamer should be run through the bushing to make sure that the bushing is not burred. The stem should be inspected for galled spots and tested for straightness.

Steam Chest Butterfly Valve

The steam chest butterfly valve "5" is located in the steam inlet passage of the steam chest body "1" as shown in Figure 18. This valve is used only with special applications in which, either the governor valve is omitted, or a separate valve is required on which the automatic stop governor functions.

The butterfly valve "5" is secured to the shaft "6" by a taper pin. The shaft "6" which turns in bushings in the steam chest body is keyed to the valve trip lever "7". The valve "5" is held in the open position by the engagement of the trip lever latch plate "8" with the trip lever latch rod latch plate "13" which is fastened to the end of the latch rod "9". When the turbine overspeeds the weight of the automatic stop governor strikes the knock-off lever "20" which through the linkage disengages the trip lever and allows the trip lever spring "14" to close the butterfly valve instantaneously.

Governor Poppet Valve

The governor poppet valve "32" is located in the steam chest "70". It is of the double seated type and is held in a horizontal position by the valve stem "34". The governor valve "32" is pinned on the valve stem "34". The valve stem "34" is supported by the bearing in the valve cage "33" and the two bushings "72" and "73" in the steam chest cover "71".

The valve cage "33" is pressed into place in the steam chest. The steam chest cover "71" is centered in the steam chest by a spigot fit and bolted in place. The bushings "72" and "73" and the bearing in the valve cage "33" should be reamed in position to insure alignment for the valve stem.

The valve stem spring "37" besides taking up lost motion prevents spinning of the governor valve.

The governor poppet valve should never be ground to its seat in order to make a tight joint, inasmuch as the valve will become unbalanced inwardly and will cause hunting of the governor. A test of whether the valve is leaking too badly for use may be applied as follows: With the valve held firmly on its seat by hand, a full head of steam should be turned on and if the turbine begins to revolve it is evident the leakage of the valve is too great for practical use. If the turbine does not turn over, even though there is considerable leakage, no harm is done by using the valve. In case a valve leaks too badly, it must be removed and reseated. In reseating, do not bevel seats indicated as sharp but face off these seats to maintain line contact.

Setting the Governor Poppet Valve

Reference to Figure 4 shows the position of the poppet valve and poppet valve stem as it will be received from the factory. Before operating a machine the setting of the governor poppet valve should be checked and if any work has to be done on the governor linkage, the valve travel should again be set and adjusted, if necessary. To adjust the governor poppet valve "32" remove the nut "35" and push the valve stem forward with the hand until it is felt that the valve has seated. Measure the distance from the spool to the contact of the governor lever "21" and adjust the spool by screwing it backward or forward to give the correct valve travel. This travel should correspond with the value given in the valve setting table (Fig. 4 Page 6) but this dimension will vary with different steam conditions.

Governor Poppet Valve
(Oil Operated)

On some turbines of this type which require a comparatively large governor valve, the governing arrangement is altered by placing a hydraulic operating mechanism between the governor lever and the poppet valve. When this mechanism (shown in Fig. 5) is used, movements of the governor in response to changes in speed are transmitted to the small relay and the actual work of moving the valve is done by oil under pressure working in opposition to a compression spring. The oil pressure required is supplied from some source external to the turbine, usually from the reduction gear oil pump when the turbine is connected to its driven apparatus through a gear unit.

The mechanism consists of an operating cylinder, 4-F-351 and cover 4-G-156 containing an operating piston 4-F-246-20 and guide 4-F-246-21 subjected on one side to oil pressure and on the other to the pressure of a helical spring 4-H-257 under compression. The piston is ported for the passage of oil and, held within it by the guide 4-F-246-21, is a relay plunger 4-H-342 which has freedom of end motion of approximately ¼ inch. In its inner position this plunger opens the oil ports to drain and in its outer position it closes them. The operating piston is connected to the governor valve stem by means of a coupling 4-F-247-42.

When the turbine is at rest the governor spring, being stronger than the operating piston spring, holds the valve mechanism in the wide open position. When oil under pressure is admitted to the operating cylinder, the pressure tends to overcome the resistance of the spring 4-H-257, but since outward motion of the piston relatively to the relay plunger opens the piston ports, enough oil escapes to drain to produce equilibrium between oil pressure and spring pressure. When the turbine comes up to governing speed, the action of the governor moves the relay plunger in the closing direction thus opening ports and allowing oil to escape to drain, whereupon the spring pressure moves the operating piston (and with it the governing valve) in the closing direction until the operating piston overtakes the relay and closes the oil ports to re-establish equilibrium. Hence any movement of the governor and relay plunger produces a corresponding movement of the steam valve.

If the overspeed stop is tripped the action of the powerful overspeed stop lever rod spring 4-H-258, aided by the operating piston spring, causes a very rapid closing of the valve.

Nozzles and Reversing Chambers

The nozzles "41" (Fig. 2) and reversing chambers "57" are located in the cylinder base. 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 reversing chamber; in other words, set the turbine rotor centrally before making any adjustment on the machine. After setting the rotor centrally check up the clearance on the gland runners "20" as shown on Fig. 7. With these clearances correct, adjust the thrust bearing to hold the rotor in this position.

The nozzle is bolted to the steam chest body "70". If a new nozzle is to be installed it should first be connected to the steam chest body and the nozzle set centrally in the cylinder base. In setting new nozzles and reversing chambers, refer to Fig. 2 and note that the reversing chamber should be set as shown so that it will be flush with the nozzle. It is important that the reversing chamber be so set as to catch all steam emerging from the blades.

Bearings

Inasmuch as it sometimes becomes necessary to rebabbitt a bearing in the field, we have prepared Fig. 6 for this purpose. The table given indicates the proper machining for each bearing which can be readily identified by measuring the journal of the shaft. In rebabbitting a bearing, if care is used to properly groove and machine it in accordance with the dimensions given, good results should be obtained.

On all direct connected turbines of this type, the bearings are of the single oil ring type, the bearing next to the coupling being known as the coupling end bearing, and the other end bearing

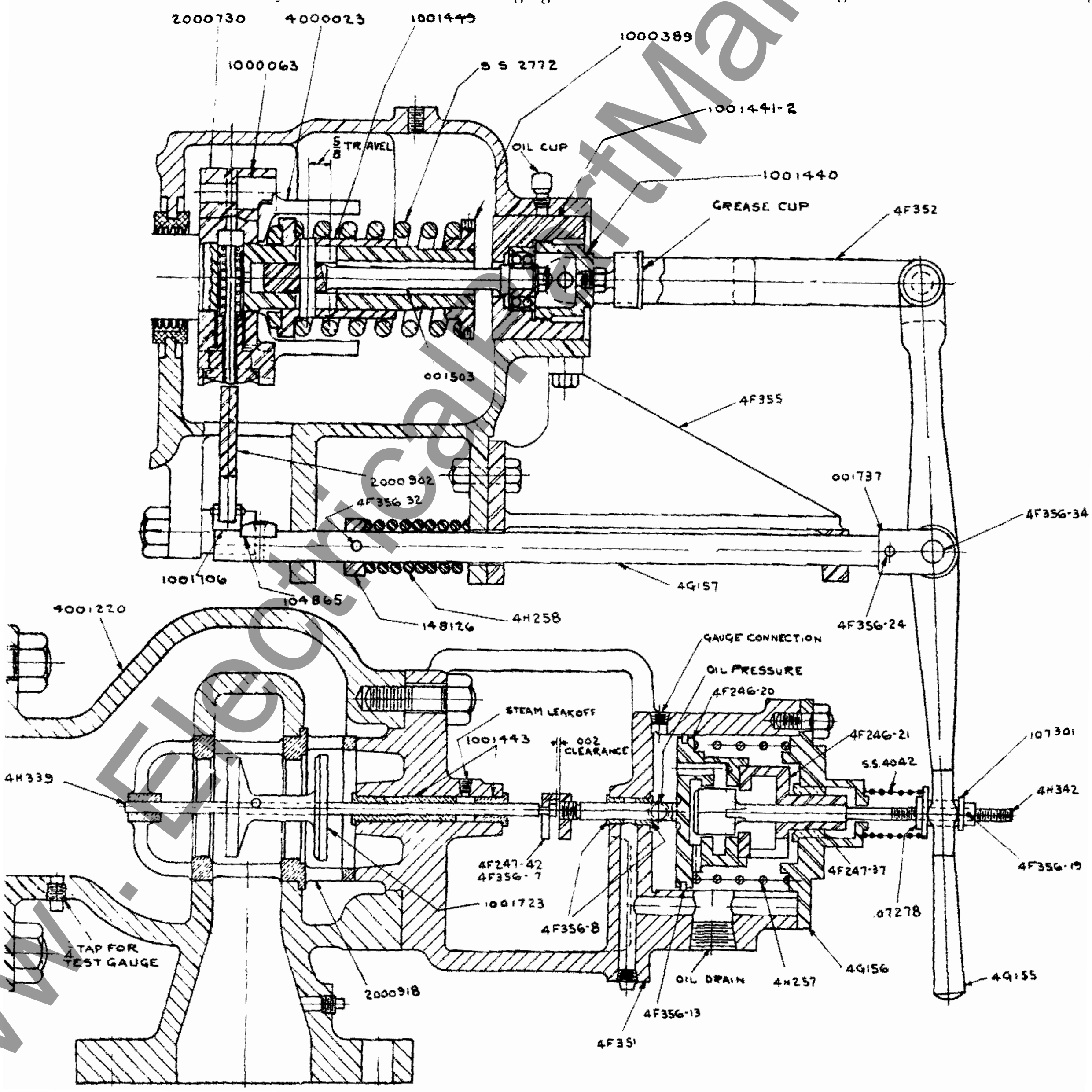


Fig. 5—Governor Valve (Oil Operated)

being known as the thrust bearing. It is to be noted that while both bearings are made in the same general manner, the grooving is different on the thrust bearing. In order to allow proper lubrication of the thrust face, and on the bearing particularly, it is important that this grooving be properly made. The thrust bearing should be set for end play to the clearances, as given in the table (Fig. 6). This clearance may be adjusted by screwing the thrust collar "65" on the thrust screw "66". It is essential that these clearances be properly set in order to get good results.

Glands
(Labyrinth and Water Sealed)

The standard gland arrangement used on these turbines is of the combination labyrinth and water sealed type, shown in Figure 7. The labyrinth packing is placed inside of the gland runners so that for cases of very low speed, where the runner is of little value, the labyrinth packing accomplishes the sealing of the gland. In making an inspection of the glands, the gland horizontal flange bolts should be removed and the upper half of the gland should be raised with the cylinder cover. In replacing, the joint should be made up with shellac and a fine linen thread be placed on the outside of the gland runner and the packing rings, and the joint should be made before the shellac hardens. The water portion of the gland is piped up as shown in Fig. 7 when the direction of rotation is as shown by the arrow, and the proper height of stand-pipe is given in the official outline drawing furnished with each machine. When the direction of rotation is opposite to that shown by the arrow the water connections should be reversed.

Valve "B" (Fig. 7) should be so adjusted that enough water will circulate through the glands to maintain a temperature slightly below that of the boiling point.

Excessive water leakage from the gland may indicate that the standpipe is too high and the head on the gland should be reduced. It may also indicate that the gland is not properly 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 give a considerable stoppage of water.

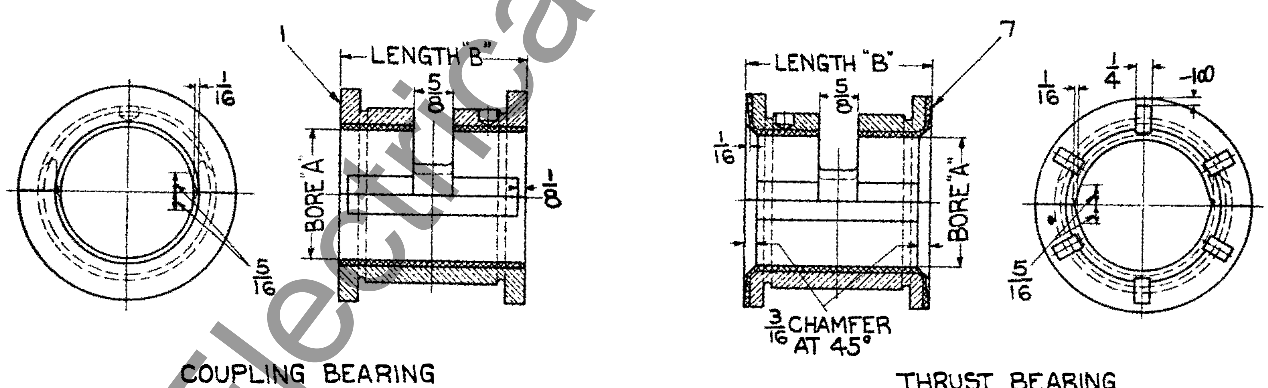
Glands
(Carbon Ring)

A comparatively few machines of this type are equipped with carbon ring glands, shown in Fig. 8. This illustration shows three rings. However, the number of rings may vary, depending on the pressure against which they must seal. The gland cases are split horizontally to facilitate dismantling and assembling.

The carbon rings are made in three segments and the ends are fitted so that a radial clearance of approximately .003 inch exists between the carbon and the shaft when cold. It is essential that the joints at the end of the segments be perfectly square and radial, to prevent leakage at these points. Each ring fits in a separate groove and is held around the shaft by a garter spring which holds the ends of the segments together. Each ring is prevented from rotating by a key in the casing which engages a slot in the carbon ring. If the gland is dismantled, it is important to reassemble the segments in the same grooves and in the same relative positions as found originally.

When fitting the carbon rings, every precaution must be taken to see that they are free to move radially in their individual grooves. If the rings are tight in the grooves, they will wear rapidly and in extreme cases may injure the shaft. The axial clearance necessary to insure this freedom of movement should be from .013 to .023 inch. No oil should be used in fitting the rings.

A leak-off is provided between the two outer rings to prevent the leakage of steam past the outer ring to the atmosphere. If the turbine exhausts to a vacuum, this same opening serves as an inlet for gland sealing steam.



BORE "A"	LGTH. "B"	BEARING CLEARANCE	THR. BRG. CLEAR. ENDWISE
2.125 {2.126 / 2.124	3	.008-.012	.003-.007
2.500 {2.501 / 2.499	4¼	.008-.012	.004-.008
2.500 {2.501 / 2.499	4¼	.008-.012	.004-.008

Fig. 6—Bearings

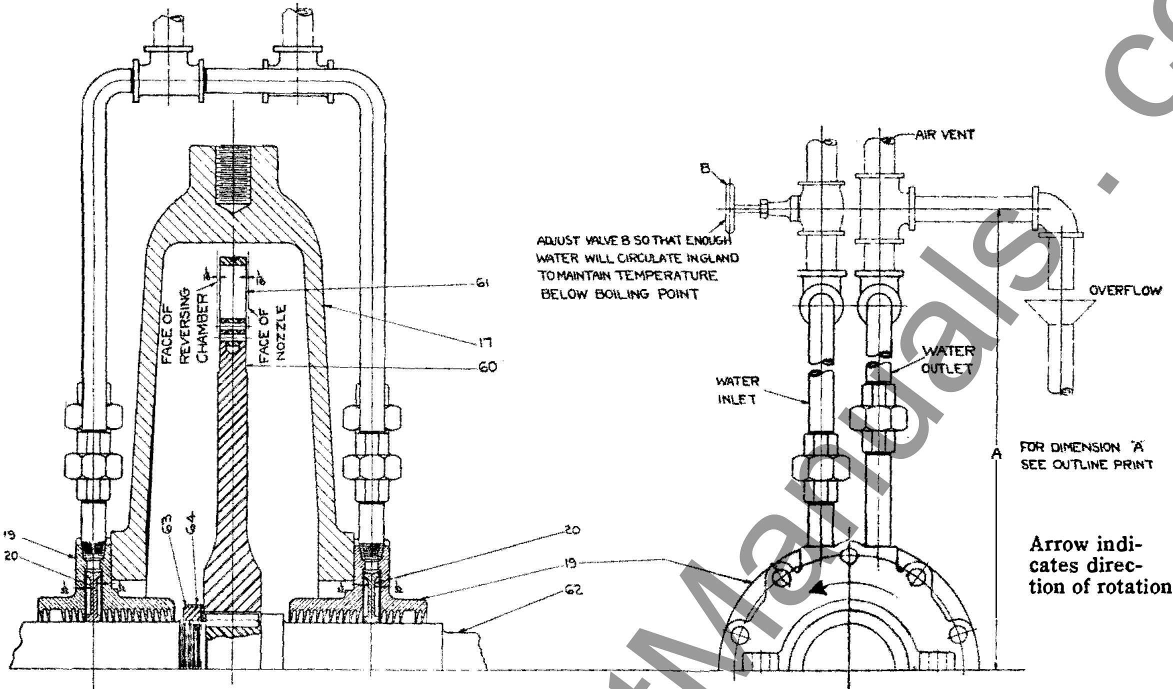


Fig. 7—Labyrinth and Water-Glands

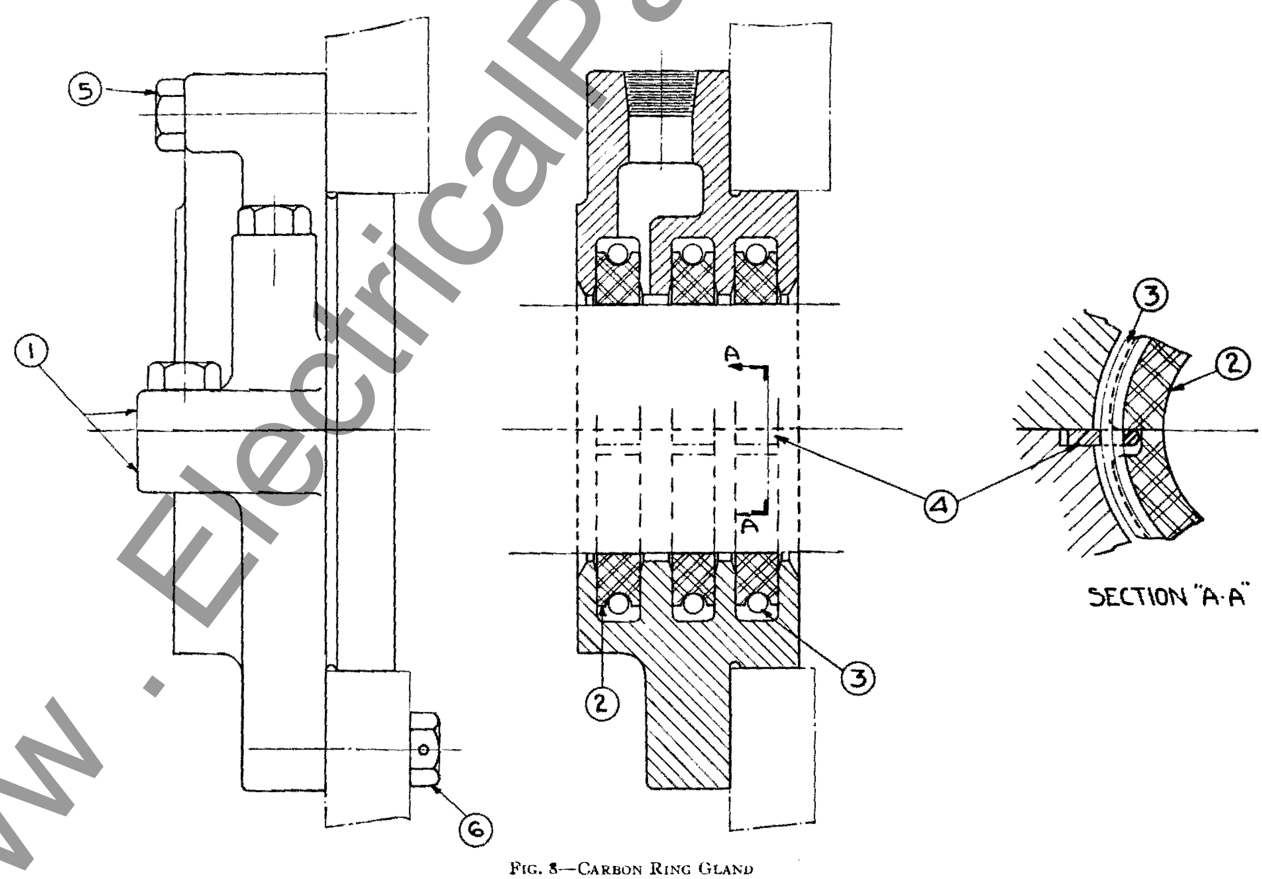


Fig. 8—Carbon Ring Gland

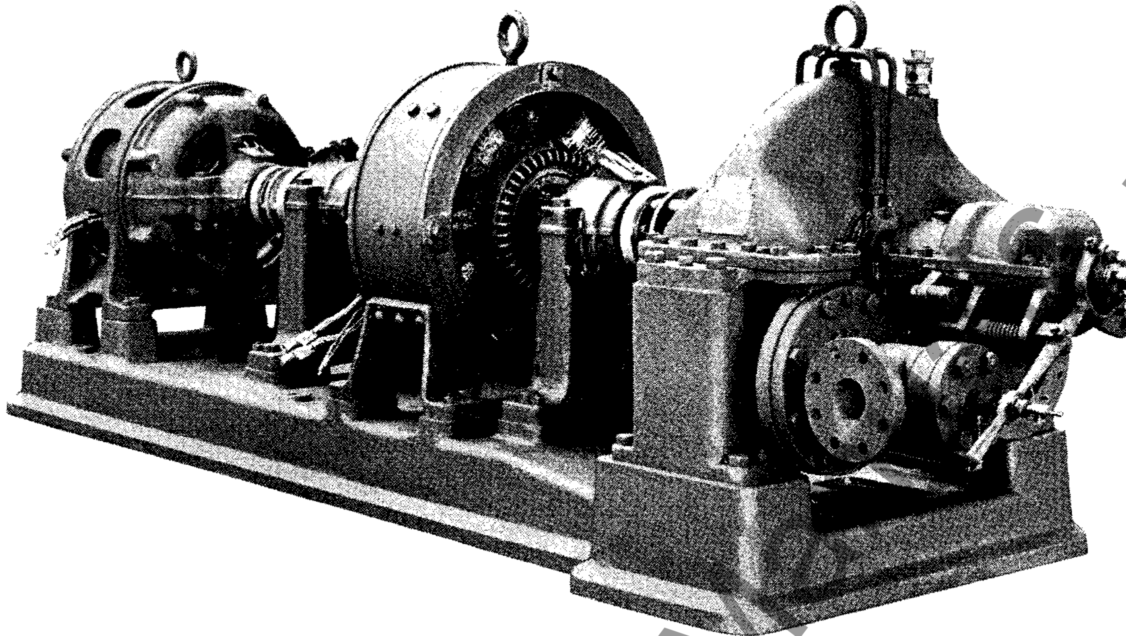


Fig. 9—Dual Drive Unit

Dual Drive Units

Dual drive units find their application in driving electrical generators for excitation and other purposes, and also for driving condenser auxiliaries. This type of drive is desirable for two reasons: first, that it makes the apparatus more reliable by having a stand-by unit always at hand, and second that the turbine end offers a ready means of regulating the heat balance of the plant. Figure 9 shows the turbine and motor directly connected to the generator. The operation of such a set is as follows:

Under normal conditions the no load speed of the turbine will be set, as nearly as possible, about 1 or 2 per cent below the full load motor speed, the motor being used practically all the time as the main driving element. When the motor comes up to speed, driving both the generator and the turbine, and since the turbine speed is set slightly lower than the motor speed it follows that the governor valve of the turbine will be closed and no steam will pass through it. The turbine will then run idle. If there is a disturbance on the motor circuit, and it should be thrown out of service, the turbine will take the full load at about 4 per cent below the normal full speed of the motor, thereby preventing a shutdown of the exciter.

The function of regulating the heat balance of the plant is accomplished in the following manner: Assume that the motor is carrying the full load with the turbine running idle, and it is desirable to introduce steam into the feed water heater for heat balance regulation. The hand speed changer, as shown on Fig. 4, may then be brought into operation so that the turbine speed is slightly raised. The speed of the turbine by this speed changer can then be regulated so as to take any portion or all of the load from the motor.

The installation and maintenance of a dual drive unit of this type is exactly the same as previously described in this instruction book.

Refer to Fig. 4, showing cut of hand speed changer. The speed changer handwheel "81" is pinned to the valve stem "34" and the stem nut "77" is threaded so that the stem may be screwed into or out of this nut.

This type of speed changer is known as the release type, which, when the unit is being driven by the motor, allows the governor lever "21" to move in response to the higher speed after the governor valve is closed, without adding excess loading to the governor lever ball bearing "23". This overtravel is obtained by means of the spring "78" which forms a collapsible member in the linkage.

It should be noted that the speed of the turbine can be regulated by the hand speed changer while the unit is in operation. If the speed is to be decreased, the governor valve should be screwed inward nearer to its seat by means of the handwheel. If the speed is to be increased, screw the handwheel in the opposite direction.

With the speed changer installed, the valve travel cannot be checked by the same method described under "Setting the Governor Poppet Valve". However, it is of utmost importance to make sure this setting is such that the governor travel is sufficient to close the valve even with the speed changer in its outermost (or maximum speed) position. As shown in the illustration, outward movement of the handwheel is limited by the inner collar on the handwheel coming against the stop plate "82" and the position in which the handwheel is pinned on the valve stem, determines the valve travel. To check this travel, proceed as follows:

1. Make sure that the autostop mechanism is latched in its normal running position.
2. Screw the valve stem inward until the valve is on its seat.
3. Measure the clearance "A" between the inner collar of the handwheel and the stop-plate "82". This clearance is the valve travel and should agree with the values given in the table of Fig. 4.

If the travel found in this manner is not in accordance with the table, remove the handwheel pin "80" and relocate the handwheel to give a clearance at "A" equal to the valve travel desired.

Foundation

This turbine may be bolted directly to the bedplate supporting the machine

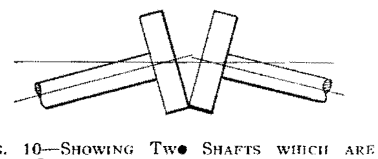


Fig. 10—Showing Two Shafts which are Concentric but are in Angular Misalignment

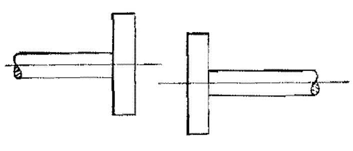


Fig. 11—Showing Two Shafts with no Angular Misalignment but which are not Concentric

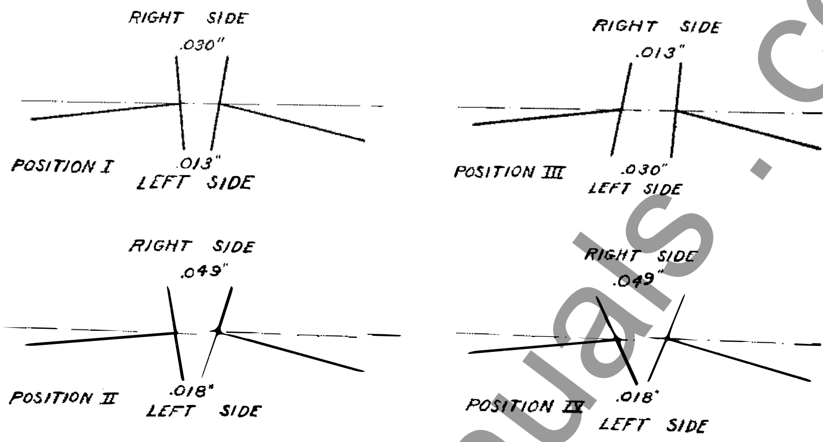


Fig. 12—Coupling Alignment

it is to drive, or it may be mounted on a separate soleplate.

Build the foundation solid and of ample weight. Sleeves around the foundation bolts should have about ½-inch clearance for lining up the bedplate. Leave the top of the foundation at least 1 inch low to provide for grout. The foundation must be rigid, thoroughly settled, and independent of the building as far as possible.

Erection

It is most important that the machine be properly installed. Misalignment, distortion of the bedplate, and errors of this kind will, later, bring about serious operating troubles even though the machine seems to run fairly well at first.

In some cases the turbine and driven apparatus are mounted upon a continuous bedplate and in other cases they are on two separate bedplates. In either case, the method of procedure is the same.

There are three steps in erecting a unit. The first is to grout the unit in as nearly correct alignment as possible. The second is to check the alignment after the grouting has set and make any changes necessary to bring about accurate alignment by moving the turbine on its bedplate. The third is to dowel the turbine and driven apparatus to the bedplate.

First set the bedplate level, supported upon iron wedges, spaced from 12 to 18 inches apart. Do not depend upon the stiffness of a cast iron bedplate to give or maintain good alignment. Care must be exercised to see that the weight is evenly distributed on the wedges to keep the bedplate from springing. Put the turbine in proper position relative to the driven apparatus. Leveling may be done on any finished projecting pads, which offer a rest for the level.

If the position of the driven apparatus is to be determined by the pipes to which it connects, be sure that this point is checked up at this time. Check also the exhaust and inlet flanges on the turbine and all pipe connections on the driven apparatus to see that they are vertical. If they are not, this would indicate that the preceding work has not been done accurately and should therefore be rechecked.

Next check the alignment of the coupling, making any changes necessary to bring about good alignment.

After this is done, a dam of boards or bricks of sufficient height should be built around the bedplate and the grouting poured. It is recommended that the interior of the bedplate be filled solid with grout. Make grouting thin, using a mixture of one part high grade Portland cement and one part clean, sharp sand.

Allow grouting to become thoroughly set and then slug up foundation bolts tight.

To set on steel work, set bedplate on shims not over a foot apart, and provide against these shims slipping out by screwing them to the steel work. Level up bedplate as previously described and make sure that it sets level on all shims. After carefully pulling down the foundation bolts, the final alignment of the outfit should be checked.

Do not run the unit until the final alignment is completed.

Alignment of Coupling

All couplings must be lined up for two conditions namely: **Angular Misalignment and Concentricity.** The two conditions are illustrated in figures 8 and 9.

In lining a cold turbine to the driven apparatus, it is customary to set the turbine several thousandths of an inch low to allow for expansion when the turbine becomes heated up. With the Westinghouse construction of supporting the turbine at the center line, this allowance is not necessary. (See description, Turbine Support, page 3.)

Aligning Coupling for Sidewise Angular Misalignment

Inasmuch as coupling faces are rarely true with their respective shafts, it is necessary to make the alignment by some method which takes care of this condition. This is accomplished by the use of the following method which should be used even though the coupling faces have just been trued up in the lathe:

1. Remove coupling pins or bolts.
2. Mark a line with chalk on the side of both coupling halves at the approximate horizontal centerline.
3. Measure the distance between coupling faces at the chalk marks with a feeler gauge both on the right side and left side.

For example let us suppose that the following are the readings taken: See Position I of Fig. 12.

Right side, distance between coupling faces	.030"
Left side, distance between coupling faces	.013"
Subtracting the two values given	.017"

4. Turn **both** couplings 180 degrees and measure the distance as before.

With couplings in this position suppose that the following readings are taken: See Position II of Fig. 12.

Right side, distance between coupling faces	.049"

Left side, distance between coupling faces .018″

Subtracting the two values given .031″

The couplings then are out of alignment across the diameter by the amount (.017″ plus .031″) divided by 2, equals .024″.

Note: The values in the parentheses are added if the greater distance between the coupling faces is measured on the same side in both positions as shown by Positions I and II, subtracted if the greater distance between the coupling faces is measured first on one side and then on the other as shown by Positions III and IV, Fig. 12.

5. To put the couplings in line when they are in this position, move the shafts so that the reading on the right side equals .049″ minus .012″ or .037″. Then the reading on the left side equals .018″ plus .012″ equals .030″.

Note: .024″ out of alignment across the diameter equals .012″ on the radius.

With this setting the following readings are taken:

Right side, distance between coupling faces .037″

Left side, distance between coupling faces .030″

Subtracting the two values given .007″

The shafts are now in vertical alignment.

To check this setting, turn **both**, couplings **back** 180 degrees and take readings:

Right side, distance between coupling faces, .030″—.012″ = .018″

Left side, distance between coupling faces, .013″ + .012″ = .025″

Subtracting the two values given .007″

Check: Using same methods as in (4) the couplings are out of alignment across the diameter by the amount (.007″ minus .007″) divided by 2, equals .000″ or in other words, they are in alignment.

Note: Since after the shafts were reset, the greater distance between coupling faces changes from right to left and the values are subtracted instead of added.

6. **When the greater distance between coupling faces changes from one side** as in position III **to the other** as in position IV let us suppose that the following are the readings taken: Position III.

Right side, distance between coupling faces .013″

Left side, distance between coupling faces .030″

Subtracting the two values .017″

Turn **both** couplings 180 degrees and measure the distance as before:

With the couplings in this position suppose that the following readings are taken: Position IV.

Right side, distance between coupling faces .049″

Left side, distance between coupling faces .018″

Subtracting the values given .031″

The couplings are then out of alignment across the diameter by the amount (.031″ minus .017″) divided by 2, equals .007″, or .007″ divided by 2, equals .0035″ on the radius.

To put the couplings in line when they are in this position move the shafts so that the readings on the right side equal .049″ minus .0035″ equals .0455″. Then the reading at the left side should be .018″ plus .0035″, equals .0215″. With this setting the following readings are taken:

Right side, distance between coupling faces .0455″

Left side, distance between coupling faces .0215″

Subtracting the two values given .0240″

The shafts are now in vertical alignment.

To check this setting turn **both** couplings **back** 180 degrees and take readings.

Right side, distance between coupling faces, .013″—.0035″ = .0095″

Left side, distance between coupling faces, .030″ + .0035″ = .0335″

Subtracting the values given .0240″

The couplings are then out of alignment across the diameter by the amount (.024″ minus .024″) divided by 2 = .000″ or in other words, they are in alignment.

7. To line up top and bottom repeat this operation in the vertical plane, using either method that applies.

Coupling Alignment to Bring the Shafts Concentric

Couplings which are eccentric with regard to their respective shafts are the most difficult to align properly. This can be checked up by means of a dial indicator. If this condition exists, much time can be saved by putting the shafts in a lathe and turning the couplings so that they are round and also of the same diameter.

Consider a coupling as indicated on Figure 13, a scale held firmly on top of the upper half of the coupling gives a feeler gauge reading at A of .005 inches. A reading at B gives .005 inches. It is evident, therefore, that one shaft must be moved .005 inches. The same process should be used for bringing the shafts central in the horizontal plane.

Consider a coupling as indicated in Figure 14, when half of the coupling is .020 inches smaller in diameter than the other half of the coupling and the shaft is again .005 inches out of concentricity.

In this case, one shaft should be moved .005 inches as before, which will give the readings as shown on Figure 15. Follow the above procedure in the horizontal plane and bring the shafts central by sidewise movement if necessary.

As the alignment of the turbine to the driven apparatus nears completion, the bolts holding the turbine to the bedplate should be gradually tightened. If tightening these bolts throws the turbine out of line, it indicates that either one corner is lower than the other or the clearance holes for the bolts are too small. In the first case, this can be remedied by shimming up the low corner, and in the second, by chipping the clearance hole larger.

After the above work has been satisfactorily completed the turbine and driven apparatus must be dowelled to the bedplate.

Alignment is not complete until readings are correct with the turbine holding down bolts drawn up tight.

Piping

When connecting the turbine to a steam and exhaust line, always begin the piping from the connecting line and end at the turbine, making the turbine connection the last one in the line.

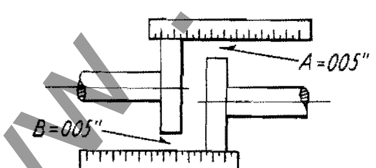


Fig. 13

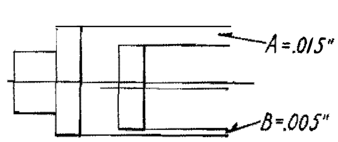


Fig. 14—Coupling Alignment

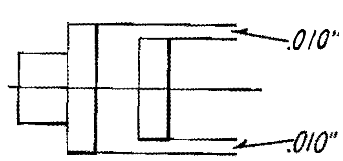


Fig. 15

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.

The steam piping must not impose any strain 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 put in the piping to take up the expansion of the steam line. Support the piping at a point near the turbine in such a manner that the weight of the piping is taken by this support. The piping 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 the flanges together or to match the bolt holes. After installing 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. 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 connecting to the turbine.

In all cases where the turbine is to be realigned, disconnect the steam and exhaust piping, and in reconnecting be sure that the flanges line up without putting a strain upon the turbine.

To Operate

Before starting up, clean the turbine, taking out the bearings so that all dirt may be taken from the bearing cavities, and after replacing bearings, fill cavities with a good grade of clean oil. See that rotor turns freely by hand. Disconnect the governor linkage and make sure that the governor poppet valve can easily be moved in and out without sticking. Clean off all rust and corrosion that may have collected upon exposed parts of the governor mechanism. See that the governor thrust bearing grease cup is full of grease. Pull back governor lever "21" (Fig. 2) until the knife edges of the latch plates "46" and "50" (Fig. 2) are engaged. Trip automatic stop by means of hand tripping device. This is accomplished by striking hand lever "45" (Fig. 2) sharply. Reset auto stop as indicated above.

Open drains on steam and exhaust line. Open up exhaust valve. Crack the steam valve and when live steam appears at the drains, close them off. Bring the turbine slowly up to speed and note that the oil rings are turning in the bearings. When the turbine begins to come up to speed, watch the governor lever arm to see that the governor is functioning properly. When the turbine is up to speed and under control of the governor, open throttle valve wide. Turn on gland water.

With the unit under way, check the speed by means of a tachometer or speed counter. This may be accomplished at the outboard end of the driven apparatus. If the speed is not correct, it should be made so at this time. To decrease the speed, screw back on the governor spring adjusting nut "29" (Fig. 2), to increase the speed, tighten up the adjusting nut. Run turbine under observation until the temperature of the bearings has ceased to rise.

To Shut Down

Shut off gland water. Strike knock-off lever "45" (Fig. 2) sharply, which will close governor poppet valve and indicate that the automatic closing device is working properly. Close throttle valve, and when this is totally closed reset automatic trip. Close exhaust valve; open steam and exhaust drains.

Adjustments

1. Bearing clearances (See Fig. 6).
2. Catch on auto stop "46" (Fig. 2) Latch plate knife edges overlap $\frac{1}{16}$ inch.
3. Clearance between blades "61" and nozzle "41" (Fig. 7).
4. Clearance between blades "61" and reversing chamber "57" (Fig. 7).
5. Clearance on either side of gland runners "20" Fig. 7).
6. Clearance between auto stop pin "56" and knock off lever "45" (Fig. 2), should be $\frac{1}{16}$ inch.
7. Clearance between governor valve stem "34" and bushing "72" and "73". (Fig. 4) should be .002 inch.
8. Clearance between governor lever "21" and spool "36" (Fig. 4) should be about .005 inch.
9. Clearance between bearing oil retaining ring "11" and shaft (Fig. 2) should be .002 to .006 inch on radius.
10. Clearance between governor spring seat "30" and shaft "62" (Fig. 2) should be .003 to .009 inch.
11. Clearance between governor pin and spring seat "30" (Fig. 2) should be .001 inch on diameter.
12. Governor poppet valve settings, see (Fig. 4).
13. Clearance between governor spindle "22" and hole in the shaft "62". (Fig. 2) should be .015 to .017 inch.
14. Governor spindle "22" and pin (Fig. 2) should be .001 inch on dia.
15. Oil level should be within ½ inch of top of gauge glass.
16. Thrust bearing clearance (Fig. 6).
17. To increase speed (Refer to last paragraph under "To Operate," also see "Governor").
18. To decrease speed (Refer to last paragraph under "To Operate", also see "Governor").
19. To set governor poppet valve (See Page 6.)
20. To adjust speed at which automatic stop operates (see "Auto Stop").

Care of the Turbine

1. Keep machine clean.
2. Keep bearing reservoirs well filled with good quality, clean oil.
3. Keep grease cup on governor thrust bearing well filled and turn occasionally. Do not use graphite in the bearing.
4. Wash out bearing cavities with kerosene and re-fill with clean oil every three or four months.
5. If steam is contaminated with boiler compound or sludge, clean off poppet valve stem as often as necessary to keep it working freely.
6. Before starting a unit that has been idle for some months dismantle governor and governor valve linkage to see that all parts are free.
7. Bearings should be inspected occasionally to see that they are not wearing out.
8. The automatic stop should be tripped occasionally to see that it is in working order.
9. Check speed of machine at least once a week as this is a good caution against possible trouble.
10. Keep exhaust drain open when turbine is standing idle, otherwise rotor will rust and become unbalanced.

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.

To make complete inspection, see description of part to be inspected.

Operating Difficulties

Governor Hunting

1. Too great a travel of governor valve.
2. Sticking of governor valve in guide.
3. Sticking of governor spindle in turbine shaft.
4. Bent valve stem.
5. Broken governor weight knife edges.
6. Distorted or bent governor linkage.
7. Weakening of governor spring.

Turbine Fails to Come Up to Speed

1. Low boiler pressure or high back pressure.
2. Steam line clogged.
3. Nozzle throat plugged by foreign matter.
4. Governor speed set too low. (Note action of governor lever).
5. Too small valve travel.
6. Too much water in steam.
7. Driven apparatus takes more power than specified.

Glands Leaking Steam

1. Water passages clogged with dirt or scale.
2. Recesses in gland runners clogged with scale.
3. No water in glands.
4. Gland joint improperly made up.

Glands Leaking Water

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

Vibration

1. Misalignment between turbine and driven apparatus.
2. Steam and exhaust pipe straining turbine cylinder.
3. Bent shaft.
4. Coupling running out of true.
5. Governor running out of true.
6. Driven apparatus out of balance.

To correct vibration troubles, misalignment should be corrected, bearings put in proper shape, and any parts not true should be made so. It may also be necessary to balance the rotor. In severe cases of vibration, the best procedure is to get in touch with the nearest District Service Office and apply for the services of an engineer.

Repair Parts

The list of parts shown on the following pages was made up for your convenience on ordering repair parts. To order a spare part, give serial number of turbine and name and number of the part desired. Due to the necessity of avoiding interruption in service, it is well to carry a number of spare parts on hand. Carrying such a stock will also avoid a delay in shipment at a time when the parts are most needed.

We recommend that the following spare parts be carried for each machine.

- 1. Set of bearings.
- 1. Governor spindle thrust bearing.
- 1. Governor spindle with pin.
- 1. Governor valve stem with spools and bushings.
- 1. Knock off lever with knife edges.
- 1. Governor valve and seat.

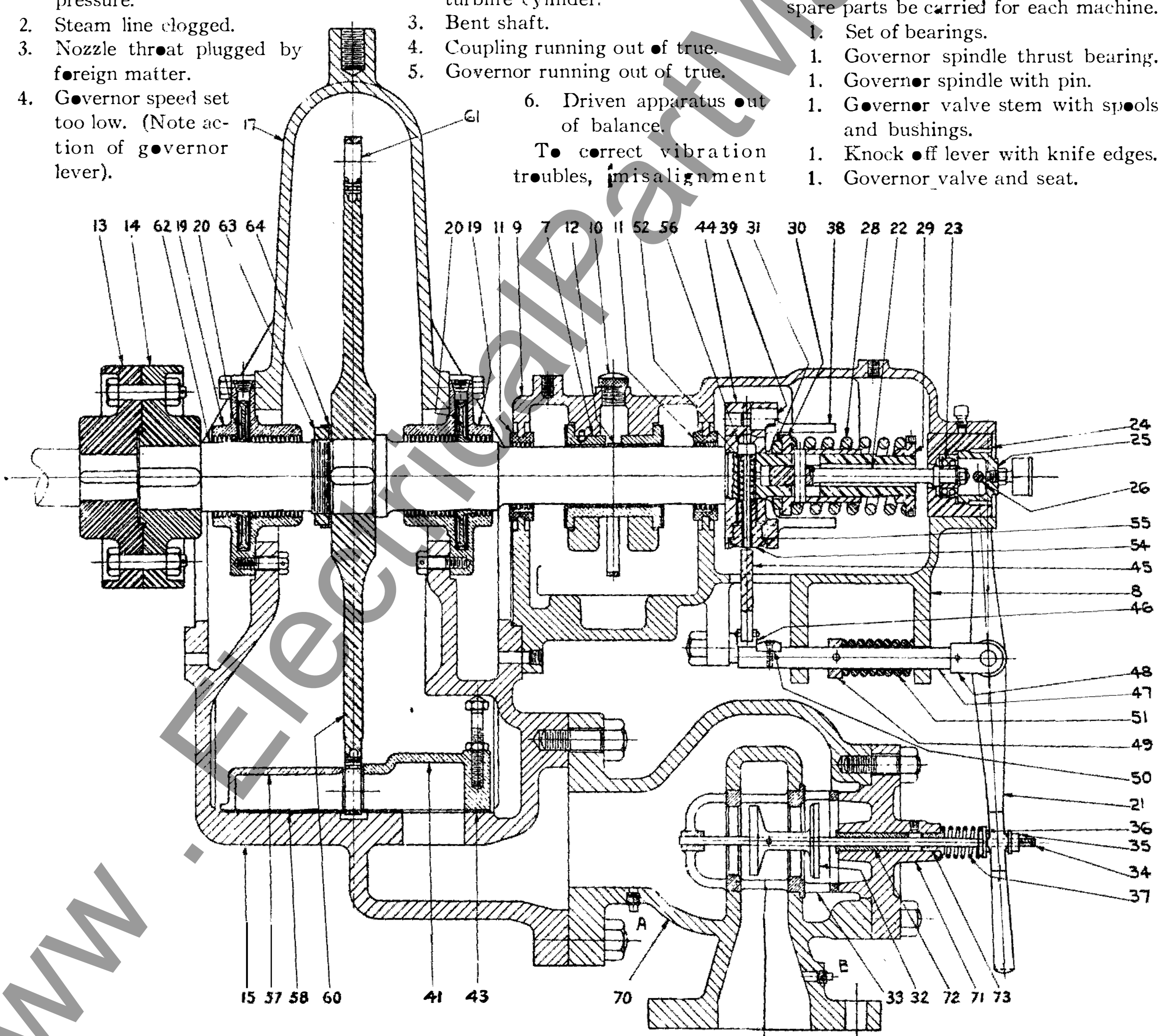


Fig. 16—Longitudinal Section, 3-AMD and 4-AMD Turbines

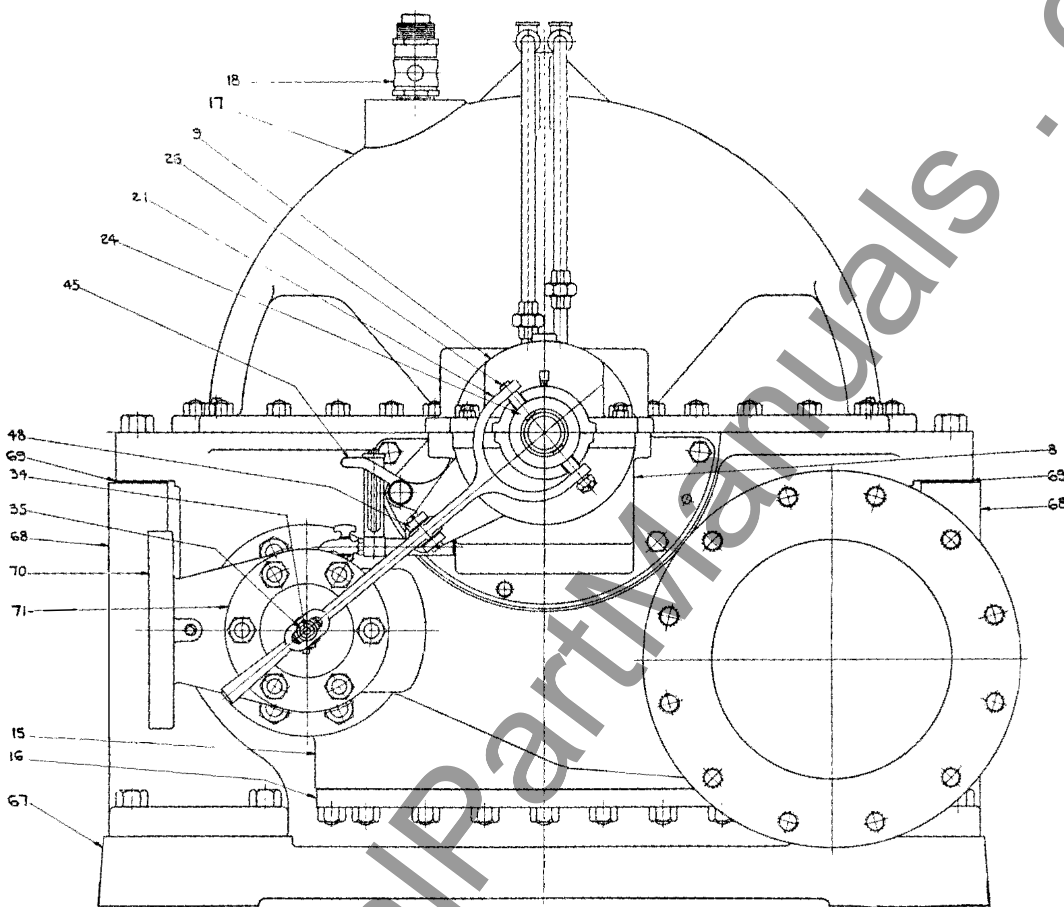


Fig. 17—End View, 3-AMD and 4-AMD Turbines

List of Parts for Figures 2, 3, 4, 7, 16 and 17—(Continued)

1. Bearing (Coupling End)
2. Bearing Bracket (Coupling End)
3. Bearing Cover
4. Bearing Cover Sight Hole Plug
5. Bearing Oil Retainer Ring
6. Bearing Oiling Ring
7. Bearing (Governor End)
8. Bearing Bracket (Governor End)
9. Bearing Cover
10. Bearing Cover Sight Hole Plug
11. Bearing Oil Retainer Ring
12. Bearing Oiling Ring
13. Coupling (Gear Half)
14. Coupling (Turbine Half)
15. Cylinder Base
16. Cylinder Base Cover
17. Cylinder Cover
18. Cylinder Relief Valve
19. Gland Case
20. Gland Runner
21. Governor Lever
22. Governor Spindle
23. Governor Spindle Thrust Bearing
24. Governor Spindle Thrust Bearing Housing
25. Governor Spindle Thrust Bearing Retainer
26. Governor Spindle Thrust Bearing Retainer Bolt
27. Governor Spindle Thrust Bearing Retainer Bolt Bushing
28. Governor Spring
29. Governor Spring Adjusting Nut
30. Governor Spring Seat
31. Governor Spring Seat Toe Block
32. Governor Valve
33. Governor Valve Cage
34. Governor Valve Stem
35. Governor Valve Stem Nut
36. Governor Valve Stem Spool
37. Governor Valve Stem Spring
38. Governor Weight
39. Governor Weight Fulcrum Block
40. Name Plate
41. Nozzle Block
42. Nozzle Block Cover
43. Nozzle Block Liner
44. Overspeed Stop Housing
45. Overspeed Stop Knockoff Lever
46. Overspeed Stop Knockoff Lever Latch Plate
47. Overspeed Stop Knockoff Lever Rod
48. Overspeed Stop Knockoff Lever Rod Clevis
49. Overspeed Stop Knockoff Lever Rod Collar
50. Overspeed Stop Knockoff Lever Rod Latch Plate
51. Overspeed Stop Knockoff Lever Rod Spring
52. Overspeed Stop Spring
53. Overspeed Stop Spring Liner
54. Overspeed Stop Spring Retainer
55. Overspeed Stop Spring Retainer Lock
56. Overspeed Stop Weight
57. Reversing Chamber
58. Reversing Chamber Liner
59. Reversing Chamber Liner Screw
60. Rotor
61. Rotor Blade
62. Rotor Shaft
63. Rotor Shaft Nut
64. Rotor Shaft Nut Locker Washer
65. Rotor Shaft Thrust Collar
66. Rotor Shaft Thrust Collar Screw
67. Soleplate
68. Soleplate Support
69. Soleplate Support Cylinder Base Liner
70. Steam Chest Body
71. Steam Chest Cover
72. Steam Chest Cover Bushing (Inner)

List of Parts for Figures 2, 3, 4, 7, 16 and 17—(Continued)

73. Steam Chest Cover Bushing (Outer)
74. Speed Changer Release Spring Spool Bolt
75. Speed Changer Release Spring Spool Bolt Nut
76. Speed Changer Handwheel Plate
77. Speed Changer Handwheel Nut
78. Speed Changer Release Spring
79. Speed Changer Release Spring Spool
80. Speed Changer Handwheel Rivet
81. Speed Changer Handwheel
82. Speed Changer Handwheel Pawl Stop Plate
83. Speed Changer Idling Range Indicator Plate

Part List
Figure 5—Governor Valve (Oil Operated)

Item No.	Name
4-F-246-20	Relay Valve Operating Piston
4-F-246-21	Relay Valve Operating Piston Guide
4-F-247-37	Relay Valve Operating Piston Guide Bushing
4-F-247-42	Relay Valve Operating Piston Coupling
4-H-257	Relay Valve Operating Piston Spring
4-F-351	Relay Valve Operating Cylinder
4-G-156	Relay Valve Operating Cylinder Cover
4-F-352	Governor Lever (Upper)
4-G-155	Governor Lever
4-G-157	Governor Lever Rod
4-H-339	Governor Valve Stem
4-H-342	Relay Plunger
4-F-355	Governor Lever Rod Bracket
4-F-356-7	Relay Valve Operating Piston Coupling Screw
4-F-356-8	Relay Valve Operating Cylinder Bushing
4-F-356-13	Relay Valve Operating Piston Ring
4-F-356-19	Cotter Wire
4-F-356-24	Pin
4-F-356-32	Pin
4-F-356-34	Pin
4-H-258	Overspeed Stop Lever Rod Spring

Part List
Figure 8—Carbon Gland

1. Gland Case
2. Carbon Ring
3. Carbon Ring Spring
4. Carbon Ring Key
5. Gland Case Tap Bolt
6. Gland Case Tap Bolt

Part List
Figure 18—Steam Chest Butterfly Valve

1. Steam Chest Body
2. Steam Chest Body Cover
3. Steam Chest Body Cover Bushing (Outer)
4. Steam Chest Body Cover Bushing (Inner)
5. Steam Chest Butterfly Valve
6. Steam Chest Butterfly Valve Shaft
7. Steam Chest Butterfly Valve Trip Lever
8. Steam Chest Butterfly Valve Trip Lever Latch Plate
9. Steam Chest Butterfly Valve Trip Lever Latch Rod
10. Steam Chest Butterfly Valve Trip Lever Latch Rod End
11. Steam Chest Butterfly Valve Trip Lever Latch Rod End Shoulder Bolt
12. Steam Chest Butterfly Valve Trip Lever Latch Rod Guide
13. Steam Chest Butterfly Valve Trip Lever Latch Rod Latch Plate
14. Steam Chest Butterfly Valve Trip Lever Spring
15. Steam Chest Butterfly Valve Trip Lever Spring Stud
16. Steam Chest Butterfly Valve Trip Lever Spring Stud
17. Steam Chest Governor Lever
18. Steam Chest Governor Lever Clevis
19. Steam Chest Governor Lever Clevis Shoulder Stud
20. Steam Chest Governor Knock-off Lever
21. Steam Chest Governor Valve
22. Steam Chest Governor Valve Cage
23. Steam Chest Governor Valve Stem
24. Steam Chest Governor Valve Stem Nut
25. Steam Chest Governor Valve Stem Spool
26. Steam Chest Governor Valve Stem Spring

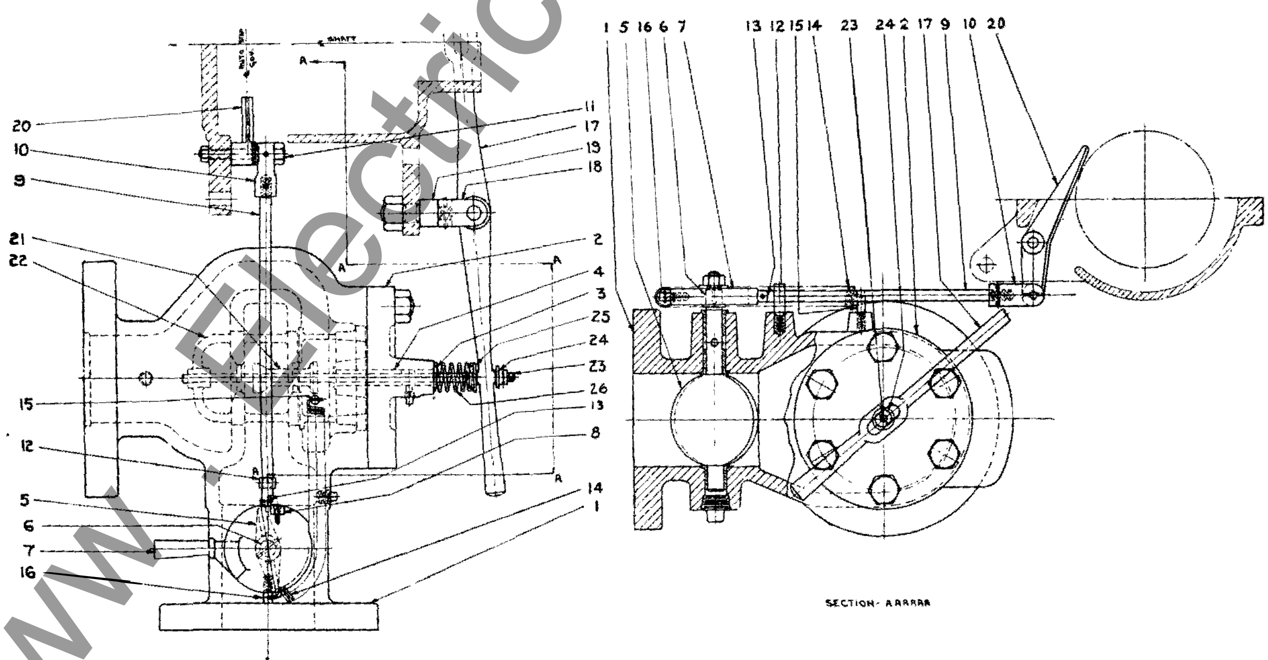


Fig. 18—Steam Chest Butterfly Valve