GOVERNOR

(Vertical Flyball, With Pressure Transformer)

This mechanism consists essentially of three parts, each of which has a definite function. These parts are:

(1) Governor, consisting of the flyball mechanism which, due to centrifugal force, moves in response to changes in turbine speed.

(2) Pressure transformer, consisting of a cup valve operating within a ported bushing. This mechanism transforms the changes in force received from the governor weights into oil pressure changes acting on the servo motor relay.

(3) Hydraulic servo motor for operating the steam valves. This mechanism is of the conventional type of relay controlled operating piston, utilizing oil as the motive fluid.

Governor

The governor is of the vertical shaft, centrifugal type in which the centrifugal force of the weights is opposed by the compression force of the governor spring plus the oil pressure acting on top of the cup valve. The governor hub which holds the weights is driven from the end of the turbine rotor shaft by spiral bevel gears. The governor weights are secured to a strap of spring steel mounted across the diameter of a ring held by the governor hub. This spring is formed into an inverted U shape at the center and movements of the weights flex the strap thus transmitting movements through the spring seat "11" to the cup valve "25".

The upper bearing "12" 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 "14" which are provided back of the thrust collars. In addition, liners "18" are provided back of the governor gear (driver) for the purpose of obtaining correct alignment of the two gears. The lower bearing (not shown in the accompanying illustration) is located at the lower end of the governor spindle, in the oil pump case.

Pressure Transformer

The essential parts of the pressure transformer are the cup valve "25", the housing "24", and the cup valve seat "60". It is difficult to show clearly the various oil passages to and from this cup valve in the main illustration. Consequently, these parts are shown diagrammatically at the left hand side of the Figure 1.

High pressure oil enters the central chamber (or hole) of the seat "60" through a metering orifice formed on the cup valve. The cup valve seats over this central chamber and controls the flow of oil to the drain, thereby controlling the pressure maintained in the central chamber. This pressure thus maintained by the cup valve is the secondary governing pressure, denoted by "Z", and is connected to the chamber above the servo motor relay piston "35-A" to regulate the steam valve opening. Since there is a continuous flow of high pressure oil into the cup valve seat there will also be a continuous flow past the cup valve to the drain in order to maintain equilibrium.

From the above, it is evident that upward movement of the cup valve decreases the flow to the drain, thereby increasing the secondary governing pressure "Z". Conversely, downward movement of the cup valve increases the

flow to the drain, thus decreasing the pressure "Z". As described before, the position of the cup valve is determined by the position of the governor weights. Therefore, movements of the cup valve, and hence the secondary governing pressure "Z" respond to changes in turbine speed. In following the operation of this mechanism, it is important to bear in mind that the pressure "Z" exerts a downward force on the cup valve at all times, and any change in this pressure results in a change in the force acting downward on the cup valve.

In normal operation, the cup valve is balanced by the force exerted by the governor weights acting in an upward direction and the force exerted by the secondary governing pressure "Z" on top of the cup valve plus the governor spring acting in a downward direction.

In normal operation, this governor will have the customary regulation (or frequency change) between no load and full load. However, by opening the needle valve this regulation can be reduced to a small figure and the governor made practically isochronous. By connecting the passage at the top of the cup valve to the chamber at the bottom, the effect of the secondary governing pressure upon the cup valve is neutralized, and the secondary governing pressures required for various loads are balanced by the same predetermined speed of the turbine. This is accomplished by admitting pressure "Z" through the needle valve and air bell to the bottom of the cup valve.

In order to maintain stability of operation, the change in pressure "Z" cannot be applied below the cup valve immediately, a certain time lag being essential. This time lag is obtained by an air bell and needle valve. The function of this time lag is to allow the normal speed change, due to load change, to move the governing valve to its proper position first, and then by slowly applying the change in pressure "Z" below the cup valve, the position of the governing valve is further changed until the same speed which existed before the load change is re-established.

Opening the needle valve renders the governor isochronous. Closing the valve causes the governor to operate with its normal regulation characteristics. When changing over from one type of operation to the other, the needle valve should be moved slowly a part of its travel, and then, to compensate for the change in speed, correct it with the speed changer. Repeat this operation in relatively small steps, until the needle valve is adjusted to give the desired regulation.

Servo Motor

The principal parts of the servo motor used to operate the governing valves are the operating piston "56", the relay "33", and the servo motor relay piston "35-A". The governor lever is fulcrumed so that downward movement of the operating piston opens the steam inlet valves and upward movement closes them. The upper land on this relay controls ports which admit high pressure oil to the space above the operating piston, the lower land controls ports which admit high pressure oil to the chamber below the piston, and the central land controls ports which connect either side of the operating piston to the drain. Consequently, upward movement of this relay causes the operating piston to move downward, while downward movement of the relay causes the piston to move upward. In normal operation, this relay is balanced in its neutral position by the force of the compression spring "30", plus the force of the tension spring "41" acting in an upward direction and the force exerted by the secondary governing pressure "Z" above the servo motor relay piston (plus the force of the compression spring "41-A" when the turbine is an extraction type) acting in a downward direction. Note: For certain applications the compression spring "41-A" is not required and is omitted together with the spring seat "38-A".

Following any movement of this servo motor relay, the operating piston moves in the opposite direction. The follow-up lever "48", which connects the operating piston rod and the servo motor relay spring "41", is fulcrumed so that following any relay movement, the resulting piston movement changes the tension in spring "41", so as to return the relay to its neutral position until another change in speed (or load) occurs.

On those turbines which do not have an auxiliary oil pump, a spring "55" is provided above the operating piston to hold it in its lower position which in turn holds the governing valves open during the starting period. This spring holds the valves open until the speed increases to the point where the governor takes control.

Operation

Briefly, a complete cycle of this control is as follows: If the load decreases, the turbine speed increases and the increased centrifugal force of the governor weights moves the spring seat and cup valve upward. Upward movement of this cup valve increases the secondary governing pressure "Z", until the increased oil pressure acting on top of the cup valve is sufficient to balance the increased centrifugal force of the governor weights.

The increased pressure "Z" thus established by the cup valve has, at the same time, increased the downward force on the servo motor relay piston. Downward movement of this relay piston moves the servo motor relay downward, thus admitting high pressure oil below the operating piston, which moves the piston upward and closes the governing valves. The upward movement of the operating piston, acting through the follow-up lever, increases the tension in spring "41" until the increased pressure "Z" acting above the relay piston is balanced and the servo motor relay again returns to its neutral position.

If the load increases, the turbine speed decreases, and the decreased centrifugal force of the weights allows the oil pressure above the cup valve to move it downward. Downward movement of this cup valve decreases the pressure "Z", until the decreased oil pressure acting on top of the cup valve balances the decreased force exerted by the weights.

This decreased secondary governing pressure "Z" thus established by the cup valve has at the same time, decreased the downward force on the servo motor relay piston, thus allowing the servo motor relay spring "30" to move the relay upward. Upward movement of this relay admits high pressure oil above the operating piston, thus moving the piston downward and opening the governing valves. Downward movement of the operating piston, acting through the follow-up lever, decreases the tension in the spring "41" sufficiently to compensate for the decreased pressure acting above the relay piston, thus allowing the relay to return to its neutral position again.

Speed Changer

The hand or motor operated speed changer, by means of which the speed (or load) can be varied, consists essentially of a worm wheel "2" which is threaded on the transformer cup valve housing and acts directly on the governor spring. This worm wheel forms the upper support for the governor spring and consequently downward movement of the worm wheel on its threads increases the governor spring compression and thereby increases the turbine speed. Conversely, upward movement of the worm wheel on its threads decreases the compression of the governor spring and decreases the turbine speed. A suitable mechanism is provided by means of which this worm wheel can be operated either by hand or by motor. The hand operated mechanism is shown in Section "C-C". The hand wheel "68" is connected directly to the worm "1", which meshes with the worm wheel "2". The motor driven worm "62" meshes with the sleeve "75"

and drives through this sleeve, the collar "70" and the hand wheel "68" to the second worm "1" and worm wheel "2". The faces of the hand wheel "68" and the collar "70" with the plate "69" form a friction type clutch which is held in engagement by the spring "76". This clutch slips when the hand operated feature is used.

Pressure Regulators

When pressure regulators, such as exhaust and pump pressure, are used in conjunction with this governor, the regulators are of the hydraulic type and are connected to the chamber below the servo motor relay piston as indicated on the illustration. Consequently, changes in pressure delivered by the regulators act on the servo motor relay in the same manner as the secondary governing pressure delivered by the transformer to change the governing valve opening, and hence, the speed (or load) of the turbine.

Adjustments of Governor

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

(1) The bevel gears "15" and "17" are lapped together in the finishing process, and three mating teeth are marked. When re-assembling 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.)

(2) Adjust the thickness of liners "14" back of the upper collar "13" and liners "18" to bring the bevel gears "15" and "17" into correct alignment. This alignment is correct when the ends of the teeth (at point Y) are flush with 3 to 5 mils backlash in the gear teeth.

(3) Adjust the thickness of liners "14" back of the lower collar "13" 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.

(4) Move the speed changer to its low speed limit of travel. This will relieve the compression of the governor spring "5".

(5) Remove the governor housing "58".

(6) Screw the stop screw "22" downward making sure that there is clearance between the screw and the spring seat button socket "23".

(7) In order to obtain the correct setting of the cup valve "25" check the following measurements:

Dimension "A": With cup valve "25" against its seat "60" measure the distance from the lower flange face of the governor housing "58" to the end of the cup valve stem "25". Use a steel straight edge and inside micrometers to obtain this dimension.

Dimension "B": Measure the distance from the top of the governor spring seat ball "23-A" to the top flange face of the governor pedestal. Use the same method as above for obtaining this measurement. The adjustment is correct when: Dimension "B" = Dimension "A" plus .015 (plus or minus .005). Liners are provided

below the governor hub to obtain this correct relation if a change is necessary. In the event that the cup valve stem is too long after removing all liners, grind a small amount off the end of the stem, noting that the end must be true and perpendicular to the axis.

It is important to note that no gasket is used in the joint between the governor housing "58" and the governor pedestal. A gasket at this point will cause incorrect setting of the cup valve.

The above measurements are difficult to obtain accurately without special micrometers and block gauges, and this work should not be attempted except by an experienced service engineer.

(8) Screw the stop screw "22" upward until it just touches the socket "23". Then screw it downward three quarters of a turn and lock in place. This should give a clearance of 50 mils between the stop screw and the socket.

(9) Set the governing valve lifts according to instructions given in the "Steam Chest" description.

(10) Adjust the length of the connection to the governor valve lever so that all governing valves are closed tightly when the piston "56" is 1/4 inch away from its upper limit of travel.

(11) If the mechanism is dismantled, it is important to re-assemble the follow-up lever fulcrum pin "44" in the same hole as found originally in order to maintain the same regulation. Changing the fulcrum pin so as to increase the spring (or relay) movement per unit of piston movement will increase the regulation, and vice versa.

(12) The speed changer limit stops are shown as items "28" and "29". To set the limit stops, proceed as follows:

A - Operate the turbine at no load, and maintain normal full load speed by partially closing the throttle valve.

B - Holding this speed by means of the throttle valve, turn the speed changer in "increase" direction until all governing valves are wide open. This is determined by measuring the lifts, and checking against the lifts given on the Valve-Setting Diagram. This represents the full load position.

C - Shut the machine down. Turn the worm wheel "2" one turn more in the "increase" direction and lock the limit stop in this position. The ring "26" is saw cut in the horizontal plane so that tightening the cap screws locks the stop "29" securely.

Since the upper and lower lugs on the stop "29" are a constant distance apart, the speed changer range is fixed, and no further adjustment of the lower stop is possible.

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:

Item No.	Name
1	Speed Changer Worm (Low Speed)
2	Speed Changer Worm Wheel (Low Speed)

Item No.	Name
3	Speed Changer Worm Wheel Ball Bearing
4	Governor Spring Seat (Upper)
5	Governor Spring
6	Governor Case
7	Cup Valve Stem Bushing
8	Governor Weights
9	Governor Weights Support (Complete)
10	Governor Hub Lock Nut
11	Governor Spring Seat (Lower)
12	Governor Spindle Bearing (Upper)
13	Governor Spindle Thrust Collars
14	Governor Spindle Thrust Collar Liners
15	Governor Gear (Driven)
16	Governor Spindle
17	Governor Gear (Driver)
18	Governor Gear Liners
19	Governor Hub Spacer
20	Governor Hub Spacer Liners
21	Governor Hub
22	Governor Spring Seat Button Stop Screw
23	Governor Spring Seat Button
23-A	Transformer Cup Valve Ball and Retainer Washer
24	Transformer Cup Valve Housing
25	Transformer Cup Valve
26	Speed Changer Worm Wheel Stop Lock Ring
28	Speed Changer Worm Wheel Stop Plate
29	Speed Changer Worm Wheel Stop
29-A	Gasket (1/32 Thick)
30	Servo-Motor Relay Spring
31	Servo-Motor Relay Spring Seat
32	Servo-Motor Relay Bushing
33	Servo-Motor Relay
34	Servo-Motor Relay Piston Cover
34-A	Servo-Motor Relay Piston Nut
35	Gasket (1/32 Thick)
35-A	Servo-Motor Relay Piston
36	Servo-Motor Cylinder Cover
37	Servo-Motor Relay Piston Rod
38	Servo-Motor Relay Piston Spring Nut
38-A	Servo-Motor Relay Piston Compression Spring Seat
39	Servo-Motor Relay Piston Spring Case (Inner)
39-A	Spring Compressing - Studs
40	Servo-Motor Relay Piston Spring Case (Outer)
41	Servo-Motor Relay Piston Spring
41-A	Servo-Motor Relay Piston Compression Spring
42	Servo-Motor Relay Piston Spring Adjusting Bolt
43	Servo-Motor Follow-up Lever Support
44	Servo-Motor Follow-up Lever Fulcrum Pin
45	Servo-Motor Spring Bolt Crosshead
46	Servo-Motor Spring Bolt Crosshead Ball Bearing
47	Servo-Motor Follow-up Lever Spacer Bolt
48	Servo-Motor Follow-up Lever (In Pairs)
49	Servo-Motor Follow-up Lever Pin (Upper)
50	Servo-Motor Follow-up Lever Link
50-A	Servo-Motor Follow-up Lever Link Spacer Bushing
51	Servo-Motor Follow-up Lever Link Pin (Lower)
52	Servo-Motor Piston Rod
53	Servo-Motor Piston Rod Bushing Retainer

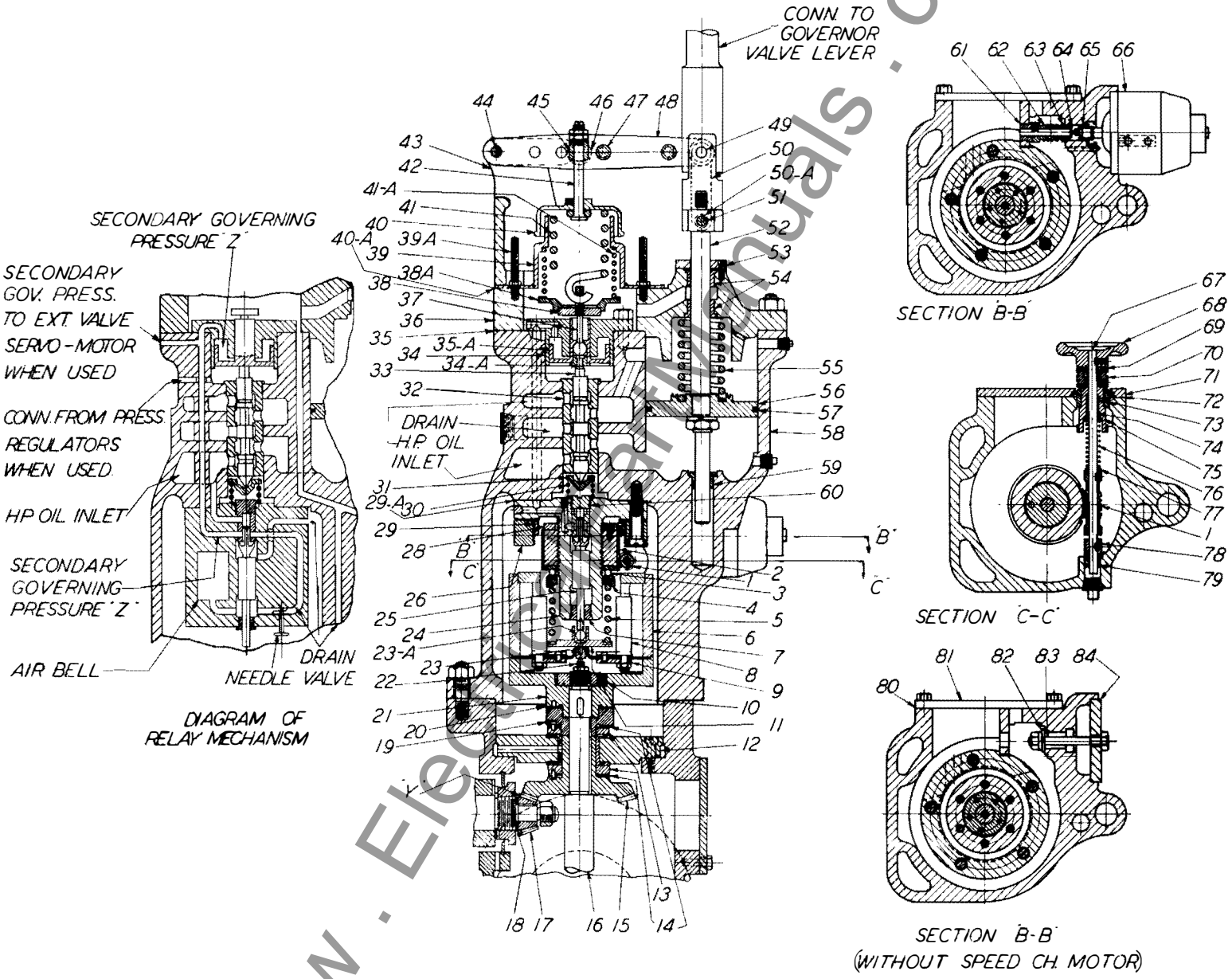

Figure 1

Item No.	Name
54	Servo-Motor Piston Rod Bushings (Upper)
55	Servo-Motor Piston Spring
56	Servo-Motor Piston
57	Servo-Motor Piston Ring
58	Governor Housing
59	Servo-Motor Piston Rod Bushing (Lower)
60	Transformer Cup Valve Seat
61	Speed Changer Shaft Bushing (Inner)
62	Speed Changer Worm (High Speed)
63	Speed Changer Shaft Bushing (Outer)
64	Speed Changer Shaft (High Speed)
65	Speed Changer Motor Shaft Bushing
66	Speed Changer Motor
67	Speed Changer Shaft (Low Speed)
68	Speed Changer Hand Wheel
69	Speed Changer Hand Wheel Clutch Plate
70	Speed Changer Hand Wheel Clutch Collar
71	Speed Changer Cover
72	Gasket
73	Speed Changer Cover Bushing
74	Speed Changer Worm Wheel Bushing
75	Speed Changer Worm Wheel (High Speed)
76	Speed Changer Handwheel Clutch Spring
77	Speed Changer Handwheel Clutch Spring Seat
78	Speed Changer Shaft Collar
79	Speed Changer Shaft Bushing
80	Gasket
81	Hand Hold Cover
82	Washer
83	Blank Flange Bolt
84	Blank Flange

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Governor

(Vertical Flyball, with Pressure Transformer)

This mechanism consists essentially of three parts, each of which has a definite function. These parts are:

(1) Governor, consisting of the flyball mechanism which, due to centrifugal force, moves in response to changes in turbine speed.

(2) Pressure Transformer, consisting of a relay operating within a ported bushing. This mechanism transforms the changes in force received from the governor weights into oil pressure changes acting on the servo motor relay.

(3) Hydraulic Servo Motor for operating the steam valves. This mechanism is of the conventional type of relay controlled operating piston, utilizing oil as the motive fluid.

GOVERNOR:

The governor is of the vertical shaft, centrifugal type in which the centrifugal force of the weights is opposed by the compression force of the governor spring plus the oil pressure acting on top of the transformer relay. The governor hub which holds the weights is driven from the end of the turbine rotor shaft by bevel gears. Three weights are used, placed 120 deg. apart. This construction makes it unnecessary to guide the spring seat, because the governing forces are applied in three planes instead of one. Each weight is fulcrumed on a ball bearing, thus eliminating knife edges and reducing friction to a minimum. The complete rotating element is carried in two bearings.

The upper bearing "12" 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 "14" which are provided back of the thrust collars. In addition, liners "18" are provided back of the governor gear (driver) for the purpose of obtaining correct alignment of the two gears. The lower bearing (not shown in the accompanying illustration) is located at the lower end of the governor spindle, in the oil pump case.

PRESSURE TRANSFORMER:

The essential parts of the pressure transformer are the relay "25" and the bushing "24". It is difficult to show the various oil passages to and from this relay in the main illustration. Consequently, these parts are shown diagrammatically at the left-hand side of the Figure 1.

The upper land on the relay controls ports which admit high pressure oil to the central annulus around the relay, while the lower land controls ports which connect this central annulus to the drain. The central annulus between the two relay lands is connected to the chamber inside the servo motor bellows "34", and also to the chamber above the relay. This central annulus contains oil under the regulating (or transformed) pressure, denoted by "Z", which pressure varies with movements of the relay and exerts a downward force on the relay at all times.

From the above, it can readily be seen that upward movement of the relay closes the drain ports and opens the high pressure ports, thus increasing the regulating pressure "Z". Conversely, downward movement of the relay closes the high pressure ports and opens the drain ports, thus decreasing the regulating pressure "Z". In following the operation of this mechanism, it is important to bear in mind that whatever pressure "Z" exists in the annular chamber between the two relay lands is transmitted also to the chamber above the relay, and any change in this pressure results in a change in the force acting downward on the top of the relay.

In normal operation, the transformer relay is balanced in its neutral position by the force exerted by the governor acting in an upward direction and the force exerted by the regulating pressure "Z" above the relay acting in a downward direction. Any change from this neutral position changes the regulating pressure "Z" above the relay so as to return it to its neutral position and restore the balanced condition.

In normal operation, this governor will have the customary regulation (or frequency change) between no load and full load. However, by opening the needle valve (indicated in the diagram) this regulation can be reduced to a small figure and the governor made practically isochronous. As described above, the regulating pressure "Z", which is controlled by movement of the relay "25", acts on top of the relay to return it to its neutral position. By connecting the top of this relay "25" to the bottom, the effect of the regulating pressure on top of the relay is eliminated, and the relay does not return to its neutral position until the oil pressure above the bellows "34" and hence the speed of the turbine return to their respective normal values.

In order to maintain stability of operation, the change in pressure "Z" cannot be applied below the relay immediately, a certain time lag being essential. This time lag is obtained by an air bell and needle valve which are placed in the passage between the chambers above and below the relay. The function of this time lag is to allow the normal speed change, due to load change, to move the governing valves to their proper positions first, and then by slowly applying the change in pressure "Z" below the relay, the motion of the governing valves is further increased until the same speed which existed before the load change is re-established.

The top of the relay is connected to the chamber at the bottom (as shown in the diagram), and this passage is opened or closed manually, as desired, by the needle valve. Opening the valve renders the governor isochronous. Closing the valve causes the governor to operate with its normal regulation characteristics. When changing over from one type of operation to the other, the needle valve should be moved slowly a part of its travel, and then, to compensate for the change in speed, correct it with the speed changer. Repeat this operation, in relatively small steps, until the needle valve is fully open or closed as the case may be.

SERVO MOTOR:

The principal parts of the servo motor used to operate the valves are the operating piston "56", the relay "33", and the flexible bellows "34". The governor lever is fulcrumed so that downward movement of the operating piston opens the steam inlet valves and upward movement closes them. The upper land on this relay controls ports which admit high pressure oil to the space above the operating piston, the lower land controls ports which admit high pressure oil to the chamber below the piston, and the central land controls ports which connect either side of the operating piston to the drain. Consequently, upward movement of this relay causes the operating piston to move downward, while downward movement of the relay causes the piston to move upward. In normal operation, this relay is balanced in its neutral position by the force of the compression spring "30", plus the force of the tension spring "41" acting in an upward direction and the force exerted by the regulating pressure "Z" inside the bellows "34" acting in a downward direction.

Following any movement of this servo motor relay, the operating piston moves in the opposite direction. The follow-up lever "48", which connects the operating piston rod and the servo motor relay spring "41", is fulcrumed so that following any relay movement, the resulting piston movement changes the tension in spring "41" so as to return the relay to its neutral position until another change in speed (or load) occurs.

On those turbines which do not have an auxiliary oil pump, a spring "55" is provided above the operating piston to hold it in its lower position which in turn holds the governing valves wide open during the starting period. This spring holds the valves open until the speed increases to the point where the governor takes control.

OPERATION:

Briefly, a complete cycle of this control is as follows: If the load decreases, the turbine speed increases and the increased centrifugal force of the governor weights moves the spring seat and transformer relay upward. Upward movement of this relay increases the regulating pressure "Z", until the increased oil pressure acting on top of the relay is sufficient to overcome the increased centrifugal force of the governor weights and return the relay to its neutral position.

The increased regulating pressure "Z" thus established by the transformer relay has, at the same time, increased the downward force inside the servo motor bellows. Downward movement of this bellows moves the servo motor relay downward, thus admitting high pressure oil below the operating piston, which moves the piston upward and closes the governing valves. The upward movement of the operating piston, acting through the follow-up lever, increases the tension in spring "41" until the increased regulating pressure "Z" inside the bellows is balanced and the servo motor relay again returns to neutral.

If the load increases, the turbine speed decreases, and the decreased centrifugal force of the weights allows the oil pressure above the transformer relay to move it downward. Downward movement of this relay decreases the regulating pressure "Z", until the decreased oil pressure acting on top of the relay balances the decreased force exerted by the weights and again returns the relay to its neutral position.

This decreased regulating pressure "Z" thus established by the transformer relay, has at the same time, decreased the downward force inside the servo motor bellows, thus allowing the servo motor relay spring "30" to move the relay upward. Upward movement of this relay admits high pressure oil above the operating piston, thus moving the piston downward and opening the governing valves. Downward movement of the operating piston, acting through the follow-up lever, decreases the tension in the spring "41" sufficiently to compensate for the decreased regulating pressure within the bellows, thus allowing the relay to return to its neutral position again.

SPEED CHANGER:

The hand or motor operated speed changer, by means of which the speed (or load) can be varied, consists essentially of a worm wheel "2", which is threaded on the transformer relay bushing and acts directly on the governor spring. This worm wheel forms the upper support for the governor spring, and consequently downward movement of the worm wheel on its threads increases the governor spring compression and thereby increases the turbine speed. Conversely, upward movement of the worm wheel on its threads decreases the compression of the governor spring and decreases the turbine speed. A suitable mechanism is provided by means of which this worm wheel can be operated either by hand or by motor. The hand operated mechanism is shown in "Section C-C". The hand wheel "68" is connected directly to the worm "1" which meshes with the worm wheel "2". The motor driven worm "62" meshes with

the sleeve "75" and drives through this sleeve, the collar "70" and the hand wheel "68" to the second worm "1" and worm wheel "2". The faces of the hand wheel "68" and the collar "70" with the plate "69" form a friction type clutch which is held in engagement by the spring "76". This clutch slips when the hand operated feature is used.

PRESSURE REGULATORS:

When pressure regulators such as exhaust pressure, extraction pressure, and pump pressure, are used in conjunction with this governor, the regulators are of the hydraulic type and are connected to the chamber below the servo motor bellows as indicated in the illustration. It is obvious that an increased pressure below the bellows is equivalent to a decreased regulating pressure "Z" above the bellows and vice versa. Consequently, changes in pressure delivered by the regulators act on the servo motor relay in the same manner as the regulating pressure delivered by the transformer relay to change the governing valve opening, and hence, the speed (or load) of the turbine.

ADJUSTMENTS:

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

(1) The bevel gears "15" and "17" are lapped together in the finishing process, and three mating teeth are punched marked. When re-assembling 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 punch marks can be observed.)

(2) Adjust the thickness of liners "14" back of the upper collar "13" and liners "18" to bring the bevel gears "15" and "17" 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.

(3) Adjust the thickness of liners "14" back of the lower collar "13" 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.

(4) With the turbine shut down and the governor weights in their inner position, the upper edge of the lower land on the transformer relay "25" should be 87 mils below the corresponding edge of the annulus in the bushing "24".

This can be determined from the following measurements:

A - Distance from upper edge of drain port in bushing "24" to bottom flange face of governor housing.

B - Distance from upper edge of lower land of relay "25" to lower end of relay stem.

C - Distance from top of relay ball "23" to governor housing flange face (that is, to top of gasket "22") with governor weights in their innermost position.

Then the correct relation is:

$$A - 87 \text{ mils} = B + C.$$

Liners "20" are provided below the governor hub to obtain this correct relation if a change is necessary.

However, the above measurements are difficult to obtain accurately without special micrometers and block gauges, and this work should not be attempted except by an experienced service engineer.

(5) Set the governing valve lifts according to instructions given in the "Steam Chest" description.

(6) Adjust the length of the connection to the governor valve lever so that all governing valves are closed tightly when the piston "56" is 1/4 inch away from its upper limit of travel.

(7) If the mechanism is dismantled, it is important to re-assemble the follow-up lever fulcrum pin "44" in the same hole as found originally, in order to maintain the same regulation. Moving this fulcrum pin to the right gives a wider regulation, and moving it to the left gives a closer regulation.

(8) The speed changer limit stops are shown as items "28" and "29". To set the limit stops, proceed as follows:

A - Operate the turbine at no load, and maintain normal full load speed by partially closing the throttle valve.

B - Holding this speed by means of the throttle valve, turn the speed changer in "Increase" direction until all governing valves are wide open. This is determined by measuring the lifts, and checking against the lifts given on the Valve Setting Diagram. This represents the full load position.

C - Shut the machine down. Turn the worm wheel "2" one turn more in the "Increase" direction and lock the limit stop in this position. The ring "26" is saw cut in the horizontal plane so that tightening the cap screws locks the stop "29" securely.

Since the upper and lower lugs on the stop "29" are a constant distance apart, the speed changer range is fixed, and no further adjustment of the lower stop is possible.

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.

Item No.	Name
1	Speed Changer Worm (low speed)
2	Speed Changer Worm Wheel (low speed)
3	Speed Changer Worm Wheel Ball Bearing
4	Governor Spring Seat (upper)
5	Governor Spring
6	Governor Case
7	Transformer Relay Stem Bushing (lower)
8	Governor Weights
9	Governor Weight Ball Bearing
10	Governor Weight Ball Bearing Pin
11	Governor Spring Seat (lower)

Item No.	Name
12	Governor Spindle Bearing (upper)
13	Governor Spindle Thrust Collars
14	Governor Spindle Thrust Collar Liners
15	Governor Gear (Driven)
16	Governor Spindle
17	Governor Gear (Driver)
18	Governor Gear Liners
19	Governor Hub Spacer
20	Governor Hub Spacer Liners
21	Governor Hub
22	Gasket
23	Transformer Relay Ball
24	Transformer Relay Bushing
25	Transformer Relay
26	Transformer Relay Bushing Retainer
27	Transformer Relay Stem Bushing (upper)
28	Speed Changer Worm Wheel Stop Plate
29	Speed Changer Worm Wheel Stop
30	Servo-Motor Relay Spring
31	Servo-Motor Relay Spring Seat
32	Servo-Motor Relay Bushing
33	Servo-Motor Relay
34	Servo-Motor Bellows
35	Gasket
36	Servo-Motor Cylinder Cover
37	Servo-Motor Bellows Rod
38	Servo-Motor Bellows Spring Nut
39	Servo-Motor Bellows Spring Case (inner)
40	Servo-Motor Bellows Spring Case (outer)
41	Servo-Motor Bellows Spring
42	Servo-Motor Bellows Spring Adjusting Bolt
43	Servo-Motor Follow-Up Lever Support
44	Servo-Motor Follow-Up Lever Fulcrum Pin
45	Servo-Motor Spring Bolt Crosshead
46	Servo-Motor Spring Bolt Crosshead Ball Bearing
47	Servo-Motor Follow-Up Lever Spacer Bolt
48	Servo-Motor Follow-Up Lever (in pairs)
49	Servo-Motor Follow-Up Lever Pin (upper)
50	Servo-Motor Follow-Up Lever Link
51	Servo-Motor Follow-Up Lever Link Pin (lower)
52	Servo-Motor Piston Rod
53	Servo-Motor Piston Rod Bushing Retainer
54	Servo-Motor Piston Rod Bushings (upper)
55	Servo-Motor Piston Spring
56	Servo-Motor Piston
57	Servo-Motor Piston Ring
58	Governor Housing
59	Servo-Motor Piston Rod Bushing (lower)
60	Transformer Relay Stop Nut
61	Speed Changer Shaft Bushing (inner)
62	Speed Changer Worm (high speed)
63	Speed Changer Shaft Bushing (outer)
64	Speed Changer Shaft (high speed)
65	Speed Changer Motor Shaft Bushing
66	Speed Changer Motor
67	Speed Changer Shaft (low speed)
68	Speed Changer Handwheel
69	Speed Changer Handwheel Clutch Plate
70	Speed Changer Handwheel Clutch Collar
71	Speed Changer Cover
72	Gasket
73	Speed Changer Cover Bushing
74	Speed Changer Worm Wheel Bushing

Item No.	Name
75	Speed Changer Worm Wheel (high speed)
76	Speed Changer Hand Wheel Clutch Spring
77	Speed Changer Hand Wheel Clutch Spring Seat
78	Speed Changer Shaft Collar
79	Speed Changer Shaft Bushing
80	Gasket
81	Hand Hole Cover
82	Washer
83	Blank Flange Bolt
84	Blank Flange

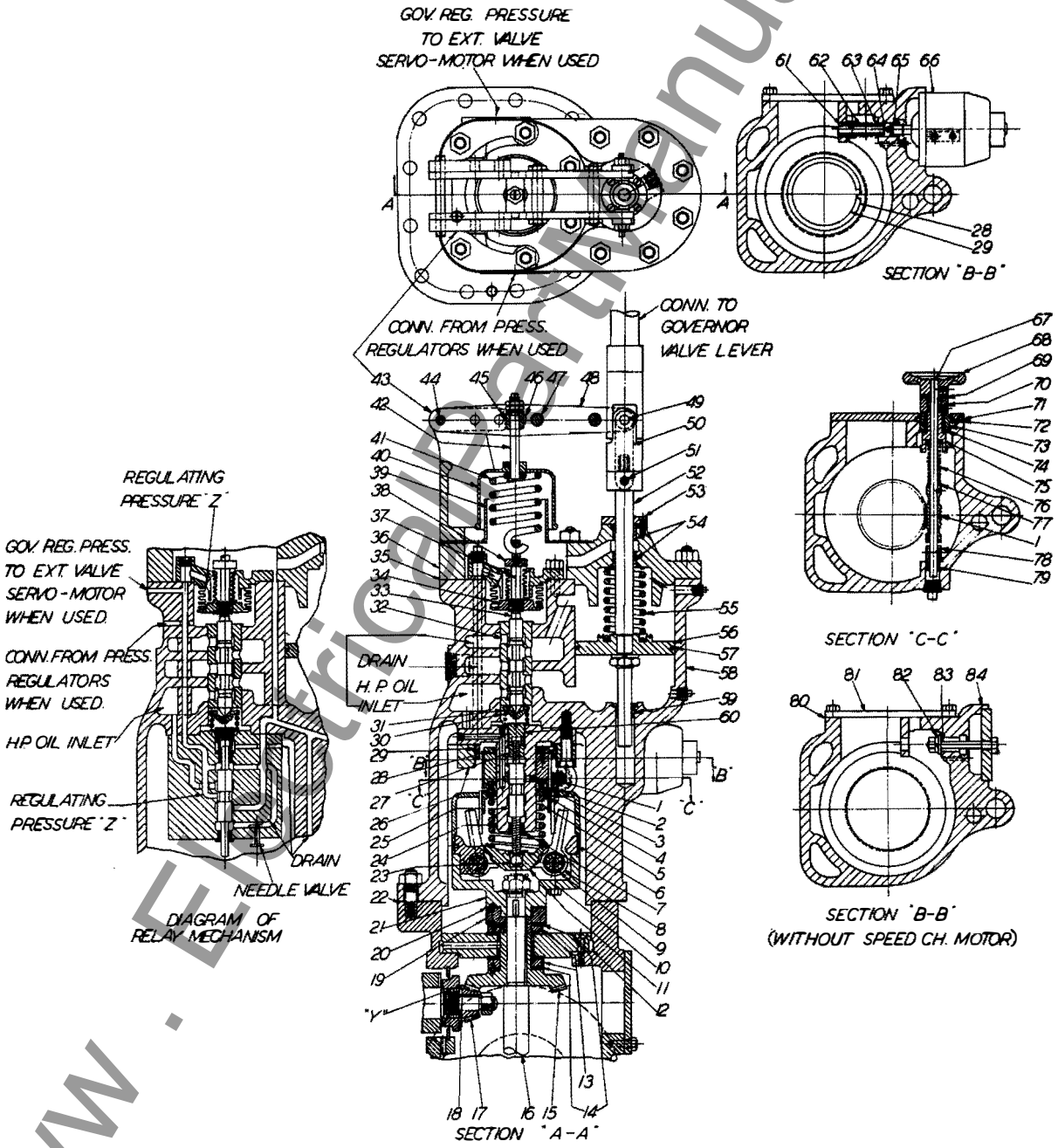

Fig. 1