



MAINTENANCE INSTRUCTION

LOCOMOTIVE LOAD CONTROL AND COMMUTATOR-TYPE LOAD REGULATORS

DESCRIPTION

Load regulation is an essential part of locomotive operation, particularly from the standpoint of efficient performance and long equipment life. The commutator-type load regulator, Fig. 1, operates in conjunction with the diesel engine governor as a primary part of the locomotive load control system.

Although commutator-type load regulators may have different part numbers depending upon installation, they are all basically the same and differ only in minor detail not affecting their operation or maintenance. For this reason, the information presented in this bulletin applies to all commutator-type load regulators. For details concerning any specific regulator, consult the EMD Master Parts Catalog for locomotives.

LOAD REGULATION PRINCIPLES

The RPM and power output of the diesel engine is dependent upon the quantity of fuel it receives. This is controlled by the governor (mounted on the engine) which functions in response to throttle position. Thus as the throttle is advanced, the governor responds by causing the injector racks to move in giving the engine more fuel which increases RPM and power. Reducing throttle position similarly reduces engine fuel, RPM, and power. For any given throttle position, the engine should use a certain amount of fuel, and turn at a specific RPM, which yields a predetermined power output. In other words, for every throttle position there is a definite RPM-fuel ratio that must be maintained.



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Fig. 1 – Commutator-Type Load Regulator

* This bulletin is revised and supersedes previous issues of this number.

NOTE: The proper RPM-fuel ratio is established by precise adjustments and settings made to the governor. Refer to the Engine Maintenance Manual for complete information.

Once the governor is adjusted to the exact fuel-RPM ratio for that particular engine application, it is then programmed to maintain the correct RPM.

If the engine receives more or less than the preset amount of fuel for a given throttle position, then it is overloaded or underloaded and corrective action is necessary.

The mechanical energy developed by the diesel engine is converted to electrical energy by the main generator which is directly coupled to the engine. This electrical energy is then supplied to the traction motors for actual locomotive movement. Locomotive power and train speed is thus, for the most part, controlled by throttle position. In actual operation however, locomotive power and train speed changes occur even though the throttle position is not changed.

If the locomotive encounters an increased load, such as an upward grade, the traction motors demand more current from the main generator. This increased electrical demand on the generator is reflected as an increased mechanical load on the engine. This increased demand causes the engine to slow down. As the engine tends to slow down, the governor compensates to maintain a specific RPM by increasing the fuel supplied by the injector racks. Thus the engine is supplied with more fuel than it is programmed to receive for that particular RPM.

If locomotive load is decreased, the traction motors demand less current. This is reflected as decreased mechanical load, and the engine tends

to speed up. The governor compensates, and the engine is supplied with less fuel than it should receive for that particular RPM.

Under such conditions it can be seen that the engine would be overloaded or underloaded as the case may be. Neither of these conditions is desired from the standpoint of stable, efficient operation and long life of the diesel engine components.

The load control system as a whole must detect and correct for load changes that would cause diesel engine overloading or underloading when the proper RPM-fuel ratio is disturbed.

The detection part of the system is accomplished within the diesel engine governor. The governor senses the load changes and, through the action of a load control pilot valve, controls the flow of oil to the load regulator.

The load correction part of the system is accomplished by the load regulator, Fig. 1.

The load regulator incorporates a hydraulic vane-type motor that is operated by oil pressure from the governor. The vane causes rotation of a shaft which moves a brush arm over the commutator. The commutator segments are connected to a bank of resistors in the pedestal type housing. The resistance being controlled is in the battery field circuit for main generator excitation. Load correction thus is accomplished by varying main generator excitation.

The moving parts of the load regulator are enclosed within a metal cover having a window through which brush arm position may be viewed. Check valves are used to permit oil flow through the vane motor when the vane is in either extreme of its travel. The extreme positions are 4 o'clock for minimum field excitation and 8 o'clock for maximum field excitation.

OPERATION

LOAD CONTROL

Fig. 2 illustrates the conditions existing in the load control system during normal operation at any given throttle position when the RPM-fuel ratio is correct. As previously mentioned, the RPM-fuel ratio is established by precise settings made to the governor which result in a definite relationship between the power piston pilot valve (throttle speed), power piston (fuel), and load control pilot valve.

The RPM setting piston position and resulting position of the left end of the floating lever and linkage is determined by throttle position. These positions will not change unless the throttle position changes.

NOTE: For complete information on governor control of engine RPM, refer to the governor section of the Engine Maintenance Manual.

When the engine RPM is correct, the flyweights will be revolving in a vertical position which results in the power piston pilot valve being in the position shown, closing off the bushing port and trapping oil under the power piston. The

power piston position controls engine fuel since it is connected to the injector racks by linkages. Its position and tailrod extension to the right end of the floating lever and linkage will not change unless the flyweights change.

Connected to the floating lever and linkage between the RPM setting piston and power piston is the load regulator pilot valve. It is shown in the balanced position (ports closed) which occurs when fuel (power piston) is in the correct ratio to RPM requirements (RPM setting piston). With the upper and lower ports closed, the oil in the load regulator vane motor and piping is trapped resulting in the brush arm being in a fixed position.

Assume now an increased generator load on the engine. This results in a loss of engine speed (RPM) since the fuel it was receiving is no longer sufficient to maintain the previous RPM under increased load. The governor reacts to bring the engine RPM back up to normal by increasing fuel. This occurs when flyweights move inward (due to loss of RPM) resulting in the power piston pilot valve moving downward, opening the port which allows pressure oil to flow to the power piston.

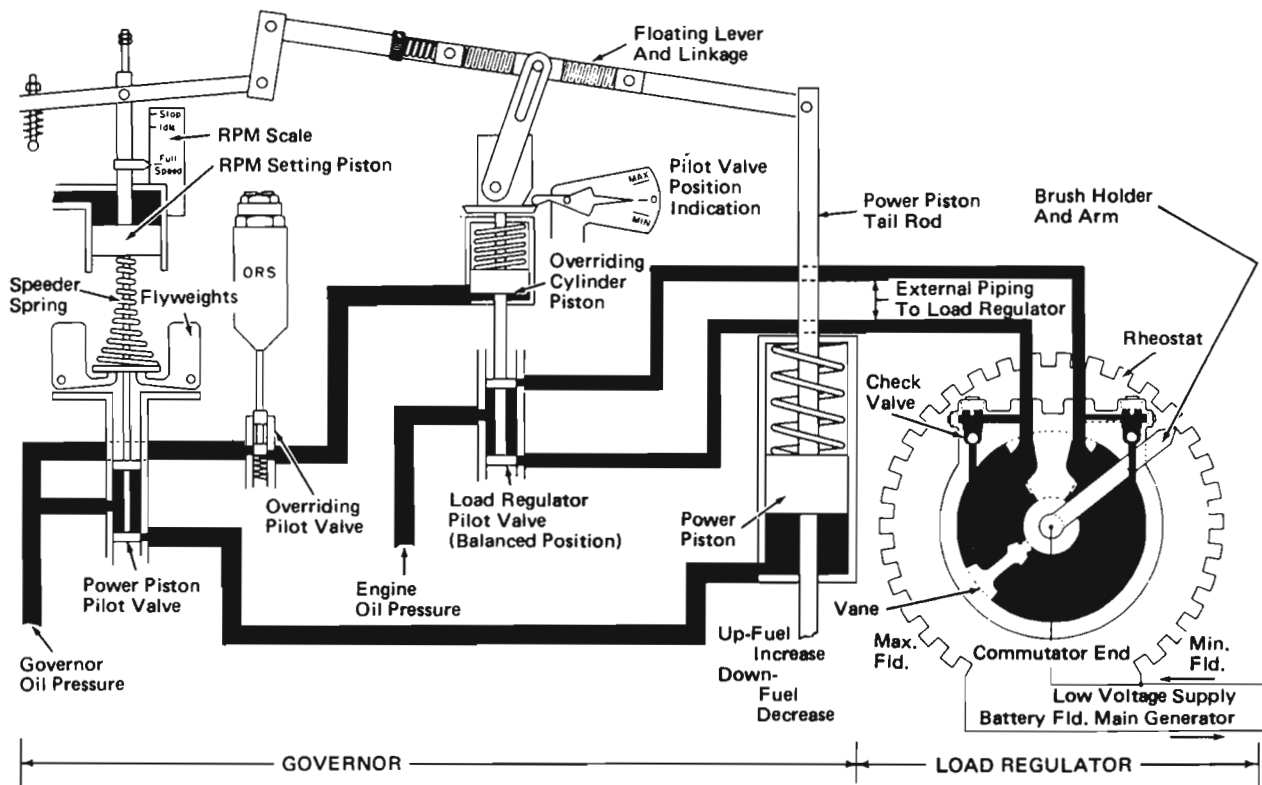


Fig. 2 - Locomotive Load Control Arrangement

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The power piston now moves upward moving the injector racks in to give the engine additional fuel. This would continue (if not corrected by load control) until the RPM was regained and flyweights returned to the vertical position. The engine of course would then be overloaded.

As the power piston moves upward beyond its normal position, the tailrod also moves upward, lifting the right end of the floating lever and linkage. Since the left end of the linkage has not moved (throttle position unchanged), this results in the load regulator pilot valve being lifted above its balanced position. When this pilot valve moves up, it uncovers both the upper and lower ports. Engine oil pressure can now flow through the upper port to the load regulator vane motor. Oil on the opposite side of the vane can drain through the uncovered lower port to engine sump.

The load regulator brush arm now moves towards minimum field, adding resistance to the battery field circuit which reduces main generator excitation and load on the engine. As the load diminishes, the engine's need for additional fuel ceases. The flyweights now move outward since engine RPM will be above normal due to load regulator action. The power piston pilot valve is thus raised, draining the excess oil from under the power piston. Through spring action, the power piston moves downward, reducing engine fuel. The tailrod and floating linkage also move downward, which results in lowering of the load regulator pilot valve.

When the power piston returns to its normal position (RPM-fuel ratio correct), the flyweights will be vertical and oil under the power piston will be trapped. The load regulator pilot valve will also be balanced and the load regulator brush arm will be stopped in a different position from that which existed at the time of the overload. The operation has now returned to normal and engine overload has been removed.

The opposite effect of that outlined above will occur when engine load is decreased. In such instances the load regulator moves towards maximum field to reduce battery field circuit resistance which increases generator excitation and load on the engine until the proper RPM-fuel ratio is again regained.

By means of this load control system, all load changes on the engine are quickly detected and corrected. The engine can thus perform efficiently at rated load and power without undesirable over or under loading.

OVERRIDING SOLENOID (ORS)

Besides the method outlined above for actuating the load regulator pilot valve, another means of doing this is provided by the overriding solenoid, ORS, which is built into electro-hydraulic and electro-pneumatic governors. This solenoid is electrically energized during certain phases of locomotive operation such as during transition and wheel slip control and causes load regulator movement towards minimum field. It is also used to provide locomotives with a modified maximum field start.

In addition to such usage common to all locomotives, the ORS is also used when such features as dynamic braking or hump control are applied to the locomotive. For specific details concerning ORS functions, refer to the appropriate Locomotive Service Manual or wiring diagram.

The method in which ORS functions may be seen by referring to Fig. 2. When energized, its plunger moves down allowing governor oil pressure to flow to the overriding cylinder piston. This piston then moves up carrying with it the load regulator pilot valve, uncovering the ports and allowing engine oil pressure to flow to the load regulator vane motor. As previously described, the load regulator would then move towards minimum field.

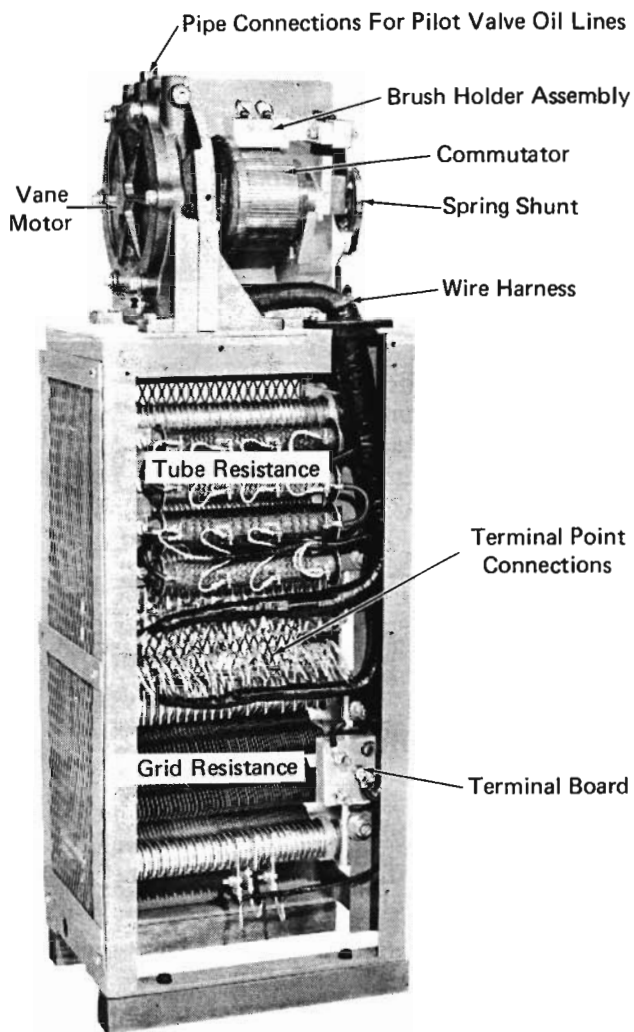
When ORS is de-energized, a spring moves its plunger back to stop the flow of oil to overriding cylinder piston. Oil previously under this piston can drain, allowing the load regulator pilot valve to again function in accordance with RPM-fuel ratio conditions in normal load control.

MAINTENANCE

The load regulator is of rugged construction with few moving parts. This ensures a minimum of maintenance required to keep the device in good operating condition. At inspection intervals outlined in the Scheduled Maintenance Program, the load regulator covers should be removed and attention given to the internal components.

INSPECTION AND CLEANING

1. Remove load regulator covers as in Fig. 3, and using low air pressure, blow dust and dirt from the commutator and brushes as well as the resistor banks.



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Fig. 3 - Load Regulator - with covers removed.

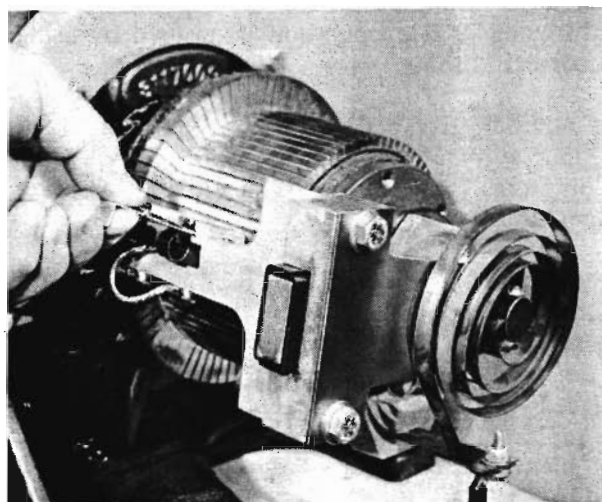
2. Using a clean cloth, wipe away dirt accumulations or oil that might be remaining after air cleaning.
3. The commutator should be cleaned if necessary, using canvas or crocus cloth. Do not use sandpaper or cleaning solvents for this purpose.
4. Check condition of resistors and all wiring connections for tightness.

5. Check tightness of lube oil piping connections.

6. Inspect for lube oil leakage at the cover gasket and regulator shaft gasket areas.

BRUSHES AND BRUSH HOLDER ASSEMBLY

The brush spring clip is a combination brush retainer and spring. It is easily removed without tools, as in Fig. 4. Remove clips and raise and lower brushes in the carbonways to release any accumulations of dirt. Wipe dirt from brushes. Check to see that brushes can move freely in the brush holder. Measure brush length, replacing commutator brushes worn to 7/8 inch. Cracked, chipped or broken brushes should also be replaced.



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Fig. 4 - Removing Brush Retainers

When new brushes are applied or when old ones have faces grooved or imbedded with copper, they should be sanded in for proper fit. This is done by using a fine grade of sandpaper placed sand side up under the brush. Move the brush arm or draw the sandpaper under the brush in one direction only. Repeat as necessary until proper brush face contour has been achieved. Blow away carbon dust.

If the brush holder assembly has been loosened during maintenance or is being replaced, it should be carefully positioned so that the bottom of the carbonway is 1/8" above the commutator. When properly adjusted, tighten assembly securely.

Brush spring pressure should be checked. Correct pressure is 2 to 2 1/4 lbs.

COMMUTATOR

Inspect commutator and if it requires undercutting, use a .033" thick saw and cut to a depth of 1/32". Clean grooves carefully to remove any dirt or copper slivers.

LOAD REGULATOR TIMING

The load regulator pilot valve is built into the electro-hydraulic and electro-pneumatic governors and it operates within a special ported bushing. This ported bushing controls the rate at which oil flows into the regulator vane motor. The stability of the entire load control system is dependent upon how fast the vane motor responds to load fluctuations. Stable operation is ensured by using the correct bushing.

The number, size and location of ports in such bushings automatically limits the rate of oil flow to or from the load regulator thereby assuring proper timing.

Several types of bushings are used depending on locomotive application. Some have 4 ports and others, 5 ports. Whenever a governor is changed or the load regulator pilot valve and bushing is replaced, care should be exercised to make sure the replacements are identical to those removed. For identification of proper components to be used on various locomotives, consult the EMD Locomotive Replacement Parts Catalog.

Load regulator timing is not adjustable when ported bushings are used thus timing need not be checked unless the correctness of the bushing is in doubt.

SETTING OF ORS AND LOAD CONTROL PILOT VALVE

Refer to the Engine Maintenance Manual for complete information on the settings and adjustments of the ORS, the engine injector rack linkage and the governor load control pilot valve. These items are all concerned with locomotive power and load control thus should be given careful attention.

FLUSHING LOAD REGULATOR

Flushing of load regulators as a routine maintenance practice is unnecessary. This is due to the fact that they are equipped with ball check valves which allow a constant circulation of oil through the vane motor when the vane is in either extreme of its travel. The load regulator is thus being flushed in normal operation and will be

kept clean in this manner. Any air trapped in the vane motor or piping will similarly be purged as soon as the engine is started and oil circulation begins.

Whenever it becomes necessary to remove the vane motor cover for inspection of interior components, the vane motor should first be drained. This is easily done by removing the 1/4" pipe plug, as in Fig. 5, that is screwed into the drain hole at the bottom center of the vane motor. When replacing the vane motor cover it is recommended that a new cover gasket be installed.

RENEWING SHAFT GASKET

The oil which lubricates the vane motor shaft is prevented from running out the end of the regulator by the gasket shown in Fig. 5. This gasket should be removed and replaced whenever oil leakage is noted at this point. The drain for the shaft oil should also be checked to ensure that it is not blocked.

To replace shaft gasket, refer to Fig. 5 and follow the procedure given under "Load Regulator Disassembly."

LOAD REGULATOR DISASSEMBLY

For inspection or replacement of parts beyond the items previously covered, it is recommended that the load regulator be disassembled by referring to Fig. 5 and following the procedure below.

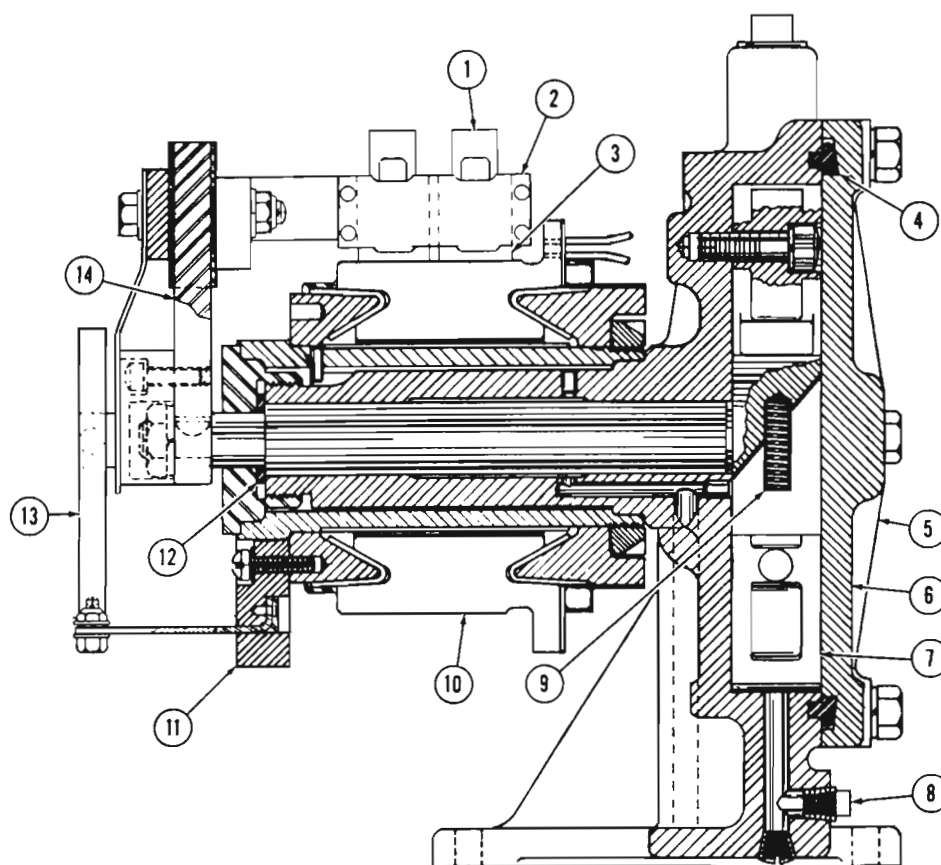
NOTE: A slight variation of the basic procedure below may be necessary due to differences between load regulators.

COVER

1. Remove cover from top of load regulator.
2. Remove felt strips and discard them, as they should be replaced by new ones on reassembly.
3. Replace glass window if cracked or broken.

SPRING SHUNT

1. Remove spring shunt and handle carefully to avoid distortion or damage.
2. Inspect for cracking of the spring (particularly at terminal ends) which would require replacement of the shunt.



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|----------------------------|-----------------------------------|
| 1. Spring Clip Assembly | 8. Drain Plug |
| 2. Brush Holder Assembly | 9. Compression Spring |
| 3. Carbon Brushes | 10. Commutator |
| 4. Vane Motor Cover Gasket | 11. Clock Spring Support Assembly |
| 5. Vane Motor Cover | 12. Vane Motor Shaft Gasket |
| 6. Vane Motor Assembly | 13. Clock Spring Shunt |
| 7. Vane | 14. Brush Holder Arm |

Fig. 5 - Load Regulator - Commutator And Vane Motor Cutaway View

BRUSH HOLDER ASSEMBLY

1. Remove carbon brushes.
2. Remove the two 5/16" hex head bolts that clamp the brush holder assembly to the arm.
3. Remove brush holder assembly, the two "U" insulators and jumper plate. It is recommended that two new "U" insulators be applied on reassembly.
4. Remove the silastic compound over the head of the single 1/4" fillister head screw that secures the insulating block to the arm. Remove screw, lock washer and insulating block.

5. Remove the 1/2" nut and lock washer that hold arm to shaft. Remove arm, being careful not to lose the 3/32" x 1/2" Woodruff key that holds arm in correct relationship to shaft.
6. Remove commutator retainer nut and regulator shaft gasket. Discard gasket, as new one should be installed on reassembly.

COMMUTATOR

1. Disconnect cable form from resistor banks making sure all leads and terminals are properly marked to aid in proper reassembly.

2. Remove commutator and cable form assembly.
3. Inspect commutator surface for pitting, burning or excessive wear. Clean surface if necessary with crocus cloth or canvas. Measure diameter. Condemning limit is 4-1/2".
4. Resolder any loose wire connections to the commutator.
5. Check for bar to bar shorts.
6. Clean creepage surfaces then paint with red air drying insulating varnish.
7. Using a megohmmeter, check commutator resistance to ground.

VANE MOTOR

1. Disconnect lube oil piping. Remove drain plug to drain oil from vane motor.
2. Remove vane motor assembly from top of resistor cabinet and place on workbench for convenience of further disassembly.
3. Check vane motor shaft end play. It should be not less than .002" or more than .005".
4. Remove the six 3/8" hex head bolts from vane motor cover. Remove cover and gasket. Discard gasket, as a new one should be applied at reassembly.

5. Remove vane, compression spring and shaft. Handle parts carefully, as they are manufactured to close tolerances to minimize oil leakage.
6. Remove plugs and ball check valves.

RESISTOR CABINET

1. Check all resistors for signs of overheating or cracking.
2. Check resistor terminals and resistor mounting for secureness.
3. Measure resistance values using data and wiring diagram shown in Fig. 6.
4. Using a megohmmeter, measure resistance of assembly to ground.

LOAD REGULATOR ASSEMBLY

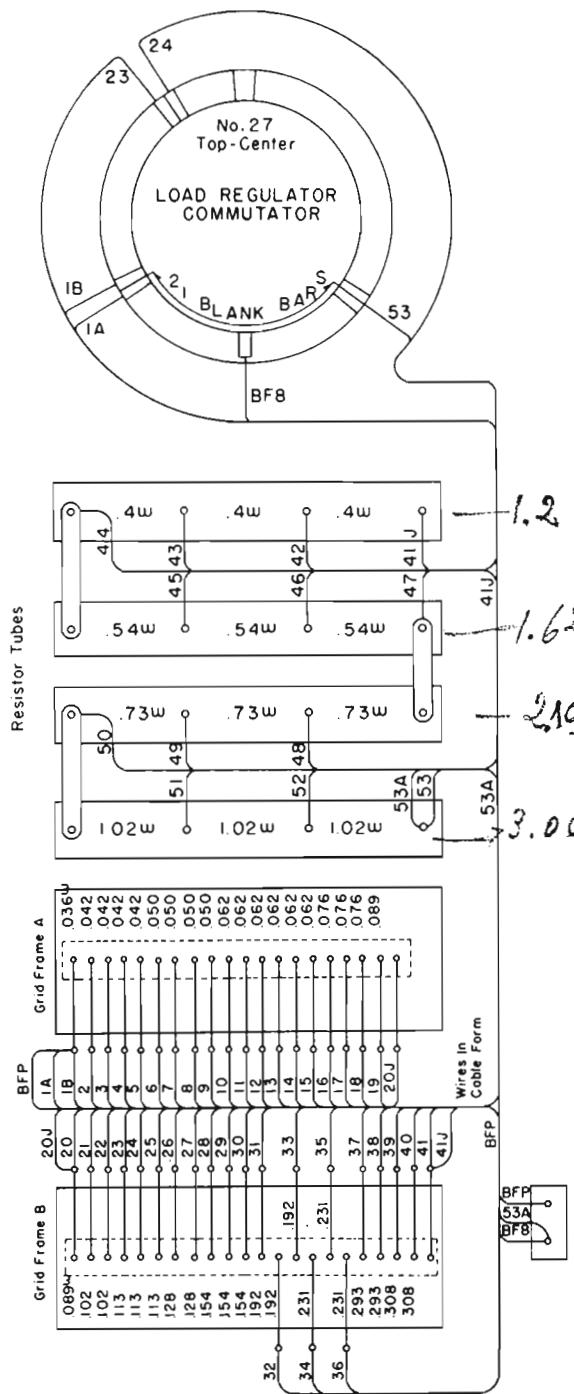
After disassembly, all parts of the load regulator should be thoroughly cleaned and inspected. Parts showing excessive wear or damage should be replaced.

The load regulator may be assembled by reversing the procedure outlined above for disassembly. For proper wiring of the resistors to the commutator assembly, refer to the wiring diagram in Fig. 6.

After assembly, the load regulator should be installed and completely checked for proper performance. Make sure cover is applied to protect moving parts from dust and dirt before returning locomotive to service.

MAINTENANCE DATA

COMMUTATOR TYPE LOAD REGULATOR RESISTANCE AND AMPERE PER STEP



Gen. Batt. Fld. Res. *
Field Fixed Res. **
Total Ext. Res.
Grid Frame #A
8058048

Grid Frame #B
8058049

Res. Tube #8005141

Res. Tube #8005142

Res. Tube #8005143

Res. Tube #8005144

Step No.	Load Regulator Resistors		Locomotives With D15. 25 Main Generators		Locomotives With D12. 22. 32*** Main Generators	
	Ohms Step	Total Ohms	Total Ohms	Amps @74V	Total Ohms	Amps @74V
0			1,212		1,190	
1			0.0		0.0	
2	.042	.078	1,212	61.1	1,190	62.2
3	.042	.120	1,248	59.4	1,226	60.4
4	.042	.162	1,290	57.4	1,268	58.4
5	.042	.204	1,416	52.3	1,394	53.1
6	.050	.254	1,466	50.6	1,444	51.2
7	.050	.304	1,516	48.9	1,494	49.5
8	.050	.354	1,566	47.3	1,544	47.9
9	.050	.404	1,613	45.8	1,594	46.4
10	.062	.466	1,678	44.1	1,656	44.7
11	.062	.528	1,740	42.6	1,718	43.1
12	.062	.590	1,802	41.1	1,780	41.6
13	.062	.652	1,864	39.7	1,842	40.2
14	.062	.714	1,926	38.4	1,904	38.9
15	.062	.776	1,988	37.2	1,966	37.6
16	.076	.852	2,064	35.8	2,042	36.2
17	.076	.928	2,140	34.6	2,118	34.9
18	.076	1,004	2,216	33.4	2,194	33.7
19	.089	1,093	2,305	32.1	2,283	32.4
20	.089	1,182	2,394	30.9	2,372	31.2
21	.102	1,284	2,496	29.7	2,474	29.9
22	.102	1,386	2,598	28.7	2,576	28.7
23	.113	1,499	2,711	27.3	2,689	27.5
24	.113	1,612	2,824	26.2	2,802	26.4
25	.113	1,725	2,937	25.2	2,915	25.4
26	.128	1,853	3,065	24.1	3,043	24.3
27	.128	1,981	3,193	23.2	3,171	23.3
28	.154	2,135	3,347	22.1	3,325	22.3
29	.154	2,289	3,501	21.1	3,479	21.3
30	.154	2,443	3,655	20.3	3,633	20.4
31	.192	2,635	3,847	19.2	3,825	19.3
32	.192	2,827	4,039	18.3	4,017	18.4
33	.192	3,019	4,231	17.5	4,209	17.6
34	.231	3,250	4,462	16.6	4,440	16.7
35	.231	3,481	4,693	15.8	4,671	15.8
36	.231	3,712	4,924	15.0	4,902	15.1
37	.293	4,005	5,217	14.2	5,195	14.2
38	.293	4,292	5,510	13.4	5,488	13.5
39	.308	4,606	5,818	12.7	5,796	12.8
40	.308	4,914	6,126	12.1	6,104	12.1
41	.400	5,314	6,526	11.3	6,504	11.4
42	.400	5,714	6,926	10.7	6,904	10.7
43	.400	6,114	7,326	10.1	7,304	10.1
44	.540	6,654	7,866	9.4	7,844	9.4
45	.540	7,194	8,406	8.8	8,384	8.8
46	.540	7,734	8,946	8.3	8,924	8.3
47	.730	8,464	9,676	7.7	9,654	7.7
48	.730	9,194	10,406	7.1	10,384	7.1
49	.730	9,924	11,136	6.6	11,114	6.7
50	1,020	10,944	12,156	6.1	12,134	6.1
51	1,020	11,964	13,176	5.6	13,154	5.6
52	1,020	12,984	14,196	5.2	14,174	5.2

*Average generator field resistance at 75° C.

**Refer to specific locomotive wiring diagram for possible field resistance in series or parallel with load regulator.

***Not applicable to single field D32D or D32E generators.

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Fig. 6 - Load Regulator Wiring Diagram And Resistance Values

