Auto-Stop and Main Governor

In order to simplify the description, it can be divided conveniently into two parts, each of which has a definite function. These parts are:

(1) Automatic stop governor or overspeed trip which automatically shuts down the turbine if, for any reason the speed increases to approximately 10% above normal.
(2) The main governor, linkage and valve, which, under normal operating conditions controls the speed (or load) on the turbine.

AUTO STOP GOVERNOR

The automatic stop governor or overspeed trip consists of a plunger (or weight "5") which is set in the governor hub "11", perpendicular to the rotor axis. This weight is placed with its center of gravity slightly off-set so that the centrifugal force exerts an unbalanced force tending to throw it outward, but normally, it is held in its inner position by the compression spring "1" and retainer "4".

If the speed increases to the tripping point (approximately 10% above normal) the centrifugal force of the weight "5" overcomes the compression of the spring "1" and the weight flies outward and strikes the trip lever "6". Movement of this lever disengages the latch plates "7" and "8". When the rod latchplate "8" is released by the trip lever plate "7", the compression spring "36" slides the rod "9" inward and closes the governor valve "62", thus shutting off the flow of steam to the turbine.

This trip must be reset by hand when the weight "5" returns to the inner position, which occurs when the speed returns to normal (or slightly below.) The mechanism can then be reset by pushing inward on the resetting lever (not shown in the Figure) which extends outward in a horizontal direction and which moves the coupling "37", until the trip lever plate "7" re-engages the latch plate "8" so as to hold the rod "9" in its running position.

A turbine should be overspeeded occasionally to check the speed at which the weight flies out and disengages the trip rod latch plate. When the driven apparatus to which the turbine is connected, is such that the load cannot be removed it may be found difficult (or even impossible) to increase the speed to 10% above normal. In such cases it is advisable to disconnect the driven apparatus when running the overspeed test. In order to increase the speed, gradually pull outward on the lower end of the lever "31" and at the same time push inward on the governor end cover "26". The speed should be watched carefully so that it does not go more than 10% above normal operating speed.

The trip lever "6" projects outward through the housing and forms a convenient "trip finger" by means of which the mechanism can be tripped by hand. By striking the lever (or trip finger), the trip rod latch is released and the governor valve closes instantly.

Adjustment

In order to increase the tripping speed, insert thin liners or washers "2" (.005 or .010 inch thick) between the spring retainer "4" and the end of the spring "1" so as to increase the spring compression.

In order to decrease the tripping speed, remove liners from between the retainer and the spring. In case there are no liners, grind the end of the spring squarely, just enough to obtain the desired decrease in compression.

When making these adjustments, it is important to place the liners between the retainer and the spring and not between the spring and the collar on the end of the weight. Before making any changes in the liners, the weight should be examined to see that it works freely in the housing and is not stuck by dirt or excessive wear. The linkage pins should receive a few drops of oil occasionally to prevent rust and consequent sticking.

GOVERNOR AND LINKAGE

The governor is of the horizontal, centrifugal type, in which the centrifugal force of the weights is opposed by the compression force of the governor springs. This same principal has been used for many years but the detail construction of the governor differs materially from the older types.

Referring to Figure 2, the governor hub "11" is a tight fit on the rotor shaft and is further secured to the shaft by the auto stop governor weight retainer "4". This hub carries the weight fulcrum blocks "12" which support the governor weights. Each weight "13" 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 of the strut "14". The other knife edge of the strut "14" works against the strut seat "15". All of these knife edges and seats are properly hardened to withstand the service to which they are subjected.

With the machine at rest, the governor weights are held in their inner position by the force exerted by the compression springs "21" and "22". These springs are secured to the shaft at the outer end and exert a force which is transmitted to the toe of each governor weight through the spring seat "20", the bearing retainer sleeve "19", the inner race of the ball bearing "17", the strut seat "15" and the struts "14".

As the speed of the turbine increases, the governor weights move outward due to the increased centrifugal force and, being fulcrumed on the blocks "12", this movement compresses the governor springs and moves the ball bearing "17" outward. As the speed decreases, the spring force moves the ball bearing "17" and adjacent parts inward with the weights moving inward a corresponding amount. Therefore, the axial position of the ball bearing "17" varies with the speed. In order to transmit this governor movement to the governor valve which controls the steam inlet, the sleeve "25" is threaded in the bearing housing "16" so as to clamp the outer race of the ball bearing. The outer end of the sleeve is connected to the governor lever by the pin "29", thus completing the linkage. The ball bearing carries any thrust which may be exerted by the steam valve and transmits the governor movement with a minimum of friction. The governor lever is fulcrumed so that outward movement of the governor weights closes the steam valve while inward movement of the weights opens the steam valve.

Lubrication

The governor ball bearing "17" is lubricated by oil placed in the sleeve "25". The end cap "26" should be removed and the housing filled up to the level at which it overflows past the inner ring which holds the end cap snap spring. A good grade of turbine oil should be used. Periodically (say once a week or once a month, depending upon the nature of the service) the oil level should be checked and more oil added if the level is below the overflow point.

To Dismantle Governor

1. Remove the pins "29" and "33" (note that the spacer "28" is loose and will fall out when the pin "29" is removed). Pull the upper end of lever "31" outward to allow the removal of governor cover "24".
2. Remove the bearing and governor cover "24".
3. Loosen the set screw which will allow sleeve "25" to be unscrewed.
4. Mark the nut "23" and the shaft, and count the number of threads exposed so the nut can be tightened to the same point when re-assembling.
5. Loosen the nut "23" until all compression on springs "21" and "22" is relieved. (Note:-In some cases the inner spring is omitted).
6. As the springs "21" and "22" become loose, lift out the governor weights "13". As soon as the weights are removed the struts "14" must be removed to insure their not being lost. These weights "13", struts "14" and the hub "11" should be marked so they can always be assembled in their original positions.
7. Take the nut "23" all the way off. Then the springs, sleeve, and bearing parts can easily be taken off the end of the shaft. Note:- In rare instances it may be necessary to remove the strut retainer "15" and if so the stop screws "34" must be removed.

To Assemble Governor

1. If the strut retainer "15" has been removed install it together with the stop screws "34".
2. Assemble on the end of the shaft in the following order:-The bearing housing "16", the bearing "17", the ring "18", and the spring seats "19" and "20".
3. Then assemble the springs "21" and "22" and start the nut "23".
4. Insert the struts "14", place the weights "13" in position and push inward on the springs to hold them. Note:-To see if these parts operate properly, press inward on the governor spring, and at the same time pull one of the weights 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.
5. Tighten the nut "23" the same amount as originally found.
6. Install the sleeve "25" and lock with set screw.
7. Install the governor lever "31".

Adjustment

Before making any change in the governor setting, be sure that the governor valve is set correctly according to instructions under "Governor Valve".

The normal speed maintained by the governor is determined by the compression on the springs "21" and "22" and can be adjusted by means of the nut "23".

To increase the speed tighten the nut "23".

To decrease the speed loosen the nut "23".

One complete turn of the nut "23" will change the speed approximately 70 rpm.

Governor Linkage

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

The motion of the governor weights is transmitted through the self-aligning ball bearing "17" to the end of the housing "25" as described above. The other end of the housing is pinned to the end of the governor lever "31" by the pin "29". The self-aligning bearing "17" accommodates the small angularity produced in the housing "25" by the rotation of the governor lever "31". The lower portion of the governor lever connects through a yoke to a spool on the adjusting screw "54" on the oil relay valve "40". The screw "54" is provided with a knurled knob "46" for adjustment. A lock nut "53" prevents the screw "54" from being turned too far and causing the turbine to overspeed. The spring "47" tends to eliminate lost motion by the constant application of force in one direction.

To take apart the governor linkage the knock-off lever "6" is blocked in its normal operating position after which the fulcrum pins can be removed.

Governor Relay

The governor relay is an arrangement through which the action of the governor is transmitted to the valve so that the actual work of moving the valve is done by means of oil pressure working in opposition to a coil spring under compression.

The relay consists of an operating cylinder "59" and cover "42" containing an operating piston "39" and guide "43" subjected on one side to oil pressure and on the other side to the pressure of a helical spring "41" under compression. The piston "39" is ported for the passage of oil and held within it by the guide "43" is the relay valve "40", which has freedom of end motion. In its inner position the relay valve "40" opens the oil ports to drain and in its outer position closes them off. The operating piston is connected to the governor valve stem "55", by the coupling "37".

When the turbine is at rest, the governor spring being stronger than the operating piston spring "41", holds the valve in the open position. When oil under pressure is admitted to the operating cylinder the oil pressure tends to overcome the resistance of the spring "41"; but since outward motion of the piston "39" relative to the relay valve "40" opens the piston ports, enough oil escapes to drain, to produce equilibrium between oil pressure and spring pressure. When, however, the turbine comes up to governing speed, the action of the governor moves the relay valve "40" in the closing direction thus opening the ports and allowing oil to escape to drain whereupon the spring pressure moves the operating piston "39" and with it the governor valve in the closing direction until the operating piston overtakes the relay plunger and closes the oil ports to re-establish equilibrium. Hence, any movement of the governor and relay valve produces a corresponding movement of the relay piston and governor valve.

Oil drains are provided to take care of any leakage at the ends of the operating cylinder.

Governor Valve

The steam chest "63" which encloses the governor valve is located below and to one side of the governor and is bolted and dowelled to the cylinder base.

The governor valve "62" is of the double seated, balanced poppet type and operates within the cage "61". The valve is pinned to the stem "55" which is guided by the cage at the inner end, and by the bushings "57" and "58" at the outer end. The stem is connected to the governor lever "31" by the yoke "37", stem "54" and spool "50", so that the valve "62" opens and closes in response to movements of the governor. The valve stem spring "47" tends to eliminate lost motion between the valve and lever by constantly exerting a force in one direction.

The bushings "57" and "58" serve also to reduce to a minimum, the leakage of steam along the stem. A leak-off connection is provided between the two bushings so any steam which does leak past the inner one can be led to a point at atmospheric pressure where a small amount of escaping steam will not be objectionable. No other form of stem packing is used and excessive leakage should be corrected by installing new bushings. Any binding or sticking of this stem will cause unstable governor action.

Valve Adjustment

The valve travel (or lift) is very important and is set correctly 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, 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 this setting, the following procedure should be followed:

1. Trip the turbine which will close the throttle valve.
2. Measure the distance between the coupling "37" and the end of the bushing "57".
3. After re-setting, slowly bring the turbine up to approximately half speed, so as to establish oil pressure under the operating piston "39", to open the valve "62" to its maximum position.
4. When approximately half speed is reached, again measure the distance between the coupling "37" and the end of the bushing "57". Subtract the first reading from this one and record for future reference. It is advisable to go through the above checking process a second time to insure the correctness of the record.

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. Leakage is excessive if upon being tripped by the overspeed governor the valve permits enough steam to enter the turbine to prevent its coming to rest without load. If it should be found necessary to re-seat the valve, the following procedure should be followed (Refer to Figure 1): Chuck the valve cage in a lathe with a compound slide rest and center the cage so that its axis runs true. Remove sufficient metal from the face "C" at an angle of 45° until a clean surface is obtained. Next remove sufficient metal from the face "k" until a clean surface is obtained. Do not increase the bore "E" because any increase in this diameter will unbalance the valve. Mount the valve between lathe centers and remove sufficient metal from the face "J" to obtain a clean surface and then machine surface "A" at an angle of 45° until all markings are removed. Do not decrease diameter "F" because any decrease in this diameter will unbalance the valve. Insert the valve in the cage and determine whether "A" makes contact with "B" and "D" with "C". Machine sufficient material off "A", if "A" and "B" are contacting; or off "C" if "C" and "D" are contacting, until "A" and "B" are in contact at the same time that "C" and "D" are in contact.

A piece of thin paper placed between the valve and seats while the valve is turned a little will help to determine where the metal is to be removed. If the above conditions are fulfilled, the valve will be balanced for pressure and give good service. Any grinding-in, however little, will cause an unbalanced condition.

When removing the valve cages the steam chest should be heated by turning steam into it and the cages cooled by ice or water (preferably ice). The cage can then easily be bumped out of the steam chest.

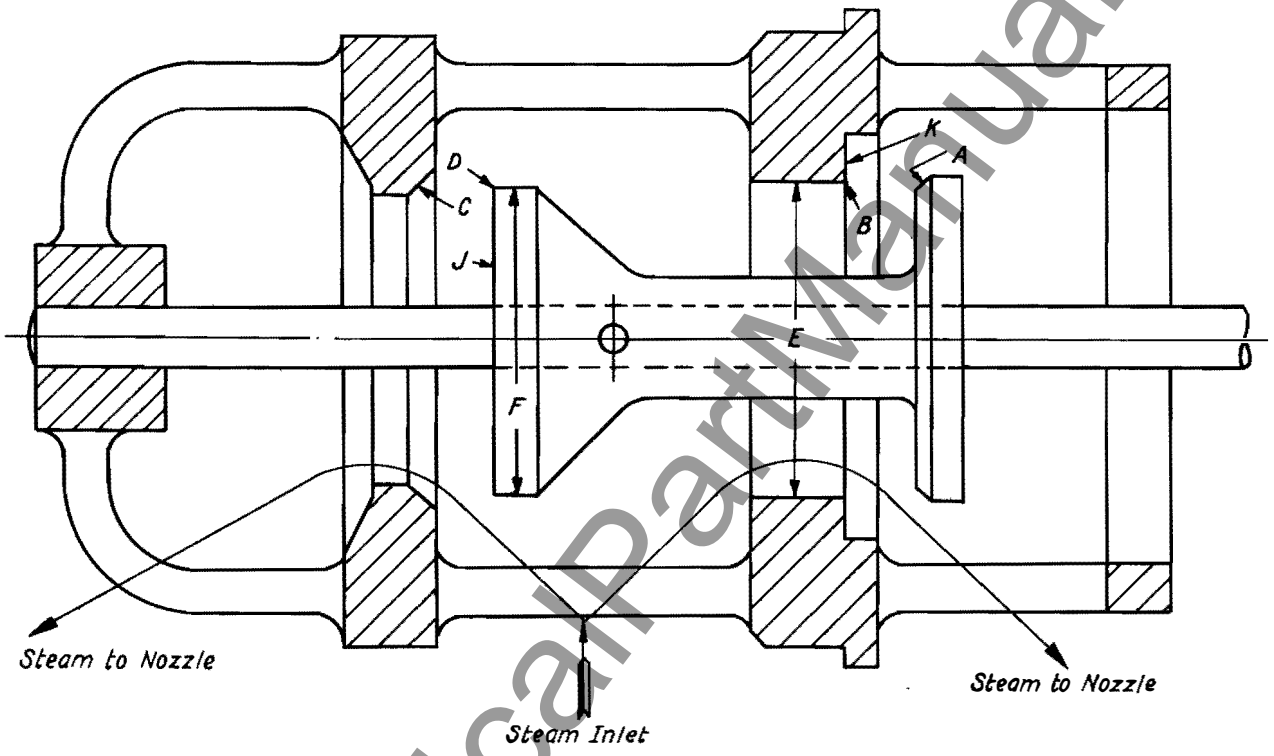

Fig. 1 - Valve and Valve Cage

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

Item No.	Name
1	Auto Stop Governor Weight Spring
2	Auto Stop Governor Weight Spring Shims
3	Auto Stop Governor Weight Spring Retainer Lockwasher
4	Auto Stop Governor Weight Spring Retainer
5	Auto Stop Governor Weight
6	Auto Stop Trip Lever
7	Auto Stop Trip Lever Latch Plate
8	Governor Lever Rod Latch Plate
9	Governor Lever Rod
10	Trip Lever Fulcrum Pin
11	Governor Hub
12	Governor Weight Fulcrum Block
13	Governor Weight

14 Governor Weight Strut
15 Governor Weight Strut Seat and Retainer (Comp.)
16 Governor Thrust Bearing Housing
17 Governor Thrust Bearing
18 Governor Thrust Bearing Retaining Ring
19 Governor Thrust Bearing Retaining Sleeve
20 Governor Spring Seat
21 Governor Spring (Outer)
22 Governor Spring (Inner)
23 Governor Spring Adjusting Nut
24 Governor Bearing Bracket Cover
25 Governor Housing
26 Governor End Cover
27 Governor Lever Fulcrum Pin Spacer
28 Governor Lever Fulcrum Pin Spacer Ring
29 Governor Lever Fulcrum Pin
30 Governor Bearing Bracket
31 Governor Lever
32 Auto Stop Governor Lever Rod Clevis
33 Auto Stop Governor Lever Rod Clevis Fulcrum Pin
34 Governor Stop Screw
35 Auto Stop Governor Lever Rod Spring Seat
36 Auto Stop Governor Lever Rod Spring
37 Valve Steam Coupling
38 Operating Piston Bushing
39 Operating Piston
40 Oil Relay Valve
41 Operating Piston Spring
42 Operating Cylinder Cover
43 Operating Piston Cover
44 Operating Piston Cover Packing
45 Operating Cylinder Cover Bushing
46 Oil Relay Stem Hand Knob
47 Oil Relay Stem Spring
48 Lock Nut
49 Resetting Lever Plate
50 Oil Relay Stem Spool
51 Oil Relay Stem Spool Washer
52 Oil Relay Stem Spool Lock Nuts
53 Valve Lever Stop Nut
54 Oil Relay Valve Stem
55 Main Valve Stem
56 Resetting Lever Spring
57 Main Valve Stem Bushing (Outer)
58 Main Valve Stem Bushing (Inner)
59 Operating Cylinder and Bracket
60 Gasket
61 Valve Cage
62 Valve
63 Steam Chest
64 Gasket

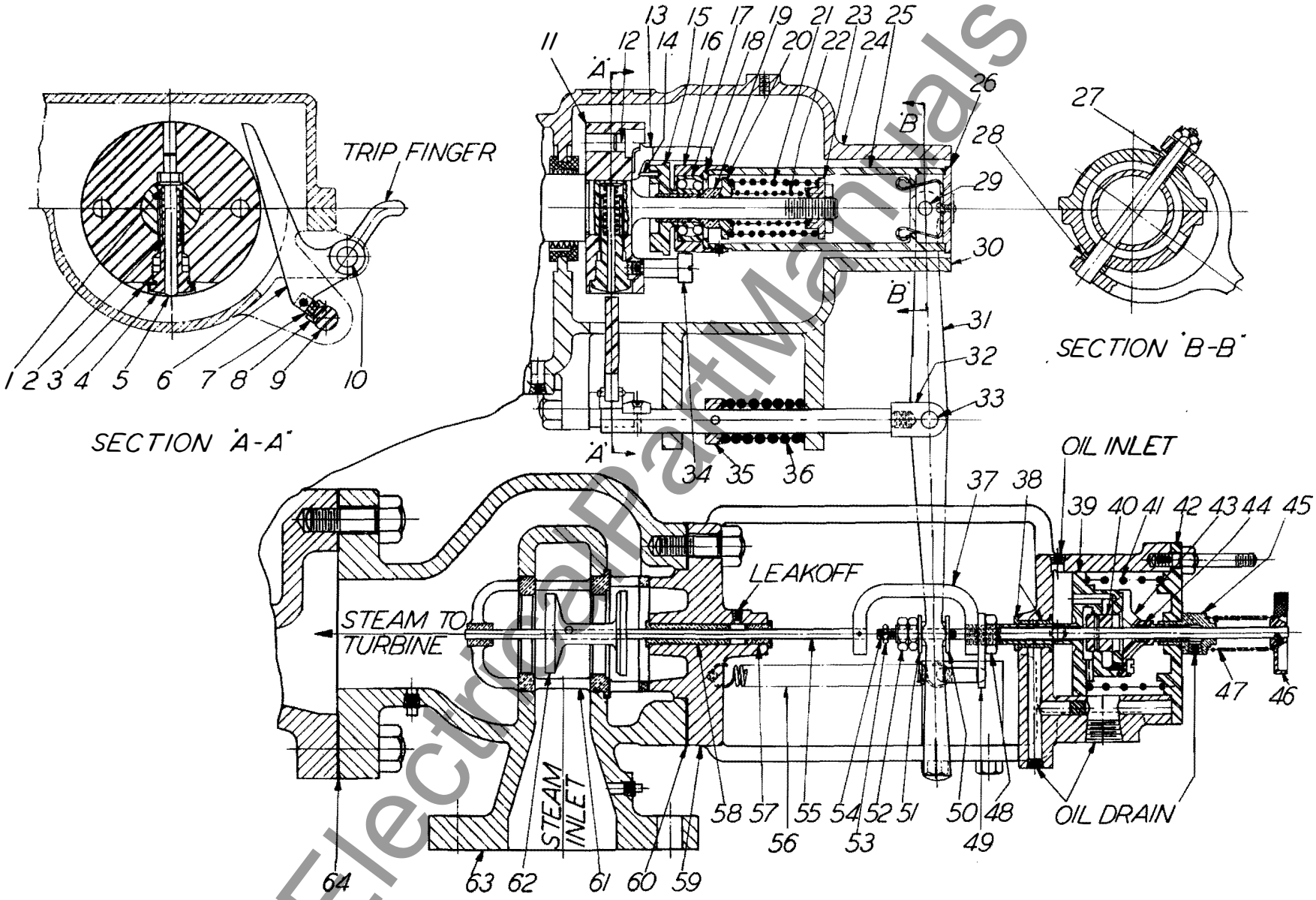

Fig. 2 - Auto Stop and Main Governor

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