Governor, Governing Valve, Automatic Stop and Oil Pump

The mechanisms listed above are closely related and all are illustrated in Figure 1. However, in order to simplify the description, the various parts are segregated as follows, and considered separately:

(1) The main governor, governing valve and linkage (shown in the main view) which controls the speed (or load) of the turbine.
(2) The automatic stop governor (or emergency overspeed trip) which automatically shuts down the turbine if, for any reason, the speed increases to approximately 10% above normal.
(3) The oil pump which supplies the oil for lubrication of all revolving parts and for operating the governing valve.

GOVERNOR

Figure 1 shows the governor, which is of the vertical shaft, fly ball type, in which the revolving weights "51" move in response to changes in centrifugal force resulting from changes in speed. Movements of these weights are transmitted by suitable linkage to a relay "41" which controls the flow of high pressure oil to and from the operating cylinder "28". Movements of the operating piston "37" are transmitted to the governing valve "23" directly. The oil required to operate the valve operating piston "37" is supplied by the main oil pump and is led to the high pressure oil inlet chamber of the relay through an external pipe.

The governor case "75" which holds the weights "51" is driven from the end of the turbine rotor shaft by the bevel gears "1" and "11". The weights "51" are fulcrumed on the ball bearings "52" and pins "53". Their movement is transmitted to the relay "41" by the lower spring seat "73", rod "76" and lever "44" and is opposed by the spring "74". Hence, with the governor at rest, the spring "74" holds the governor weights in their innermost position and allows the relay "41" to be moved to its uppermost position by the spring "39". The shaft "69" is carried in two bearings. The lower bearing "66" is inserted in the pump case "67" which is bolted to and centered in the bearing bracket. The upper bearing "12" (shown in Section B-B) is a combined radial and thrust bearing and is centered in and bolted to the bearing bracket. The thrust bearing clearance as given on the "Rotor Clearance" drawing can be obtained by means of the shims "19". The position of the bevel gear "11" can also be adjusted by means of the shims "19" and that of the bevel gear "1" by means of the shims "4".

The relay "41" operates within a ported sleeve which in this case is integral with the operating piston "37", 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 "28" and cylinder cover "38". The spring "39" exerts an upward force on the relay at all times thus causing it to follow all movements of the governor lever "44".

The operation of the governor is as follows: With the turbine at rest, the governor weights "51" are held in their innermost position by the spring "74" and since there is no oil pressure in the cylinder, the governing valve "23" is held in its full open position by the force exerted by the spring "34" on the piston "37". As soon as the throttle valve is opened, and the speed increased to normal, the centrifugal force of the governor weights "51" exceeds the force of the governor spring "74" and the weights begin to move outward, establishing oil pressure above the piston "37" which brings the unit under control of the governor.

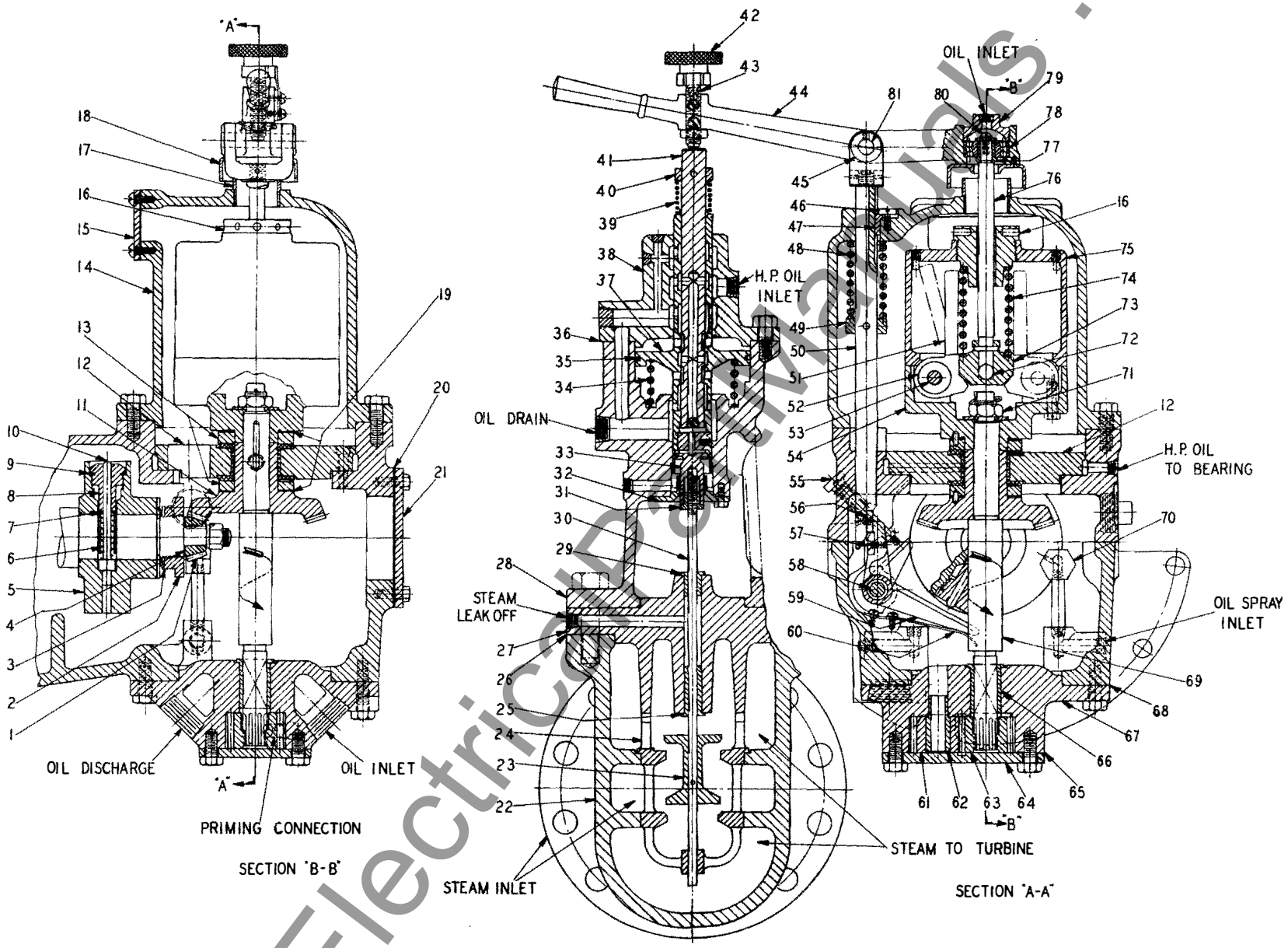

Fig. 1 - Governor, Governing Valve, Automatic Stop and Oil Pump

If the load increases, the speed decreases and the governor weights "51" move inward. As the weights move inward, the spring "74" moves the governor end of the lever "44" downward and allows the spring "39" to move the relay "41" upward. This upward movement of the relay opens ports which admit high pressure oil below the piston "37" and connect the space above to the drain. The piston then moves upward, opening the governing valve "23" 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 "41". Thus following any relay movement, the resulting movement of the operating piston and sleeve re-establishes the relative position of the relay and sleeve at neutral.

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 spring "74" and through the lever "44" move the relay "41" downward. This uncovers ports which admit high pressure oil to the space above the piston "37" and connect the space below to drain. The piston, therefore, moves downward, thus closing the steam valve "23" sufficiently to maintain the required speed.

SPEED CHANGER

The knurled screw "42" 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 "44" and determines the vertical position of the relay with respect to the lever and governor parts. Screwing the knob "42" downward lowers the relay, thus giving a lower speed. Screwing the knob "42" upward raises the relay, thus giving a higher speed.

Dis-Assembly, Assembly and Adjustment

All of the fundamental adjustments on this governor were made at the factory and under normal operation, no further adjustment should be necessary. However, if it should become necessary to dis-assemble the governor mechanism, the following should be noted.

The governor housing "14", pump gear case "67" and bearing "12" are centered in and bolted to the bearing bracket to insure correct alignment of the rotating parts.

To dis-assemble the governor:

1. Remove the governor lever. This can be done by removing the pin "81", the plug "79" and the screw "80".
2. Remove the housing "14", lifting it straight up until it clears the rod "76".
3. Remove the screws in the bearing "12".
4. Since the shaft "69" is connected to the pump gear "63" by a spline fit, the entire rotating element including the bearing "12" can now be lifted straight up and out.

NOTE: Assembly is in the reverse order but certain points should be watched which are listed as follows:-

1. In assembling the housing "14" the hand trip plunger "55" should be held inward to allow the trip rod latch plate "56" to seat properly, releasing the plunger as soon as the housing is in place.
2. A single tooth on one of the bevel gears and two adjacent teeth on the other bevel gear are punch marked. The single marked tooth must be assembled between the two marked teeth on the other gear. It is important that they be assembled in this position because these gears are "lapped in", in the machining process.

To adjust the governor, proceed as follows:

1. Set the speed changer screw "42" in its mid-position; that is, with equal travel in either direction.
2. 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.
3. If the speed is not correct, change the compression on the spring "74". This can be done by means of the adjusting nut, "16".

NOTE: To gain access to the spring adjusting nut "16", remove the rectangular plate "15" on the side of the governor housing.

TO INCREASE THE SPEED SCREW THE NUT INWARD

TO DECREASE THE SPEED SCREW THE NUT OUTWARD

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.

Governing Valve

The steam chest "22" which encloses the governing valve is located to one side of the governor and is bolted and dowelled to the cylinder base.

The governor valve "23" is of the double seated, balanced, poppet type and operates within the cage "24". The valve is pinned to the stem "30" which is guided by the cage at the lower end and by the bushings "25" and "29" at the upper end. The stem is connected to the operating piston by the nut "31" and coupling "33".

The bushings "25" and "29" 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 that any steam which does leak past the lower one can be led 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 new bushings. In installing these bushings they should be pressed into the cover and reamed in place. The surface of the stem must be kept smooth and free of galled spots, paint, rust or dirt. Any binding or sticking of the 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 the setting, proceed as follows:

1. With the turbine at rest, trip the auto stop governor by hand which will cause the spring "48" to close the governing valve "23".
2. Measure the distance from the upper end of the sleeve "37" to the top of the cylinder cover "38".
3. Bring the turbine up to approximately half speed with no load which will cause the governing valve to open wide.

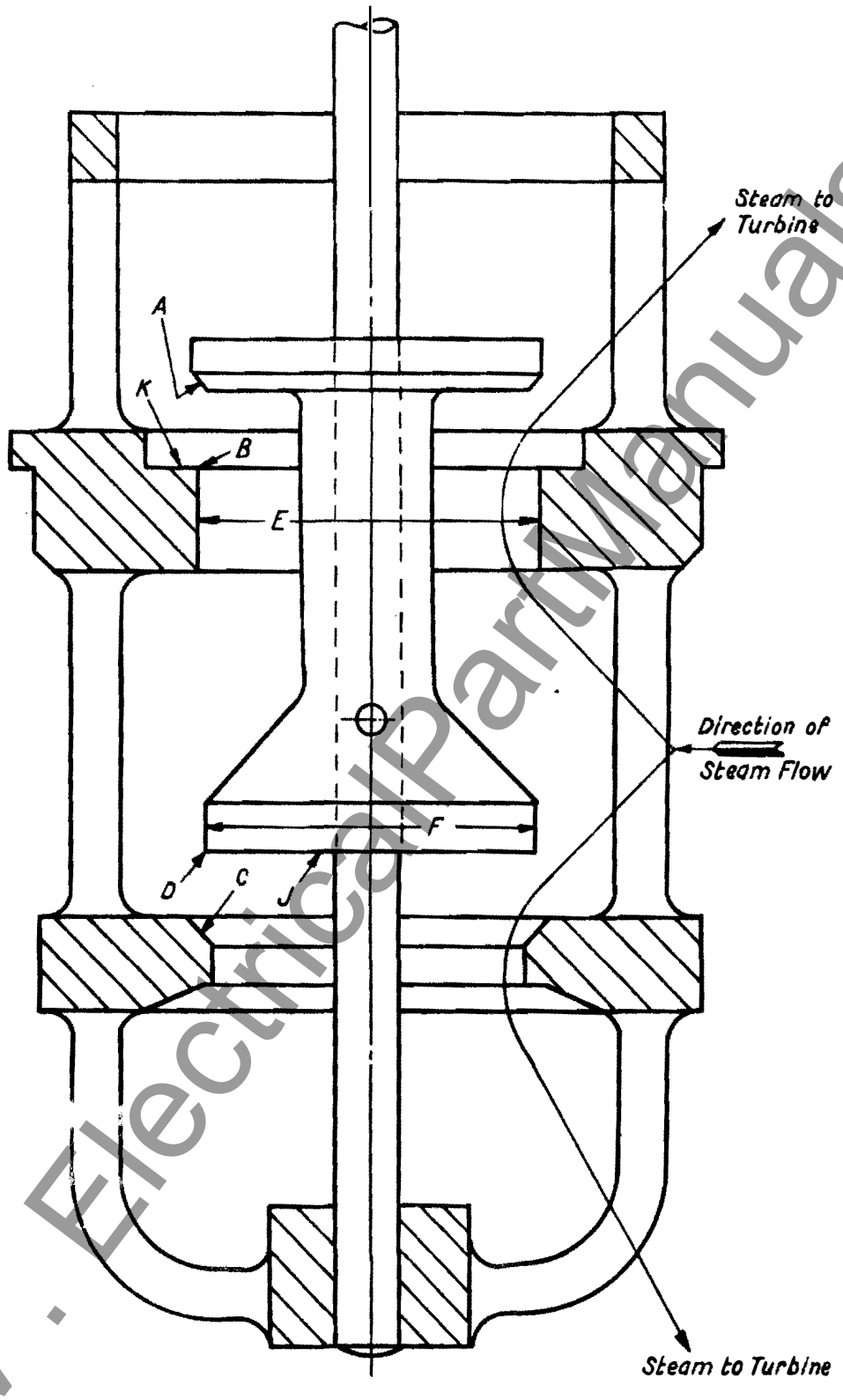

Fig. 2 - Governing Valve

4. Again measure the distance from the upper end of the sleeve "37" to the top of the cylinder cover "38". The difference between the two measurements is the valve travel which should be recorded 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 keep it rolling without load. If it should be necessary to re-seat the valve, proceed as follows: (Refer to Figure 2). 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 the surface "A" at an angle of 45° until all markings are removed. Do not decrease the diameter "F" because any decrease in the 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 metal 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 should 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 cage, the steam chest should be heated by turning steam into it and the cage cooled by ice or water (preferably ice). The cage can then be pulled out of the steam chest.

AUTOMATIC STOP

The automatic stop governor, commonly called the emergency overspeed trip, consists of a plunger (or weight) "10" which is set in the governor hub "5", perpendicularly to the rotor axis. This weight is placed with its center of gravity slightly off-set so that the centrifugal force tends to throw it outward, but normally, it is held in its inner position by the compression spring "6" and the retainer "8".

If the speed increases to the tripping point (approximately 10% above normal) the centrifugal force of the weight "10" overcomes the compression of the spring "6" and the weight flies outward and strikes the trip lever "59". Movement of this lever disengages the latch plates "56" and "57". When the rod latch plate "56" is released by the trip lever plate "57", the compression spring "48" moves the rod "50" downward, which, acting through the lever "44", closes the governing valve "23", thus shutting off the flow of steam to the turbine.

When the tripping mechanism has operated, it must be reset by hand. The re-setting is accomplished by pulling upward on the handle of the lever "44" until the rod latch plate "56" again engages the trip lever plate "57" so as to hold the rod "50" in its running position. This, of course, cannot be done until the turbine speed has decreased below normal sufficiently to allow the weight to return to its normal position.

A turbine should be overspeeded occasionally to check the speed at which the weight flies out and disengages the trip rod latch plate "56". 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 up on the handle of the lever "44" and watch the speed carefully so that it does not increase to more than 10% above normal operating speed.

A hand trip plunger "55" projects outward through the housing, by means of which, the mechanism can be tripped by hand. By striking the end of this plunger "55" the trip rod latch plate "56" is released and the governing valve closes instantly.

Adjustment

The speed at which the automatic stop functions can be varied by changing the compression of the spring "6". The liners "7" between the spring and retainer are provided for this purpose.

In order to increase the tripping speed, insert thin liners or washers "7" (.005 to .010 thick) between the spring retainer "8" and the end of the spring "6" so as to increase the spring compression.

In order to decrease the tripping speed, remove liners from between the retainer "8" and the end of the spring "6". 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 if it works freely in the hub 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.

OIL PUMP

The oil pump shown in the illustration is of the spur gear type and is driven by the lower end of the governor shaft "69". It supplies oil for lubricating purposes and for operating the governing valve. A priming opening is provided as shown, 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 pump "Inlet" and "Discharge" openings are shown for counter-clockwise rotation of the turbine. When the rotation of the turbine is clockwise the connections are reversed and the "Inlet" as shown becomes the "Discharge" and the "Discharge" as shown becomes the "Inlet". The position of the oil spray tube "70" also changes to the same relative position on the opposite side of the vertical centerline.

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	Bevel Gear and Key (Driver)
2	Auto Stop Hub Nut
3	Auto Stop Governor Hub Nut Lockwasher
4	Bevel Gear Adjusting Shims
5	Auto Stop Governor Hub
6	Auto Stop Governor Spring
7	Auto Stop Governor Spring Shims
8	Auto Stop Governor Spring Retainer
9	Auto Stop Governor Spring Retainer Lockwasher
10	Auto Stop Governor Weight
11	Bevel Gear (Driven)
12	Governor Bearing and Thrust Bearing
13	Governor Thrust Bearing Collar
14	Governor Housing
15	Governor Spring Adjusting Cover
16	Governor Spring Adjusting Nut
17	Governor Housing Bushing
18	Governor Lever Guard
19	Governor Bearing Shims
20	Gasket
21	Bearing Bracket End Cover
22	Steam Chest
23	Governing Valve
24	Governing Valve Cage
25	Governing Valve Stem Bushing (lower)
26	Gasket
27	Steam Chest Cover
28	Operating Cylinder and Support
29	Governing Valve Stem Bushing (upper)
30	Governing Valve Stem
31	Governing Valve Stem Coupling Nut
32	Operating Cylinder Cover (lower)
33	Governor Valve Stem Coupling
34	Operating Piston Spring
35	Operating Piston Ring
36	Gasket
37	Operating Piston and Sleeve
38	Operating Cylinder Cover
39	Relay Stabilizing Spring
40	Spring Collar
41	Governor Relay
42	Speed Changer Screw
43	Speed Changer Screw Lock Spring
44	Governor Lever
45	Governor Lever Clevis
46	Auto Stop Trip Rod Key Retaining Screw
47	Auto Stop Trip Rod Key
48	Auto Stop Trip Rod Spring
49	Auto Stop Trip Rod Spring Collar
50	Auto Stop Trip Rod
51	Governor Weight
52	Governor Weight Ball Bearing
53	Governor Weight Ball Bearing Pin
54	Governor Hub
55	Auto Stop Hand Trip Plunger (complete)
56	Auto Stop Trip Rod Latch Plate
57	Auto Stop Trip Lever Latch Plate

Item No.	Name
58	Auto Stop Trip Lever Shaft
59	Auto Stop Trip Lever
60	Auto Stop Trip Lever Spring
61	Oil Pump Gear (idler)
62	Oil Pump Idler Shaft
63	Oil Pump Gear (driver)
64	Oil Pump Housing Cover
65	Gasket
66	Governor and Pump Shaft Bearing (lower)
67	Oil Pump Housing
68	Gasket
69	Governor and Pump Shaft
70	Oil Spray Tube (complete)
71	Governor Shaft Nut
72	Governor Rod Ball Seat
73	Governor Spring Seat
74	Governor Spring
75	Governor Casing
76	Governor Rod
77	Governor Lever Ball Bearing Bushing
78	Governor Lever Ball Bearing
79	Governor Lever Ball Bearing Retaining Plug
80	Governor Lever Ball Bearing Retaining Screw
81	Governor Lever Fulcrum Pin

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