UNIT 3 17MG8 GE GOVERNOR

OBJECTIVES

After completion of this unit, you should be able to:

- Understand principle of operation of GE Governor
- Understand the mechanical construction of GE Governor
- Learn its hydraulic circuit
- Fuel increase and decrease mode of operation
- Appreciate the interfacing with locomotive through electric circuits
- Appreciate its fuel limit system
- Appreciate its load control system
- Appreciate maintenance and inspection
- Learn test and adjustments

STRUCTURE

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1. INTRODUCTION

This governor is a hydraulic servomechanism used to control the position of the injection pump racks on the diesel engine. Its hydraulic circuits are controlled electrically by the signal from the Engine Control Panel (ECP). Oil under pressure for use in the governor, is supplied by a motor driven pump, which may be, mounted anywhere on the locomotive. However in WDM2 it is mounted towards the free end of the engine. The governor is not mechanically connected to any of the engine's rotating parts.

2. PRINCIPLES OF OPERATION

The system is closed loop or `feedback' system. The tachometer generator (TG) produces an AC electrical signal proportional to engine speed. The engine control panel (ECP) contains resistors, which are connected into the circuit between the tachometer generator and the governor. The switching in or out of these resistors is done by the speed relays -ESR 1,2,3 &4 whose coils are selectively energized by interlocks controlled by the throttle handle (TH).

In Fig.E 3.1 the engine speed signal device is shown as an AC tachometer generator, as used on locomotives equipped with E -type excitation equipment. On locomotives equipped with static excitation, the engine speed signal originates with the exciter-alternator and is converted to DC voltage by components within the reference panel (RP) .In the following discussions, both of these systems will be referred to as a tachometer generator (TG) or speed sensitive voltage signal, however, the principle is illustrative of either system.

The operating principle of the MG8 governor is to control engine speed to a level, which always results in the governor receiving an electrical signal of 475 milliamperes. Consider the arrangement illustrated in Fig.E 3.2 where the "TG" is a D-C generator producing voltage proportional to engine speed. The governor would always adjust the fuel rack so that the engine speed and resulting "TG" voltage are correct to put 475 mA into the governor speed pilot valve coil. Only one speed would be available, although this speed would be maintained regardless of the load on the engine so long as the load did not exceed the desired horsepower.

The ECP is required to "fool" the governor into thinking engine speed has changed. It does this by adding or removing resistance from the circuit, thus altering signal, the governor receives at any given engine speed. The governor must then increase or decrease fuel to speed up or slow down the engine, changing the "TG" voltage until it again puts 475 mA through the circuit. To illustrate this principle, refer to the right hand portion of Fig.E3.2. Inserting the extra resistance of 90 ohms by opening the relay contact will cause the engine to speed up; producing more "TG" voltage until the balance current of 475 mA exists. On the locomotive, ECP contains several resistors required to obtain eight speeds. Switching is done by remotely mounted speed relays.

3. MECHANICAL CONSTRUCTION

The governor components are contained in steel housing, the base of which forms an oil sump. The housing also contains an oil pressure regulating valve, strainer, sight glasses for checking oil level and supply and return connection for the oil pump.

3.1 CLUTCH ARMS AND BIAS-SPRINGS OUTPUT SHAFT

The output shaft of the governor extends through one end of the housing and is keyed and tapered for application of a lever by which movement is transmitted to the fuel rack linkage. Within the governor, the shaft is supported on needle bearings, and has keyed to its lever known as the "B" arm. Behind the "B" arm, a second lever known as the "A" arm is supported by a bearing concentric with the output shaft, but is free to rotate about it. The two arms are magnetically held together and rotate as an assembly during normal operation. The governor clutch coil, mounted between the two arms, is energised from the locomotive battery and produces a magnetic force to hold the arms together. When the clutch is de-energized, the arms are separated by a pair of extension coil springs known as the bias springs. The clutch mechanism provides a convenient and reliable method of shutting the engine down when called for by protective equipment such as the low lube oil pressure switch. These devices are wired to interrupt the current to the clutch coil, thus allowing the bias spring to snap the B-arm and output shaft to "fuel-off" position.

3.2 OVER TRAVEL SPRING

The governor "A" arm assembly is connected by linkage to the over travel spring housing. Torque is transmitted from the governor main shaft to the housing through the over travel spring (a helical torsion spring hub and lever winding up the torsion spring. As the lever moves away from the stop on the outer housing, the spring rotates the housing. The linkage then moves arm "A". The distance and the rate at which the arm can move is limited by the fuel cam Fig.E3.5 shows this action from fuel off to full fuel.

Since the torque produced in the governor main shaft must be transmitted through the over travel spring, the force available to move the racks is always limited by the pre-load in the over travel spring. If the racks or their linkage are stuck and do not move, the over-travel spring merely winds up producing no movement of the output shaft.

3.3 SLAVE PISTONS

Two slave pistons are used in the governor. The governor main and fuel limit cam shaft pinions mesh with rack teeth machined into the mid portion of each piston. No.1 slave piston controls the governor main shaft, and is positioned by oil pressure on either the top or bottom of the piston. No.2 slave piston rotates the fuel limit camshaft. It is positioned by oil pressure on the top opposing a compression spring below.

3.4 FUEL LIMIT CAM

The "A"-"B" arm assembly in moving from idle to full fuel, strikes a cam at approximately mid rack travel. The cam and cam follower (on the "A" arm) are shown in Fig.E3.5. moving from mid point to full fuel, rate of movement is restricted by the cam, which is rotated slowly out of the way by movement of No. 2 slave piston. The time required for slave piston No.2 rotate the cam to full fuel position is regulated by orifices in the governor cylinder head and is approximately 20 seconds. This action is required to allow time for the turbocharger to pick up speed and to prevent excessive exhaust smoke during engine acceleration.

3.5 GEAR BOX

The end of the governor housing opposite to the output shaft contains a gear box. The governor main shaft extends into the gear box and rotates the drive gear. The brush arms of the stabilizing and the load control potentiometers which are mounted on the gear case are driven by the gear on the main shaft.

3.6 SPEED PILOT VALVE

The speed pilot valve is a spool type valve used to direct the flow of oil in the governor to the proper side of the No.1 slave piston. The valve spool is positioned by two opposing forces, the "reference spring" which always tries to move the valve up (increase fuel) and the "speed coil" (solenoid) which when energized tries to move the valve down (decrease fuel). Hydraulic forces on the valve all cancel each other out. A second spring, in addition to the reference spring, is provided for fine adjustment of valve action. This trimmer spring is adjusted at steady engine speed to bring the balance current in the speed coil to its design value of 475 ma. A second coil, wound on the same core as the speed coil is provided for stabilizing control.

4. GOVERNOR HYDRAULIC CIRCUITS

Fig.E3.3 illustrates schematically the hydraulic circuits of the 17MG8 governor. Oil is piped from the sump by the remote mounted pressure pump. Oil under 130-psi pressure is piped back to the governor through the removable strainer and through a drilled passage to the speed pilot valve. Excess above the required amount (to maintain 130-psi pressure) is returned to the sump by the regulating valve. Oil within the speed pilot valve sleeve assembly, escapes through angle drilled holes in the lower part of the sleeve, impinging on the pilot valve spinner. This rotates the pilot valve and eliminates any tendency of the valve to stick.

4.1 Steady speed (Fig.E3.3-A)

When the speed pilot valve is in the balanced position, that is, the engine is maintaining the speed selected by the engine-man and a 475 mA signal is passing through the speed coil, the valve spool is positioned to cut off the oil flow into or cut of the slave piston circuits.

4.2 Accelerating (Fig.E3.3-B)

When the throttle is advanced to higher notch, additional resistance is inserted in the speed coil circuit, resulting in a temporary reduction of current in the coil. The magnetic effect on the core is no longer strong enough to balance the reference spring, which raises the pilot valve. Oil now flows to the lower side of No.1 slave position pushing it up and rotating the governor main shaft in the direction, which will increase the fuel rack setting. The upper side of No.1 slave piston is vented to the sump through the pilot valve during this operation.

When the engine attains the proper steady speed for the new throttle setting, the signal, to the speed coil will again be 475ma, and the pilot valve will again assume a balanced position.

4,3 Decelerating (Fig.E3.3-C)

Governor action is called for whenever there is a change in engine speed for any reason. A change in the load imposed on the engine by the generator or auxiliary equipment tends to change engine speed even though the throttle position is not changed. When an increase in loading occurs (example-compressor cutting in) the engine tends to lose speed, lowering the signal to the speed coil. The governor acts as described under "Accelerating" to increase fuel until normal notch speed is restored.

During a decrease in load (example-locomotive wheel slip action) the engine tends to speed up and the governor acts as described under "Decelerating".

5. FUEL INCREASE RATE CONTROL (Fig.E3.5)

The governor may advance the racks to approximately midpoint with no delay. Whenever an increase in fuel beyond this point is called for, the fuel limit cam located on the end of the fuel limit camshaft restrains movement of the "A" clutch arm. This delay is needed to allow time for the engine turbo supercharger to accelerate.

When the "A" clutch arm strikes the fuel limit cam during acceleration, slave piston No.1 continues to move upward winding up the over travel spring. When the limit of travel is reached oil pressure builds up and is forced through the right hand orifice shown in Fig.E3.4 into the space above slave piston No.2 forcing it down against its springs. As the piston moves down it rotates the cam allowing the "A" arm to advance. The characteristic of this orifice provides for the proper time delay (about 20 seconds) between full rack travel and the rack reading at which the "A" arm first contacted the cam.

When the governor acts to reduce fuel, the supply line to the top of slave piston No.2 is vented to the sump through the speed pilot valve. The slave piston is moved upward by its spring, oil flows out of the space above the piston through two sets of orifices in parallel, providing faster slave piston movement than occurred during acceleration. The second set of orifices can pass oil in this case because the check valve permits oil to flow in the deceleration direction. Some delay on return of the fuel limit cam is always necessary. This is because during normal operation the governor may be required to move the racks from full to zero fuel and back to full fuel in less than a second, as for example, during transition or in the event of a wheel slip may. If the fuel limit cam were allowed to move back to its extreme low fuel position each time this occurred. Locomotive performance would be adversely affected. The return delay time of the cam is intended to approximately match the time taken for the engine turbo-supercharger to lose speed. The orifices are located in the governor cylinder head.

6. GOVERNOR ELECTRIC CIRCUITS

Fig.E3.6 shows a typical schematic of the governor and engine speed control circuits. Input to the circuits is the DC voltage (Engine speed signal) between points A and B on the schematic. This voltage is always proportional to engine speed.

On locomotives having static excitation, this signal originates from the exciter alternator. One phase of the alternator output is used in the reference panel to produce a DC voltage proportional to the frequency of the A-C input signal and thus proportional to engine speed. On all static locomotives, this is called "Reference voltage" and may be measured between wires 31E and 31T.

On locomotives having "E" type excitation, the speed signal originates from the 3 phase tachometer generator. It is fed into the primaries of a saturating transformer in the engine control panel. The characteristics of this transformer are that its secondary voltage is proportional to input frequency rather than voltage. A six-diode network (CRT5) rectifies the output of the engine speed saturating transformer secondary, and the D.C. output of this network represents the engine speed signal fed into the speed setting circuit.

7. ENGINE SPEED CIRCUIT (Fig.E3.6)

Analysis of the speed setting circuit will show that net resistance of the circuit can be adjusted to eight different values by energizing the engine speed relays ESR 1,2,3 & 4 in various combinations. Eight successively higher resistances are obtained as the throttle is moved from notch 1 to 8. Since the current in this circuit must be the same in each notch to maintain steady engine speed, eight different voltages must be used to produce this current, corresponding to eight different engine speeds.

Rheostats SAR 1 & 2 are used to set 8th and 1st notch (Idle) speeds respectively. Rheostat SAR3, which is normally set at ZERO resistance, provides a means to temporarily increase engine speed above the 8th notch value in order to check the speed sat which the over-speed device shuts down the engine.

If the signal to the speed coil fails for any reason, the governor will immediately move the racks to full fuel. Under certain conditions, this could result in considerable overshoot of engine speed above the over-speed trip setting. To protect against this, safety auxiliary relay (SAR) coil is in series with the governor speed coil, so loss of signal causes the SAR relay to de-energize. This interrupts the governor clutch coil circuit immediately returning the racks to fuel off position.

Capacitor CC3 is used to boost speed coil current during a speed reduction (for any reason) accelerating this action. Devices intended to hold engine speed at idle regardless of throttle position have control inter locks between wire 31A and 4. Protective devices intended to stop the engine have control interlocks in the governor clutch supply wire (50L).

8. STARTING DIESEL ENGINE (Fig.E3.7)

1 Battery knife switch, BS in nose compartment is closed.
(a) Wire No 40 is energized. (b) Wire 44 is connected.

2 Main breaker MB1 (Battery) & MB2 (Control) are closed these circuit breakers are situated on Control panel.
(a) Wire 50 is energised by wire 49 through MB1 & BAS
(b) Wire 40 is connected to wire 44 through MB2.

3 Auxiliary generator field breaker (AGFB) on C.P. at this instant is also closed (this is not shown in the diagram), so that as the engine runs battery charging will take place through voltage regulator.

4 Lighting Breakers (not shown) on C.P. are closed.

5 Master fuel pump Breaker (MFPB) (`A` and `B`) on C.S. (Control stands) are closed.

(a) Wire 13 is energized by wire 50 through MFPB-A wire 13C and MFPB"B".
(b) F P C is energised by 13.
(c) Crank case exhauster signal lamp SLP comes on.

6 Crank case exhauster breaker CEB on C.P. is closed.
(a) Crank case exhauster motor (EXH) runs and signal lamp SLP goes off. SLP will come on only when CEB trips.

7 Fuel pump Breaker F.P.B. on C.P. is closed.
(a) Wire 71 is energized by wire 50 through contacts of FPC, wire 70 and FPB.
(b) Fuel pump motor F.P. runs furnishing 2.45-3.16 Kg/Cm2 (35-45psi) fuel pressure and 9.13 Kg/cm (130 psi) governor oil pressure.
(c) Governor stabilising coil is energised by wire 71, through OPS, wire 50F, CRT2 (rectifier) normally closed interlock CK2, ECR3 and wire 50M.
(d) Governor arm A is forced to arm B indicated by stabilising brush arm, SP moving to 6 O'clock position (forcing circuit).
(e) Engine start light ESLP comes on through wire 50 and ESLPR.

8. Engine control switch ECS is brought to run per position for 5 secs and brought back to idle position, alarm gong operates (circuit not shown).

This operation is done to ring the warning bell so that person inside the engine room may know that the engine is going to be started.

9. Master control breakers MCB (A and B) on C.S are closed (not shown in the circuit).

10. Engine start button on C.P. is pushed and held:-

(a) Governor clutch coil is energised by wire 71, through START wire 50D, LWS and wire 50J to magnetically lock arm "A" and "B".
(b) Cranking contactors CK1 and CK2 are energised by wire 71, through ESR4 (Idle) wire 50 START, wire 43 contact P22, wire 43A contact S1 and wire 43B.
(c) Main contactor armature and starting fields are connected across the battery through wire 49, contact CK1, ACCR, contact CK2 and wire 44.
(d) Diesel engine cranks.
(e) Forcing circuits is de-energized allowing governor to advance fuel rack to fire the engine.

(f) In Static Excitation, reference panel receives a signal (Proportional to the engine speed) from exciter alternator EA, transformer ET and transmit it to the governor speed coil through auxiliary safety. In E-type Excitation, Engine Speed Sensing Transformer (ESST) receives speed signal in terms of frequency from Tacho meter generator and transmits to governor speed coil.
(g) S A R is energised.
(h) Engine lube oil pressure rises above 2.11 Kg/Cm2 (30 psi) to reposition the oil pressure switch OPS. Governor clutch coil is maintained by wire 71 through OPS, contact of SAR, wire 50D and LWS independent of engine start switch.
(j) Wire 50F is de-energised and engine start light signal lamp goes off.

11. Engine start button is released.

(a) Engine cranking contractors CK1&CK2 are de-energized.
(b) Main generator is disconnected from battery.
(c) Engine runs at idle speed 400 rpm.
(d) Control air pressure rises to 4.92 Kg/cm2 (70 psi) to reposition pneumatic control switch (PCS) - not shown in circuit.

(For moving locomotive and train all brakes should be released, reverser handle should be installed and put either in forward or reverse position. Engine control switch should be moved to run position Generator field contactor GFCO.(A and B) on CS should be closed and selector handle should be put to position 1 and throttle handle should be advanced gradually).

After starting the diesel engine will come to a speed of 400 rpm at this speed, the reference current will be 475 mA. The pilot valve will be in the balance position as long as speed remains at 400 rpm.

When the engine is idling its speed should be 400 rpm.If the speed should increase or decrease, the governor will change fuel to bring the speed back to 400 rpm. If for example, speed should drop to 398 rpm, the governor action would be as follows:-

1 Engine speed drops below 400 rpm. The alternator or tachogenerator slows down and reference panel voltage drops. The reference panel current to the pilot valve speed coil drops below 475 milliamperes.

2 With less than 475 MA in speed coil, reference spring pulls pilot valve plunger upwards (See Fig.E3.4).

3 Oil pressure reaches bottom of slave piston No.1 to push piston up.

4 Piston operates governor linkage to increase fuel injection.

5 With more fuel engine speeds up.

6 When speed rises to 400 rpm, the increased voltage will once again put 475 MA through speed coil.

7 This current will cause pilot valve plunger to be pulled down to block off inlet port and stop oil flow to slave piston. Further increase in fuel is prevented.

If the engine has speeded up, instead of slowing below 400 rpm the governor would have decreased fuel instead of increasing it.

9. EFFECT OF THROTTLE MOVEMENT ON GOVERNOR

The engine control switch must be turned to the "RUN" position before a movement of the engine man's throttle will have any effect on the diesel engine speed.

As long as the resistances of the governor speed coil circuit remain in a particular combination, the diesel engine will operate at 400 rpm. When the engine man desires to increase the engine speed, he "notches up" the throttle. When the throttle is notched up from 1 to 2, it closes its 7A-15 contacts to energize relay -ESR1. ESR1. Pick up a contact in the speed coil circuit to and another part of resistor GCR to the circuit. This added resistance lowers the reference panel current. When the current in the speed coil drops below 475 mA, the reference spring pulls the pilot valve up and the inlet gets connected to the bottom outlet of the sleeve. It causes the oil to appear under the speed slave piston and it is pushed up. The movement is ultimately transmitted to the governor output shaft and fuel is increased. With increased fuel, when the diesel engine speed increases, the alternator rotates faster and develops more voltage. At 450 engine rpm, the voltage will be strong enough to bring the current up to 475 mA once again, inspite of the added resistance of GCR. This current value will pull the plunger down to balance position, to cut off the flow of oil to the slave piston. The diesel engine fuel, racks will now have higher setting and the engine will be operating at its second notch speed of 450 rpm. The governor will hold it at 450 rpm until the throttle is moved again.

Movement of the throttle through positions 2 to 8 inclusive, operates speed setting relays ESR1, ESR2, ESR3, ESR4 every time the throttle is notched up or down. One or more of these relays operate to change the resistance of the speed coil circuit, with a resultant change in diesel engine speed. Table below lists the relays, which operate in various throttle positions and the diesel engine rpm, which results from the various relay combinations. Also it shows the GCR resistance and H.P. developed at each notch.

TABLE-I

Throttle Notch	Relay Operation	Resistance in Ohms	Engine RPM	H.P. (Input to transmission)
1 & idle	None	25	400	75
2	ESR1	36	450	135
3	ESR3	57	550	310
4	ESR1-ESR3	77	650	650
5	ESR2-ESR3-ESR4	101	750	1085
6	ESR1-ESR2-ESR3-ESR4	121	850	1575
7	ESR2-ESR3	117+SAR1	920	1925
8	ESR1-ESR2-ESR3	137+SAR1	1000	2400

10. FUEL LIMIT SYSTEM (Fig.E3.3 & 3.5)

Whenever the diesel engine is slowed down by an increase in load, or whenever the throttle handle is notched up, the speed pilot valve acts to increase fuel as described under SPEED CONTROL AND EFFECT OF THROTTLE MOVEMENT ON GOVERNOR section. Action of the speed pilot valve on slave piston No.1 tends to force the "A" and "B" Arm further to the right to increase fuel. The arms, however, are kept from moving to the right by the fuel limit cam. The fuel limit cam must be moved out of the way before the 'A' and 'B' arms can move to increase fuel.

Let us assume that the engine is operating in second throttle notch position and that the engine man has just notched up to the third throttle notch.

The decrease in current through speed coil allows the speed solenoid to rise uncovering the inlet port. Oil then flows to the bottom of slave piston No.1 and to the top of slave piston No.2. Movement of slave piston No. 2 moves the fuel limit cam out of the way of the 'A' and 'B' arms so that they can move further to the right to increase the fuel.

The rate of movement of slave piston No 2 is restricted by the orifice plates in the cylinder head. This means that the fuel limit cam moves allowing the "A" and "B" arms to follow increasing fuel at a limited rate. This accelerates the diesel engine more smoothly and improves locomotive performance.

The movement of the fuel limit cam is slower than the rate at which the 'A' and 'B' arms want to increase fuel. As a result the over-travel spring tends to wind up. However, the load control rheostat is not effective until the throttle reaches notch 5 or above. This allows the locomotive to accelerate at normal rate.

Now when the current in the speed circuit balances at 475 mA the pilot valve plunger closes off the inlet port stopping the flow of oil to the slave pistons. All movement of the slave pistons due to oil flow from the pump stops at this time.

The over travel spring, however, is still wound up. It exerts a pressure of about 100-psi on the top of slave piston No.1. The pressure of the spring on the bottom of slave piston No. 2 varies between 60 and 90 psi, but is always less than that of the over-travel spring.

The unbalance of spring pressure will thus allow the over-travel spring to unwind, causing oil to flow to the top of slave piston No.2 pushing it downward. This moves the fuel limit cam slightly away from the "A" and "B" arms. This allows the arms some control of fuel to maintain speed without restriction of fuel cam.

Due to the design of the electrical system with which this governor is used, a maximum fuel limit stop is not necessary except at full fuel. At full fuel rack position, slave piston No. 2 is completely at the end of its travel. It cannot be moved down any further by action of the over-travel spring. As a result, the over travel spring causes load control action which will be described under load control.

11. LOAD CONTROL SYSTEM

The governor's load control system and the excitation system control the speed of the diesel engine by preventing the traction generator from overloading the engine.

During normal operation in any throttle notch, the electrical horsepower at the generator input is limited by the static or type `E' excitation control system. The excitation control system also maintains a current limit and voltage limit in each throttle notch. These limits are for electrical protection of the equipment and smooth control over the application of power to move the train.

If the horsepower limits in 8th notch is higher than available engine horsepower the load control rheostat action will trim generator demand to the value, which allows the engine to deliver horsepower without slowing down.

Let us assume that with the engine running at 1000 rpm the engine is delivering maximum horsepower and that the fuel racks are in the full on position. The maximum horsepower being delivered may not necessarily be the engine's rated horsepower, but is all that the engine can deliver with full fuel.

12. ENGINE SHUTDOWN

When it is desired to shut down the engine the `stop` button is pushed in. This strongly energizes the stabilizing coil to force "A" and "B" arms to "no fuel position". When it is desired to shut down all engines working in multiple, the emergency stop button is pushed. This de-energizes ESR1, 2 and 3 while it energizes ESR4 on all units in multiple. The stabilizing coil is energized from the 71 wire through ESR4, ESR3 contacts. These forces the clutch arms to a 'No fuel' position and the engine shuts down.

13. MAINTENANCE

13.1 Frame

Damaged frame, such as bottom cracked, clutch stop section broken, cast AN connector broken, requires replacement. Repairs by brazing or welding are not recommended. Frames having any bore worn beyond condemning limits require replacement or re-bushing. Dowel pin holes in bottom frame outside of tolerances require correction. Abnormal excessive piston wear on one side indicates too hard frame metal. In such case, either the frame is to be replaced or re-bushed.

After thorough cleaning of the frame with a suitable cleaning solvent (ORION etc.), it should be kept covered with a clean cloth to prevent entry of dirt.

13.2 Pistons

Pistons having out-of-tolerance dimensions at any point on circumference and in diameter require replacement. Repairs by metalizing or plating are not recommended.

13.3 Pressure Regulator

Oil escape port of pressure regulator chamber should not get plugged. Regulator piston (plunger for frame) and the bore on frame beyond condemning limit, require replacement. Regulator spring is inspected for nicks or corrosion.

13.4 Magnet plug

Plug is to be removed and the chips etc. adhering to magnet are cleaned. Presence of magnetic property of the plug is also ensured before re-plugging.

13.5 Oil plug

Damaged, deformed and dirty stacks beyond proper cleaning are to be replaced. O-ring must be renewed after every dismantling.

13.6 Dowels

Dowel pins are to be checked against tolerances.

13.7 Clutch arms

The "A" and "B" arms and associated output shaft must be kept as matched set; if one is defective, all three must be renewed, or magnetic action between the two will be affected.

13.8 Clutch residual and holding power

13.8.1 Residual Torque

If clutch has high residual, exposed steel surface on partly copper coated contact face of clutch arm is to be scrapped. If this does not reduce the residual torque, entire assembly to be replaced.

13.8.2 Holding Torque

Copper coating should be scrapped evenly over the entire surface if the arms are residual torque and should not be made excessive.
NOTE To test residual and holding torque, adjustment and test procedures are to be followed.

13.9 Clutch shaft and spring

All the individual components are to be checked for physical damage and sign of wear. Building up by metalizing is not recommended.

13.10 Over travel mechanism

Before disassembly, all the torque values are to be checked. Values beyond limits require replacement of the spring. Link binding or excessive play (more than .002") indicates defective needle bearing. It should be renewed or greased. Reassembling the mechanism, greasing is to be done with a grease gun.

13.11 Bearing bracket

Replace aluminium bracket by brass one. There should not be any crack.

13.12 Ball bearings

After cleaning the bearings properly, they should be checked for rough spots on balls and race grooves.

13.13 Needle bearings

Needle bearings are not to be removed. Cleaning the bearings with a non-corrosive solvent, the dirt is to be flashed out and its free movement is to be assured. If it has no physical damage, should be repacked again with suitable grease.

13.14 Oil seals

Renewing of oil seals at overhauls is good practice.

13.15 Harness

Low insulation resistance (less than 1 meg-ohm with 250V megger) or damaged insulation of any wire require complete replacement. To clean it, CTC is not to be used. Damaged terminals are also to be renewed.

13.16 Speed solenoid

Dismantle the solenoid completely and clean all the parts to make them free from dirt and oily substances. Removing of paralleling springs may be avoided if the coil assembly does not require renewal.

14 INSPECTION

Concentrated wear in sleeve bore indicates bent valve. Similar wear appears on the valve also and should be replaced. Deep pit-mark on yoke also requires changing of valve. Connecting rod with bearing should be checked for bent con. rod, excessive play and clearance of bearing, etc. Fitting the clevis in valve yoke, the clearance should be checked. Its limit is +.002". Clearance more than +0.002" indicates defective valve or connecting rod assembly. Reference spring is to be checked for condemning limits and distortion. Filter screen provided on the sleeve must be free from dirt and in healthy state. The O-ring is to be replaced. During assembling, free movement of the valve assembly inside the sleeve is to be ensured. The connecting rod is to be turned putting a screw driver on the slot provided on it to get proper mid-travel of pilot valve. This can be checked by pushing the pilot valve assembly down and releasing it. (see Fig.E3.8). The mid-travel adjustment is achieved perfectly on the test bench as described in "BENCH TEST AND ADJUSTMENTS".

14.1 Cylinder head

Head should be thoroughly checked for plugged oil passages. Steel ball and spring must be checked for any distortion and replaced if required. The cartridges are to be cleaned thoroughly and replaced if the screen is damaged. The O-rings should be changed.

14.2 Rheostat

The rheostats are to be checked for correct resistance values. Change in value beyond permissible limits require replacement. The commutator surface is to be reconditioned using 4/0 sandpaper on flat wooden block and finished using crocus cloth. Dirt between segments is to be removed using suitable fibre-glass eraser.

15 ADJUSTMENTS AND TESTS

15.1 Continuity and resistance

With a 250V megger IR between male contacts (pins) of AN connector & ground and amongst the pins is checked. If the reading is least 1Megohm, high potential test with 1000V 50Hz for one minute is conducted to find out faulty point. Resistance values are checked according to "resistance data".

15.2 Bench test and adjustments

15.2.1 Mounting

Mount the governor on the mounting plate bolting to the bolt holes located at the corners, the output shaft pointing to the right.

15.2.2 Oil connections and Filling Reservoir

Screw fast flexible oil inlet and outlet hoses to proper connections on governor base. Valves should be opened or closed on stand to agree with governor table on valve setting chart, for operation "FILL".

15.2.3 Valve operations

Valve No.	Fill	Run-Test	Drain
1	Close	Close	Open
2	Close	Open	Open
3	Open	Close	Open
4	Close	Close	Open
5	Open	Open	Close

- **Close Valve No. 3 slowly and observe sight-glass.**

15.2.4 Check resistance by measuring from the main amphenol

Item	On connector	Resistance in ohms
Clutch coil	J-K	362 - 412
Speed winding on Solenoid	F-H	15.2 - 17.3
Stabilizing winding	H-B	49.5 - 60.5
Stabilizing Rheostat	H-G	109 - 120.5
Load Control Rheostat	D-L	10.1 - 11.2

15.2.5 Mechanical Check

(a) Set governor on travel test stand, bolt down, connect the oil supply, and fill base with oil to line in upper sight gauge. Remove relief-valve spring and relief valve. Replace adjusting screw and brass plug and flush regulator chamber five minutes.

(b) Tighten needle valve in fuel-limit bore plug. It may be necessary to have this plug very tight to get the proper time delay.

(c) Set oil-pressure regulator at 135-140psi gauge (Observe throughout testing for creeping pressure-increasing or decreasing). Check for foaming in top oil sight gauge.

(d) Clutch and Over-travel Spring:- Check with governor oil pressure on, place a 0.001-inch shim on the copper surface of the clutch jaws and depress the speed pilot (WARNING: KEEP FINGERS CLEAR OF CLUTCH JAWS) to close clutch jaws. The clutch jaws must hold the 0.001-inch shim as long as the speed pilot valve is depressed.

(e) Output shaft check

(i) Key the governor lever into place. Insert the indicator linkage in the Universal bearing. The indicator must fall on 0 degree plus or minus 1/4 degree. Connect the main amphenol. Put 75 volts across the clutch coil. Depress the speed pilot valve to pick up the clutch and get full travel. The free travel must be 17 degrees 36 minutes plus or minus 1/4 degree; full travel position must be 30 degree plus or minus 1/2 degree.

(ii) If the above values are out of tolerance, put the governor on the output-shaft position checking device and determine whether the shaft location is within the prescribed limits.

(f) Operation Check of Clutch

(i) Holding torque. With 75 volts across clutch coil, depress speed-solenoid pilot valve to pick up clutch arms. Open R1 (Clutch-coil short switch) and adjust variable rheostat in clutch-coil circuit for 0.06 ampere. Attach the 10-inch arm and spring scale balance to output shaft and pull clutch jaws apart. Torque should not be less than 200 inch -pounds. To recheck, saturate coil with full 75 volts before limiting current to 0.06 ampere.

(ii) Residual holding torque. Remove clutch springs. Put 75 volts across clutch coil and pick up clutch arms as above. After clutch has become sufficiently saturated, turn off main power and observe the exact time. Thirty seconds after the power is removed less than 30 inch-pounds torque should separate the clutch jaws. After power has been removed, operate free half of clutch by hand to check for absence of binding or friction in the clutch shaft, bearings, etc. Check cam set screw for tightness, and see that clutch-spring bearing snap-rings are in place. Replace clutch springs.

(g) Check for leaks throughout test

(i) Regulator cap.

(ii) Wash area around base gasket with alcohol and paint base gasket all the way around with whiting compound, to make any oil leaks easier to detect.

(iii) All pipe plugs.

(iv) Around oil seals and ends of piston shafts.
(v) Between head and frame.
(vi) Seepage due to spongy frame and base castings.

(h) Place the governor on the test stand. Bolt down and make the necessary connections (oil piping, main and solenoid amphenols and air-motor throttle linkage), and fill base with oil to line on upper sight gauge.

(j) Set brush arms. (Wear allowance on enclosed brush design is 0.071 inch, plus 0.019" minus 0.014").

(i) Load- control rheostat. With oil pressure on, depress speed solenoid and then release. Check to make sure that brush arm moves across the active section of the commutator.

(ii) Stabilizing rheostat. Depress the speed solenoid. The brush arm should be on the blank section of the commutator and just adjacent to the active section that requires CCW motion to enter. Release the speed solenoid pilot valve . The brush arm should travel across the active portion and just enter the blank section on the opposite end.

(iii) Inspect each brush for positive contact on the commutator and the slip rings.

(k) Running check. Start the governor and adjust the speed to 750 rpm.

(i) Set the speed and fuel-limit solenoids for 0.475 plus or minus 0.001 amperes by adjusting the trimmer nut on the solenoid (do not remove the lock wire completely). If necessary, to make adjustment, re-lock trimmer nut with lock wire.

(ii) Check governor operation with no load at 300, 500, 800, 1000 rpm running for at-least 5 minutes at each speed. Operation should be steady and stable.

(iii) With 1000 rpm speed setting, close the exciter-field switch and with manual load rheostats apply load slowly until the governor has gone 75% into overload. The brush arm on the load-control rheostat must not stay against the CCW end of the rheostat (100% overload) for any appreciable length of time, as this denotes a bogged-down conditions of the prime mover. The speed at 75% overload must not drop below 995 rpm with a 1000-rpm unloaded setting. Run loaded for 5 minutes. Unload and perform similar tests at 800, 500 and 300 rpm. Record speed at 75% overtravel.

(l) Over-travel spring check. At 500 rpm. close the exciter-field switch and run the load-control rheostat between no load and 100% overload. The over-travel spring arm should travel the full length; this being indicated by stabilizing brush arm going to its extreme CCW position.

(m) With a hot frame (120 to 1800F) and oil of the same temperature range, the governor should move from "off" to "full" travel in 15 to 25 seconds when speed solenoid is released after being fully depressed for 15 seconds.

(n) With frame and oil as above fuel-rate cam should move from "full" to "minimum" in 5 to 15 seconds when speed solenoid is depressed.

(p) Run governor at 3/4 load at 1000 rpm. Suddenly reduce speed setting to 850 rpm. Fuel-rate cam should reset and touch clutch arm. If not, loosen needle valve in fuel-limit solenoid plug. (If loosened more than 1/8 turn, check for speed drop.)

(r) Replace the solenoid covers.

(s) Record the casting temperature (Cool, warm or hot).

(t) Remove from test stand and replace all plugs.

(u) Check torque at output shaft as follows:

- (i) Disconnect linkage to air motor.
- (ii) Turn on oil pressure.
- (iii) With clutch arm up against fuel-limit cam at minimum fuel limit, measure torque. Reading must be taken while cam is moving away from minimum fuel limit.

16. DRAINING AFTER TEST

Drain the oil reservoir in the base of the 17MG8 governor after testing, by turning oil valves to "Drain" positions (Valve Setting Chart); Start oil pump, and run until governor reservoir oil is pumped back into storage tank.

17. SUMMARY

GE governors used in diesel electric locomotives of WDM1 & WDM2 class locomotives of Indian Railways are targeted towards availability of specified power in lower notches by moving higher fuel rack, in an unhealthy diesel engine. However, at final notch, the rack is limited at maximum and the availability of power is compromised. The stabilizing system helps in getting smooth changeover from one state to another, which has higher sensitivity in lower notches in order to reduce hunting. The fuel limiting system is time biased and the limit cam is suitable for a specific application. The governor can anticipate the change in state and takes prior corrective action to avoid speed variation in case of load changing. The pump to create hydraulic pressure and its step speed achieving arrangement are not in-built to the governor.

18. SELF-ASSESMENT EXCERCISES

1. Draw the hydraulic circuit of GE governor and describe fuel increase mode.

2. Explain how are the different speed settings are achieved in different notches.

3. Write short notes on fuel limiting and load control.

4. Dismantle a governor and overhaul it after replacing defective components.

5. Test a governor and write down the results.