

GOVERNOR, GOVERNING VALVE AND OIL PUMP

This governor mechanism comprises a vertical shaft centrifugal weight governor, a gear type oil pump and a balanced double seated governing (steam inlet) valve, operated by an oil servo-motor. The above parts together with a manually operated throttle valve, with a quick closing device arranged to be actuated by the overspeed trip mechanism on the turbine shaft, are shown in Figure 1.

GOVERNOR

The governor is of the centrifugal weight type, in which the centrifugal force of the weights is opposed by the compression force of the governor spring or springs. The governor hub "28" is keyed to the governor spindle which is driven from the end of the turbine rotor shaft by the bevel gears "12" and "14". This hub carries the weight fulcrum blocks "19" which support the governor weights "21". Each weight is made in a single piece and has machined on it the knife edge about which it pivots and a knife edge seat which works against the knife edge on the strut "27". The other knife edge on the strut works against the strut seat "29". All of these knife edges and seats are properly hardened to withstand the service to which they are subjected. Movements of the weights are transmitted to the servo-motor relay by the struts "27", strut seat "29" ball thrust bearing "31", thrust bearing housing "30", governor sleeve "32", sleeve extension "36" and lever "47".

The complete rotating element is carried in two bearings. The lower bearing "4" is inserted in the pump body "6" which is bolted to and centered in the bearing bracket. The upper bearing "20" is a combined radial and thrust bearing and is centered in and bolted to the main turbine bearing housing. The vertical position of the governor and also the clearance in this thrust bearing can be adjusted by means of the liners "16" and "26" which are provided back of the thrust collars. In addition, liners "13" are provided back of the governor gear (driver) "12" for the purpose of obtaining correct alignment of the two gears.

An oil nozzle in the governor housing directs a continuous flow of oil into the governor sleeve extension which does not rotate. Suitable drilled passages then direct the oil to all wearing parts of the governor. At any disassembly of the governor these oil passages should be inspected and cleaned if necessary.

SERVO-MOTOR

The principal parts of the servo-motor are: the relay "58" and operating piston "62". High pressure oil discharged by the main oil pump is admitted to the servo-motor relay at the point indicated in the illustration. The relay operates within a ported sleeve, which in this case is integral with the operating piston, to control the flow of high pressure oil to and from the operating cylinder. This sleeve (or piston) is a sliding fit in the cylinder "65" and cover "61". The spring "60" exerts an upward force on the relay at all times, thus causing it to follow all movements of the governor lever. With the turbine operating at normal speed, the relative positions of the relay and operating piston are such that the piston is balanced by oil pressure on top and oil pressure plus the spring compression acting against the bottom. In this position, all relay ports are practically closed and the relay is in its neutral position.

A complete cycle of operation of the governor and servo-motor is as follows:

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With the turbine at rest, the governor weights "21" are held in their innermost position by the spring "39" and "41" and since there is no oil pressure in the cylinder, the operating piston "62" is held in its upper position by the force exerted by the spring "64". When the throttle valve is opened, and the speed increases to normal, the centrifugal force of the governor weights exceeds the force of the governor springs and the weights begin to move outward, establishing oil pressure above the piston "62" which brings the unit under control of the governor.

If the load increases, the speed decreases and the governor weights move inward. As the weights move inward, the springs "39" and "41" move the governor end of the lever "47" downward and allow the spring "60" to move the relay "58" upward. This upward movement of the relay opens ports which admit high pressure oil below the piston "62" and connect the space above to the drain. The piston, therefore, moves upward, opening the governing valve "82" sufficiently to maintain the required speed. As the operating piston moves upward, the sleeve which is integral with it moves to its neutral position with relation to the relay "58".

If the load decreases, the speed increases, and the governor parts move in the opposite directions. The governor weights then move outward, compressing the governor springs and through the lever "47" move the relay "58" downward. This downward movement opens ports which admit high pressure oil to the space above the piston 62 and connects the space below to the drain. The piston, therefore, moves downward, thus closing the steam valve "82" sufficiently to maintain the required speed. Downward movement of the piston again returns the sleeve to its neutral position with relation to the relay.

From the above, it can be seen that following any movement of the relay, the resulting movement of the operating piston and sleeve re-establishes the neutral relation of the relay and sleeve until another change in speed occurs.

SPEED CHANGER

The knurled screw "56" serves as a hand operated speed changer, by means of which the speed can be varied while the machine is in service. This screw is threaded in the lever "47" and determines the vertical position of the relay with respect to the lever and governor parts. Screwing "56" downward lowers the relay, thus giving a lower speed. Screwing "56" upward raises the relay, thus giving a higher speed.

GOVERNING VALVE

The steam chest "83" which encloses the governing valve is located to one side of the governor and is bolted and dowelled to the cylinder base.

The governing valve "82" is of the double seated, balanced, poppet type and operates within the cage "84". The valve is pinned to the stem "80" which is guided by the cage at the inner end and by the bushing "78" at the outer end. The stem is connected to the operating piston by the bell crank and linkage, items 72-77, incl. the purpose of which is obvious.

The bushing "78" serves also to reduce to a minimum the leakage of steam along the stem. The leak-off should be connected to a point at atmospheric pressure where a small amount of escaping steam is not objectionable. No other form of stem packing is used and excessive leakage should be corrected by installing a new bushing.

The surface of the valve stem must be kept smooth and free of galled spots, paint or dirt. Any binding or sticking of the stem will cause unstable governor action.

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It will be noted that the valve and seats form line contacts and not surface contacts. Therefore, this valve cannot be "ground-in" to stop leakage. A test to determine whether or not the valve is leaking too badly for use may be applied as follows:

- (a) With the turbine operating at no load, bar upward on the governor end of the lever "47" to hold the governing valve on its seat.
- (b) If the steam leakage is sufficient to keep the turbine rotating, it is evident that the valve is leaking too badly for practical use.

If it should be necessary to re-seat the valve, the inner disc must be faced off maintaining a 90° angle, and the bevel on the outer disc faced off the same amount. The seats in the cage must be bored in the same manner, maintaining a 90° angle on the outer seat and a bevel on the inner seat. If this is not done accurately, the areas of the valve discs will be changed, thus throwing the valve out of balance which will undoubtedly cause "hunting" of the governor. It is difficult to do this work without proper facilities and, since the parts are relatively inexpensive, it is recommended that new parts be obtained from the factory when such repairs are necessary. From the above it will be obvious that the cage and valve should be ordered and replaced together because these parts are made in sets and are not furnished separately.

When removing the cage, the steam chest should be heated by turning steam into it, and the cage cooled by ice or wet rags (preferably ice). The cage can then be pulled out of the steam chest. Likewise, the steam chest should be heated when installing the cage in order to avoid galling the press fit.

Disassembly, Assembly, and Adjustment

The governor is thoroughly tested and adjusted at the factory and should operate satisfactorily as received. However, when reassembling the parts after an inspection or if it should become necessary to check the accuracy of the adjustment, the following points should be noted:

To Disassemble Governor

1. Remove the governor lever. This is accomplished by removing the pin "52" and the crosshead plug "48" and nut "49".
2. Remove the housing "38", lifting it straight upward until it clears the extension "36".
3. Remove the screws in the bearing "20".
4. Since the spindle "9" is connected to the pump gear "3" by a spline fit, the entire rotating element can now be lifted straight up and out.
5. Loosen the set screw and remove the sleeve "32". Mark the nut "44" and the shaft, and count the number of threads exposed so the nut can be tightened to the same point when reassembled.
6. Remove the nut "44". The springs are then relieved of all tension and the remaining parts can easily be taken off the end of the shaft. The weights, struts and hub should be marked so they can always be assembled in their original positions.

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Note: In rare instances it may be necessary to remove the strut seat and retainer "25" and "29". In order to do this the stop screws (one of which is shown in broken lines in the illustration) must first be removed.

To Assemble Governor (Do this in vertical position to facilitate operations)

7. If the strut seat and retainer have been removed, install it together with the stop screws.
8. Assemble on the end of the shaft in the following order: the bearing housing "30", the bearing "31" the sleeve "35" the bearing retaining ring "33" and the spring seat "37".
9. Then assemble the spring or springs.
10. Install the struts "27", place the weights "21" in position and push downward on the springs and start the nut "44".

Note: To see if these parts operate properly, press downward on the governor springs and at the same time pull one weight outward. Release the weight suddenly, still maintaining pressure on the spring. If the weight snaps back freely, it is correct. If a rub occurs, it can be felt. Repeat this test for the other weight, and then for both weights.

11. Tighten the nut "44" the same amount as originally found.
12. Install the sleeve "32" and lock it with the set screws.
13. Install the complete governor assembly on the machine. Then install the housing "38" and lever "47". It is important to reassemble the governor lever fulcrum pin "52" in the same hole as found originally in order to maintain the same regulation. Changing the fulcrum pin so as to increase the governor weight movement per unit of relay movement will increase the regulation, and vice versa.

Adjustment of Governor Gears and Bearings

14. The gears "12" and "14" are lapped together in the finishing process, and three mating teeth are punch marked. When reassembling the governor, it is important to see that the single marked tooth on one gear is meshed between the two marked teeth on the other gear (an access hole is provided in the housing through which these marks can be observed).
15. Adjust the thickness of liners "26" back of the upper collar "24" and liners "16" to bring the gears "12" and "14" into correct alignment. This alignment is correct when the ends of the teeth (at point "Y") are flush and with 3 to 5 mils backlash in the gear teeth).
16. Adjust the bearing clearance by adding or removing liners "16" back of the lower collar "17" to obtain 3 to 5 mils vertical clearance in the governor spindle thrust bearing; the radial clearance of this bearing also should be between 3 and 5 mils on the diameter.

Adjustment of Governing Valve

The valve travel (or lift) is very important and is set accurately at the factory when the turbine is tested. Therefore, it is recommended that the travel (or lift) be checked on each new machine when first received,

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and this travel recorded in a permanent record. Then at any future time, the travel can be checked against the original setting.

In order to check the travel, proceed as follows:

17. With the turbine at rest, bar upward on the governor end of the lever "47" to hold the valve "87" on its seat. Then measure the distance which the operating piston sleeve "62" protrudes beyond the plate of the cover "61" (distance "P").
18. With the turbine at rest, but this time without barring the governor lever, again measure the distance which the sleeve "62" protrudes beyond the cover plate.
19. The difference between the two measurements "P" gives the valve travel (or lift) and is the figure to be recorded.

Note: It is advisable to go through the checking process a second time to insure a correct reading.

Adjustment of Governor

20. Set the speed changer in its mid-position, that is, with equal travel in either direction.
21. Bring the turbine up to speed slowly, under control of the throttle valve and note the speed maintained when under control of the governor. The no load speed should be approximately 4% above normal full load speed.
22. If the speed is not correct, change the compression on the springs "39" and "41". This can be done by means of the adjusting nut "44".

TO INCREASE THE SPEED SCREW THE NUT DOWNWARD.

TO DECREASE THE SPEED SCREW THE NUT UPWARD.

One complete turn of the nut will change the speed approximately 10%. It is not advisable to give this nut more than one complete turn at a time without first observing the results.

OIL PUMP

The oil pump shown in the illustration is of the spur gear type and is driven from the lower end of the governor spindle "9". It supplies oil for lubrication purposes and for operating the governing valve servomotor. A priming opening is provided, but priming should be necessary only when starting up for the first time or when the turbine has been out of service for a long period.

The following list has been compiled to facilitate ordering spare or renewal parts by item number and name together with the serial number of the turbine.

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Item No.	Name of Part	Item No.	Name of Part
1	Oil Pump Gear - Driven	46	Governor Lever Guard
2	Oil Pump Gear - Spindle	47	Governor Lever
3	Oil Pump Gear - Driver	48	Governor Lever Crosshead Plug
4	Bushing	49	Governor Sleeve Extension Nut
5	Oil Pump Body Cover	49-A	Governor Sleeve Extension Washer and Lock Washer
6	Oil Pump Body	50	Governor Lever Crosshead
7	Oil Pump Body Dowel	51	Governor Lever Crosshead Ring (upper)
8	Bearing Bracket - Thrust End	51-A	Governor Lever Crosshead Ring (lower)
9	Governor Shaft	52	Governor Lever Fulcrum Pin
10	Lock Washer	53	Governor Lever Fulcrum Bracket
11	Turbine Shaft Nut	54	Governor Lever Fulcrum Bracket Dowel
12	Governor Gear - Driver	55	Governor Lever Fulcrum Bracket Stud
13	Governor Gear Adjusting Liners	56	Speed Changer Adjusting Screw
14	Governor Gear - Driven	57	Speed Changer Adjusting Screw Spring
15	Pin	58	Governor Relay
16	Thrust Collar Liners	59	Relay Stabilizing Spring Collar
17	Thrust Collar - Lower	60	Relay Stabilizing Spring
18	Governor Driving Gear	61	Operating Cylinder Cover
19	Oil Spray Fitting	62	Operating Piston and Sleeve
20	Governor Weight	63	Operating Piston Ring
21	Knife-Edge Block	64	Operating Piston Spring
22	Thrust Bearing	65	Operating Cylinder
23	Governor Weight	66	Governor Valve Stem Coupling
24	Bearing Bracket Cover	67	Operating Cylinder Cover (lower)
25	Governor Hub Nut	68	Governing Valve Stem Coupling Nut
26	Thrust Collar - Upper	69	Governing Valve Stem Actuating Rod
27	Governor Weight	70	Steam Chest Cover Bracket Bushing
28	Strut Retainer	71	Steam Chest Cover and Linkage Bracket
29	Thrust Collar Liners	72	Actuating Rod Adjusting Nut
30	Governor Weight Strut	73	Bell-Crank Lever
31	Governor Hub	74	Bell-Crank Lever Fulcrum Pin Bushing
32	Governor Weight Strut Seat	75	Bell-Crank Lever Fulcrum Pin
33	Governor Ball	76	Valve Stem Balance Spring Retainer
34	Bearing Housing	77	Valve Stem Balance Spring
35	Governor Ball Bearing	78	Steam Chest Cover Bushing
36	Governor Sleeve	79	Valve Cage Stop Pin
37	Governor Ball Bearing Retaining Ring	80	Steam Chest Valve Stem
38	Governor Sleeve Oil Thrower	81	Steam Chest Valve Pin
39	Governor Ball Bearing Retainer Sleeve	82	Steam Chest Valve
40	Governor Sleeve Extension	83	Steam Chest Body
41	Governor Spring Seat	84	Steam Chest Valve Cage
42	Governor Spring		
43	Governor Spring Adjusting Nut Set Screw		
44	Governor Sleeve Extension Set Screw		
45	Governor Spring Adjusting Nut		
	Governor Sleeve Extension Screen		

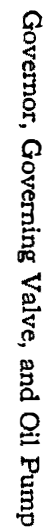


Figure 1