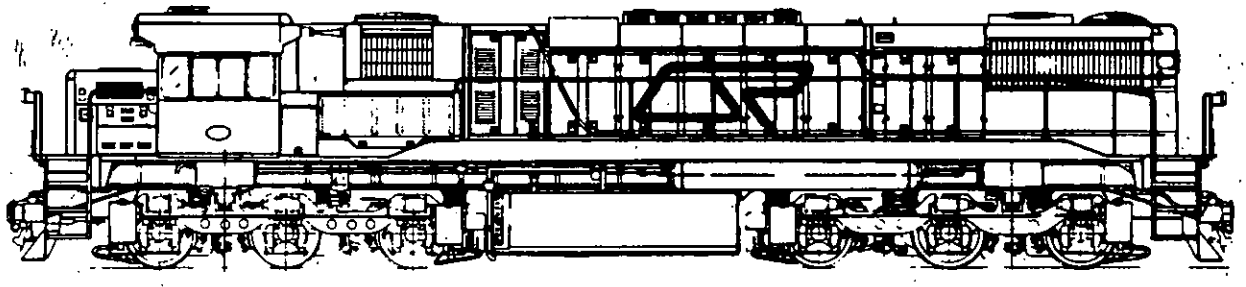
with amendments recd 29/7/80 JRM

Classes 2400 2470
2150 2170

GL22C-2 & GL26C-2

LOCOMOTIVE SERVICE MANUAL



THE CLYDE ENGINEERING COMPANY
PTY. LIMITED
A Member of The Clyde Group of Companies

in association with

Electro-Motive Division
La Grange, Illinois

GM
MARK OF EXCELLENCE

LOCOMOTIVE SERVICE MANUAL

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FOREWORD

This manual covers mechanical and electrical maintenance. Its purpose is to provide instructions for what may be called "on-the-locomotive" maintenance, and to provide under separate cover material for general familiarization with locomotive components and systems. The material included is applicable to the basic locomotive and common extra equipment. The presence or absence of coverage for any particular system or component in no way implies that the equipment is or is not part of any specific locomotive.

Instructions for maintenance that requires deep involvement with component repair, or instructions for rework that involves use of bench apparatus, will be presented in the standard EMD Maintenance Instruction form and in manufacturer's publications covering special equipment.

Instructions covering the diesel engine appear in the EMD Engine Maintenance Manual. Certain engine mounted equipment may receive brief mention in this locomotive service manual, but information in the engine maintenance manual covering such equipment takes precedence.

SERVICE DATA PAGES

A Service Data page is included at the back of some sections of the Locomotive Service Manual. This page provides the following:

1. Reference to applicable Maintenance Instructions and technical manuals.

2. Reference to applicable tool and testing apparatus numbers.

3. Specific system values for operation or testing.

EMD SERVICE DEPARTMENT

LOCOMOTIVE SERVICE MANUAL

GENERAL INFORMATION

Model Designation	GL22C-2
Locomotive Type	(C-C)0660
Locomotive Horsepower	
Gross	1231 kW (1650 HP)
Traction	1119 kW (1500 HP)
Diesel Engine	
Model	645
No of Cylinders	12
Cylinder Arrangement	45° - V
Cylinder Bore and Strokes	230 mm x 254 mm
Compression Ratio	16:1
Direction of Rotation (Facing Flywheel)	Counterclockwise
Full Engine Speed	900 R. P. M.
Idle Engine Speed	315 R. P. M.
Operating Principle	2 Stroke, Cycle, Blower Scavenged, Unit Injection, Water Cooled
Main Generator	
Traction Alternator	AR10-G
Nominal Voltage	600V
Continuous Rating	4200 Amperes
Number of Poles	10
Frequency (at 900 R. P. M.)	75 Hz
Companion Alternator	D14
Nominal Voltage (D14)	180V
Frequency (at 900 R. P. M.)	120 Hz
Auxiliary Generator	
Voltage (D. C.)	74V
Rating	18 kW
Traction Motors	
Model	D29
Number	6
Type	DC, Series Wound, Axle Hung with Rubber Nose Suspension to Damp Torque Shock
Rating	
Continuous (63:14 Gear Ratio)	450 Amperes
Maximum Speed (63:14 Gear Ratio)	100 km/h (62 mph)

GENERAL INFORMATION (CONT'D)

Air Compressor	
Type WBO	Gardner Denver
Number of Cylinders	3
Displacement	120 l/s (254 cu. ft/min)
Air Compressor Cooling	Water Cooled
Lube Oil Capacity	11.63 litres
Storage Battery	
Number of Cells	32
Voltage	64
Rating (5 Hour)	300 Amp/Hr.
Supplies	
Lube Oil	625 litres
Cooling Water	683 litres
Fuel Capacity	6365 litres
Sand	0.68 m^3
Air Brakes	Type 26L
Approximate Weight on Rails	91.44 tonnes
Weight on Drivers	100%
Major Locomotive Dimensions	
Overall Height - Top of Rail to Top of Exhaust Stack	3848 mm
Width Over Underframe	2768 mm
Distance Over End Sheets	17043 mm
Distance Between Coupler Pulling Faces	18059.4 mm
Distance Between Bolster Centres	11684 mm
Distance - Locomotive Wheelbase	13665.2 mm

Curve Negotiation Capability

Truck Swing Limits Single Unit Curve Negotiation to a Curve Radius of 80.46 metres.

Truck

Model ..... HI-AD

Motor Orientation in one direction

Each motor rests on a separate Truck Frame Transom.

Trimount Secondary Suspension using stiff rubber pads between bogie and centre pivot bolster and between underframe and sliding pads.

Wheels	
Rim Thickness	87.3 mm (new)
Diameter	1016 mm
Journal Boxes	139.7 mm x 254 mm, Rigid Type, Grease Lubricated.

GENERAL INFORMATION (CONT'D)

Brake Rigging	Single Shoe
Shoes	Non Metallic
Cylinders	12
Independent Brake (Brake Cylinder Pressure)	310 kPA (45 p.s.i.)
Gear Case Clearance	129.5 mm

Truck Dimensions - Nominal

Length Over Sandboxes and End Transom	5689 mm
Length Over Sand Hoses	6041 mm
Width	2434 mm
Wheel Base	3810 mm
Axle Spacing (Equal Spacing)	1905 mm
Loaded Height Over Bolster Bowl	1076 mm

GENERAL INFORMATION (CONT'D)

Model Designation	GL26C-2
Locomotive Type	(C-C) 0660
Locomotive Horsepower	
Gross	1641 kW (2200 HP)
Traction	1492 kW (2000 HP)
Diesel Engine	
Model	645E
No. of Cylinders	16
Cylinder Arrangement	45° "V"
Cylinder Bore and Strokes	230 mm x 254 mm
Compression Ratio	16:1
Direction of Rotation (Facing Flywheel)	Counterclockwise
Fuel Engine Speed	900 R. P. M.
Idle Engine Speed	315 R. P. M.
Operating Principle	2 Stroke Cycle, Blower Scavenged, Unit Injection, Water Cooled.
Main Generator	
Traction Alternator	AR10-G
Nominal Voltage	600 V
Continuous Rating	4200 Amperes
Number of Poles	10
Frequency (at 900 R. P. M.)	75 Hz
Companion Alternator	D14
Nominal Voltage (D14)	180 V 215V P SEE 6-2
Frequency (at 900 R. P. M.)	120 Hz
Auxiliary Generator	
Voltage (D. C.)	74 V
Rating	18 kW
Traction Motors	
Model	D29
Number	6
Type	DC, Series Wound, Axle hung with Rubber Nose Suspension to Damp Torque Shock.
Rating	
Continuous (63:14 Gear Ratio)	450 Amperes
Maximum Speed (63:14 Gear Ratio)	100 km/h (62 mph)
Air Compressor	
Type WBO	Gardner Denver
Number of Cycles	3
Displacement	120 l/s

GENERAL INFORMATION (CONT'D)

Air Compressor Cooling ..... Water Cooled
Lube Oil Capacity ..... 11.63 litres

Storage Battery
- Number of Cells 32
- Voltage 64
- Rating (5 Hour) ..... 300 Amp Hr

Supplies
- Lube Oil ..... 757 litres
- Cooling Water ..... 832 litres
- Fuel Capacity ..... 7275 litres
- Sand ..... 0.68 m^3

Air Brakes ..... Type 26L

Approximate Weight on Rails ..... 97.54 tonnes
Weight on Drivers 100%

Major Locomotive Dimensions
Overall Height - Top of Rail to Top of
Exhaust Stack ..... 3848 mm
Width Over Underframe ..... 2768 mm
Distance Over End Sheets ..... 17043 mm
Distance Between Coupler Pulling Faces .... 18059.4 mm
Distance Between Bolster Centres ..... 11684 mm
Locomotive Wheel Base ..... 13665.2 mm

Curve Negotiation Capability
Truck Swing limits single unit curve negotiation to a curve radius of 80.46 metres.

Truck
- Model ..... HI-AD

Motor orientation in one direction
Each motor rests on a separate truck frame transom.

Trimount secondary suspension using stiff rubber pads between bogie and centre pivot bolster and between underframe and sliding pads.

Wheels
- Rim Thickness ..... 87.3 mm
- Diameter ..... 1016 mm

Journal Boxes ..... 139.7 mm x 254 mm, Rigid Type, Grease Lubricated.

GENERAL INFORMATION (CONT'D)

Brake Rigging	Single Shoe
Shoes	Non Metallic
Cylinders	12
Independent Brake (Brake Cylinder Pressure)	310 kPA (45 p.s.i.)
Gear Case Clearance	129.5 mm

Truck Dimensions - Nominal

Length over Sand Boxes and End Transom	5689 mm
Length over Sander Hoses	6041 mm
Width	2434 mm
Wheel Base	3810 mm
Axle Spacing (Equal Spacing)	1905 mm
Loaded Height Over Bolster Bowl	1076 mm

GENERAL INFORMATION (CONT'D)

GENERAL INFORMATION

The diesel engine operates on a two-stroke cycle, with power applied on each downward stroke. At the bottom of each downward stroke cylinders are aspirated through cylinder wall ports opening to a chamber that is supplied with pressurised air from a rotary blower. The pressurised air scavenges spent gases from the cylinder through multiple exhaust valves in the cylinder head. As the piston moves upward the ports are closed off and the exhaust valves close. Air is compressed in the cylinder. At the top of the stroke fuel is injected into the cylinder and ignited by heat of compression to provide power to drive the piston downward until the cylinder wall ports and the exhaust valves again open.

The exhaust gases from the cylinder pass through spark arresting manifolds before leaving through the locomotive stacks.

Engine mounted gear driven centrifugal pumps (two on 2400 class and one on 2150 class and 2450 class) supply coolant to engine manifolds connected to cylinder head and liner jackets. A coolant return manifold encloses cylinder exhaust ducts. Heated coolant is piped from the engine through the radiators, and through an oil cooler before it returns to the centrifugal pumps. Part of the supply from the pumps is used for air compressor cooling.

The entire system is pressurised, with pressure level maintained by a relief valve at the storage tank cap. A low water pressure detector is connected to the discharge side of the centrifugal pumps to bring about engine shutdown should pump pressure fail.

Automatic temperature control is accomplished by temperature sensing switches flange mounted on a manifold connected to the discharge side of the pumps. The switches control AC power from the D14 alternator to motor driven cooling fans at the radiators. These locomotives have no radiator shutters on the cooling hood arrangement. A high temperature switch in the manifold operates to give an indication and reduce locomotive power when engine temperature exceeds a predetermined maximum.

The coolant storage tank is provided with a fill pipe fitted to the top of the tank and emerging on the roof. The tank is filled from the roof.

A positive displacement gear type scavenging oil pump draws oil from the engine sump and through a strainer, then pumps it through filters and a cooler and to a second strainer chamber. A dual piston-cooling and lubricating oil pump recieves oil from the second strainer and delivers it to engine manifolds for engine lubrication and piston cooling.

Engine fuel is drawn from the underframe mounted tank through a wire mesh suction strainer to a gear type D C motor driven pump. The pump forces fuel through a primary filter assembly equipped with a dial indicator and pressure bypass that functions should the filter plug. Engine mounted fuel filters provide secondary filtration before the fuel reaches the fuel injectors located at each cylinder. Excess fuel not used by the injectors provides cooling before being returned to the tank.

Fuel injectors supply a precisely metered quantity of atomised fuel to the engine cylinders at a precise moment in the firing cycle. The engine governor operates injector gear racks to maintain the proper amount of fuel needed for engine speed and power level called for.

ELECTRICAL TRANSMISSION

Power from the diesel engine is applied to a main generator consisting of a high power alternator with integral rectifier assembly that changes the generate d alternating current to direct current.

Main generator output is transmitted to traction motors by means of heavy duty power contactors and gang operated switchgear. The power contactors are rated at 1000 amperes and 1500 volts. They are equipped for flashover protection.

The gang operated switchgear uses a single motor to drive the multiple poles. The poles all operate together and will not drop out, since a positive feed is required to move the poles in either direction. Interlocks are provided for positive co-ordination of devices.

Direct current traction motors are directly geared to each axle mounted in the locomotive trucks. The motors turn the axles and wheels to provide locomotive pulling power.

LOCOMOTIVE CONTROL

An A. C. auxiliary generator driven from the engine gear train provides nominally 74 volts DC for control circuits, battery charging, and lighting. Auxiliary generator voltage is automatically maintained at the desired level by a voltage regulator that uses solid electronic devices to control the level of the auxiliary generator field excitation.

74 volt DC is delivered from the auxiliary generator to a reference voltage regulator that maintains very stable 68 volts DC at control circuits. The control circuits are "packaged" in modular form and can be inserted and removed by means of a handle affixed to the face of the module. All modular circuits are bench set and require no readjustment on the locomotive, therefore any modules bearing identical identification numbers are completely interchangeable.

All circuit modules are provided with test points at the face of the module to permit troubleshooting and qualification of the module .

The circuit modules accomplish all control functions such as voltage regulation, throttle response, power control, performance control, generator excitation regulation, matching of generator voltage and current feedback signals with a reference signal, excitation control, wheel slip control, wheel overspeed protection, field shunting, dynamic braking, and various protective and backup functions.

The load regulator, however, is still the main power controlling device. It modulates the voltage reference signal used by the control modules in order to maintain horsepower at a level related to injector rack position by the linkage and valves in the engine governor.

The horsepower demand of the main generator is maintained by varying the level of excitation current in the main generator field coils. This current, provided by the D14 auxiliary alternator, is rectified by a controlled rectifier that is triggered by the modular control circuits so that the needed value of excitation current is passed by the rectifier.

GENERAL INFORMATION (CONT'D)

GENERAL LEGEND OF ELECTRICAL REFERENCE DESIGNATIONS

In the following general legend of reference designations, the long dash "--" means that a numeral or numerals will appear when the designation is used in a specific wiring diagram. The symbols appear in alpha/numeric order with letters of the alphabet taking first position followed by numerals (Represented by the long dash "--". The list is general, and all of the reference designations do not necessarily appear on a given wiring diagram.

ALT	Auxiliary (D14) Alternator
ARL	Automatic Ground Reset Relay
AN--	Annunciator Module
APS	Alert Pressure Switch
ATR	Acknowledgement Time Relay
AV	Governor "A" Valve
AWV	Magnet Valve Alert Whistle
B	Brake Contactor
BATT	Battery (64V DC)
BC	Battery Charging Assembly
BCT	Brake Current Transductor
BCP	Brake Cylinder Pressure Switch
BCS	Brake Cylinder Switch
BKS	Brake Handle Switch
BP--	Brake Power Contactor
BR--	Brake Relay
BRA	Brake Auxiliary Relay
BV	Governor "B" Valve
CA--	Capacitor
CB	Circuit Breaker
CCS	Compressor Control Switch
CDR	Contactor Delay Relay
CMV	Compressor Magnet Valve
COR	Motor Cutout Relay
COP	Compressor Oil Pressure Switch
CR--	Rectifier
CR-BC	Battery Charging Rectifier
CR-GR	Ground Relay Rectifier
CT	Current Transformer
CV	Governor "C" Valve
DB1	Dynamic Brake Interlock
DC--	Brake Grid Shorting Contactor
DE--	Extended Range Dynamic Brake Control
DGT	Dynamic Brake Grid Transductor
DGX	Dynamic Grid Excitation Relay
DG--	Dynamic Brake Grid Protection Module
DP--	Dynamic Brake Protective Module
DP--	Dynamic Brake Pilot Relay
DPC	Dynamic Pneumatic Switch
DR--	Dynamic Brake Regulator Module
DV	Governor "D" Valve
ELT	Excitation Limit Transductor
EL--	Excitation Limit Module
EQP	Equipment Protective Relay
ER	Engine Run Relay
ESS	Emergency Sanding Switch
ETS	Engine Temperature Switch
FCT	Field Current Transductor
FC--	Fan Contactor
FCX	Fan Contactor Auxiliary Relay
FCY	Fan Contactor Auxiliary Relay
FL	Flange Lubrication Control Unit
FLMV	Flange Lubrication Magnet Valve
FOR	Forward Directional Relay

FP--	Feedback and Performance Module
FPC	Fuel Pump Control Relay
FP-ES	Fuel Prime-Engine Start Switch
FPR	Fuel Pump Relay
FSRA	Field Shunt Auxiliary Relay
FS--	Field Shunt Module
FSV	Magnet Valve Forward Sanding
GFC	Generator Field Contactor
GFD	Generator Field Delay Contactor
GFX	Generator Field Auxiliary Relay
GOV	Governor
GPT--	Generator Potential Transformer
GR	Ground Relay
GSR	Governor Shutdown Relay
GV--	Generator Voltage Module
GVL	Generator Voltage Limit Relay
GX--	Generator Excitation Module
IPS	Independent Pressure Switch
IS	Isolation Switch
LR	Load Regulator
LUR	Lead Unit Relay
MCOX	Motor Cutout Auxiliary Relay
MB	Motor-Brake Transfer Switch
MR	Motoring Relay
NVR	No (AC) Voltage Relay
OCP	Open Circuit Grid Protection Relay
ORS	Overriding Solenoid
PEP	Valve Penalty Electro-Pneumatic
PKS	Power Knockout Switch
P--	Parallel Power Contactor
PRR	Power Control Relay
R--	Resistor
RC	Rate Control Module
RE-BC	Battery Charging Resistor
RE-GR	Dynamic Brake Resistor
RER	Reverse Directional Relay
RHS	Reverser Handle Switch
RH--	Rheostat
RSV	Magnet Valve Reverse Sanding
RV--	Directional Transfer Switch
SCR	Gen. Excitation Controlled Rectifier
SE--	Sensor Module
SM	Starting Motor
SPC	Station Protection Control
SPY	Series-Parallel Auxiliary Relay
ST	Starting Contactor
STA	Starting Auxiliary Contactor
TA, TB	Temperature Sensing Switches
TDS	Time Delay Sand Relay
THL	Throttle Limit Relay
THS	Throttle Handle Switch
TH--	Throttle Response Module
THX	Throttle Auxiliary Relay
TM--	Traction Motor
TSR	Transfer Switch Relay
T--	Transformer
VCR	Vigilance Control Relay
VR--	Voltage Regulator Module
WL	Wheelslip Light Relay
WS--	Wheelslip Control Module
WS--	Wheelslip Relays
WST--	Wheelslip Transductor

FUEL SYSTEM AND ENGINE STARTING

DESCRIPTION

A pictorial diagram of the fuel oil system is shown in Fig. 1-1. Fuel is drawn from the storage tank through a suction fuel strainer by the motor driven gear type fuel pump.

From the pump the fuel is forced through a primary fuel filter to the engine mounted filter. After passing through the engine mounted double element filter, the fuel flows through manifolds that extend along both banks of the engine.

These manifolds supply fuel to the injectors. The excess fuel not used by the injectors returns to the fuel tank through the return fuel sight glass mounted on the filter housing. A restriction inside the return glass causes back pressure, thus maintaining a positive supply of fuel for the injectors.

The fuel pump delivers more fuel to the engine than is burned in the cylinders. The excess fuel circulated is used for cooling and lubricating the fine working parts of the injectors.

A 25 psi bypass valve is connected across the primary filter. If the primary filter becomes plugged, fuel will bypass and impose the total filtering load on the engine mounted filter.

FUEL SIGHT GLASSES

Two sight glasses, Fig. 1-2, are located on the engine mounted filter housing to give visual indication of fuel system condition.

For proper engine operation the return fuel sight glass (the glass nearer the engine) should be full, clear, and free of bubbles. The fuel flowing through this glass is the excess not required by the engine. Upon leaving the glass it returns to the fuel tank for recirculation.

At the time of engine start the sight glass will be empty. When the fuel system is primed, turbulent flow will occur and when the fuel in the glass flows clear and free of bubbles the engine may be cranked.

The engine mounted filter is also equipped with a bypass relief valve and sight glass. This sight glass, farther from the engine, is normally empty. When more than a trickle of fuel is seen in the bypass sight glass, it indicates that the relief valve is open.

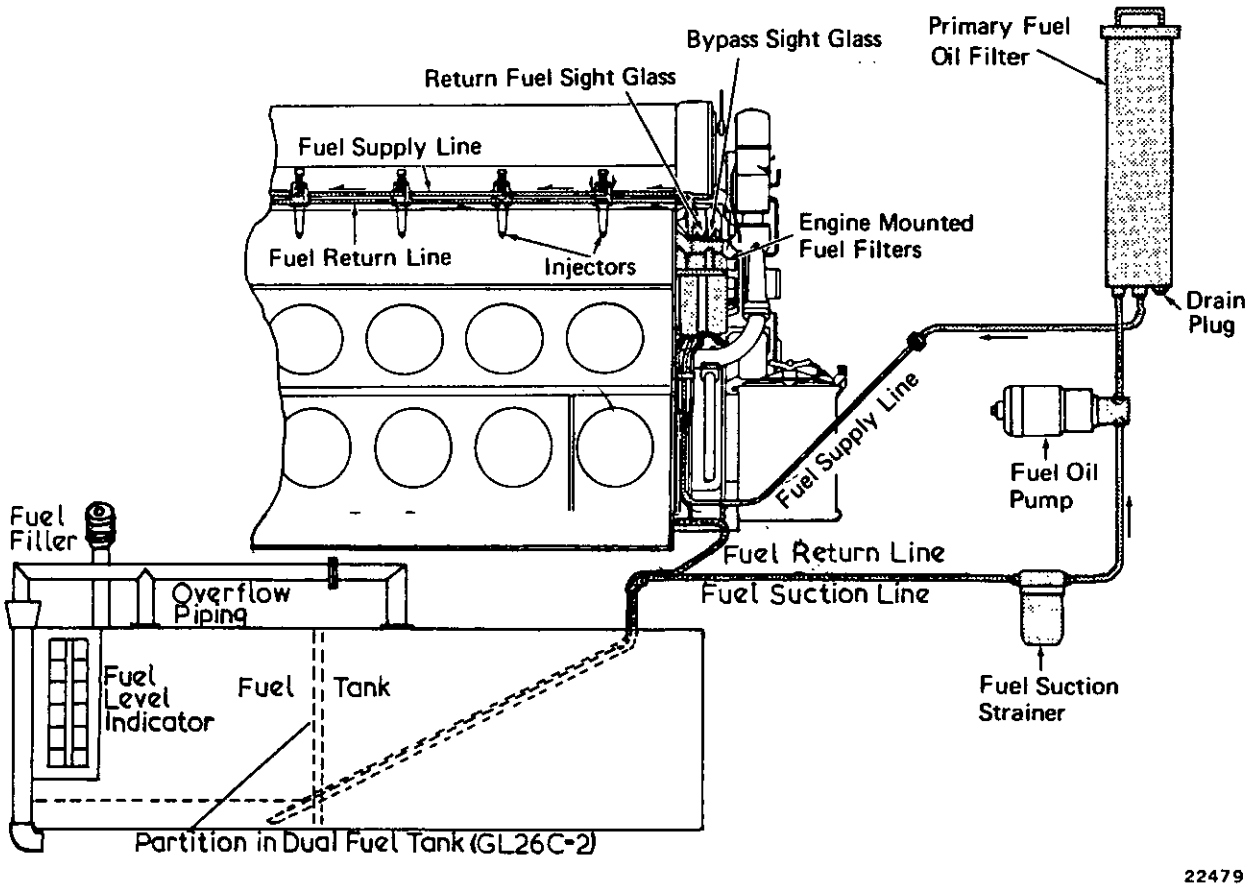


Fig. 1-1 - Fuel Oil System, Pictorial Diagram

Fuel will pass through the bypass sight glass and relief valve to bypass the engine and return to the fuel tank when the filter elements become clogged. This condition may become serious and cause the engine to shut down from lack of fuel.

MAINTENANCE

FUEL STORAGE FACILITIES

The presence of slime on fuel filters indicates that bacteria and fungi are present in troublesome quantities. Water in the fuel storage tanks should be kept at the lowest possible level. Contact the Electro-Motive Division of General Motors Corporation or the fuel oil supplier for recommendations regarding antiseptic treatment of fuel storage facilities.

DRAINING CONDENSATE FROM THE FUEL TANK

Condensate should be drained from the locomotive fuel tank at the intervals stipulated in the Scheduled Maintenance Program, or more frequently if conditions warrant. During draining, the locomotive should be placed on an incline with the drain end of the tank facing down hill to ensure condensate accumulation at the drain plug, Fig.1- 1, and adequate drainage without loss of fuel.

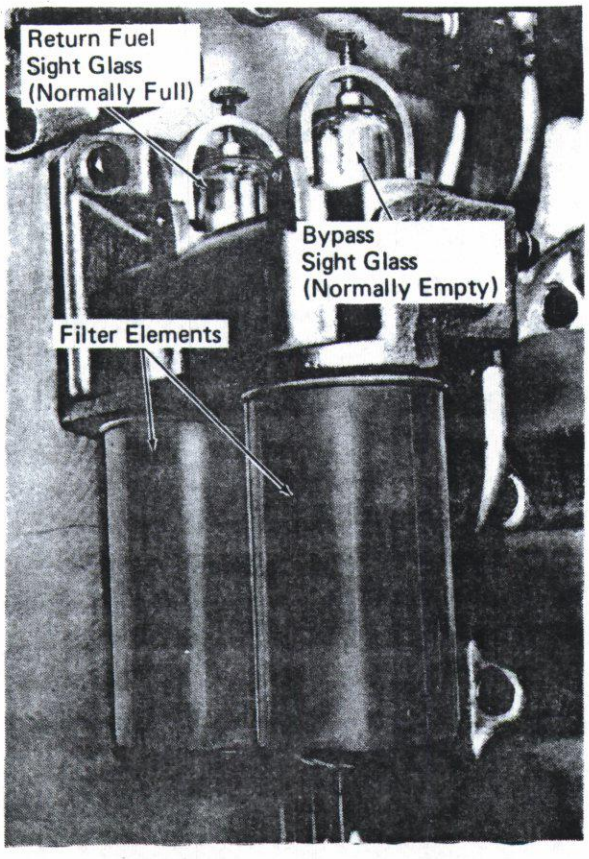


FIG 1-2 FUEL SIGHT GLASSES

The drain plug is secured to the drain block by a retaining screw.

FILLING THE FUEL TANK

The fuel tank can be filled from either side of the locomotive. A sight level gauge is located next to each fuel filter.

DO NOT HANDLE FUEL OIL NEAR AN OPEN FLAME.

The basic filler cap assembly, is equipped with a strainer and pressure relief cap. Periodically inspect the fuel strainer and test the relief cap for operation against the spring. Also check the condition of the filler cap gasket.

The fuel filler is equipped with automatic shutoff. This is controlled by a float located in the tank working through a float valve. If the tank is to be topped up there is an override button which overrides the float and allows fuel to flow.

CAUTION; Never fill fuel tank beyond automatic cutoff level unless instructed by the appropriate authorities.

PRIMARY FUEL SUCTION STRAINER FIG1-3

The fuel suction strainer should be cleared and inspected at the intervals stated in the Scheduled Program or at shorter intervals if operating conditions warrant.

CLEANING PROCEDURE

1. Stop the diesel engine, and place the fuel pump circuit breaker in the OFF position.

2. Remove the bolts holding the strainer shell to the strainer cover, and remove the shell and strainer from the cover. To prevent loss, thread the bolts with washers into the strainer shell threaded openings.

3. Withdraw the mesh strainer element, discard the oil and sediment held in the strainer shell.

4. Clean the mesh element in a container of clean fuel oil. A brush may be used and a round wooden dowel employed to spread the pleats and determine the degree of cleanliness, but no special tools are necessary.

CAUTION: Chlorinated hydrocarbon solvents and temperatures above 180°F will damage the epoxy material bonding the strainer element to the end caps.

5. Clean the shell with fuel oil and wipe clean. Note that the spring in the bottom is spot welded to the shell.

6. Inspect the housing-to-cover "O" ring and replace it with a new ring if necessary.

7. Place the cleaned strainer element in the shell and reapply the shell to the strainer cover. Tighten firmly into place after making certain the "O" ring is properly seated.

PRIMARY FUEL FILTER, FIG 1-4

The primary fuel filter element should be changed at the intervals stated in the Scheduled Maintenance Program or at shorter intervals if operating conditions warrant.

CLEANING PROCEDURE

1. Stop the diesel engine; place isolation switch in ISOLATE position.

2. Place a container (about 5 gallon size)to catch fuel drainage, and remove the $\frac{1}{2}$" drain plug located at the bottom plate of the filter housing.

NOTE: If the pipe plug or the filter cover are opened shortly after engine shutdown, pressure retained in the system will cause fuel to spurt out of the opening.

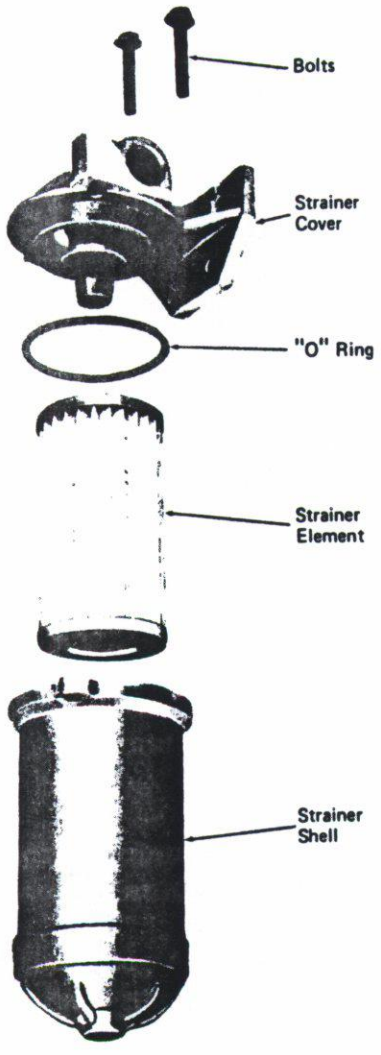


FIG 1-3 FUEL SUCTION STRAINER
EXPLODED VIEW

3. Loosen the filter cover plate retaining nuts, then twist the cover and remove it. Withdraw and discard the cageless waste-type filter element.

4. Place the fuel prime switch in FUEL PRIME position to introduce a flow of fuel and wash out any sediment that may be held at the base of the filter housing.

5. Insert a new filter element into the housing, being careful not to damage the lower seal on the filter element.

6. Inspect the filter housing cover gasket and replace with a new gasket if necessary. Replace the housing cover and firmly tighten the retaining bolts.

7. Tighten drain plug securely.

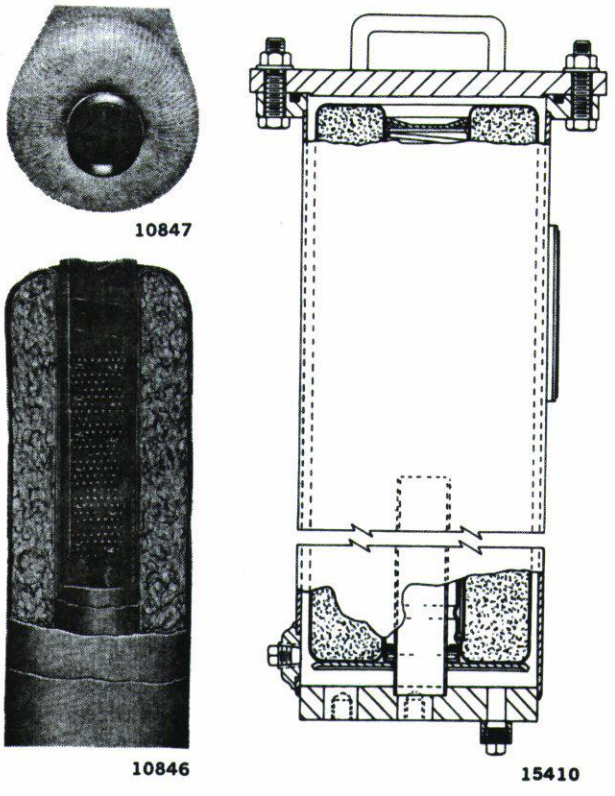


Fig. 1-4 – Primary Fuel Filter And Housing

8. Operate the fuel prime switch until fuel runs free and clear of bubbles in the return fuel sight glass. Check for leakage at the drain plug and the housing cover.

ENGINE MOUNTED FUEL FILTERS

The engine mounted fuel filters should be changed at the intervals stipulated in the Scheduled Maintenance Program and the filter assembly should be maintained in accordance with the instructions in the Engine Maintenance Manual.

1. Shut down the engine.
2. Unscrew and discard the elements. Use a strap wrench if necessary.
3. Clean the filter assembly and sight glasses.
4. Apply a film of oil to the element gaskets.
5. Apply the elements to the filter body. Hand tighten until the gasket contacts the filter body, then tighten one-half turn.
6. Check for leaks after the engine is started.

FUEL PUMP AND MOTOR

The motor driven fuel pump, Fig. 1-5 is mounted on the equipment rack. It is an "internal" gear pump driven by battery power during system priming and by power from the auxiliary generator during operation.

Fuel is drawn into the inlet portion to fill a space created by the gear teeth coming out of mesh. The fuel is then trapped in the space between the gear teeth and carried to the outlet side of the pump. There the gears mesh, forcing the fuel from between the gear teeth and through the outlet.

The fuel pump and motor need no routine maintenance if operation is satisfactory. However the motor and pump should be reconditioned in accordance with E. M. D. Maintenance Instructions listed on the Service Data page. Maintenance should be performed at the intervals stipulated in the Scheduled Maintenance Program.

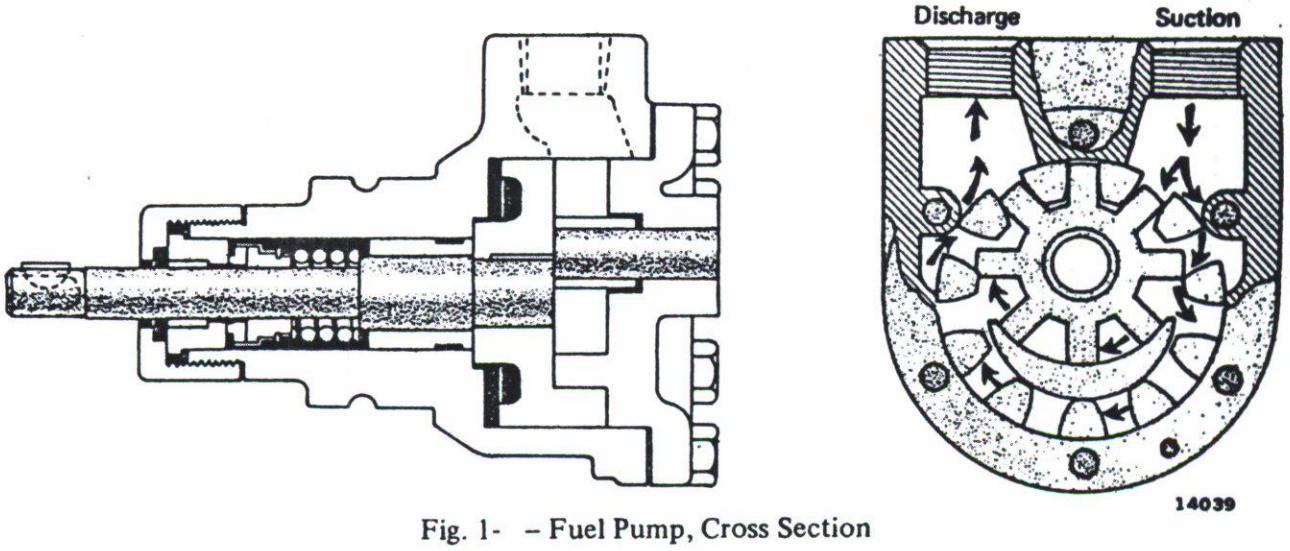


Fig. 1- – Fuel Pump, Cross Section

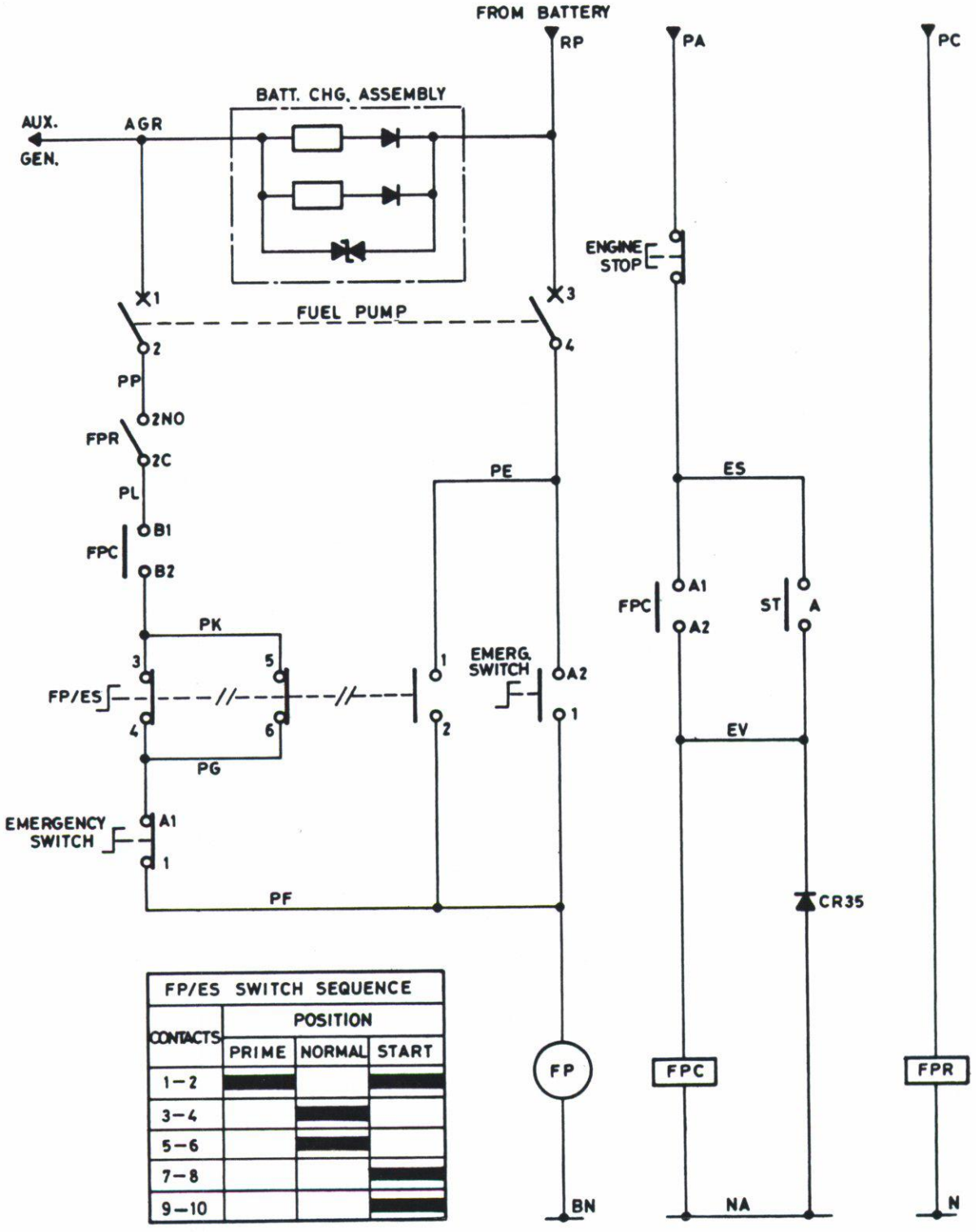
CAUTION: Use care during washing of the engine room to protect the fuel pump motor from water. Water in the motor can cause an electrical ground.

FUEL PUMP CIRCUIT FIG1-6

When the main battery switch is closed and the control and fuel pump switch is closed the FPR relay is energised through the PC wire. This will ensure that the control circuit (energised through PC) is activated when the engine is started.

The Fuel Prime / Engine Start Switch (FP/ES) is held in Fuel Prime to allow the Fuel Pump to run from the battery via the PE wire until the return fuel sight glass is full and clear (See Fig. 1.2 for location of the Return Fuel Sight Glass). When the return fuel sight glass is full and clear it is an indication that the fuel line from the fuel pump is full without air or gas bubbles and fuel will flow uninterrupted to the injectors.

Rotating the switch to Engine Start reconnects the fuel pump to the battery, but also activates the start circuits. Correct operation of the start circuits allows FPC (Fuel Pump Contactor) to pick up via the ST interlock and provides a path for supply to the fuel pump from the Auxiliary Generator positive through a FPC contact and an FPR interlock. Once the engine has started the FP/ES switch is returned to its normal position.



FP/ES SWITCH SEQUENCE			
CONTACTS	POSITION		
	PRIME	NORMAL	START
1–2	■		■
3–4		■	
5–6		■	
7–8			■
9–10			■

FIG 1.6 FUEL PUMP CIRCUIT, SCHEMATIC DIAGRAM

EMD SERVICE DEPARTMENT

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LUBRICATING OIL SYSTEM

DESCRIPTION

A schematic diagram of the lubricating oil system is shown in Fig. 2-1. Oil is drawn from the engine oil pan sump and into the scavenging oil strainer. The scavenging oil pump draws oil through the strainer and forces it under pressure to the lubricating oil filter housing. Oil passes through the filter elements and is piped to the lube oil cooler. If the filters are clogged, a pressure release valve opens to bypass the clogged filters.

In the oil cooler the oil flows around tubes through which cooling water from the radiator is circulated. The cooled oil is then forced to the main and piston cooling oil strainer compartment of the engine oil strainer housing. Oil flows through the two strainers and into the upper deck of the compartment. Since the volume of oil pumped by the scavenging oil pump is greater than that drawn by the main and piston cooling oil pumps, the excess overflows back to the engine oil sump.

Oil is drawn by the main and piston cooling oil pumps from the upper deck of the strainer compartment. This oil is pumped to the engine to lubricate bearings and to cool the underside of the pistons. Oil is also pumped to the load regulator pilot valve in the engine governor and is directed by the valve to operate the load regulator vane motor clockwise and counterclockwise through a maximum arc of about 300°. Oil from the load regulator vane motor returns through the governor pilot valve to the engine oil sump. Note that governor oil is separate from the engine oil that passes through the load regulator pilot valve located in the governor.

Another engine oil connection is made to the governor. It connects to that portion of the engine where lowest oil pressure exists (the blower end). It provides a pressure indication to a sensor in the governor. When engine oil pressure is too low, a shutdown device trips to stop the diesel engine.

Engine protective devices, such as the low water detector, are connected to the oil pressure line from the engine. The devices dump oil from the line, bringing about engine shutdown.

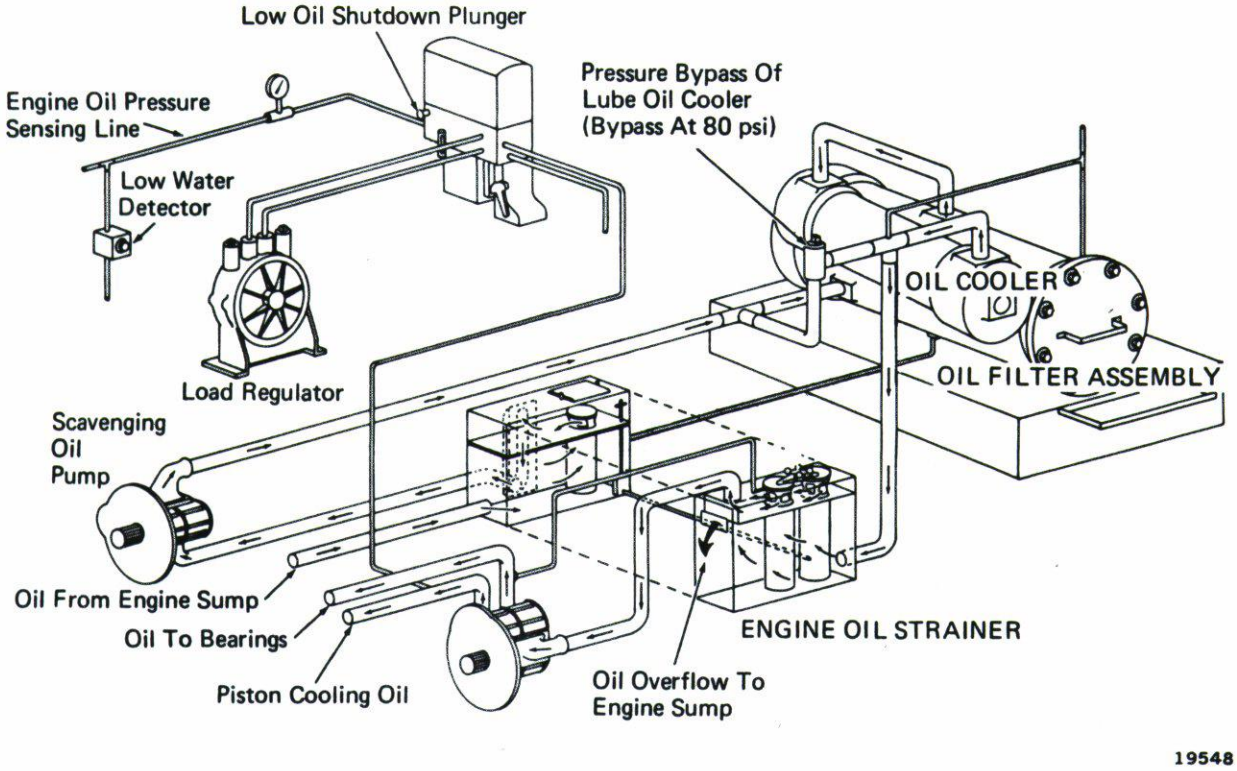


Fig. 2-1 – Lube Oil System Simplified Diagram

ENGINE OIL LEVEL

The engine oil level should be checked with the engine hot and running at idle speed. Dipsticks, Fig. 2-2, are located on both sides of the engine. With the engine running, they should show a level between the LOW and FULL marks.

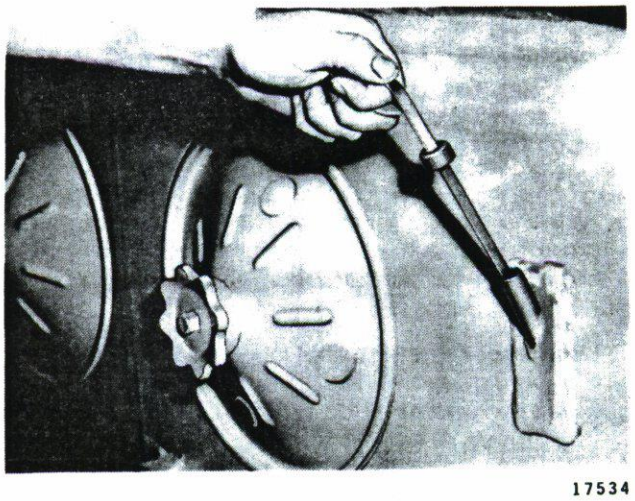


FIG 2-2 CHECKING OIL LEVEL

When the engine is stopped, oil from the filter, cooler, and associated piping will drain back into the engine oil sump. If the oil level is checked with the engine stopped, the readings on the dipsticks will be above the FULL mark if the system contains the normal amount of oil.

FILLING OR ADDING OIL TO THE SYSTEM

When filling or adding oil to the system, it is recommended that the oil be poured into the strainer housing through the square opening as shown in Fig. 2-3. Two additional oil filling points have been added to the engine. These are located on either side of the engine where the filling pipe is incorporated in one of the handhole covers on each side of the engine. On many GM locomotives the lube oil points are provided, necessarily, with filters to prevent sand and/or other foreign matter entering the engine sump. With filters the oil filling is carried out more easily under difficult maintenance conditions. It is imperative when filling through the handhold covers that the strainer housing be filled before starting the engine. Failure to do this may result in serious engine damage due to the time delay before oil is completely circulated through the system and thence to all working parts of the engine.

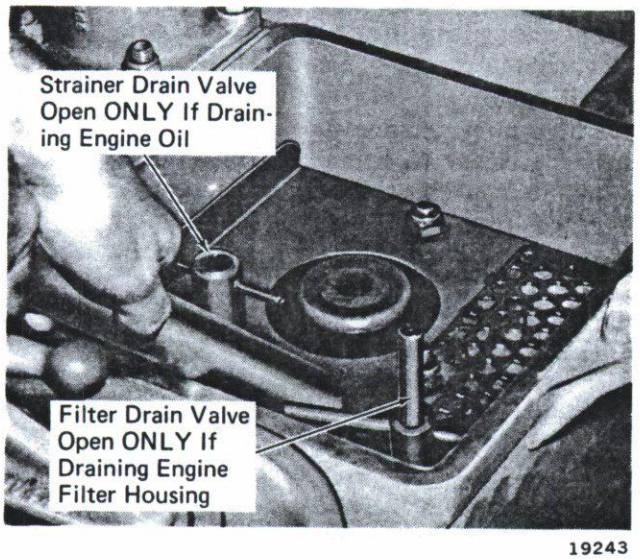


FIG 2-3 ADDING OR FILLING OIL INTO THE SYSTEM

If the system has not been drained, oil may be added to the strainer housing with the engine running or stopped.

CAUTION: Do not remove the round caps from the strainer housing while the engine is running as hot oil under pressure will come from the openings and serious injury could result.

PRELUBRICATION OF ENGINE

The prelubrication of newly installed overhauled engines or engines which have been stopped for 48 hours or more is a necessary procedure. This procedure eliminates loading of unlubricated engine parts during the interval when the lube oil pump is filling the passages with oil. Also, it offers protection by giving visual evidence that oil distribution in the engine is satisfactory.

The line from the external pump should be connected to the system at the 3/4" pipe plug in the main bearing pump discharge line. The oil supply should be warm and the oil pressure at a minimum of 68.95 kilopascals for not less than 3 and not more than 5 minutes.

When pumping the oil through the engine, a visual inspection should be made at the rocker arms, camshaft bearings, and main bearings to see that oil is reaching these parts.

The crankshaft should be rotated at least one revolution so as to distribute oil over various moving parts. Sufficient oil should be pumped to ensure oil reaching all parts of the engine.

Before starting the engine, pour a liberal quantity of oil over the cylinder mechanism of each bank. This applies also to new engines. Make certain that the oil strainer housing is full.

NOTE: When an engine is replaced due to mechanical breakdown, it is important that the entire oil system, such as oil coolers, filters, and strainers, be thoroughly cleaned before a replacement engine or the reconditioned engine is put in service. A recurrence of trouble may be experienced in the clean engine, if other system components have been neglected.

In some cases engines have been removed from service and stored in the "as is" condition by draining the oil and applying anti-rust compound. When these engines are returned to service, before adding oil and prelubing, care must be taken to see that any loose deposits are flushed out before adding a new change of oil. The entire engine should be sprayed with fuel, to break up any sludge deposits, and then drained, being careful that the drains do not plug. Fuel should not be sprayed directly on the valve mechanism or bearings, as lubrication will be removed or dirt might be forced into these areas. The surfaces should then be wiped dry before the new oil is added to the engine.

LUBRICATING OIL SAMPLING AND ANALYSIS

A lubricating oil sample should be taken for analysis at the intervals stipulated in the Scheduled Maintenance Program. The sample should be submitted to a competent laboratory to monitor the suitability of the oil for continued use. Obtain the sample in the following manner.

1. Run the engine long enough to ensure thorough circulation.
2. Shut the engine down and remove the starting fuse.
3. Obtain the oil sample (normally 1 pint) at the centre of the engine oil pan half-way between the surface and the bottom of the pan.

NOTE (1) In consistent sampling techniques will produce inconsistent results.

(2) There is a Lube Oil Sampling Cock located on the end cover of the Lubricating Oil Filter - this may be used as a convenient place to obtain a lubricating oil sample.

OIL COOLER INSPECTION AND MAINTENANCE

Major servicing of the oil cooler should not be undertaken until the need for such maintenance is definitely established by unsatisfactory operation, suspected oil cooler core leaks, or wide temperature differential between cooling water and engine lube oil.

DETECTION OF LEAKS

There are no simple methods of detecting water leaks to the oil side of the lubricating oil cooler assembly; however, evidence of water contamination will show up in the routine engine oil samples taken and analysed as prescribed in the Scheduled Maintenance Program. Any such evidence calls for a close examination of the cooler. Maintenance Instructions for cleaning and repair of the lubricating oil cooler are listed on the Service Data page.

DETECTION OF DIRTY OIL COOLER CORE

Proper lubricating oil temperatures are dependent upon maximum lube oil cooler performance. In order to obtain a valid indication of oil cooler performance, the locomotive must be operated at its full rated load and engine speed while the oil and water temperatures are allowed to stabilise.

PROCEDURE

1. Set up engine loading apparatus capable of taking the full rated load of the locomotive.
2. Remove the square cover from the engine mounted oil strainer and hang a caged thermometer in the overflow oil compartment of the strainer housing, Fig. 2-4. This is oil out of the cooler. Make certain that the thermometer bulb is approximately 75 mm below the surface of the oil and is kept well submerged when readings are taken.
3. Insert a thermometer into the well located at the engine water inlet.

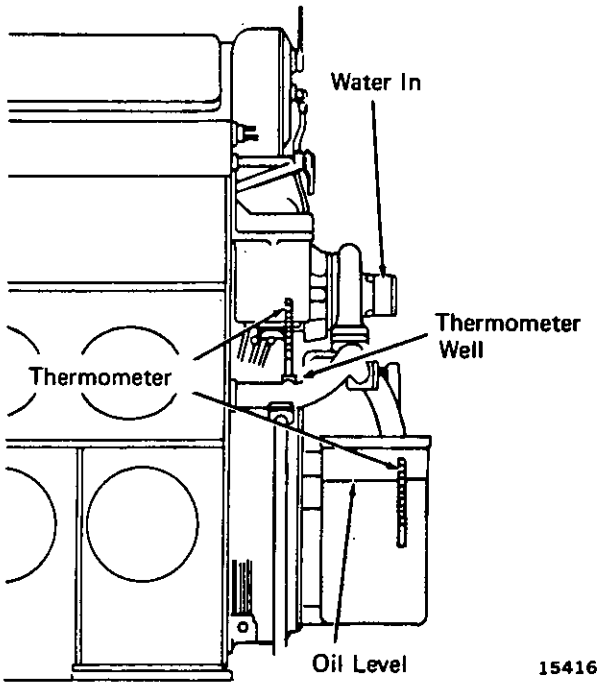


Fig. 2-4 – Location Of Thermometers To
Determine Oil And Water Temperature Differentials

4. Operate the engine and apply load. Do not operate above throttle position No. 3 until water temperature is above 55°C. Operate at full load and full engine speed until the engine water inlet temperature is stabilised. It may be necessary to operate fan by jumpers across TA and TB to maintain a constant water temperature in the range of 71°C to 80°C. Refer to the cooling system schematic diagram in Section 3.

NOTE: Equal readings taken at 15 minute intervals will indicate a stable operating condition.

5. Record the temperature readings and compare them with the performance baseline given on the Service Data page. When oil temperature for a given water temperature reading is higher than the limit indicated by the line, the oil cooler should be serviced in accordance with the Maintenance Instruction listed on the Service Data page.

OIL FILTER INSPECTION AND MAINTENANCE

To obtain maximum benefit from full flow oil filtration, it is essential that the filters be operating properly at all times. The change out period recommended in the Scheduled Maintenance Program for pleated paper filter elements will provide good filtration under average service conditions. However, an excess amount of water or other contaminants in the lube oil will result in premature collapse of the pleated paper filter elements. Collapse of the filter elements result in loss of filtration and possible engine damage.

Condition of pleated paper filter elements may be determined by monitoring the pressure inside the lube oil filter tank. A lube oil pressure filter tank test kit is available for monitoring purposes. The part number of this test kit is provided in the Service Data Page at the end of this section. Filter tank pressure readings may be taken by using the test kit connected to a quick disconnect fitting 8367564 mounted in a $\frac{1}{4}$" -18 NPTF tapped hole in the filter tank cover.

Filter tank pressure checks should be made at fueling or turnaround points before the locomotive is at the ready track or at least once a week. Frequent checks will help to prevent undue engine wear by alerting the maintenance crew before filter element plugging and bypass occurs. If a particular locomotive has short filter element life, there may be water leaks or a heavy contaminent load which demand investigation and corrective action. High tank pressure readings which persist directly after filter changeout may indicate a plugged or fouled oil cooler condition.

Filter tank pressure readings should be taken with the lube oil temperature of 66°C, or above (54.4°C water temperature into the engine). The engine may be loaded or unloaded during the check. Paper filter elements should be replaced if filter tank pressure exceeds the value provided on the Service Data page. Readings taken at full engine speed are the most reliable. Therefore, if a marginal reading is obtained at idle engine speed, the filter condition should be verified at full engine speed and the oil temperature condition rechecked.

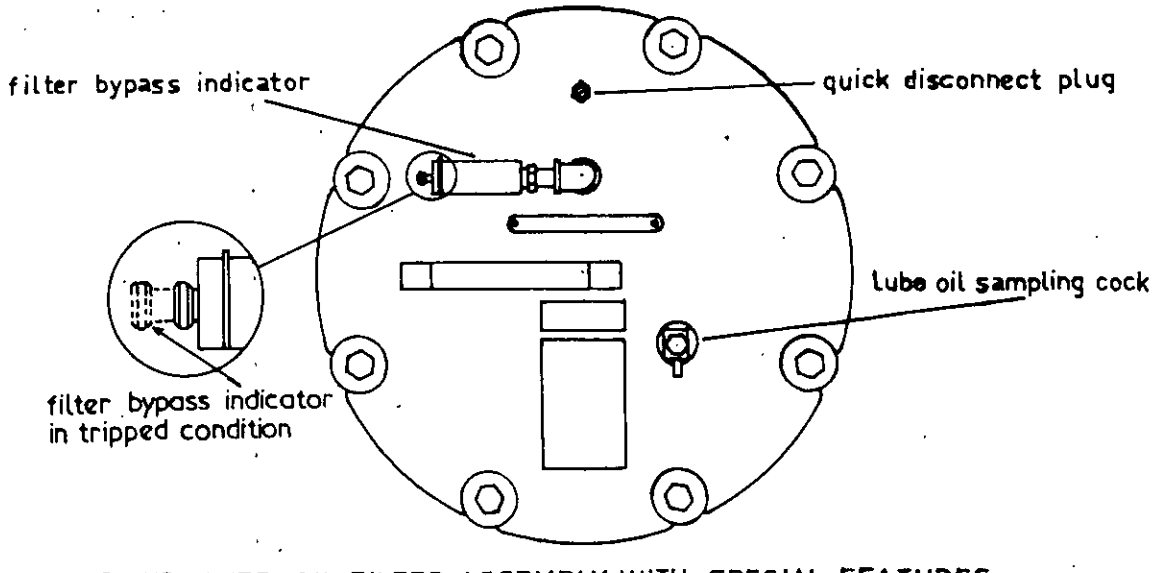


Fig2-5 END COVER, OIL FILTER ASSEMBLY WITH SPECIAL FEATURES

PLEATED PAPER FILTER REPLACEMENT

Pleated paper filter elements should be replaced with new elements at the intervals stipulated in the Scheduled Maintenance Program. Use only approved elements as indicated on the Service Data page.

1. Operate the diesel engine until oil is warm and circulating freely, then stop the engine and remove the starting fuse.

NOTE: Depending upon the temperature of the oil and system, adequate drainage of the lube oil filters may take from $\frac{1}{2}$ hour for hot oil and a hot system to several hours for a cool system.

2. After enough time has elapsed to allow adequate drainage and easy handling of the filters, slightly loosen the nuts on the filter housing cover. Oil remaining at the bottom of the housing will leak into the drain pan. From there it is piped to the engine room drainage sump.

3. Provide adequate quantities of bound edge shop towels.

4. Place a container for used filter elements at a convenient location.

5. After oil has stopped draining from under the flat filter housing cover, loosen the retaining nuts and swing the hinge bolts clear of the cover. Swing the cover open. Remove and quickly dispose of used filter elements.

6. Using bound edge shop towels, clean out the interior of the filter housing. Clean up the drain pan and surrounding area.

7. Insert a set of four new filter elements consisting of part number shown on the Service Data page. Make certain that the elements are fully seated over the standpipes.

8. When the filter elements are properly inserted, place a new gasket into the circular groove in the housing cover. Discard the used gasket.

9. Close the cover. A guide hole in the filter cover must mate with a dowel on the filter housing body before the cover can be closed.

10. Swing the hinge bolts into place and tighten the hold down nuts.

11. At the intervals stipulated in the Scheduled Maintenance Program, remove and inspect the bypass valve assembly, Fig. 2-7. The procedure is detailed in "Inspection of Bypass Valve Assembly".

12. Before starting the engine, check the oil level, using the dipstick. Oil level should be above the full mark on the dipstick with the engine shut down. Start the engine and allow it to run at idle speed. Check the oil level at the dipstick. Add oil if necessary.

13. Inspect for oil leaks at the filter housing. Tighten the hold-down nuts as necessary to stop any leaks.

FILTER BYPASS INDICATOR

The filter bypass indicator is set into the cover of the lubricating oil filter (See Fig 2-5).

This works on the principle that as there oil is unable to pass through the filters pressure builds up in the filter housing. When pressure reaches a certain level the oil is bypassed by the filter bypass valve. The filter bypass indicator gives an indication when this pressure is reached. When the indicator has tripped, it should be reset and a pressure gauge applied to determine actual filter tank pressure.

INSPECTION OF FILTER BYPASS VALVE ASSEMBLY

The bypass valve assembly Fig. 2-7, should be removed and checked periodically at intervals stipulated in the Scheduled Maintenance Program or whenever improper oil filtration is suspected. However operation of the valve assembly can not be effectively checked on the locomotive. For this reason it is recommended that qualified spare assemblies be available for exchange with the assembly in use. A bench test and inspection may then be performed in accordance with the appropriate Maintenance Instruction listed on the Service Data page.

PROCEDURE

1. After the oil has been drained from the filter housing, the filters removed, and the housing cleaned; remove the four hold-down nuts from the bypass valve port cover. Remove the valve assembly and discard the port cover gasket.

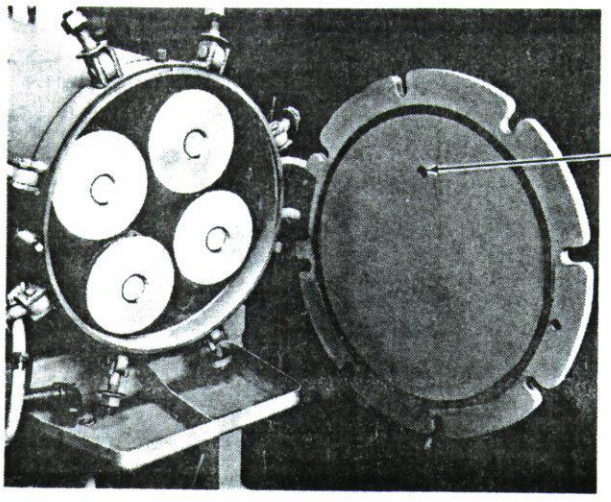
NOTE: Three light springs hold the valve assembly seated in position and and against the valve port cover.

2. Replace the bypass valve assembly with a qualified spare. Seat the assembly properly with the three light guide springs in place. Apply a new port cover gasket and the port cover. Tighten the cover hold-down nuts to between 74.6 Nm and 81.36 Nm torque, using standard tightening procedure.

If a qualified spare is not available the valve assembly should nevertheless be removed from the filter housing and cleaned free of sludge and varnish by washing in solvent. The assembly should be carefully inspected after cleaning. If the poppet stem or valve body guide is worn, those pieces should be replaced with new pieces. Part numbers are listed on the Service Data page.

TEST OF VALVE SPRING

If a qualified spare is not available, the valve spring should be tested by compressing it to a specific height. If this requires more or less than the values shown on the Service Data page, the spring should be replaced with a new spring.



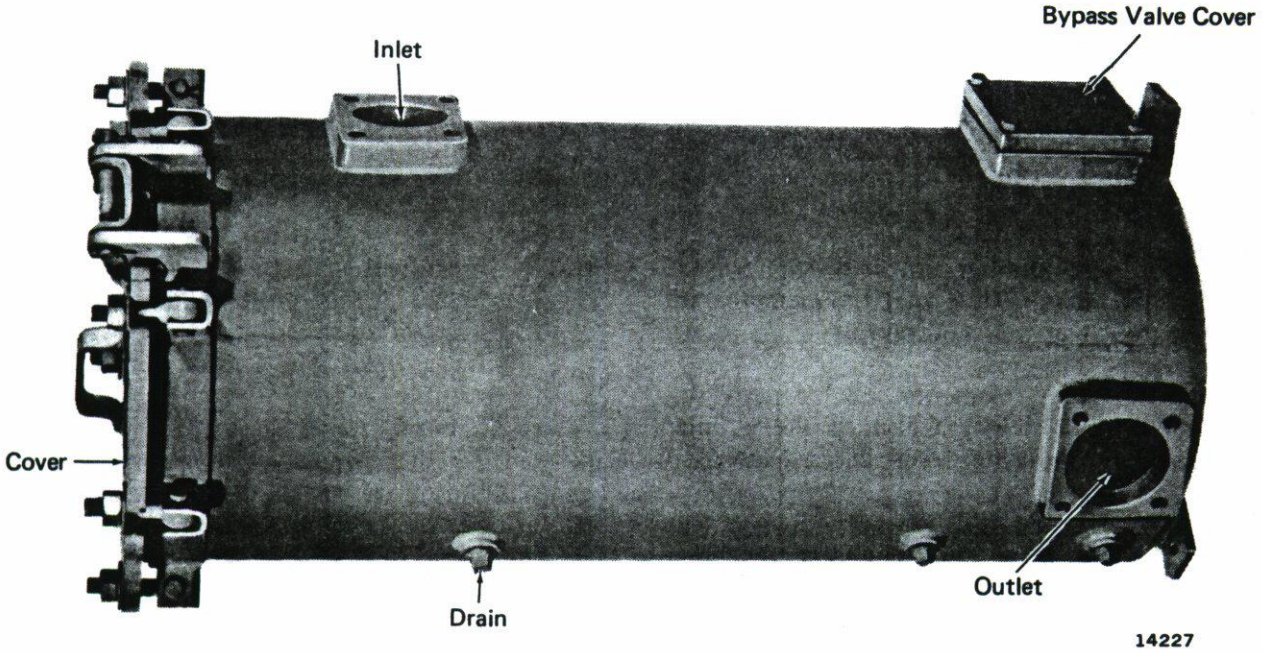


Fig. 2-6– Four Element Lubricating Oil Filter Assembly

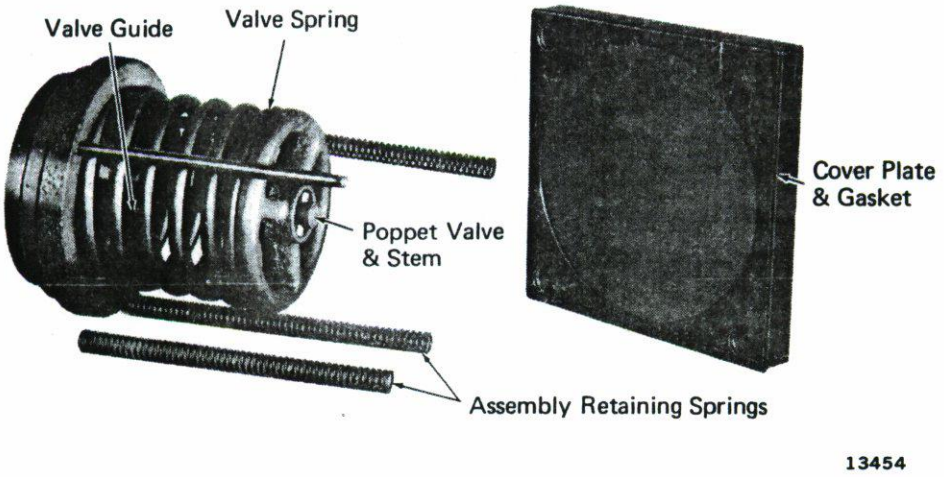


Fig. 2-7– Filter Bypass Valve Assembly

HOT LUBRICATING OIL DETECTOR

A thermostatic valve located on the outlet elbow from the main lube oil pump is calibrated to open when lube oil temperature reaches nominally 127°C. At this temperature the probability exists that either the lube oil cooler is plugged on the water side, or steam pressure in the cooling system is preventing engine shutdown by the low water detector.

Start to Open Temperature °C	Full Open Temperature °C
122.2 - 125	135

When oil temperature causes the valve to open, pressure to the oil pressure sensing device in the engine governor is dumped. The device sees low pressure and reacts to shut the engine down. The thermostatic valve is not latching, and it will reset automatically when oil temperature falls. Do not attempt to restart the engine until cause of shutdown is determined and the governor low oil plunger is reset.

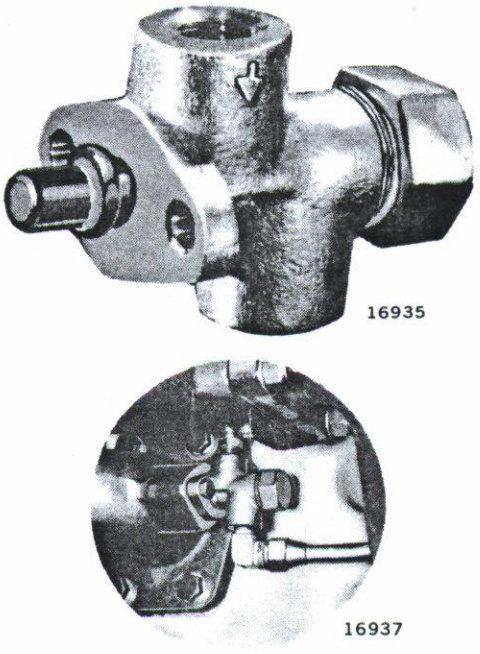


Fig. 2-7– Hot Oil Detector Thermostatic Valve

CAUTION: After it has been determined that hot oil is the cause for engine shutdown, make no further engine room inspections until the engine has cooled sufficiently to preclude the possibility that hot oil vapor may ignite.

When a low oil shutdown occurs, always inspect for an adequate supply of water and oil. Also check engine water temperature. Do not add cold water to an overheated engine.

HOT OIL DETECTOR QUALIFICATION TEST

Remove detector from engine and test as follows:-

1. Connect air lines to and from valve so that flow is in the direction of arrow.
2. Place valve in an agitated liquid bath so that half the valve body is immersed. (Dow glycerine, USP 96% recommended).
3. Heat the bath. When the bath reaches 113°C, the rate of rise must not exceed 1°C per minute.
4. Apply 345 kPa air pressure and observe for leaks. Leaks between the valve body and cap are not permissable.
5. At 121°C the maximum rate of leakage is 283 litres per hour.
6. Remove air flow to avoid chilling.
7. Raise temperature to 126°C.
8. Turn on air. Minimum rate of flow to be 566 litres per hour.

QUICK DISCONNECT FITTING

The lube oil filter tank cover is equipped with a male quick disconnect fitting, Fig. 2-9 to accept a female coupler. The fitting facilities application of a pressure gauge to monitor filter tank pressure, which indicates the condition of the filter elements. Part numbers for the quick disconnect fittings are provided in the Service Data pages.

Fig. 2-8 - Lube Oil Filter Quick Disconnect Fitting Application

Periodic pressure readings will help prevent undue engine wear by alerting the maintenance crew when filter element plugging and bypass are about to occur. If a locomotive has a short filter element life, there may be water leaks or a heavy dirt load. The engine probably needs maintenance.

Pressure checks are to be made weekly or more often at fueling or turn about points before the locomotive is at the ready track. Readings must be taken with lube oil temperature at least 66°C (54°C water temperature into the engine). The engine may be loaded or unloaded. Filter elements must be renewed if filter tank pressure reaches:-

172 kPa at throttle position No. 8 engine speed.

48 kPa at idle speed

Readings taken at throttle No. 8 engine speed are the most reliable. Therefore, if a marginal reading is obtained at idle engine speed, verify filter element condition at No. 8 Engine Speed.

CENTRE BEARING LUBRICATION

2 litres all purpose lubricating oil, per M.I. 1756, should be added to the truck centre bearing at the interval indicated in the Scheduled Maintenance Program.

LUBRICATION AT TIME OF TRUCKING

Remove oiler pipe plugs, Fig. 2.9 before trucking or untrucking the locomotive. Apply oil as follows.
If the bearing is dry, add enough oil to cover the centre bearing wear plate, and add another 2.5 litres after the unit is trucked. Re-apply oiler pipe plugs after unit is trucked and oiled.

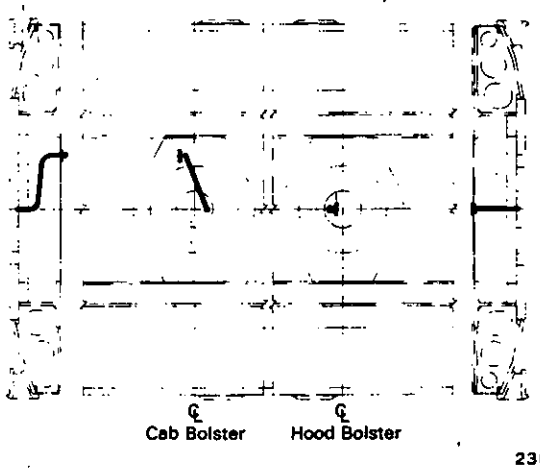


Fig. 2-9 - Center Bearing Oiler Pipe Location

SERVICE DATA

LUBRICATING OIL SYSTEM

REFERENCES

Lubricating Oil Filter Maintenance	M.I. 926
Lubricating Oil Cooler Maintenance	M.I. 927
Lubricating Oil Qualified for 645E Engines	M.I. 1752
Lubricant Specifications	M.I. 1756

ROUTINE MAINTENANCE PARTS AND EQUIPMENT

FILTERS

Lubricating Oil Filter Assembly	8373237
Pleated Paper Filter Elements (4 per housing)	8345482
Bypass Valve Port Cover Gasket	8296030
Quick Disconnect Fitting	8367564

Kit; Lube Oil Tank Pressure Test
(0-689 kPa gauge, hose and nipple coupler)

NOTE: It is recommended that qualified spare bypass assemblies be kept available for scheduled maintenance replacement

Poppet Valve	8322839
Valve Guide	8322840
Valve Spring	8317190

SPECIFICATIONS

Weight required to compress the filter bypass valve spring 8317190 to a height of 92 mm must be not less than 191 kgs or more than 227 kgs (This is the 276 kPa spring).

Lubricating Oil System Capacity	920 litres
Lube Oil Cooler Bypass Valve Opens at	552 kPa

Maximum Allowable Filter Tank Pressure

	Full Speed Pressure	Idle Speed Pressure
Units Equipped with Tube and Fin (Rectangular) Oil Coolers	172 kPa	48 kPa
Units Equipped with Shell And Tube (Cylindrical) Oil Coolers	345 kPa	103 kPa

EMD SERVICE DEPARTMENT

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COOLING SYSTEM

The cooling system is pressurised to provide uniform cooling throughout the operating range of the diesel engine. A schematic diagram of the system is shown in Fig. 3-1. Coolant is pumped by the engine mounted pumps from the cooling water expansion tank and lubricating oil cooler assembly and into the engine. The heated water leaves the engine and flows through the radiator assembly where it is cooled. The cooled water returns to the oil cooler to repeat the cycle.

Part of the water from the engine mounted water pump is piped to the air compressor. There are no valves in the line, thus air compressor cooling will be provided whenever the engine is running. Upon leaving the air compressor, water is pumped through a temperature switch manifold, then back to the water tank for recirculation. Temperature sensing elements located in the manifold operate switches that control radiator fan operation and a hot engine alarm. The water tank filler is located on the roof top of the locomotive and water is allowed to flow into the top of the water tank. The engine and air compressor drain valve is located between the engine and the engine accessory rack on the right hand side.

CAUTION ; Allow all valves to remain open until the system is completely drained. Do not close a valve independently when its discharge stops.

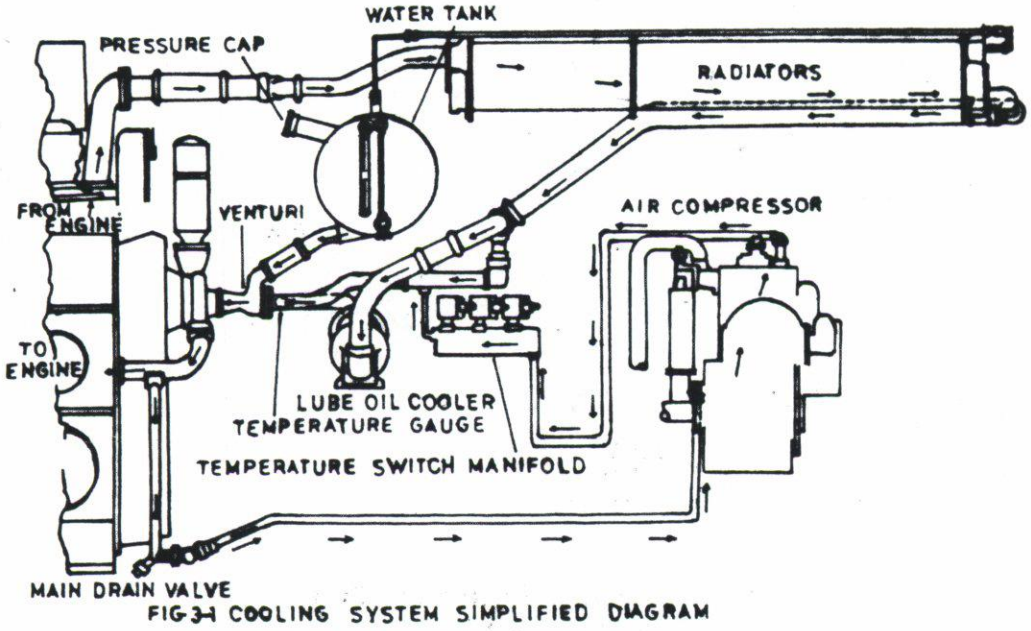

FIG 3-1 COOLING SYSTEM SIMPLIFIED DIAGRAM

TEMPERATURE CONTROL

During circulation through the diesel engine and air compressor, the cooling system water picks up heat which must be dissipated. This heat is dissipated and the water temperature controlled by means of a radiator assembly and AC motor driven cooling fans. The radiators are assembled in a hatch in the top of the long hood end of the locomotive. The hatch contains radiator Sections which are grouped in two banks. Two A. C. motor driven cooling fans which operate independently are located in the roof above the radiators. They are numbered 1 and 2 from front to rear with the No. 1 fan being closest to the cab.

Temperature control switches, Fig. 3-2 are designated TA and TB. These switches are located at the equipment rack and are flange mounted to a manifold located in the cooling system piping. As the water discharges from the compressor it passes through the manifold where it acts upon thermal elements that causes the switches to respond and establish electrical circuits to cooling fan contactors. A third switch, ETS, responds to overheating. It sounds on alarm and reduces engine speed and load.

The cooling fan contactors are designated FC1 and FC2. These contactors are located in a cabinet mounted below the radiator structure on the right hand side of locomotive. When energised they electrically connect their respective AC cooling fans to the alternating current supply from the alternator to run the fans.

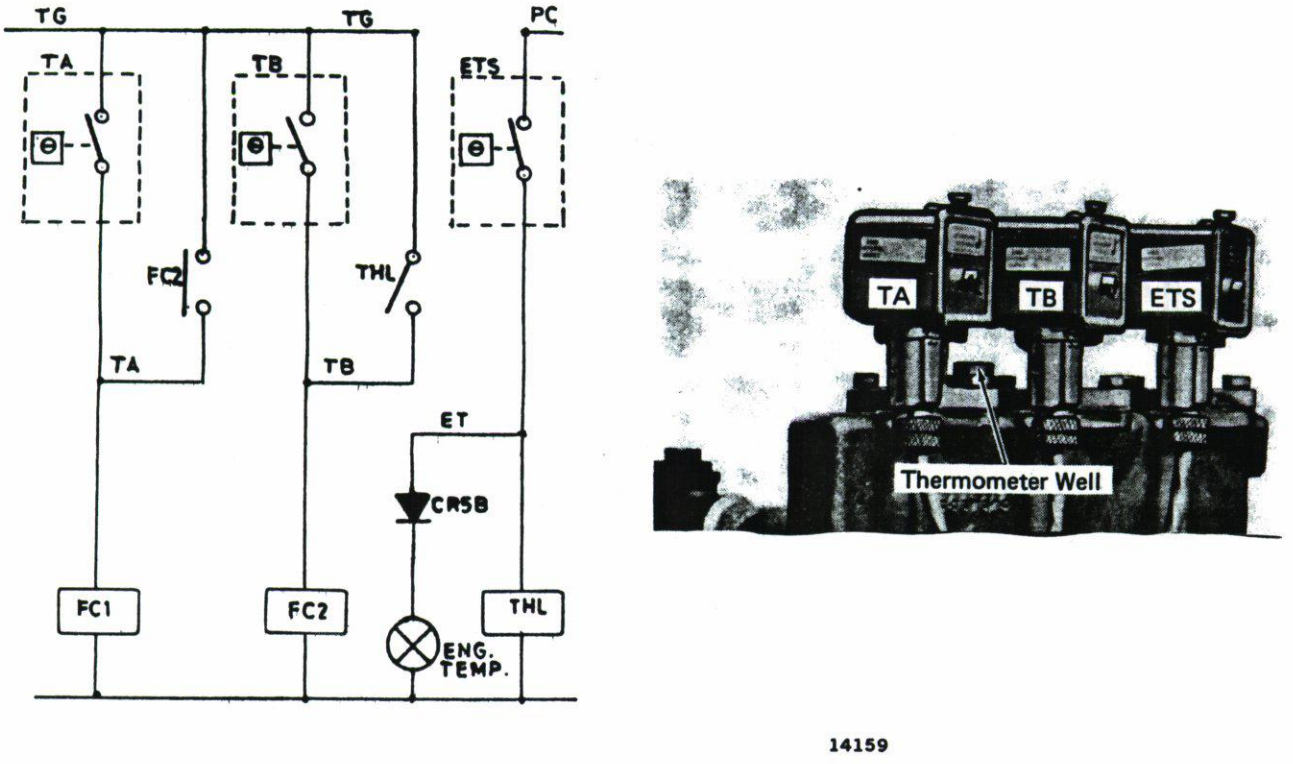

Fig. 3-2 – Engine Temperature Switch And Circuit Diagram

FAN CONTROL

TA picks up first. This energises FC1, which starts the No. 1 cooling fan. If the temperature of the water continues to rise TB picks up. This energises FC2, which starts No. 2 fan and also completes the holding circuit to FC1.

Once started both fans operate until TB drops out to break the holding circuit.

The operating temperatures of TA and TB are given on the Service Data page, and on the switch nameplate. Part numbers of the switches are listed in the Locomotive Wiring Running List.

HOT ENGINE ALARM

A hot engine alarm switch ETS will close when water temperature at the outlet from the engine approaches the boiling point of water in the pressurised system. This is not the temperature at the switch sensing element. There is heat loss between the engine outlet and the temperature switch, therefore the switch is calibrated to pick up at a lower temperature. This temperature is close to the normal boiling point of water, but much lower than the boiling point of water in the pressurised system.

When the switch picks up, the Engine Temperature light on the Fault Light will come on in the unit affected. Pick up of ETS will also energise a throttle limit relay THL. This relay operates to light the hot engine indication on the annunciator and to reduce engine speed and power. The reduction of power facilitates engine cooling, and the reduction of engine speed reduces the possibility of cavitation at the water pumps. The return to full power and speed can be accomplished only by reducing cooling system temperature to a normal level.

Engine water temperature may be readily checked by means of a gauge located in the water inlet line leading to the left bank water pump. The gauge is colour coded to indicate COLD (blue), NORMAL (green), and HOT (red), engine temperatures.

A more accurate check of engine water temperature may be obtained by placing a thermometer in the thermometer well located on the temperature switch manifold, Fig. 3-2. The proper operating temperature for the engine temperature switch is given on the temperature switch nameplate and is given on the Service Data page. The switch part number can be verified on the locomotive wiring running list.

As a backup to ETS action, a hot oil detector is located on the outlet elbow of the main lube oil pump.

Should ETS fail to reduce engine temperature and a boiling condition creates pressure that prevents low water detector trip, oil temperature will increase. A thermostatic valve will dump pressure oil in the line to the governor low oil pressure detector and bring about engine shutdown.

The thermostatic valve will reset automatically after the hot oil cools, but it is recommended that no attempt be made to start the engine after a hot oil shutdown until a thorough engine inspection is made by qualified personnel.

WARNING; After it has been determined that hot oil is the cause for engine shutdown, make no further engine room inspections until the engine has cooled sufficiently to preclude the possibility that hot oil vapor may ignite.

COOLING SYSTEM PRESSURIZATION

The cooling system is pressurised to increase the boiling point of the coolant and prevent cavitation at the water pumps during transient high temperature conditions, such as operation through long tunnels. A pressure cap, on the water tank filler pipe opens at approximately 48 kPa to relieve excessive pressure and prevents damage to cooling system components. The cap is also equipped with a vacuum breaker valve that operates as the system cools. Refer to the Service Data page for pressure cap operating limits and identifying numbers.

The pressure cap is equipped with a handle that facilitates application and removal, but more importantly it interlocks with the fill/relief valve handle. This ensures that system pressure is released through the fill/relief pipe before the cap can be loosened.

WARNING; Always relieve system pressure before attempting to remove pressure cap or water tank plugs.

LOW WATER SHUTDOWN

A low water detecting device, Fig. 3-3, balances water pressure against air box pressure. When water pressure falls, the device dumps oil from the governor supply line, causing an engine shutdown. When a low water shutdown occurs, the low water button pops out to display a red band, the low oil plunger on the governor protrudes and the governor shutdown light on the annunciator module comes on.

While there is no air box pressure when an engine is shutdown, there is spring pressure.

This spring pressure must be acted against by water pressure in order to keep the device latched in. On certain devices the static water pressure working against spring pressure will not keep the device latched in when the engine is shut down. This is not necessarily an indication that the device is defective. It is merely necessary to reset the device immediately after engine start.

If the low water detector latches in with the engine shut down, it still may trip at engine start, particularly when the engine is cold or after the pressure in the system has been released. The reason for the trip being that the water pumps may cavitate until water is drawn from the make up tank and distributed to the radiators, for proper circulation. Tripping at engine start is not an indication that the device is defective. It is merely necessary to reset the device immediately after engine start within about 50 seconds after trip during starting. If the device is difficult to reset, operate the injector rack manual control lever momentarily to speed up the engine, and then press the reset button.

Excess suction may damage the detector diaphram.

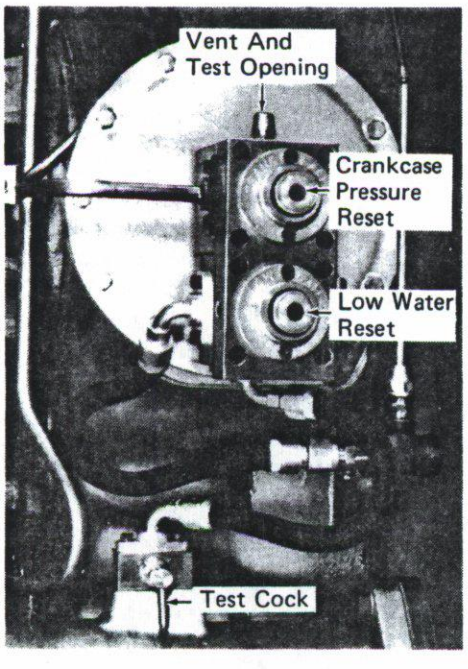

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Fig. 3-3 – Low Water And Crankcase (Oil Pan) Pressure Detector

OPERATING WATER LEVEL

An operating water level instruction Fig. 3-4 is provided next to the water level sight glass. The instructions indicate minimum and maximum water level with the engine running or stopped. The water level should not be permitted to go below the applicable "low" water level mark.

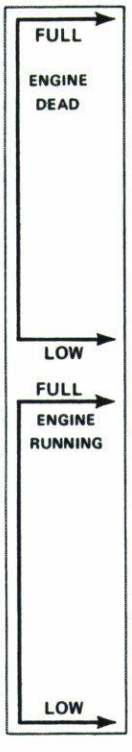

Fig. 3 4 – Typical Water Level Instruction Plate

Progressive lowering of the water in the gauge glass indicates a water leak in the cooling system, and should be reported. Normally, there should be no need to add water to the cooling system, except at extended intervals.

MAINTENANCE

FILLING THE COOLING SYSTEM

The coolant used in the engine cooling system should be made up and tested in accordance with the coolant Maintenance Instruction listed on the Service Data page.

CAUTION ; Do not overfill the tank. Overfilling can result in frozen radiators, and can constitute a hazard to personnel.

After filling a dry or nearly dry system, the engine should be run, with the filler cap removed, to eliminate any air pockets in the system. After running the engine, check the water level and if necessary add water to the system.

CAUTION ; Draining the cooling system will trip the low water shutdown device; therefore, when filling the cooling system the low water reset button must be pressed before engine start.

After filling operations have been completed and before starting the engine, the pressure cap must be replaced.

DRAINING THE COOLING SYSTEM

The engine cooling system should be drained immediately in the event that the diesel engine is stopped and danger of freezing exists.

To drain the system the engine and air compressor water drain valve is opened to drain the cooling system. This valve is located adjacent to the engine lube oil drain. All the valves on the system are tagged and open when the handles are in line with piping.

After system pressure is released, remove the water tank fill cap to allow drainage at an increased rate.

CAUTION ; If a hot engine is drained, always allow the engine to cool before refilling with fresh coolant.

OBTAINING AN ENGINE WATER SAMPLE

When a sample of engine coolant is desired, it should be obtained with the engine warm and running. The coolant should be taken from a point where water flow is turbulent. Allow the water to run a few seconds to drain off any accumulated sediment.

TESTING ENGINE WATER TEMPERATURE SWITCHES

It is recommended that a routine check of temperature switch operation be made at the intervals specified in the Scheduled Maintenance Program. A thermometer well is provided in the temperature switch manifold to facilitate testing.

Temperature switches, Fig. 3-5, are easily removed from the temperature switch manifold and replaced with new switches. If a replacement switch with a new gasket attached is held at a ready position, the old switch and gasket can be removed and the new switch inserted with only a small loss of engine coolant.

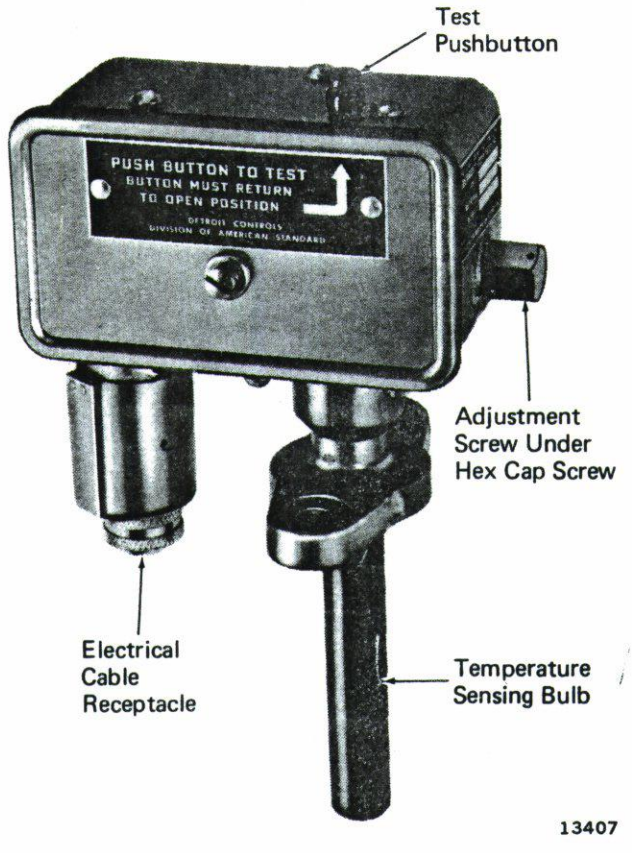

Fig. 3-5 – Engine Temperature Switch

On the locomotive, pickup and dropout of temperature switches can be checked by placing a thermometer along with some oil or water in the well located temperature switch manifold, Fig. 3-2 and loading the locomotive.

To facilitate the pickup check, disable fans by disconnecting the feed wires to the fan contactor coils. Use a test lamp at the disconnected leads to indicate temperature switch closure. The temperature switches will close in sequence TA, TB, ETS. When ETS picks up the Fault and Hot Engine lights will come on and, in Notches 7 or 8, Engine Speed and Load will be reduced. Record temperature at pickup of each switch.

After the visual alarms indications, reconnect the feed wires to the fan contactor coils in sequence FC2, FC1. Allow time for the first fan to come up to full speed before starting the other fan.

When temperature comes down and ETS drops out, engine speed and load will increase. Record ETS drop-out temperature, then reduce throttle to Notch 5 and place the generator field switch in the OFF position to drop load. Record engine water temperature as each fan contactor drops out.

The correct part numbers for replacement switches are listed on the Service Data page and in the "Locomotive Wiring Running List", supplied with the locomotive wiring diagrams.

After replacement switches are installed and the engine is running, press the switch test pushbuttons in sequence to verify fan operation.

CAUTION ; Do not press switch test pushbuttons simultaneously. Allow time for a given fan to pick up speed before pressing the test button to bring in the other fan.

Instructions for checking the temperature switches are referenced on the Service Data sheet, and plans for construction of bench testing apparatus can be obtained from the Clyde Engineering Service Department upon request. Note that in any test of temperature switches, critical factors such as circulation of the test bath to prevent stratification, immersion of the temperature bulb to a proper depth, and ambient temperature approximating engine room conditions must be observed.

INDICATIONS OF FAULTY SWITCH OPERATION

1. False hot engine indication due to incorrect ETS pickup.
2. Low oil shutdown due to hot engine oil. A fault exists in the cooling system and ETS did not operate properly.

NOTE; Hot lube oil can be caused by a plugged lube oil cooler. In such a case a hot engine alarm will precede the hot oil shutdown.

3. Temperature switch cycling and picking up too soon after drop out. If the switch opens during a starting, fan contactor tips may be damaged. It is possible for the tips to weld closed. Damage to fan motors and the D14 alternator is also possible.
4. Two fan contactors must not pick up at the same time. If this occurs, switches may be operating improperly or an incorrect switch is installed. The strong starting surge resulting from such a condition can cause damage to the D14 Alternator. The condition can be noted at the layshaft as the fans come in.
5. A cold engine may result from welded fan contactor tips or from sticking temperature switch pushbuttons.

INSPECTION AND CLEANING OF RADIATORS

The access covers between the engine room and the radiator compartment must always be securely clamped in place during locomotive operation. If a cover is not in place, improper circulation of cooling air will result, and the slight pressurisation of the engine room provided by cooling air from the main generator will be lost.

Periodic inspection and cleaning of the radiators should be performed at the minimum intervals called for in the Scheduled Maintenance Program, at more frequent intervals as determined by operating conditions or when trouble is suspected. Since the pressurised system will rarely require addition of water, any progressive lowering of the water level indicates that an inspection should be made for leaks. Inspect carefully for small leaks called "weep" at the junction of the radiator tubes and header.

Normally, the application of clean dry compressed air to the top surface of the radiators, followed by reverse operation of the cooling fans will satisfactorily clean the radiator cores and radiator compartment.

Reverse operation of cooling fans can be easily accomplished by interchanging the position of two A.C. leads that are bolted to the buses connecting to the fan contactors in the A.C. cabinet. The leads are indicated on Fig. 3-6. After the A.C. leads are reversed fan operation can be controlled by pressing the test pushbuttons on the manifold-mounted engine water temperature switches, Fig. 3-2.

CAUTION ; When using fan test pushbuttons, be careful not to accidently release a button during the starting surge of current and be sure to allow a given fan time to speed up before pressing another button.

Make sure that the A.C. cables are returned to their proper connection points after radiator cleaning is completed.

PRESSURE CAP

The pressure cap should be inspected, tested and replaced at intervals indicated in the Scheduled Maintenance Program. Refer to the Service Data page at the end of this section for replacement part numbers.

INSPECTION AND REPLACEMENT

1. If the pressure cap bell housing or other metal surfaces are bent, replace the entire cap with a new cap. Fig. 3 indicates how the cap pressure can be determined from the handle configuration. Provide seal and wire for use after cooling system filling if required by railway regulations.

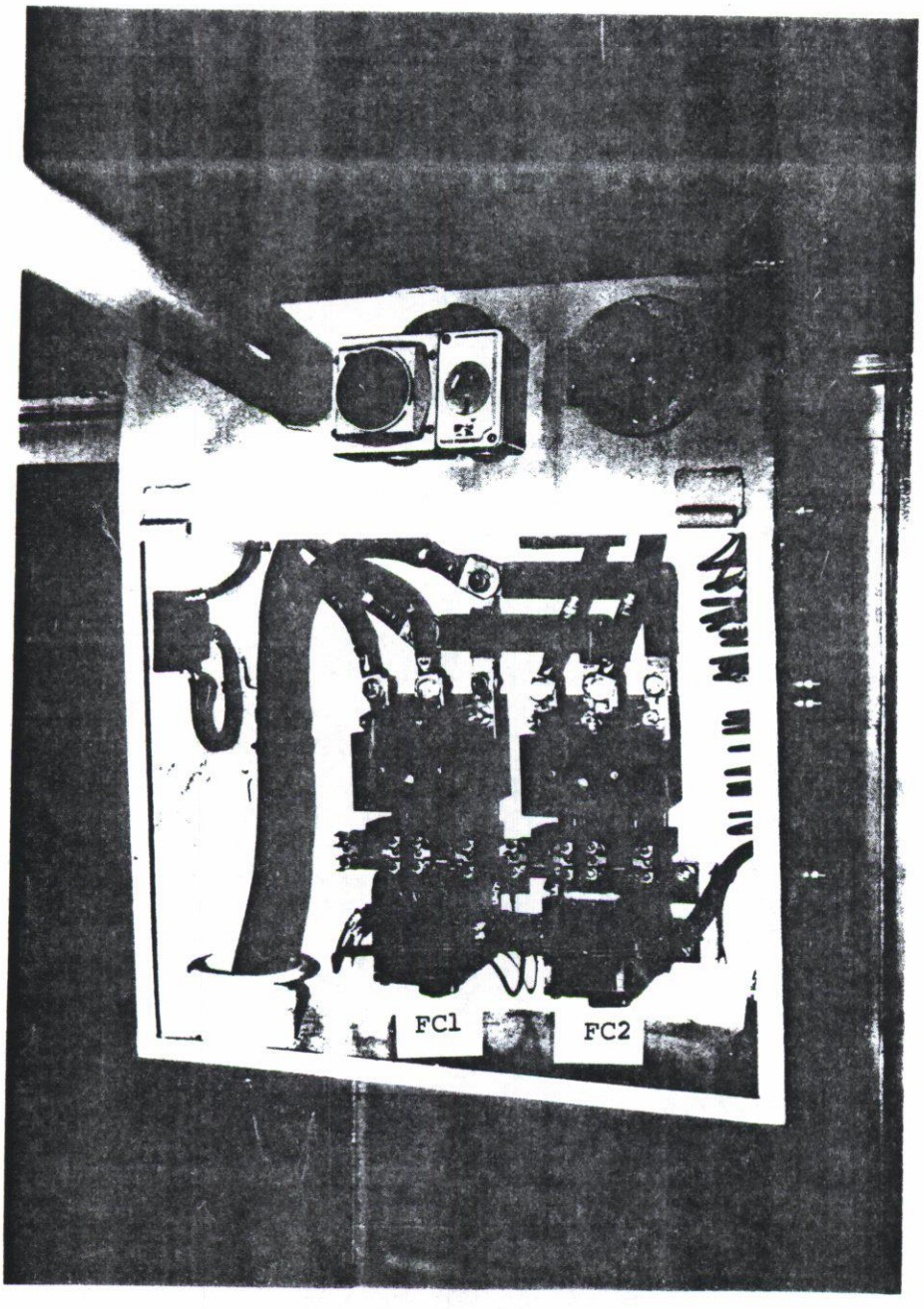

FIG.3-6. A.C.FAN CABINET

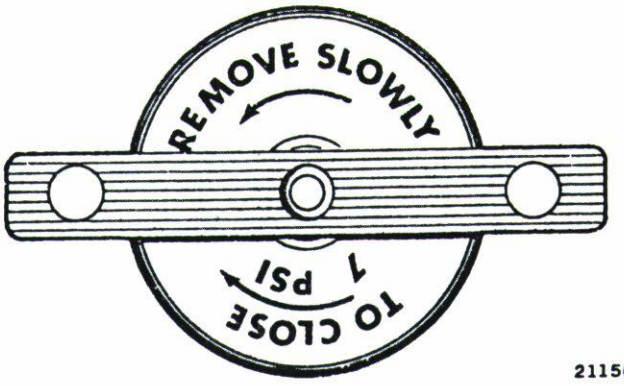

Fig. 3-11 – Cooling System Pressure Cap

2. If seals are hardened or damaged, replace the cap with a new cap.

NOTE; Rebuild of pressure caps is not recommended.

Perform a pressure test to qualify the pressure cap.

PRESSURE TESTING

Should it become necessary to pressure test the cooling system the following procedures are recommended.

Quick disconnect fittings can be provided on the water tank and in the air system piping at the equipment panel located below the water tank. A locally fabricated testing apparatus, Fig. 3-8 can be used to pressurise the cooling system with main reservoir air while the diesel engine is running and coolant is at normal level.

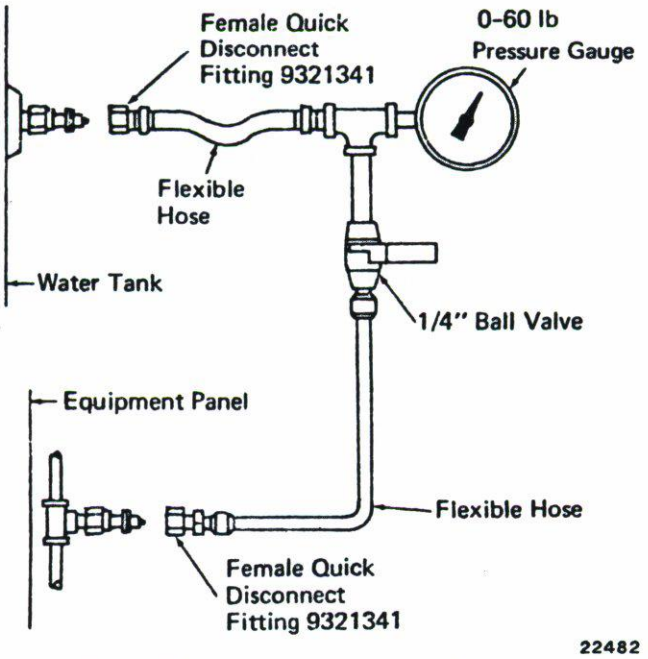

Fig. 3-12 – Cooling System Pressure Test Apparatus

WARNING ; Do not subject the water tank to pressure greater than 345 kPa.

1. Using the testing apparatus, operate the ball valve to gradually pressurise the cooling system to about 34.5kPa above pressure cap opening pressure.

   Pressure cap tolerances are as follows:-

   a. 48 kPa Cap — Min. Opening Pressure - 34.5 kPa
   Max. Opening Pressure - 55 kPa

   b. 82.5 kPa Cap — Min. Opening Pressure - 68 kPa
   Max Opening Pressure - 89.5 kPa

2. Close the ball valve and observe the pressure gauge. Pressure should drop slowly until the pressure cap closes. Pressure should then remain constant. Gauge pressure is the cap opening pressure.

3. If cap opening pressure is not within the allowable tolerance, replace the cap with a new cap and repeat the test.

4. If gauge pressure does not remain constant and the pressure falls below the allowable minimum, perform the following:-

   1. At the discharge end of the water tank overflow pipe, place a container of water so that the water level is above the end of the pipe. Observe for air bubbles. The pressure of air bubbles indicates a defective cap. Relieve system pressure, replace the cap with a new cap, and repeat the test.

5. If the above step does not detect or eliminate leakage, as indicated by a continuous drop in gauge pressure, inspect the radiators and the cooling system piping connections.

SERVICE DEPARTMENT

SERVICE DATA

COOLING SYSTEM

Temperature Control and Hot Engine Alarm Switches ..... M.I. 5511
Engine Water Treatment ..... M.I. 1748
Maintenance and Qualification of Low Water Detector ..... M.I. 259
Cooler, Lube Oil ..... M.I. 549: M.I. 927

Low Water Detector Qualification and Testing Apparatus 8349133
Gasket - Temperature Switch to Manifold 8314926
Thermometer Well 1/4" NPT 8268162
Water Tank Pressure Cap Assembly
48 kPa (Basic) 9087321

Temperature Switch Settings

Switch	Pickup	Dropout	Part No.
TA	68° ± .8°C	60° ± 1.1°C	8441557
TB	77° ± .8°C	68° ± 1.1°C	8441559
ETS	98° ± .8°C	90° ± 1.1°C	8448173

NOTE: A temperature switch identified as TB on one model locomotive is not necessarily of the same temperature setting as a switch identified as TB on a different model locomotive.

Engine temperature switches are installed with a 9 °C nominal difference between set points to provide a time interval between fan motor starts. Two companies currently supply temperature switches to E. M. D. The set points of these switches vay with atmospheric pressure, but not to the same degree.

All temperature switches applied to a locomotive operated at 1825 m or above must be made by the same manufacturer. Whenever an alternator or fan malfunction occurs, the temperature switches should be checked for mixed application and/or proper calibration.

CENTRAL AIR SYSTEM

DESCRIPTION

Air is drawn into the carbody (hood) of the locomotive to supply three separate systems.

1. Engine cooling system.
2. Dynamic Brake Grid cooling.
3. Central system for motor and generator cooling, engine fuel combustion and air compressor intake.

This section of the locomotive service manual covers the central system.

Air enters the carbody through panel type filters which are mounted in frames on the hood doors adjacent to the motor and generator blowers, engine air intake and compressor air intake. The filters are located on each side of the hood, Fig. 4-1.

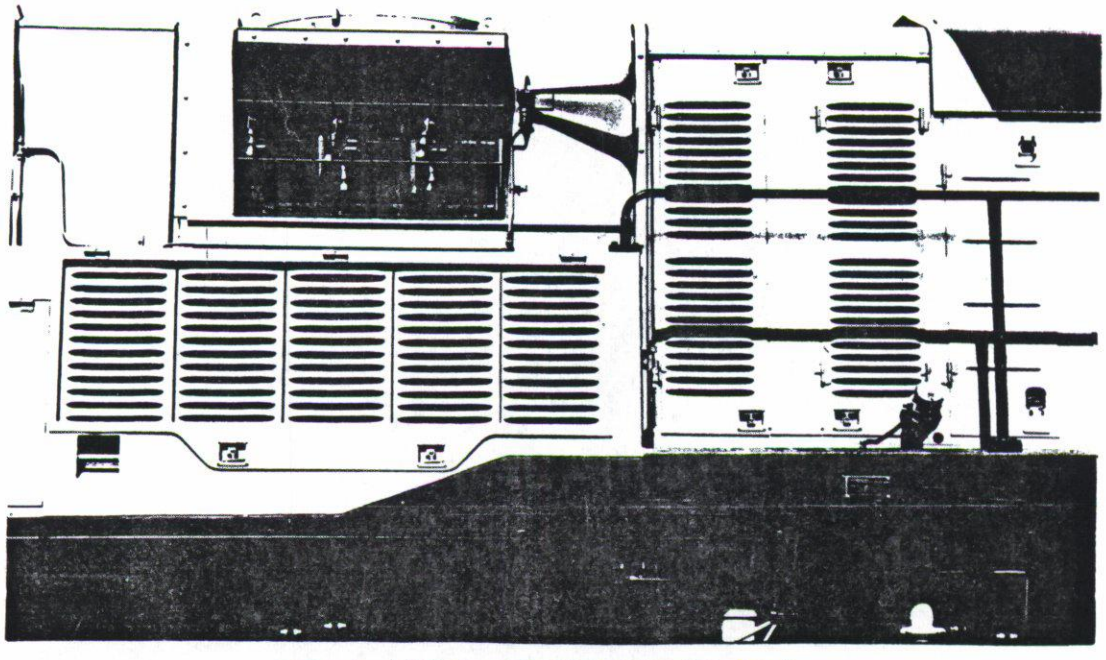

FIG4 1 FILTER LOCATION (CARBODY)

CONSTRUCTION AND OPERATION OF PANEL TYPE CARBODY FILTERS

The panel type carbody filters are 2" thick and constructed of specially formed wire mesh, enclosed within a steel frame and protected by a coarse screen. Air being drawn through the filter impinges on the wire mesh which causes it to change directions many times. In order to remove and hold air-borne contaminants such as dust, dirt, and sand the wire mesh is coated with a tacky adhesive gel.

In operation, air flows through the filter, and the air-borne contaminants impinge upon the coated surfaces of the wire mesh. These surfaces hold the dust and dirt particles while the clean air passes through the filter.

INSPECTION AND MAINTENANCE OF PANEL TYPE CARBODY FILTERS

The effectiveness of impingement type filters is entirely dependent upon their ability to hold contaminants on the coated wire mesh surfaces. As these surfaces become "loaded" with dust and dirt, the cleaning efficiency is reduced to a point where ultimately, the dirt laden air will be permitted to pass through the filter. It is also possible for the filters to become "loaded" to the point that they actually become plugged. This not only could allow unfiltered air to bypass the filters, but could cause a reduction in air supply to the blowers which in turn could result in damage to motors and generators, due to overheating.

To retain high filter efficiency they should be removed, cleaned, and recoated at intervals frequent enough to prevent them from becoming "loaded" in operation. Cleaning intervals are recommended in the applicable Scheduled Maintenance Program.

The filters are retained in their frames by spring clips and are easily removed, Fig. 4-2.

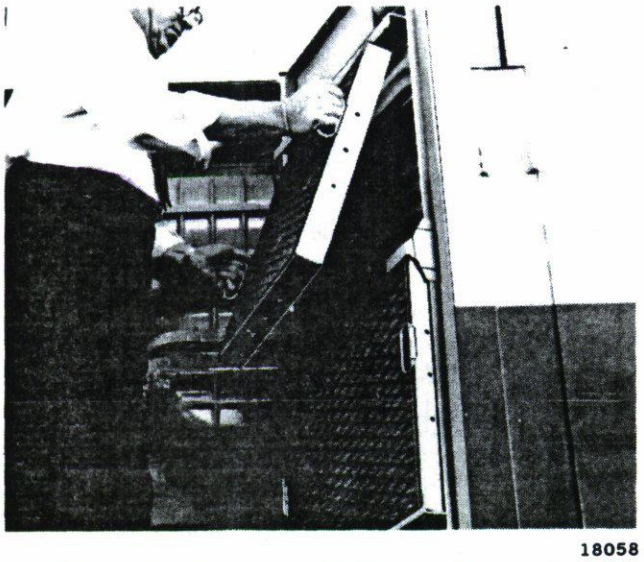

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Fig. 4-2 – Removal Of Filters (Carbody)

The proper cleaning procedure is outlined in Maintenance Instruction 435.

ENGINE AIR FILTER

GENERAL DESCRIPTION

An engine air filter is mounted on both sides of an adapter which is secured to the top of each blower on the engine, Fig. 4-3. The engine air filter is an oil bath unit that relies upon oil-wetted media to remove dirt particles from the air that is drawn through it. The filtering media is both wetted and washed by filter oil that is drawn up to the filtering media.

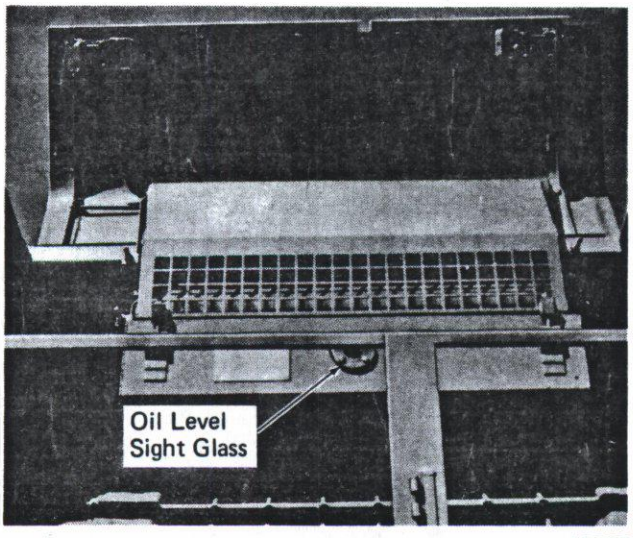

Fig. 4-3 – Engine Air Filter

FILTER OPERATION

Air is drawn in through an opening in the front cover of the panel, See Fig. 4-4. Here it strikes against an air deflector which divides the air so that a portion is diverted downward to the oil supply chamber. The air that has been diverted downward picks up oil and delivers it to the filter media before entering the engine. The balance of the incoming air supply goes through the oil wetted media where air-borne contaminants are deposited by impingement.

The constant flow of oil droplets down through the filter media carries dirt particles to the sump where they can settle and be subsequently drained away. This type filter, therefore, provides a self-cleaning action during operation.

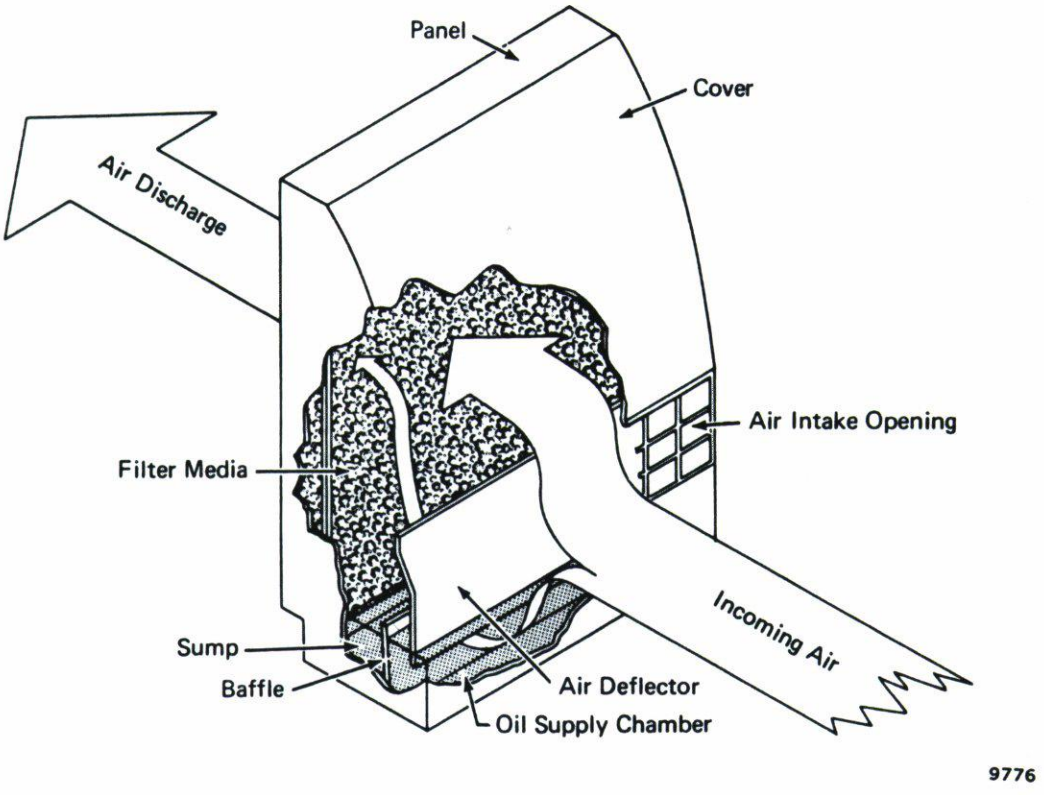

Fig. 4-4 – Panel Type Oil Bath Filter

MAINTENANCE

Operation of the engine oil bath filters should be checked at intervals stipulated in the Scheduled Maintenance Program. Filter oil should be changed and the filters cleaned at stated intervals or at shorter intervals if operating conditions warrant. Filter oil must be of the type indicated on the Service Data page.

OIL LEVEL

A sight glass, Fig. 4-3, is located at the lower front portion of each filter. Oil level after the engine has been shut down for a half hour should be at the centre of the sight glass. If frequent addition of oil is necessary, an investigation should be made to determine where the oil is being lost.

Under normal conditions, there should be no need to add oil between scheduled oil changes.

CLEANING THE FILTER

At prescribed intervals, the drain plugs should be removed and the filter sumps drained of all oil and sludge.

After draining and replacing plugs, refill with oil to proper level through the opening provided in the front cover.

The entire filter panel assembly should be removed from the adapter for thorough cleaning. With the front cover removed, the filter media is exposed and should be washed with hot water. It should then be totally immersed in an alkaline or solvent type cleaner to loosen imbedded dirt from the filter media and oil sump.

After cleaning, again wash with hot water to remove all traces of cleaning solution. Then dry with air, inspect carefully and reinstall using a new filter to adapter gasket. (See Service Data pages). Fill with oil and the filter is ready for another service cycle.

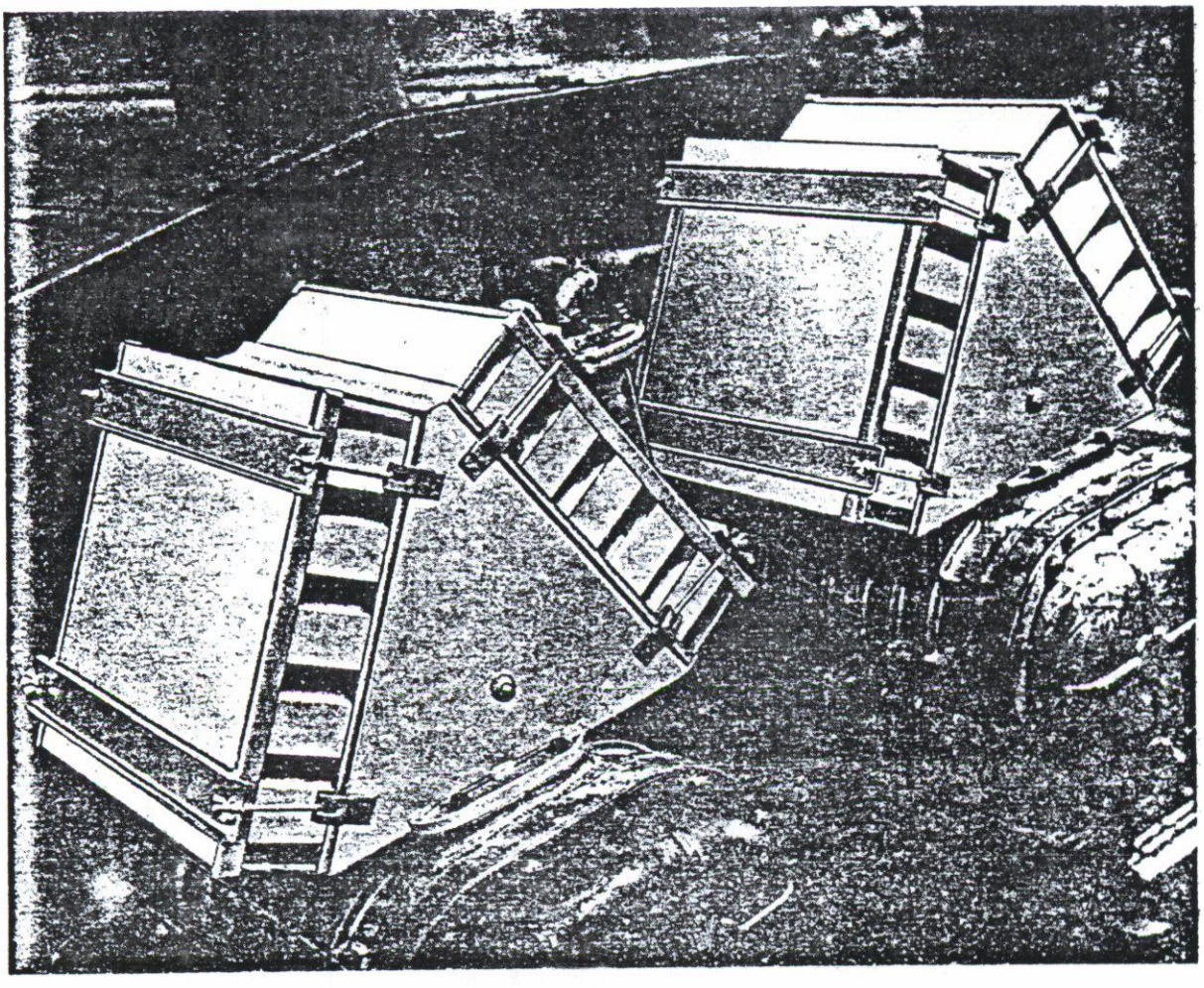

FIG4-5 DYNACELL ENGINE AIR FILTERS

DYNACELL FILTERS

Locomotives from and including 2462 use dynacell engine air filters. As opposed to the oil bath filters the dynacell air filter elements are made of paper. These types of filters are 99.95% efficient and are easily replaced. The elements are comparatively light weight.

FILTER OPERATION

The engine blower draws filtered air from the generator compartment, through the engine air filter elements to the output side of the engine air filter compartment. Air is then forced into the engine for fuel combustion.

A filter vacuum switch (FVS) is mounted inside the electrical control cabinet on the bulkhead at the right. The LO port of the switch is connected through tubing to the output side of the engine air filters. The HI port side of the switch is connected through tubing to a vent on the outside of the electrical control cabinet. This vent is open to atmosphere. Therefore, FVS monitors the depression at the output side of the engine air filters. The contacts of FVS close if this depression increases to 457 $\pm$ 13 mm (18 $\pm$ $\frac{1}{2}$") H_2O. Closing of the FVS contacts provides a feed to a latching relay in the annunciator panel.

Pickup of this relay provides a feed to the engine air filter light on the annunciator panel in the electrical cabinet.

Turn on of the engine air filter light indicates that the engine air filters probably require changeout. However, to ensure proper filtration, the engine air filters and the carbody air filters should be changed out as specified in the Scheduled Maintenance Program. The engine air filter light indication should not be used to determine filter changeout requirements of the fibreglass bag type engine air filters.

Transient conditions such as wet filter elements, snow plugged or ice plugged inertial or carbody filters may result in an engine air filter light indication. A defective FVS may also result in an engine air filter light indication. Therefore, it is recommended that manometer readings be taken where the filters are dry to determine condition of the filters. The FVS switch should also be tested periodically or whenever false indications are suspected. Procedures for taking manometer readings and testing FVS are provided in the following paragraphs.

CHECKING DEPRESSION AT OUTPUT OF ENGINE AIR FILTER

Depression at output of engine air filter may be checked when operating conditions or appearance of the filters indicate the need of such a check are provided in Steps 1 through 8 below.

NOTE: On special order a hose stem for taking filter depression readings is located on the front of the electrical cabinet.

1. Disconnect the hose connected at the LO port of FVS and connect the hose to a U-tube manometer or other vacuum measuring device, Fig. 4-5.

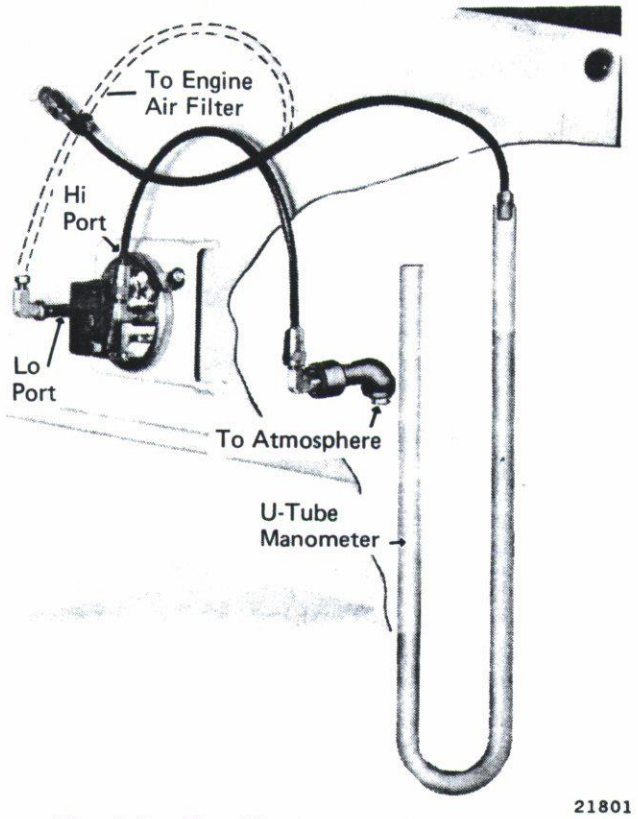

Fig. 4-5—Checking Depression At Output Of Engine Air Filter

2. Operate the engine until warm, then with reverser handle in neutral position, test switch in CIRCUIT CHECK position, and battery field circuit breaker open, advance throttle to No. 8 position and determine manometer indication. Loading is not necessary.

3. If manometer indication is less than the minimum specified on the Service Data page, ensure that all central air compartment panels, partitions, and cover plates are properly applied and that no air is bypassing the carbody filters.

4. When the filters are clean, the depression should be near the minimum value specified on the Service Data page. The engine air filters should be changed out if the depression reading exceeds the maximum value specified on the Service Data page.

5. Return throttle to idle position and disconnect manometer, then reconnect hose to LO port of FVS.

NOTE: Electrical compartment pressure reading may be taken by performing Steps 6 through 8.

6. Connect manometer to the ELECTRICAL CABINET hose stem located at the front center of the electrical cabinet.

7. Ensure that all cabinet doors are properly latched, then advance throttle to No. 8 position and observe manometer indication.

8. The electrical cabinet filters should be changed out if the manometer indicates less than the value specified on the Service Data page.

CHECK AND ADJUSTMENT OF FVS

Check and adjustment of FVS may be performed with engine running or shut down. If performed with engine running it will be necessary to disconnect the hose from LO port of FVS and open one door of the electrical cabinet while performing check and adjustment. Perform check and adjustment in accordance with Steps 1 through 6.

1. Connect voltmeter positive to COMMON and voltmeter negative to NORM OPEN contacts of FVS switch. The voltmeter should indicate 64 to 74 volts when the 13T wire is energised.

2. Connect a flexible tube to the atmospheric pressure reference port at the side of the electrical control cabinet and "Tee" the tube to a U-tube manometer, Fig. 4-6.

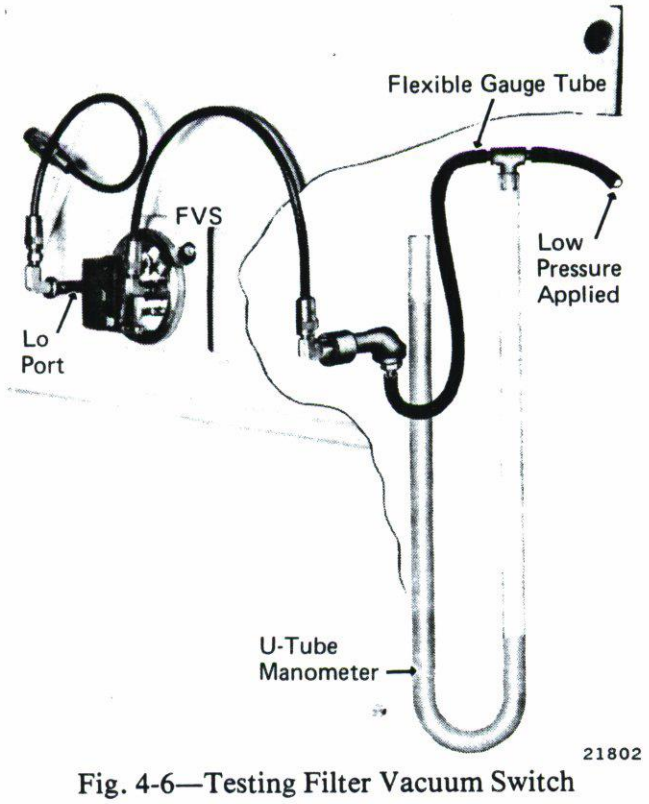

Fig. 4-6—Testing Filter Vacuum Switch

3. Apply low air pressure to the tube. This may be done by blowing into the tube. Voltmeter indication should go to zero when the manometer indicates 457 ± 13 mm (18 ± ½") H_2O.

4. If the switch does not operate as specified in Step 3, adjustment is required.

5. Turn the calibrating screw, Fig. 4-7, clockwise to increase trip value or counterclockwise to decrease trip value.

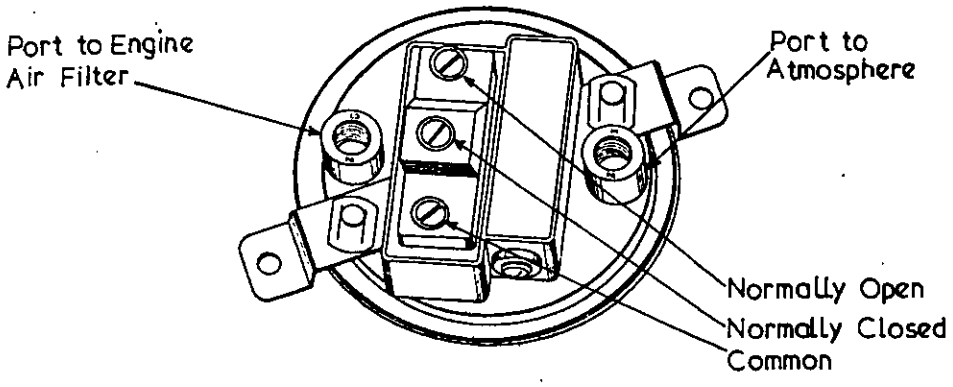

Fig. 4-7 — Filter Vacuum Switch

6. The FVS switch must be replaced if it cannot be adjusted to operate as specified in Step 3.

CAUTION: If the FVS switch is removed from the locomotive and is to be calibrated at a test bench, it is important to position the switch so that the diaphragm is in a vertical plane.

SERVICE DEPARTMENT

SERVICE DATA

CENTRAL AIR SYSTEM

ROUTINE MAINTENANCE PARTS AND EQUIPMENT

Carbody Panel Filters Element	F 2308434
Engine Oil Bath Filter Element	8273638
Engine Air filter Element (Dynacell)	9331434
Filter Vacuum Switch FVS	8490138

SPECIFICATIONS

Carbody Panel Filter

Adhesive Capacity	Approx 283 gms

Engine Oil Bath Filter

Oil Capacity	Approx. 3.8 litre
Above 32.2°C	SAE 40
Between 0°C - 32°C	SAE 20
Below 0°C	SAE 10
Filter Vacuum Switch FVS - 4	(457 ± 13 mm)H_2O Negative Pressure

COMPRESSED AIR SYSTEM

DESCRIPTION

Compressed air is used for operating the locomotive air brakes and auxiliary devices such as sanders, horn and windshield wipers.

AIR COMPRESSOR DESCRIPTION

Air is compressed by a water cooled, three cylinder two stage air compressor, Fig. 5-1. The compressor is driven through flexible couplings from the front end of the engine crankshaft.

The compressor has its own oil pump and pressure lubricating system. With the engine running, the oil level in the compressor crankcase can be checked on the dipstick. At idle speed with the lubricating oil at operating temperature (60°C), the oil pressure should be 124 to 172 kPa. A plugged opening in the relief valve block is provided for an oil pressure gauge.

The compressor is equipped with a dry type air inlet filter containing a replaceable element.

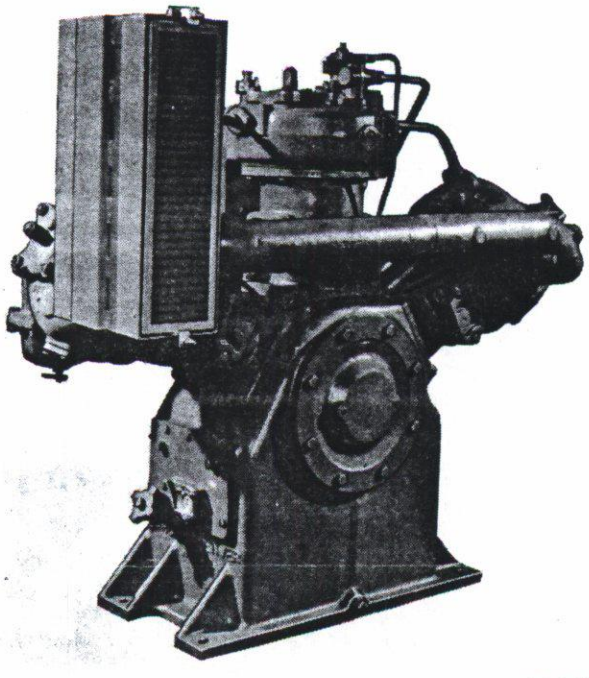

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Fig. 5-1 – Air Compressor

MAINTENANCE

The air compressor should be periodically checked to see that the lube oil dipstick is in the zone between FULL and LOW marks. If the dipstick indicates the oil level to be low approaching the LOW mark, a sufficient amount of E. M. D. approved lube oil should be added. The oil should be changed at intervals stated in the applicable Scheduled Maintenance Program. The addition of oil between changes is normally not necessary due to the high capacity of the deep crankcase.

When it is necessary to install a pressure gauge to check intercooler or lube oil pressures, be sure the gauge is removed and replaced with a plug and the plug tightened sufficiently to prevent loosening from vibration.

The air inlet filter element should be changed at intervals specified in the applicable Scheduled Maintenance Program. Consult the Service Data page at the end of this section for the correct replacement filter element.

To remove the element from the cylindrical shaped filter, remove the elastic stop nut and the retainer at the bottom of the filter. The element is then free to drop out of the filter body.

COMPRESSOR CONTROL SWITCH - CCS

DESCRIPTION

Since the air compressor is directly connected to the engine, the compressor is in operation (although not always pumping air) whenever the engine is running. An unloader piston that cuts out the compressing action when actuated by air pressure from the compressor control switch, Fig. 5-3 is provided in the head of each high and low pressure cylinder. The unloader accomplishes this by blocking open the intake valves in the high and low pressure cylinders. When the air operating the unloader is cut off, the unloader releases the intake valves and the compressor resumes pumping. Main reservoir air pressure is used to actuate the unloader valves.

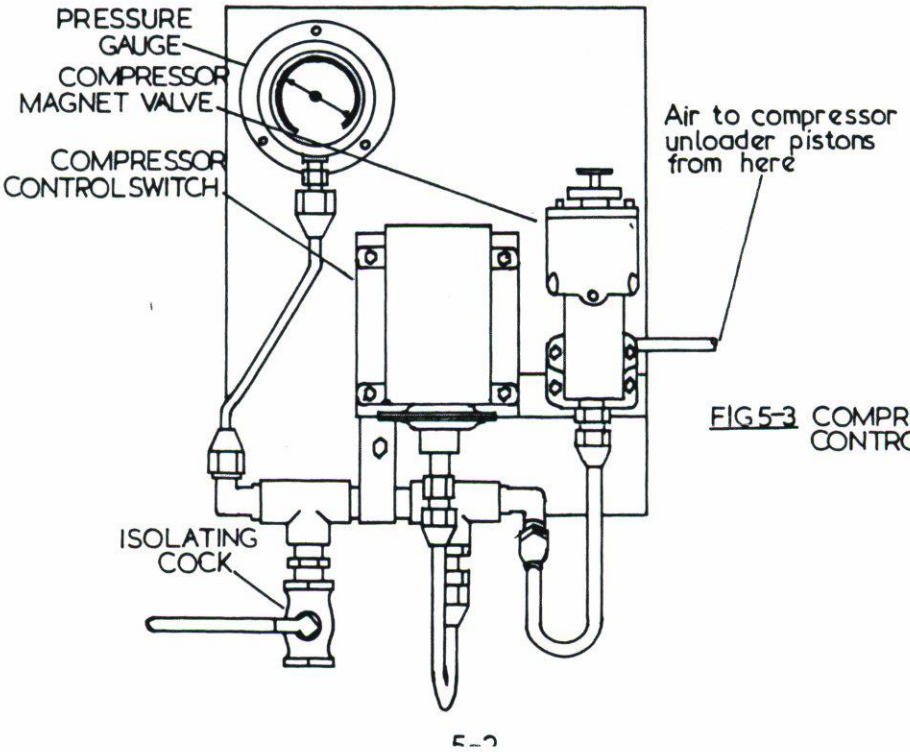


FIG 5-3 COMPRESSOR CONTROL PANEL

The locomotive is furnished with compressor synchronisation. Each locomotive unit is equipped with an electropneumatic system for compressor governor control. The electrical arrangement is such that the compressor in each unit of a consist pumps air to its own main reservoirs whenever the main reservoir pressure in any single unit drops to 725 kPa, Fig. 5-4. All units will continue to pump until main reservoir pressure in each and every unit reaches 830 kPa.

MAINTENANCE

The compressor control switch, is manufactured to close tolerances and therefore inspections should be limited to intervals specified in the applicable Scheduled Maintenance Program. If air compressor difficulties arise, all other sources of possible trouble should be investigated before any attempt is made to disturb the settings of the compressor control switch.

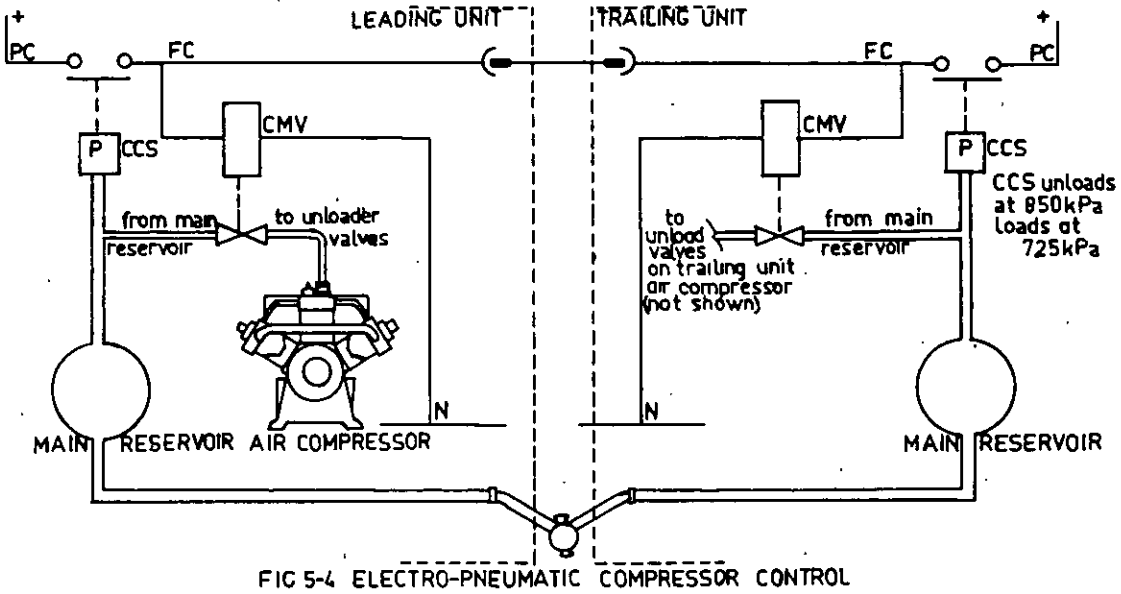


FIG 5-4 ELECTRO-PNEUMATIC COMPRESSOR CONTROL

During periodic inspections of the compressor control switch or when faulty operation is suspected, the switch should be removed from the locomotive and replaced with a qualified switch. The faulty switch should be taken to a bench for any further testing or setting.

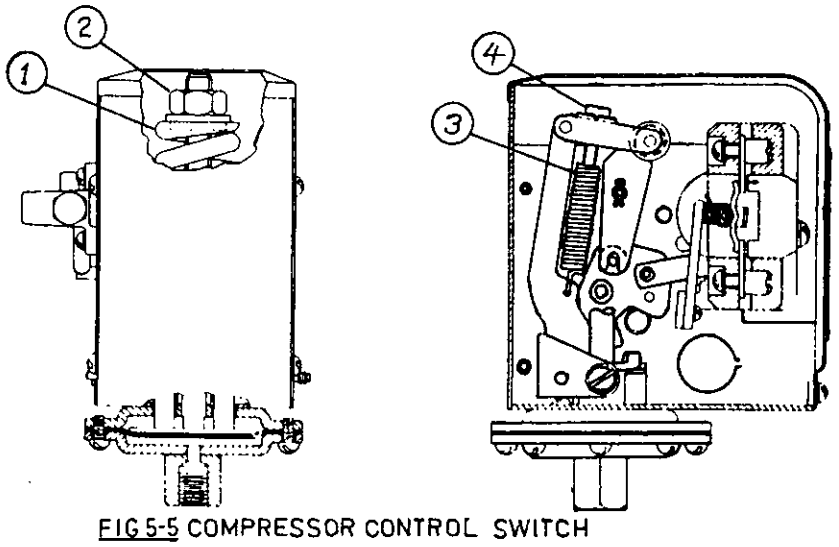


FIG 5-5 COMPRESSOR CONTROL SWITCH

NOTE; 1. Adjust range by increasing or decreasing tension on large spring (1). Range adjusting Nut (2)

2. Increase spring tension (3) to widen differential. Decrease tension for closer setting. Differential Adjusting Nut (4).

COMPRESSOR MAGNET VALVE

During starting the compressor magnet valve is de-energised and therefore as the compressor is running, the air compressor unloader piston lifts and the compressor will pump air as it is running. However when the air pressure in the Main Reservoir pipe builds up to 830 kPa the compressor control switch will close a circuit containing the compressor magnet valve (the compressor control switch being activated by air pressure).

The Compressor Magnet Valve causes air to be delivered to the top of the air compressor unloader pistons and thus causes the air compressor to cease pumping air (as described in the previous section). If faulty operation is suspected, check electrical connections for tightness and check for air leaks.

COMPRESSED AIR PRESSURE GAUGE

DESCRIPTION

A pressure gauge, Fig. 5-3, is located on the compressor control panel. The gauge is connected to the air system in the line from the main reservoir to the compressor control switch and consequently will reflect No. 1 Main Reservoir Pressure.

COMPRESSED AIR FILTERS AND STRAINERS

DESCRIPTION

The compressed air system has one Vapolex type filter Fig. 5-6 for air from the Main Reservoirs to the Air Brake System. This filter is to prevent moisture and contaminants from being carried into the air brake system. The Vapolex Filter has 1 manual drain cock to draw off moisture.

In addition to the Vapolex filters the compressed air system has 7 air line strainers which help to purify the air being used by various auxiliary air equipment from contaminants line. 3 air strainers are used for the air supplied to the sanders, 2 air line strainers are used for air supplied to the wheel flange lubrication equipment and 1 each is supplied to the alerting system and horns and the dead engine cock respectively.

MAINTENANCE

The Vapolex type filter element is to be changed whenever this becomes necessary as set out below. This is done by removing the filter element from the filter. The four standard flange bolts on the filter are taken out and then the 2 swing bolts are loosened off to about 4-5 threads from the end. The filter element can be then changed out. The filter element's weight is about 7.3kg new and when it has become about 1.47 kg heavier through the accumulation of moisture and dirt it should be replaced - at this stage it will be 85% efficient. Before removing the filter cover on the bottom of the filter make sure the cut-out cock located between the main reservoir and the filter is shut off.

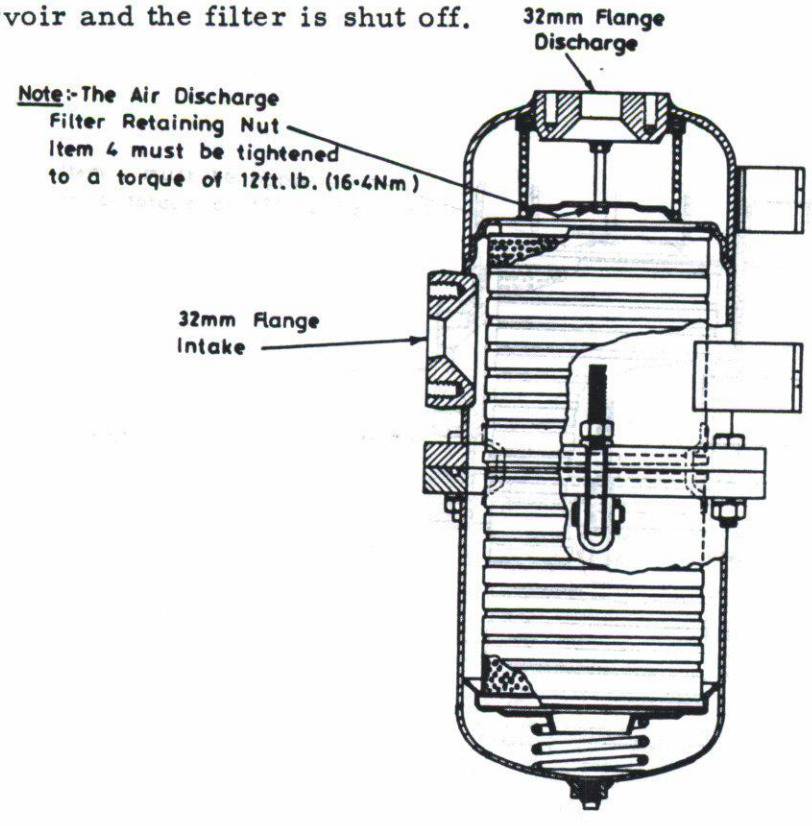
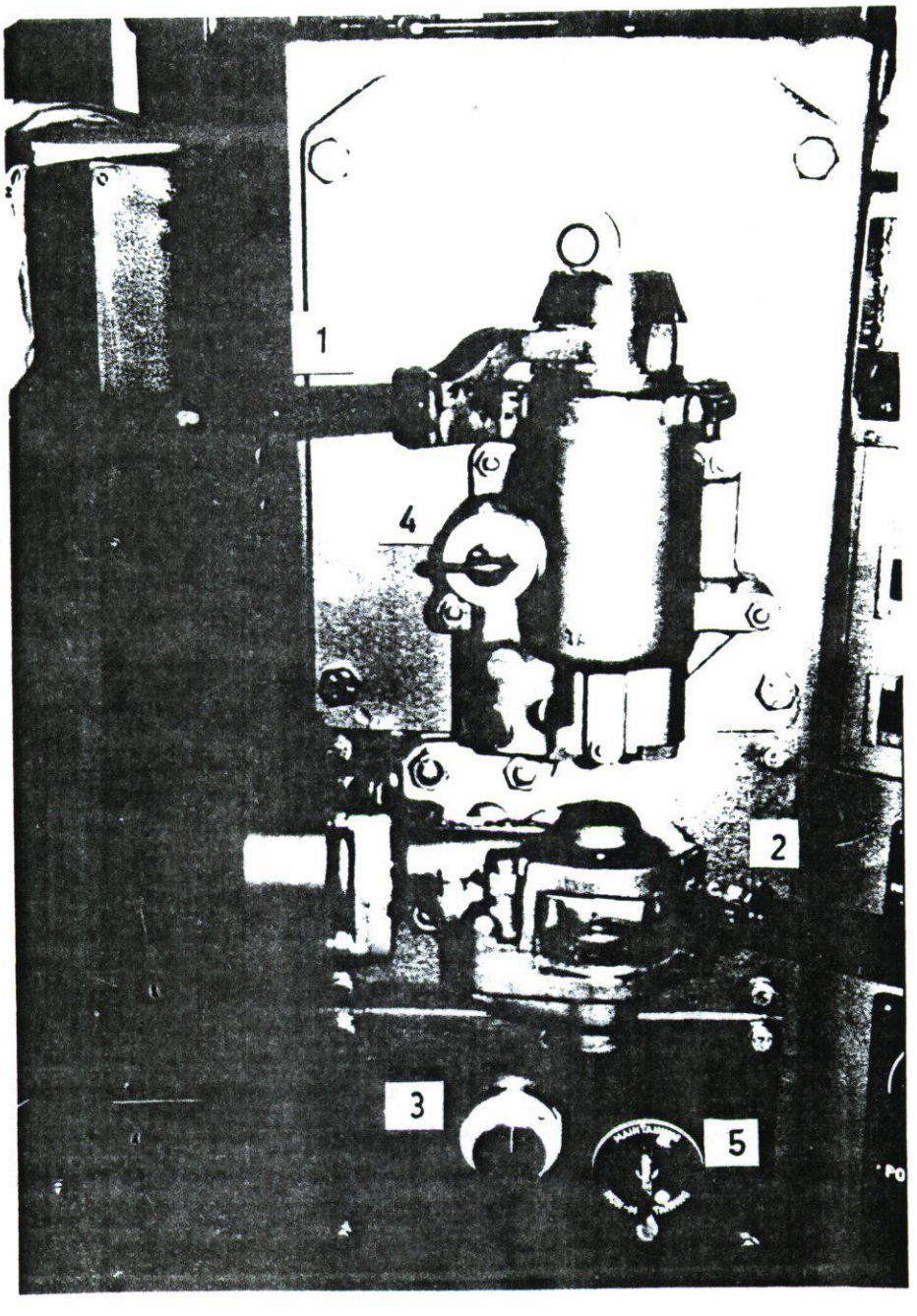


FIG. 5,6 VAPOLEX FILTER ASSEMBLY

MAIN RESERVOIR DRAIN VALVES

The No. 1 and No. 2 Main Reservoirs are equipped with combination automatic/manual drain valves. When set on automatic, these operate as the compressor loads or unloads to allow moisture to be drained from the reservoir before it is carried into the air system.



1. Automatic Air Brake Handle
2. Independent Brake Handle
3. Multiple Unit Valve
4. Cut-Off Valve
5. Maintaining, Non-Maintaining Valve

FIG. 5-7 AIR BRAKE HANDLE

AIR BRAKE EQUIPMENT

REFERENCE Westinghouse Brake & Signal Co (AUST) Pty. Ltd Descriptive Publication C128 on 26 Type Brake Equipment for Australian Locomotive Service.

DESCRIPTION

The locomotives are equipped with type 26L air brakes. The 26L air brake control equipment consists of an automatic brake, independent brake, multiple unit valve (when MU control is installed), cut off valve and a trainline air pressure adjustment device. The dead engine cock, a part of the 26L equipment, is shown in Fig. 5-10.

AUTOMATIC BRAKE VALVE

The automatic brake valve handle, which controls the air to the locomotive train brake systems, may be placed in operating positions as shown in Fig. 5-7.

INDEPENDENT AIR BRAKE

The independent air brake handle is located directly below the automatic brake handle. It has two positions, namely, RELEASE and FULL APPLICATION. Between these two positions is the application zone. Since this is a self-lapping brake, it automatically laps off the flow of air and maintains brake cylinder pressure corresponding to the position of the handle in the applicable zone. Depression of the independent brake valve handle when in the RELEASE position causes release of any automatic brake application on the locomotive.

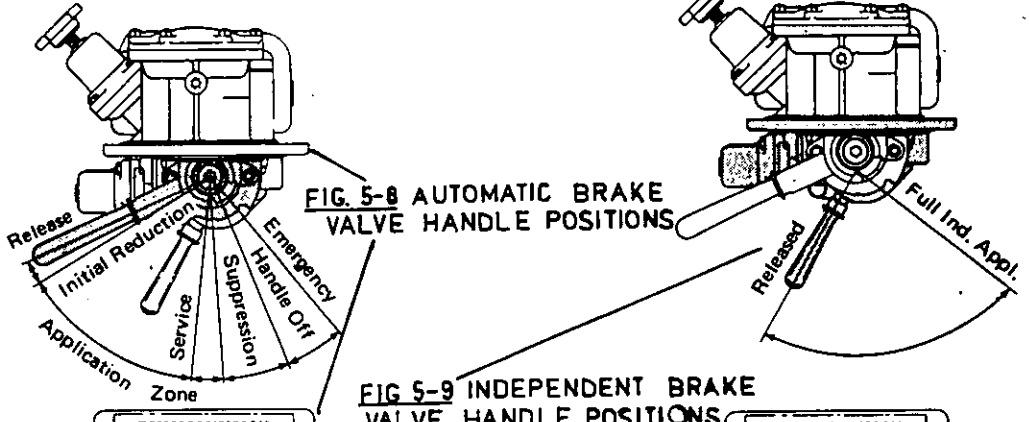
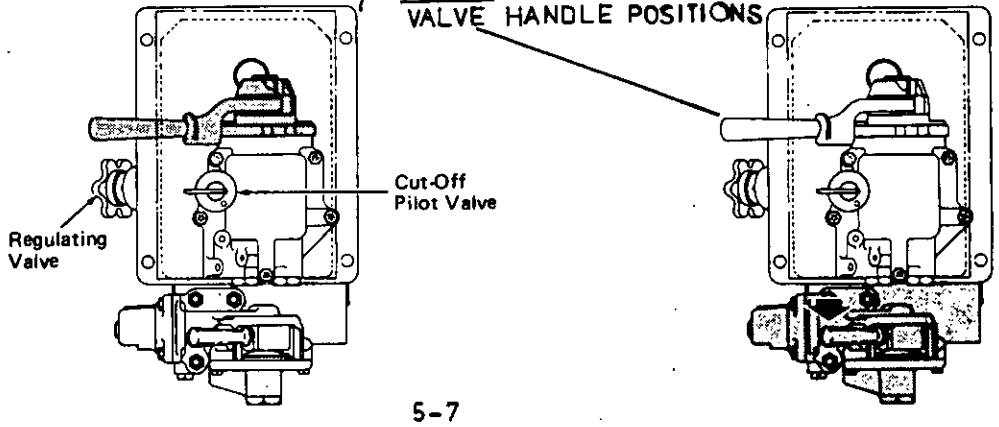


FIG. 5-8 AUTOMATIC BRAKE VALVE HANDLE POSITIONS

FIG 5-9 INDEPENDENT BRAKE VALVE HANDLE POSITIONS



MULTIPLE UNIT VALVE

The universal multiple unit (MU-2A) valve is located on the left hand side of the control stand. Its purpose is to pilot the F1 selector valve which is a device that enables the air brake equipment of one locomotive unit to be controlled by that of another unit.

A typical MU-2A valve application has three positions which are

1. LEAD or DEAD
2. TRAIL 6 or 26*
3. TRAIL 24

The valve is positioned by pushing in and turning to the desired setting
* Whenever the MU-2A valve is in the TRAIL 6 or 26 position, and if the actuating trainline is not used, then the actuating end connection cutout cock must be opened to atmosphere. This is necessary to prevent the inadvertent loss of air brakes due to possible pressure build up in the actuating line.

CUTOFF VALVE

The cut off valve, see Fig. 5-7, is located on the automatic brake valve housing directly beneath the automatic brake valve handle. This valve has the following two positions.

1. CUT OUT
2. CUT IN

TRAINLINE PRESSURE ADJUSTMENT

The trainline air pressure adjusting knob is located behind the automatic brake valve at the upper portion of the brake pedestal.

DEAD ENGINE CUTOUT COCK

A dead engine cutout cock, Fig 5-10 is provided as part of the 26L braking equipment. When a locomotive is to be shipped dead in a train the cutout cock handle should be in the open position.

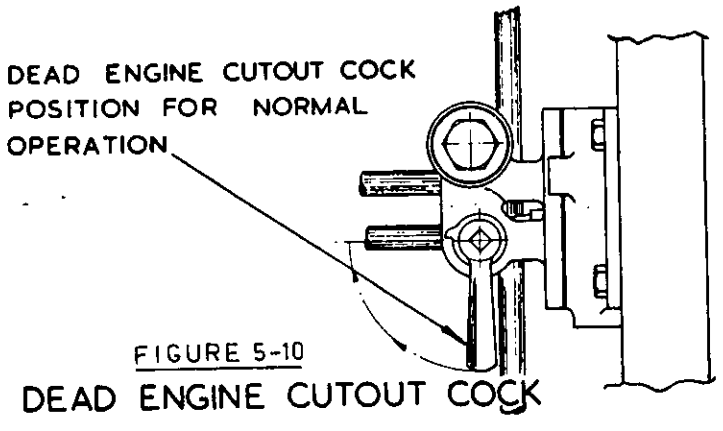
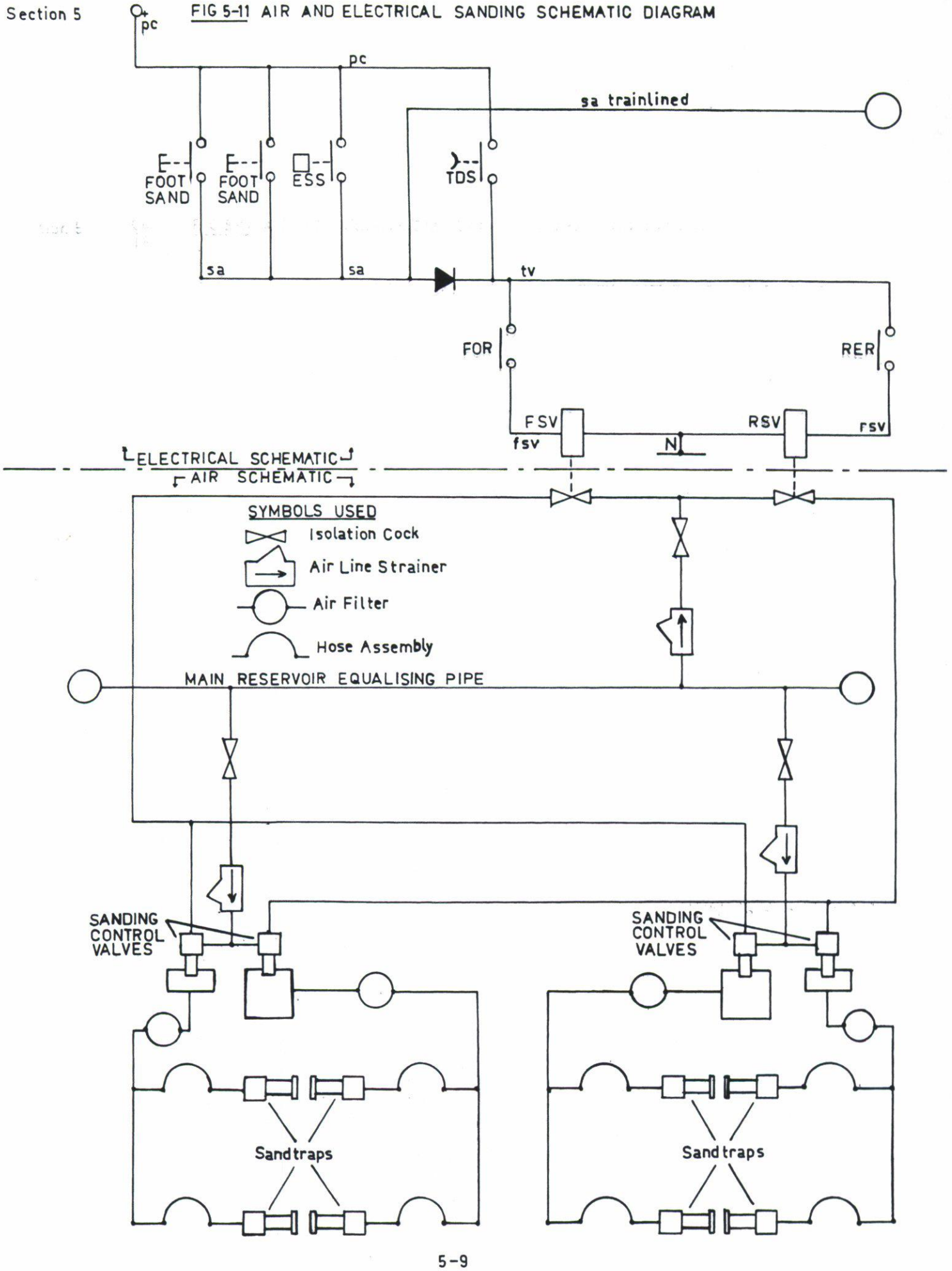


FIGURE 5-10
DEAD ENGINE CUTOUT COCK

FIG 5-11 AIR AND ELECTRICAL SANDING SCHEMATIC DIAGRAM



SANDING SYSTEM DESCRIPTION

Sand is applied to the rails in the event of any of the following conditions:-

(1) During an emergency brake application.

(2) During severe wheelslip as detected by the WS module.

(3) When foot operated sand switches are depressed.

1. Sanding during an emergency application of the brakes is automatic. As the emergency sanding switch (P.U. 245 kPa, D.O. 120 kPa) is operated pneumatically, a pair of electrical contacts pick up to provide power to operate the sanding valve.

2. During primary wheelslip control, power reduction occurs, but no sand is applied to the rails. However if the wheelslip is relatively severe the 'R' relay in the WS module pulses a timing relay which provides sand for each output pulse until the wheelslip is corrected.

3. Foot operated sanding switches are provided in the cab as a means of prevention of wheelslip under wet or slipping conditions.

Before each trip check operation of the sanders by placing the reverser handle in the direction to be sanded. Close the throttle and move the foot sanding switch to the sand position. Check the sanding nozzles to the rail to make sure they are aligned correctly and that the sand is being delivered to the rail.

Extreme care should be taken that the proper grade of clean dry sand is used. Damp or dirty sand with foreign material in it is likely to clog the traps.

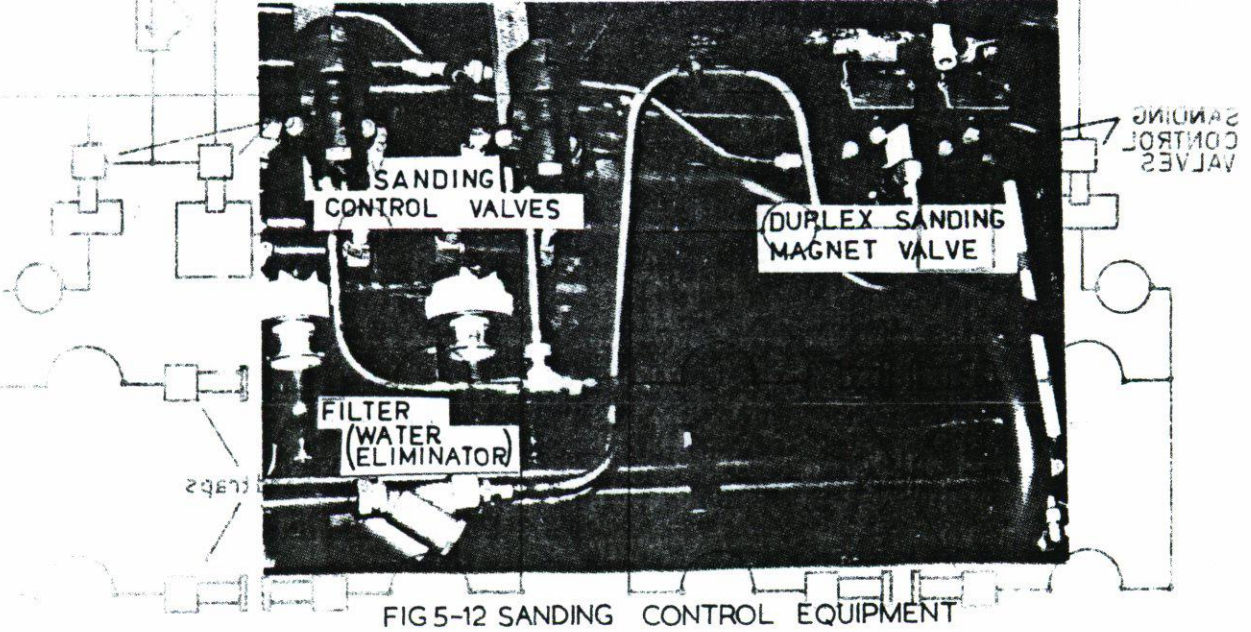


FIG 5-12 SANDING CONTROL EQUIPMENT

SANDING CONTROL VALVE
DESCRIPTION

There are two sets of sanding control valves in the locomotive, Fig. 5-12. One set is for each bogie. Each set has a control valve for forward sanding and a control valve for reverse sanding. The control valves provide main reservoir air to the respective forward and reverse sand traps. When an electrical signal is received, the Duplex magnet valves are energised (either Forward or Reverse) to open an air valve which allows the main reservoir air to be admitted to the sand traps. The electrical signal can be initiated by the manual sanding switch, a wheelslip or an emergency brake application. If repair is required on the valve remove it from the locomotive and replace it with a qualified mechanism.

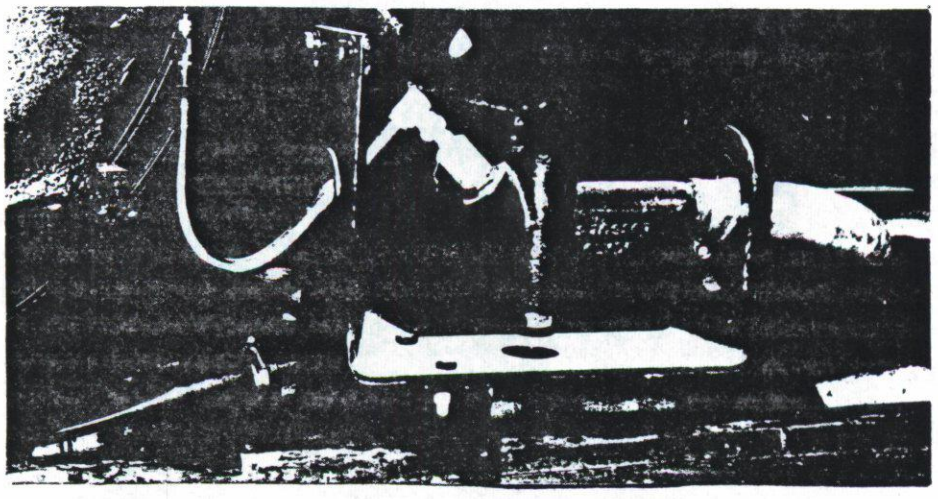


FIG 5-13
SANDTRAP

SANDTRAP - DESCRIPTION

Sand is fed to the trap Figure 5-13 by gravity through an inlet at the top of the trap. Actuating air enters the trap through the air nozzle. The nozzle is always covered by sand and therefore the air moves the sand that lies ahead of the discharge end of the nozzle. Sand entering at the trap inlet replaces the sand in front of the nozzle, thus a uniform flow of sand is delivered to the rail through the trap outlet.

AIR SYSTEM ACCESSORY EQUIPMENT
WINDSHIELD WIPER ASSEMBLY
DESCRIPTION

A separate wiper assembly is provided for each window in front and behind the driver's and fireman's side of the locomotive cab. Each air motor is controlled by its own hand operated air valve which is located just above the side windows on each side of the cab. Each motor is equipped with a hand operated lever which can be used to operate the wipers in an emergency.

MAINTENANCE

If a windshield wiper air motor is not operating correctly, check to see that the air connections at the motor and the manual control valve are tight and free from leaks. With the air turned on, operate the air motor with the hand lever attached to the air motor shaft.

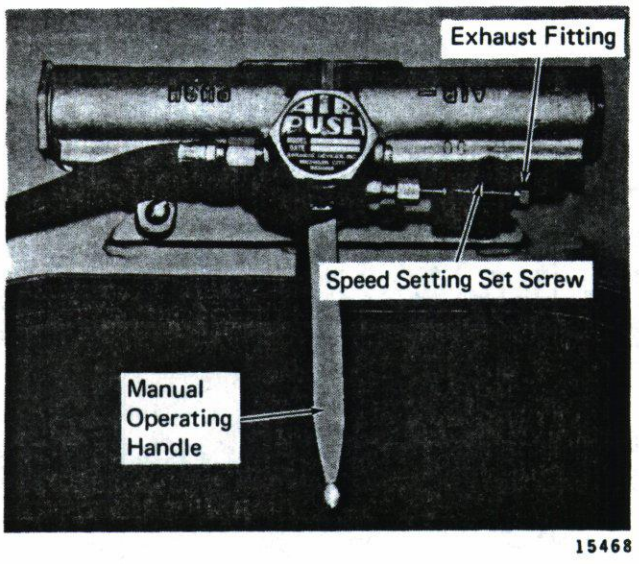


Fig. 5- – Windshield Wiper Air Motor

NOTE: The Manual Operating Handle is now fitted with a rubber handle on GL22C-2 and GL26C-2 locomotives.

If this fails, turn the air off and again try to operate the motor by hand. In most cases this will clean the valve seat of any foreign particles that may have been forced in through the air line.

Remove exhaust fitting, Figure 5-14 and check for dirty filter or plugged hole. Remove reverser ball housing and check for broken or jammed ball spring.

Check the internal air flow by removing the cylinder end caps and blowing out the holes in the valve chamber. Also blow into the exhaust outlet to make sure the hole is not plugged.

If the air motor still does not operate properly, it will have to be replaced with a qualified motor and taken to the bench to be repaired.

If the wiper connecting arm must be removed from the air motor shaft, remove the acorn nut on the end of the shaft and pull the connecting arm off the splined shaft. When replacing the connecting arm on the shaft, be careful not to overtighten the acorn nut. The wiper motor and wiper mechanism are designed to operate at a maximum speed of 60-65 cycles per minute.

The speed of the wiper motor is adjusted by a set screw (See Fig. 5-14) located in the exhaust restrictor. The following procedure should be used in making the adjustment.

1. Place a piece of paper between the wiper blade and the glass to simulate a wet glass condition which reduces frictional drag on the blades.

2. Make sure main reservoir air pressure is 759 to 828 kPa. Turn operating valve in cab to the fully open position.

3. Turn the adjusting screw in the exhaust restrictor until the wiper motor is running at 60-65 cycles (120-130 strokes) per minute.

AIR HORN

DESCRIPTION

The basic horn arrangement is of a dual chime, Figure 5-15. The air horns are operated by pulling cab roof mounted cord. This actuates a horn releasing compressed air supplied to the horns. Automatic operation of the horn also occurs on the operation of the Detonator Sensing Device.

MAINTENANCE

To inspect and clean the air horn diaphragm, remove back cover bolts and back cover. The diaphragm ring and diaphragm can be removed by taking out the diaphragm ring screws.

Whenever a back cover is removed, it is good practice to blow out the air lines by opening the air horn operating valve wide with full reservoir pressure on the line. This will also clean out the orifice dowel pin.

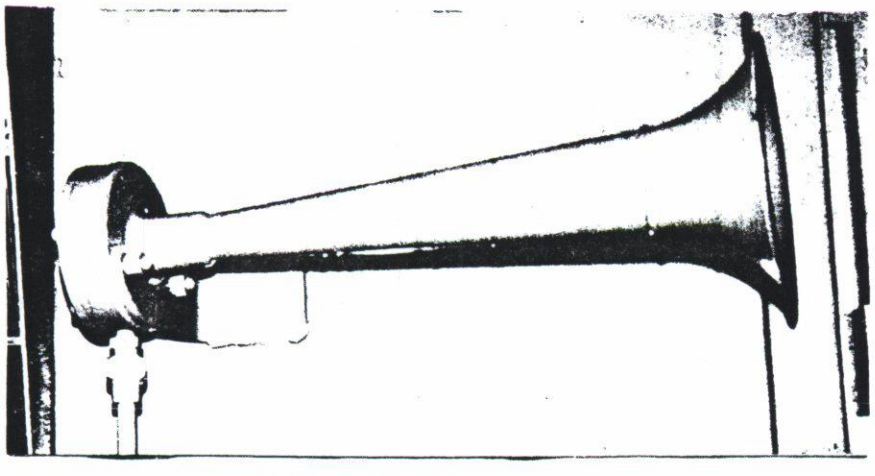


FIG5 15 AIR HORN

SERVICE DATA
COMPRESSED AIR SYSTEM

REFERENCES

Air Compressor Maintenance ..... M.I. 1110 & 1144
Sanding Equipment Maintenance ..... M.I. 1926
Air Horn Maintenance ..... M.I. 2926
Magnet Valve Maintenance ..... M.I. 4707

ROUTINE MAINTENANCE PARTS AND EQUIPMENT

FILTERS

Inlet Compressor Air Filter Element
(Cylindrical Filter) 8402068

AIR COMPRESSOR

Lube Oil Pressure Gauge 8127030

SPECIFICATIONS

AIR COMPRESSOR

Type ..... 2 Stage
Number of Cylinders (Basic) 3
Displacement At 900 RPM (3 cylinder) ..... 254 Cu. Ft. / Min.
Lube Oil Capacity (3 cylinder) ..... 10-1/2 Gal.
Cooling ..... Water .

Lube Oil

Compressor lube oil must be SAE 10 weight rubine type oil containing anti-rust, anti-oxidation and anti-foam inhibitors and should contain the following properties:

Viscosity-Saybolt Universal (ASTM D88 or D2161)
@ 100°F. seconds ..... 130 to 180
@ 210°F. seconds ..... 42 to 45
Pour Point (ASTM D97 Degrees F. - minimum) 0
Rust-Distilled Water (ASTM D665) ..... No Rust

ELECTRICAL EQUIPMENT

The locomotive electrical circuits are designed so that no adjustments need be made on the unit. All circuits are bench tested and adjusted before being applied to the locomotive. To facilitate this arrangement, as well as to simplify maintenance procedures and reduce locomotive down time, more control circuits and devices are packaged on plug-in circuit modules. All modules bearing the same identification are interchangeable.

This section of the manual provides a brief description of the circuit module function, along with brief descriptions of other electrical devices and components. For a thorough analysis of the control circuits contained on the modules refer to Section 7 of the Locomotive Service Manual.

ELECTRICAL ROTATING MACHINERY

MAIN GENERATOR FIG1-6

The main generator is a three-phase alternator equipped with two independent and interwoven sets of stator windings and a rotating field common to the windings. The dual output from the generator stator is supplied to two air cooled rectifier assemblies in an air box that is an integral part of the main generator. The rectifier assemblies consist of high current, high voltage silicone diodes in three-phase, full wave rectifier circuits. The circuits are provided with delta connected resistors and capacitors for suppression of commutation transients, and are provided with fuses for automatic removal of failed diodes. Each fuse is equipped with a spring loaded indicator that protrudes when a diode failure causes the fuse to blow. Windows for fuse inspection are located in the air-box.

Three current transformers are also mounted in the air box. The transformers sense output at each of three phases, and provide a proportional signal to circuits that control excitation.

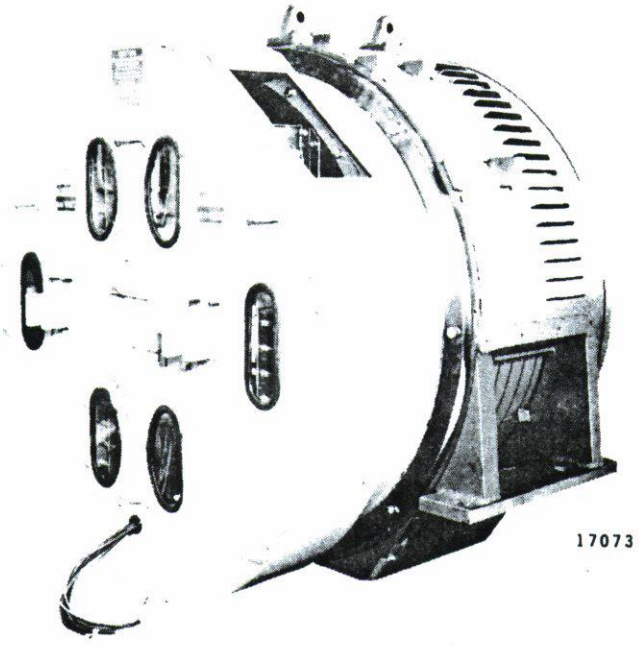
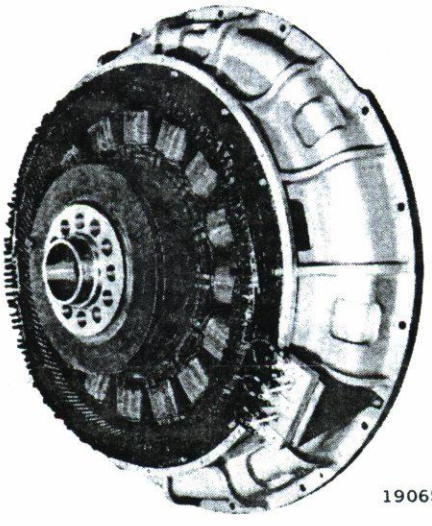


Fig. 6-1 – AR10 Main Generator

D14 AUXILIARY ALTERNATOR FIG 6-2

The D14 alternator is physically connected to but electrically independent of the traction alternator. The D14 rotor (field) is excited by low voltage current which it receives from the DC auxiliary generator through a pair of slip rings adjacent to the slip rings for the main generator.

There are no controls in the D14 excitation circuit, thus the alternator will be excited and developing power whenever the diesel engine is running. Output voltage will vary with speed of rotation, alternator temperature, and load. Nominally D14 output is 215 volts at 120 cycles per second with the engine running at full speed of 900 RPM.



16 pole.

Fig. 6-2 – D14 Auxiliary Alternator

TRACTION MOTORS FIG 6-3

Electrical power from the main generator is distributed to traction motors mounted in the trucks. Each motor is geared to a pair of wheels, with the gear ratio selected for the type of service intended. The motors are cooled by means of an external blower located in the locomotive unit and mechanically driven from the engine.

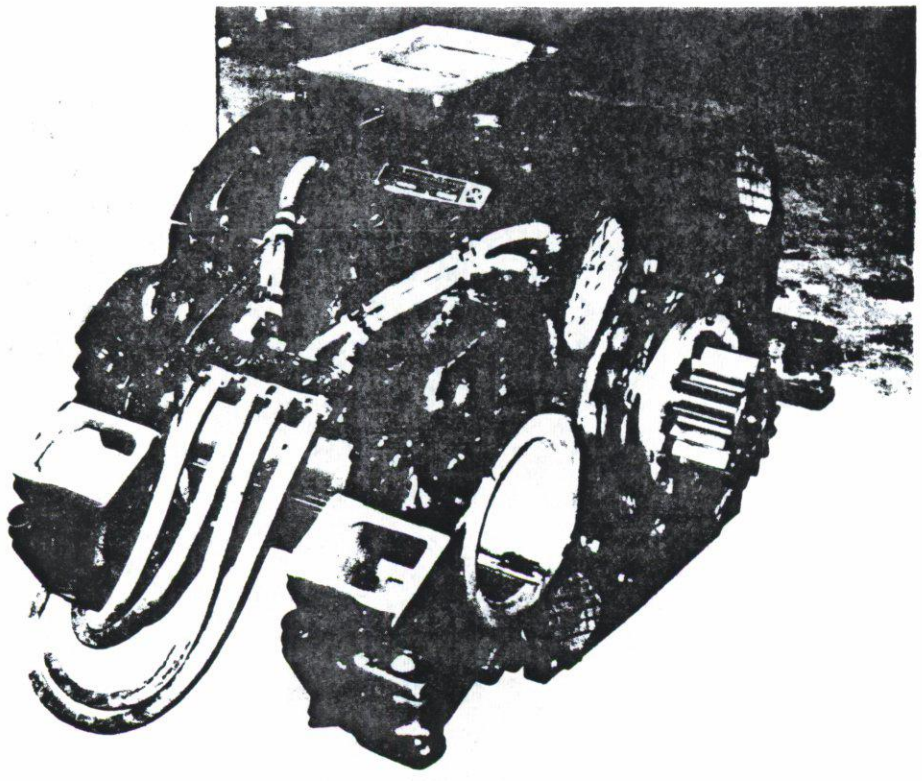


FIG 6-3 TRACTION MOTOR

The motor fields and armatures are connected in series to provide the high starting torque required for locomotive service.

Motor rotation is reversed by reversing the flow of current through the field windings. This is accomplished by switch gear in the locomotive electrical cabinet. Similar switchgear is also used to convert the traction motors to electrical generators for dynamic braking.

During braking, the motor fields are connected in series with the main generator output and the motor armatures are connected to heat dissipating resistor grids and fans.

The brush holder assembly is formed with a heavy cross section to minimise flexing and fatigue damage and to enable the assembly to withstand severe flashover. Brush holder cabling is arranged and clamped for increased mechanical strength.

AUXILIARY GENERATOR FIG6-4

All low voltage direct current electricity required during locomotive operation comes from the auxiliary generator. The current is used for battery charging and for excitation of the D14 alternator as well as for energising control circuits and actuating electrical switch gear. The auxiliary generator is a self-excited machine that uses residual magnetism for initial excitation. To hold voltage at a constant 74 volts, a static type voltage regulator is used in the field excitation circuit. The regulator is packaged as a plug-in circuit module VR11 and is provided with a voltage adjustment for battery charging purposes.

The locomotive is equipped basically with the 18 kW auxiliary generator.

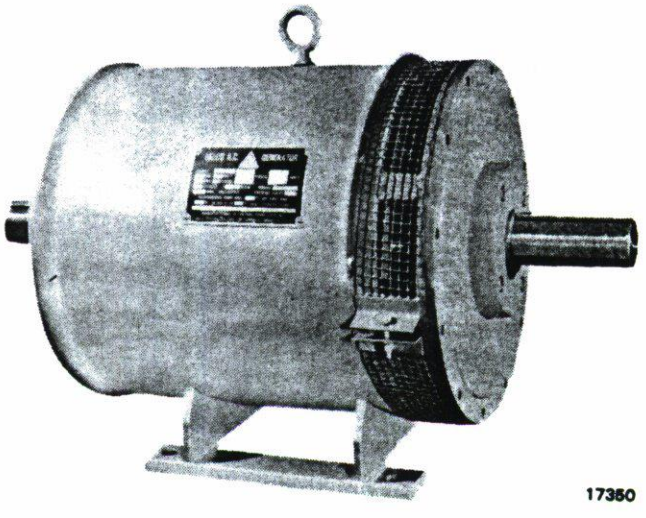


Fig. 6-4 – Auxiliary Generator

RADIATOR COOLING FAN MOTORS FIG 6-5

These motors are inverted squirrel cage induction type and are an integral part of the cooling fan assembly. The term "inverted" indicates that they differ from the conventional squirrel cage motor in that the rotor is located outside of the stator. Motor and fan rotating speed are directly proportional to the AC frequency of the D14 alternator which in turn is dependent upon engine speed.

On GL22C-2 locomotives one 36" cooling fan motor is used and one 48" cooling fan motor whereas on GL26C-2 locomotives 2 48" fans are used.

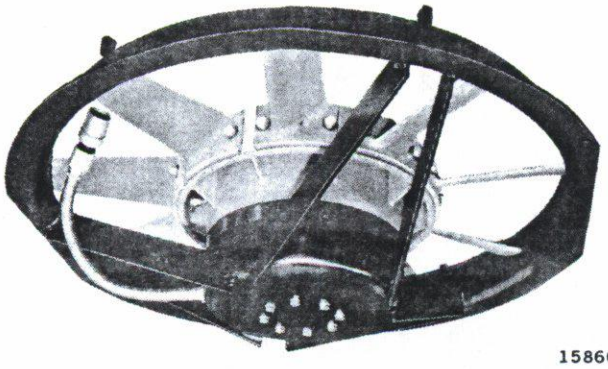


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Fig. 6-5 – Cooling Fan Assembly

DYNAMIC BRAKE GRID BLOWER ASSEMBLY FIG 6-6

The dynamic brake grid cooling blower assembly consists of a fan powered by a series wound direct current motor. During dynamic braking the locomotive traction motors operate as generators, and the electrical power generated is converted to heat at the braking resistor grids. A portion of the electrical current from the traction motors is shunted around one of the resistor grids and used to power the grid blower motor. Air driven by the grid blower drives grid heat to atmosphere.

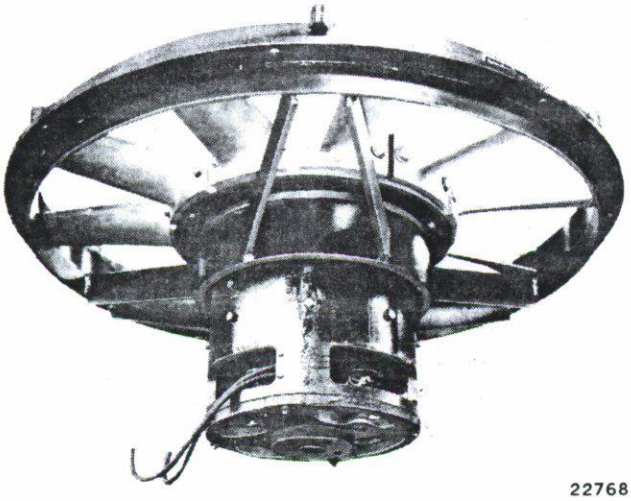

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Fig. 6-6 -- Dynamic Brake Grid Blower Assembly

FUEL PUMP MOTOR

This is a 1/4 HP 1200 RPM 64-74 volt DC motor coupled directly to a fuel pump and mounted on the equipment rack. During engine operation the pump supplies fuel oil for combustion and injector cooling. A bypass valve at the primary fuel filter protects the motor against overloading due to filter plugging.

STARTING MOTOR AND SOLENOID FIG6-7

The starting motor solenoid mounted on the starting motor housing contains concentrically wound coils PU and HOLD. When energised, the low resistance PU coil drives the starter motor pinion into place. The starting contactor then shorts out the PU coil and the high resistance HOLD coil has sufficient energy to hold the pinion engaged. When cranking signal is removed, the starting contactors drop out.

The diesel engine is equipped with dual motors for cranking. Power circuits to the motors are interlocked so that the pinions of both starting motors must be engaged with the engine ring gear before cranking power can be applied.

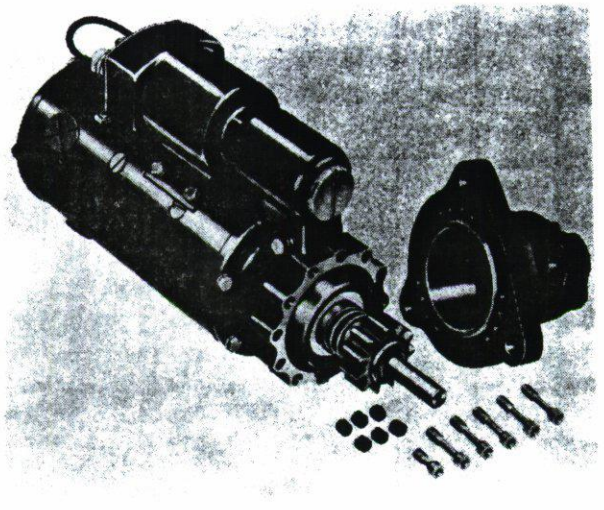
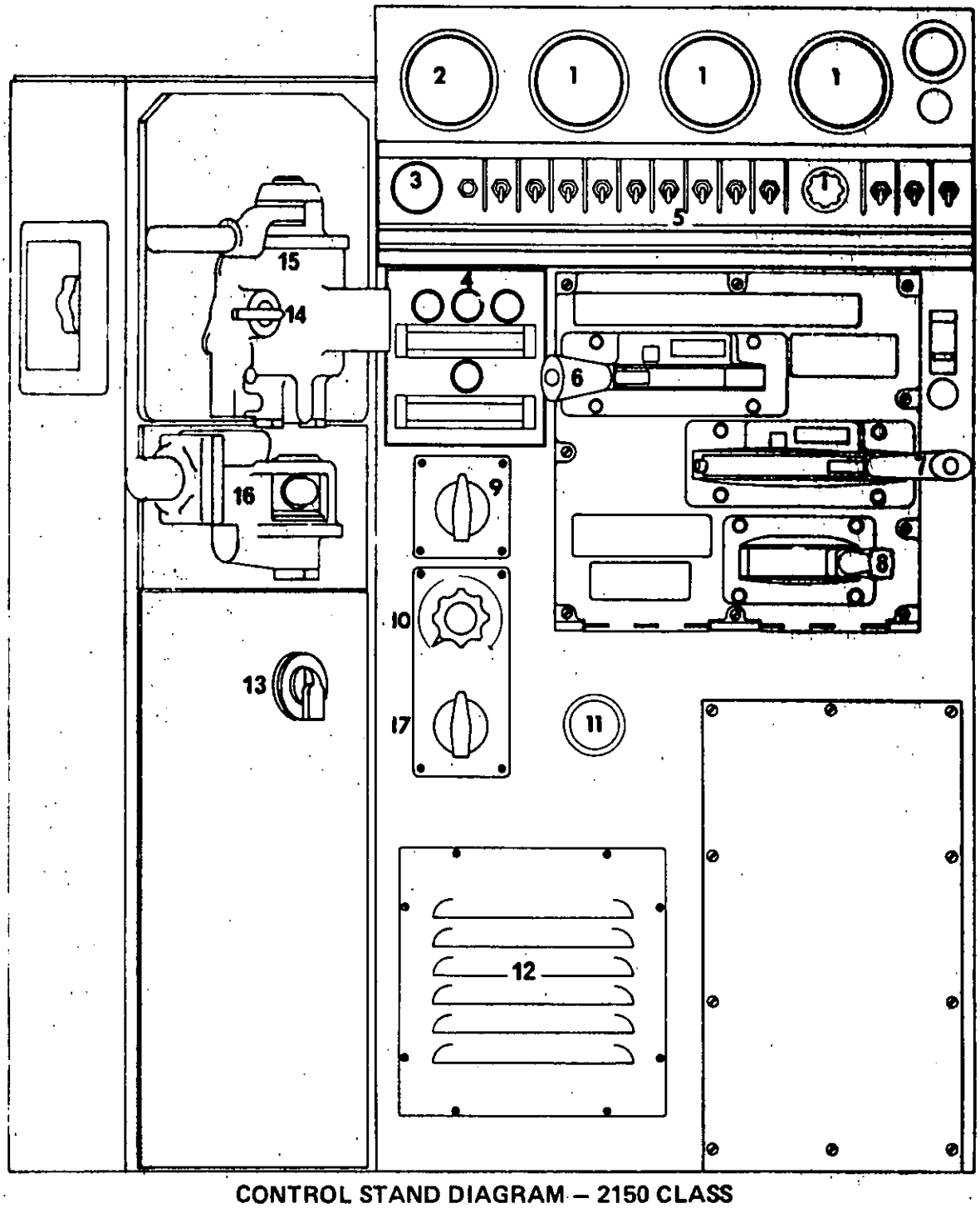


Fig. 6-7 – Engine Starting Motor

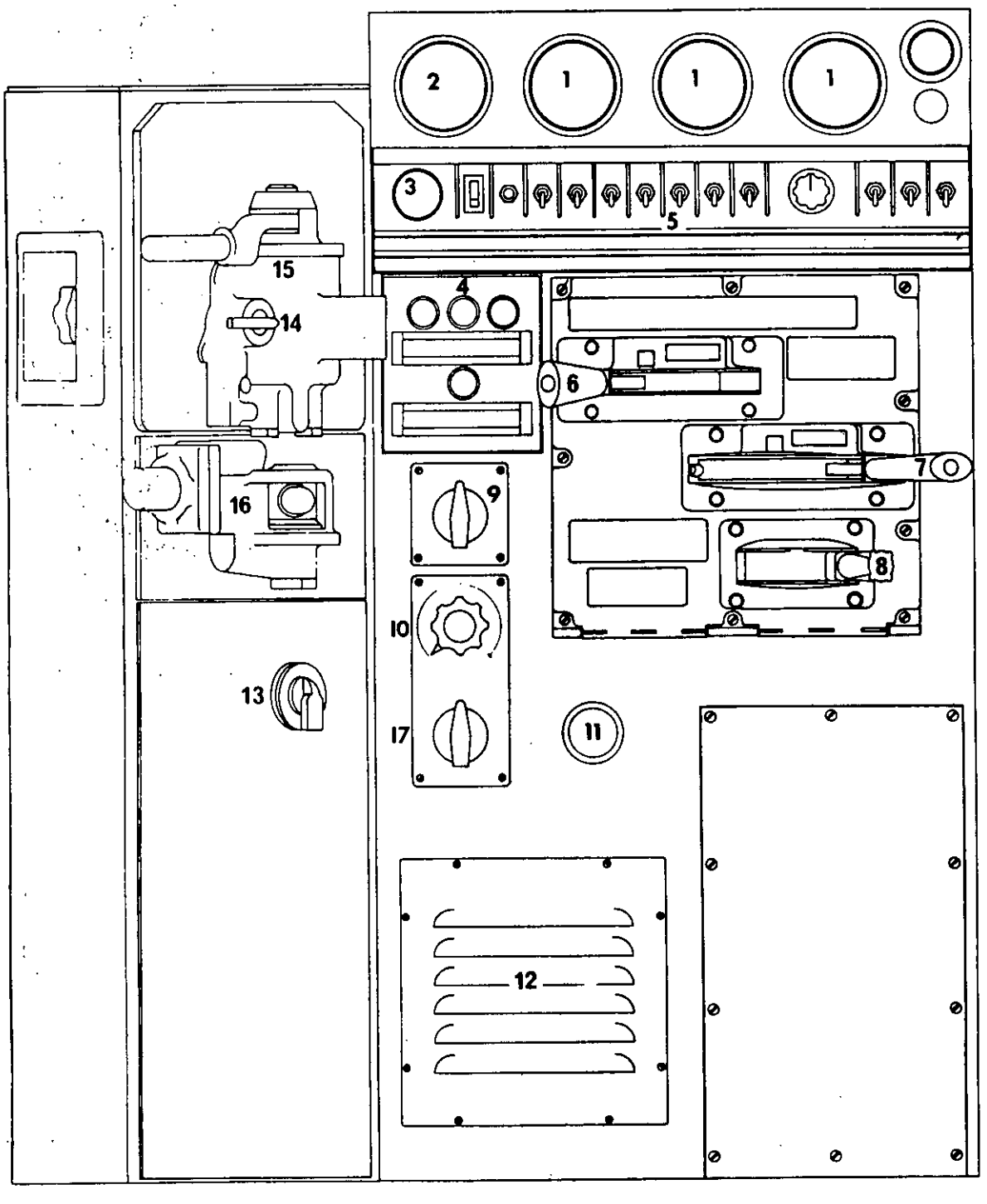
LOCOMOTIVE CONTROL STAND FIG6-8

The locomotive control stand contains operating handles, switches, gauges, and indicating lights used by the operator of the locomotive. The air brake valves and handles are at the left side of the stand, with the controller assembly to the right. Various gauges and indicating lights are located above the controller, and various operating switches are adjacent to it or below.



CONTROL STAND DIAGRAM – 2150 CLASS

1. Pressure Gauges, MR/ER, BC/BP, & Flowmeter
2. Load Indicating Ammeter (Power & Dynamic Brake)
3. Ground Relay Reset Button
4. Alarm Lights
5. Switch Panel
6. Dynamic Brake Selector
7. Throttle
8. Reverser Handle
9. Headlight Selector Switch
10. Manual Power Control
11. Alerting System Acknowledge Switch
12. Cab Heater Outlet
13. Mu. 2A Valve
14. Cut-out Valve
15. Automatic Brake Valve
16. Independent Brake Valve



CONTROL STAND DIAGRAM – 2400 CLASS

1. Pressure Gauges, MR/ER, BC/BP, & Flowmeter
2. Load Indicating Ammeter (Power & Dynamic Brake)
3. Ground Relay Reset Button
4. Alarm Lights
5. Switch Panel
6. Dynamic Brake Selector
7. Throttle
8. Reverser Handle
9. Headlight Selector Switch
10. Manual Power Control
11. Alerting System Acknowledge Switch
12. Cab Heater Outlet
13. Mu, 2A Valve
14. Cutout Valve
15. Automatic Brake Valve
16. Independent Brake Valve

CONTROLLER ASSEMBLY FIG 6-9

The controller contains the three main operating handles; throttle, reverser, and dynamic brake. Nameplates identify each handle, and the position of the throttle and dynamic brake handles are indicated in illuminated windows located directly above those handles. The controller assembly is hinged to the control stand, and can be swung down for maintenance and troubleshooting.

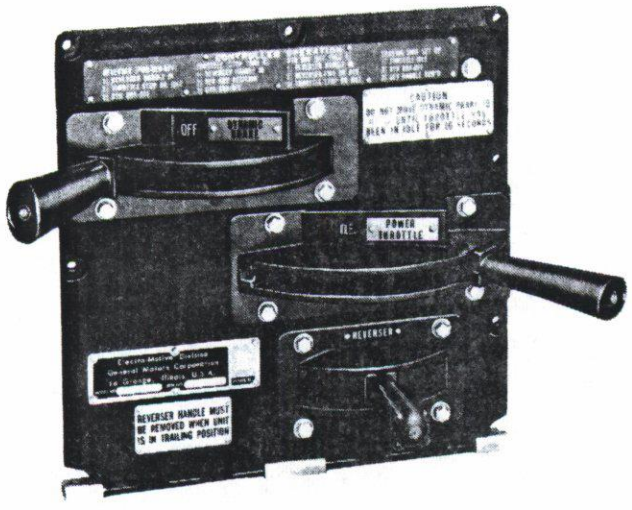


Fig. 6-9 – Locomotive Controller

DYNAMIC BRAKE HANDLE

A separate handle is provided for control of dynamic brakes. It is uppermost on the controller panel and is moving from left to right to increase braking effort. The handle grip is somewhat out of round with the flattened surfaces vertical to distinguish it from the throttle handle, which has its flattened surfaces horizontal. The brake handle has two detent positions; OFF and SET UP, and an operating range through which the handle moves freely without notching. The handle is in the OFF notch when positioned fully left. The SET UP position is one notch to the right of OFF. When the handle is moved to the right out of the SET UP Notch, it can then be moved without notching to positions 1 through FULL 8 to increase the signal from the dynamic brake rheostat, which is part of the controller assembly. Mechanical interlocking prevents the dynamic brake handle from being moved out of the OFF position unless the throttle is at IDLE and the reverser handle is positioned for either forward or reverse operation.

CAUTION During transfer from power operation to dynamic braking, the throttle must be held in IDLE for 10 seconds before moving the dynamic brake handle to the SET UP position. This is to allow time for decay of magnetic flux and preclude a sudden surge of braking effort with possible train run in or motor flashover.

THROTTLE HANDLE

The throttle is the middle handle on the controller panel. It is moved from right to left to increase engine speed and power. The handle grip is somewhat out of round, with the flattened surfaces horizontal to distinguish it from the dynamic brake handle, which has its flattened surfaces vertical. The throttle has nine detent positions; IDLE, and 1 through 8 plus a STOP position which is obtained by pulling the handle outward and moving it to the right beyond IDLE to stop all engines in a locomotive consist. Mechanical interlocking prevents the throttle handle from being moved out of idle when the dynamic brake handle is advanced to SET UP or beyond, or when the reverser handle is centred and removed from the controller.

REVERSER HANDLE

The reverser handle is the lowest handle on the controller panel. It has three detent positions; left, centred and right. When the handle is moved to the right towards the short hood end of the locomotive, circuits are set up for the locomotive to move in that direction. When the handle is moved to the left, towards the long hood end of the locomotive, circuits are set up for movement in that direction. With the reverser handle centred, mechanical interlocking prevents movement of the dynamic brake handle, but the throttle handle can be moved to increase engine speed. In such case, power will not be applied to the traction motors, but a load test may be made if the proper circuit set up is made.

The reverser handle is centred and removed from the panel to lock the throttle in IDLE position and the dynamic brake handle in OFF position.

LOAD CURRENT INDICATING METER

This meter indicates current through the No. 3 traction motor. Since all motors will carry approximately equal current, main generator current will be three times the meter indication during series-parallel operation, and six times the indication during full parallel. The motor indicates from zero to 800 Amperes during power operation, with a red zone indicating maximum allowable continuous motor current, beginning at 500 Amperes.

On units equipped with dynamic brakes, the meter has a dial with the zero point located at top centre. During power operation the meter needle moves clockwise from zero to indicate increasing motor current. During dynamic braking the meter needle moves.

AIR SYSTEM GAUGES

Duplex gauges provide indication of various air brake system pressures.

INDICATING LIGHTS PANEL FIG 6-10

Indicating lights alert the locomotive operator of various operating conditions. The panel assembly is located adjacent to the upper left corner of the controller.

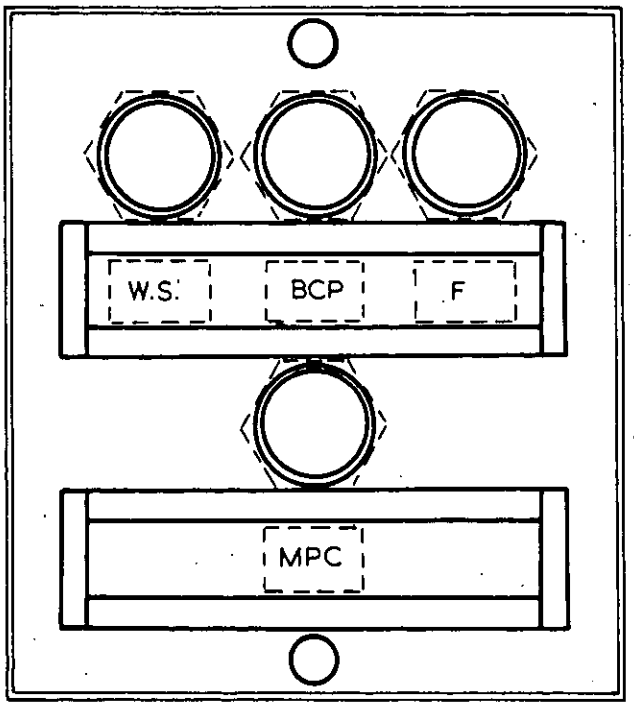


FIG 6-10 INDICATING LIGHTS PANEL

OPERATING SWITCHES

The engine run, generator field, and control and fuel pump switches are located at the right side of the control stand. They must be placed ON in the controlling unit of a multiple unit consist and OFF in the trailing units. Other switches at this location control various lights and are placed ON as needed.

HEADLIGHT DIMMING SWITCH

Provides for dim or medium brightness of either front or rear headlights.

BRAKE VALVE HANDLE

The upper handle controls the automatic or train brakes. The lower handle controls the independent or locomotive brakes.

ELECTRICAL CABINET

HIGH VOLTAGE CABINET FIG.6-11,6-12,6-13 & 6-14

The high voltage cabinet houses the majority of the locomotive electrical switch gear and static devices. The front of the cabinet forms the rear wall of the locomotive cab, and the rear of the cabinet forms one wall of the central air compartment of the locomotive.

The lower rear of the electrical cabinet houses heavy duty switch gear used to connect the main generator to the traction motors. Devices that sense current and voltage are generally located in this portion of the cabinet.

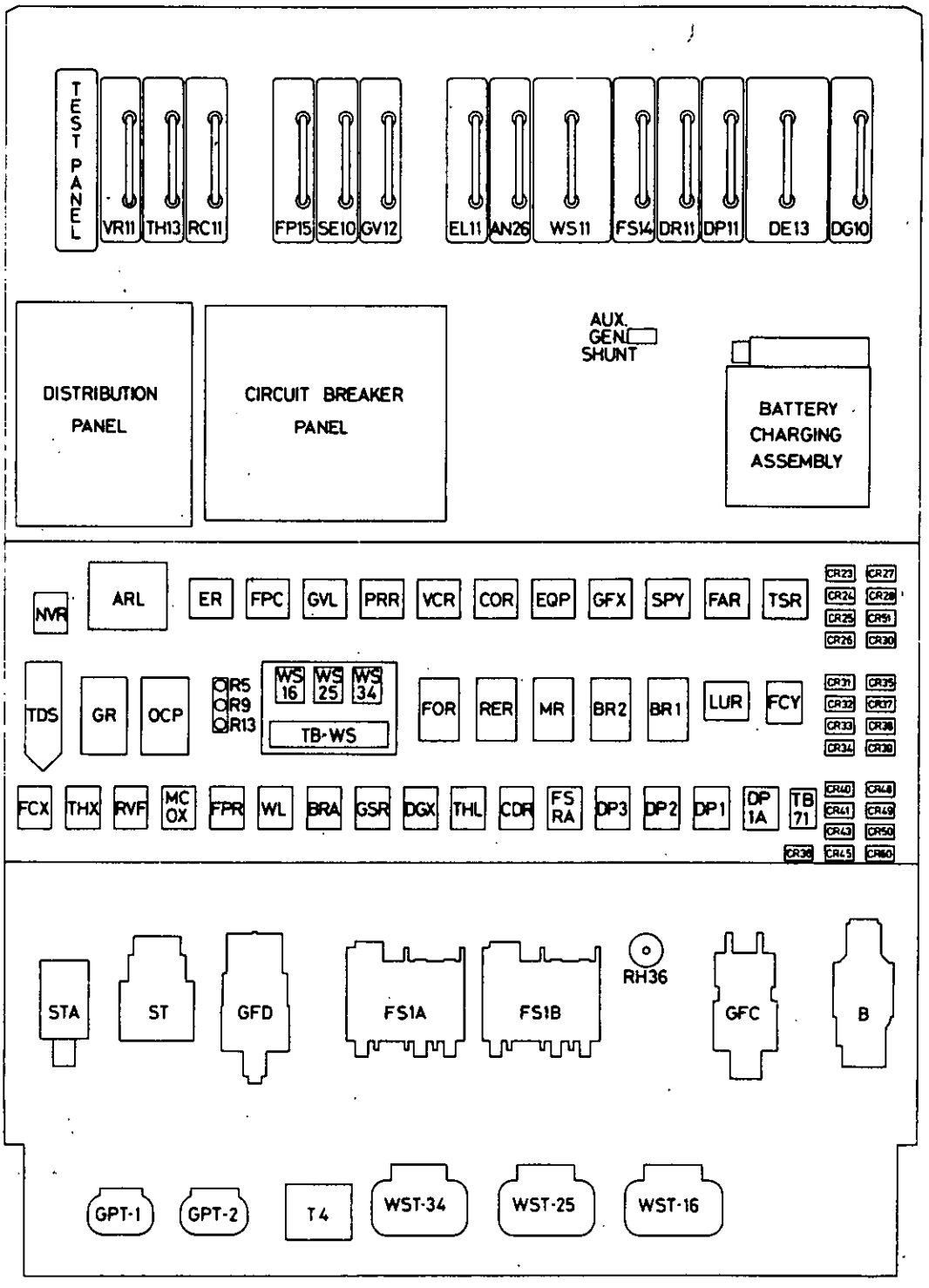
ACCESSORY PANEL

The accessory panel contains various switches and warning lights. The functions of the switches and lights follow .

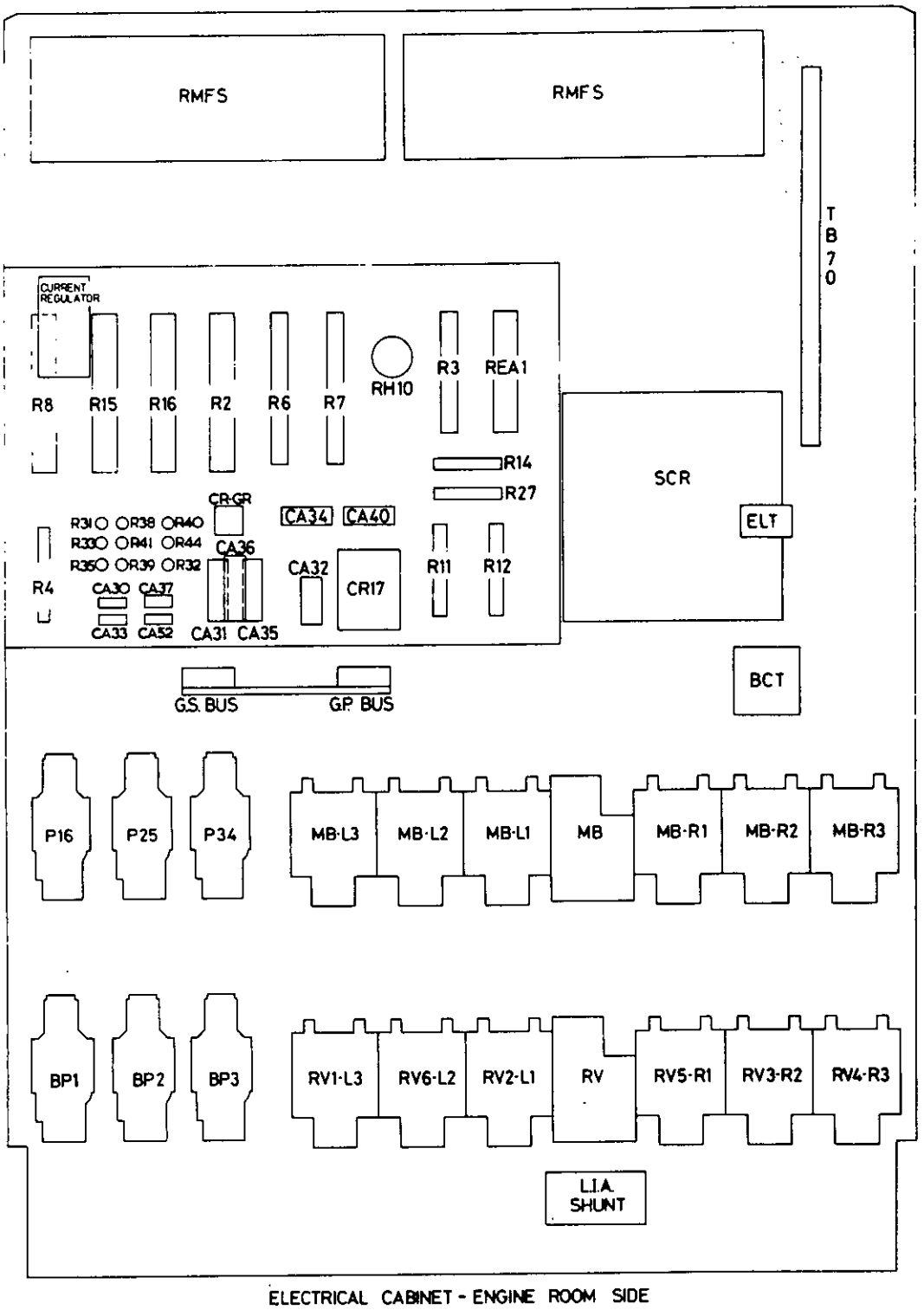
TEST LIGHT

This light comes on when circuits are set up for circuit check or load. testing. On locomotive units equipped for automatic loading on the locomotive dynamic braking resistor grids, circuit set up is automatic when the reverser handle is centred and a rotary snap switch located on a test panel in the module compartment is properly positioned. If the unit is not equipped for automatic self loading, a loading resistor grid must be connected to perform the load test.

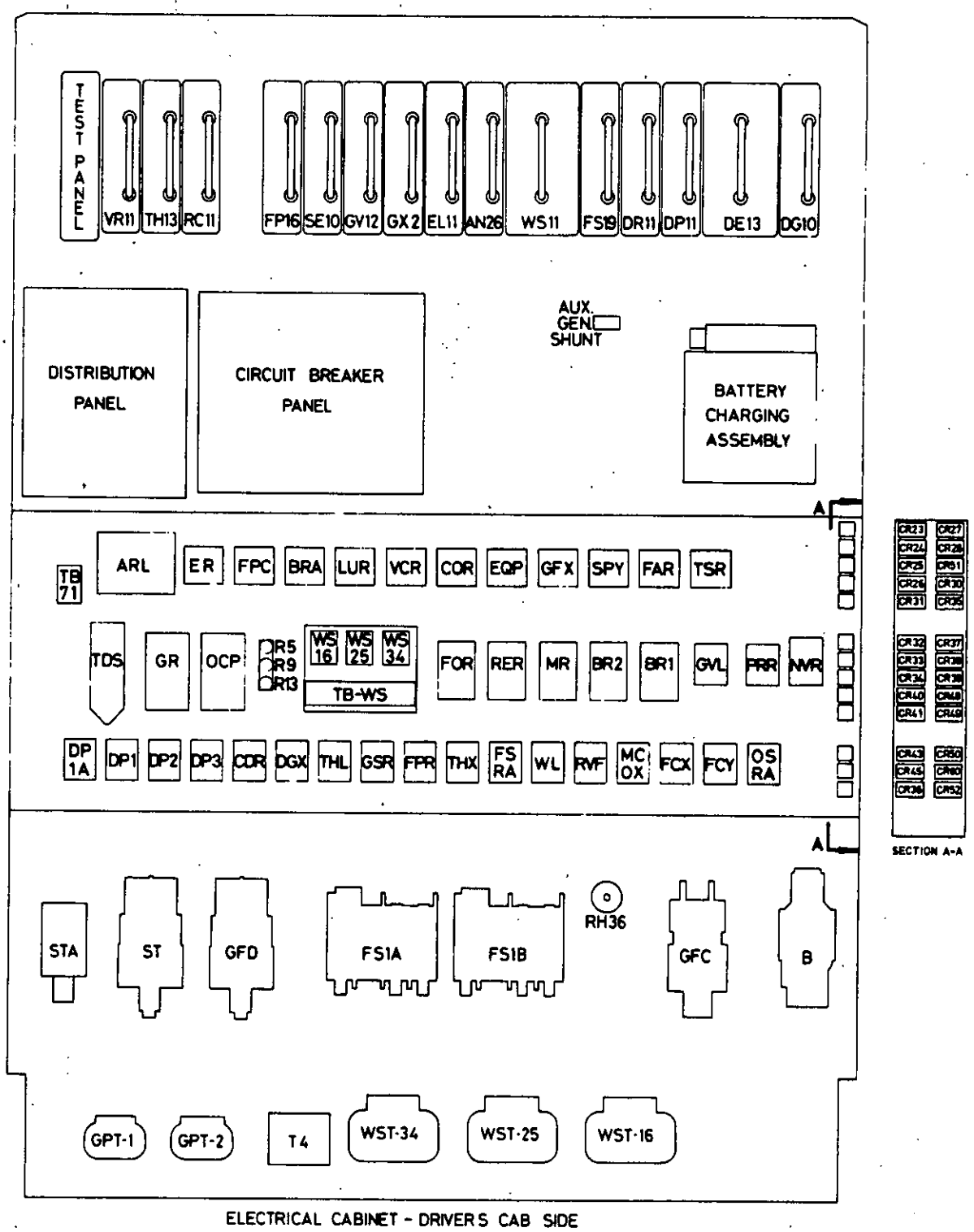
WARNING On units not equipped for automatic self loading, the main generator will be open circuit during a load test setup unless an external loading resistor grid is connected.



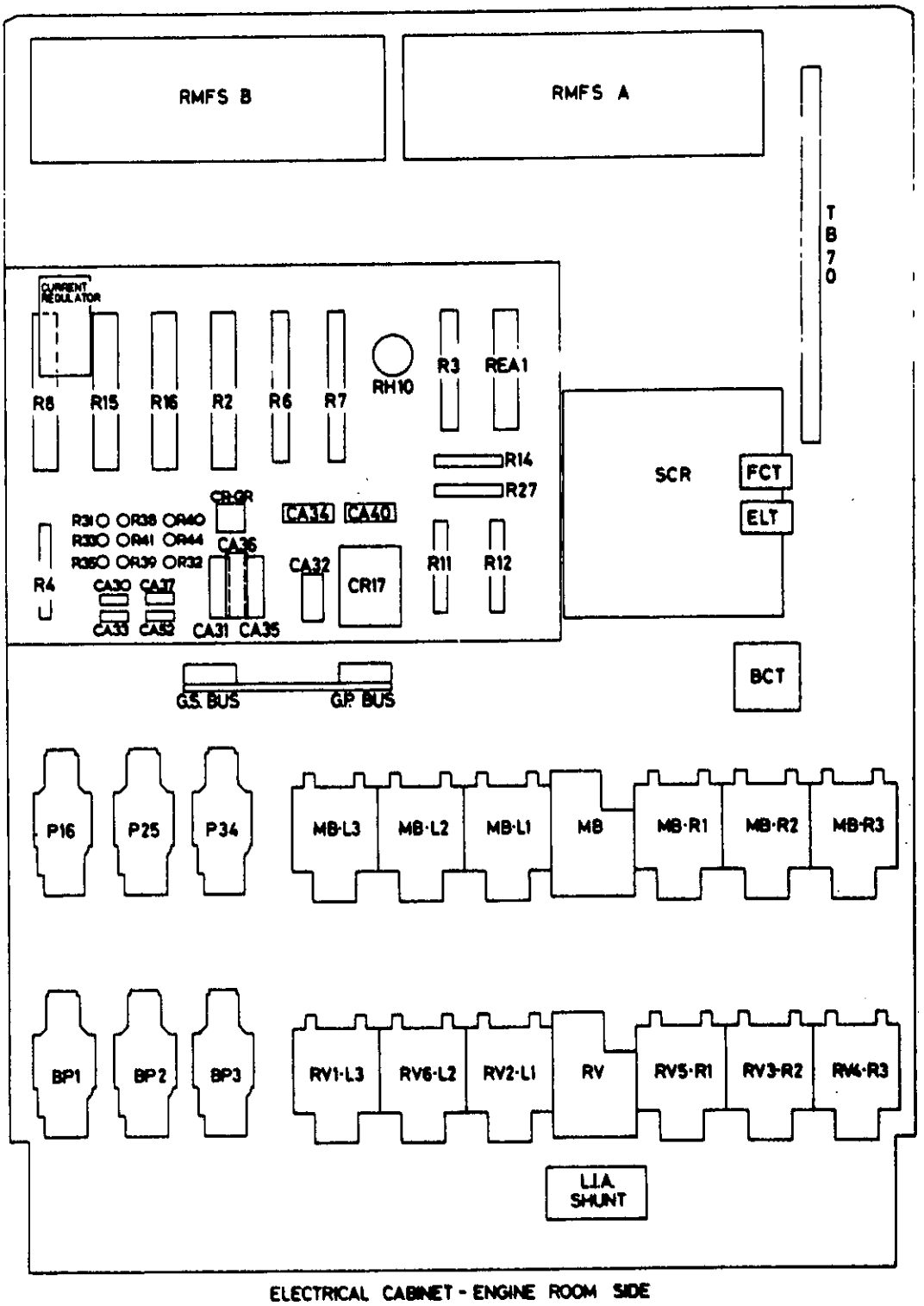
ELECTRICAL CABINET - DRIVER'S CAB SIDE
2400 CLASS



ELECTRICAL CABINET - ENGINE ROOM SIDE
2400 CLASS



ELECTRICAL CABINET - DRIVER'S CAB SIDE
2150 CLASS



ELECTRICAL CABINET - ENGINE ROOM SIDE
2150 CLASS

During CIRCUIT CHECK position of the test switch, the generator field circuit breaker must be in off position to prevent excitation of the main generator.

Do not return the test switch to NORMAL position until the throttle is in IDLE position.

GROUND RELAY LIGHT

Indicates that an electrical path to ground has occurred or that a group of five diodes in the main generator has failed. The light is held on until a reset button is pressed or an automatic reset is made on locomotives so equipped.

FIRE ALARM LIGHT & CANCEL SWITCH

The fire alarm light indicates that the fire detectors have been activated and the alarm will sound.

A fire alarm cancel switch is located adjacent to indicating light and will cancel the alarm.

HOT ENGINE LIGHT

Indicates that engine coolant temperature is excessive. Engine speed and power are automatically reduced to a lower level until proper maintenance is restored.

COMPRESSION AND ENGINE PROTECTION LIGHT

The energisation of this light is accompanied by engine shutdown. Engine shutdown takes place when the Engine Protector in the Governor operates causing the Governor to shut down the engine. Engine shutdown takes place for one of the following reasons:-

1. Excessively hot lube oil.

   This type of shutdown will normally be preceeded by a hot engine light indication. The low oil plunger on the governor will move out and the engine will be shutdown.. Do not attempt to restart the engine until it has been allowed to cool down and an engine inspection has been made by qualified personnel.

2. Low engine oil pressure.

   Low oil level, or failure of the lube oil pump may bring about this type of shutdown. The low oil plunger on the engine governor will protrude, with no other fault indication given.

ACCESSORY PANEL

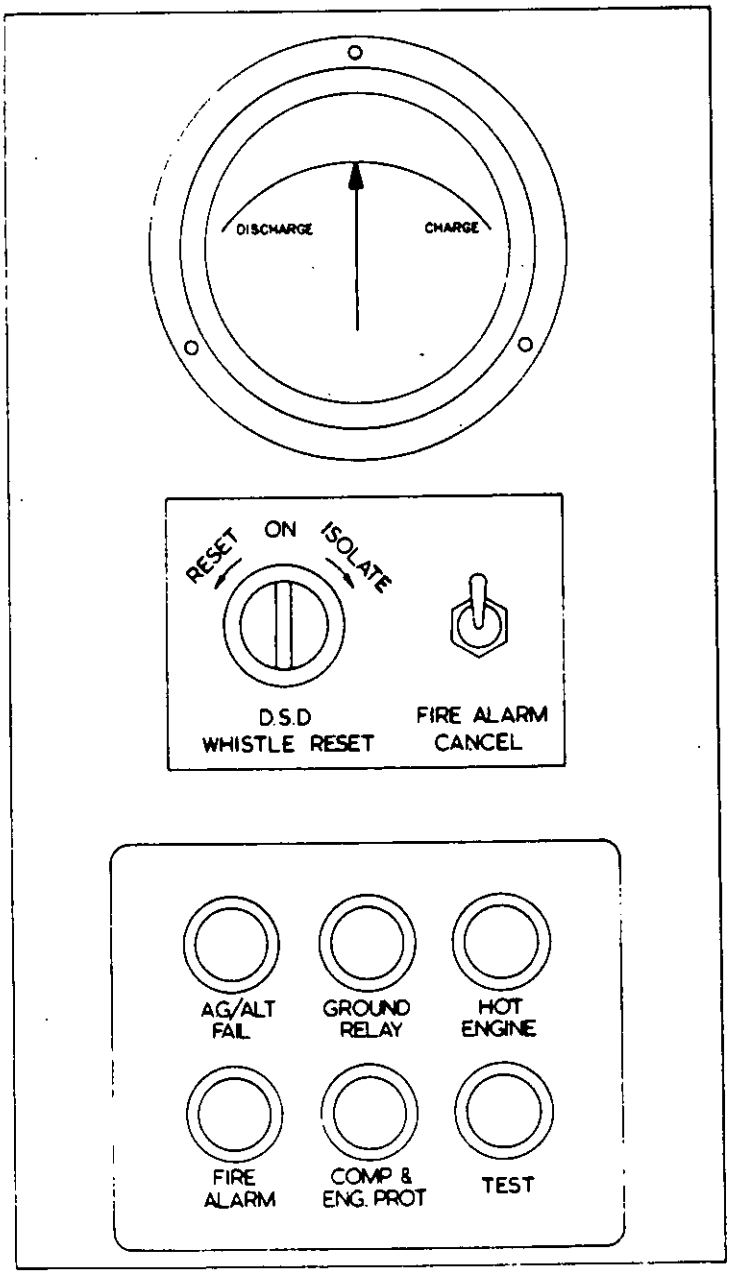


FIG 6-15 ACCESSORY PANEL

3. Low water level or low pressure at the water pumps.

   A detector at the engine accessory drive gear housing senses low water pressure and actuates the low oil shutdown mechanism. The low water detector reset button will protrude along with the governor low oil pressure plunger.

4. Crankcase (oil pan) overpressure due to an engine fault.

   Pressure in the crankcase (oil pan) will trip the crankcase overpressure detector and bring about a low oil pressure shutdown. The reset button will protrude along with the governor low oil pressure plunger. Overpressure may be caused by a crankcase explosion, or by a fault allowing cylinder or airbox pressure into the oil pan.

   When a crankcase overpressure trip indication is observed leave the engine room area. Allow a 2 hour cool down period before making further inspections or taking corrective action.

In addition to the above this light will be energised but the engine will not shutdown on detection (through the Compressor Oil Pressure (COP) Switch) of low compressor oil pressure caused by low oil level, low oil pressure or broken compressor drive shaft.

ISOLATION SWITCH

This switch allows any unit in a locomotive consist to be "taken off the line" regardless of the control signals from the controlling unit. The switch has two positions:-

1. START/STOP/ISOLATE POSITION

   Must be in this position before the engine can be started, but the unit will not develop power. However, if a controlling unit of a multiple unit consist is isolated, all trailing units will still respond to the controls of the controlling unit. It is recommended that the isolation switch be placed in this position before stopping the engine, but the switch in no way negates any engine stopping switch or device.

2. RUN POSITION

   When the switch is in this position, the unit will respond to controls and will develop power. If the engine is shutdown with the switch in this position, the alarm bell will sound.

ENGINE STOP SWITCH

Momentary pressure on this pushbutton de-energises governor speed setting solenoids and independently energises the governor shutdown solenoid. The governor brings the fuel injector racks to no fuel position and the engine shuts down immediately from lack of fuel.

DYNAMIC BRAKE CIRCUIT BREAKER

In the cutout position this switch prevents the individual unit from going into dynamic braking, yet allows the unit to operate under power. The switch is used to limit the amount of braking effort available in a multiple unit consist or to cut out a faulty dynamic braking system while allowing operation under power.

LIGHT SWITCHES

Switches are provided for various lights employed on the locomotive.

TRACTION MOTOR CUTOUT SWITCH

When the locomotive unit is isolated, an unlock solenoid is energised when the cutout switch handle is pressed in. This also causes the reversing switchgear motor to operate and repeatedly drive the switch gear from one position to another until the handle is released. While the handle is pressed in and turned to a position to cut out a suspected faulty motor, the appropriate switches move to centre and become locked in neutral position. Appropriate power contactors are also dropped out. Control circuits are re-arranged for safe operation at a lower power level.

EMERGENCY SWITCH

In the event of a voltage regulator failure or an auxiliary generator failure this switch may be placed into either VR FAIL or AG/ALT FAIL positions respectively. In the VR FAIL position a resistor is inserted in parallel with the auxiliary generator field circuit. This provides an auxiliary generator voltage output proportional to engine speed. To prevent overexcitation the resistor is set to give a generator output of 74 volts in Notch 8 to provide limited battery charging. In the AG/ALT FAIL position the battery will provide excitation for the D14 alternator field and the locomotive control circuits; Auxiliary circuits, apart from the D14 alternator field, are not supplied with power. In both cases, the EMERGENCY SWITCH is used only to take the locomotive to the nearest point where maintenance can be carried out.

NOTE: Engine Cooling Fans operation is restricted to Notches 6-8 during operation of the Emergency Switch in the VR FAIL position.

CIRCUIT BREAKER PANEL FIG 6-16

The following circuit breakers must be closed for locomotive operation:-

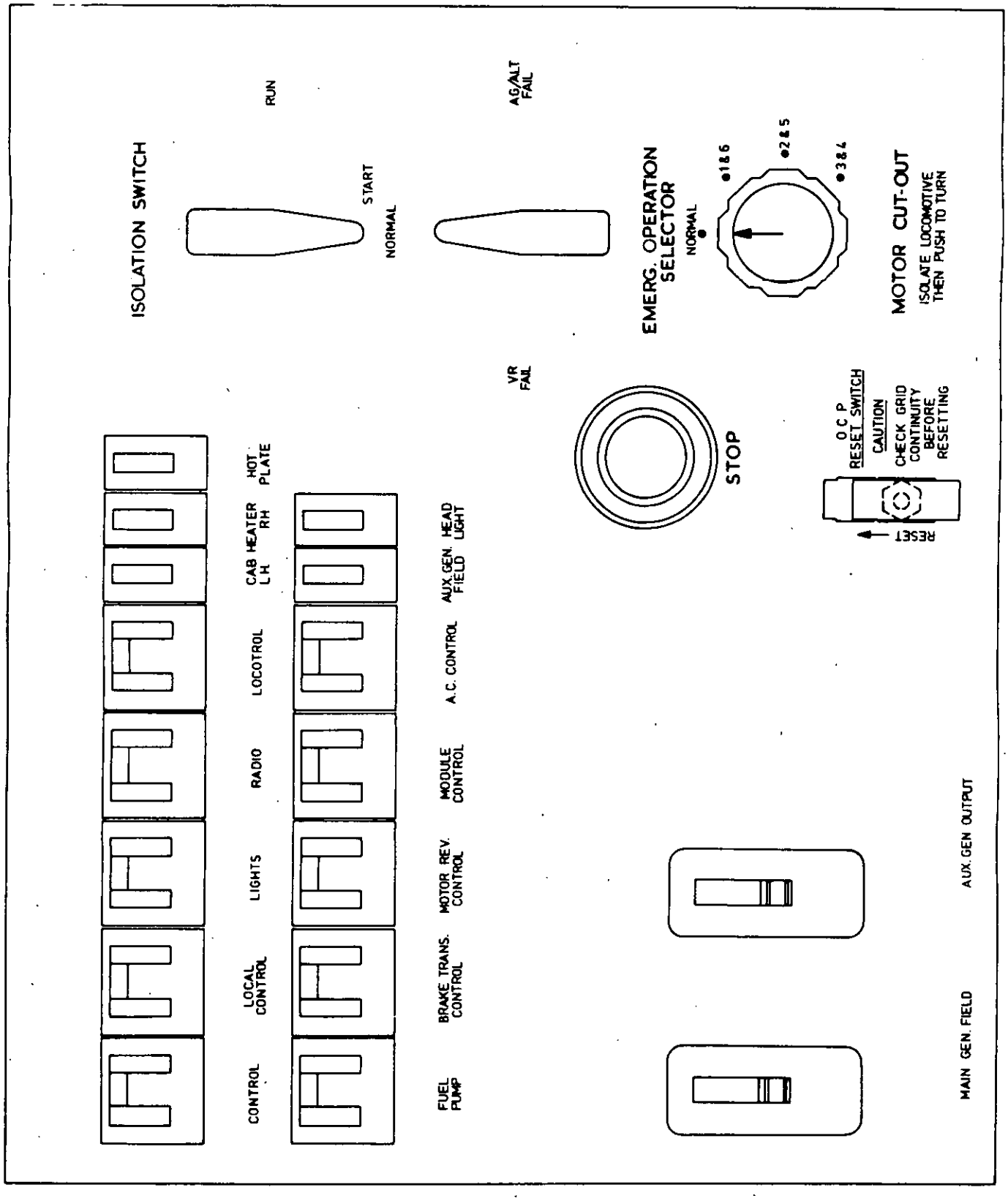
FUEL PUMP

Three pole breakers protect the fuel pump motor and contactor circuits. The engine will shutdown from lack of fuel if this breaker trips.

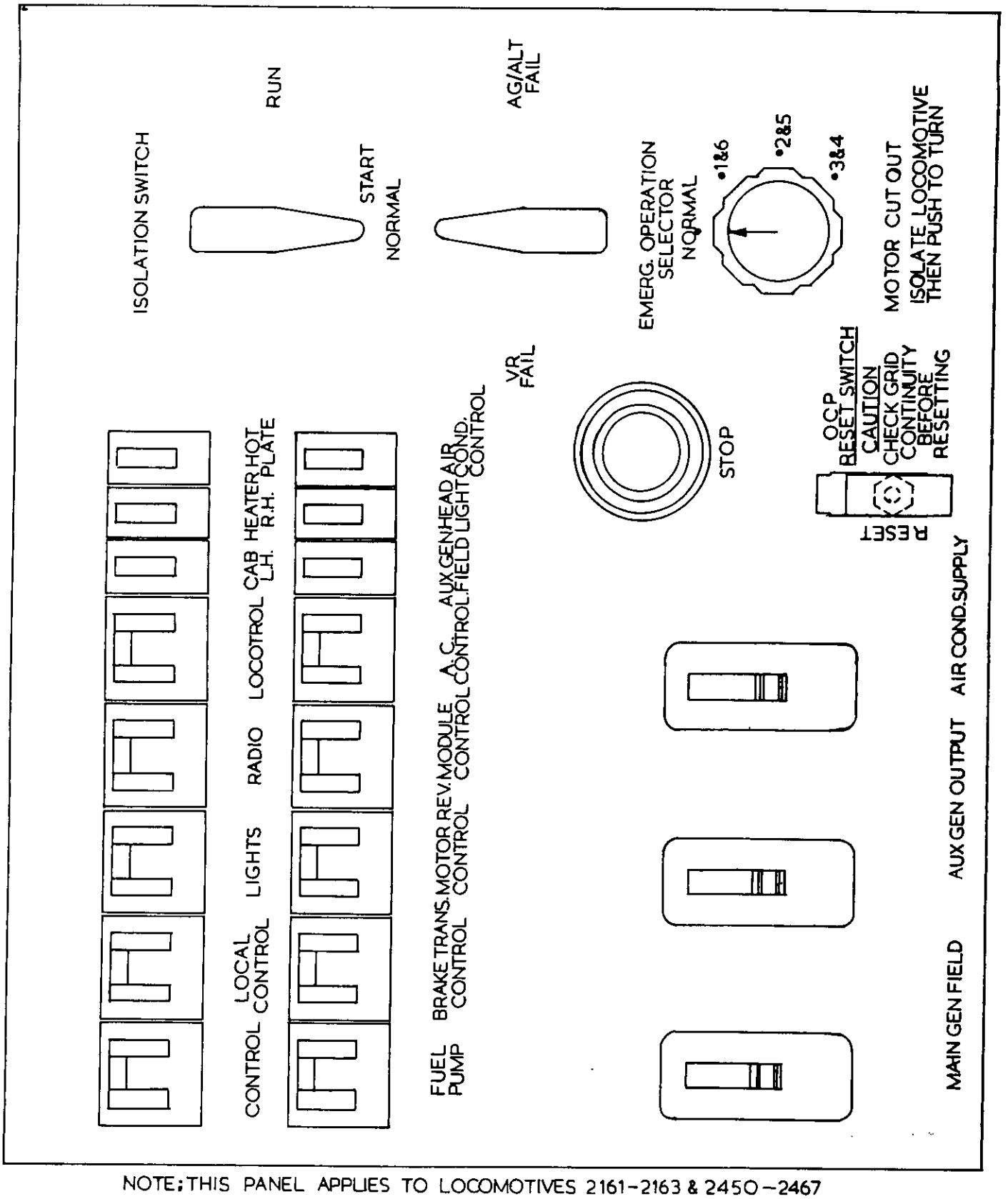
CONTROL

Two pole breaker protects circuits supplying low voltage trainlined control power to all units in a consist.

CIRCUIT BREAKER & SWITCH PANEL



NOTE; THIS PANEL APPLIES TO LOCOMOTIVES 2150 – 2160 & 2400 – 2423



NOTE: THIS PANEL APPLIES TO LOCOMOTIVES 2161-2163 & 2450-2467

LOCAL CONTROL

Two pole breaker protects circuits supplying low voltage control power to the individual locomotive unit.

AUXILIARY GENERATOR FIELD

Single pole breaker protects the field circuit to the auxiliary generator.

MODULE CONTROL

Two pole breaker protects low voltage DC circuits to control modules.

REV CONTROL

Two pole breaker protects motor operated switchgear motor circuit.

AC CONTROL

Two pole breaker protects circuit supplying D14 AC power to control modules, various transductors, and the no voltage relay NVR.

BRAKE TRANSITION CONTROL

Two-pole breaker protects motor operated switch gear motor circuit.

GENERATOR FIELD

Two-pole breaker protects circuit supplying D14 AC power to the main generator controlled rectifier SCR.

AUXILIARY GENERATOR OUTPUT

Two pole 100 A circuit breaker provides protection for all the auxiliary generator's output circuitry.

The following circuit breakers are placed on as required:-

CAB HEATER

Two-pole breaker protects cab heater circuit.

LIGHTS

Two-pole breaker protects the various light circuits.

HEADLIGHTS

Two-pole breaker protects the headlight circuits.

RADIO

Two-pole breaker for radio circuits.

AIR CONDITIONING

One two pole breaker for the whole air conditioning circuit and one single pole breaker for the air conditioning control circuits.

LOCOTROL

Two pole circuit breaker to locotrol equipment.

ALTERNATOR FIELD FUSE

This 60 Ampere fuse provides protection for the D14 alternator field. In the event of a fuse or alternator failure, an alternator failure light and alarm will occur.

FUSE TEST EQUIPMENT

A fuse test block and test lamp are provided, with a switch to test the lamp. Always test fuses before installing them.

GROUND RELAY CUTOUT SWITCH

The purpose of the ground relay cutout switch is to eliminate the ground protective relay from locomotive circuits during certain shop maintenance inspections and in the event of continuous ground relay operation.

STARTING FUSE

A 400 Ampere fuse is installed to protect the starting motors. The fuse is in use only during engine cranking.

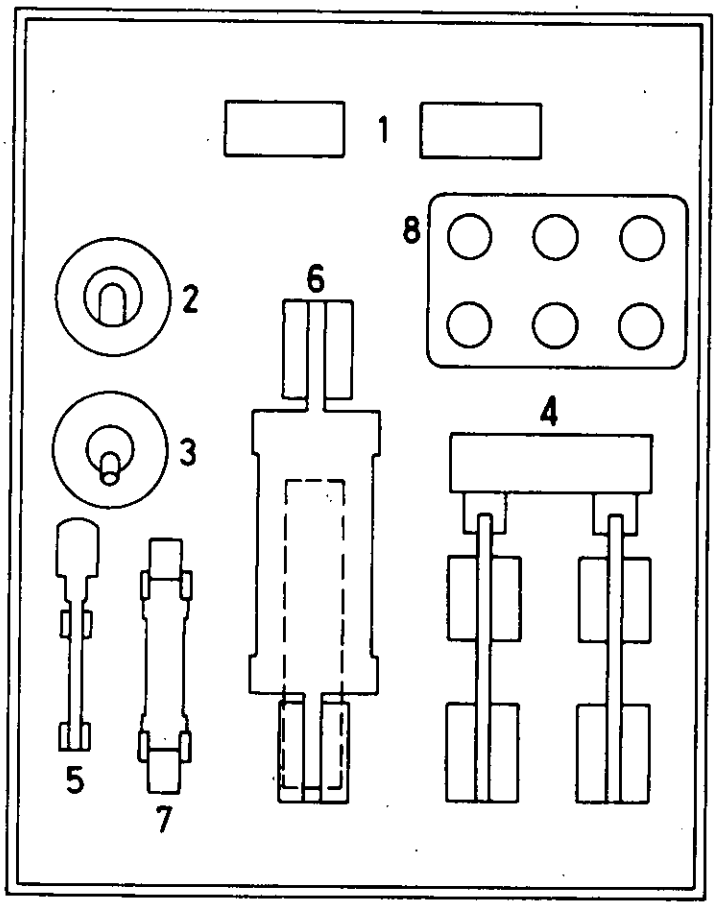
MAIN BATTERY KNIFE SWITCH

This switch connects the battery to the locomotive low voltage system. The switch must always be closed during locomotive operation. It may be opened during shop inspections and locomotive layover.

GROUND FAULT CONTROL LIGHTS

Located forward of the Distribution Panel is a ground fault control light panel. These two lights are each connected in series across the battery. There is a ground connection between the two lights. During normal operation both lights are on with half brilliance. However should a fault appear in either the positive or negative rails of the control circuit there is a path for the battery current around one or other of the lights through the ground fault and back through the ground between the lights. Depending on whether the fault is in the positive or negative rail one of the lights will be cut out and the other will shine with full brilliance. If the fault is in the positive rail the light electrically closest to the battery positive terminal will go out.

DISTRIBUTION PANEL



1 FUSE TEST TERMINALS
2 FUSE TEST LIGHT
3 FUSE TEST LIGHT SWITCH
4 MAIN BATTERY KNIFE SWITCH
5 GROUND RELAY CUT-OUT SWITCH
6 START 400 AMP FUSE
7 DI4 ALTERNATOR FIELD 60 AMP FUSE
8 METER TERMINALS

CIRCUIT MODULES

Each circuit module contains components and wiring for one or more locomotive control functions. The components are mounted on one or more circuit boards. All circuit boards are of the same size, and terminals on the boards are placed on a common grid pattern. The boards are fitted with receptacle strips arranged in a vertical plane, and as the board is inserted into guideways and fully seated, the receptacles mate with pins that are connected to terminal strips. Cabinet wiring completes the circuit connection. Face plates and handles are attached to the circuit boards, and test points are located on the face plates. In addition to the test points the face plates may contain test buttons and lights.

AN CIRCUIT MODULE

Fault Annunciator

The annunciator records, by means of latching relays and lights, faults or abnormal operating conditions that occur during locomotive operation. Once lit, the annunciator lights will stay on until a guarded reset switch is operated by a qualified maintenance man. Correction of a fault or resetting of protective devices does not reset the annunciator.

The annunciator provides the following indications:-

1. HOT ENGINE
2. GOVERNOR SHUTDOWN
3. GROUND RELAY OPERATED
4. EXCITATION LIMIT OPERATED
5. GRID OVERCURRENT
6. MOTOR OVEREXCITATION
7. GRID OPEN CIRCUIT
8. GRID BLOWER FAILURE
9. EMERGENCY SWITCH OPERATION
10. FIRE ALARM
11. T.M. CUTOUT OPERATION

DE CIRCUIT MODULE

Extended Range Brake Control

During dynamic braking a signal from the brake control rheostat is compared at the SB transistor with the main generator feedback signal in the FP module. Main generator excitation is regulated as a result of this comparison and main generator regulation results in motor field and braking current regulation. During extended range dynamic braking the feedback signal from the FP module is compared also with a signal from brake current transductor BCT, and when the BCT signal falls below the FP feedback signal (indicating less dynamic braking grid current than called for by braking lever position) the DE circuits operate to energise a grid shorting contactor. The grid shorting contactor decreases total dynamic braking grid resistance, and more current flows in the grids.

The DE circuit module also compares the BCT signal with the brake rheostat signal during extended range braking. When the BCT signal exceeds the level called for by the brake rheostat, a DE circuit activates the brake regulator circuit in the DR module and holds dynamic braking current at a maximum established by braking handle position.

DG CIRCUIT MODULE

Grid Blower Protection

Excessive current, as with a stalled grid blower motor; or lack of motor current, as with an open motor or cable will be detected by the dynamic grid current transductor. The transductor signal will trigger a latching circuit in the DG module. The braking power contactor "B" is dropped out to prevent dynamic brake operation. A reset button on the DG module allows resetting of the circuit after inspection and correction has been made. A test button is provided on the DG module to test the DG circuit function. The button provides a DC signal to test windings on the transductor in order to simulate a current unbalance at the transductor.

DP CIRCUIT MODULE

Brake Warning

Motor Field Protection

The dynamic brake protective module provides back up protection should normal regulating devices fail. Should the dynamic brake regulator fail, the brake warning circuit of the DP module will provide rough backup regulation and an annunciator signal. Should motor fields become too hot, the motor field protection circuit of the DP module will protect the motors, provide rough backup regulation, and provide an annunciator signal.

DR CIRCUIT MODULE

Brake Regulator

The DR circuit senses voltage across a dynamic braking resistor grid. When that voltage reaches a value indicative of the maximum allowable amperes in the grids, a transistor in the DR circuit acts to shunt the input to the rate control capacitor of the RC module directly to negative. The rate control capacitor then discharges through a fixed resistance in the RC module. Main generator excitation is thereby controlled to maintain traction motor field excitation for maximum braking current.

A further modification of braking current regulation is in effect during extended range dynamic braking. The turn on point of the DR transistor is controlled not by maximum allowable current in the grids, but by braking handle position. In other words, maximum braking current at lower braking handle positions is low, regardless of train speed. This type of regulation is required to snub braking current surges that occur when grid shortening contactors pick up or drop out.

EL CIRCUIT MODULE

Excitation Limit

The excitation limit transductor senses main generator field current, and provides a signal to the EL module. When an overcurrent condition occurs the EL module causes drop out of the generator field contactor. In this manner the EL module provides backup protection in case of GX module failure, and allows rough regulation of generator current to allow the locomotive to operate under power to reach a maintenance point. The test button on the EL module is used to energise a test winding on the ELT transductor and simulate an overcurrent condition.

FS CIRCUIT MODULE

Field Shunting Control

The field shunting control module FS initiates field shunting of the six traction motors.

As locomotive speed increases, main generator output voltage increases and output current decreases. A signal proportional to the main generator output current is obtained from the performance control module and a three phase signal proportional to main generator output current is obtained from the performance control module and a three phase signal proportional to main generator output voltage is obtained from the generator potential transformer and applied to the FS module. The FS module monitors the main generator output voltage and output current. When voltage approaches a high value for power level as determined by throttle position, the FS module initiates motor field shunting.

Pickup of FS module contacts provides a circuit for shunting some current around motor fields. This weakens the motor field, which decreases the counter electromotive force of the motors to extend the range of the main generator within the power level called for.

FP CIRCUIT MODULE

Performance Control

Current transformers within the main generator apply a signal to FP module proportional to main generator current. Potential transformers in the electrical cabinet apply a signal proportional to main generator voltage. These AC signals are rectified and loaded on precisely determined values of resistance within the FP module. DC voltages across the resistors are combined, added and applied to the sensor bypass transistor in the module for comparison with the reference signal from the load regulator to control current in the control winding of the SE (Sensor) Module. The SE module current directly controls generator excitation and hence output. The ohmic values of the FP resistors are selected to obtain performance control characteristics desired for locomotive response to throttle position during train starting, and to obtain a suitable balance point for the load regulator during normal operating service.

GV CIRCUIT MODULE

Voltage Regulation

The normal condition of the GV circuit module during locomotive operation is full on. There is very slight voltage drop across the 8 and 4 terminals. When the GV module regulates there is a large drop across the terminals. Regulation occurs when a signal from generator potential transformer GPT is great enough to bias the GV transistor off. The function of GV is to maintain main generator voltage at a safe level.

GX CIRCUIT MODULE

Excitation Regulation

The normal condition of the GX circuit module during locomotive operation is full on. There is a very slight voltage drop across the 8 and 4 terminals. When the GX module regulates there is a large voltage drop across the terminals. Regulation occurs when a signal from excitation limit transductor FCT is great enough to bias the GX transistor off.FCT senses generator field excitation current.

RC CIRCUIT MODULE

Rate Control

The response of the main generator and the main generator control system is so fast that sudden changes in the level of reference voltage would result in rough train handling. The RC module makes use of an RC (resistance & capacitance) circuit to smooth out power changes even though an abrupt change in reference signal occurs.

SE CIRCUIT MODULE

Sensor

This magnetic amplifier provides shaped signal pulses to turn on the silicon controlled rectifier assembly that provides excitation current to the main generator. Small amounts of current in the control windings of the magnetic amplifier control large amounts of current in the main generator field. The ability to use signals to control large currents simplifies the construction of protective and regulating devices related to main generator excitation, and allows rapid and precise control.

TH CIRCUIT MODULE

Throttle Response - Reference Voltage Regulator

The voltage reference regulator section of the TH circuit module provides extremely stable reference voltage for the excitation control system. The throttle response section of the TH module provides reference voltage directly related to throttle position. This reference voltage is impressed upon power control circuits and locomotive power is precisely controlled by throttle position.

A test button on the TH module is provided to energise the ORS solenoid in the engine governor. This is merely to provide test control of the load regulator.

VR CIRCUIT MODULE

Voltage Regulator

The locomotive low voltage system and equipment are designed for operation on 74 volt DC power supplied by the auxiliary generator. This voltage must be kept constant regardless of changes in engine (and generator) speed.

The voltage regulator is used in the auxiliary generator field excitation circuit and functions to vary excitation as needed to hold output voltage constant despite speed changes. This device functions entirely automatically and should never be disturbed during operation.

The regulator utilises solid state electronic components to regulate auxiliary generator voltage. The regulator does this by rapidly turning the generator field circuit on and off. Time "ON" in relation to time "OFF" establishes auxiliary generator voltage. The regulator is called a static voltage regulator because with the exception of a starting relay it uses no moving parts.

The face of the VR module is provided with a slotted-shaft rheostat to adjust generator voltage between 72 and 76V DC. This adjustment is provided for battery charging purposes only.

NOTE: The VR circuit module does not provide stable reference voltage for the excitation system. The stable reference voltage is provided by a regulating circuit located on the TH module.

The diesel engine must be completely stopped before the VR module is removed or inserted.

WS CIRCUIT MODULE

Instantaneous Detection And Correction Unit (IDAC)

Wheelslip correction is based upon acceleration of slipping wheels in the first and second stages. The first stage being immediate power reduction and immediate return to power in small increments. The second stage involves essentially a first stage reduction of power followed by a slower return to power. The third stage of correction is based upon a level value of wheelslip signal rather than a rate of change.

The WS module is provided with a test button that is operative with the unit isolated or with the throttle in idle. When the test switch is operated a green light on the face of the module indicates with a high degree of probability that the wheelslip system is functioning properly. A red test lamp indicates that the WS module is faulty.

TEST PANEL FIG 6-20

A test panel located in the module compartment contains terminals and receptacles that provide an easy place to read significant test voltages during operation or test. The test selector switch has the following positions:-

1. NORMAL for locomotive operation.
2. CIRCUIT CHECK, which allows control circuits to function when the generator field circuit breaker is opened.

3. LOAD TEST, which allows control and excitation circuits to operate when the reverser is centred, but prevents delivery of power to traction motors.

The Circuit Check position does not prevent excitation of the main generator.

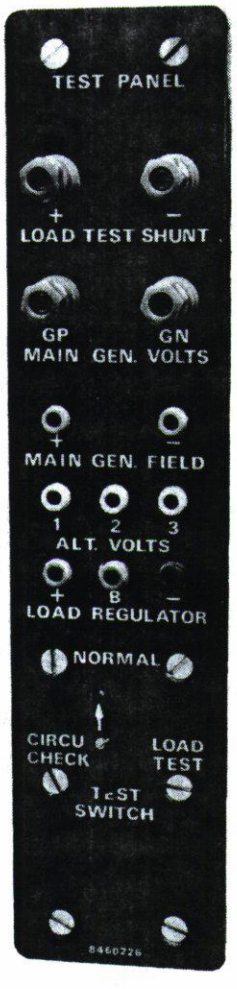


Fig. 6-19 - Test Panel

NOTE There is no facility for load test on the panel as supplied on the GL22C-2 and GL26C-2 locomotives. Consequently upper two terminals marked LOAD TEST + SHUNT - on the test module in Fig. 6-20 are not present.

ELECTRICAL DEVICES

The following devices are listed alphabetically for ease of reference. For the most part the devices are located within the main electrical cabinet.

BRAKING POWER CONTACTOR

During dynamic braking this contactor is connected in series with traction motor fields and the main generator. It has high current interrupting capability, and must always open before transfer switchgear operates. Interlocks prevent operation of transfer switches while the "B" contactor is closed.

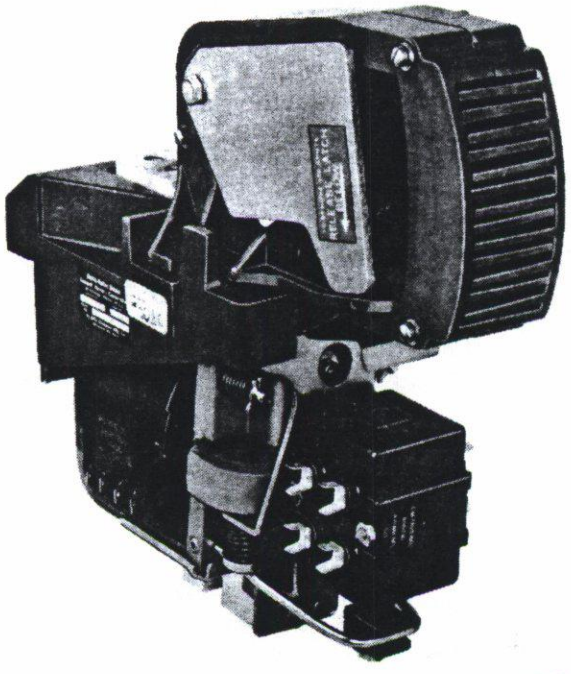


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Fig. 6-20- Braking Power Contactor

BRAKING CURRENT TRANSDUCTOR; BCT

On locomotives equipped for grid current trainline control and those equipped for extended range dynamic brakes, this transductor is used to provide a signal proportional to current in the dynamic brake resistor grids. The transductor consists of coils wound on iron cores. A cable that carries braking current passes through the cores. The transductor coils are connected in series with a transformer T4 across the D14 alternator. The strength of dynamic braking current controls the impedance of the BCT coils, and the output transformer T4 provides a sign that is proportional to braking current. This signal is applied to dynamic brake control circuits in the DR and DE modules.

The DR and DE modules use the signal to regulate maximum braking grid current according to braking handle positions. The DE module uses the signal to bring about pickup of grid shorting contactors at given values of braking current.

BRAKE RELAYS; BR1, BR2

These relays are energised when the selector handle is indexed to the brake position. BR relay contacts set up dynamic braking circuits and nullify power circuits. BR1 contacts are made of gold alloy material and are located in control circuits that carry small amounts of current. BR2 contacts are located in circuits carrying greater amounts of current.

When transfer from power to brake is made, a time delay interlock in the feed to the BR coils ensures the decay of generator residual before circuit transfer is initiated by pickup of the BR relays.

CA: CAPACITORS

CA30

Connected around the operating coil of the GFD contactor to suppress arcing at circuit interrupting interlocks.

CA31

Connected in series with a resistor around the operating coil of contactor delay relay CDR to delay dropout of the relay.

CA32

When the controlled rectifier SCR is turned on, this capacitor in conjunction with R32 suppresses the voltage spike that occurs when the "free-wheeling" diode around the generator field is turned off.

CA33

Suppresses arcing at CDR contacts which operate to drop out power contactors.

CA34, CA40

When dynamic braking current is rapidly rising to the regulated value, charging current in CA34 anticipates the approach of full current and triggers the DR transistors. This anticipation effect results in stable DR function with little or no overshoot.

CA35

In conjunction with R35 provides a time delay on dropout of RVF relay during traction motor cutout operation.

CA36

In conjunction with R38 provides a time delay on dropout of MCOX relay during Traction Motor Cut Out Operation.

CA52

Suppresses arcing of DPC contacts which operate to drop out dynamic brake operation when an emergency brake application is made.

COMPRESSOR CONTROL SWITCH; CCS

The compressor control switch senses main reservoir pressure. When main reservoir pressure reaches 830 kPa., the feed to the compressor control magnet valve will be interrupted and the compressor will unload. When main reservoir pressure falls to 726 kPa contacts of the compressor control switch will close, energising the compressor control magnet valve and causing the compressor to pump.

CONTACTOR DELAY RELAY, CDR

Contacts of CDR are connected in the feed to power contactor operating coils. A resistor-capacitor combination connected around the operating coil of CDR delays drop out and prevents interruption of the feed to power contactor operating coils. CDR drop out is initiated by direction transfer, motor-brake transfer, isolation or intermittent trainline feed. CDR delays prevents the power contactors from interrupting high voltage and current, with resulting increase in contactor life and elimination of high voltage transients that can damage main generator diodes. One set of CDR contacts latches the CDR relay in against drop out of the MR relay when the throttle is placed in the idle position. This prevents unnecessary operation of power contactors and requires return of the throttle to idle position before power contactors will pick up after a circuit change is made.

MOTOR CUTOUT RELAY; COR

On units equipped for motor cutout the contacts of this relay perform a variety of functions to ensure proper operation with two traction motors cut out. This involves disabling 2 "P" power contactorsand certain contactors wheelslip control circuits, changing the slope and position of power control lines, and providing circuits around the interlocks that are not positioned because the related motor is cut out.

RECTIFIERS; C R

CR1 to CR11

Steering diodes for indication and fault warning lights

CR17

This rectifier is connected as a discharge rectifier around the D14 field to stabilise D14 output. The "freewheeling" characteristics smooths out fluctuations resulting from variations in field current.

CR31 to CR33, CR36 and CR28 to CR40

Perform blocking functions in circuits to govern and throttle response module.

CR34

Blocks backfeed from TDS operation of sanding valves to other locomotives in consist.

CR35

Delays drop out of fuel pump contactor relay FPC to ensure against engine shutdown due to transient circuit interruption.

CR37

Blocks backfeed from the DE module to the RC module discharge capacitors.

CR41

Blocks rate control capacitor discharge through the TH module.

CR43

Blocks backfeed during emergency operation.

CR45

Blocks backfeed from ORS circuit.

CR46

Blocks regenerative feedback from brake current transductor BCT through DE module circuits to RC module circuits.

CR48

Blocks backfeed on drop out of MCOX and therefore will not shunt time delay.

CR50

Acts to suppress transient or dropout of TDS.

CR49

Acts to suppress a transient generated upon ORS dropout.

CR-BC, BATTERY CHARGING RECTIFIER AND RESISTOR ASSEMBLY, FIG 6-22

The resistor and rectifier assembly consists of a full wave three phase rectifier bridge, a battery charging rectifier and a battery charging resistor. The full wave three-phase rectifier bridge rectifies the 55 V AC output of the AC auxiliary generator providing 74V DC for battery charging, D14 alternator excitation and 74V DC control power. The battery charging rectifier isolates certain equipment which is to be operational only with the engine running. The battery charging resistor provides the necessary voltage drop for battery charging.

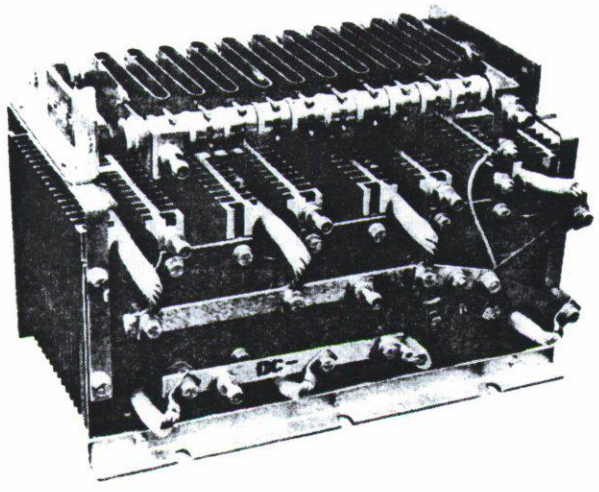

Fig. 6-21— Battery Charging Rectifier and Resistor Assembly

GROUND RELAY RECTIFIER CR-GR

It is the function of the ground relay to detect high voltage DC and AC grounds and AC phase unbalance at the main generator. The fast acting relay uses an operating coil of high impedance, consequently the relay will not respond properly to alternating current. The ground relay rectifier changes AC signals to DC at the ground relay operating coil, thus ensuring rapid operation of the relay.

CURRENT TRANSFORMERS; CT

Current transformers are located within the main generator airbox. Three cables, one from each phase of the three-phase AC output, pass through the CT's before connecting to the main generator rectifier assembly. The cable from phase A passes through CTA, from phase B through CTB, and from phase C through CTC. The signals from the CT's are proportional to main generator DC output. They are applied to the performance control module FP from which a feedback signal is derived and used for locomotive control.

DYNAMIC BRAKE GRID SHORTING CONTACTORS; DC1,2,3 FIG 6-23

On locomotives equipped with extended range dynamic brakes, the DC power contactors close in sequence to short out approximately one fourth dynamic braking grid resistance for each contactor. This reduction of braking grid resistance allows current flow through the remaining grids to continue at a high level as locomotive speed decreases.

The contactors are rated to carry more than 2000 Amperes continuously, and are equipped with arc chutes that contain, expand and extinguish arcs by action of a permanent magnet blowout structure. The contactor is rated to open in parallel with dynamic braking grids on volts up to 350 and current up to 2400. Contactor operation is controlled by the DE module and pilot relays.

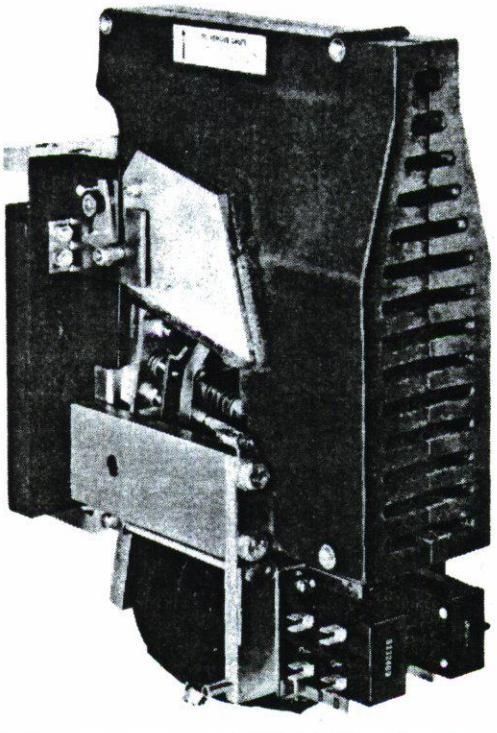

Fig. 6-22- Dynamic Brake Grid Shorting Contactor

DYNAMIC GRID TRANDUCTOR; DGT

This transductor is constructed of the same basic parts as the wheelslip transductors, but in addition is equipped with a spool to accept and firmly hold several turns of cables leading to braking grid fan motors. In the event of a stalled fan or motor, or an open in the motor circuit, currents at the transductor create an unbalance.

The unbalance is sensed at the DG circuit module, and the braking power contactor is locked out. A reset button on the DG circuit module will reset the lockout after the fault has been corrected.

DYNAMIC BRAKE RELAYS;DP1,2,3

These relays are controlled by the extended range dynamic brake control circuit module DE. They pilot the extended range dynamic brake power contactors DC1, 2 and 3.

AUXILIARY PILOT RELAY; DP1A

Establish grid current control during extended range dynamic braking. Units with extended range dynamic brakes and no DP1A relay are equipped for full range grid current control.

EXCITATION LIMIT TRANSDUCTOR; ELT

If generator field current exceeds a safe level, ELT actuates the EL circuit module. The equipment protective relay is dropped out, which in turn drops out the generator field contactor GFC until current falls to a safe level. The action protects equipment, yet allows rough regulation to get the locomotive to a maintenance point.

EQUIPMENT PROTECTIVE RELAY;EQP

It is the function of the EQP relay to drop out the generator field contactor GFC when protective devices operate to back up faulty regulating devices. EQP dropout can occur through operation of the following:-

1. DP circuit module brake warning and motor field protective relays.
2. Through pickup of the excitation limit relay of the EL circuit module.
3. Through pickup of the FS module OSR relay when wheel overspeed is sensed. (GL26C-2 locomotives).
4. Through dropout of the generator field decay relay that is piloted by the ground relay.

All of the above accomplish rough regulation to enable the locomotive to get to a maintenance point. None of the devices lock in after pick up. However the ground relay latches in after a specific number or a specific rate of GR operations.

ENGINE RUN RELAY; ER

The function of the engine run relay is to set up control circuits to the governor speed setting solenoids. Therefore, if the engine run relay is de-energised by placing the engine run switch in the OFF position or by operation of safety devices, the diesel engine will not run above idle speed.

The engine run switch on the locomotive control stand must be in the "ON" position before the engine run relay can be energised.

ENGINE TEMPERATURE SWITCH; ETS

This switch is located in a water manifold on the equipment rack. It senses engine water temperature and picks up to indicate excessive temperature. Upon pickup it turns on the HOT ENGINE light and energises the TH relay which operates to reduce engine speed and power. Contacts of ETS also protect against failure of other temperature sensing switches by providing a backup feed to a cooling fan contactor.

FIELD CURRENT TRANSDUCTOR; FCT

This transductor consists of two toroidal iron cores, each with a 1000 turn test winding is also common to both cores. The cores and windings are completely enclosed and hermetically sealed. D14 AC is impressed upon the windings, and a hole in the molded enclosure admits a cable carrying current through the transductor and to the generator field. When field current reaches a specific level, output from the transductor causes the GX module to go into a blocking state. Control current ceases to flow in the SE module (Sensor) control windings and generator excitation is reduced.

COOLING FAN CONTACTORS ; FC1,2

The cooling fan contactors operate to supply D14 AC power to the radiator cooling fan motors. They are controlled by temperature switches mounted in a water manifold on the equipment.

FOR ; DIRECTIONAL RELAY, FORWARD

This relay along with RER controls the direction in which the locomotive will move. The designation FOR is related to the short hood end of the unit. The relay is energised by trainlined control current when the reversing lever on the controller is placed in the appropriate position.

Contacts of the relay make or break circuits using local control current to activate heavy duty motor driven transfer switches. The transfer switches establish the direction of high voltage main generator current flow through traction motor fields.

Crossover wires at each of the jumper cable receptacles between units of a consist are so arranged that whatever the makeup of the consist, the appropriate relays in trailing units will be energised.

FUEL PUMP CONTACTOR; FPC

Use of this contactor relieves the fuel prime-engine start switch of fuel pump motor current load.

FUEL PUMP RELAY; FPR

The primary purpose of the fuel pump relay is to provide the locomotive operator with the means of shutting off the fuel pump from a switch on the control stand. Before the engine is running, the relay performs no function, but it must be picked up to set up the fuel pump contactor circuit.

CAUTION The control and fuel pump switch must always remain in the ON position while the engine is running. If an engine shuts down from lack of fuel, damage to the engine injectors is possible.

FIELD SHUNTING CONTACTOR ; FS1A ,FS1B

These contactors are energised by pick up of FSRA relay. Pick up of FS1A and FS1B connects field shunt resistors RMFSA and R MFSB in parallel with the traction motor fields.

FIELD SHUNTING AUXILIARY RELAY; FSRA

This relay is energised by operation of the field shunting control module FS. Pickup of FSRA energises field shunting contactors FS1A and FS1B.

GENERATOR FIELD CONTACTOR;GFC

The main contacts of this device are located in the AC supply from the D14 alternator to the main generator excitation rectifier SCR. The contactor will pick up to close the main contacts when circuits are complete for power operation, dynamic braking or load testing. A GFC interlock pilots an auxiliary relay GFX whose contacts perform interlocking functions associated with GFC operation.

GENERATOR FIELD DECAY CONTACTOR ; GFD

During ground relay action, GFD operates to drop out equipment protective relay EQP which in turn drops out generator field contactor GFC. GFD main contacts open to insert resistance in series with generator field discharge circuit, and thereby increase the field decay rate by limiting the duration of circulating current.

GENERATOR FIELD AUXILIARY RELAY; GFX

This relay is piloted by operation of the GFC contactor. Its primary function is to complete the throttle reference voltage circuit from the throttle response function of the TH circuit module to the rate control function of the RC circuit module. Secondary functions nullify various module test circuits during power or braking operation.

GENERATOR POTENTIAL TRANSFORMERS ; GPT

Voltage from the AC side of the main generator rectifier assembly is applied to the primary windings of GPT. An output signal proportional to main generator voltage is applied from GPT to the generator voltage regulating module GV, to performance control module FP.

GROUND RELAY ; GR

The ground relay detects AC and DC high voltage grounds or the loss of five paralleled main generator diodes in a group. It does not detect low voltage grounds. When the relay is tripped, the GRD/FAULT light comes on. This light is located on the accessory panel and on the annunciator module within the electrical cabinet. The accessory panel light goes out when the ground relay is reset, but the annunciator light remains on until the annunciator is reset.

The ground relay is held in its tripped position by a mechanical latch in the relay. It is reset by an automatic reset device on locomotives so equipped. The automatic resetting device also provides a reset lockout that prevents further resetting after a specific number of resets or after a specific number of resets within a specific time period.

INDEPENDENT PRESSURE SWITCH ; IPS

Application of the locomotive air brake during extended range dynamic braking will actuate this switch and will nullify extended range dynamic braking. This is done to prevent the possibility of sliding wheels.

LOAD REGULATOR ; L R FIG 6-24

The load regulator is a plate type rheostat driven by a hydraulically operated vane motor. A pilot valve in the engine governor controls a flow of engine oil under pressure to drive the vane motor clockwise or counter-clockwise through a maximum arc of about 300 degrees, thereby positioning the rheostat brush arm and regulating the output of the main generator by varying a signal to a system that controls excitation of the generator field. Control of generator field excitation results in control of the load on the engine. Load control of the engine by the governor permits the governor to maintain engine speed with regulation of power at the correct level for a given speed.

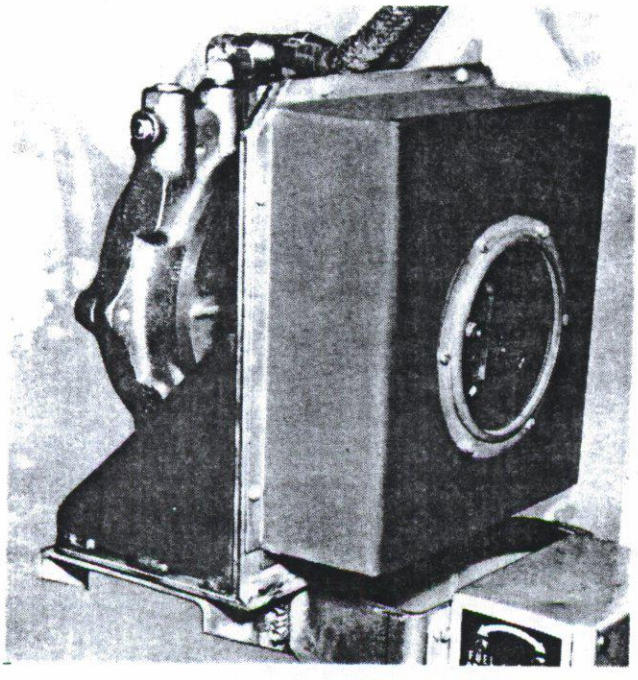

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Fig. 6-23 - Load Regulator

MOTOR BRAKE TRANSFER SWITCH; MB FIG 6-25

This switchgear is used to transfer circuits from the power mode of operation to the dynamic braking mode on locomotives so equipped. The device is made up of motor driven gang operated switches rated at 1200 Amperes and 1500 volts. There can be from two to six double-pole double-throw switches per device. Being motor driven, once the switch is positioned, it will not drop out. A positive feed is required to move the contacts. When they do move, all poles operate together, and a single interlock suffices to indicate the position of all switches. This increases interlock availability and allows complete protective interlocking.

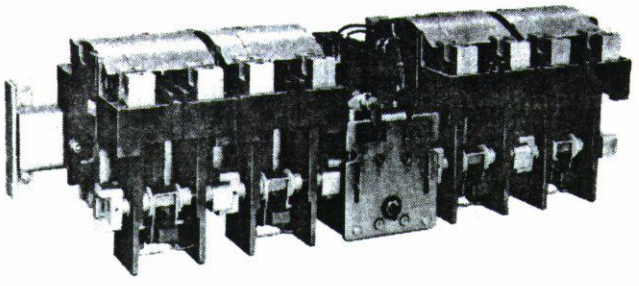

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Fig. 6-24- Typical Motor Operated Transfer Switch

MOTOR CUTOUT AUXILIARY RELAY; MCOX

MCOXoperates in conjunction with relay RVF to drive the motor operated transfer switches RV from one position to another when the rotary cutout switch in the cab is operated. This allows MCO relays to lock transfer switch contacts to an open centered position and cutout the power circuits to the appropriate traction motors.

MOTOR CUTOUT MAGNET COIL AND LIMIT SWITCH; MCO

On units equipped for traction motor cutout, an MCO magnet coil is mounted on each RV transfer switch. An MCO coil is energised whenever the rotary cutout switch in the cab is operated to cutout a faulty motor. When the rotary switch is operated, the motor operated transfer switch assembly will cycle between forward and reverse positions. As the switch to be cutout passes through centred position, the MCO locks the contact operator in the centred or neutral position, and the MCO armature operates a limit switch assembly to pick up the COR relay which functions to set up control circuits for operation with motors cut out. The limit switch contacts also hold the appropriate "P" power contactor dropped out.

MOTORING RELAY; MR

This relay performs functions formerly assigned to the relay identified as GFR. It is energised when the throttle is opened for power. It is dropped out during dynamic braking. Contacts of the MR relay perform functions associated with excitation of the main generator field.

MAGNET VALVE, COMPRESSOR CONTROL; CMV

When the compressor control magnet valve is de-energised, the air compressor unloader valve opens and the compressor begins to pump. The magnet valve is de-energised on the basic system by action of the compressor control switch CCS. On units equipped for synchronisation of all compressors in a consist, the magnet valve is de-energised when the compressor relay responds to the compressor control switch in the individual unit or to the compressor control switch in each or any unit of a consist.

NO VOLTAGE RELAY; NVR

This relay is energised by AC current from the D14 alternator when the engine is running. In the event that auxiliary AC power is somehow lost, NVR drops out. This sets up circuits to sound an alarm and restrict the diesel engine to idle speed.

Loss of AC to NVR can be caused by the engine stopping, by tripped main generator field or AC control circuit breakers, by trip of the auxiliary generator field circuit breaker, or by failure of the D14 alternator or the auxiliary generator fuses.

OPEN CIRCUIT PROTECTIVE RELAY; OCP

On units equipped with extended range dynamic brakes, this latching relay is bridge connected between motor armatures and dynamic braking resistor grids during dynamic braking. If an open occurs in the grid or cables, the relay picks up and latches in. It can not be reset by the locomotive operator, and should be reset by maintenance personnel after a thorough examination of the dynamic braking grids and cables. The reset button is located within the electrical cabinet.

CAUTION; Do not reset OCP until a thorough inspection has been made to ensure that dynamic braking grids and cables are in satisfactory condition.

OVERRIDING SOLENOID; ORS

This solenoid is located within the engine governor. When energised it operates the load regulator pilot valve, and causes governor oil pressure to drive the load regulator to minimum field position. ORS is energised when protective devices operate, and during transition on units that require transition. A test button on the TH module provides the means for checking governor control of the load regulator by energising ORS.

RESISTORS

R2A-B

This resistance is inserted in series with the main generator field to increase the rate of field decay when ground relay action occurs.

R3A-B

Provide limiting resistance in the circuits for the ground relay.

R4A-B

Preset dropping resistors for headlight indicators R5, R9 & R13. These resistors will cause a drop in reference voltage to the load regulator in the event of a wheelslip during dynamic braking.

R6A-B-C, R7A-B-C

These adjustable resistors provide proper voltage for the headlights.

R8A-B, R15A-B, R16-A-B

These voltage divider resistors form a bridge circuit which if unbalanced during dynamic brake will cause pick up of wheelslip relays.

R11, R12

These resistors provide a load during initial pickup of starter motor solenoids.

R14

Provides the load for the output from the wheelslip transductors. The voltage drop across this resistor is the wheelslip signal to the WS module.

R27A-B

These dropping resistors reduce supply voltage for speedo lamps.

R31

With CA31 establishes time delay dropout of contactor delay relay CDR.

R32

With CA32 acts to suppress voltage spikes at the SCR.

R33

With CA32 acts to suppress arcing at CDR relay contacts.

R35

With CA35 establishes time delay dropout of RVF relay.

R38

With CA36 establishes time delay dropout of MCOX relay.

R39

Used to modify SE Module operating characteristics during dynamic braking.

R40

This dropping resistor protects TH module from high input signal during manual power control.

R41

With CA37 acts to suppress a transient generated upon GFC contactor dropout.

R44

Controls the rate control capacitor discharge rate through grid current control circuits on units equipped for extended range dynamic brakes.

DIRECTIONAL RELAY, REVERSE,RER

This relay along with FOR controls the direction in which the locomotive will move. The designation is related to the long hood end of the unit. The relay is energised by trainlined control current when the reversing lever on the controller is placed in the appropriate position. Contacts of the relay make and break circuits using local control current to actuate heavy duty motor driven transfer switches. The transfer switches establish the direction of high voltage main generator current flow through traction motor fields.

Crossover wires at each of the jumper cable receptacles between units of a consist are so arranged that whatever the make up of the consist, the appropriate relays in trailing units will be energised.

DYNAMIC BRAKE RHEOSTAT, RH50

During dynamic braking this rheostat is operated by the braking handle. It consists of a plate type potted assembly.

TRANSFER SWITCH FORWARD RELAY,RVF

On units equipped for traction motor cutout, this relay operates in conjunction with motor cutout auxiliary relay MCOX to drive the motor operated transfer switches RV from one position to another to allow the motor cutout relays to lock transfer switch contacts at an open centred position and cutout the power circuits to the appropriate traction motor(s).

DIRECTIONAL TRANSFER SWITCH, RV

This switch is used to change the direction of current flow through the traction motor fields. The device is made up of motor driven gang operated switches rated at 1200 amperes and 1500 volts. There are from two to six double-pole double-throw switches per device. Being motor driven, once the switch is positioned, it will not drop out. A positive feed is required to move the contacts. When they do move, all poles operate together, and a single interlock suffices to indicate the position of all switches. This increases interlock availability and allows complete protective interlocking.

SILICON CONTROLLED RECTIFIER, SCR

AC power from the D14 alternator is rectified and applied to the main generator in controlled amounts by this rectifier assembly. A triggering device in the power control system signals the amount of power that the SCR sends to the generator field.

SERIES PARALLEL AUXILIARY RELAY, SPY

This relay is energised when the SP contactors are picked up. The SPY relay provides a holding feed to the SP contactors during field shunting and sets up the circuit to the FS1 relay.

STARTING CONTACTOR, ST

The cranking motor assemblies are equipped with heavy duty contact tips that make contact when the starting solenoid has operated to engage the cranking motor pinion with the starting gear. Such contacts are normally used to carry current to the cranking motors; however, to ensure reliability of the cranking devices, the locomotive uses the solenoid operated contacts to pilot a still heavier duty contactor ST. Use of this starting contactor also ensures engagement of each of the paired cranking motor pinions before power is applied to the cranking motors.

STARTING AUXILIARY CONTACTOR, STA

When the fuel prime-engine start switch is placed in the ENGINE START position, the STA contactor closes to apply battery power to starting solenoids that are part of the cranking motor assembly. The solenoids drive the cranking motor pinions in to mesh with the starting ring gear. When the pinions are meshed, solenoid operated contacts close to energise cranking contactor ST, which applies battery power to the cranking motors.

TEMPERATURE SWITCHES; TA,TB

These switches are located in a manifold on the equipment rack. They sense engine water temperature and operate to activate cooling fan contactors.

THROTTLE LIMIT RELAY, THL

When for any reason a hot engine occurs, the engine temperature switch ETS contacts close to sound the alarm, turn on the hot engine light on the engine control panel, and energise the THL relay coil. THL contacts turn on the hot engine light on the annunciator and acts to reduce engine speed and power to accomplish engine cooling if the hot engine was caused by a transient condition. If the hot engine was due to an engine or system fault, the hot engine condition may persist until engine shutdown is brought about by engine protective devices.

TRANSFER SWITCH RELAY, TSR

The transfer switch relay is energised only when all power contactors have dropped out. Its interlocks prevent operation of the transfer switches until all power contactors are dropped out. The transfer switches will therefore not open while they are carrying current.

BRAKING CURRENT SIGNAL TRANSFORMER, T4

This transformer provides a signal of usable value from braking current transductor BCT that is proportional to current in the dynamic braking grids. On units equipped for extended range dynamic braking, the signal is applied to the DE module to bring about pickup of dynamic brake grid shorting contactors. On units equipped for trainlined control of dynamic brake grid current, the signal is applied to bring about regulation of braking effort according to braking handle position.

WHEELSLIP LIGHT RELAY, WL

This relay is energised by pickup of either the WSR or "L" relays in the WS circuit module upon wheel overspeed. "L" relay pickup indicates a large steady current differential of the traction motors, such as would occur with a locked sliding wheel. WSR relay pickup indicates wheelslip during dynamic braking.

In the event of a locked-sliding wheel, pickup of WL contacts opens the wheelslip circuit feed to the governor ORS coil. This is to prevent driving the load regulator near minimum field position where it would be held by wheelslip rate circuits, thus preventing the required WL pickup and wheelslip light indications.

WHEELSLIP TRANSDUCTORS, WST

The transductor consists of two coils wound on independent iron cores. The coils are in series across on alternating current source - the D14 alternator. Cables carrying traction motor current pass within the frame of the iron cores. The current in the cables is normally of equal value and in opposite direction. When wheelslip occurs the currents are unbalanced, causing a change in magnetic fluxes in the cores. This results in a decrease in the impedance of the coils and the impedance change is seen as a wheelslip signal at the WS module.

GUIDE TO THE EXCITATION AND POWER CONTROL SYSTEM

CAUTION

The data appearing in this section is intended only as a guide in explaining the locomotive excitation and power control system. The circuits shown in this section represent typical components and do not necessarily agree with the wiring diagrams and troubleshooting section of this manual when performing troubleshooting on the excitation and power control system.

INTRODUCTION

The purpose of this section is to describe the locomotive excitation and power control system. A block diagram of the excitation and power control system is provided in Fig 7-1.

The excitation and power control system is designed for high reliability, high performance, and minimum down time. Minimum down time is assured by using top quality components mounted on plug-in modules. The modules are centrally located in the electrical cabinet on the cab side. Each module contains components that are functionally related. For example, the wheel slip module contains components that initiate correction for a wheelslip condition.

The modules are provided with test jacks for making voltage measurements when performing troubleshooting. Some of the modules are equipped with press-to-test pushbuttons for performing functional checks on the modules. The modules are designed to be adjusted on the test bench in the shop. Therefore when a module is changed out it is not necessary to adjust the module while installed on the locomotive. This feature greatly reduces locomotive down time.

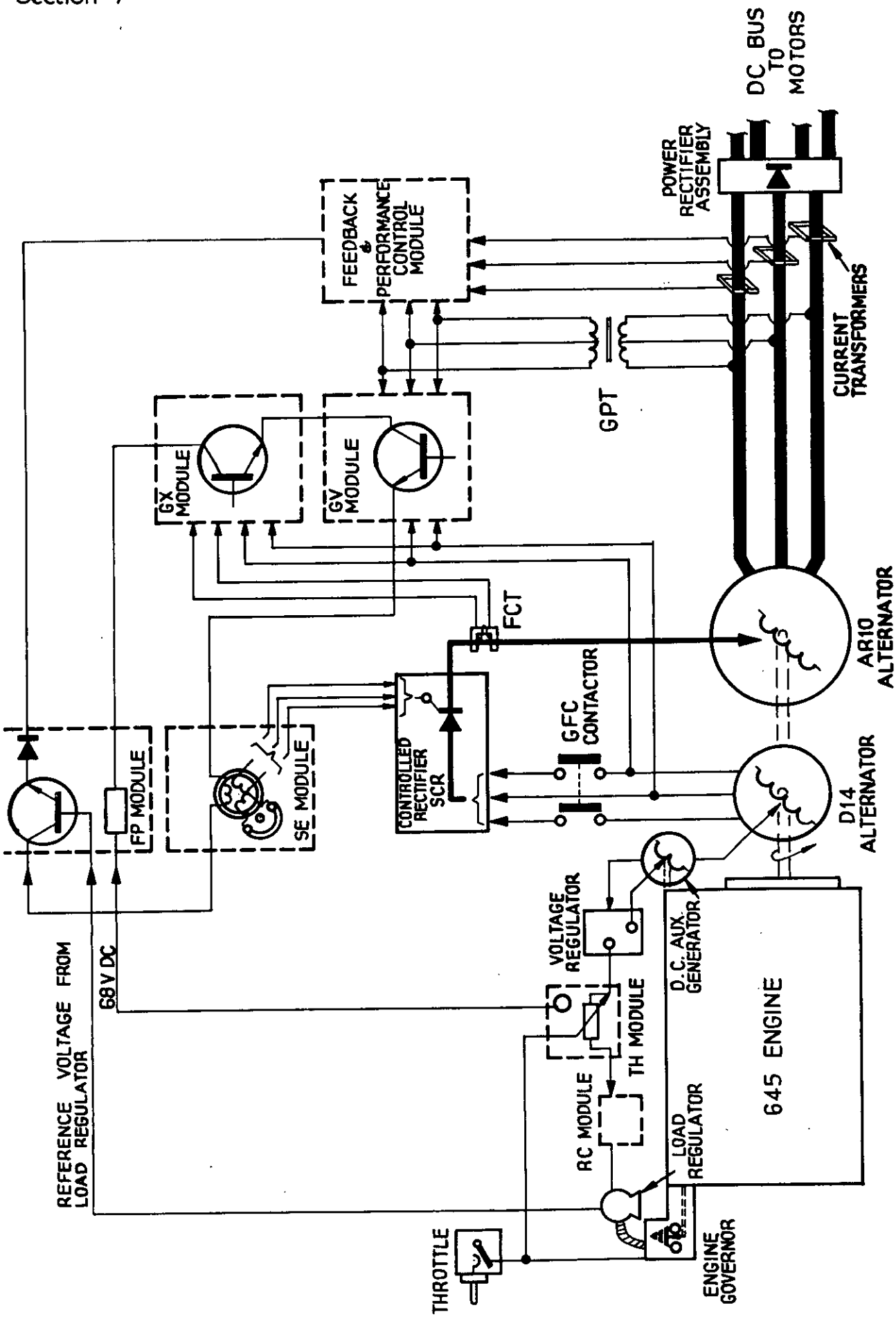

Fig. 7-1 — Excitation System Block Diagram

Some of the other significant characteristics of the excitation and power control system include:-

1. Use of the AR10 alternating current generator with integral solid-state rectifier assembly to provide DC power to the traction motors.

2. Use of solid-state components to match the reference signal from the load regulator with feedback signals from the AR10 main generator.

3. Use of a silicone controlled rectifier assembly to apply power from the D14 alternator to the field of the AR10 main generator.

4. Use of throttle controlled variable resistance during locomotive starting to reduce reference voltage signals from the load regulator, which rests in maximum output position at the time of locomotive start. Locomotive response to throttle change is thereby rapid but smooth, and power is held at a low level during low throttle position.

GENERAL

When the diesel engine starts to turn, the AC auxiliary generator is initially self excited by residual magnetism. An integral solid state rectifier assembly provides a DC output. This D. C. voltage builds up and part of the auxiliary generator output is fed back through the static voltage regulator. Output from the voltage regulator is used to control excitation to the auxiliary generator and maintain constant voltage.

Part of the auxiliary generator output is used to excite the field of the D14 alternator. When the diesel engine is running, the D14 field excitation is maintained at a nominally constant level.

Three phase alternating current is taken from the D14 alternator and fed through a silicone controlled rectifier assembly to excite the field of the AR10 main generator. The output from the silicone controlled rectifier assembly is determined by a magentic amplifier type SENSOR and solid state components that respond to signals related to AR10 main generator output, throttle position or load regulator position.

Three phase alternating current from the stator of the AR10 main generator is applied to a power rectifier assembly located within the AR10 main generator housing. DC power from the rectifier assembly is applied to the traction motors.

CONTENTS

This section is divided into the following parts;

PART A Generators and Voltage Regulator

Description of the auxiliary generator, voltage regulator, AR10 main generator and D14 alternator.

The contents of Section 7 Part A are presented in the following order:-

1. A.G. - Auxiliary Generator
2. Main Generator and Ground Relay Protection System
3. D14-D14 Alternator
4. VR - Voltage Regulator Module

PART B Excitation and Power Control System

General Description of the excitation and power control system and a detailed description of each module or assembly used in the excitation and power control system.

The contents of Section 7 PART B are presented in the following order:-

(1) EL Excitation Limit Backup Protection System (EL Module)
(2) FS Field Shunting Module
(3) GV Generator Voltage Regulator Module
(4) GX Generator Excitation Regulator Module
(5) LR Load Regulator Assembly
(6) FP Feedback and Performance Control Module
(7) RC Rate Control Module
(8) SE Sensor Module
(9) SCR Silicon Controlled Rectifier Assembly
(10) TH Throttle Response and Voltage Reference Regulator Module

PART C Wheelslip Detection and Correction System

General description of the wheelslip detection and correction system and detailed description of each module or assembly used in the wheelslip detection and correction system.

The contents of Section 7 PART C are presented in the following order:-

1. WSBC Wheelslide Bridge Circuit
2. WS Wheelslip Module
3. WST Wheelslip Transductor

PART D Dynamic Braking System, Excitation and Control

General description of the dynamic braking system excitation and control. Includes a detailed description of each module or assembly used in the dynamic braking system.

The contents of Section 7 PART D are presented in the following order:-

1. DE Extended Range Dynamic Brake Module
2. DG Dynamic Brake Grid Protection Module
3. DP Dynamic Brake Protection Module
4. DR Dynamic Brake Regulator Module

PART E Indicating Lights and Devices

Description of the use and location of indicating lights and devices such as indicating lights on the engine control panel, the load indicating meter, and the annunciator module.

PART F Miscellaneous Control Circuits and Devices.

Description of various types of automatic ground relay reset circuits and hot engine.

The contents of Section 7 PART F are presented in the following order:-

1.	AGR	Automatic Ground Relay Reset Assembly	8488371
2.	AGRL	Automatic Ground Relay Reset Limiter	8408360

On the GL26C-2 locomotives the following modules are used:-

Annunciator	AN26
Dynamic Brake Extended Range	DE13
Dynamic Brake Grid Protection	DG10
Dynamic Brake Protection	DP11
Dynamic Brake Regulator	DR11

Excitation Limit	EL11
Feedback and Performance	FP16
Field Shunt	FS19
Generator Voltage	GV12
Generator Excitation	GX2
Rate Control	RC11
Sensor	SE10
Throttle Response	TH13
Voltage Regulator	VR11
Wheelslip	WS11

On the GL22C-2 locomotive the following modules are used:-

Annunciator	AN26
Dynamic Brake Extended Range	DE13
Dynamic Brake Grid Protection	DG10
Dynamic Brake Protection	DP11
Dynamic Brake Regulator	DR11
Excitation Limit	EL11
Feedback & Performance	FP15
Field Shunt	FS14
Generator Voltage	GV12
Rate Control	RC11
Sensor	SE10
Throttle Response	TH13
Voltage Regulator	VR11
Wheelslip	WS11

GENERATORS AND VOLTAGE REGULATOR

Part A of Section 7 provides a general description of the auxiliary generator, auxiliary generator voltage regulator, D14 alternator, and AR10 main generator assembly.

The auxiliary generator provides a nominal output voltage of 74 volts for excitation of the D14 alternator field and other low voltage DC circuits.

The auxiliary generator voltage regulator is a solid-state voltage regulator that maintains a constant output of approximately 74 volts from the auxiliary generator.

The D14 alternator provides three-phase AC power for the radiator blower motors, the filter blower motor, various control circuits, and the silicon controlled rectifier assembly. The rectifier output of the silicon controlled rectifier is applied to the field of the AR10 main generator for excitation.

The AR10 main generator assembly provides DC power for the traction motors.

CONTENTS

The contents of Section 7 Part A are arranged in the following order:

1. AC Auxiliary Generator
2. Main Generator And Ground Relay Protection System
3. D14 Alternator
4. Voltage Regulator Module, VR11

SERVICE DEPARTMENT

Electro-Motive Division
Of General Motors
La Grange, Illinois 60525

LOCOMOTIVE SERVICE MANUAL

AC AUXILIARY GENERATOR

The AC auxiliary generator consists of a three-phase pilot exciter assembly and a three-phase AC auxiliary generator field and armature assembly. The nominal output rating of the AC auxiliary generator is 18 KW at 55 V AC. The three-phase 55 V AC output is applied to a full-wave three-phase rectifier assembly to obtain 74 V DC output for battery charging, D14 alternator excitation, and low voltage DC control power.

The three-phase pilot exciter assembly consists of a stationary field, a rotating armature, and a rotating rectifier assembly. The AC auxiliary generator has a rotating field and a stationary armature. The pilot exciter rotating armature and rotating rectifier assembly and the AC auxiliary generator rotating field are installed on a common shaft.

During start up, residual magnetism of the pilot exciter stationary field induces a voltage into the pilot exciter rotating armature. This AC voltage is rectified by the pilot exciter rotating rectifier assembly and applied to the AC auxiliary generator rotating field. This rotating field induces a voltage into the AC auxiliary generator stationary armature. Output voltage of the AC auxiliary generator armature is applied to an external three-phase full-wave rectifier and fed back to the pilot exciter stationary field through a voltage regulator assembly. This positive feedback results in fast voltage buildup. Description of the voltage regulator assembly is provided in Section 7 Part A-VR11.

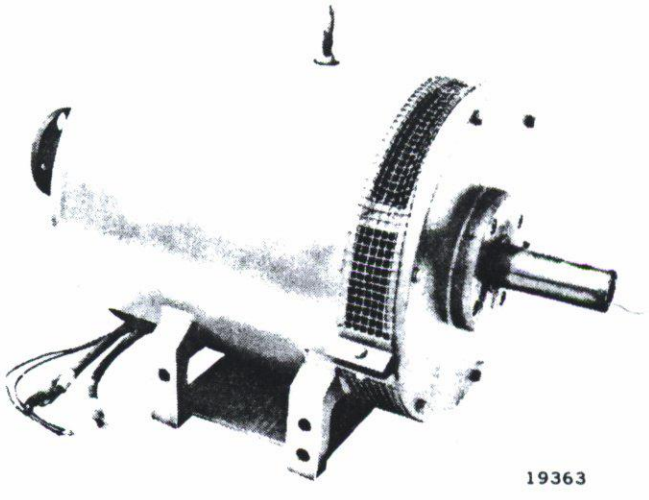

Fig. ACAG-1 – AC Auxiliary Generator

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LOCOMOTIVE SERVICE MANUAL

MAIN GENERATOR AND GROUND RELAY PROTECTION SYSTEM

(AR6 MAIN GENERATOR IS SIMILAR TO THE AR10 MAIN GENERATOR IN ALL MATTERS DISCUSSED IN THIS SECTION.)

AR10 MAIN GENERATOR

In the diesel electric locomotive, mechanical power developed by the diesel engine is converted to electrical power by a rotating electrical machine. The construction of rotating electrical generators is such that alternating current is produced, but since alternating current will not efficiently power variable speed motors, the alternating current is converted to direct current before being applied to the traction motors. In conventional direct current generators, commutator bars and brushes are used to convert the alternating current to direct current. This method of converting alternating current to direct current has mechanical and electrical limitations that become more pronounced as the amount of usable electrical power is increased. The conventional direct current generator has been replaced by the AR10 main generator that uses silicon diodes to convert the alternating current to direct current.

The AR10 main generator assembly consists of two mechanically coupled, but electrically independent, air cooled, three phase generators – the D14 alternator and the AR10 main generator. The D14 alternator is described in Part A – D14 of this section. The three major components of the AR10 main generator are shown in Figs. AR10-1, AR10-2, and AR10-3.

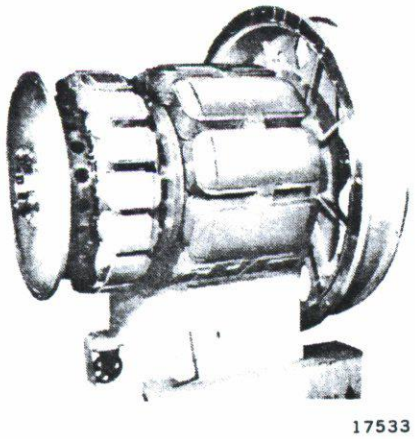

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Fig. AR10-1 – AR10 Rotor Assembly

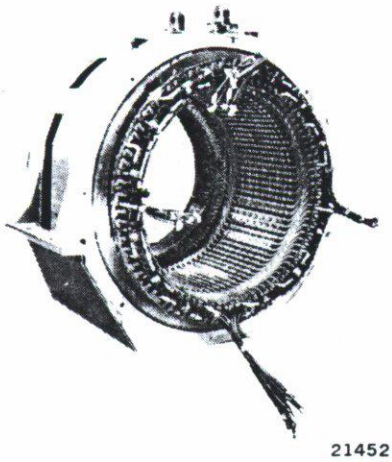

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Fig. AR10-2 – AR10 Stator Assembly

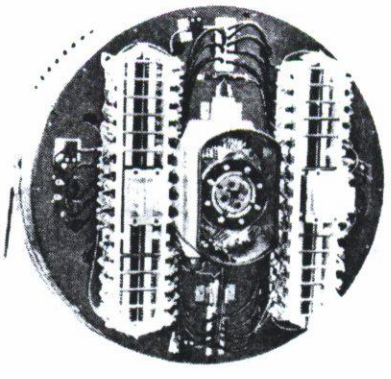

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Fig. AR10-3 – AR10 Rectifier Bank Assembly

The main generator consists of 10 field poles and the required stator windings for generating three phase AC power. The AC power is rectified by two banks of air cooled silicon diodes that are an integral part of the AR10 main generator assembly. The resulting DC power is applied to the traction motors.

The operating principle of the AR10 main generator is illustrated in Fig. AR10-4. Direct current from the silicon controlled rectifier assembly is applied to the rotating field through a pair of slip rings. The magnetic lines of force developed by the rotating field induce a voltage in the stationary armature windings as the rotor turns.

One three phase group of armature windings and a three phase waveform are shown in Fig. AR10-4. There are ten groups of these "wye" connected armature windings distributed about the circumference of the stator. Five of the groups are connected to the left bank of rectifiers and the other five groups are connected to the right bank of rectifiers. A separate positive and negative bus is provided for each bank of rectifiers. A simplified schematic diagram of the stator windings, bridge rectifiers, and DC buses is provided in Fig. AR10-5.

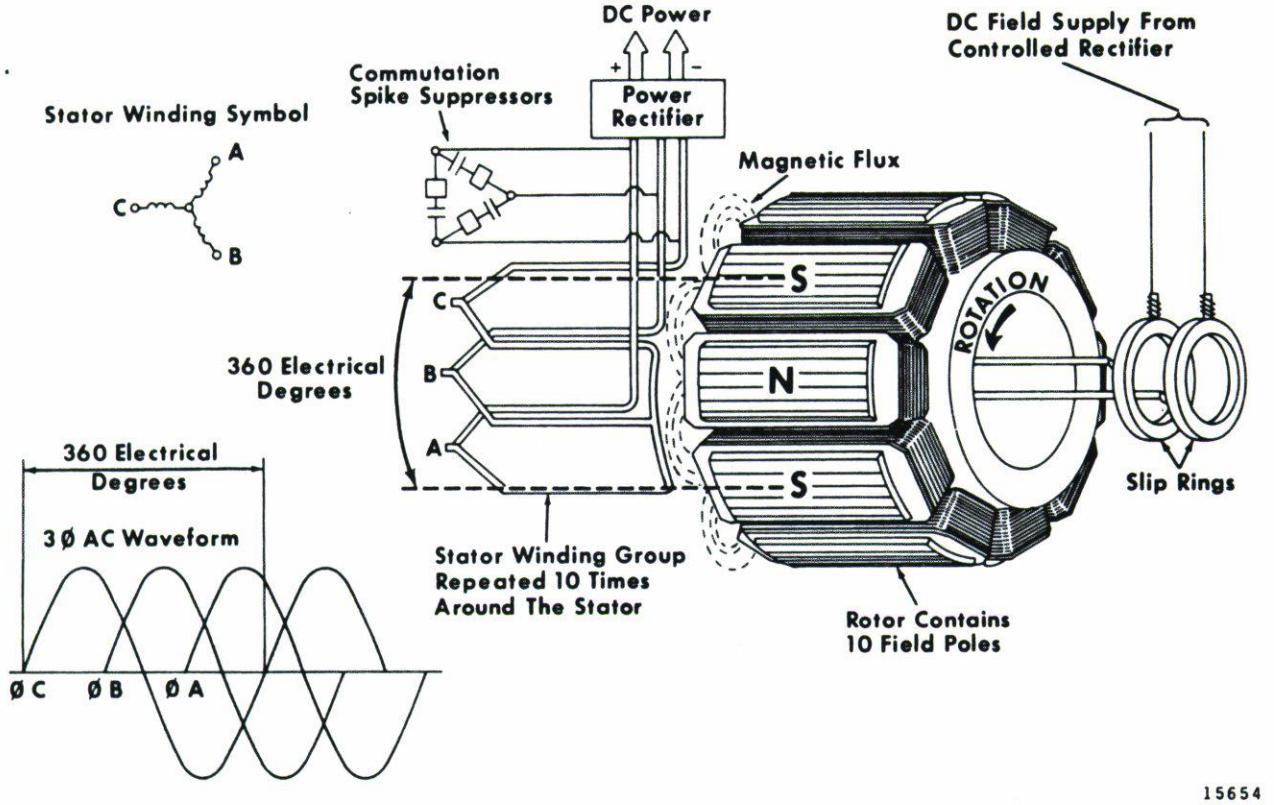

Fig. AR10-4 – Main Generator Pictorial Diagram

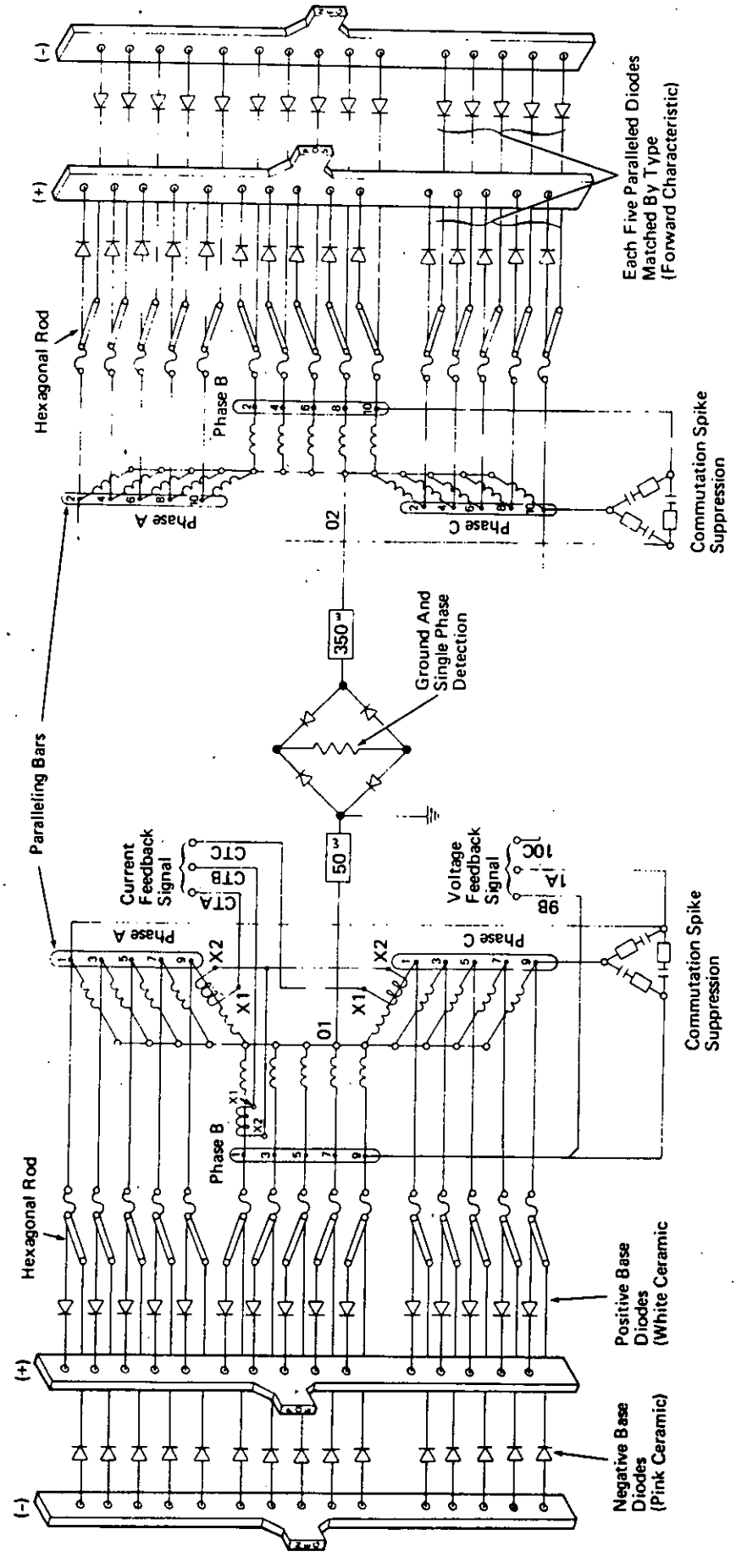

Fig. AR10-5 – AR10 Wiring Diagram

Fig. AR10-6 illustrates rotor pole position at an instant called the "V." Pole position is in respect to a single stator winding group. By applying the right-hand rule for generators, current flow in the stator windings can be determined, and the conditions existing at a given point of time determined.

Note that the phase A winding is centered over the poles (point of greatest flux density) and is at negative potential. Note also that the potential at phase C is decreasing while the potential at phase B is increasing. At the moment depicted, the potentials at C and B are equal and positive. Therefore, current at equal potential flows to the rectifier bridge, and two diodes at the positive side of the bridge conduct. Total current then flows through the load and from there through a single diode back to the phase A winding, which is at negative potential.

Generator potential can be observed at the waveform in Fig. AR10-6.

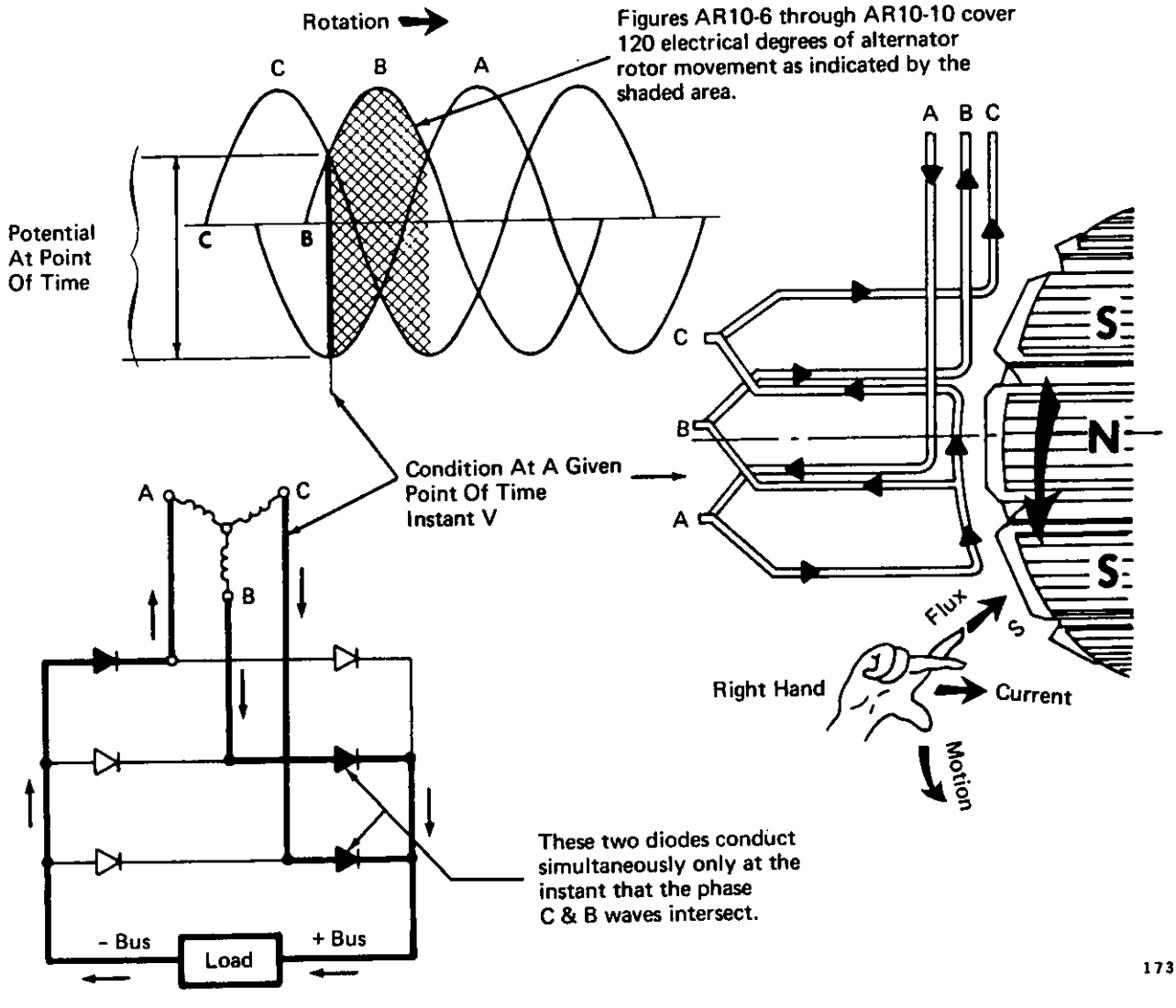

Fig. AR10-6 -- Current Flow In Stator Windings And Rectifier Bridge - Instant "V"

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In Fig. AR10-7, instant "W," the alternator rotor has turned nominally 20 electrical degrees. Phase A is still negative, but of decreasing potential. Phase B is now more positive than phase C. The change in potential has turned off the phase C diode, and no current flows in the phase C winding. Total current at potential slightly greater than that at instant "V" now flows out of phase B winding, through the load, and back to the phase A winding which is still negative.

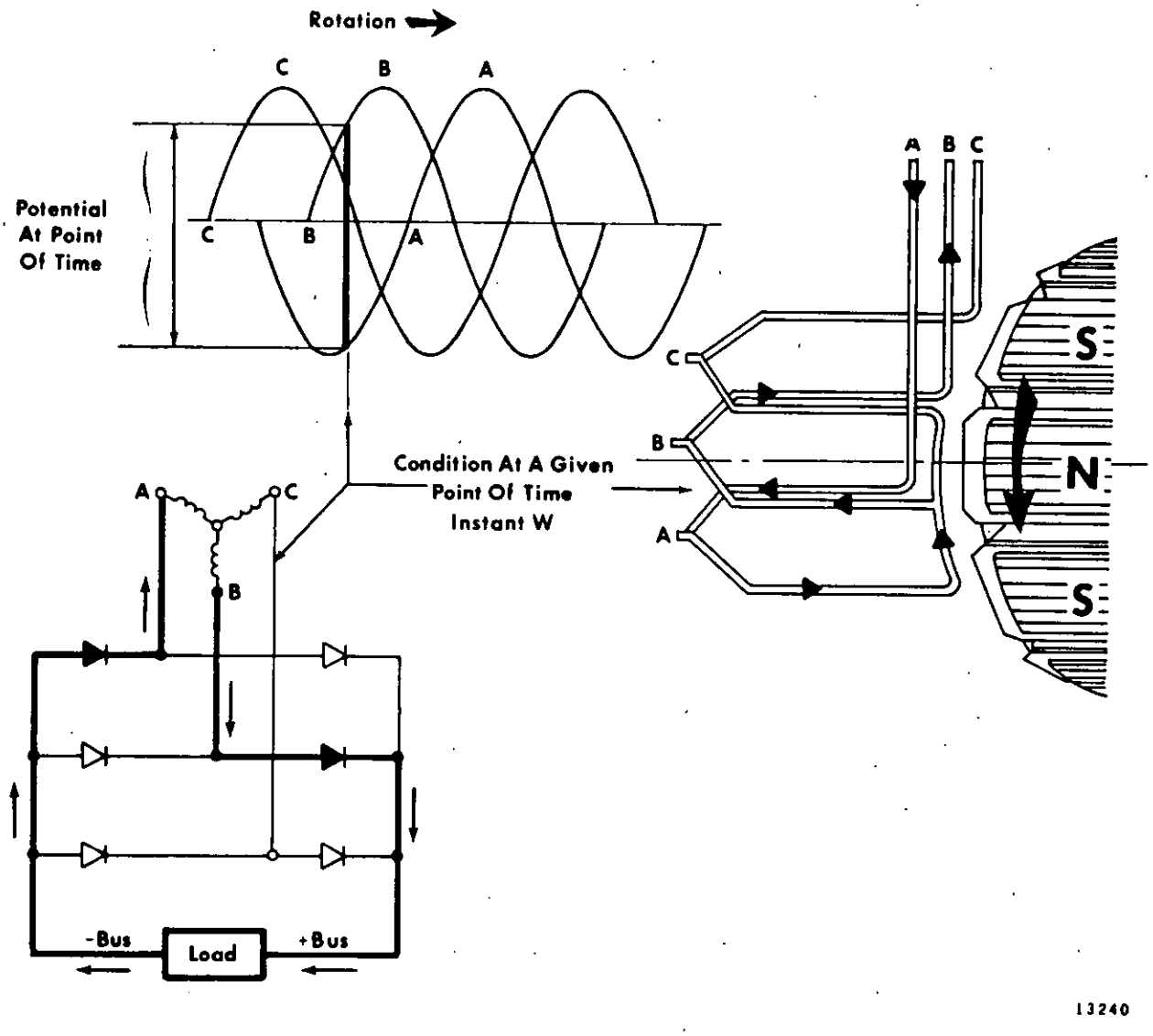

Fig. AR10-7 – Current Flow In Stator Windings And Rectifier Bridge - Instant "W"

At instant "X" in Fig. AR10-8, the alternator rotor has turned about 60 electrical degrees. Phase C and Phase A are at equal negative potential, and phase B is at positive potential. The direction of current flow in the C winding has reversed, and since potentials at the negative side of the rectifier bridge are equal, both the phase A and phase C diodes conduct. Total winding current at potential equal to that at instant "V" now flows out of phase B winding through the load and back through two diodes at the negative side of the rectifier bridge.

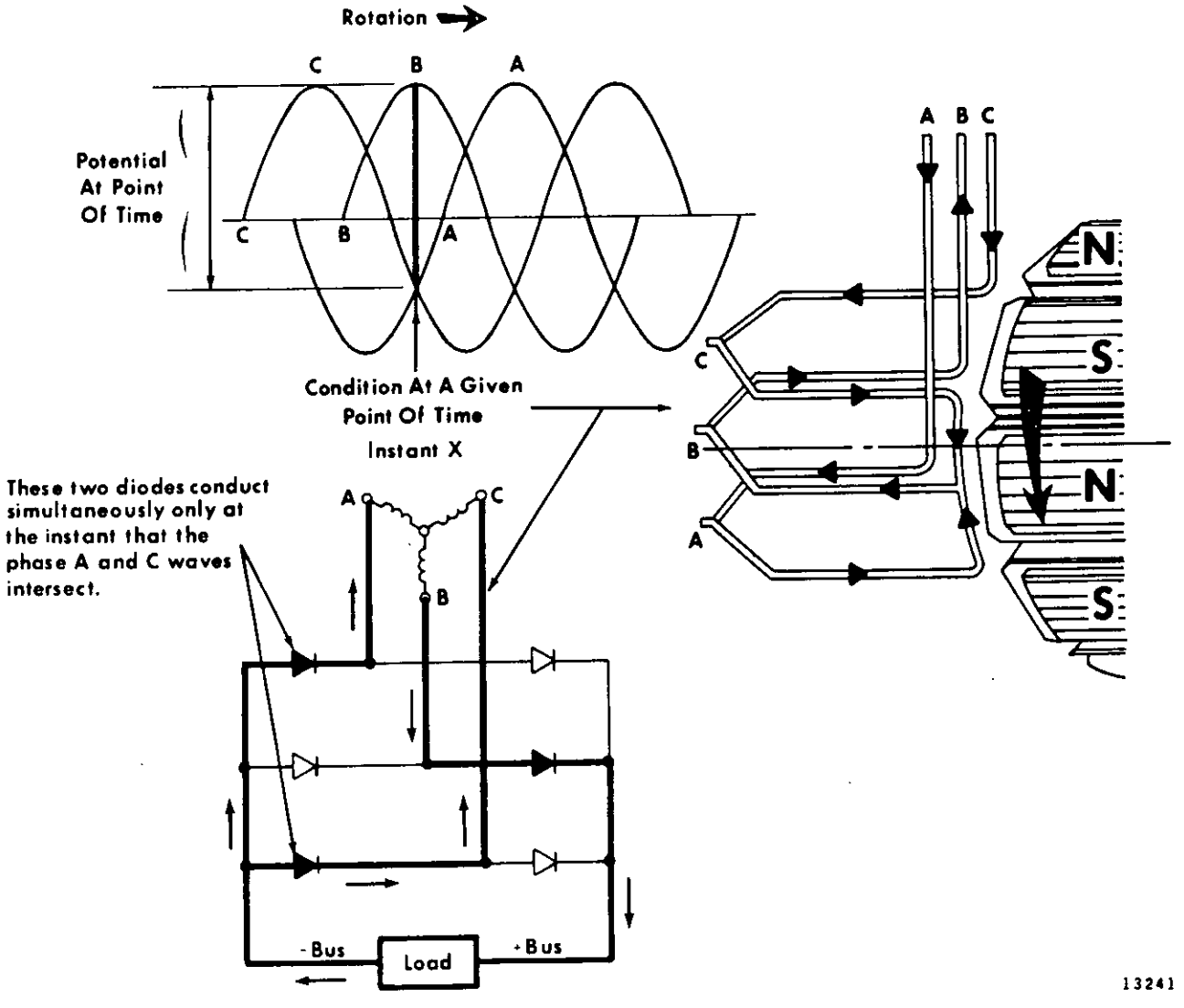

Fig. AR10-8 – Current Flow In Stator Windings And Rectifier Bridge - Instant "X"

At instant "Y," Fig. AR10-9, the alternator rotor has turned about 100 electrical degrees. Phase C is now more negative than phase A. The change in potential has turned off the phase A diode at the negative side of the bridge, and no current flows in the phase A winding. Total current at potential slightly greater than that at instant "V" now flows out of phase B winding, through the load, and back to phase C winding which is negative.

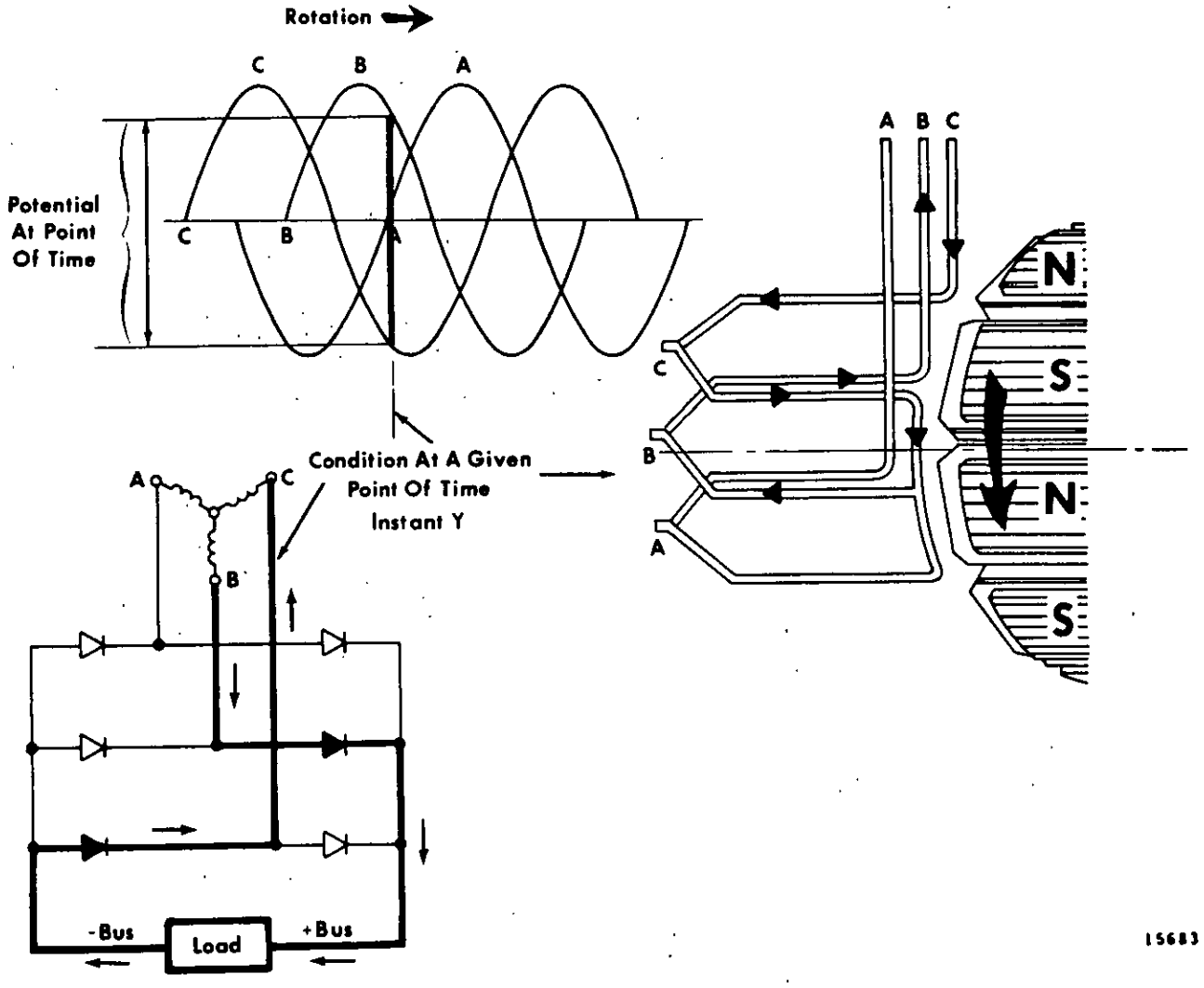

Fig. AR10-9 – Current Flow In Stator Windings And Rectifier Bridge - Instant "Y"

n Fig. AR10-10, the alternator rotor has turned 20 degrees. Phases A and B are at equal positive otential, and phase C is negative. Since potenials at the positive side of the rectifier bridge are qual, both the phase A and B diodes conduct. Total winding current at potential equal to that at instant "V" now flows out of the phase A and B windings, through the load, and back through the phase C diode at the negative side of the bridge.

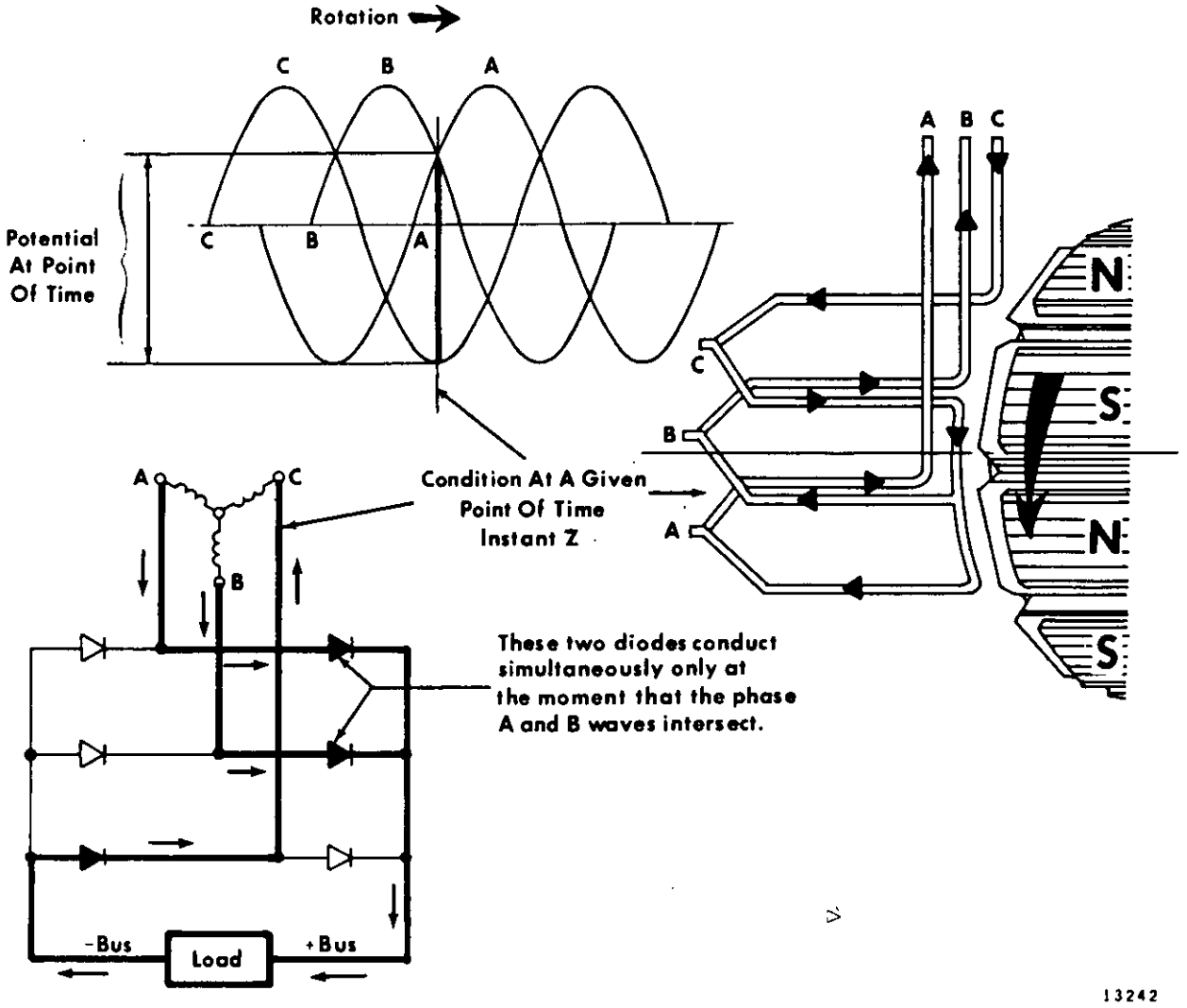

Fig. AR10-10 – Current Flow In Stator Windings
And Rectifier Bridge - Instant "Z"

AR10 COMMUTATION TRANSIENT VOLTAGE SUPPRESSION

During commutation voltage transients are produced. The action of diodes switching from a conducting to a blocking state in the AR10 generator is called commutation. During commutation high reverse current flows in the diodes for a few microseconds, after which time the value of reverse current flow in the diode suddenly drops to almost zero. The rate at which current flow changes from a high value to almost zero, multiplied by circuit inductance determines the magnitude of the transient voltage spike. If this transient voltage exceeds the reverse rating of the diode, the diode will immediately fail.

The AR10 generator is provided with a system for capacitive storage of energy from circuit inductance during commutation. The system is called the commutation transient voltage suppression system. It utilizes a total of six 2 microfarad capacitors and six 5 ohm resistors. The resistors and capacitors are connected in delta fashion, Fig. AR10-11, between the "A," "B," and "C" phase paralleling bars on both the left and right banks of the generator.

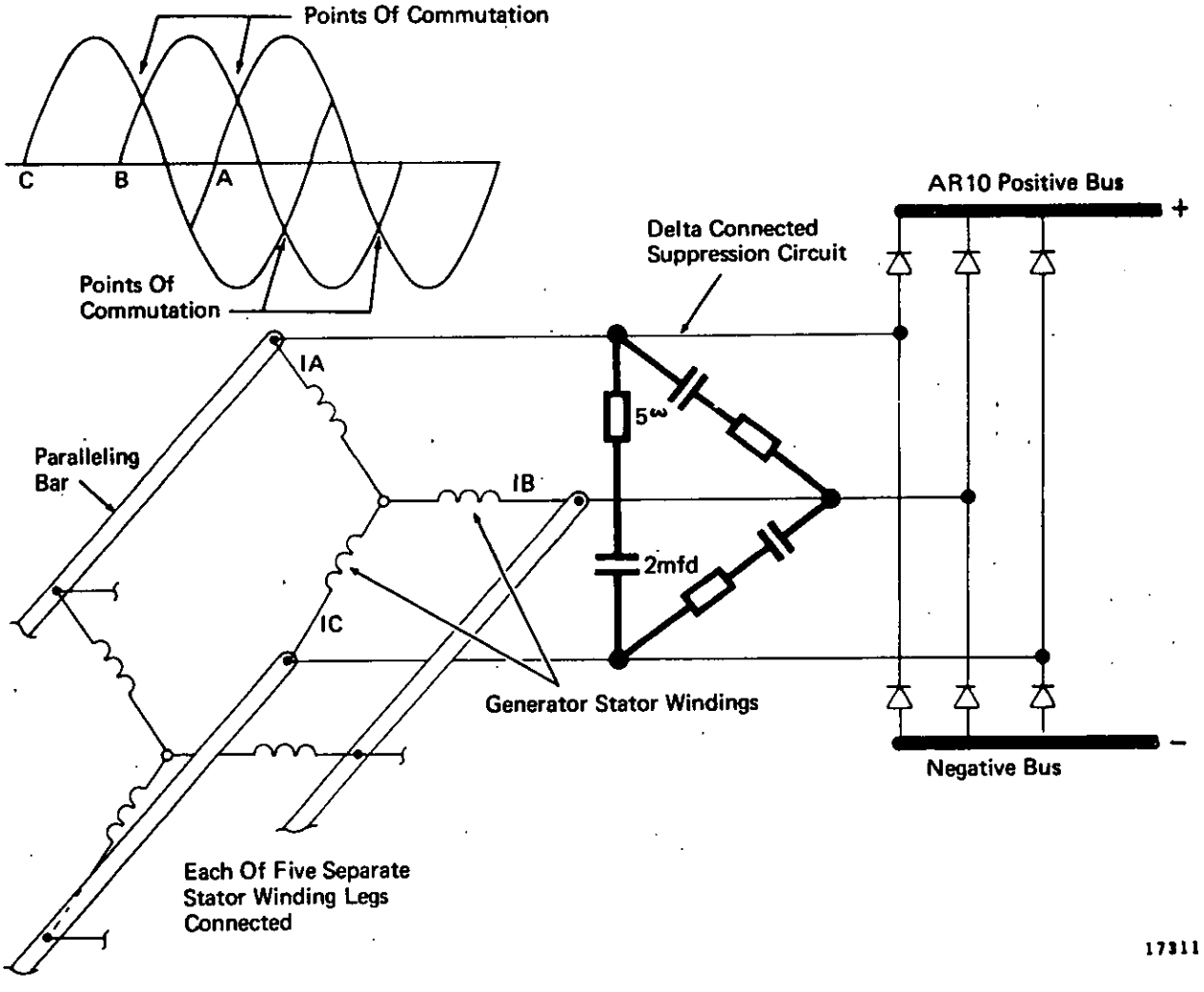

Fig. AR10-11 – Delta Connected Suppression Circuit - Simplified Diagram

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GROUND RELAY PROTECTION SYSTEM

INTRODUCTION

The purpose of the ground relay protection system is to protect the main generator, traction motors, and high voltage wiring, and to reduce the possibility of electrical fires by removing excitation from the main generator field when a ground or certain faults occur in the high voltage system. The ground relay protection system detects high voltage DC grounds, main generator AC grounds, shorted windings, or the loss of one phase group in the main generator. Figure AR10-12 is a simplified schematic diagram of the ground relay detection circuit. Each phase group consists of five stator windings, five positive base diodes, and five negative base diodes. Three phase groups are connected in each bank. However for simplification, only one stator winding, one positive base diode and one negative base diode of each phase group for each bank are shown in Fig. AR10-12.

OPERATION

The ground relay detection circuit is connected between the left and right bank neutral. A high voltage DC ground, main generator AC ground, shorted windings, or the loss of one phase group on either bank results in energising the ground relay GR pickup coil. Pickup of GR provides a feed to the ground relay light on an AN module, to the ground fault light on the accessory panel, and also sets up the circuit between the GR reset coil and the automatic reset limiter on basic order locomotives, pickup of GR operates a mechanical latch so that GR contacts remain in the operated position, opposite to the position shown in Fig. AR10-14 Dropout of ER results in reducing engine speed to idle and also provides a feed to the alarm. Dropout of GFD places a 4.8 ohm resistor in series with the main generator field.

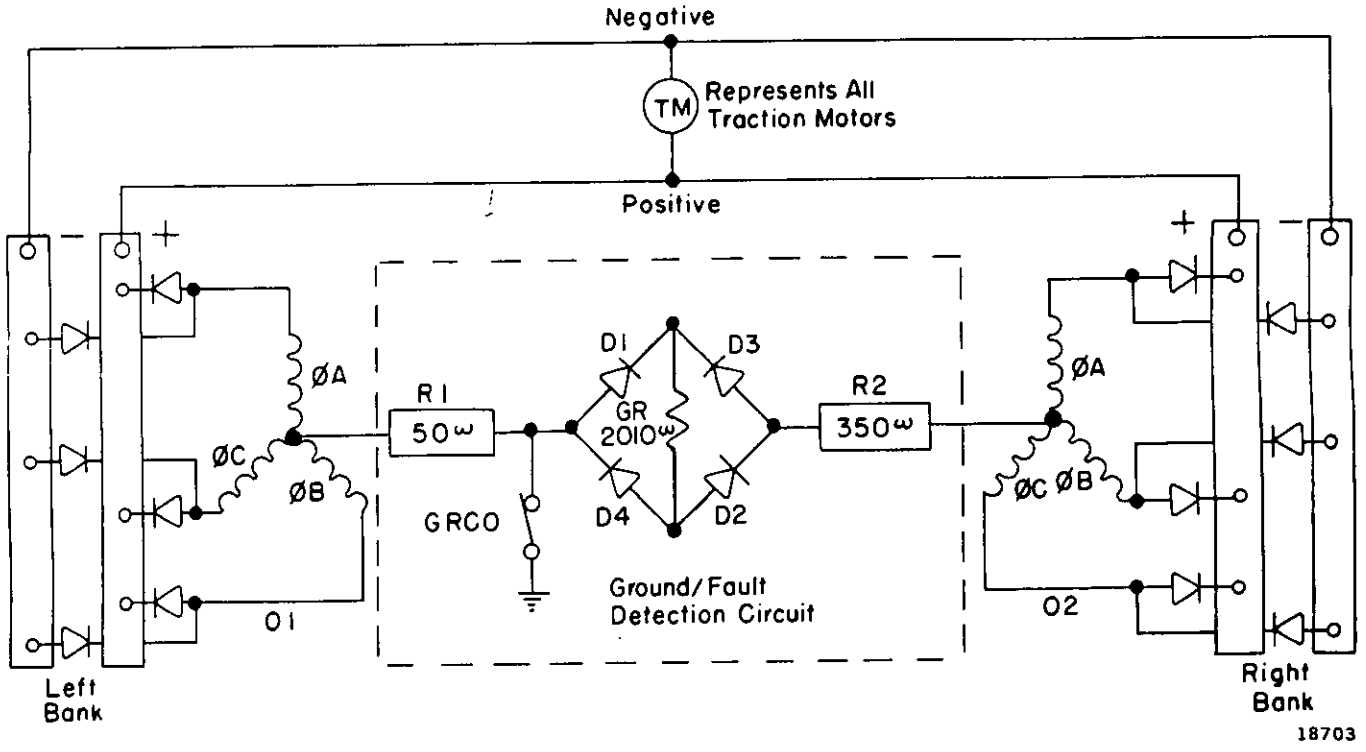

Fig. AR10-12 - Ground/Fault Detection Circuit, Simplified Schematic Diagram

This 4.8 ohm resistor results in an immediate decrease in main generator field current and provides for fast decay of the main generator field when GFC drops out. Dropout of GFD also removes the feed from EQP which removes the feed from GFC. Dropout of GFC removes excitation from the main generator field. Therefore pick up of GR provides a ground/fault light indication, removes excitation from the main generator, and provides a feed to the alarm. The feed to the alarm is trainlined so that the alarm rings in all units of this consist. After pickup, GR will be reset after a 20 second waiting period.

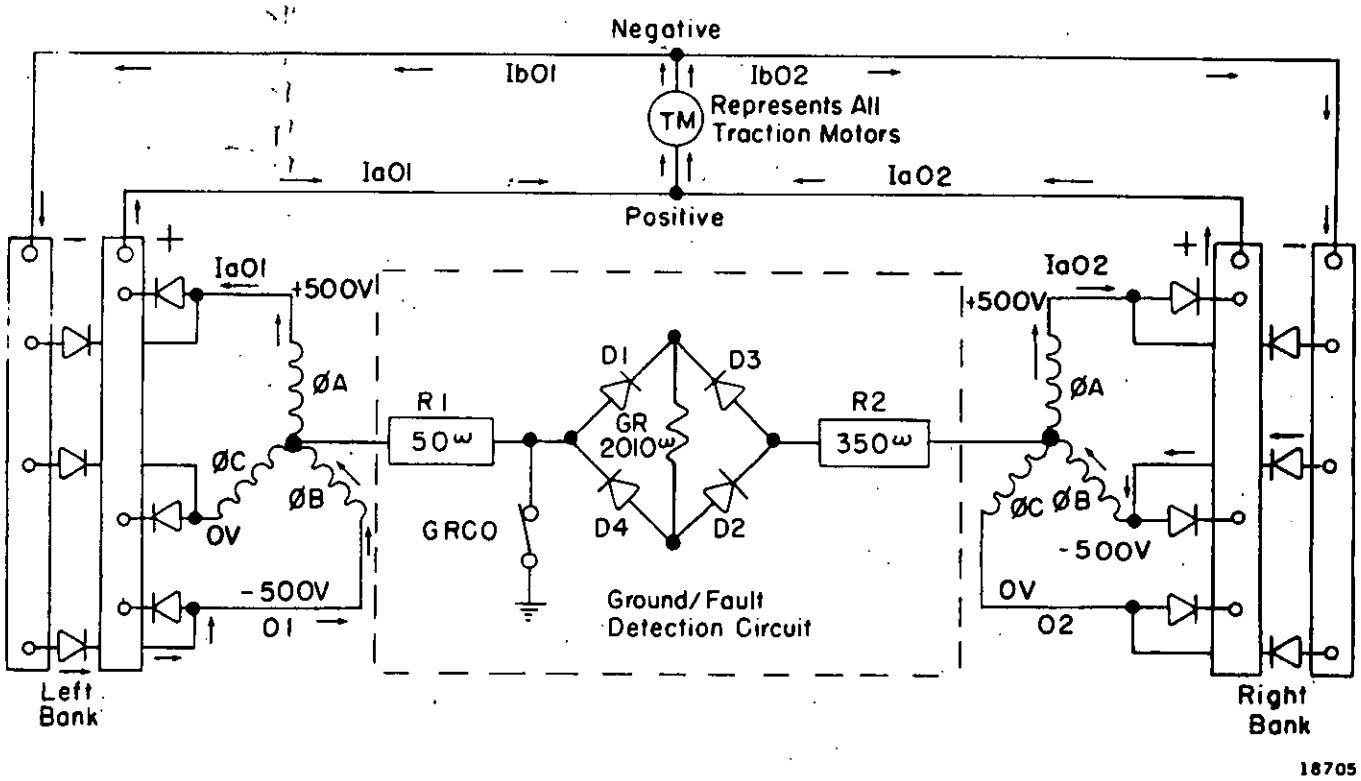

Fig. AR10-13 - Ground/Fault Detector Circuit. Showing Current Flow During Normal Operation Of Main Generator

CAUTION; Always report ground/fault light indications to proper maintenance personnel.

A ground relay cutout switch GRCO is provided to eliminate the ground protective relay circuit from locomotive circuits during certain shop maintenance inspections.

MAIN GENERATOR A.C. GROUND FAULT

The ground fault detection circuit consists of R1, GR, R2, D1 through D4 and the connection to ground through the ground relay cutout switch GRCO, Fig. AR10-12. A current of 0.016 to 0.020 amperes through GR will result in the pickup of GR. Therefore a voltage unbalance of approximately 38 to 48 volts between left and right bank neutral should result in pickup of GR.

An imbalance between the neutrals may be caused by an open phase group on the left or right bank, or by shorted windings in a phase group on the left or right banks. Leakage current to ground from a phase group of the left or right bank will result in a circulating current from ground through the ground/fault detector circuit to neutral. This circulating current may not be sufficient to cause a noticeable unbalance between left and right bank neutral. However, the ground/fault detector circuit will result in pickup of the ground relay, if a leakage to ground occurs at a point which is 38 to 48 volts or more from the neutral.

RIGHT BANK PHASE A OPEN

A voltage unbalance between left and right neutral will occur whenever an open occurs in a left or a right bank phase group. This voltage unbalance results in current flow through the ground/fault detector circuit. A description of this action is presented in the following paragraphs.

Assume that the main generator is operating under a normal balanced condition and at a specific instant of time when left bank phase A is 500V positive, left bank phase B is at 500V negative, and left bank phase C is at zero volts with respect to left bank neutral. Also assume these same conditions are true for the right bank. The system is balanced and no current flows through the ground/fault detector circuit Fig. AR10-10-13

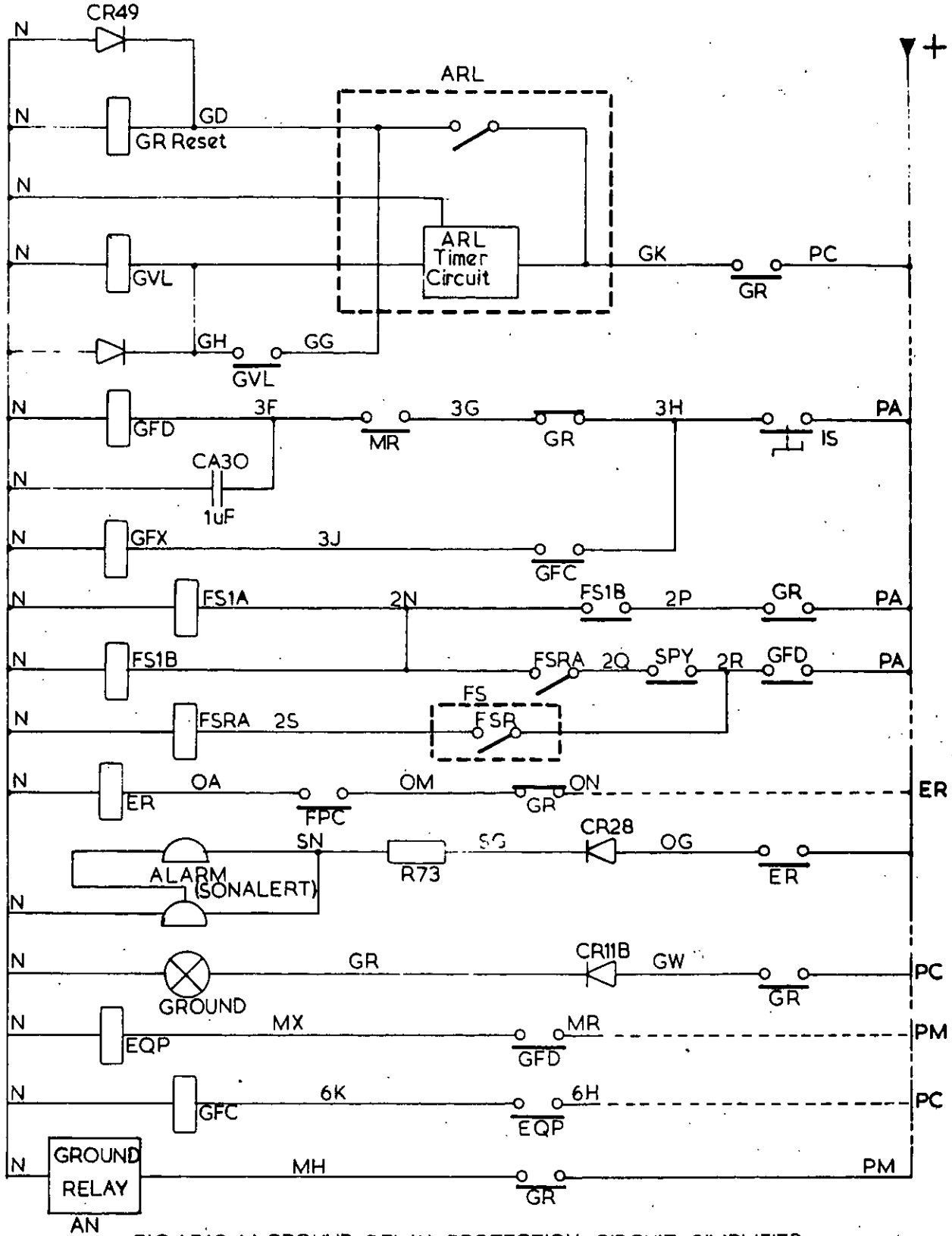

FIG.AR10-14 GROUND RELAY PROTECTION CIRCUIT SIMPLIFIED SCHEMATIC DIAGRAM

Now assume that all five positive base diodes in phase A of the right bank become open as shown in Fig. AR10-15. Current will flow from left bank phase A through a diode to the positive bus, from positive bus through the traction motor to the negative bus, from negative bus through a negative base diode to left bank phase B, then to neutral and back to left bank phase A. Current will also flow from the negative bus through a negative base diode to right bank phase B, through phase B and the ground/fault detector circuit to left bank neutral and back to left bank phase A. This current through the ground/fault detector circuit results in pickup of GR.

SHORTED TURNS IN RIGHT BANK PHASE A

Shorted turns in any phase group results in an unbalance between left and right bank neutral. This unbalance causes pickup of the GR relay. A description of this action is presented in the following paragraphs.

Assume that the main generator is operating under a normal balanced condition and at a specific instant of time as shown in Fig. AR10-13 The system is balanced and no current flows through the ground/fault detector circuit.

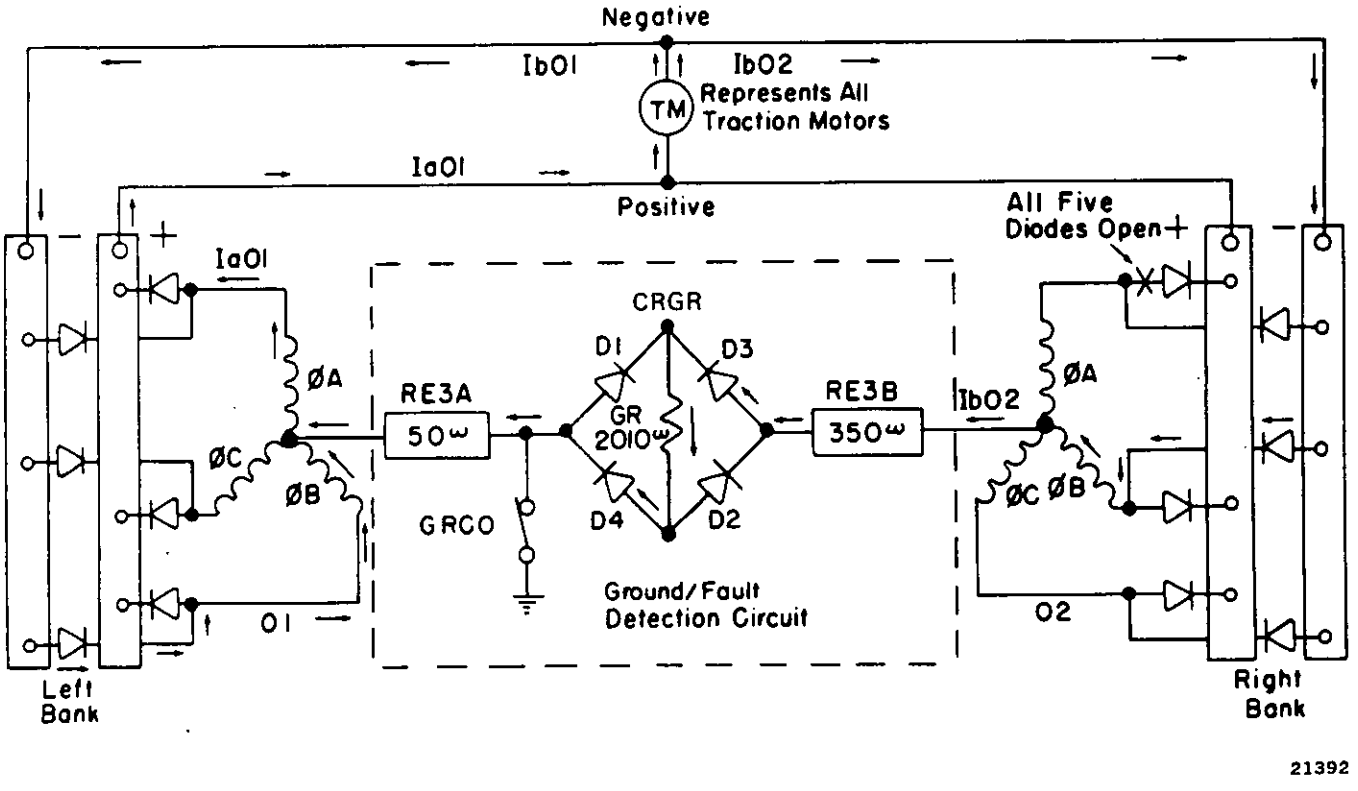

Fig. AR10-15 – Ground/Fault Detector Circuit Operation With The Loss Of One Phase

Now assume that one half the turns of right bank phase A become shorted. This would reduce right bank phase A voltage to +250 volts. Fig. AR10-16. Under these conditions left bank phase A would be the most positive point. Current would flow from left bank phase A to the positive bus, through the traction motors to the negative bus, then from negative bus through left bank phase B and right bank phase B to left bank neutral. This would cause the positive bus to be at +500 volts which would reverse bias the positive base diodes in right bank phase A. The potential on the negative bus would be -500 volts which would reverse bias the negative base diodes in right bank phase A, right bank phase C, and left bank phase C. Therefore, no current would flow through right bank phase A, right bank phase C, or left bank phase C. The current flow would be limited to the circuit as shown in Fig. AR10-16. This is the same circuit for current flow as that shown in Fig. AR10-15. This current flow through the ground/fault detector circuit results in pickup of GR.

AC GROUNDS

The effect on the ground/fault detection circuit due to AC grounds depends upon the location of the AC ground.

Assume that a ground occurs at the right bank neutral. This places a ground on each side of the series combination of the 350 ohm resistor and the GR relay circuit. There will be no difference in potential between these two grounds or between left and right bank neutral. Therefore, no current will flow through GR.

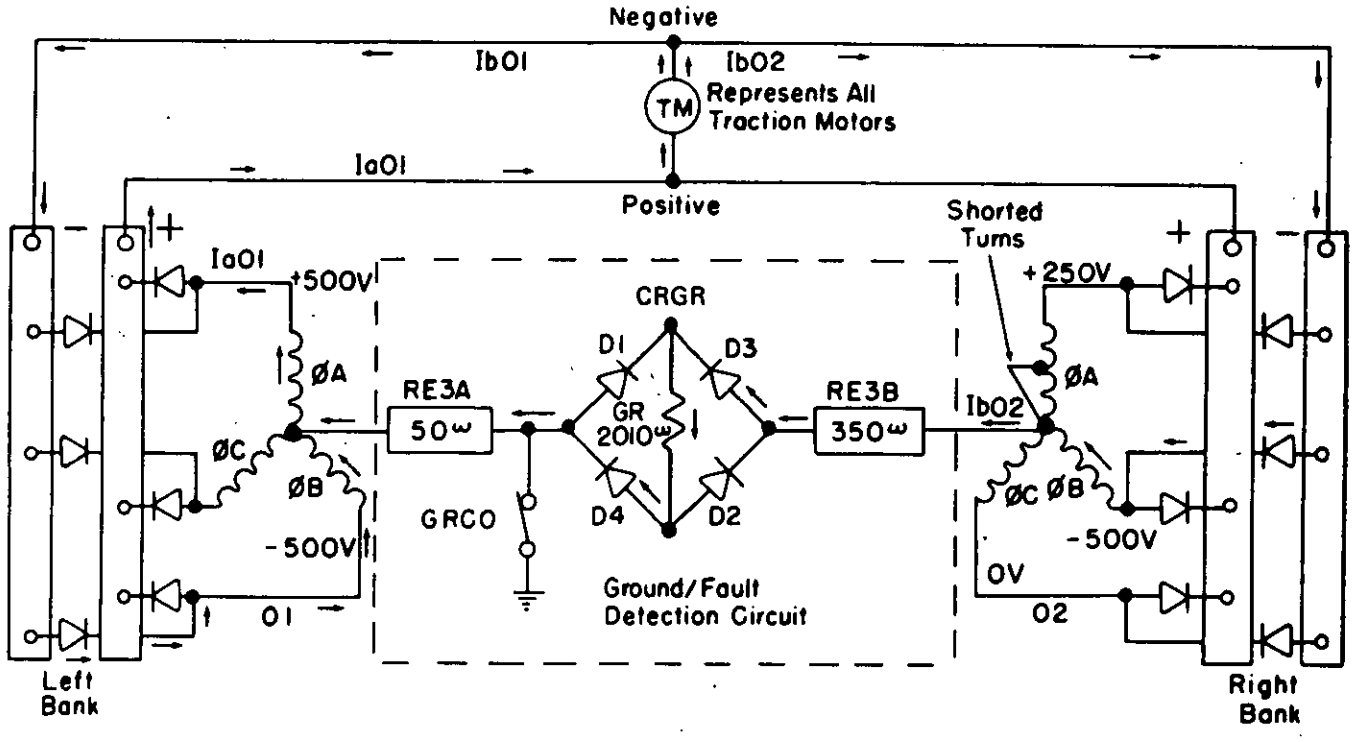

Fig. AR10-16 – Ground/Fault Detector Circuit With Shorted Turns In One Phase

Assume that a ground occurs in right bank phase A at a point that is 10 volts positive with respect to right bank neutral. Fig. AR10-17. This ground results in a potential of +10 volts at point X of the ground/fault detection circuit with respect to right bank neutral. This difference in potential causes a flow of current through GR. The amount of current flow through GR is equal to 10 volts divided by 2360 ohms or 0.00424 amperes. The GR relay requires 0.016 to 0.020 amperes for pickup. Therefore, a ground at a point +10 volts from neutral will not result in pickup of GR.

We will assume pickup of GR with a current flow of 0.018 amperes. Therefore, we must have a potential difference of approximately 0.018 amperes times 2360 ohms or 42.5 volts between point X and right bank neutral in order to pick up GR. If the ground is in right bank phase A, current will flow from the grounded point through the normally closed GRCO contacts to point X, from point X through D1, GR, D2, and the 350 ohm resistor to right bank neutral. This small amount of current is not sufficient to cause an unbalance between the left and right bank neutral. Therefore, since the two neutrals are at the same potential, current will also flow from point X to left bank neutral. The current flow from point X to left bank neutral will be 42.5 volts divided by 50 ohms or approximately 0.850 amperes. The total current from phase A ground is equal to 0.018 plus 0.850 or approximately 0.868 amperes.

The ground/fault detection system has a ground fault pickup sensitivity rating of 875 milliamperes. This rating means that a ground or insulation leakage to ground that permits a current flow of 875 milliamperes to ground should operate the ground/fault detection system.

If the ground occurs in left bank phase A, current will flow from the grounded point through the normally closed GRCO contacts to point X, and from point X to left bank neutral. Current will also flow from point X through the GR relay circuit and the 350 ohm resistor to right bank neutral.

If ground occurs in right bank phase B, the grounded point will be negative with respect to right bank neutral. Therefore, current will flow from right bank neutral through the 350 ohm resistor and the GR relay circuit to point X, then from point X through the normally closed GRCO contacts to ground. The grounded point is negative with respect to left bank neutral. Therefore, current will flow from left bank neutral through the 50 ohm resistor and the normally closed

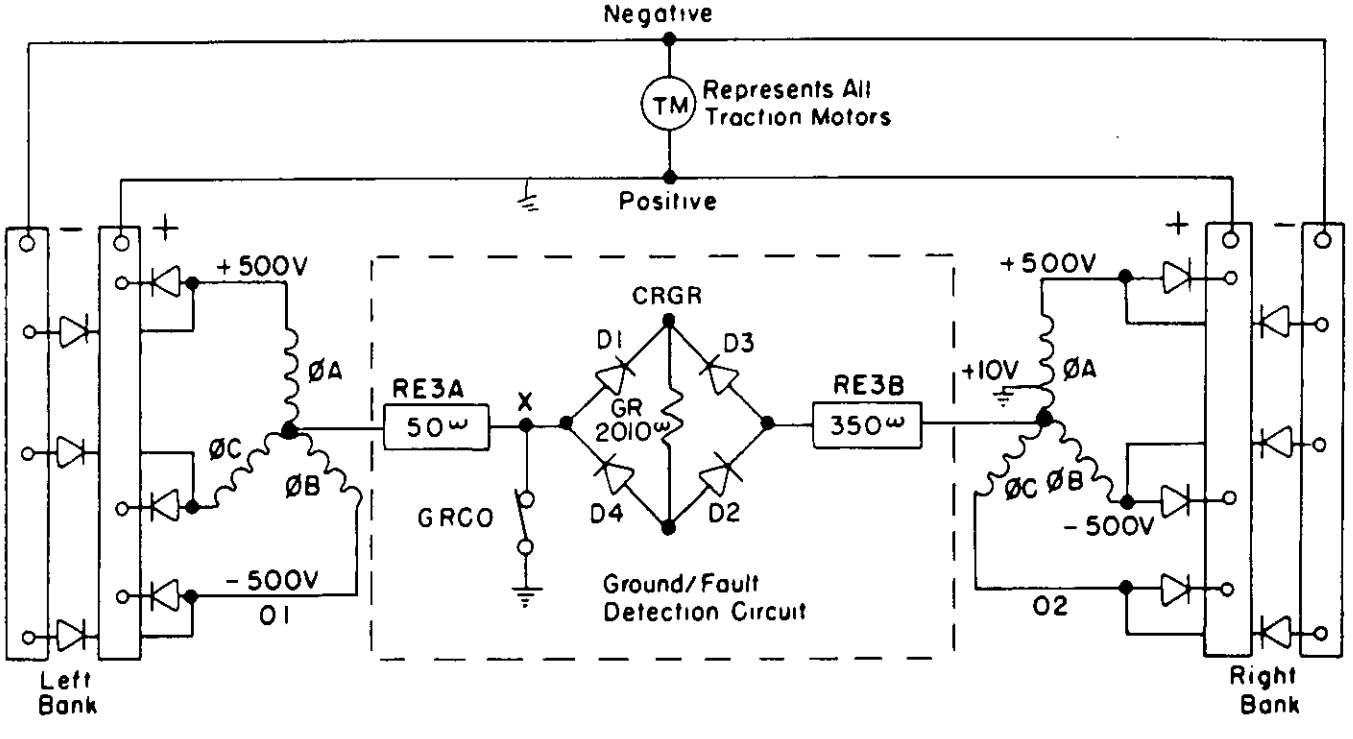

Fig. AR10-17 – Ground/Fault Detector Circuit With DC Ground In One Phase

GRCO contacts to ground. Again we must have approximately 875 milliamperes of current flow through the grounded point in order to pick up the GR relay.

HIGH VOLTAGE DC GROUNDS

High voltage DC grounds may be caused by traction motor flashover, by current leakage through insulation, or by a positive or negative conductor touching a grounded object.

Traction motor flashover is usually caused by arcing between positive and negative brushes on the traction motor. The arcing results in ionization of air in the vicinity of the arc. The ionized air provides a low resistance path to the grounded traction motor housing.

If flashover to ground occurs near the positive brush, the potential at the grounded point will be positive with respect to the left and right bank neutral. This results in current flow from ground through the normally closed contacts of GRCO then through D1, GR, D2 and the 350 ohm resistor to right bank neutral. Current will also flow through the 50 ohm resistor to left bank neutral.

If flashover to ground occurs near the negative brush, the potential at the grounded point will be negative with respect to left and right bank neutral through the 350 ohm resistor, then through D3, GR, D4 and the normally closed GRCO contacts to ground. Current will also flow from left bank neutral through the 50 ohm resistor and the normally closed GRCO contacts to ground.

If a ground occurs at the positive bus or at one of the cables attached to the positive bus, operation will be the same as for a flashover near the positive brush of a traction motor. If a ground occurs at the negative brush or at one of the cables attached to the negative bus, operation will be the same as for a flashover near the negative brush of a traction motor.

D14 ALTERNATOR

The D14 alternator, Fig. D14-1, is a variable frequency, variable voltage rotating field, stationary armature, three phase, wye connected AC generator with a rating of 100 KVA at 0.8 power factor. Nominal output of the D14 alternator is 215 volts at 120 cycles per second when the diesel engine is rotating at a speed of 900 RPM. The D14 alternator is physically connected to, but electrically independent of the main generator. The D14 alternator and main generator rotating assembly is directly coupled to the crankshaft of the diesel engine.

The D14 alternator provides power for the radiator blower motors, excitation for the main generator, and for various control circuits. The maximum output of the D14 alternator is approximately 15 Amperes for each ampere of field excitation. The auxiliary generator provides approximately 30 Amperes of field excitation current to the D14 alternator when the field is hot. The 30 Amperes of field excitation current is determined by dividing the nominal output voltage of the auxiliary generator (74 volts) by the nominal hot resistance of the D14 alternator field (2.46 ohms). The D14 alternator can provide an output of approximately 450 amperes with the 30 Amperes of field excitation. With the exception of a protective fuse there are no controls in the D14 alternator excitation circuit. Therefore, the D14 alternator will be excited and developing power whenever the diesel engine is running.

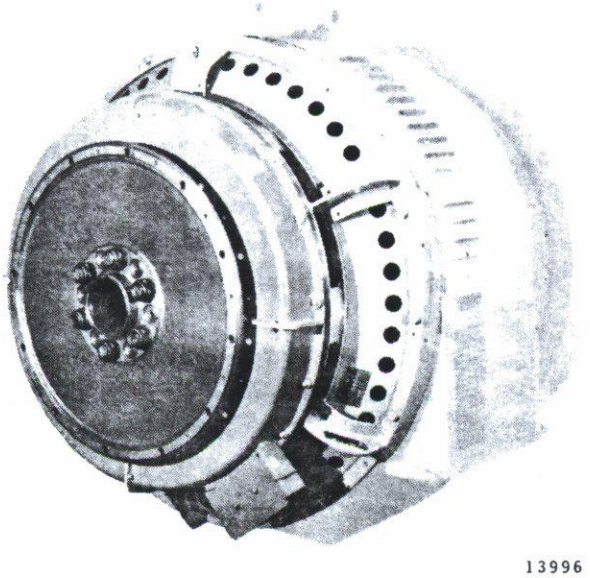

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Fig. D14-1 – D14 Alternator

VOLTAGE REGULATOR MODULE, VR11 (SPECIAL ORDER)

INTRODUCTION

The voltage regulator module VR11 is a solid state voltage regulator designed to maintain output voltage of the three-phase AC auxiliary generator at 55 V AC. This 55 V AC output voltage is applied to a three-phase full-wave rectifier to provide 74 V DC for control circuits, battery charging, and excitation for the D14 alternator. Description of the AC auxiliary generator is provided in Section 7 Part A-ACAG.

The VR11 module contains a starting circuit, a detector circuit, and a power circuit. A simplified schematic diagram of a typical VR11 module, Fig. VR-1, is provided for reference only. The locomotive wiring diagram should be used when performing troubleshooting or maintenance.

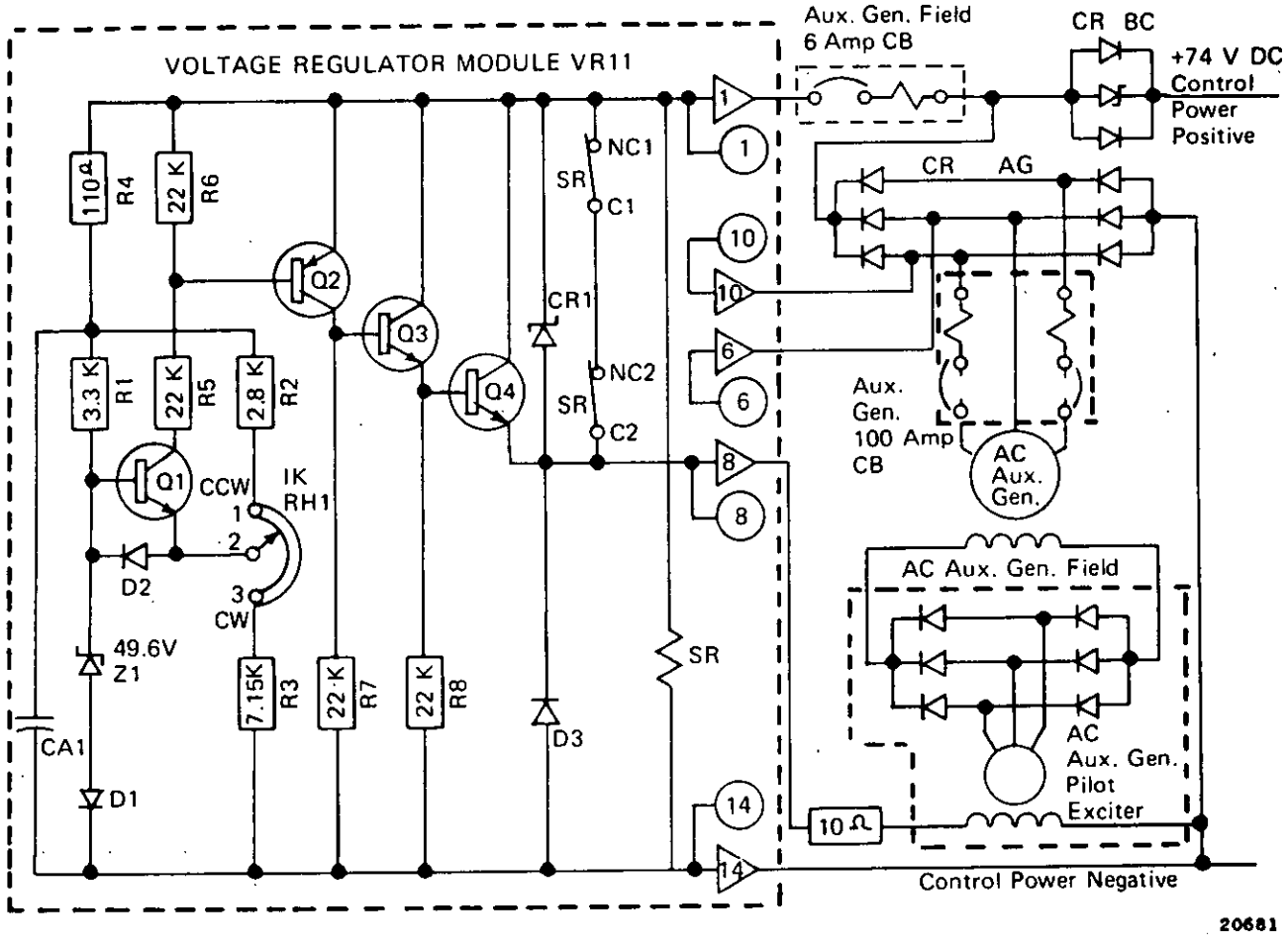


Fig. VR-1 – Voltage Regulator Module VR11, Simplified Schematic Diagram

OPERATION

The starting circuit consists of a starting relay SR with two series connected normally closed contacts. The SR coil is connected across the rectified output of the AC auxiliary generator. The SR contacts, in series with the field of the AC auxiliary generator pilot exciter and a 10 ohm resistor, are also connected across the rectified output of the AC auxiliary generator.

During normal operation, the SR contacts are open and excitation current for the pilot exciter field is supplied through transistor Q4. However, during start up, initial excitation is provided by residual magnetism and the initial output voltage is very small. Therefore, the normally closed SR contacts provide a low resistance path for current flow to the field of the AC auxiliary generator pilot exciter. This current flow aids the residual magnetism which results in a larger output voltage from the AC auxiliary generator. This increased voltage results in an increase in field excitation which, in turn, results in a larger output voltage and another increase in excitation current. This positive feedback results in a rapid buildup of output voltage from the AC auxiliary generator.

As output voltage increases, the detector circuit operates to turn on transistors Q1, Q2, Q3, and Q4. Turn on of Q4 provides a parallel path to the pilot exciter field. Starting relay SR picks up when the output voltage rises to about 35 to 45 volts. Pickup of SR opens the normally closed SR contacts so that all excitation current to the pilot exciter field is provided through Q4. Suppression rectifier CR1 suppresses arcing when the SR contacts open. CR1 also protects Q4 by suppressing voltage spikes.

The detector circuit consists of R1, R2, R3, RH1, Z1, D1, and transistor Q1. Resistor R4 and capacitor CA1 reduce the ripple magnitude of the voltage applied to the detector circuit. Rheostat RH1 is adjusted to obtain an output voltage of 74 V DC between module receptacles 1 positive and 14 negative. This output voltage may be increased by adjusting RH1 clockwise or decreased by adjusting RH1 counterclockwise. The nominal set point is 74 V DC. The three-phase rectified output is not smooth 74 V DC, but contains small ripples indicated in Fig. VR-2. The ripple magnitude shown in Fig. VR-2 is not intended to show the actual ripple magnitude.

Zener diode Z1 in series with R1 maintains a constant 49.6 V DC at the base of Q1. The voltage at the emitter of Q1 is proportional to the rectified output of the AC auxiliary generator. However, the magnitude of the ripple voltage is reduced by the action of R4 and CA1.

During normal operation, and with a constant load applied to the auxiliary generator, the voltage at the base and emitter of Q1 will be as represented in Fig. VR-2. Transistor Q1 is forward biased when the voltage at the emitter falls below 49.6 V DC. Turn on of Q1 provides a path for current flow from module receptacle 1 through R6, R5, Q1, the lower portion of RH1, and R3 to negative at module receptacle 14.

The voltage drop across R6 decreases the potential at the base of Q2 which provides forward bias for Q2. Turn on of Q2 provides forward bias for Q3 by applying a positive potential at the base of Q3. Turn on of Q3 provides forward bias for Q4 by applying a positive potential at the base of Q4. Turn on of Q4 provides a path for pilot exciter excitation current from module receptacle 1, through Q4 to module receptacle 8, then through the 10 ohm resistor and the pilot exciter field to negative.

Transistor Q1 becomes reverse biased when the voltage at the emitter rises above 49.6 V DC. Turn off of Q1 blocks current flow through R6 which removes forward bias from Q2. Turn off of Q2 removes forward bias from Q3 and Q4. Turn off of Q4 blocks excitation current to the pilot exciter field. Therefore, excitation to the pilot exciter field is applied in pulses rather than continuous. However, these pulses of excitation current occur whenever the voltage at the emitter of Q1 falls below 49.6 volts. This normally occurs each time the ripple decreases from its peak value to its minimum value. Inductance of the pilot exciter field smooths these pulses so that field strength is essentially constant, and the average DC voltage is maintained at 74 volts.

A large sudden increase in the load applied to the AC auxiliary generator or a sudden decrease in RPM results in a temporary decrease in output voltage of the AC auxiliary generator. This may result in the peak of the ripple voltage at the emitter of Q1 to fall below 49.6 volts. In this case Q1 may remain on for two or three cycles of ripple voltage to provide the necessary increase in excitation required for the increase in load current or for a decrease in RPM.

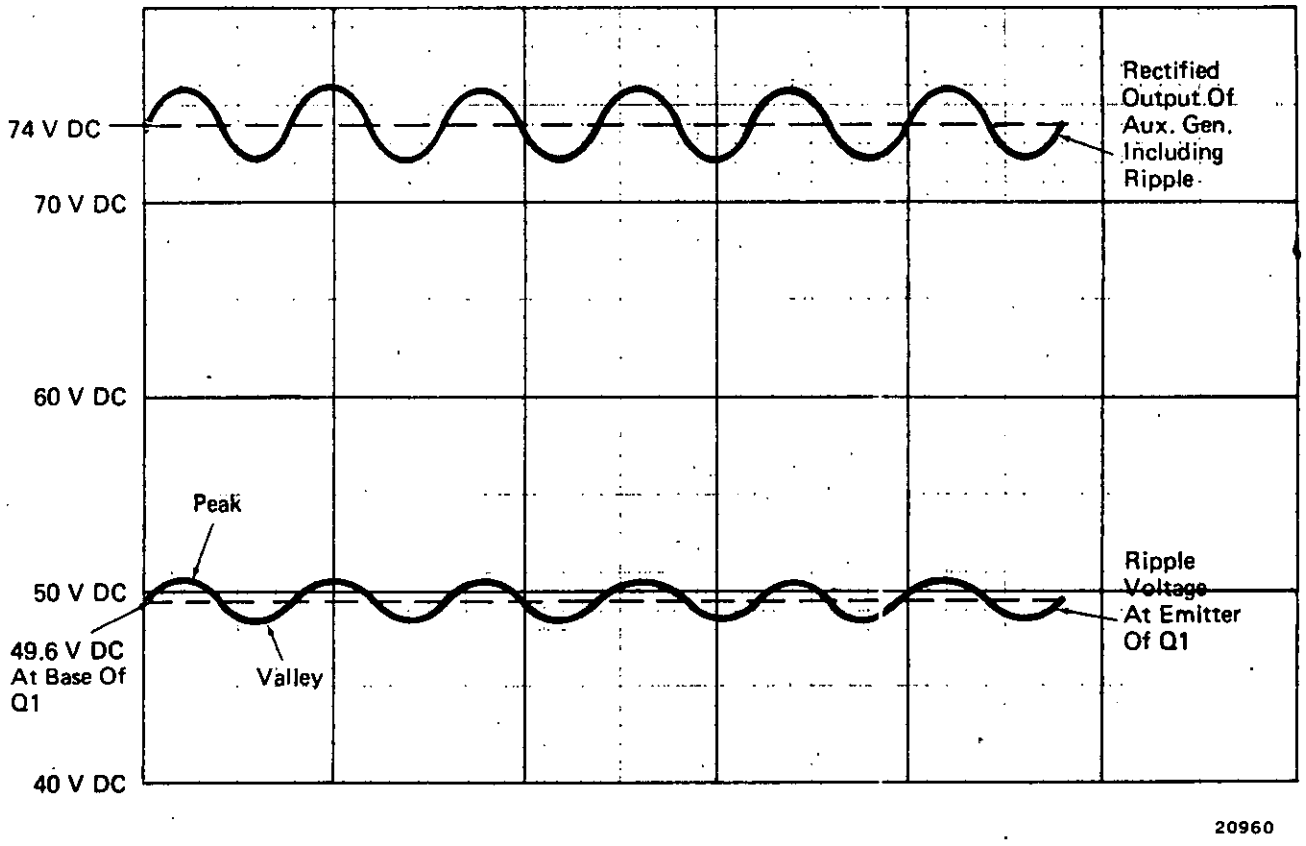


Fig. VR-2 – Representation Of Rectified AC Auxiliary Generator Output Voltage, Including Ripple

A large sudden decrease in the load applied to the AC auxiliary generator or a sudden increase in RPM results in a temporary increase in output voltage of the AC auxiliary generator. This may result in the valley of the ripple voltage at the emitter of Q1 to rise above 49.6 volts. In this case Q1 remains off for two or three cycles of ripple voltage to provide the necessary decrease in excitation current required for the decrease in load current or for the increase in RPM.

One phase of the three-phase AC auxiliary generator output voltage is connected between module receptacles 6 and 10. Module receptacles 6 and 10 are connected to module test jacks 6 and 10 so that the AC output voltage of the auxiliary generator may be measured at test jacks 6 and 10 on the module face plate. This voltage should be approximately 55 V AC during normal operation.

Rectified output of the AC auxiliary generator is connected to module receptacles 1 positive and 14 negative. Therefore, rectified output of the AC auxiliary generator may be measured at test jacks 1 positive and 14 negative on the module face plate. This voltage should be approximately 74 V DC during normal operation.

CAUTION: The voltage regulator module should not be removed while the engine is running. Removing the voltage regulator module while the engine is running will cause arcing at the module connector and may result in damage to the module.

EXCITATION AND POWER CONTROL SYSTEM

This section provides a general description of the excitation and power control system. Description of the system is followed by a detailed description of typical modules and assemblies used in the system. Simplified schematic diagrams of the modules are provided for convenient reference. The locomotive wiring diagram should be used when performing troubleshooting or maintenance.

GENERAL DESCRIPTION

A flow diagram of the excitation and power control system is provided in Fig. 7B-1. Electrical power and electrical control signals are represented in the flow diagram by solid interconnecting lines. Mechanical and hydraulic signals are represented by broken interconnecting lines.

The voltage reference regulator VRR, located in the TH module, and the throttle switches receive 74 volts DC input from the auxiliary generator. The 74 volts applied to the throttle switches is used to energize the speed setting solenoids in the engine speed governor and to energize the throttle response circuits located in the throttle response circuit of the TH module.

The speed setting solenoids in the engine speed governor are energized individually or in combination depending upon throttle position. The speed setting solenoids change the speed characteristics of the engine speed governor so that the governor will maintain a different engine speed for each throttle position. The nominal engine speed for each throttle position is given in Fig. 7B-1.

The throttle response relays, located in the throttle response circuit of the TH module, are energized individually or in combination depending upon throttle position. The throttle response circuits control the magnitude of the reference signal output from the throttle response module. This is accomplished by shorting out resistance in the throttle response circuit.

The voltage reference regulator VRR provides a very stable 68 volts DC output to the throttle response circuit and to the generator voltage module GV.

The throttle response circuit of the TH module provides an output reference signal related to throttle position. The nominal value of the throttle response circuit output reference signal for each throttle position is given in Fig. 7B-1.

The reference signal from the throttle response circuit is applied to the load regulator assembly LR, through the rate control module RC. The rate control module limits the rate of change in the reference signal. Limiting the rate of change results in a fast, but smooth, increase or decrease in the reference signal as the throttle position is changed. The reference signal is also decreased as it passes through the rate control module. An input reference signal of 68 volts DC to the rate control module, in throttle 8 position, provides an output reference signal of 50 volts to the load regulator. The nominal value of the rate control reference signal from the RC module for each throttle position is given in Fib. 7B-1.

The reference signal from LR is applied to the feedback module FP as an input to the excitation and power control servo loop consisting of the generator voltage regulator module GV, sensor module SE, silicon controlled rectifier SCR, main generator current transformers CT, generator potential transformers GPT, and the feedback module FP. Excitation to the main generator is determined by the reference signal from the load regulator LR. The LR wiper arm position is controlled by the engine speed governor so that the load on the diesel engine as well as engine RPM is determined by throttle position.

The FP module compares the input reference signal with feedback signals which are proportional to main generator output. Main generator output is sensed by current transformers CT and generator potential transformers GPT. Current transformers

THROTTLE POSITION	*ENGINE RPM	*TH13 OUTPUT	*RC11 OUTPUT
IDLE	315		
1	315	12.5	9.6
2	395	22.5	16.9
3	480	31.2	23.2
4	560	43.0	31.8
5	650	51.2	37.8
6	735	57.3	42.2
7	815	63.2	45.6
8	900	68.0	50.0

*Approximate Nominal Values With FP Module Disconnected Or During Normal Road Operation.

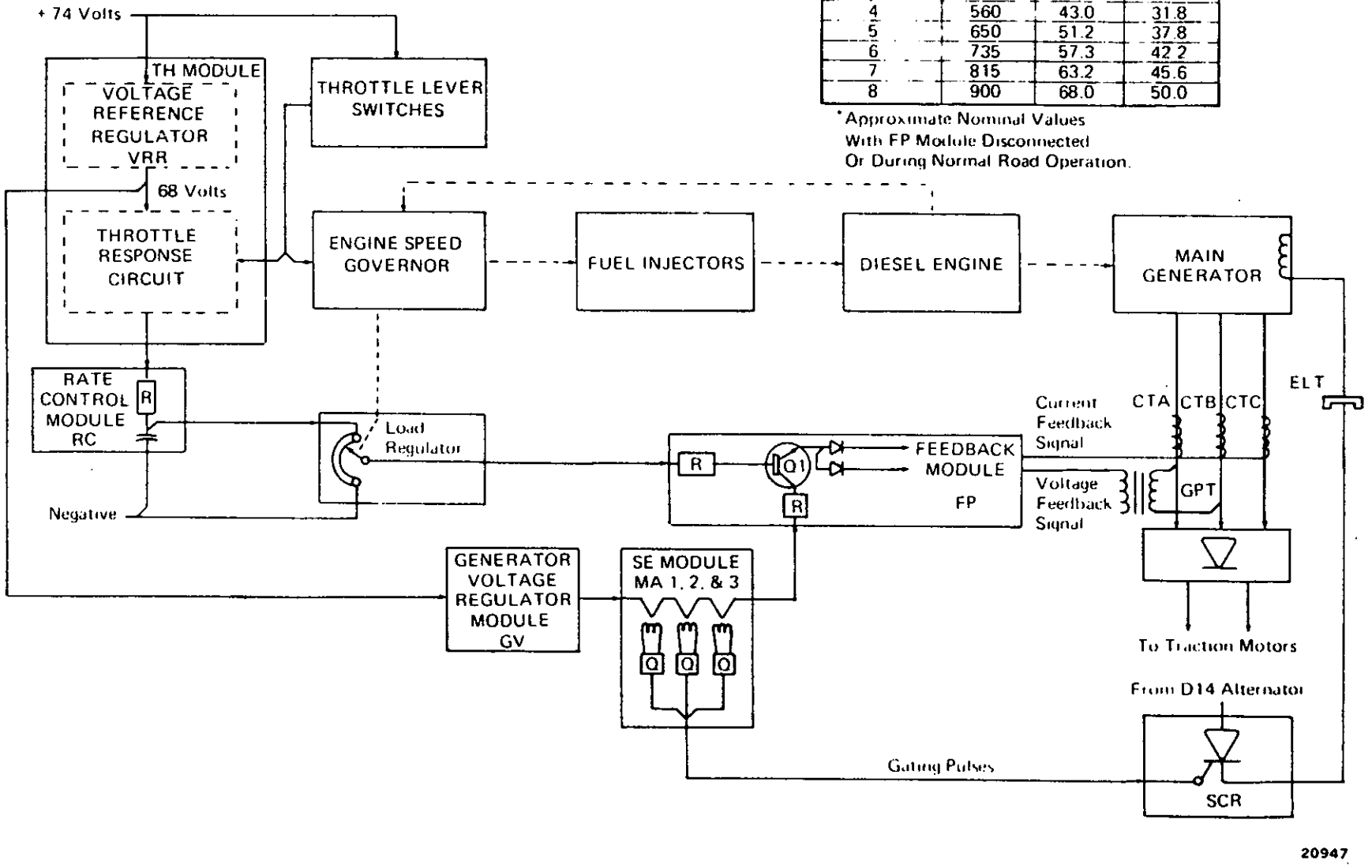


Fig. 7B-1 — Excitation And Power Control System, Simplified Flow Diagram

CT provides a feedback signal to the FP module proportional to main generator output current. The generator potential transformers GPT provides a feedback signal to the FP module proportional to main generator output voltage. The current feedback signal and the voltage feedback signal from GPT1 are combined by the FP module to provide a power control feedback signal. A performance control feedback signal is obtained by combining the voltage feedback signal from GPT2 with the current feedback signal. Both the power control feedback signal and the performance control feedback signal are proportional to main generator voltage and main generator current. However, the power control feedback signal is smaller than the performance control feedback signal during low current, high voltage operation. The performance control feedback signal is smaller than the power control feedback signal during low voltage high current operation.

The FP module compares the reference signal from the load regulator with the feedback signals. The load regulator reference signal is relatively constant for a given throttle position, provided operating conditions such as track, terrain, altitude, temperature, and fuel are constant. However the feedback signals contain ripples having peaks and valleys. Transistor Q1 of the FP module, Fig. 7B-1, is forward biased whenever the instantaneous value of the reference signal is larger than the instantaneous value of either of the feedback signals. Therefore, Q1 will be forward biased at intervals even when the average value of the reference signal is smaller than the average value of the feedback signals.

With forward bias on Q1, a control signal is applied to the sensor module SE. This signal passes through the SE module and through the generator voltage regulator module GV. The GV module passes the control signal as long as the main generator output voltage remains below the maximum safe value. The GV module blocks the control signal if generator output voltage rises above a safe value.

The control signal applied to the SE module causes the SE module to apply gating pulses to the silicon controlled rectifier assembly SCR. The SCR is forward biased during each positive alternation of output voltage from D14 alternator, however, the SCR will not conduct until gating pulses are applied to the gate of the SCR. When the SCR is forward biased and a pulse of the proper magnitude is applied to the SCR gate, conduction occurs as in a regular diode. After conduction starts, the pulse loses control and conduction continues as long as the SCR is forward biased. When forward bias is removed, the SCR is cut off until the next pulse is applied to the SCR gate along with forward bias between anode and cathode.

Excitation to the main generator field, from the D14 alternator, is controlled by the gating pulses. When the gating pulses are applied to SCR, excitation and main generator output increase until the instantaneous difference between the reference signal and the feedback signal is just large enough to maintain the control signal from FP to SE.

When the locomotive is operating with a constant quality of fuel and at a constant load, speed, and temperature, the reference signal will stabilize at some value. The feedback signal will also stabilize, so that a constant control signal will be applied to SE and constant excitation will be applied to the main generator field. However, the track, terrain, temperature, and fuel quality are variables. Therefore, the reference signal varies to compensate for the changing conditions and the feedback signal also varies in attempting to match the reference signal.

When operating in throttle 8 position, the reference signal from the load regulator LR has a maximum value of 50 volts with LR in maximum field position However, during normal operation the actual value of the reference signal is usually less than 50 volts. The maximum value of the reference signal decreases as the throttle position is decreased. Assume that the locomotive is operating in throttle 8 position, the consist is moving at high speed, main generator output current is low, main generator output voltage is high and the load regulator is below maximum field position. This condition may be represented by point "A" on the constant horsepower curve of Fig. 7B-2. Note that the feedback signal at point "A" on the constant horsepower curve of Fig. 7B-2 is approximately 40 volts. This value was selected for descriptive purposes only and does not necessarily indicate the actual value of the feedback signal under the stated conditions.

If the locomotive now starts climbing a grade, the load on the traction motors increases. The increased load causes a decrease in traction motor speed. The decrease in traction motor speed results in an increase in traction motor current due to less counter-electromotive force. An increase in traction motor current results in a decrease in voltage applied to the traction motors. This decrease in voltage is partly due to the increased I^2R and IZ losses in the main generator. If the reference signal did not change, the horsepower output of the main gen-

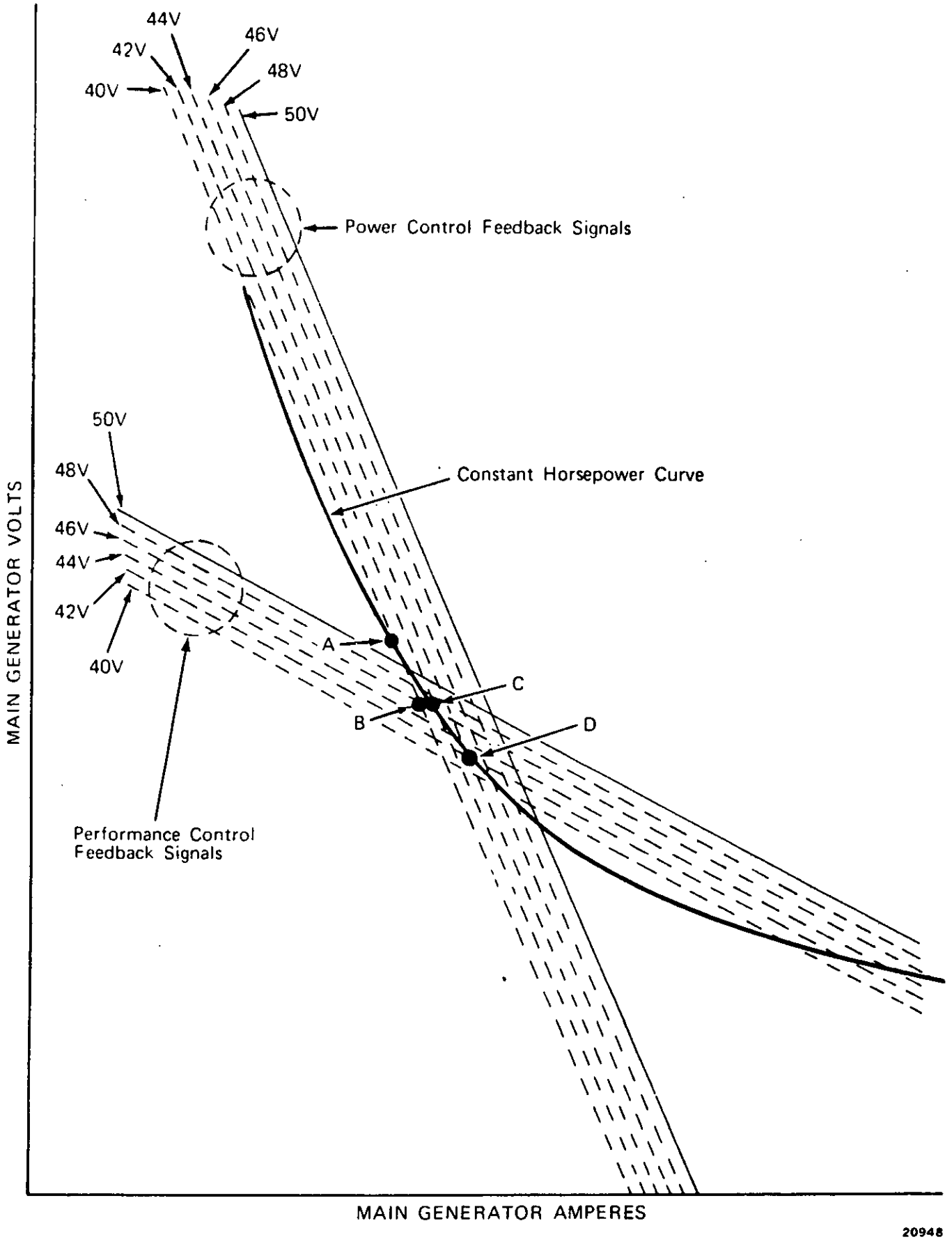


Fig. 7B-2 – Constant Horsepower Curve With Power Control Feedback Signals And Performance Control Feedback Signals

erator would decrease by following the 40 volt signal line from point "A" to point "B" in Fig. 7B-2.

A decrease in horsepower tends to cause an increase in speed of the diesel engine. This increase in speed is sensed by the engine speed governor. The governor reacts to temporarily decrease the amount of fuel injected into the diesel engine and thereby maintains a constant engine speed. At the same time the fuel is decreased, a pilot valve in the engine speed governor directs hydraulic pressure into the load regulator vane motor which causes the load regulator vane motor which causes the load regulator to move toward maximum field position.

Movement of the load regulator toward maximum field position results in an increase in the reference signal. Increasing the reference signal results in an increase of excitation to the main generator field and an increase in main generator horsepower output. This increased horsepower tends to decrease diesel engine speed, however, the governor again reacts to maintain a constant engine speed. The pilot valve in the governor also causes a slight adjustment in load regulator position so that the main generator output moves along the constant horsepower curve of Fig. 7B-2 from point "A" to point "C" instead of moving from point "A" to point "B." The response of the engine speed governor and the load regulator is fast enough to prevent any noticable difference in diesel engine speed or main generator output during the corrective action. This corrective action continues as the locomotive operates on the constant horsepower curve of Fig. 7B-2 to point "D."

As the locomotive operates between points A and D, the power control feedback signal is lower than the performance control feedback signal and, therefore, it is the controlling signal. However, the power signal level is increasing and the performance signal level is decreasing during this time. At point "D," the feedback signal levels become equal. Past point "D" the performance feedback signal is lower than the power feedback signal and therefore it becomes the controlling signal. This action causes the main generator output to follow the constant horsepower curve.

When operating in a throttle position lower than throttle 8, the feedback signals, reference signal, and constant horsepower curve will have lower values than in throttle 8. However, the general operating description is the same for all throttle positions.

Refer to description of individual modules and components for a more detailed description of components used in the excitation and power control system.

CONTENTS

The contents of Section 7 Part B are presented in the following order:

1. Excitation Limit Backup Protection System.
2. Field Shunting Module.
   - FS19 Applicable to GL26C-2 model locomotives.
   - FS14 Applicable to GL22C-2 model locomotives.
3. Generator Voltage Regulator Module
4. Generator Excitation Regulator Module.
5. Load Regulator Assembly
6. Feedback & Performance Module
   - FP16 Applicable to GL26C-2 model locomotives.
   - FP15 Applicable to GL22C-2 model locomotives.
7. Rate Control Module
8. Sensor Module
9. Silicon Controlled Rectified Assembly.
10. Throttle Response and Voltage Reference Regulator Module.

EXCITATION LIMIT BACKUP PROTECTION SYSTEM

INTRODUCTION

The excitation limit backup protection system consists of an excitation limit module EL11 and an excitation limit transductor ELT. The ELT provides an input signal to the EL module which is proportional to main generator field current. The EL module provides protection against excessively high excitation current to the main generator field by dropping the feed to the equipment protection relay EQP in case a fault in the GX module allows excitation current to rise above a safe value. A simplified schematic diagram of the excitation limit backup protection system, Fig. EL-1, is provided for reference only. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance on the excitation limit backup protection system.

EXCITATION LIMIT TRANSDUCTOR, ELT

The excitation limit transductor ELT consists of two laminated iron cores, two AC windings, a field current bias winding, and a test winding. The two cores are magnetically isolated from each other by an air gap and each core contains an AC winding. The bias winding and the test winding are common to both cores. A simplified schematic diagram of the ELT is provided in Fig. EL-1.

The two AC windings are connected series opposing so that the magnetic lines of force (flux lines) in the two cores travel in opposite directions. The AC windings, in series with the primary of transformer T1 on the EL module, are energised by current from the D14 alternator.

The reactance of the AC windings is much larger than the reactance of T1, when no current is flowing in the main generator field. Therefore, with no main generator field current practically all of the input AC voltage is developed across the AC windings and very little voltage appears across T1. Transformer T1 provides an input signal to the EL module. Consequently, the input signal to the EL module is very small when no current is flowing in the main generator field.

The field current bias winding consists of a single conductor passing through both cores and is connected in series with the main generator field windings.

The flux lines set up by the bias winding aids the flux lines set up by the AC winding in one of the cores and opposes the flux lines set up by the AC windings in the other core. The core in which the flux lines aid moves toward magnetic saturation which reduces the reactance of the AC winding on this core: The core in which the flux lines oppose moves away from saturation, but the reactance of the AC winding on this core is affected by only a very small amount. Therefore, the combined reactance of the two AC windings decreases as current increases through the field current bias winding. The current through the field current bias winding controls the current in the AC winding according to the ampere-turns ratio between the bias winding and the AC winding. Therefore, an increase of current in the bias winding results in an increase of current through the AC windings and through transformer T1, located on the EL module. The increase in current through T1 causes an increase in the signal applied to the EL module. If the field current in the main generator rises above a safe value, the signal from T1 is sufficient to cause the EL module to operate. Operation of the EL module results in drop out of EQP, which opens the feed to the GFC contactor coil. Dropout of GFC results in disconnecting the D14 alternator from the main generator field.

The test winding on ELT provides a means for testing the excitation limit backup protection system. Closing the test switch on the EL module allows current to flow through the test winding. Current flow through the test winding causes one of the cores of ELT to move toward saturation and results in an increase of current through T1.

This increase in current through T1 causes the EL module to operate, thereby testing ELT and the EL module. The excitation limit light on the annunciator module should light and stay on until the annunciator module is reset.

EXCITATION LIMIT MODULE, EL FIG EL-1

An input signal, which is proportional to the main generator field current is applied to transformer T1. The rectified output of T1 is applied to a voltage divider consisting of resistors R3, R4, R6, R7, and rheostat RH1. Capacitor C2 which is connected to the base of transistor Q1 prevents turn on of Q1 due to transient voltage output from T1. Transistor Q1 is forward biased when the output of T1 is large enough to charge C2 to a value in excess of 6.2 volts. This forward bias causes Q1 to turn on and results in a current flow from terminal 1 of the EL module, through ELR and ELRA relays, from collector to emitter of Q1, then to negative. This results in pickup of ELR and ELRA.

Pickup of ELRA provides a feed to the excitation limit light on the annunciator module AN.

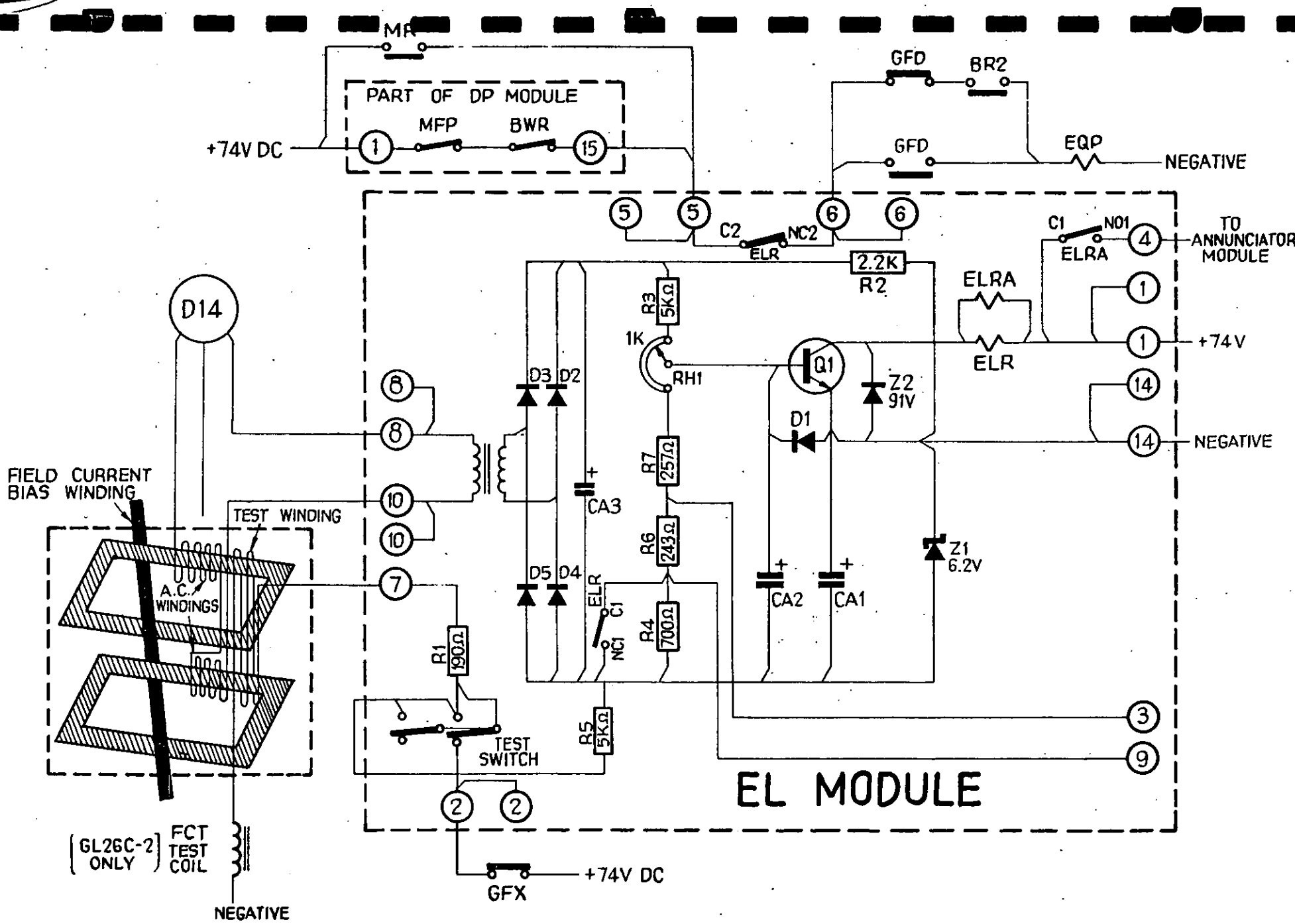


Fig. EL-1 — Excitation Limit Protection System, Simplified Schematic Diagram

Pickup of ELR drops the feed to EQP by opening the ELR contacts between terminals 5 and 6 on the EL module. Pickup of ELR also recalibrates the voltage divider biasing circuit by inserting resistor R4 in series with R3, R6, R7, and RH1. Recalibrating the voltage divider biasing circuit increases forward bias on Q1. Increasing forward bias on Q1 prevents dropout of ELR and ELRA until field current decreases several amperes below the safe value. Dropout of EQP removes the feed from generator field contactor GFC which results in disconnecting the D14 alternator from the main generator field. Disconnecting the D14 alternator from the main generator field causes field current to decrease. The decrease in field current reduces the signal to transformer T1 causing Q1 to turn off. Turn off of Q1 results in dropout of ELR and ELRA. Dropout of ELR re-establishes feed to EQP which in turn re-establishes feed to GFC and results in reconnecting the D14 alternator to the main generator field. The locomotive will now operate in a normal manner, provided the condition that causes over excitation has cleared up. However, if the condition still exists, excessive current will flow through the field and again cause the EL module to operate. This cycling will continue as long as the over excitation condition exists. The cycling results in very rough regulation of power and also causes undesirable wear on the generator field contactor GFC. Therefore, the condition should be corrected as soon as practicable.

On GL22C-2 and GL26C-2 locomotives the EL module provides backup protection at 114 Amperes field current at all track speeds.

GENERATOR VOLTAGE REGULATOR MODULE, GV

INTRODUCTION

The generator voltage regulator module GV11 or GV12 limits the maximum output voltage of the main generator to a safe value. This regulation is provided by modulating the control signal to the sensor module SE in the event that main generator output voltage tends to rise above a safe value. Decreasing the control signal to the SE module results in a decrease of excitation to the main generator field and a corresponding decrease in main generator output voltage.

A simplified schematic diagram of the GV module, Fig. GV-1, is included for reference only. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance. The GV11 and GV12 modules differ only in the ohmic value of resistors RE6 and RE7. Refer to the shaded area of Fig. GV-1 for values of RE6 and RE7.

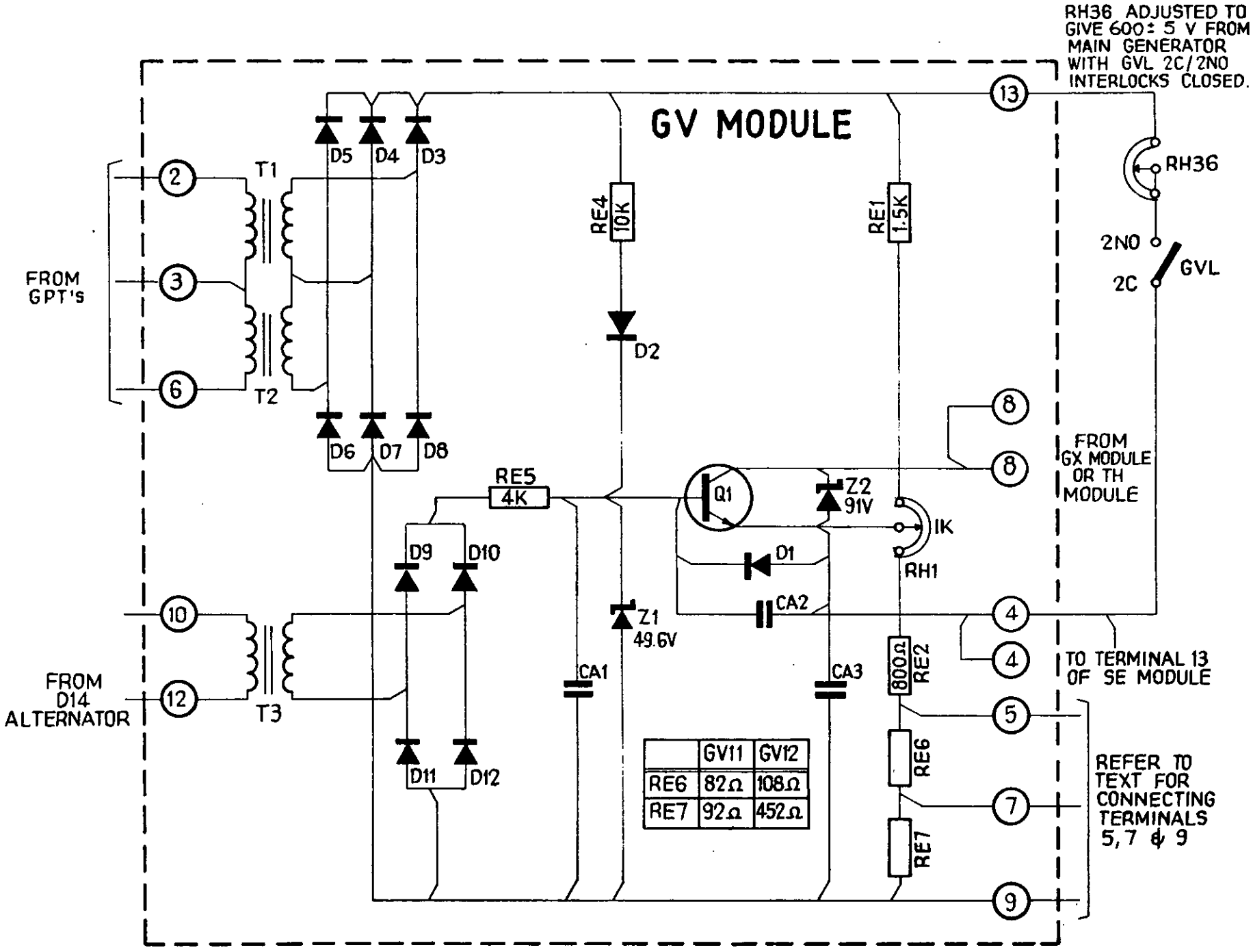
GENERAL DESCRIPTION

During normal operation, transistor Q1 on the GV module is forward biased. With forward bias applied to Q1, the control signal passes through the GV module from terminal 8 to terminal 4 then to the SE module. The control signal applied to the SE module causes gating pulses to be applied to the silicon controlled rectifier SCR. The gating pulses turn on the SCR so that excitation is applied to the main generator field. The amount of excitation applied to the main generator field is proportional to the magnitude of the control signal applied to the SE module. If main generator output voltage tends to rise above a safe value, the GV module modulates the control signal to the SE module as necessary to limit the main generator voltage to a safe value.

Output of the D14 alternator is applied to transformer T3 on the GV module. The rectified output of T3 is applied to resistor RE5 and capacitor CA1 in series causing a voltage to be developed across CA1. The voltage developed across CA1 is applied to the base of transistor Q1. The series combination of capacitors CA2 and CA3 is connected in parallel with CA1. The emitter is connected to the junction of CA2 and CA3, therefore the voltage applied to the emitter of Q1 is less than the voltage applied to the base and Q1 is forward biased. With forward bias on Q1, the control signal passes through the GV module from terminal 8, through Q1 from collector to emitter, to terminal 4, then to the SE module. The control signal applied to the SE module results in gating pulses to the silicon controlled rectifier SCR and excitation to the main generator field. This excitation causes build up of main generator voltage.

An input signal, which is proportional to main generator output voltage, is applied to transformers T1 and T2. The rectified output of T1 and T2 is applied to the series combination of resistor RE4, diode D2, and capacitor CA1. The voltage developed across CA1 is applied to the base of Q1. The rectified output of T1 and T2 is also applied to a voltage divider consisting of resistor RE1, rheostat RH1, resistors RE2, RE6 and RE7. The wiper arm of RH1 is connected to the emitter of Q1. During normal operation, an increase in main generator voltage results in a proportional increase in voltage at the base and at the emitter of Q1.

As the main generator output voltage increases, the voltage applied to T1 and T2 increases and the voltage developed across CA1 increases until the breakdown voltage of zener diode Z1 is reached. After breakdown of Z1 the voltage applied to the base of Q1 assumes a constant value which is equal to the breakdown voltage of Z1. A further increase in main generator output voltage results in an increase of voltage applied to the emitter of Q1, but the voltage on the base remains constant at the breakdown value of Z1.



	GV11	GV12
RE6	82Ω	108Ω
RE7	92Ω	452Ω

Fig. GV-1 – Generator Voltage Regulation Module GV Simplified Schematic Diagram

If the main generator voltage tends to rise above a safe value, the voltage at the emitter of Q1 increases causing a decrease in forward bias on Q1. The decrease in forward bias, or a reverse bias, causes a decrease in the control signal to the SE module and consequently a decrease in excitation to the main generator field and a decrease in output voltage of the main generator. Therefore, the output voltage of the main generator is limited to a safe value by applying a signal to the GV module that is proportional to the output voltage of the main generator.

REGULATION FOR DIFFERENT VALUES OF MAIN GENERATOR OUTPUT VOLTAGE

The maximum output voltage of the main generator may be regulated, by the GV11 module, to any one of the three different values. The specific value is determined by the external connections applied to terminals 5, 7, and 9 of the GV11 module. Refer to Fig. GV-1. The GV11 module will limit main generator output voltage to 1300 volts when no external connections are applied to terminals 5, 7, and 9. Main generator voltage will be limited to 1350 volts when terminal 5 is connected to terminal 7 and terminal 9 is left open. Main generator voltage will be limited to 1400 volts when terminal 5 is connected to terminal 9. The GP40-2 locomotive is equipped with the GV11 module with terminals 5, 7, and 9 open. This provides for a maximum output voltage of 1300 volts.

The maximum output voltage of the main generator may be regulated, by the GV12 module, to any one of the three different values. The specific value is determined by the external connections applied to terminals 5, 7, and 9 of the GV12 module. Refer to Fig. GV-1. The GV12 module will limit main generator output voltage to 1050 volts when no external connections are applied to terminals 5, 7, and 9. Main generator voltage will be limited to 1200 volts when terminal 7 is connected to terminal 9 and terminal 5 is left open. Main generator will be limited to 1250 volts when terminal 5 is connected to terminal 9. The GP38-2, SD38-2, SD40-2, and SD45-2 model locomotives are equipped with the GV12 module with terminal 5 connected to terminal 9. This provides for maximum output voltage of 1250 volts for these locomotives.

AUTOMATIC GROUND RELAY RESET LIMITER RECALIBRATION OF THE GV MODULE

The automatic ground relay reset limiter assembly provides a feed to the generator voltage limit relay GVL after the fourth pickup of the ground relay in any given sequence. Pickup of GVL connects GV module receptacles 13 to 4, through RH36. Refer to Fig. GV-1. This recalibrates the GV module so that main generator voltage is limited to a maximum value of 600 $\pm$ 5 volts until the automatic ground relay reset limiter is reset to zero. This reduced voltage reduces the probability of ground relay pickup in the presence of low leakage moisture grounds. Therefore, it may be possible to continue locomotive operation at reduced power output until the moisture is dissipated and then return to normal operation.

NOTE: GL22C-2 and GL26C-2 locomotives have no external connections between terminals 5, 7 and 9 of the GV12 module and consequently the main generator output voltage is limited to 1050 volts.

GENERATOR EXCITATION REGULATING SYSTEM

(GX2 is only applicable to GL26C-2Locomotives)

INTRODUCTION

The generator excitation regulating system consists of the generator excitation regulating module GX2 and a field current transductor FCT. The FCT provides an input signal to the GX module proportional to main generator field current. The GX module provides protection against excessively high excitation current to the main generator field by modulating the control signal to the sensor module SE in the event that excitation to the main generator field tends to rise above a safe value. A simplified schematic diagram of a typical generator excitation regulating system, Fig. GX-1, is included for reference only. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance.

FIELD CURRENT TRANDUCTOR, FCT

The field current transductor FCT consists of two laminated iron cores, two AC windings, and a field current bias winding. The two cores are magnetically isolated from each other by an air gap and each core contains an AC winding. The bias winding is common to both cores, Fig. GX-1 contains a simplified schematic diagram of FCT.

The two AC windings are connected series opposing so that the magnetic lines of force (flux lines) in the two cores travel in opposite directions. The AC windings, in series with the primary of transformer T1 on the GX module, are energised by current from the D14 alternator.

The reactance of the AC windings is much larger than the reactance of T1, when no current is flowing in the main generator field. Therefore, with no main generator field current, practically all of the input AC voltage is developed across the AC windings and very little voltage appears across T1. Transformer T1 provides an input signal to the GX module. Consequently, the input signal to the GX module is very small when no current is flowing in the main generator field.

The field current bias winding consists of a single conductor passing through both cores and is connected in series with the main generator field windings. The flux lines set up by the bias winding aids the flux lines set up by the AC winding in one core and opposes the flux lines set up by the AC winding in the other core.

The core, in which the flux lines aid, moves toward magnetic saturation which reduces the reactance of the AC winding on this core. The core in which the flux lines oppose, moves away from saturation, but the reactance of the AC winding on this core is affected only by a very small amount. Therefore, the combined reactance of the two AC windings decrease as the field current increases. The decrease in reactance results in an increase in current through the AC windings and through transformer T1, located on the GX module. If the main generator field current rises above a safe value, the signal from T1 is sufficient to cause transistor Q1, on the GX module, to modulate the control signal to the SE module. Modulating the control signal to the SE module results in decreasing the main generator field current.

GENERATOR EXCITATION REGULATING MODULE, GX

Fig. GX-1 contains a simplified schematic diagram of GX2.

During normal operation, transistor Q1 on the GX module is forward biased. With forward bias applied to Q1, the control signal is passed through the GX module from terminal 8 to terminal 4. This control signal is applied through the GV module, to terminal 13 of the SE module. The control signal applied to the SE module causes gating pulses to be applied to the silicon controlled rectifier SCR. The gating pulses turn on the SCR and excitation current flows through the SCR to the main generator field. The amount of excitation applied to the main generator field is proportional to the magnitude of the control signal applied to SE. If the main generator field current tends to rise above a safe value, the GX module modulates the control signal to the SE module as necessary to limit the main generator field current to a safe value.

Output voltage of the D14 alternator is applied to transformer T2 on the GX module. The rectified output of T2 is applied to resistor R4 and capacitor C1 in series, causing a voltage to be developed across C1. The voltage developed across C1 is applied to the base of transistor Q1. The series combination of capacitors C2 and C3 is connected in parallel with C1. The emitter is connected to the junction of C2 and C3 therefore the voltage applied to the emitter is less than the voltage applied to the base. This places forward bias on Q1. With forward bias on Q1, the control signal passes through the GX module from terminal 8, through Q1 from collector to emitter, to terminal 4, then through the GV module to the SE module. The control signal applied to SE results in gating pulses to the silicon controlled rectifier SCR and excitation to the main generator field. This excitation causes build up of main generator voltage.

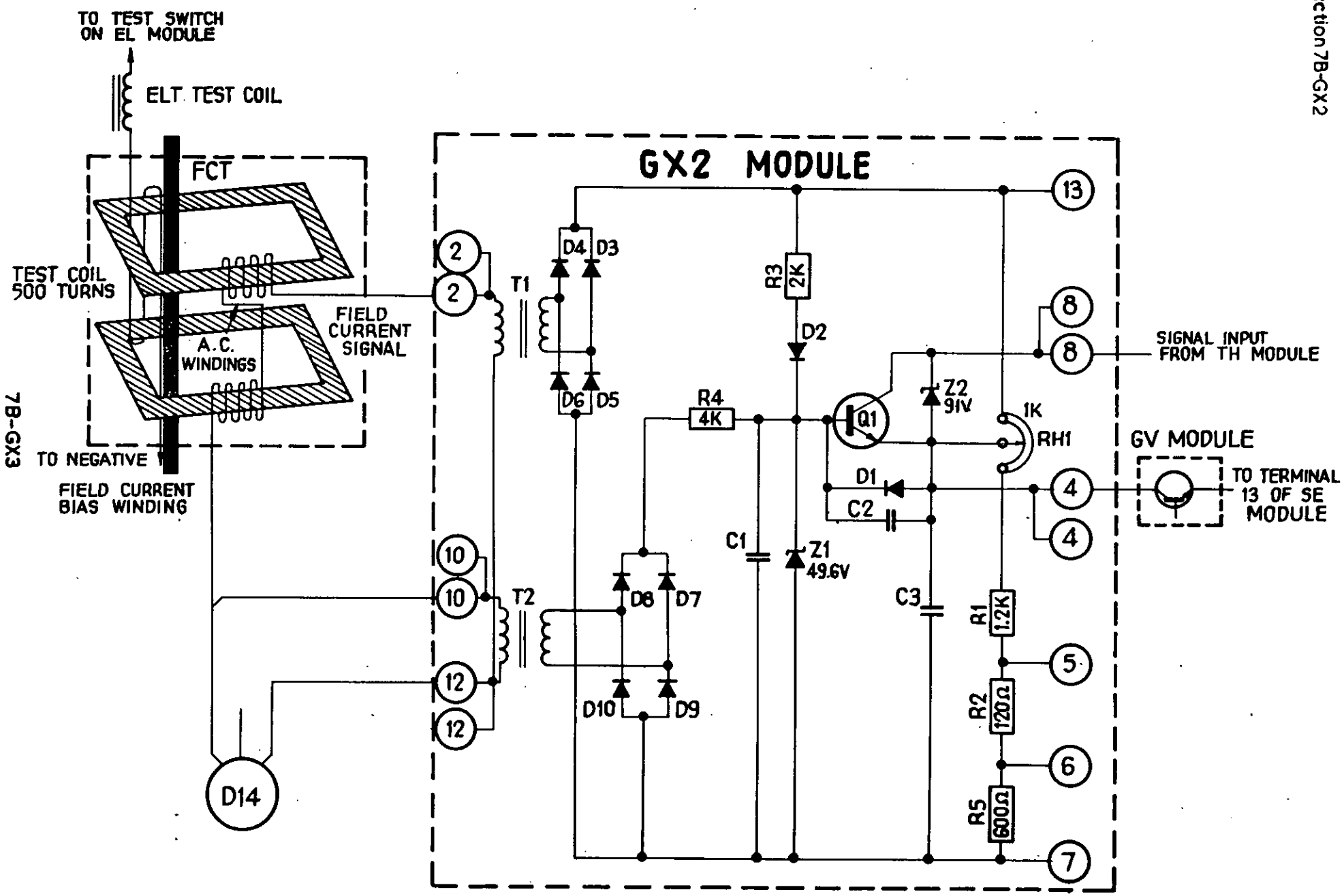


Fig. GX-1 — Generator Excitation Regulating Module, Simplified Schematic Diagram

An input signal, which is proportional to main generator field current, is applied to transformer T1. The rectified output of T1 is applied to the series combination of resistor R3 diode D2, and capacitor C1. The voltage developed across C1 is applied to the base of Q1. The rectified output of T1 is also applied to a voltage divider consisting of rheostat RH1, resistor R1, R2 and R5. The wiper arm of RH1 is connected to the emitter of Q1. During normal operation, an increase in main generator field current results in a proportional increase in voltage at the base and at the emitter of Q1 which maintains forward bias on Q1.

As the main generator field current increases, the voltage applied to T1 increases and the voltage developed across C1 increases until the breakdown voltage of zener diode Z1 is reached. After breakdown of Z1, the voltage applied to the base of Q1 assumes a constant value which is equal to the breakdown voltage of Z1. A further increase in main generator field current results in an increase of voltage to T1 which results in an increase in voltage applied to the emitter of Q1, but the voltage on the base remains constant at the breakdown value of Z1.

If the main generator field current tends to rise above a safe value, the voltage at the emitter of Q1 increases, and this causes a decrease in forward bias on Q1. The voltage at the emitter of Q1 may increase to a value that results in reverse bias on Q1.

The decrease in forward bias, or reverse bias, causes a decrease in the control signal to SE and consequently a decrease in main generator field current. Therefore, the field current of the main generator is limited to a safe value by applying a signal to the GX module that is proportional to the main generator field current.

REGULATION FOR DIFFERENT TYPES OF LOCOMOTIVES

The GX2 module is designed so that main generator field current may be regulated at a maximum limit of any one of three different values. Refer to Fig. GX-1. The GX2 module will limit field current to 103 amperes when no external connections are applied to terminals 5, 6, and 7. Field current will be limited to 108 amperes when terminal 5 is connected to terminal 6 and terminal 7 is left open. Field current will be limited to 144 amperes when terminals 5, 6, and 7 are connected together.

GP MODEL LOCOMOTIVES

On GP model locomotives, resistor R2 is shorted out by external connection between terminals 5 and 6. During low speed operation resistor R5 is shorted out by closed RB relay contacts on the WO module.

Field current is limited to a maximum of 144 amperes when R2 and R5 are shorted out. The RB relay picks up when track speed increases. Pickup of RB recalibrates the GX module by removing the short circuit from R5. Field current is limited to 108 amperes after recalibration.

SD MODEL LOCOMOTIVES

On SD model locomotives, resistor R2 is shorted out by external connection between terminals 5 and 6 and terminal 7 is left open. Under these conditions field current is limited to 108 amperes. Recalibration of the GX module is not applicable to SD locomotives. Therefore, field current is limited to 108 amperes regardless of track speed.

FCT TEST WINDING

A test winding on FCT provides a means for testing GX module operation. The winding is connected in series with a test winding on excitation limit transductor ELT, Fig. EL-1. When the locomotive throttle is at idle with the engine running, closing a test switch on the EL module allows current to flow through both the ELT and FCT test windings, causing one FCT core to move toward saturation. This results in an increase of current through R1 of GX. The increased current causes the GX module to regulate, and voltage can be seen across GX-TP8 to GX-TP4.

FIELD SHUNTING MODULE, FS14

INTRODUCTION

The locomotive is equipped with six traction motors. These motors are connected across the main generator so that six parallel paths are provided for main generator output current. Each parallel path consists of one motor armature in series with its field.

One step of motor field shunting is provided for the traction motor fields. Motor field shunting is initiated by field shunting module FS14. A simplified schematic diagram of the FS14 module is provided in Fig. FS-1 for convenient reference. The applicable locomotive wiring diagrams should be used when performing troubleshooting or maintenance.

OPERATION DURING INCREASE IN TRACK SPEED

A signal proportional to main generator output voltage is obtained from generator potential transformer GPT2 and applied to receptacle 2, 3 and 4 of the FS module. This signal passes through isolation transformers T1 and T2, is rectified by diodes D1 through 6, filtered by CA1, CA2 and R1. The signal is then applied to a voltage divider consisting of zener diodes Z1 and Z2, resistors R2 and R3, rheostats RH1 and RH2. The signal from the wiper arm of RH2 is applied through diode D7 to the base of Q1. Therefore, the signal applied to the base of Q1 is proportional to main generator output voltage.

A signal proportional to main generator output current is obtained from receptacle 11 of the feedback module FP and applied to receptacle 13 of the FS module. This signal which has an absolute maximum value of about 50 volts is applied to the base of Q3. The emitter of Q3 is connected through R7 to 74V DC at receptacle 1. Therefore, Q3 is always forward biased and a signal proportional to main generator output current is applied to the emitter of Q1.

A horsepower curve for throttle 8 position is shown in Fig. FS-2. At start up and during heavy drag operation, the locomotive will be operating toward the right end of the applicable horsepower curve. In this region, the current signal applied to the emitter of Q1 is larger than the signal applied to the base of Q1.

As track speed increases, the operating point moves to the left along the horsepower curve. Main generator output voltage and the signal applied to the base of Q1 increases while output current and the signal applied to the emitter of Q1 decreases. Transistor Q1 turns on when the operating point reaches the region designated as FSR PICK-UP area in Fig. FS-2.

Turnon of Q1 provides forward bias for Q2. Turnon of Q2 provides a feed to FSR. Pickup of FSR recalibrates the voltage divider connected to the base of Q1. This recalibration increases forward bias for Q1. This increased forward bias prevents on-off cycling of Q1 by setting the turnoff point of Q1 to the FSR DROP-OUT area in Fig. FS-2. Pickup of FSR also connects receptacle 6 to receptacle 7 which provides a feed to the field shunt auxiliary relay FSRA.

The field shunt auxiliary relay FSRA

(i) Causes FS1A and FS1B contactors to energise. This causes the traction motor fields to be shunted by a path containing a heavy duty resistor to achieve motor field shunting.

(ii) Energises the ORS relay momentarily. The FSRA relay picking up and the FS1A contactor picking up are subject to a short time overlap which allows the ORS to be energised. The ORS relay being energised causes the load regulator to move to minimum field. This prevents a sudden increase in effective voltage taking place after field shunting leading to traction motor flashovers.

Decreasing the traction motor fields results in decreasing the counter electromotive force CEMF of the motors. This decrease in CEMF results in an increase of main generator output current which shifts the operating point along the horsepower curve to the right from the FSR PICK-UP region in Fig. FS-2. The increase in main generator current results in a decrease in main generator voltage and extends the range of full horsepower operation within the limits of the motors and the generator. There are FS1A and FS1B interlocks in the TDS circuit. These are meant to prevent sanding in the Field Shunt position as the sanding relay was set off whenever the locomotive went into traction motor field shunt.

OPERATION DURING DECREASE IN TRACK SPEED

A decrease in track speed results in shifting the operating point to the right along the power curve (refer to Fig. FS-2). This action reduces the voltage signal applied to the base and increases the current signal applied to the emitter of Q1 in Fig. FS-1.

When the operating point moves into the FSR DROP-OUT region of Fig. FS-2, the current signal applied to the emitter is larger than the voltage signal applied to the base of Q1.

This reverse bias turns off Q1 which removes forward bias from Q2 and results in dropout of FSR. Dropout of FSR opens the circuit between receptacles 6 and 7 which drops the feed to the FSRA relay connected to receptacle 6. Dropout of FSR also recalibrates the voltage divider connected to the base of Q1. This recalibration decreases the voltage signal applied to the base of Q1. This decreased signal prevents on-off cycling of Q1 by setting the turnon point of Q1 to the area in Fig. FS-2 designated as FSR PICK-UP. Dropout of FSRA drops the feed to FS1A and FS1B which removes the shunt from the traction motor fields.

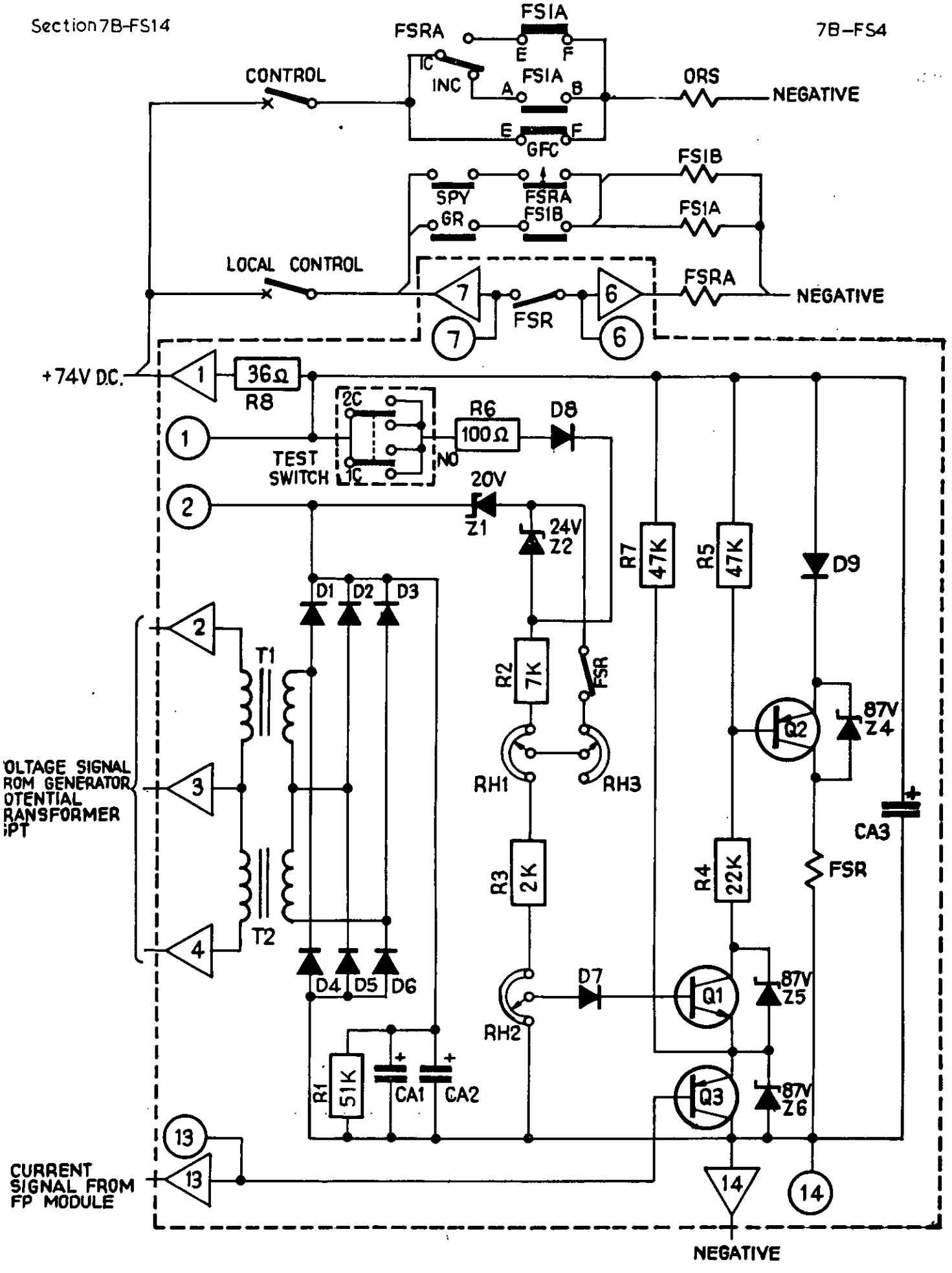


Fig. FS-1 — Field Shunting Module FS14, Simplified Schematic Diagram

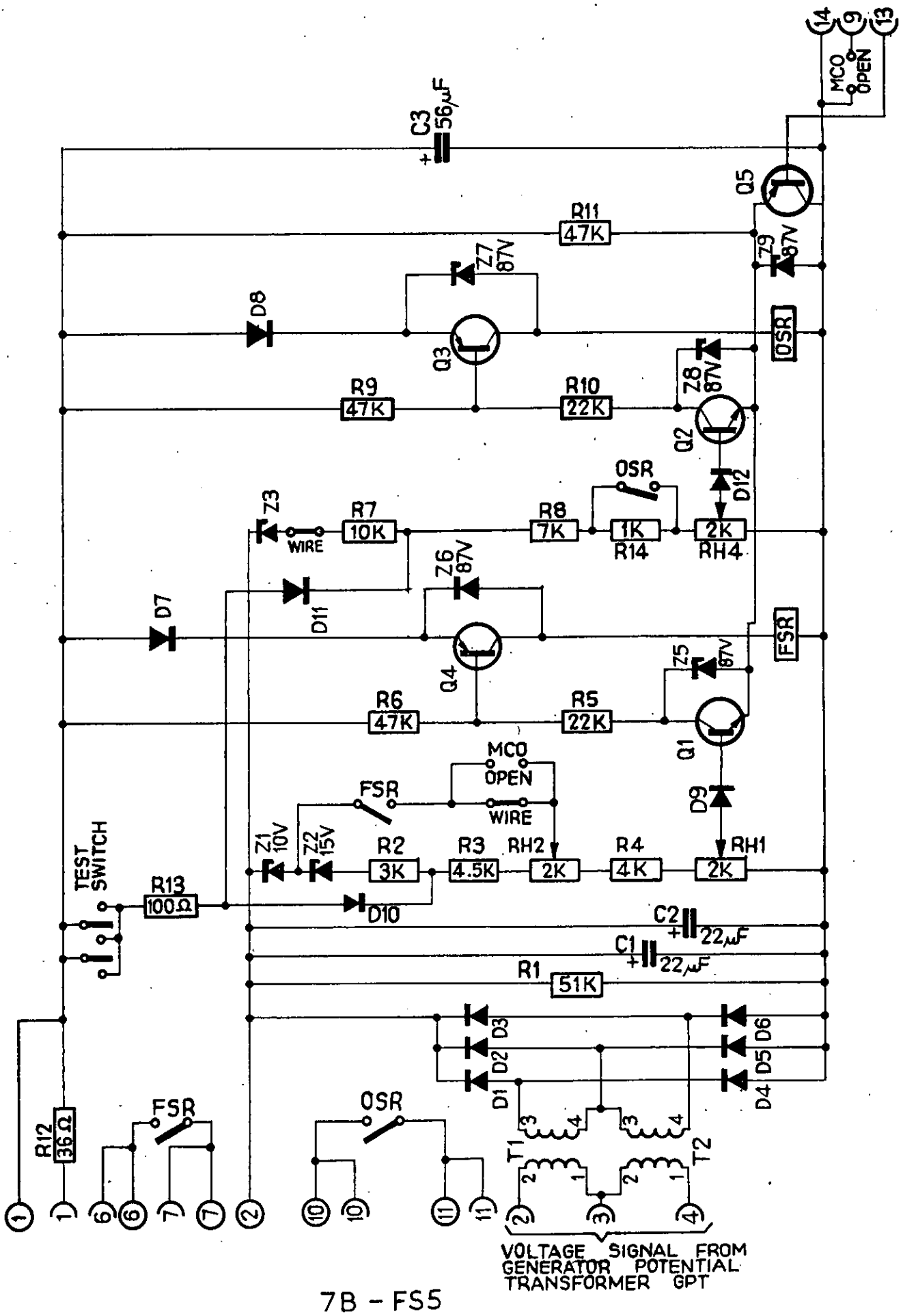
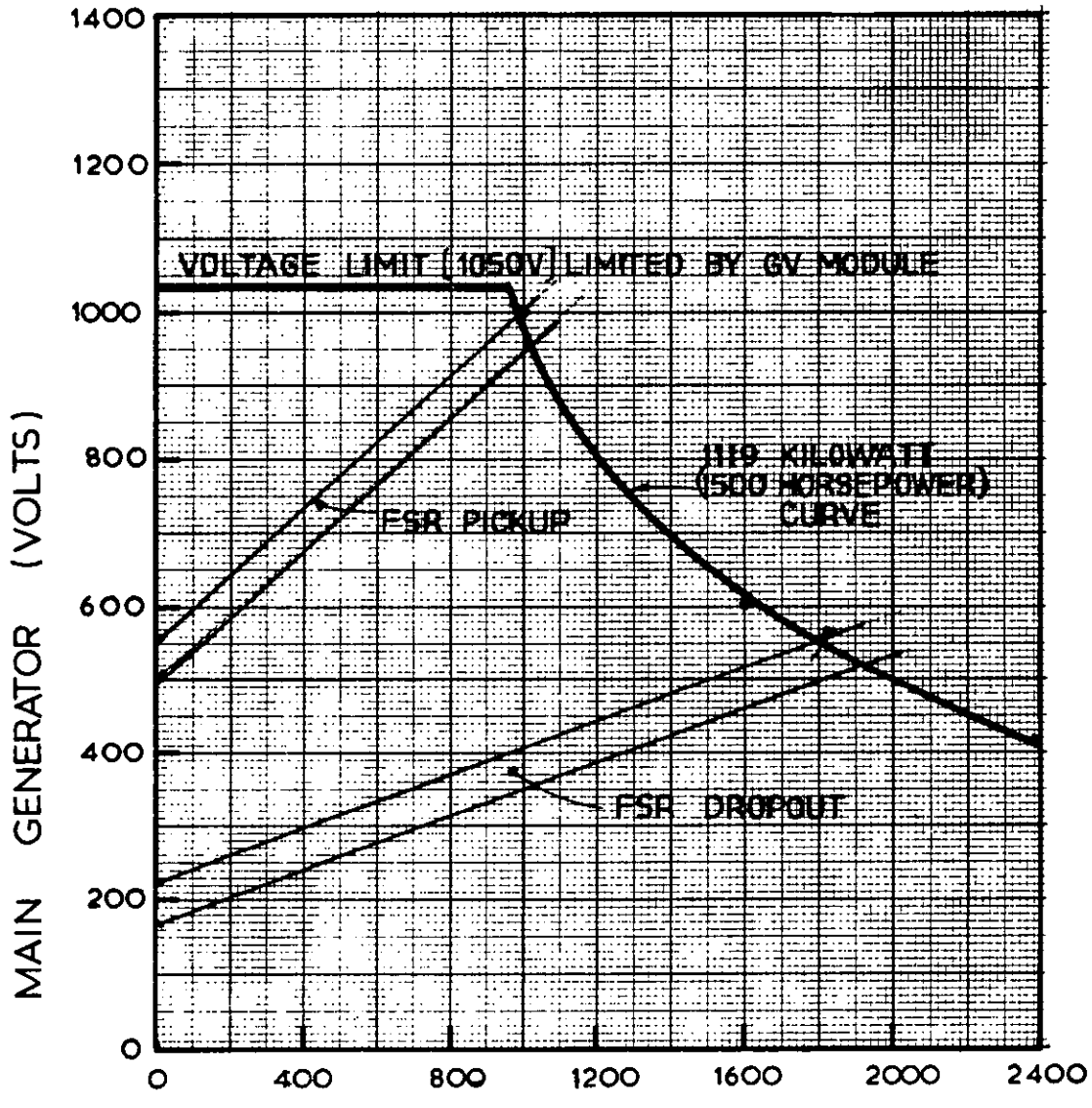


Fig. FS-1 – Field Shunting Module FS-19, Simplified Schematic Diagram

FS14 OPERATING CHARACTERISTICS



PICK UP 1000 & 975V

DROPOUT 1850 & 525V

Fig. FS-2 – Field Shunting Pickup and Dropout Chart

INTRODUCTION

The locomotive is equipped with six traction motors. These motors are connected across the main generator so that six parallel paths are provided for main generator output current. Each parallel path consists of one motor armature in series with its field.

One step of motor field shunting is provided for the traction motor fields. Motor field shunting is initiated by field shunting module FS19. A simplified schematic diagram of the FS19 module is provided in FS-1 for convenient reference. The applicable locomotive wiring diagrams should be used when performing troubleshooting or maintenance.

OPERATION DURING INCREASE IN TRACK SPEED

A signal proportional to main generator output voltage is obtained for generator potential transformer GPT2 and applied to receptacles 2, 3, and 4 of the FS module. This signal passes through isolation transformers T1 and T2, is rectified by diodes D1 through 6, filtered by C1, C2 and R1. The signal is then applied to a voltage divider consisting of zener diodes Z1 and Z2, resistors R2 and R3, rheostats RH1 and RH2. The signal from the wiper arm of RH2 is applied through diodes D7 to the base of Q1. Therefore, the signal applied to the base of Q1 is proportional to main generator output voltage.

A signal proportional to main generator output current is obtained from receptacle 11 of the feedback module FP and applied to receptacle 13 of the FS module. This signal which has absolute maximum value of about 50 volts is applied to the base of Q5. The emitter of Q5 is connected through R11 and R12 to 74V D. C. at receptacle 1. Therefore, Q5 is always forward biased and a signal proportional to main generator output current is applied to the emitter of Q1. Q5 prevents field shunting occurring in the event of a breakdown to the feedback signal.

A horsepower curve for throttle 8 position is shown in Fig. FS-2. At start up and during heavy drag operation, the locomotive will be operating toward the right end of the applicable horsepower curve. In this region, the current signal applied to the emitter of Q1 is larger than the signal applied to the base of Q1.

As track speed increases, the operating point moves to the left along the horsepower curve. Main generator output voltage and the signal applied to the base of Q1 increases while output current and the signal applied to the emitter of Q1 decreases. Transistor Q1 turns on when the operating point reaches the region designated as FSR pickup area in Fig. FS-2.

Turn on of Q1 provides forward bias for Q2. Turnon of Q2 provides a feed to FSR. Pickup of FSR recalibrates the voltage divider connected to the base of Q1. This recalibration increases forward bias for Q1. This increased forward bias prevents on-off cycling of Q1 by setting the turnoff point of Q1 to the FSR DROP-OUT area in Fig. FS-2. Pickup of FSR also connects receptacle 6 to receptacle 7 which provides a feed to the field shunt auxiliary relay FSRA.

The field shunt auxiliary relay FSRA.

(i) Causes FS1A and FS1B contactors to energise. This causes the traction motor fields to be shunted by a path containing a heavy duty resistor to achieve motor field shunting.

(ii) Energises the ORS relay momentarily. The FSRA relay picking up and the FS1A contactor picking up are subject to a short time overlap which allows the ORS to be energised. The ORS relay being energised causes the load regulator to move to minimum field. This prevents a sudden increase in effective voltage taking place after field shunting leading to traction motor flashover.

Decreasing the traction motor fields results in decreasing the counter electromotive force CEMF of the motors. This decrease in CEMF results in an increase of main generator output current which shifts the operating point along the power curve to the right from the FSR region in Fig. FS-2. The increase in main generator current results in a decrease in main generator voltage and extends the range of full horsepower operation within the limits of the motors and the generator.

There are FS1A and FS1B contacts in the TDS circuit, which prevent sanding upon the introduction of field shunting.

OPERATION DURING DECREASE IN TRACK SPEED

A decrease in track speed results in shifting the operating point to the right along the horsepower curve. Refer to Fig. FS-2. This action reduces the voltage signal applied to the base and increases the current signal applied to the emitter of Q1 in Fig. FS-1.

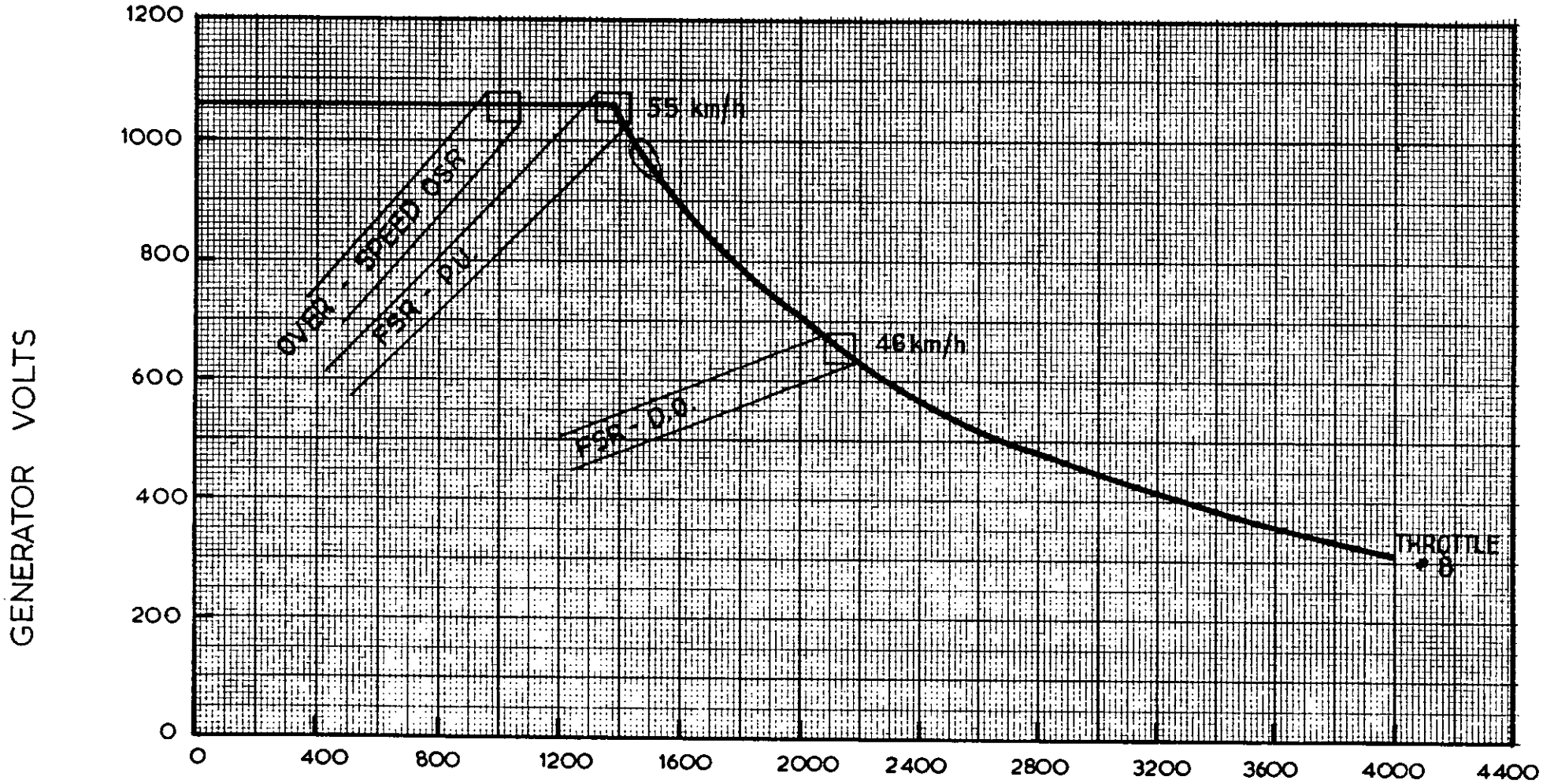
When the operating point moves into the FSR DROP-OUT region of Fig. FS-2, the current signal applied to the emitter is larger than the voltage signal applied to the base of Q1. This reverse bias turns off Q1 which removes forward bias from Q2 and results in drop out of FSR. Drop out of FSR opens the circuit between receptacles 6 and 7 which drops the feed to the FSRA relay connected to receptacle 6. Dropout of FSR also recalibrates the voltage divider connected to the base of Q1. This recalibration decreases the voltage signal applied to the base of Q1. This decreased signal prevents On-Off cycling of Q1 by setting the turn on point of Q1 to the area in Fig. FS-2 designated as FSR PICK-UP. Dropout of FSRA drops the feed to FS1A and FS1B.

OPERATION OF THE OVERSPEED RELAY (OSR)

On the introduction of Field Shunt and wheelslip detecting circuits are recalibrated to ensure that the wheelslip pickup is desensitised. This desensitisation is necessary to accept the wider tolerances of voltages and currents in the field weakened motor. Simultaneous wheelslip and motor overspeeding can be a problem at higher locomotive speeds. The Overspeed Relay, located in FS module, is sensitive to simultaneous wheelslip due to an input combination of high voltage and low current; this will energise the OSR. The OSR when energised causes the EQP relay to drop out which stops main generator excitation. The Wheelslip light (WL) indication is also energised.

ZTR PU 50 km/hr
do 42 km/hr

FS19 OPERATING CHARACTERISTICS



7B – FS4

The load regulator assembly LR consisting of a 1500 ohm tapered plate-type rheostat and a hydraulically operated vane motor, receives an input voltage from the rate control module RC and provides a reference voltage to the (feedback comparison) module FP. The wiper arm of the load regulator, which may be moved through an arc of 300 degrees, is attached to the vane motor. A pilot valve, located in the engine speed governor, controls the flow of engine oil under pressure to drive the vane motor clockwise or counterclockwise to position the wiper arm. Refer to Fig. LR-1.

The input voltage applied to the load regulator depends upon the throttle setting and the state of charge on the rate control capacitors on the rate control module. When operating in throttle 8 position, and with rate control capacitors fully charged, the input voltage applied to the load regulator is 50 volts. The input voltage applied to the load regulator decreases as the throttle position is decreased.

The output voltage available at the load regulator wiper arm depends upon the input voltage applied to the load regulator and the position of the wiper arm. At locomotive standstill and during initial startup,the load regulator is in maximum field position. Output voltage of the load regulator when in maximum field position is approximately equal to input voltage.

During normal operation, with the throttle in a fixed position, the output voltage from the load regulator is determined by the input voltage to the load regulator and main generator current. Assume that the locomotive is operating in throttle 8 position with a 40 volt reference signal from LR as shown in Fig. LR-2. If load is increased, such as when starting up a grade, the speed of the traction motors will decrease due to the increased load.

With decrease in traction motor speed, the load current increases due to a decrease in counter electromotive force. An increase in traction motor current results in a decrease in voltage. This decrease in voltage is partly due to the increased I^2R and IZ losses in the main generator.

If the reference signal from LR remains at 40 volts, the horsepower applied to the traction motors would follow the 40 volt reference line from point "A" toward point "B" in Fig. LR-2. However, to follow the 40 volt reference line the operating point would fall below the constant horsepower curve and less horsepower would be applied to the traction motors.

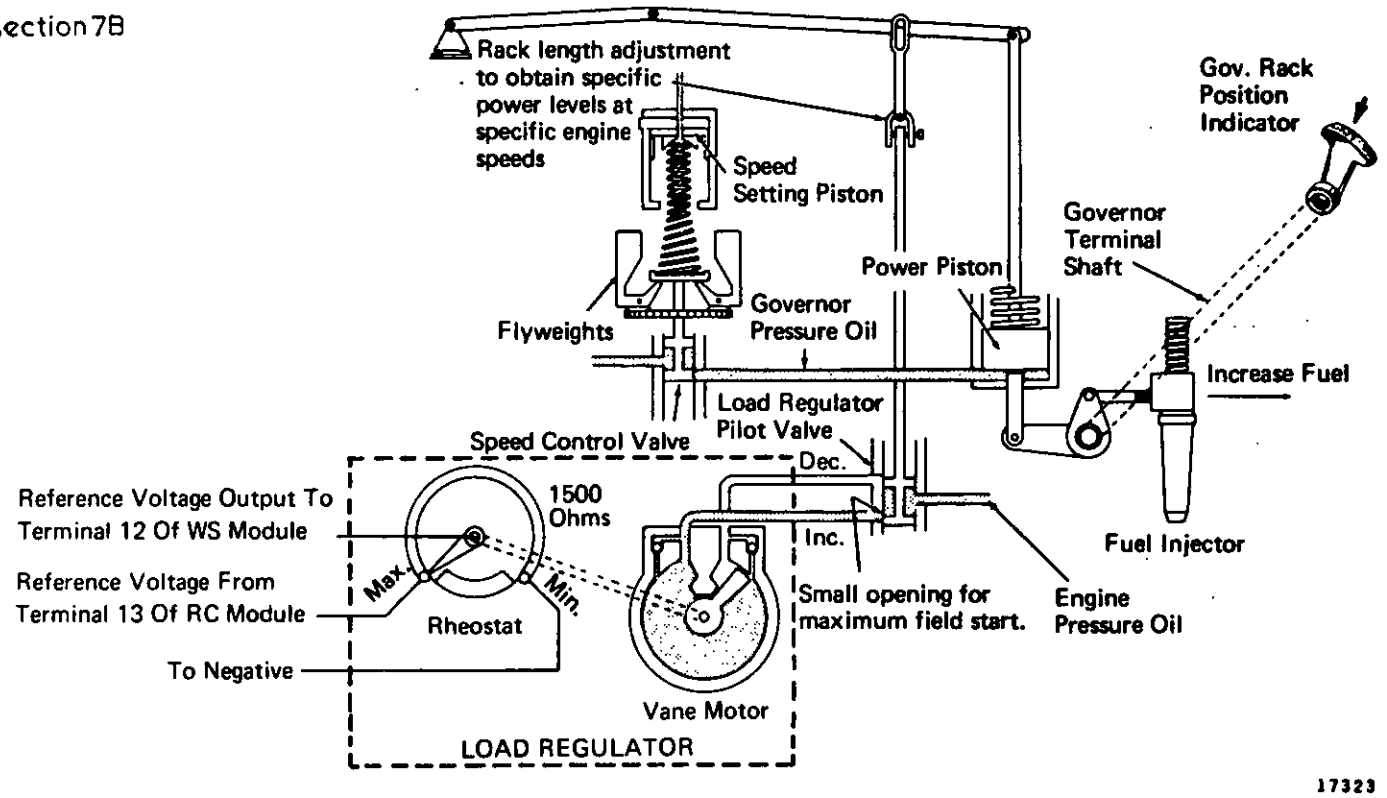


Fig. LR-1 – Load Regulator, Simplified Diagram

The decrease in horsepower tends to cause an increase in diesel engine speed. This increase in speed is sensed by the engine speed governor. The governor reacts to temporarily decrease the amount of fuel injected into the engine and thereby maintains a constant engine speed. At the same time that the fuel is decreased a pilot valve in the engine speed governor directs hydraulic pressure to the load regulator vane motor which causes the load regulator to move toward maximum field position. This action can be followed by referring to Fig. LR-1. The increase in speed causes the governor fly weights to pivot outward which results in raising the speed control valve plunger. This allows some of the oil under the power piston to escape below the lower land on the speed control valve plunger causing the power piston to move downward. The escaped oil returns to the oil sump in the governor. Downward movement of the power piston causes a downward movement of the load regulator pilot valve plunger and also moves the governor rack to decrease the fuel to the engine. Downward movement of the load regulator pilot valve plunger directs engine oil, under pressure, to the increase port of the load regulator vane motor. This causes the vane motor to drive the wiper arm of the load regulator rheostat toward maximum field position.

Movement of the load regulator toward maximum field position results in an increase in the reference signal from LR. Increasing the reference signal results in an increase of excitation to the main generator field and an increase in main generator horsepower output. This increased horsepower tends to decrease diesel engine speed however; the governor again reacts to maintain a constant engine speed. The pilot valve in the governor also causes a slight adjustment in load regulator position so that the main generator output moves along the constant horsepower curve from point "A" to point "C" instead of from point "A" to point "B" in Fig. LR-2.

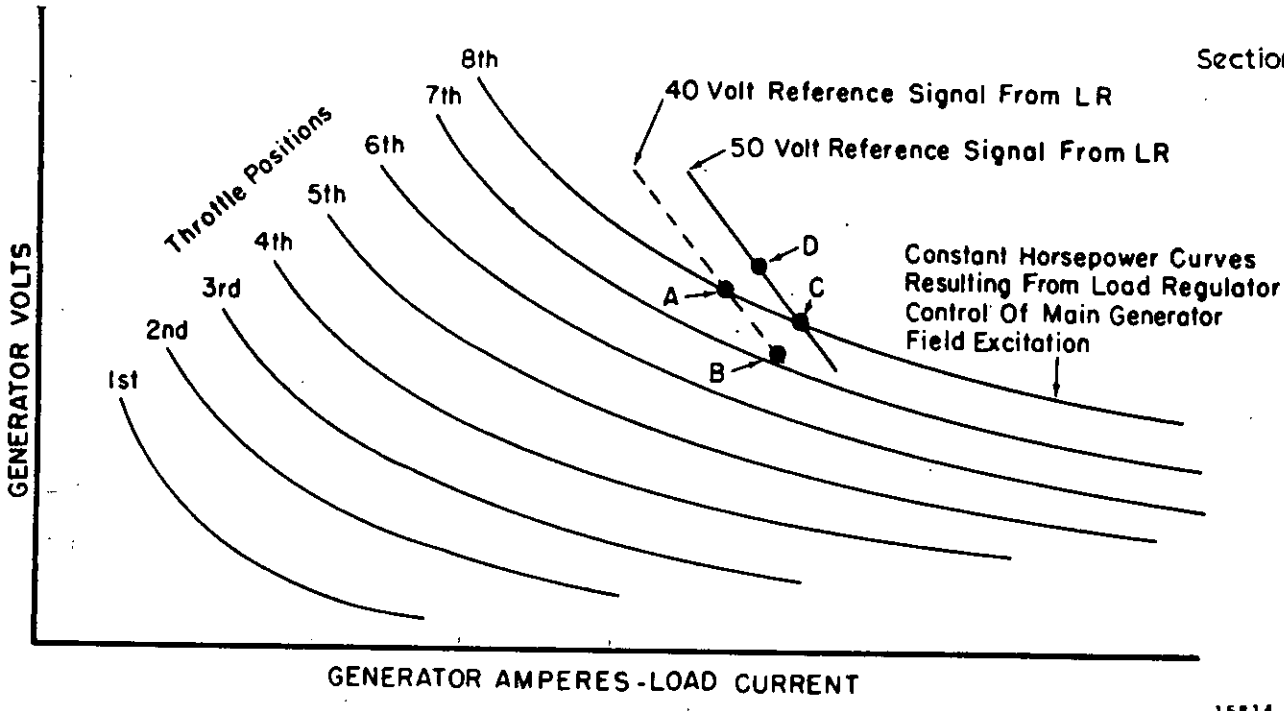


Fig. LR-2 – Constant Kilowatt (Horsepower) Curves - Nominal

Refer to Fig. LR-1. The decrease in engine speed causes the governor fly weights to move inward which results in lowering the speed control valve plunger. This allows the governor oil, under pressure, to be forced under the power piston causing the power piston to move upward. Upward movement of the power piston causes an upward movement of the load regulator pilot valve plunger and also moves the governor rack to increase the fuel to the engine. Upward movement of the load regulator pilot valve plunger allows the oil from the increase port to drain into the engine oil sump and also opens the decrease port to engine oil pressure. Oil pressure at the decrease port causes the vane motor to drive the load regulator wiper arm toward minimum field position. Therefore, the engine speed governor maintains a constant engine speed and the load regulator maintains a constant horsepower output within the normal operating range of the locomotive. The response of the engine speed governor and the load regulator is fast enough to prevent any noticeable difference in diesel engine speed or main generator output.

Assume that the locomotive is operating in throttle position 8 with a 50 volt reference signal from LR as shown at point "C" of Fig. LR-2. If load is decreased, such as when starting down a grade, the speed of the traction motors will increase due to the decreased load.

With an increase in traction motor speed, the load current decreases due to an increase in counter electromotive force. A decrease in traction motor current results in an increase in voltage. If the reference signal from LR remained at 50 volts with a decrease in current, the horsepower applied to the traction motors would follow the 50 volt reference line from point "C" toward point "D" in Fig. LR-2. However, to follow the 50 volt reference line, the operating point would rise above the constant horsepower curve and more horsepower would be applied to the traction motors.

The increase in horsepower tends to decrease diesel engine speed. This increase in speed is sensed by the engine speed governor. The governor reacts to temporarily increase the amount of fuel injected into the engine and thereby maintains a constant engine speed. At the time that the fuel is increased, a pilot valve in the engine speed governor directs hydraulic pressure to the load regulator vane motor which causes the load regulator to move toward minimum field position. Refer to Fig. LR-1. The decrease in speed causes the governor fly weights to move inward which results in lowering the speed control valve plunger. This allows the governor oil, under pressure, to be forced under the power piston causing the power piston to move upward. Upward movement of the power piston causes an upward movement of the load regulator pilot valve plunger and also moves the governor rack to increase the fuel to the engine. Upward movement of the load regulator pilot valve plunger allows the oil from the increase port to drain into the engine oil sump and also opens the decrease port to engine oil pressure. Oil pressure at the decrease port causes the vane motor to drive the load regulator wiper arm toward minimum field position.

Movement of the load regulator toward minimum field position results in a decrease in the reference signal from LR. Decreasing the reference signal results in a decrease of excitation to the main generator field and a decrease in main generator output. This decreased horsepower tends to increase diesel engine speed however; the governor again reacts to maintain a constant engine speed. The pilot valve in the engine speed governor also causes a slight adjustment in load regulator position so that the main generator output moves along the constant horsepower curve from point "C" to point "A" instead of moving from point "C" to point "D" in Fig. LR-2.

The load regulator operation described above tends to cause the locomotive to operate along the horsepower curves shown in Fig. LR-2. Notice that a different horsepower curve is provided for each throttle position. The horsepower curves shown in Fig. LR-2 are general horsepower curves and do not indicate specific values of main generator current or voltage. When the locomotive is operating in the lower speed range, the operation will not follow the horsepower curves shown in Fig. LR-2, but will be modified by the action of the performance control module FP. A description of the performance control module FP is provided later in this section.

FEEDBACK MODULE FP15

(Applicable to GL22C-2 Locomotives)

The purpose of the feedback module FP15 is to control main generator output power to a level proportional to throttle position. This is accomplished by comparing the load regulator reference signal with main generator feedback signals and using this comparison to control sensor module SE magamp current. The SE module magamp current is used to control main generator excitation which, in turn, determines output power.

The FP module contains three rectifier assemblies connected to loading resistors. Two of the rectifier assemblies are connected to generator potential transformers GPT1 and GPT2, so that the signals developed across their loading resistors are proportional to main generator output voltage. The other rectifier assembly is connected to current transformers CTA, CTB and CTC so that the signal developed across its loading resistors is proportional to main generator output current.

Two feedback signals are developed and used in the FP module, Fig. FP-1. Each of these feedback signals is developed by combining two voltage levels, one level proportional to main generator current, the other level proportional to main generator voltage. Although both feedback signals are therefore related to main generator power output, a change in power level will not necessarily be reflected by equal level changes in both feedback signals. This results from the method by which the feedback signals are developed. The power control feedback signal is largely dependent on the generator current level, while the performance control feedback is more dependent on voltage level. Fig. FP-1 illustrates the method used to develop these feedback signal levels. The power control feedback signal is made up of a portion of the GPT2 output plus the entire output level of the current transformers; the performance control feedback signal is made up of a portion of the GPT1 output plus only a portion of the output level of the current transformers.

Transistor Q1 is used to compare the reference signal from the load regulator LR with the feedback signals. If the LR reference signal is at a higher voltage level than either feedback signal, excitation is applied to the main generator field.

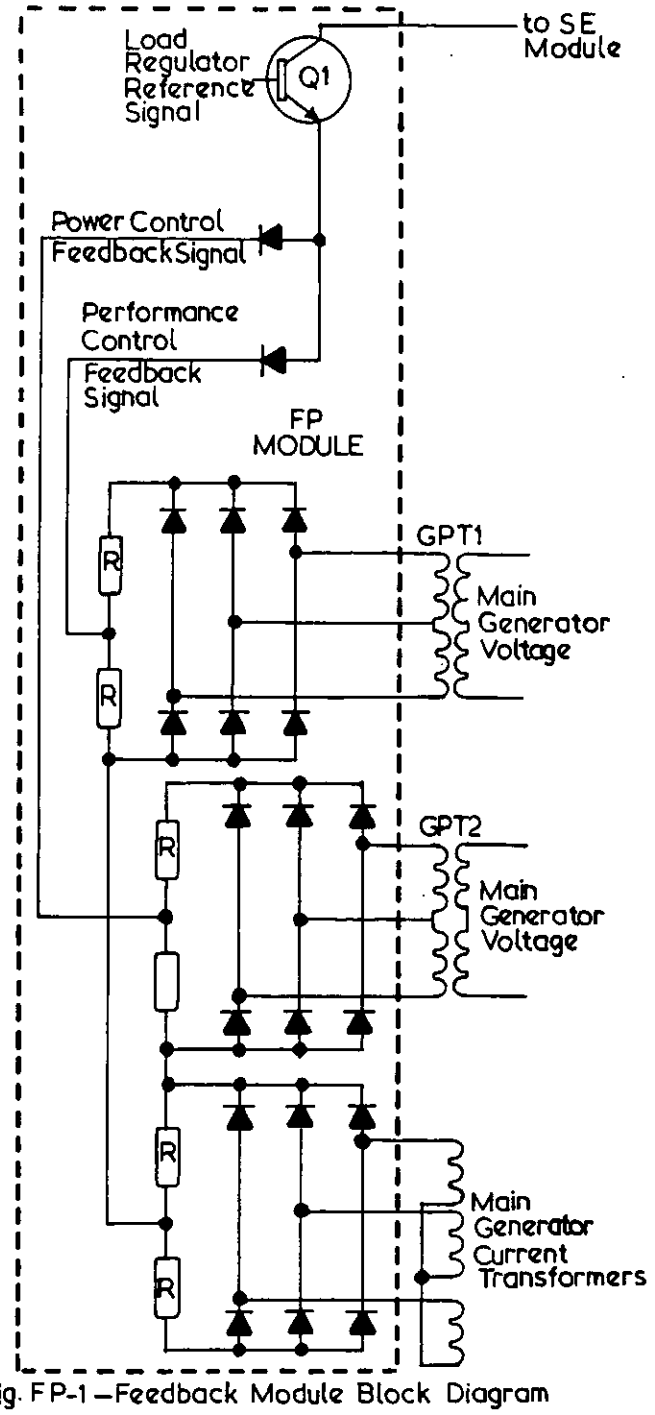


Fig. FP-1 –Feedback Module Block Diagram

The amount of excitation applied is proportional to the difference between the LR signal and the feedback signal. If the LR reference signal is at a lower voltage level than both feedback signals, main generator field excitation is removed.

A simplified schematic diagram of the FP15 module, Fig. FP-2 is provided for convenient reference only. The applicable locomotive wiring diagrams should be used when performing troubleshooting or maintenance.

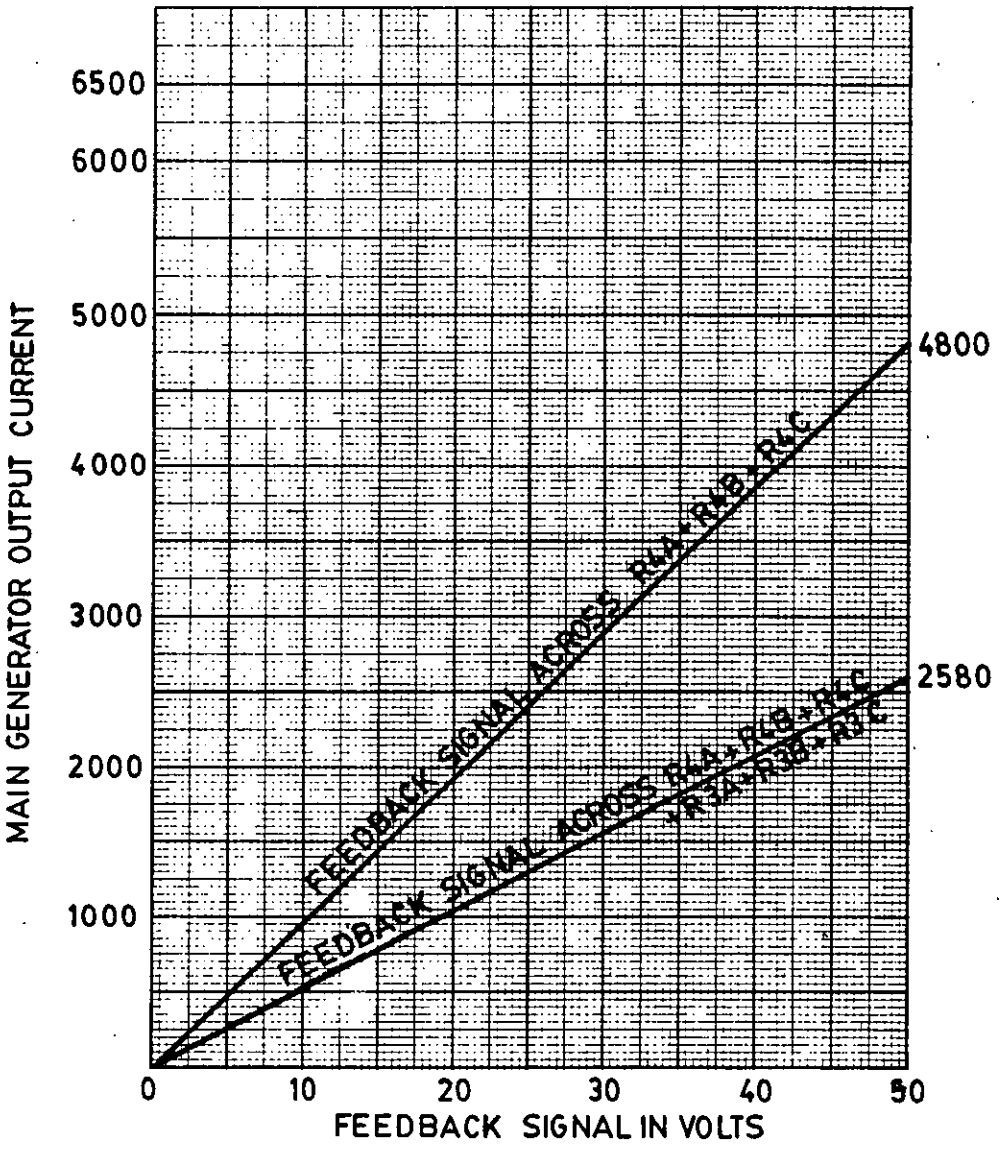


Fig. FP-3 -RELATIONSHIP BETWEEN FEEDBACK SIGNALS & MAIN GENERATOR CURRENT

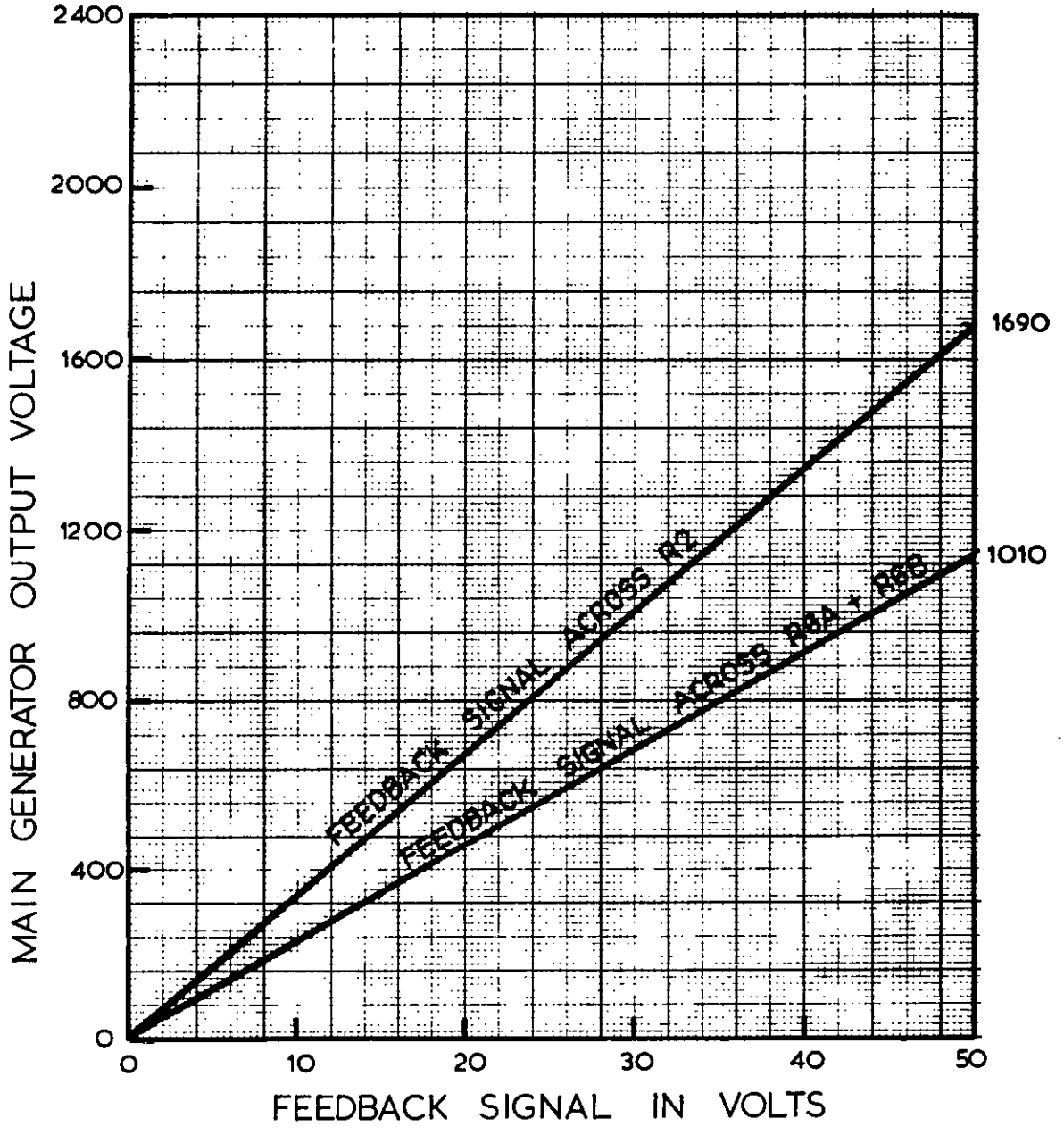


Fig. FP4 - Relationship Between Feedback Signals And Main Generator Voltage

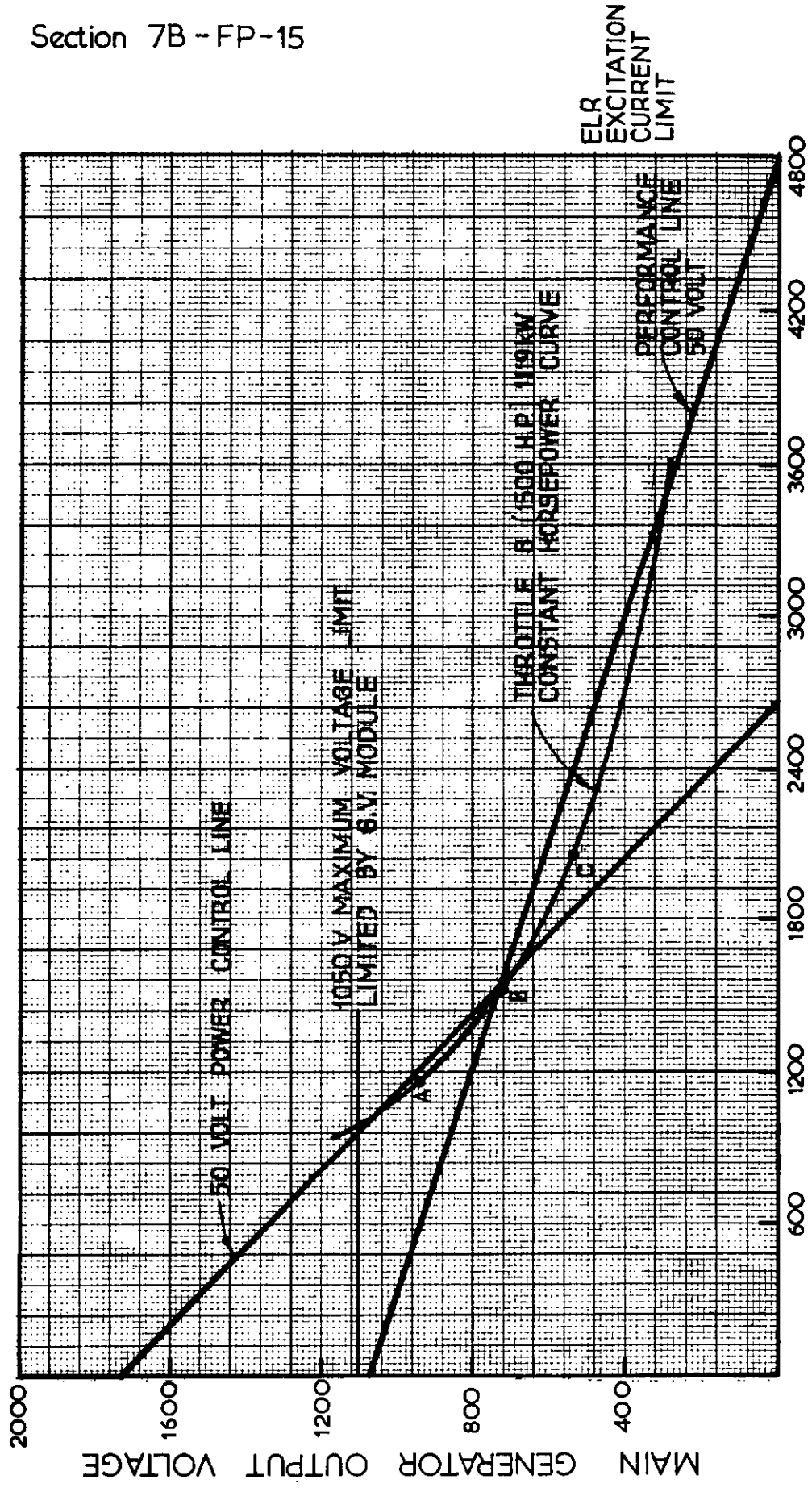


Fig. FP- Relationship of Power Control Feedback Signal Performance Control Feedback Signal and Main Generator Output

POWER CONTROL FEEDBACK SIGNAL

The power control feedback signal is obtained by combining the main generator voltage feedback signal developed across R2 with the main generator current feedback signal developed across R3A, R3B, R3C, R4A, R4B, and R4C. The relationship between main generator output and the 50 volt power control feedback signal is shown in Fig. FP-5.

Any combination of main generator current and voltage that intersects at a point above or to the right of the 50 volt power control feedback signal line will provide a feedback signal greater than 50 volts. Any combination of current and voltage that intersects at a point below or to the left of the 50 volt power control feedback signal line will provide a feedback signal less than 50 volts.

PERFORMANCE CONTROL FEEDBACK SIGNAL

The performance control feedback signal is obtained by combining the main generator voltage feedback signal developed across R6A and R6B with the main generator current feedback signal developed across R4A, R4B, and R4C. The relationship between main generator output and the performance control feedback signal is shown in Fig. FP-5.

Any combination of main generator current and voltage that intersects at a point above or to the right of the 50 volt performance control feedback signal line will provide a performance control feedback signal greater than 50 volts. Any combination of voltage and current that intersects at a point below or to the left of the 50 volt performance control feedback signal line will provide a performance control feedback signal less than 50 volts.

POWER AND PERFORMANCE CONTROL OPERATION

When operating the throttle 8 position, the engine speed governor and load regulator tend to cause the locomotive to operate along the constant power curve in Fig. FP-5 from point A to point C as locomotive speed decreases. Between points A and C, either the power control or the performance control feedback signal is less than 50 volts, which enables the FP module to maintain main generator field excitation at the level required for an output of (1119 kW power). As speed decreases below point B, the performance control signal is smaller than the power control signal and is therefore the controlling signal. As speed increases above point B, the power control signal is smaller than the performance control signal and is therefore the controlling signal.

FEEDBACK MODULE FP16

The purpose of the feedback module FP16 is to control main generator output power to a level proportional to throttle position. This is accomplished by comparing the load regulator reference signal with main generator feedback signals and using this comparison to control sensor module SE magamp current. The SE module magamp current is used to control main generator excitation which, in turn, determines output power.

The FP module contains three rectifier assemblies connected to loading resistors. Two of the rectifier assemblies are connected to generator potential transformers GPT1 and GPT2, so that the signals developed across their loading resistors are proportional to main generator output voltage. The other rectifier assembly is connected to current transformers CTA, CTB and CTC so that the signal developed across its loading resistors is proportional to main generator output current.

Two feedback signals are developed and used in the FP module. Each of these feedback signals is developed by combining two voltage levels, one proportional to main generator current, the other level proportional to main generator voltage. Although both feedback signals are therefore related to main generator power output, a change in power level will not necessarily be reflected by equal level changes in both feedback signals. This results from the method by which the feedback signals are developed. The power control feedback signal is largely dependent on the generator current level, while the performance control feedback is more dependent on voltage level. The power control feedback signal is made up of a portion of the GPT2 output plus the entire output level of the current transformers; the performance control feedback signal is made up of a portion of the GPT1 output plus only a portion of the output level of the current transformers.

Transistor Q1 is used to compare the reference signal from the load regulator LR with the feedback signals. If the LR reference signal is at a higher voltage level than either feedback signal, excitation is applied to the main generator field. The amount of excitation applied is proportional to the difference between the LR signal and the feedback signal. If the LR reference signal is at a lower voltage level than both feedback signals, main generator field excitation is removed.

A simplified schematic diagram of the FP16 module, Fig. FP-1 is provided for convenient reference only. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance.

MAIN GENERATOR VOLTAGE FEEDBACK SIGNALS

The rectifier assembly consisting of diodes D1 through D6 is connected to generator potential transformer GPT2. The rectified output of this assembly is applied to resistors R1A, R1B, R1C, and R2 connected in series. The resistance values are selected so that an output voltage of approximately 1930 volts from the main generator would result in a feedback signal of 50 volts across R2. The main generator voltage is limited to much less than 1930 volts. However 1930 volts is used in calculating the desired slope of the 50 volt feedback signal line and to establish the desired relationship between the feedback signal and main generator output voltage within the operating range of the main generator. This relationship is shown in Fig. FP-3.

The rectifier assembly consisting of diodes D13 through D18 is connected to generator potential transformer GPT1. The rectifier assembly output is applied to resistors R5A, R5B, R6A, and R6B connected in series. The resistance values are selected so that an output of approximately 940 volts from the main generator would result in a feedback signal of 50 volts across R6A and R6B. The relationship between main generator output voltage and the feedback signal developed across R6A and R6A is shown in Fig. FP-3.

Resistors R11, R6A and R6B are shorted during braking operation by BR1 contacts.

MAIN GENERATOR CURRENT FEEDBACK SIGNAL

The rectifier assembly consisting of diodes D7 through D12 is connected to current transformers CTA, CTB and CTC. The rectifier assembly output is applied to resistors R3A, R3B, R3C, R4A, R4B, R4C and R8 connected in series. Resistor R8 is shorted out by BR1 contacts during power operation.

The resistor values are selected so that;

1. An output current of approximately 7580 amperes from the main generator would result in a 50 volt feedback signal across R4A, R4B and R4C.

2. An output current of approximately 3500 amperes from the main generator would result in a 50 volt feedback signal across R3A, R3B, R3C, R4A, R4B and R4C.

The normal output current is limited to less than 7580 amperes. However the 7580 and 3500 ampere values are used in calculating the desired slope of the 50 volt feedback signal line and to establish the desired relationship between the feedback signal and main generator output current within the operating range of the main generator. The relationship of main generator output current and the feedback signals are shown in Fig. FP-4.

POWER CONTROL FEEDBACK SIGNAL

The power control feedback signal is obtained by combining the main generator voltage feedback signal developed across R2 with the main generator current feedback signal developed across R3A, R3B, R3C, R4A, R4B and R4C. The relationship between main generator output and the 50 volt power control feedback signal is shown in Fig. FP-2.

Any combination of main generator current and voltage that intersects at a point above or to the right of the 50 volt power control feedback signal line will provide a feedback signal greater than 50 volts. Any combination of current and voltage that intersects at a point below or to the left of the 50 volt power control feedback signal line will provide a feedback signal less than 50 volts.

PERFORMANCE CONTROL FEEDBACK SIGNAL

The performance control feedback signal is obtained by combining the main generator voltage feedback signal developed across R6A and R6B with the main generator current feedback signal developed across R4A, R4B and R4C. The relationship between main generator output and the performance control feedback signal is shown in Fig. FP-2.

Any combination of main generator current and voltage that intersects at a point above or to the right of the 50 volt performance control feedback signal line will provide a performance control feedback signal greater than 50 volts. Any combination of voltage and current that intersects at a point below or to the left of the 50 volt performance control feedback signal line will provide a performance control feedback signal less than 50 volts.

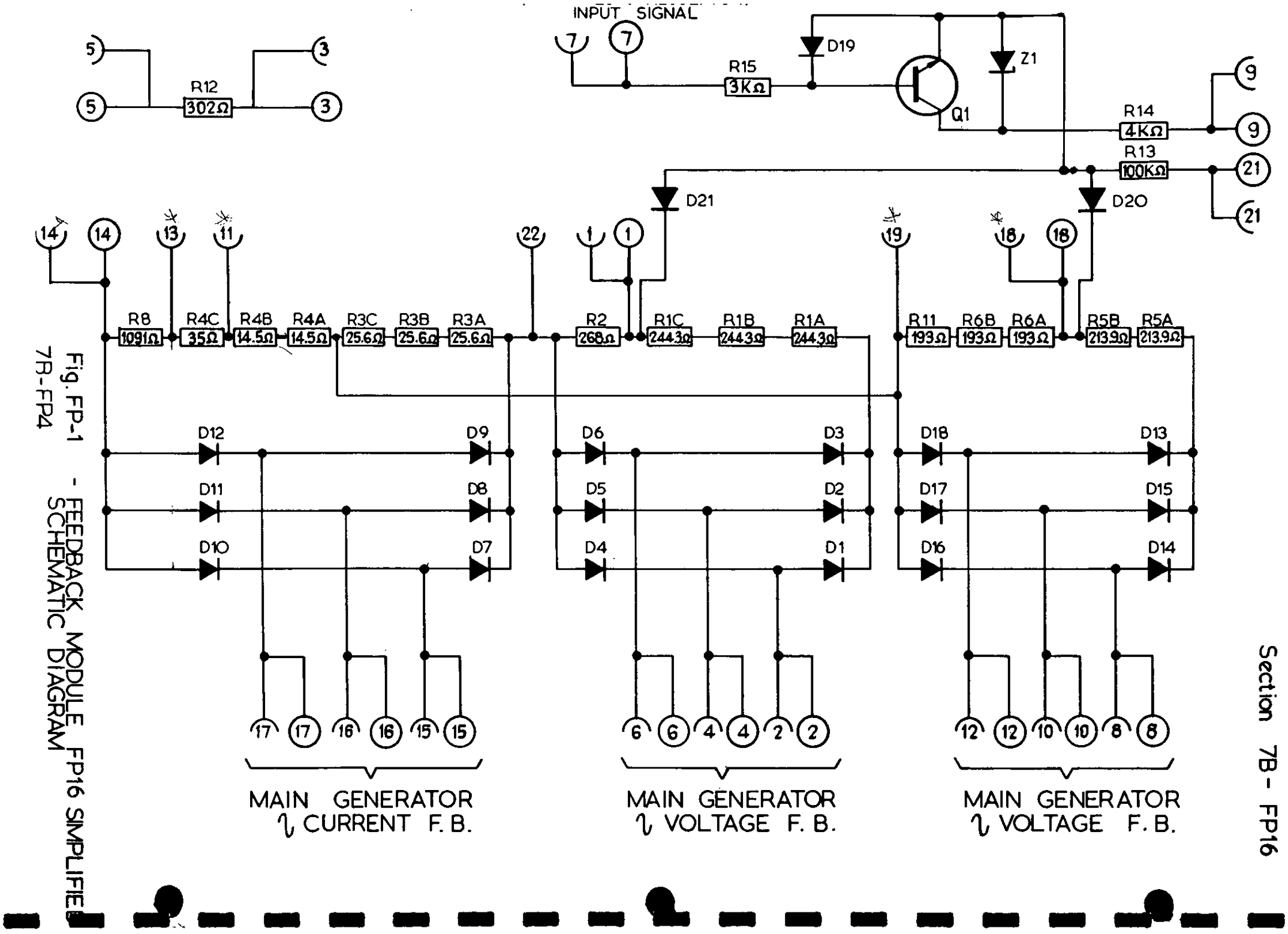


Fig. FP-1 - FEEDBACK MODULE FP16 SIMPLIFIED SCHEMATIC DIAGRAM
7B-FP4

MAIN GENERATOR VOLTAGE FEEDBACK SIGNALS

The rectifier assembly consisting of diodes D1 through D6 is connected to generator potential transformer GPT2. The rectified output of this assembly is applied to resistors R1A, R1B, R1C and R2 connected in series. The resistance values are selected so that an output voltage of approximately 1690 volts from the main generator would result in a feedback signal of 50 volts across R2. The main generator voltage is limited to much less than 1690 volts; however the 1690 volts is used in calculating the desired slope of the 50 volt feedback signal line and to establish the desired relationship between the feedback signal and main generator output voltage within the operating range of the main generator. This relationship is shown in Fig. FP-3.

The rectifier assembly consisting of diodes D13 through D18 is connected to generator potential transformer GPT1. The rectifier assembly output is applied to resistors R5A, R5B, R6A and R6B connected in series. The resistance values are selected so that an output of approximately 1010 volts from the main generator would result in a feedback signal of 50 volts across R6A and R6B. The relationship between main generator output voltage and the feedback signal developed across R6A and R6B is shown in Fig. FP-4. Resistors R6A and R6B are shorted during braking operation by BR1 contacts.

MAIN GENERATOR CURRENT FEEDBACK SIGNALS

The rectifier assembly consisting of diodes D7 through D12 is connected to current transformers CTA, CTB and CTC. The rectifier assembly output is applied to resistors R3A, R3B, R3C, R4A, R4B, R4C and R8 connected in series. Resistor R8 is shorted out by BR1 contacts during power operation.

The resistor values are selected so that:-

1. An output current of approximately 4800 amperes from the main generator would result in a 50 volt feedback signal across R4A, R4B and R4C.

2. An output current of approximately 2580 amperes from the main generator would result in a 50 volt feedback signal across R3A, R3B, R3C, R4B, and R4C.

The normal output current is limited to less than 4800 amperes; however, the 4800 and 2580 values are used in calculating the desired slope of the 50 volt feedback signal line and to establish the desired relationship between the feedback signal and main generator output current within the operating range of the main generator.

The relationship of main generator output current and the feedback signals are shown in Fig. FP-3.

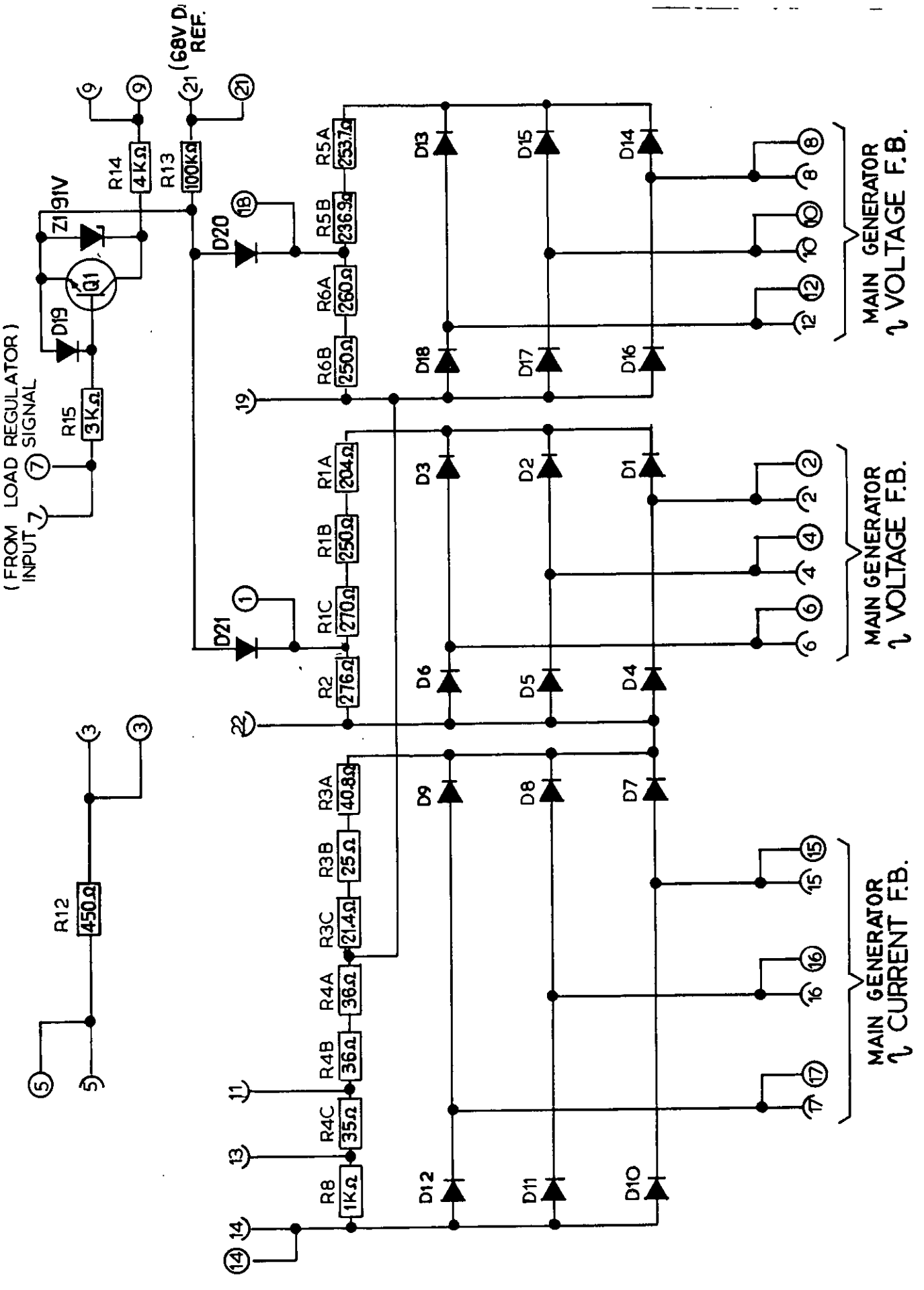


Fig. FP-2 FEEDBACK MODULE FP15 SIMPLIFIED SCHEMATIC DIAGRAM

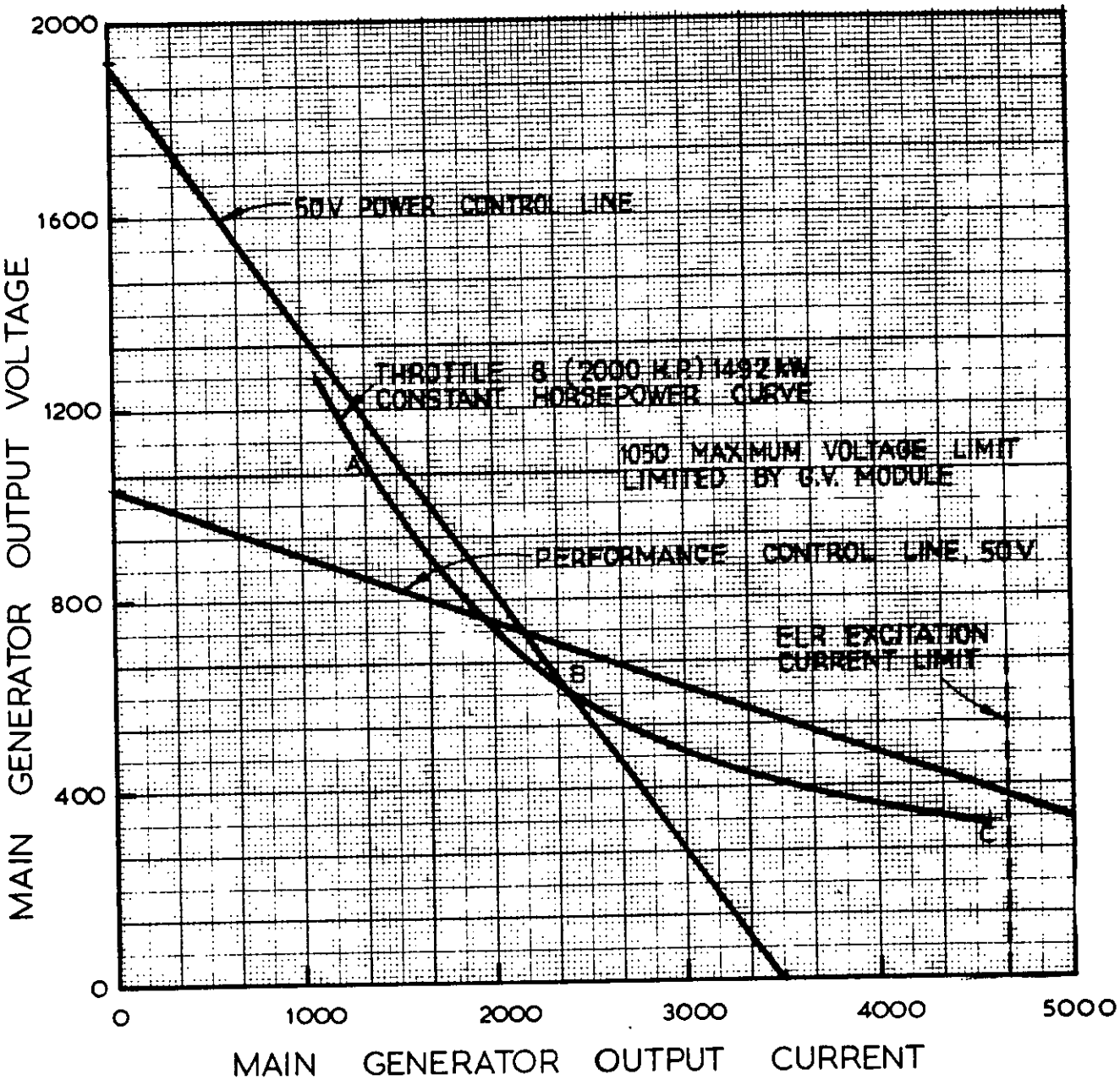


Fig. FP-2 — Relationship of Power Control Feedback Signal, Performance Control Feedback Signal And Main Generator Output

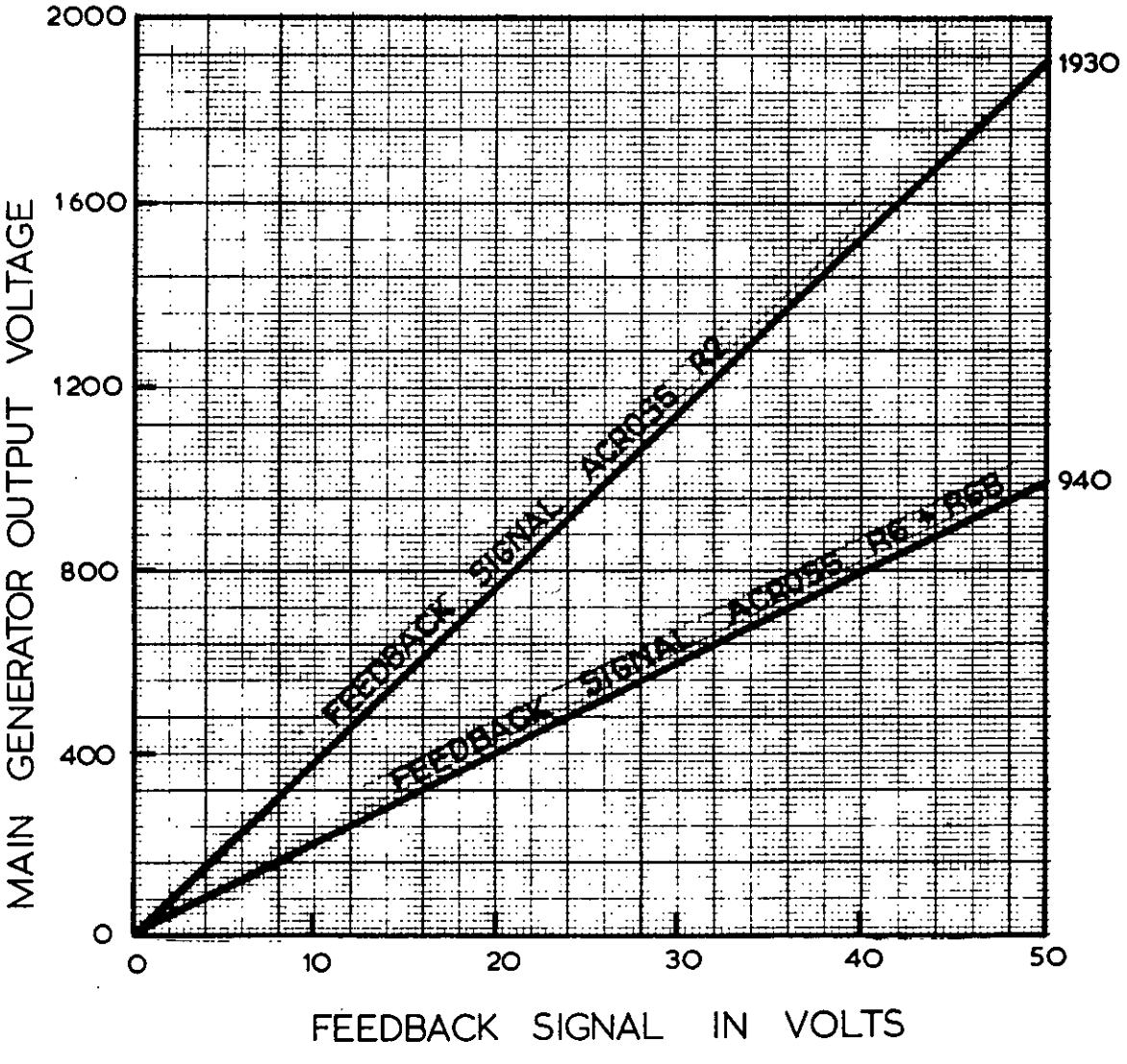


Fig. FP-3 - Relationship Between Feedback Signals And Main Generator Voltage

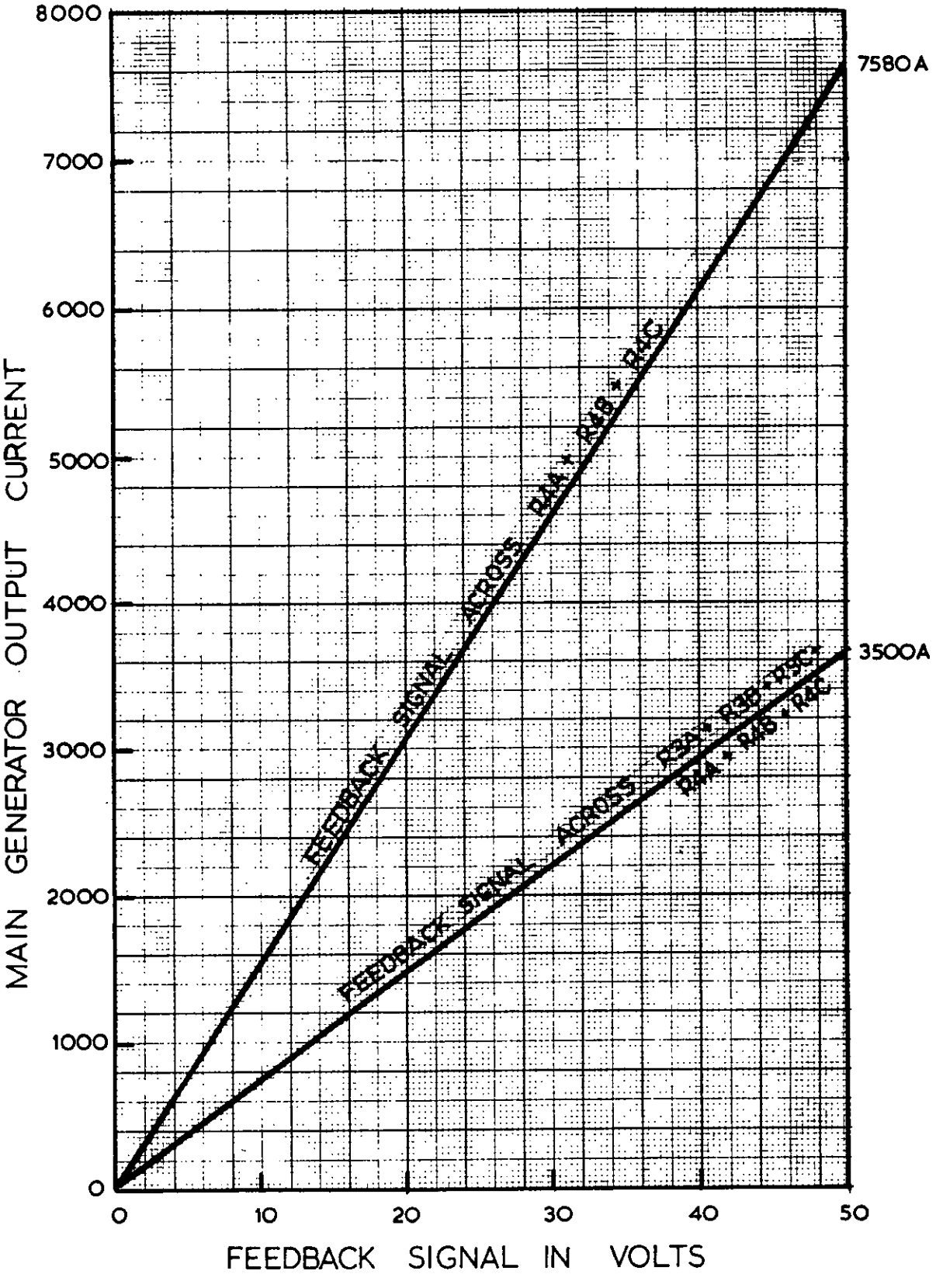


Fig. FP-4 - Relationship Between Feedback Signals And Main Generator Current

POWER AND PERFORMANCE CONTROL OPERATION

The power control and performance control feedback signals are applied to transistor Q1 where they are compared with the reference signal from the load regulator LR. Forward bias is applied to Q1 when the instantaneous value of the reference signal is larger than the instantaneous value of either the power control feedback signal or the performance control feedback signal.

When operating in throttle 8 position, the engine speed governor and load regulator tend to cause the locomotive to operate along the constant horsepower curve in Fig. FP- 2 from point A to point C as locomotive speed decreases. Between points A and C, either the power control or the performance control feedback signal is less than 50 volts, which enables the FP module to maintain main generator field excitation at a level required for a 1492 kW output. As speed decreases below point B, the performance control signal remains less than the power control signal and is therefore the controlling signal. As speed increases above point B, the level of the power control signal remains less than the performance control signal and it is then the controlling signal.

Main generator voltage is limited to approximately 1050 volts by the generator voltage regulator module GV. This prevents the operating point from moving above point A and thus any further increase in speed at point A causes the operating point to move back along the 1050 volt line.

When operating in a throttle position lower than throttle 8, the feedback signals, the LR reference signal, and the constant power curve will all have lower values. However, the general operating description is the same for all throttle positions.

SECONDARY FP16 MODULE FUNCTIONS

The FP16 module also provides a feedback signal to the FS module. The signal utilised is developed across resistor R4C by the current transformers and is therefore proportional to main generator output current.

Also located on the FP16 module is resistor R12 which provides another performance control function. This resistor is connected across a pair of contacts of the motor cut-out selector switch. The switch contacts are connected in series with the voltage reference line from the throttle response module to the rate control module. These switch contacts are closed when the switch is in the NORMAL position and open when the switch is in either of the remaining positions. Rotating the selector to cut out traction motors opens these contacts and places R12 in the circuit. This added resistance reduces the voltage level to the rate control module which, in turn, reduces the reference voltage output to the load regulator. A reduced load regulator input reference voltage reduces the maximum LR reference signal available to the FP module. The effect of this action is to reduce main generator power output.

Main Generator voltage is limited to approximately 1050 volts by the generator voltage regulator module GV. This prevents the operating point from moving above point A and thus any further increase the speed at point A causes the operating point to move back along the 1050 volt line.

When operating in a throttle position lower than throttle 8, the feedback signals, the LR reference signal, and the constant power curve will have lower values. However, the general operating description is the same for all throttle positions.

The power control and performance control feedback signals are applied to transistor Q1 where they are compared with the reference signal from the load regulator LR. Forward bias is applied to Q1 when the instantaneous value of the reference signal is larger than the instantaneous value of either the power control feedback signal or the performance control feedback signal.

SECONDARY FUNCTIONS OF FP15 MODULE

The FP15 module provides a signal to the FS module. The signal utilized is developed across resistor R4C by the current transformers and is therefore proportional to main generator output current.

Resistor R12, located on the FP12 module, provides another performance control function. This resistor is connected across a pair of contacts of the motor cut-out relay COR. The relay contacts are connected in series with the voltage reference line from the throttle response module to the rate control module. These relay contacts are closed when the motor cut-out selector is in the normal position and open when the motor cut-out selector is in either of the remaining positions to cut out a pair of traction motors. Rotating the motor cut-out selector to cut out a pair of traction motors provides a feed to COR. Pickup of COR opens the contacts in parallel with R12 which places R12 in the circuit. This added resistance reduces the voltage level to the rate control module which, in turn, reduces the reference voltage output to the load regulator. A reduced load regulator input reference voltage reduces the maximum reference signal from the load regulator brush arm. The effect of this action is to reduce main generator power output.

SILICON CONTROLLED RECTIFIER ASSEMBLY, SCR

Excitation to the main generator field is provided by the D14 alternator through the three phase silicon controlled rectifier assembly SCR. A simplified schematic diagram of the SCR assembly, Fig. SCR-1, is provided for convenient reference only. The locomotive wiring diagram should be used when performing troubleshooting or maintenance.

One silicon controlled rectifier is connected in series with each of three phases of the D14 alternator. Therefore, one of the silicon controlled rectifiers is forward biased during each positive alternation of output voltage from the D14 alternator. However, the silicon controlled rectifier will not conduct until the forward bias is accompanied by a gating signal to the cathode gate. The gating signal is a voltage, applied to the cathode gate, which is positive in respect to the voltage applied to the cathode. Therefore, the potential on both the anode and cathode gate must be positive in respect to the cathode in order to turn on the silicon controlled rectifier. After conduction starts, the gating signal loses control and conduction continues as long as the anode is positive in respect to the cathode. The silicon controlled rectifier turns off due to reverse bias between anode and cathode at the completion of the positive alternation. After turn off, conduction will not start until forward bias is accompanied by the gating signal.

Gating pulses are applied to the silicon controlled rectifiers from the SE module as necessary to maintain the required excitation current to the main generator field. The amount of excitation required is determined by comparing the reference signal from the load regulator with feedback signals from the FP module. This comparison is made in the FP module. If the reference signal is instantaneously larger than the feedback signal, the transistor in the FP module is forward biased causing the transistor to turn on and results in current flow through the SE module magnetic amplifier control windings. If the feedback signal is instantaneously larger than the reference signal, the transistor in the FP module is reverse biased and no current flows through the magnetic amplifier windings.

Current flow through the control windings drives the core of the magnetic amplifier into saturation. Saturating the core causes turn on of the transistor in the SE module and results in providing gating signals to the SCR assembly. The point at which the core becomes saturated is determined by the amount of current flow through the control windings. The amount of current flow through the control windings is determined by the value of the reference signal from LR.

If the reference signal is small, a small amount of current flows through the control windings and the core is saturated late in the positive half cycle. Therefore, the gating signal occurs late in the positive half cycle and excitation current flows for only a short period of time during the positive half cycle. If the reference signal increases, the current flow through the control windings increases and the core is saturated earlier in the positive half cycle and the gating signal occurs earlier in the positive half cycle. This results in flow of excitation current for a longer period of time and increases the average amount of excitation to the main generator field.

Excitation current passes through the silicon controlled rectifiers only during a portion of the positive half cycle. However, the current through the main generator field is relatively stable. Resistor R32 and capacitor CA32 are used for spike suppression. The flux lines from the main generator field tend to collapse during the negative half cycles. However, the decaying flux field induces a voltage into the field windings which causes a current to flow through the free wheeling diode FWD and through the main generator field. This results in a slowly decaying flux field instead of a sudden collapse and maintains a relatively stable field strength.

Refer to the description of the SE module for a more detailed description of the gating signals.

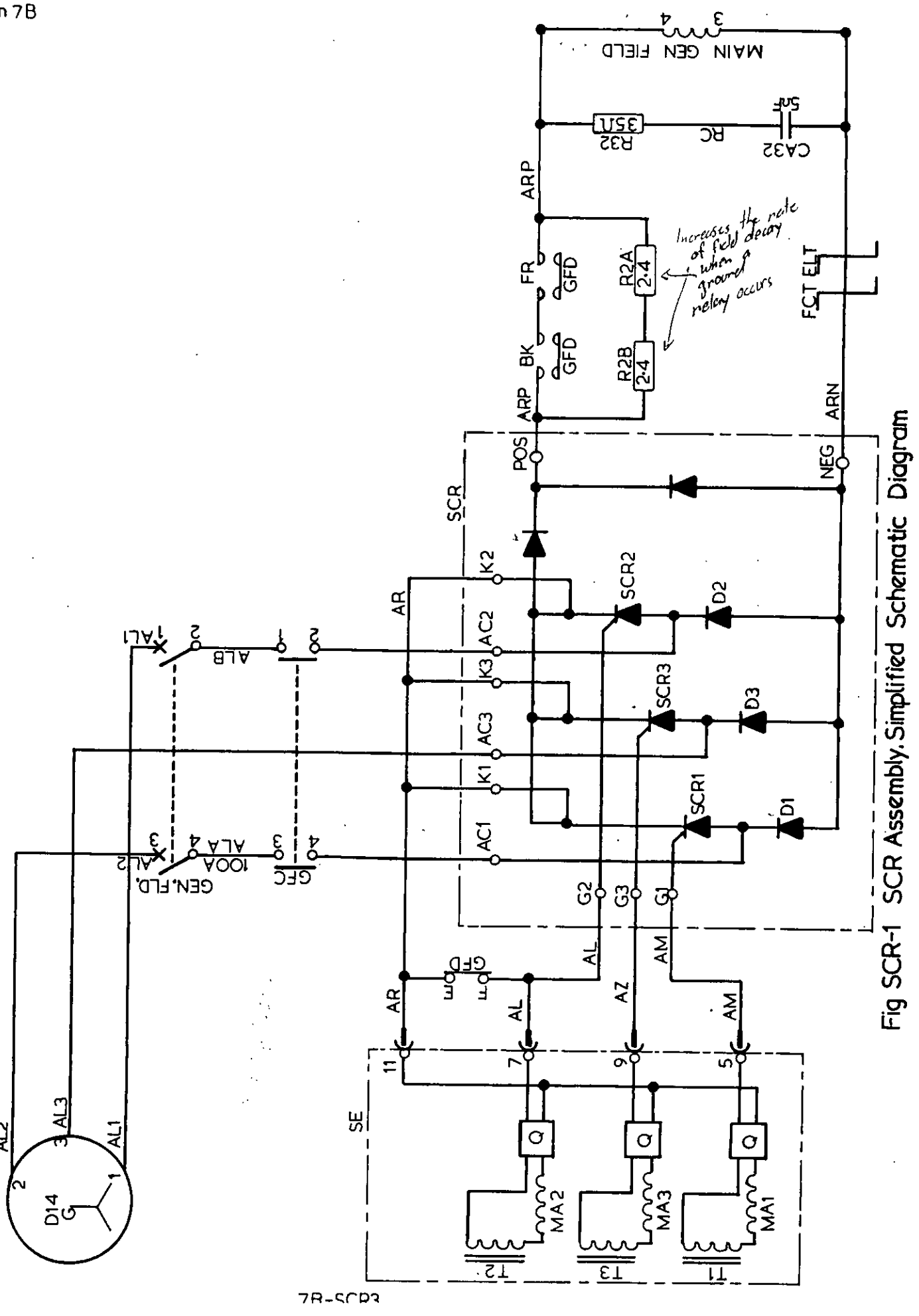


Fig SCR-1 SCR Assembly, Simplified Schematic Diagram

RATE CONTROL MODULE, RC11

INTRODUCTION

The main generator excitation system has a very fast response. Therefore, an increase in throttle position tends to cause a sudden increase in power. The rate control module RC11 provides for a fast, but smooth, increase in power instead of a sudden increase. This response is accomplished by limiting the rate of increase in power by modifying the reference signal, between the throttle response circuit and the load regulator, during changes in throttle position. The rate of change is limited by controlling the bias at the base of transistor Q1 on the RC module, through a resistor-capacitor timing circuit. Operation of the RC module during power and during dynamic braking is described in the following paragraphs. A simplified schematic diagram of the RC module, Fig. RC-1 is provided for reference only. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance on the system.

OPERATION OF RATE CONTROL MODULE WITH THROTTLE IN IDLE POSITION

With the throttle in IDLE, there is no reference signal input to the RC module. However, a potential of 74 volts is applied between terminals 1 and 14. This 74 volts provides a current flow from terminal 1 through resistor R1 and diode D3 to capacitor C1 and resistors R5 and R8. The resistance ratio of R1 to R8 permits a very small charge on C1. This very small charge provides an initial forward bias for Q1 and results in a very small current flow through resistors R1, R2, and R3, from collector to emitter of Q1, and then through the load regulator LR to negative. Therefore, the 74 volts applied between terminals 1 and 14 provides an initial forward bias for Q1 and maintains a very small amount of conduction through Q1. This initial conduction is not sufficient to provide excitation to the main generator field, but it decreases turn on time of Q1.

OPERATION OF RATE CONTROL MODULE DURING POWER OPERATION

The MR relay picks up when the throttle is advanced to No. 1 position. Pickup of MR provides a feed of approximately 12.5 volts to terminal 3 of RC module. Pickup of MR also provides a small potential (approximately 4 to 6 volts) from terminal 12 of the TH module to terminals 9, 11 and 12 on the RC module.

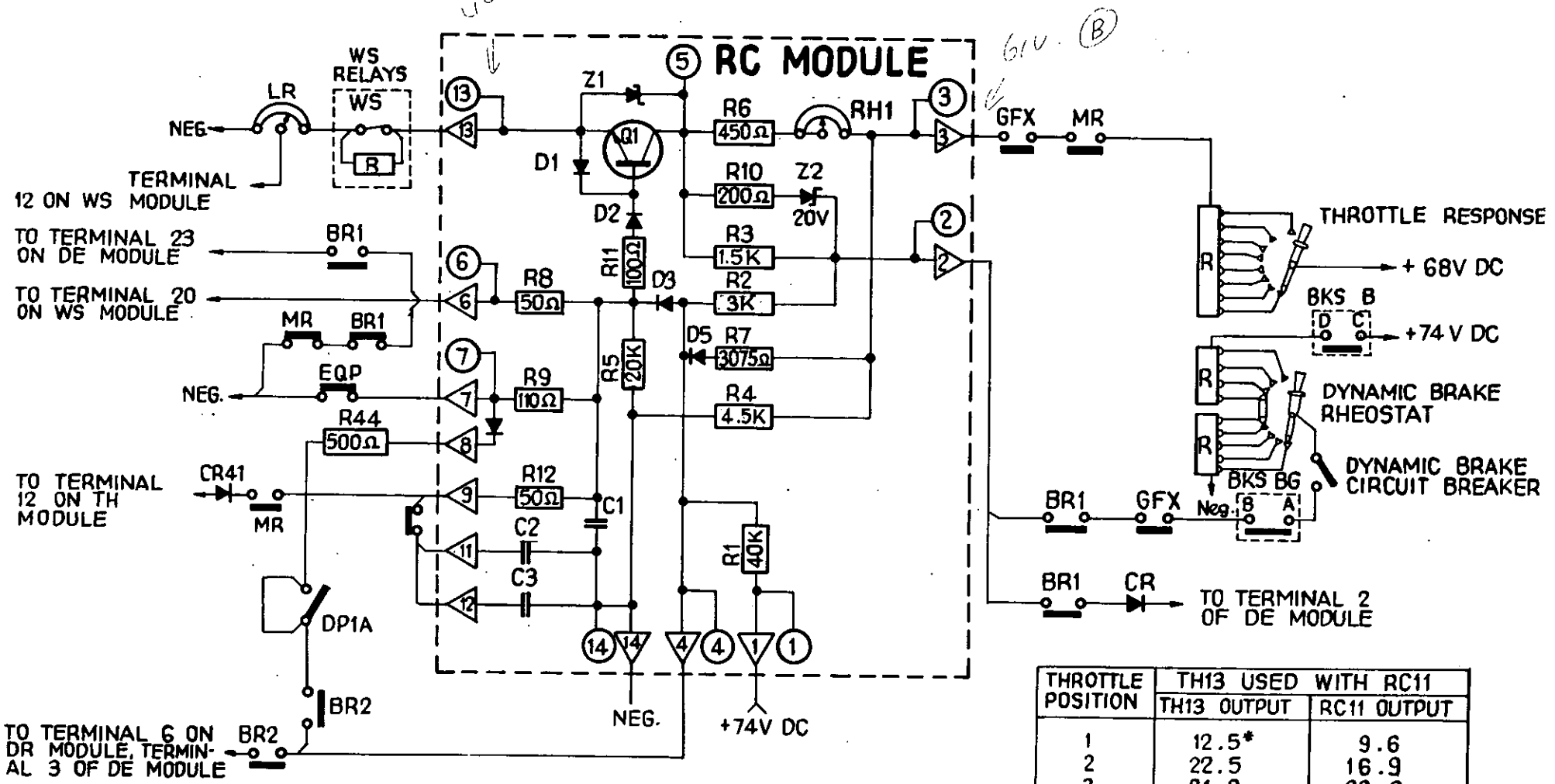
This 4 to 6 volts provides an immediate charge on capacitors C1, C2, and C3 and immediate power response. Otherwise, there would be a short time delay in power response while charging C1, C2, and C3 through R7 from terminal 3. The initial charge on C1, C2, and C3 from terminal 12 of the TH module is less than the potential applied to terminal 3. Therefore, capacitors C1, C2 and C3 will continue to charge through R7, D5, and D3 until the full charge for throttle No. 1 position is attained.

It should be noted that the voltage across the load regulator LR increases at the same rate as the increase in forward bias applied to the base of Q1. There is an immediate low level response when the throttle is advanced to No. 1 position, due to the initial charge on C1, C2, and C3. After this initial response, the rate of increase in forward bias is determined by the resistance of R7 and the capacitance of C1, C2, and C3. The values of R7, C1, C2, and C3 are selected to provide a fast and smooth response instead of a sudden increase.

Advancing the throttle results in an increase in reference voltage applied to terminal 3 from the TH module, an increase in bias, an increase in current flow through Q1, and an increase in voltage developed across the load regulator LR. With the throttle in No. 8 position, the voltage applied to terminal 3 is 68 volts and the voltage across LR and the bias applied to the base of Q1 is approximately 50 volts. The ratio of applied reference voltage to the LR voltage is approximately 1.36 to 1 for all throttle positions. The relationship between throttle position, output voltage of the TH module, and output voltage of the RC module is shown in Fig . RC-1

Reducing the throttle from No. 8 to No. 7 position results in reducing the applied reference voltage. This reduction of applied voltage results in a discharge of capacitors C1, C2, and C3 to a value proportional to the input reference voltage. Capacitors C1, C2, and C3 discharge through R5 and from base to emitter of Q1. The MR relay drops out when the throttle is reduced to IDLE. Dropout of MR provides a fast discharge path for C1, C2, and C3 through R8.

Terminal 6 of the RC module is connected to the WS module. If wheelslip is detected, terminal 6 will be connected to negative through the WS module. With terminal 6 connected to negative, C1, C2, and C3 will discharge rapidly through R8 to terminal 6 of the RC module then through the WS module to negative. Discharging C1, C2, and C3 results in less excitation to the main generator and less power is applied to the traction motors. Capacitors C1, C2, and C3 will continue to discharge until the wheelslip is corrected. For a more detailed description of wheelslip correction refer to coverage of the wheelslip control circuit.



THROTTLE POSITION	TH13 USED WITH RC11	
	TH13 OUTPUT	RC11 OUTPUT
1	12.5*	9.6
2	22.5	16.9
3	31.2	23.2
4	43.0	31.8
5	51.2	37.8
6	57.3	42.2
7	63.2	46.5
8	68.0	50.0

RELATIONSHIP BETWEEN THROTTLE POSITION, OUTPUT VOLTAGE, OF THE TH MODULE, AND OUTPUT VOLTAGE OF THE RC MODULE.

NOTE: TABLE GIVES NOMINAL VALUES FOR NORMAL ROAD OPERATION OR WITH FP MODULE REMOVED.

* APPLIES TO TH13 WITH R1 - 4248Ω.

Fig. RC-1 – Rate Control Module Simplified Schematic Diagram (For Units Equipped With Extended Range Dynamic Brakes)

OPERATION OF RATE CONTROL MODULE ON LOCOMOTIVES IN NON EXTENDED RANGE DYNAMIC BRAKES MODE

When dynamic brakes are applied, the reference signal from the dynamic brake rheostat is applied to terminal 2 of the RC module. The signal applied to terminal 2 of RC causes a current flow through R2 and D3 to capacitors C1, C2, and C3 and resistor R5. This current flow results in voltage build up across capacitors C1, C2, and C3 and consequently forward bias on the base of Q1. The increased forward bias results in an increase of current from collector to emitter of Q1 and a larger voltage is developed across load regulator LR. This increase in current is supplied from terminal 2 through R3 and to the collector of Q1.

The voltage developed across LR as determined by collector to emitter current does not increase suddenly as the braking lever is advanced, but increases at the same rate as the increase in bias applied to the base of Q1. The rate of increase in bias is determined by the resistance of R2 and the capacitance of C1, C2, and C3.

Advancing the braking lever results in an increase in the signal applied to terminal 2 of the RC module. Resistor R3 and load regulator LR form a voltage divider for the input signal. The voltage across R3 is approximately equal to the voltage across LR for all values of signal input voltage up to 40 volts. This voltage divider action provides close control of excitation during low braking effort. Zener diode Z2, connected across R3, has a breakdown voltage rating of 20 volts. Therefore, Z2 breaks down when the voltage across R3 reaches 20 volts. After breakdown of Z2, any further increase in signal input to terminal 2 of the RC module results in a corresponding increase in voltage developed across LR and results in a faster increase in excitation during high braking effort.

When the braking lever is reduced, the input signal decreases and capacitors C1, C2, and C3 slowly discharge through R5 and from base to emitter of Q1. If the braking lever is rapidly reduced from high braking effort to low braking effort, the voltage at the base of Q1 will be much higher than the voltage at the collector. This difference in potential tends to cause a reverse discharge current flow from base to collector then through the dynamic brake rheostat to negative. The 200 ohm resistor R10 prevents excessive current flow through zener diode Z2. Therefore, the reverse current from collector of Q1 to the dynamic brake rheostat must flow through R3 and R10. The resistance of R10 limits the reverse current and thereby protects Q1 from breakdown due to the reverse current.

If braking lever is positioned to release the brakes, the BR1 relay drops out and capacitors C1, C2, and C3 will rapidly discharge through the 50 ohm resistance of R8 to terminal 6 and then to negative. Capacitors C1, C2, and C3 will discharge through R9 to terminal 7 and then to negative if the EQP relay drops out.

LIMITING BRAKING GRID CURRENT TO 370 AMPERES

Terminal 4 of the RC module is connected, through BR2 contacts, to terminal 6 on the dynamic brake regulator module DR. If the braking grid current increases above 370 amperes, terminal 4 of the RC module will be connected to negative through the DR module. With terminal 4 connected to negative, the brake control input signal is removed from C1, C2, and C3 allowing discharge through R5 of the RC module. Discharging of C1, C2, and C3 results in less voltage across LR and less braking effort. When braking grid current decreases below 370 amperes, terminal 4 is disconnected from negative and the brake control signal is again applied to C1, C2 and C3. This regulating action protects the dynamic braking grids by limiting braking current to a maximum of 370 amperes. For a more detailed description of the dynamic brake regulating action refer to coverage of the dynamic brake regulator module DR.

OPERATION OF RC MODULE ON LOCOMOTIVES IN EXTENDED RANGE DYNAMIC BRAKING MODE

The DE module and the RC module are connected as follows; terminal 6 of the RC module is connected to terminal 23 of the DE module, terminal 2 of the RC module is connected to terminal 2 of the DE module, and terminal 4 of the RC module is connected to terminal 6 of the DR module, and terminal 3 of the DE module. During extended range dynamic brake operation, terminal 8 of the RC module is connected to terminal 6 of the DR module and terminal 3 of the DE module.

The connection between terminal 4 of the RC module and terminal 6 of the DR module limits braking grid current to a maximum value of 370 amperes. This limiting action is the same as that provided for non extended range dynamic braking.

The connection between terminal 6 of the RC module and terminal 23 of the DE module provides a fast discharge path for C1, C2, and C3 during the time interval between pickup of the extended range dynamic brake pilot relay DP and pickup of the dynamic brake shorting contactor. Discharging C1, C2, and C3 causes a decrease in voltage across LR which results in less excitation to the fields of the traction motors. This reduced excitation prevents excessive braking current after pickup of the dynamic brake shorting contactor. The discharge path for C1, C2 and C3 is through R8 to terminal 6 on the RC module, then through the DE module to negative.

The connection between terminal 2 of RC and terminal 2 of the DE module applies the braking lever signal from the dynamic brake rheostat to the DE module for comparison with the braking grid current signal from transformer T4. If the braking grid current signal rises above the braking lever signal during extended range dynamic brake operation, the DE module operates to complete a path between terminals 4 and 5 of the DR module.

This signal results in discharging capacitors C1, C2 and C3 through R9 and terminal 8 on the RC module then to negative through the DR module. This action limits dynamic braking grid current to a value proportional to the braking lever signal during extended range dynamic brake operation. Refer to description of the DR and DE modules for further information on this limiting action.

SENSOR MODULE, SE10 – 8458900

INTRODUCTION

The sensor module SE10 controls main generator field excitation current level. Field excitation current is provided by the D14 alternator through silicon controlled rectifiers SCR1, SCR2, and SCR3 on the SCR assembly. These silicon controlled rectifiers will not conduct until they are forward biased (anode positive with respect to cathode) and a gating signal is applied to the cathode gate. The gating signal is a voltage, applied to the cathode gate, which is positive with respect to the cathode. After conduction starts, the gating signal loses control, and conduction continues as long as the anode is positive with respect to the cathode. The SE module, Fig. SE-1, controls field excitation current by:

1. Providing the gate signals to the SCR s.

2. Controlling the time in the voltage cycle at which they occur.

Since the SCR's form part of a three-phase diode bridge, each SCR is not forward biased continuously, but only during the positive half of one phase plus a small portion of the succeeding phase. To allow SCR conduction, the gate pulse must also occur during this time. The time the SCR is forward biased, is fixed. Therefore, changing the point at which the gate pulse appears, results in changing the average amount of current flow through the SCR, and likewise through the main generator field. An early gate pulse allows conduction for a long period of time resulting in some average current level. A late gate pulse, however, allows conduction for a shorter period of time resulting in a lower average current level.

Since the SE module consists of three identical channels, one for each SCR, only one channel, Fig. SE-2 is described.

The SCR gate pulse from the SE module to SCR1 in the SCR assembly is the voltage developed across resistor R61. This voltage is present only when SCR1 (in SE) is turned on, providing a path for current flow from transformer T1 terminals 1 and 2. Turnon of SCR1 (in SE) is controlled by the operation of magnetic amplifier M1.

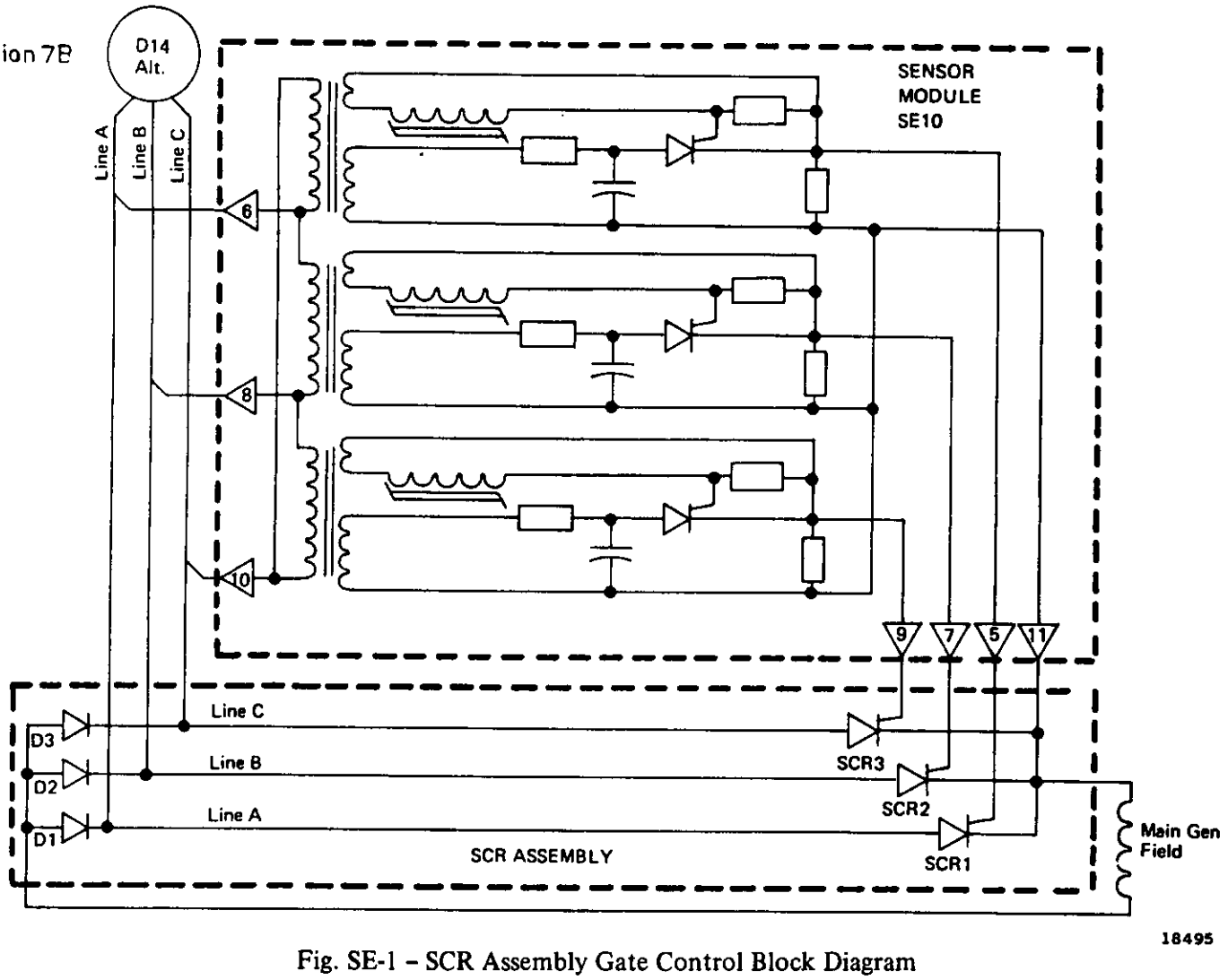


Fig. SE-1 - SCR Assembly Gate Control Block Diagram

Current flow through the magamp control windings drives the magamp core into saturation. Saturating the core allows current to flow through D31, R51 and R31, causing turn-on of SCR1 (in SE). The point in time, at which the core becomes saturated, is determined by the amount of current flow through the magamp control winding. This current level is regulated by the FP module.

The amount of main generator field excitation required is determined by comparing the reference signal from the load regulator (LR) with feedback signals from the performance control FP module. When the LR reference signal is larger than a FP feedback signal, a transistor in the FP module is turned on, providing a path for current flow through the magamp control windings. The amount of current is related to the difference between the reference signal and the feedback signal.

When a small difference exists between the reference signal and the feedback signals, a low current level flows in the magamp control windings. This low current level results in core saturation being reached and the gate signal being developed near the end of SCR forward bias time.

WHEEL SLIP TRANSDUCTOR, WST

The wheelslip transductor consists of two laminated iron cores, two AC windings, and two single conductor motor current bias windings. The two cores are magnetically isolated from each other by an air gap and each core contains an AC winding. The two motor current bias windings are common to both cores. A simplified schematic diagram of a wheelslip transductor is provided in Fig. WST-1.

One of the motor current bias windings carries current to a traction motor that drives one pair of wheels. The other motor current bias winding carries current to a traction motor that drives a different pair of wheels. The current through the two motor current bias windings is approximately equal when the motors are operating at the same speed. Therefore, the flux lines set up by the two motor current bias windings are approximately equal. The two motor current bias windings are connected so that their flux lines are opposite causing the resultant flux lines to be near zero during normal operation.

The two AC windings are connected series opposing so that the magnetic lines of force in the two cores travel in opposite directions. The AC windings, in series with resistor R14, are energised by current flow from the D14 alternator. The reactance of the AC windings is much larger than the resistance of R14. Therefore, during normal operation, practically all of the input AC voltage is developed across the AC windings and very little voltage appears across R14. The voltage across R14 is applied to the WS module. Therefore, the input signal to the WS module is very small and essentially constant during normal operation.

When a wheelslip occurs, the current flow in the two motor current bias windings becomes unbalanced. This current unbalance results in an unbalance in the flux lines from the bias windings.

During any unbalance in bias, the resultant flux lines set up by the bias winding aids the flux lines set up by the AC winding in one core and opposes the flux lines set up by the AC winding in the other core. The core in which the flux lines aid moves toward magnetic saturation causing the reactance of the AC winding on this core to decrease. The core in which the flux lines oppose moves away from saturation, but the reactance of the winding on this core is affected by only a very small amount.

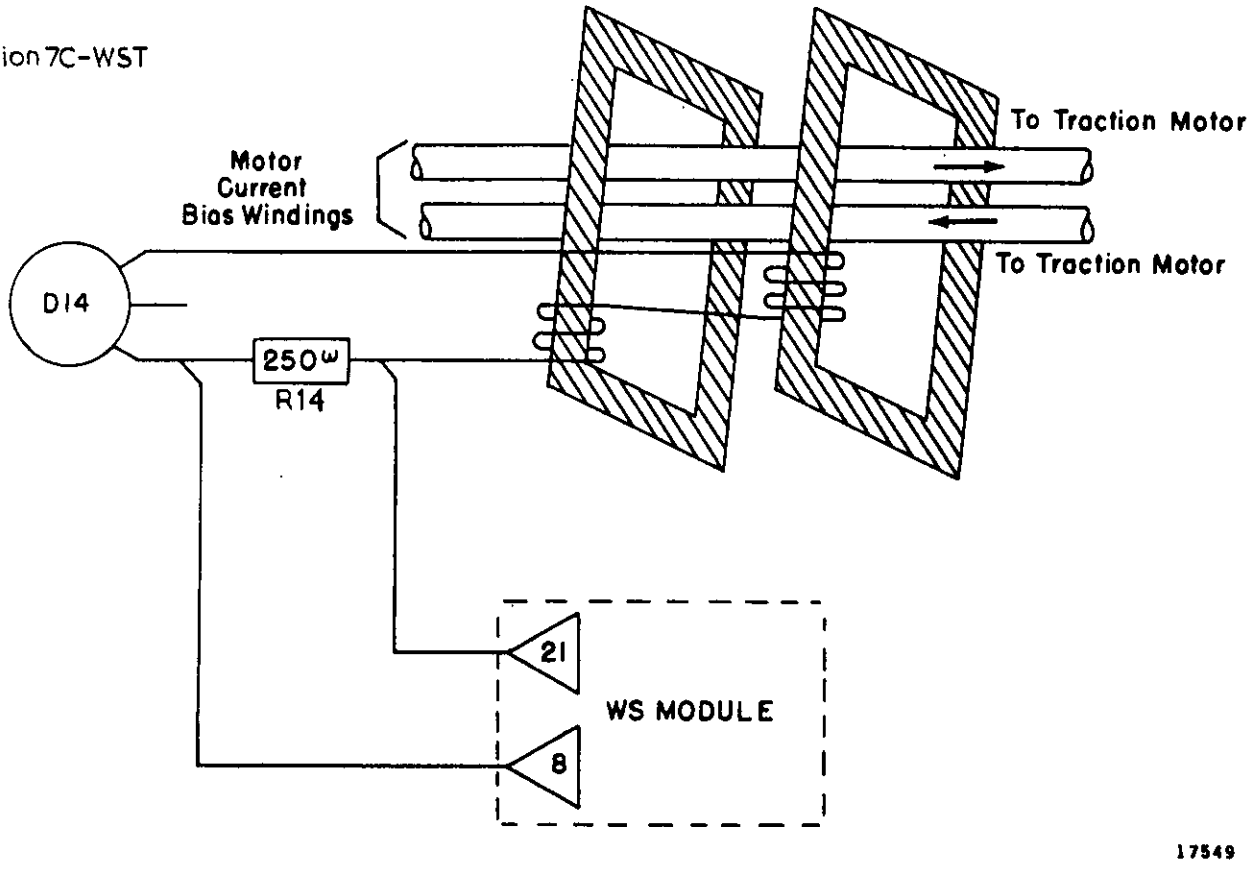


Fig. WST-1 – Typical Wheel Slip Transductor, Simplified Schematic Diagram

Therefore, the total resultant reactance of the two AC windings decreases whenever an unbalance occurs in the current flow through the two motor current bias windings. The decrease in reactance is proportional to the amount of unbalance in current flow through the motor current bias windings.

A decrease in reactance of the AC windings results in an increase in current flow through R14 and an increase in the signal developed across R14. Therefore, the signal applied to the WS module from R14 is proportional to the unbalance in current flow through the motor current bias windings.

A simultaneous wheelslip, where all wheels slip at the same rate, will not cause a current unbalance in the motor current bias windings. Therefore, the wheelslip transductors cannot detect a simultaneous wheelslip.

Refer to description of the WS module for further details on wheelslip detection and correction.

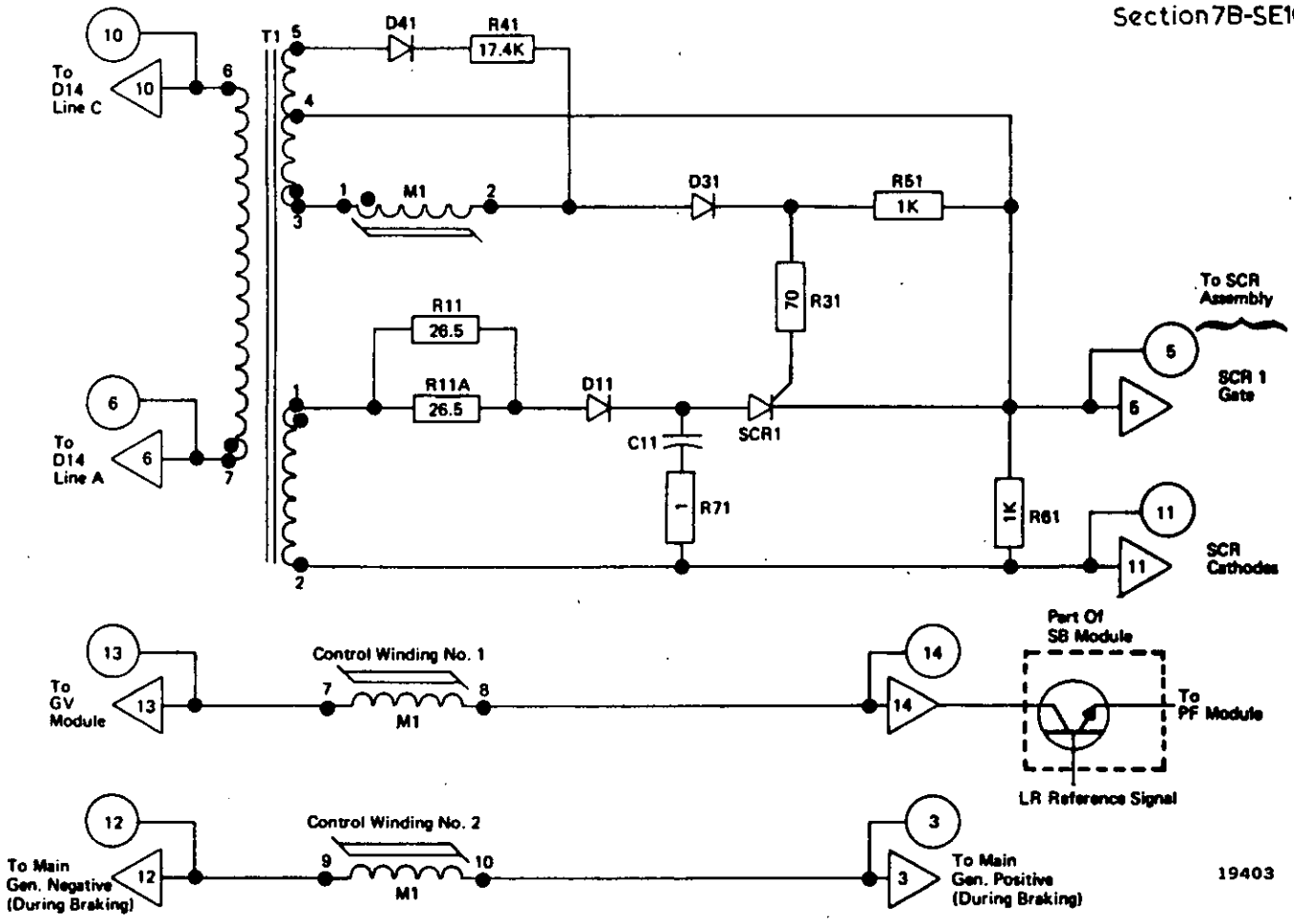


Fig. SE-2 - SE10 Partial Simplified Schematic Diagram

Therefore, main generator field current flows for only a short period of time, resulting in a low average field current level. A greater difference between the reference signal and feedback signals results in a higher current level in the magamp control winding, earlier core saturation, earlier SCR turn-on and, as a result, a higher average main generator field excitation current level.

During dynamic braking, a second magamp control winding is connected across the main generator output voltage. The resulting current flow through this winding opposes the core saturation effects of control winding 1 causing the main generator to operate at a lower output level during braking.

A simplified schematic diagram of the SE module, Fig. SE-15, is provided later in this section for convenient reference. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance.

SE/SCR ASSEMBLY OPERATION

The three-line, three-phase output of the D14 alternator, Fig. SE-3, is applied to the SCR assembly bridge, and results in the SCR's being forward biased (anode positive with respect to cathode) in the sequence-SCR1, SCR3, and SCR2.

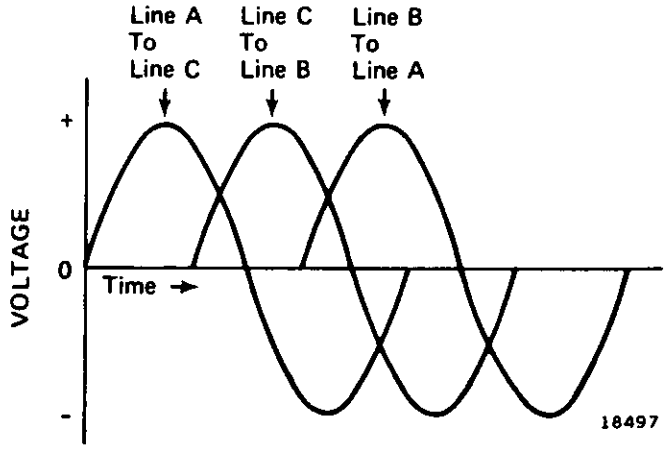


Fig. SE-3 - D14 Alternator Three-Phase Output

Diodes D1 through D3, Fig. SE-4 provide two current paths for each SCR. Therefore, each SCR is forward biased by two phases of the line-to-line voltages. For example, SCR1 is connected to lines B and C through diodes D2 and D3.

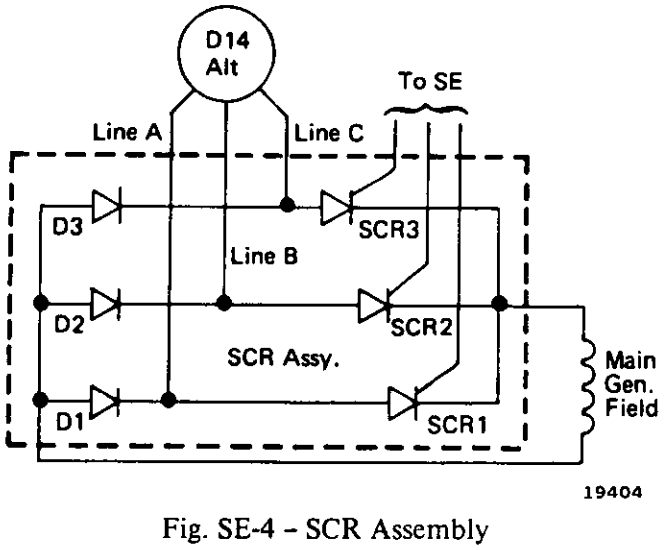


Fig. SE-4 - SCR Assembly

The instantaneous voltage across SCR1 is therefore the difference in potential of either line A with respect to line C, or line A with respect to line B, whichever is greater. This results in forward bias applied to each SCR for a time period longer than a half cycle, Fig. SE-5.

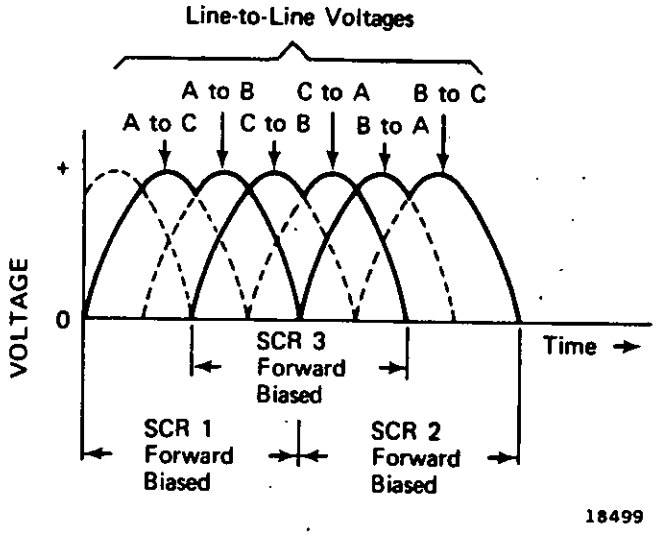


Fig. SE-5 - SCR Assembly Forward Bias Waveform

The SCR bridge output is connected to the main generator field. Turning on an SCR with a gate pulse allows current to flow through that SCR and the main generator field. If an SCR is gated on at the same time that forward bias is applied, the SCR could conduct for the full forward bias time. With this condition, main generator field current, Fig. SE-6 is the result of each SCR conducting for the maximum possible time, and field current is at the highest level possible.

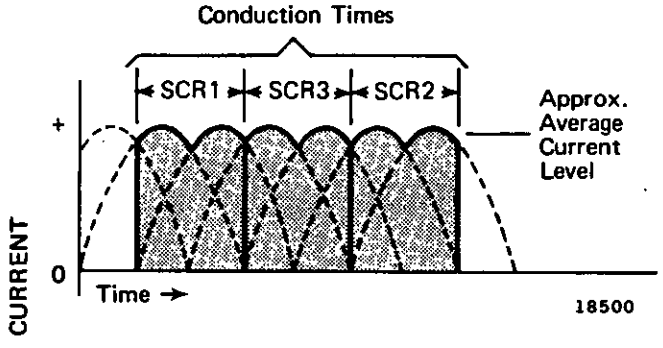


Fig. SE-6 - Main Generator Field Current With Maximum SCR Conduction

The resulting waveshape is due to the commutation characteristics of a three-phase SCR (or diode) bridge circuit. Commutation occurs at the instant one SCR (or diode) stops conducting and another starts. A conducting SCR is essentially a short circuit, therefore its cathode voltage approaches the level of its anode voltage. Since the SCR cathodes are all electrically common, the anode voltage of a conducting SCR is also present at the cathode of the other SCR's. Until anode voltage of a non-conducting SCR exceeds this value, the SCR's are reverse biased. Therefore, prior to these SCR commutation points in the waveform, Fig. SE-7, the gating signal has no control over turning on the SCR.

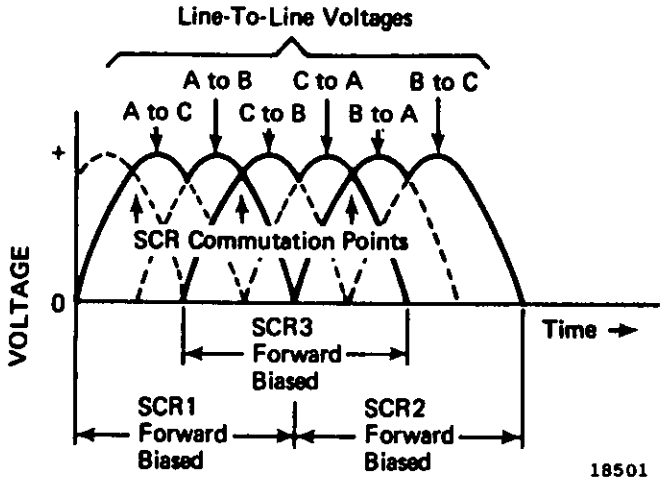


Fig. SE-7 - Three-Phase Bridge SCR Commutation Points

The function of the SE10 module, to control main generator field excitation current level, is accomplished by delaying the SCR gate signal past these commutation points. Delaying SCR turn-on, results in lower average current levels, Fig. SE-8.

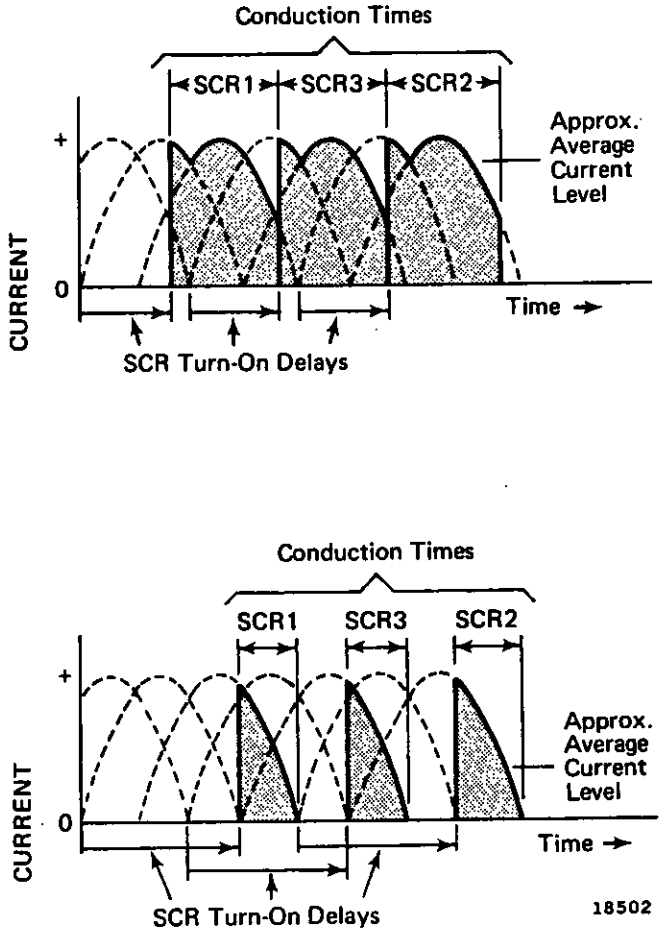


Fig. SE-8 – Main Generator Field Current Levels

The gate pulse, from the SE module to SCR1 in the SCR assembly, is the voltage developed across resistor R61. This voltage is present only when SCR1 (in SE) is turned on, providing a path for current flow. SCR1 (in SE) is turned on by the gate voltage across R51. Since SCR turn-on is very rapid, the gate signal to the SCR assembly is present at the same time the voltage across R51 reaches SCR1 (in SE) turn on level. Therefore, controlling the time at which the R51 voltage reaches that level, also controls SCR assembly turn-on delay. This turn-on delay, as described above, determines main generator field excitation current level.

MAGAMP M1 DETAILED OPERATION

The magnetic amplifier, magamp M1, is the device used to control R51 voltage level. The magamp output coil, resistor R51, and diode D31 form a series circuit connected across transformer T1 output winding terminals 3 and 4. The input signal to T1, Fig. SE-9, is the same line-to line voltage that provides the leading portion of the forward bias to SCR1 in the SCR assembly.

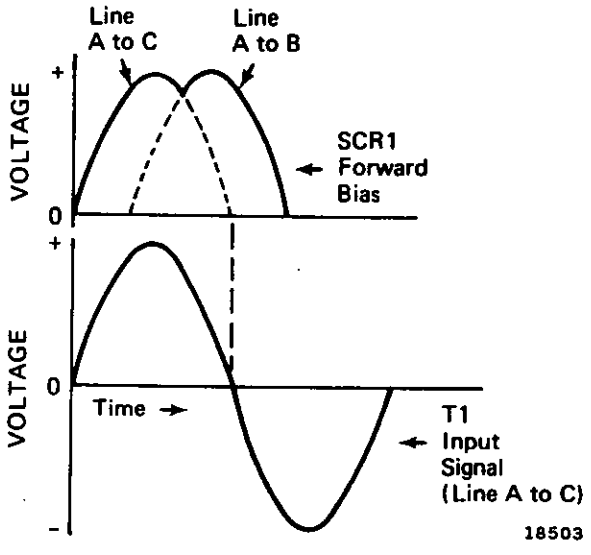


Fig. SE-9 – SE10 Module Input Voltage

The magamp output coil presents either a very high or a very low impedance to the input signal. The high impedance results in nearly the entire input signal being dropped across the coil. A low impedance, however, causes nearly the entire input signal to appear across R51.

The coil provides a low impedance if the magnetic core is saturated with flux lines, and the input signal is attempting to produce additional flux in the same direction. The high impedance is presented, however, if the applied voltage is attempting to reverse the direction of flux present in the core. Applying a positive voltage to the output coil, produces a change in flux level in the positive direction. The total amount of flux change is the product of coil voltage and length of time the voltage is present (flux change = volts x time). A graph of total flux change, Fig. SE-10, produced by a sinusoidal voltage reaches a peak at the end of the positive half cycle.

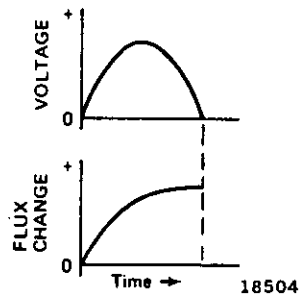


Fig. SE-10 - Coil Voltage And Flux Change

A typical hysteresis loop, Fig. SE-11, illustrates the magnetic characteristics of the magamp core.

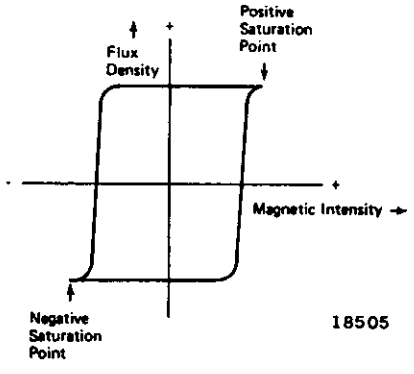


Fig. SE-11 - Magamp Core Hysteresis Loop

With core flux density near negative saturation, point A in Fig. SE-12, the positive input signal is applied. This signal produces a positive flux change to point B. Positive core saturation was not reached, therefore, coil impedance remained high and no voltage appeared across R51. The module input voltage then goes through the negative half cycle, applying the core reset voltage through diode D41 and resistor R41. The reset voltage produces a negative flux change from point C to point D in Fig. SE-12. With no current flow in the control windings, the magamp continues to operate along this path, and the SCR assembly is not turned on.

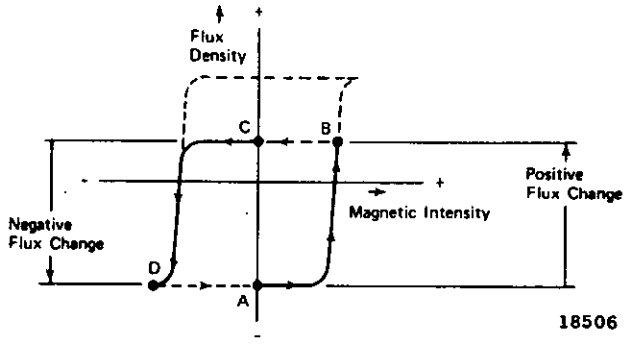


Fig. SE-12 - Magamp Core Operation - No Control Winding Current

Allowing a positive current flow through the magamp control winding changes the magamp operation. The current flow produces a positive flux change, Fig. SE-13, from point A to point A[1].

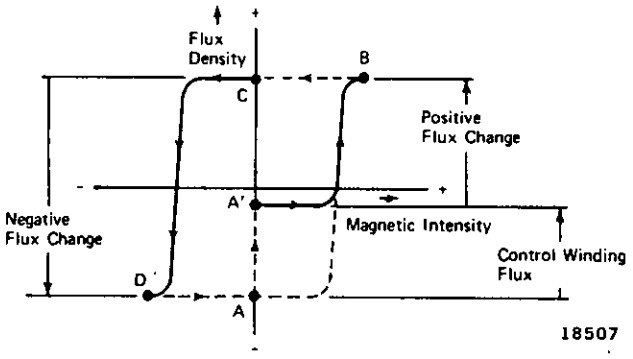


Fig. SE-13 - Magamp Core Operation - With Control Winding Current

The positive flux change produced by the module input signal now results in core saturation. At the time the core reaches saturation, coil impedance becomes zero and the voltage across it drops to zero. The entire input signal, Fig. SE-14, is then present across R51, turning on SCR1 (in SE) which produces the SCR assembly gating signal.

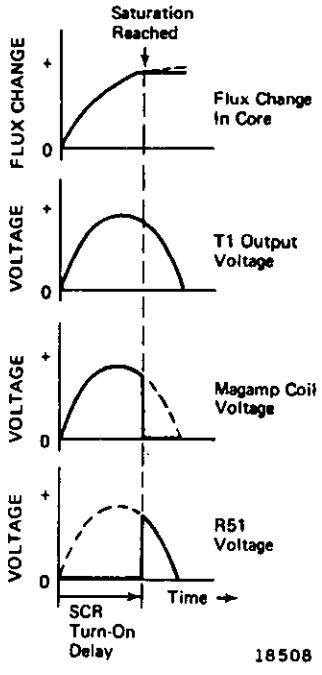


Fig. SE-14 - SE Voltage At Core Saturation

The amount of flux change due to control winding current determines both the additional flux change required from the input signal to reach core saturation and, also the time during the positive half cycle of SE input voltage at which saturation occurs. Since time to reach core saturation is also SCR assembly turn-on delay, changing the control winding current also changes this turn-on delay and therefore also changes main generator field excitation current.

Since the core tends to retain the same flux level after the magnetising force is removed, the reset voltage is required to cause the core to return to some flux density level below positive saturation. At positive saturation, the coil impedance is near zero, and the SCR assembly will continue to be turned on even after the control winding current is removed, unless the reset voltage is provided.

Resistor R71 and capacitor C11 are used to provide a fast rise time for the voltage pulse developed across R61. This fast rise time is desirable to provide a rapid SCR assembly turn-on.

The magamp has three control windings on each core: one connected in series between the feedback and performance(FP) module and the main generator voltage regulator (GV) module; the second connected, during dynamic braking, across the main generator voltage output; and the third, a spare, not used.

The current in the winding between the GV and FP modules flows through a transistor in the GV module and a transistor in the FP module. The amount of current flow is dependent on the biasing of these two transistors. The transistor in the FP module is forward biased when the load regulator reference signal is larger than the feedback signal. The transistor in the GV module is forward biased whenever the main generator output voltage is less than the preset maximum level to which the GV module limits.

An increase in current flow through this control winding, as previously described, causes a decrease of the SCR assembly turn-on delay, which increases main generator field excitation. The second winding, connected to the main generator output voltage during braking, is connected such that the current flow through it tends to produce flux lines opposing those produced by the other control winding. An increase in main generator output voltage causes current through this winding to increase. This results in a more stable control during dynamic braking. During braking the combined effect of the two magamp control windings brings about stable control of the main generator output voltage and current at the low levels required for dynamic braking.

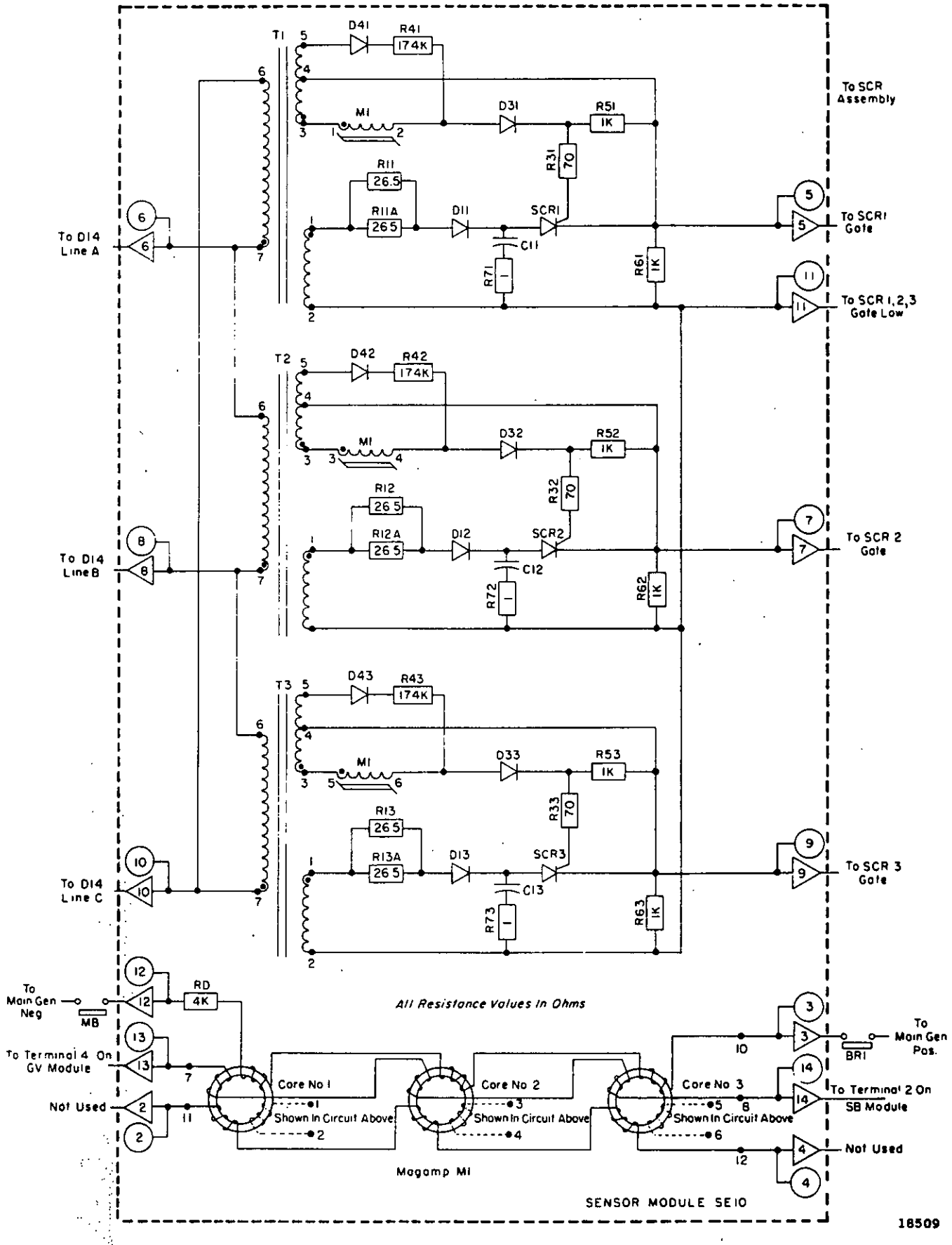


Fig. SE-15 - Sensor Module SE10 - Simplified Schematic Diagram

VOLTAGE REFERENCE REGULATOR AND THROTTLE RESPONSE MODULE

INTRODUCTION

The voltage reference regulator and throttle response modules TH13 and TH14 contain a voltage reference regulator circuit and a throttle response circuit. Output of the voltage reference regulator provides a very stable 68 volts DC to the throttle response circuit and to the FP (feedback module). Output of the throttle response circuit, which is proportional to throttle position, is applied to the rate control module for controlling locomotive power in accordance with throttle position.

The same voltage reference regulator circuit is used on both TH modules. The throttle response circuit is the same on both TH modules, except for resistance values of the throttle response resistors R1 through R7. A simplified schematic diagram of the TH module, Fig. TH-1, with resistance values of R1 through R7 for TH13 and TH14, is provided for reference only.

VOLTAGE REFERENCE REGULATOR CIRCUIT

The voltage reference regulator VRR provides a stable 68 volts DC input reference voltage to the throttle response circuit and to the (feedback comparison) module FP. Nominal input voltage to VRR is 74 volts DC from the auxiliary generator. The output voltage of VRR is equal to the input voltage minus the collector to emitter voltage E_{ce} of transistor Q4. VRR is designed so that E_{ce} of Q4 varies with changes in input voltage and changes in load to maintain a very stable 68 volts DC output voltage.

When the input voltage is exactly 74 volts, E_{ce} of Q4 will be 6 volts and the output voltage of VRR will be 68 volts. If the input voltage of VRR increases above 74 volts, E_{ce} of Q4 will increase to maintain a 68 volt output. If the input voltage decreases below 74 volts, E_{ce} of Q4 will decrease to maintain a 68 volt output provided the input voltage remains above 68 volts.

E_{ce} of Q4 is controlled by the bias applied to the base of Q4. A change in load applied to the output of VRR tends to change the output voltage of VRR, but Ece changes to compensate for variable loads and thus maintains a stable output voltage with changes in input voltage or changes in load.

Transistor Q1 with rheostat RH1, reference zener diode RZ, and resistors R9, R10 and R11 monitor the output voltage of VRR and controls the operation of transistor Q2. Transistor Q2 and resistor R8 control operation of transistor Q3 and transistor Q3 controls operation of Q4.

Reference zener diode RZ is connected to the emitter of transistor Q1. The voltage across a zener diode tends to drift slightly as current through it changes. Resistor R10 provides a stabilising current to RZ. With the stabilising current established, the very small additional emitter current I_e of Q1 will have no effect on the voltage across RZ. Therefore, RZ maintains a constant positive voltage at the emitter of Q1.

Rheostat RH1 provides a positive voltage at the base of Q1. This positive voltage increases with an increase in output voltage of VRR and decreases with a decrease in output voltage of VRR.

Resistor R11 places a positive voltage at the base of Q2 when Q1 is not conducting. Current flows through resistor RH11, diode D1, diode D3, and from base to emitter of Q3 and Q4. This current flow results in reverse bias on Q2 and prevents conduction of Q2 when Q1 is not conducting.

Resistors R9 and R11 are used as voltage dividers when Q1 is conducting. The current flowing through R11 also flows through R9, Q1, and RZ. This voltage divider action reduces the positive voltage at the base of Q2. The reduction in positive voltage at the base of Q2 is sufficient to cause the base of Q2 to become negative with respect to the emitter of Q2, thus placing a forward bias causes Q2 to conduct.

Transistor Q2 and resistor R8 provide the bias control for Q3 and Q4. When Q2 is not conducting, a large positive voltage is applied to the base of Q3 through R8. This large forward bias causes Q3 to conduct heavily and apply a large forward bias to the base of Q4. This high forward bias on Q4 results from low E_{ce} of Q3 when Q3 is operating with a large forward bias. The large forward bias on Q4 causes Q4 to go into saturation which results in a small E_{ce} for Q4.

When Q2 is conducting, current flows through R8 and Q2 causing a voltage drop across R8. This voltage drop reduces the forward bias on Q3 which reduces conduction of Q3 and reduces forward bias on Q4. The reduced forward bias on Q4 results in a larger E_{ce} for Q4.

An increase in the input voltage to VRR or a decrease in the load applied to VRR tends to increase the output voltage of VRR. The rise in output voltage results in increasing the voltage drop across RH1 which increases the forward bias on the base of Q1 and causes I_{ce} of Q1 to increase. An increase in I_{ce} of Q1 results in a larger voltage drop across R11 and decreases the positive voltage applied to the base of Q2.

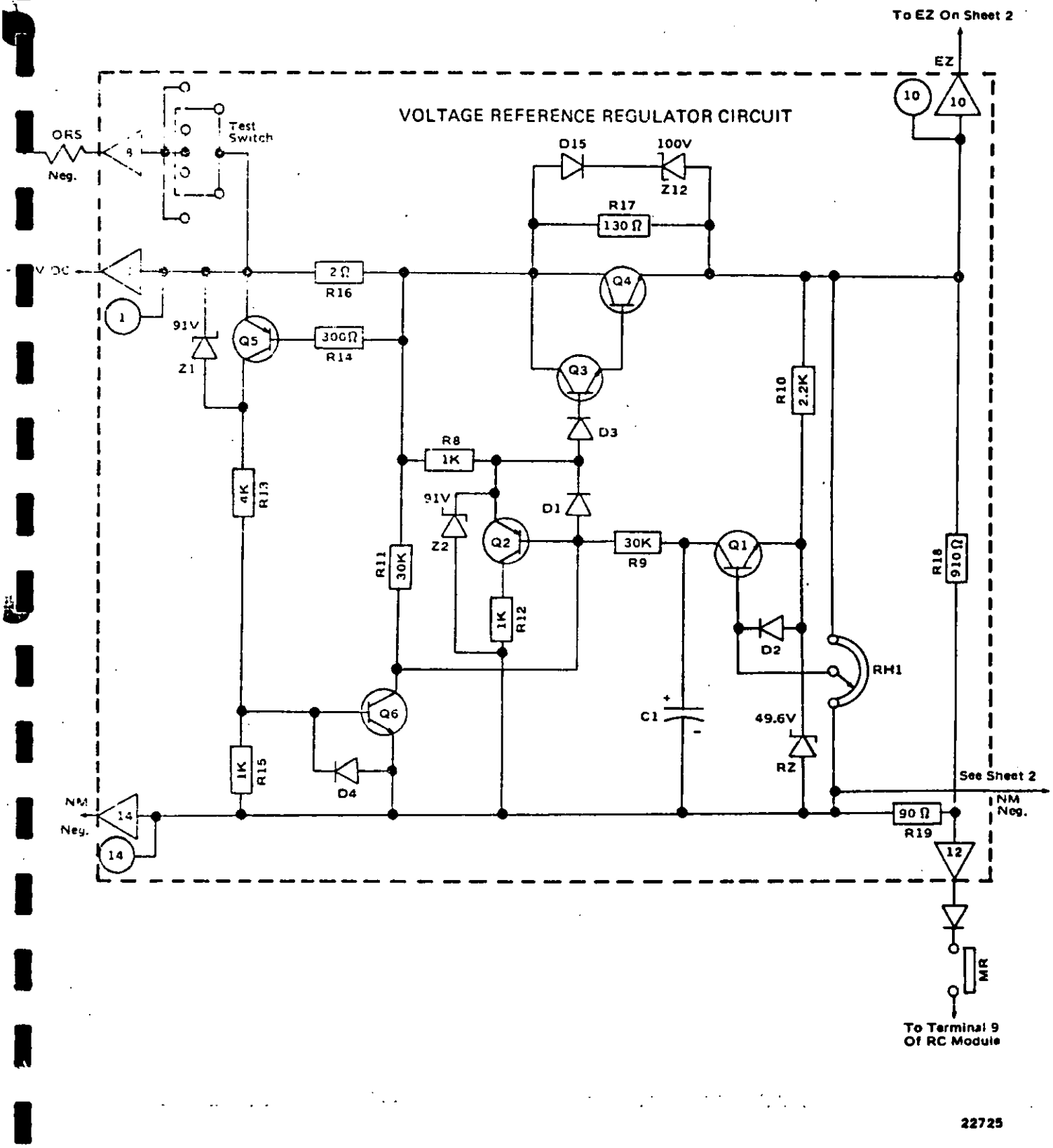
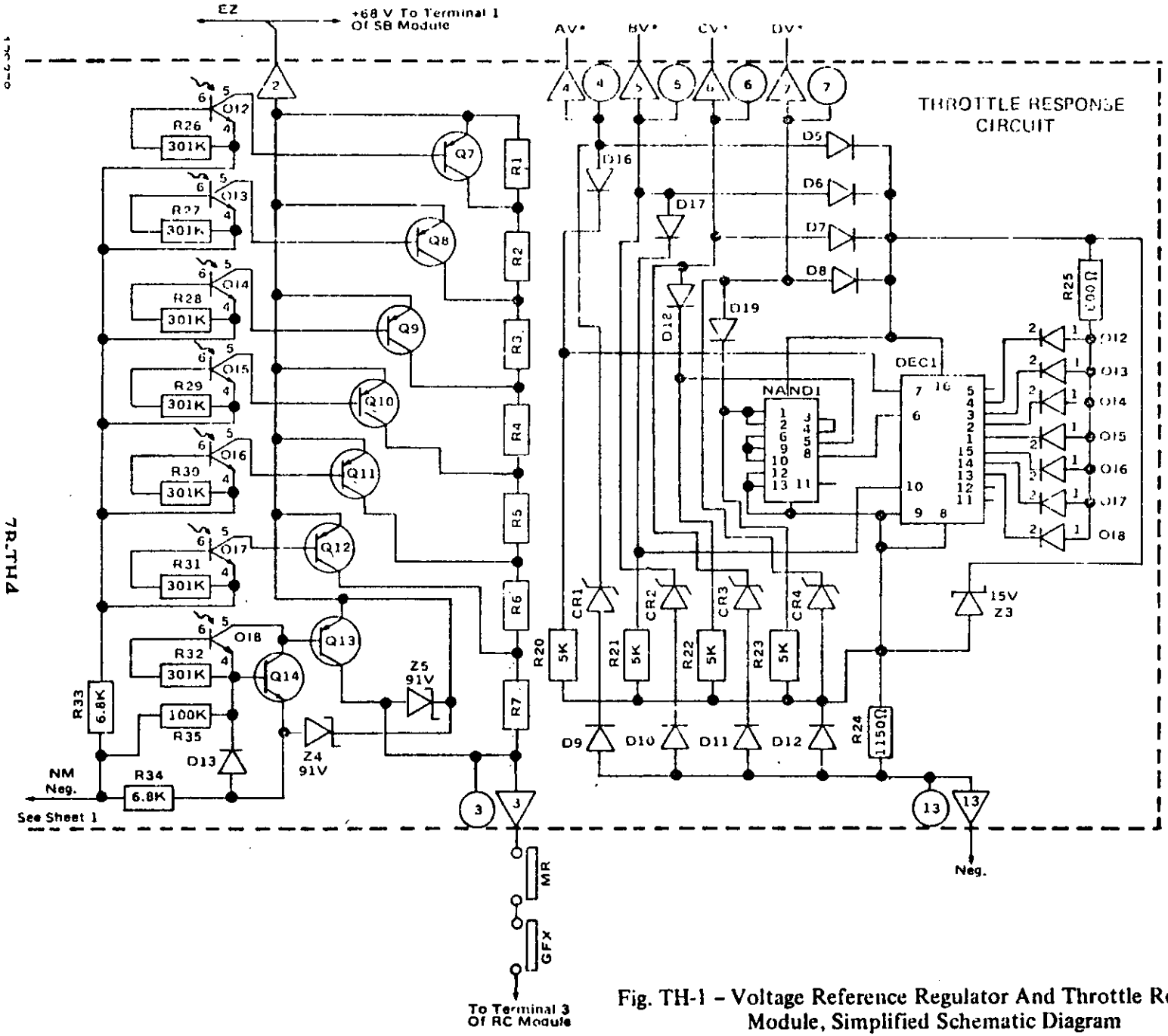


Fig. TH-1 - Voltage Reference Regulator And Throttle Response Module, Simplified Schematic Diagram

(Sheet 1 of 2)



Throttle Response Resistors	Resistance In Ohms	
	TH13	TH14
R1	4248	5180
R2	1058	1155
R3	844	683
R4	354	472
R5	192	336
R6	150	302
R7	103	144

*These terminals are energized with 24V whenever the specific governor solenoid valve is energized, as determined by throttle position.

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Fig. TH-1 – Voltage Reference Regulator And Throttle Response Module, Simplified Schematic Diagram

(Sheet 2 of 2)

The decrease in positive voltage at the base of Q2 causes I_{ce} of Q2 to increase. This increase in I_{ce} of Q2 results in a larger voltage drop across R8 causing a decrease in forward bias at the base of Q3. This decrease in forward bias on Q3 causes E_{ce} of Q3 to increase. The increase of E_{ce} of Q3 results in decreasing the forward bias on Q4. This decrease in forward bias on Q4 causes E_{ce} of Q4 to increase. The increase in E_{ce} of Q4 results in a decrease in the output voltage of VRR (output voltage equals input voltage minus E_{ce} of Q4). The sequence of events occurring from the initial increase in output voltage to the resulting decrease in output voltage is instantaneous so that change in the output voltage is very small.

VRR CIRCUIT PROTECTION

Protection of the VRR circuit from excessive input voltage and excessive overload is provided by transistors Q5 and Q6, and resistors R13, R14, R15 and R16. Normal current flow through R16 is not sufficient to provide forward bias for Q5. However, an excessive load or excessive input voltage results in an increase of current flow through R16. This increased current flow provides forward bias for Q5. Turn on of Q5 results in current flow through R13 and R15. Current flow through R15 provides forward bias for Q6. Turn on of Q6 provides reverse bias for Q3 and Q4. This results in turn off of Q4 so that output current is limited by R16 and R17.

THROTTLE RESPONSE CIRCUIT

Output from the voltage reference regulator protection of the TH module supplies a very stable 68 volts DC to a string of seven resistors connected in series on the throttle response portion of the TH module. This input voltage is modified by the throttle response resistors, as determined by throttle position, and applied to the rate control RC module as a reference for controlling main generator excitation. As throttle position is increased, an increased portion of the resistance from the throttle response resistors is removed, resulting in increased output voltage to the RC module. In throttle position 8, all resistance is removed and the full 68 volts is applied to the RC module.

The relationship of throttle position to throttle response module output voltage is given in Fig. TH-2.

Figure.TH-2

Throttle Position	Relays Energized	Approximate Output Voltage	
		TH13 Module	TH14 Module
STOP	D		
1	NONE	*12.5	**10.9
2	A	22.5	21.6
3	C	31.2	28.6
4	A C	43.0	35.7
5	B C D	51.2	43.3
6	A B C D	57.3	51.2
7	B C	63.2	61.4
8	A B C	68.0	68.0

Table gives nominal values for normal operation or with SB module removed.
*Applies to TH13 with R1 - 4248 W
**Applies to TH14 with R1 - 5180 W

part of 1020.

The throttle response circuit consists of two separate sections. The first section provides the logic for determining what position the throttle handle is in. The second section uses the logic to short out the appropriate throttle response resistors, singly or in combination, to control the output voltage to the RC module. → Rate Control Module

The logic section has four inputs. As the throttle handle is moved, switches in the controller close to energise certain governor speed setting solenoid valves. The four solenoids, AV, BV, CV and DV determine engine speed, when energised singly, in combination, or none at all. Input terminal 4 of the logic section is connected so that it is energised when the AV solenoid valve is energised. Input terminals 5, 6, and 7 are similarly connected to solenoid valves BV, CV, and DV respectively. Fig. TH-2 shows which governor solenoids are energised for each throttle position.

An input or combination of inputs to terminals 4, 5, 6 or 7 represents a binary coded decimal, indicating throttle position. These signals are decoded by the binary coded decimal (BCD) decoder. As shown in Fig. TH-3 only three logic inputs, to the BCD decoder, are necessary to provide one of seven separate outputs representing throttle position.

NOTE: Only throttle positions 2 thru 8 are shown as outputs in Fig. TH-3. In throttle position 1 no governor solenoids are energised therefore no input signal is provided to the throttle response circuit. However, the TH module provides a small voltage signal to the RC module equivalent to 68 volts minus the voltage drop provided across the total resistance of all throttle response resistors connected in series.

The three inputs to the BCD decoder are represented as A, B, and CD. The A input is "on" when governor solenoid AV is energised and the B input is "on" when BV is energised. The CD input is "on" when governor solenoid CV is energised but DV is not. This arrangement is possible by feeding the CV and DV inputs to a "NAND" gate integrated circuit. The "NAND" gate output is "on" only when input CV is "on" and the DV input is not. Inputs or a combination of inputs to the BCD decoder and the resulting output is shown in Fig. TH-4.

As shown in Fig. TH-4, for any input or combination of inputs, a single output from the BCD decoder is obtained. This output is used to turn "on" one of the opto-isolators, O12 thru O18. Each opto-isolator consists of a light emitting diode LED and a photosensitive transistor. The LED portion of O12 is connected to output pin 4 of the BCD decoder. This output is "on" on in throttle 2 position. When "on", the base of the photosensitive transistor (Q12) is exposed to the light of the LED.

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This causes collector current to increase. This collector current is applied to the base of Q7 causing Q7 collector current to increase. Increased collector current at this point effectively shorts throttle response resistor R1 out of the circuit. Throttle response module output to the RC module is increased due to the removal of a portion of the throttle response resistance. O13 thru O18 are similarly connected to the outputs of the BCD decoder and the throttle response resistors.

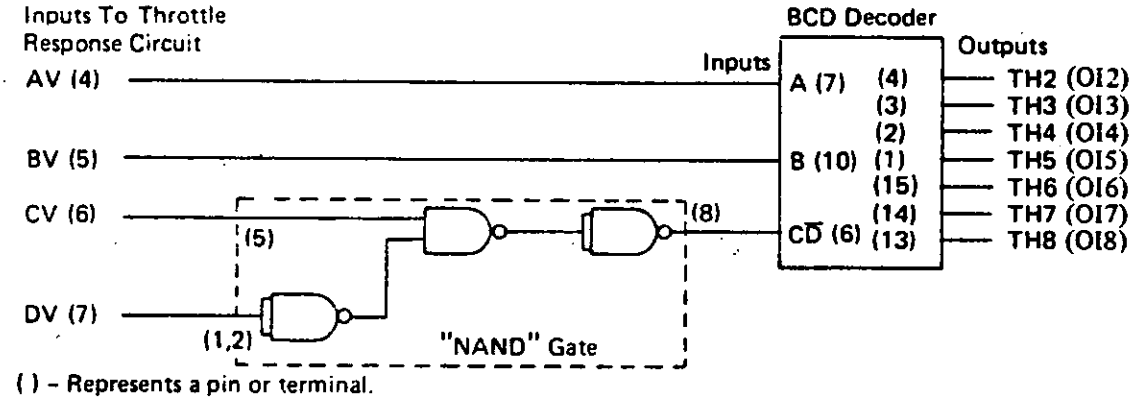

Fig. TH-3 - Simplified Diagram Of Inputs And Outputs Of The BCD Decoder

INPUTS			OUTPUTS						
A	B	$C\bar{D}$	(OI2) TH2	(OI3) TH3	(OI4) TH4	(OI5) TH5	(OI6) TH6	(OI7) TH7	(OI8) TH8
1	0	0	1	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0
1	0	1	0	0	1	0	0	0	0
0	1	0	0	0	0	1	0	0	0
1	1	0	0	0	0	0	1	0	0
0	1	1	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	1

O-Indicates input or output is "off."
I-Indicates input or output is "on."

Fig. TH-4 - Inputs To BCD Decoder And Resulting Output

WHEEL SLIP SYSTEM

INTRODUCTION

The wheelslip system helps to maintain wheel traction under adverse operating conditions and provides protection for the traction motors by detecting and correcting wheel slip conditions before the slip is severe enough to damage the traction motors.

When a locomotive is in power and experiencing slippery conditions wheels have a tendency to slip or rotate faster than normally in load. In dynamic braking under similar conditions wheels have a tendency to slide or rotate slower than is normal in braking.

The primary wheel slip detection device for a wheel slip condition is the wheel slip transductor WST. Six axle locomotives are equipped with three wheel slip transductors, and four axle locomotives are equipped with four. During normal operation the armature current is approximately equal for all traction motors and a balanced condition exists. However, during a wheel slip condition armature current through the motors is unequal and an unbalanced condition exists. The WST's are connected so that any unbalance in traction motor armature current is detected. This unbalanced condition causes the WST's to develop a wheelslip signal. This signal is applied to the wheel slip module WS. The WS module initiates corrective action for the wheel slip condition. The wheel slip transductors operate during power application. A detailed description of the wheel slip transductors is provided later in this section.

Simultaneous wheelslide on one bogie or differential wheelslide in dynamic braking is controlled by a wheelslide bridge circuit. This circuit is activated only in dynamic brake.

The output from the wheelslide bridge circuit is applied to the WS relay. The WS relay initiates corrective action for the wheelslide condition. A detailed description of the wheelslide bridge circuit is provided later in this section.

The wheelslip module WS initiates corrective action for a wheel slip condition upon receiving a wheel slip signal from the wheel slip transductor. A detailed description of the WS module is provided later in this section.

The sanding time delay relay TDS upon receiving a signal from the WS module, initiates application of sand to the rails to assist in correcting a wheelslip condition.

CONTENTS

The contents of Section 7 Part C are presented in the following order.

1. Wheel Slip Module
2. Wheelslide Bridge Circuit
3. Wheelslip Transductor

WHEEL SLIP MODULE, WS10

INTRODUCTION

The wheelslip module WS is designed to provide wheelslip correction when a wheelslip is detected by the wheelslip transductors. Three stages of wheel slip correction are provided when a wheelslip is detected by the wheelslip transductors.

The WS module is equipped with a test circuit which may be used to qualify proper operation of the WS module.

A simplified schematic diagram of the WS module is provided, in Fig. WS-1, for convenient reference. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance.

The high sensitivity of the wheelslip transductors and the instantaneous response of the WS module reduces the chances of simultaneous wheelslip by correcting the slip before severe loss of adhesion occurs. Therefore, the WS module maintains locomotive power at the optimum level under conditions of heavy drag and poor adhesion where repetitive slips are encountered. Train handling is smooth and power reduction by the operator is not required.

Transistor Q1 is connected across a power supply consisting of resistor R6, isolation transformer T2, bridge rectifier consisting of D5, D6, D7, and D8, zener diode Z1, and capacitor C4. Transformer T2 in series with resistor R6 is connected across one phase of the D14 alternator. The output of T2 is rectified by D5, D6, D7, and D8. Zener diode Z1 regulates the DC voltage at 50 volts and capacitor C4 filters the output.

Minor differences in wheel diameter and wheelslip transductor magnetising current cause the wheelslip transductors to provide a small and essential steady signal between terminal 8 and terminal 21 of the WS module during normal operation. This small signal is blocked by zener diodes Z4 and Z5. Zener diodes Z4 and Z5 block all signals below 16 volts. This blocking action helps prevent small noise signals from inducing wheelslip corrective action. A signal is applied to transformer T1 when the input signal between terminal 8 and terminal 21 rises above 16 volts. The output signal from T1 is rectified and filtered, then applied across rheostat RH1.

The wiper arm of RH1 is set at the factory to provide the desired response of the WS module. The signal available at the wiper arm of RH1 is applied, through capacitor C3, to diodes D17 and D18. A small steady state signal is not sufficient to cause conduction of D17 and D18, therefore, transistor Q1 is turned off during normal operation.

Description of the different stages of wheelslip correction is provided in the following paragraphs. The first and second stages of wheelslip correction operate on the rate of change in wheelslip instead of on the magnitude of wheelslip. The third stage of wheelslip correction operates on the magnitude or level of wheelslip.

FIRST STAGE CORRECTION

The first stage of wheelslip correction is designed to correct minor wheel slip conditions. This is accomplished by producing a sharp reduction in the reference signal applied to the base of transistor Q1 on the feedback performance module (FP). This reduction is made without discharging the rate control capacitors in the RC module, or changing position of the load regulator wiper arm. Reducing this signal results in an immediate decrease in excitation to the main generator field and a corresponding decrease in output power of the main generator. Unnecessary power reduction is prevented by reducing the reference signal to the base of Q1 on the FP module in direct proportion to the acceleration of the slipping wheels and immediate reapplication of normal power after a minor wheelslip is corrected.

When a wheelslip occurs, the voltage applied to transformer T1 increases at a rate which is directly proportional to the acceleration of the slipping wheels. The signal is rectified and applied to the upper portion of RH1 and to the lower portion of RH1 in parallel with C3 and C7. The voltage across capacitors C3 and C7 increases at a rate determined by the acceleration of the slipping wheels and the RC circuit consisting of RH1, C3, and C7.

The increase in voltage across C7 places forward bias on transistor Q1. Forward bias on Q1 results in current flow through resistor R13, diode D19, to terminal 3 on the WS module, to terminal 11 on the WS module, then from collector to emitter of Q1 on the WS module. This current flow through R3 causes an increase in the voltage developed across R3 and results in decreasing the voltage applied to the base of Q1 on the FP module. This decrease in forward bias on transistor Q1 of the FP module results in a decrease in excitation to the main generator field.

The decrease in excitation to the main generator field causes a decrease in power output from the main generator and improves traction sufficiently to correct for a minor wheelslip condition.

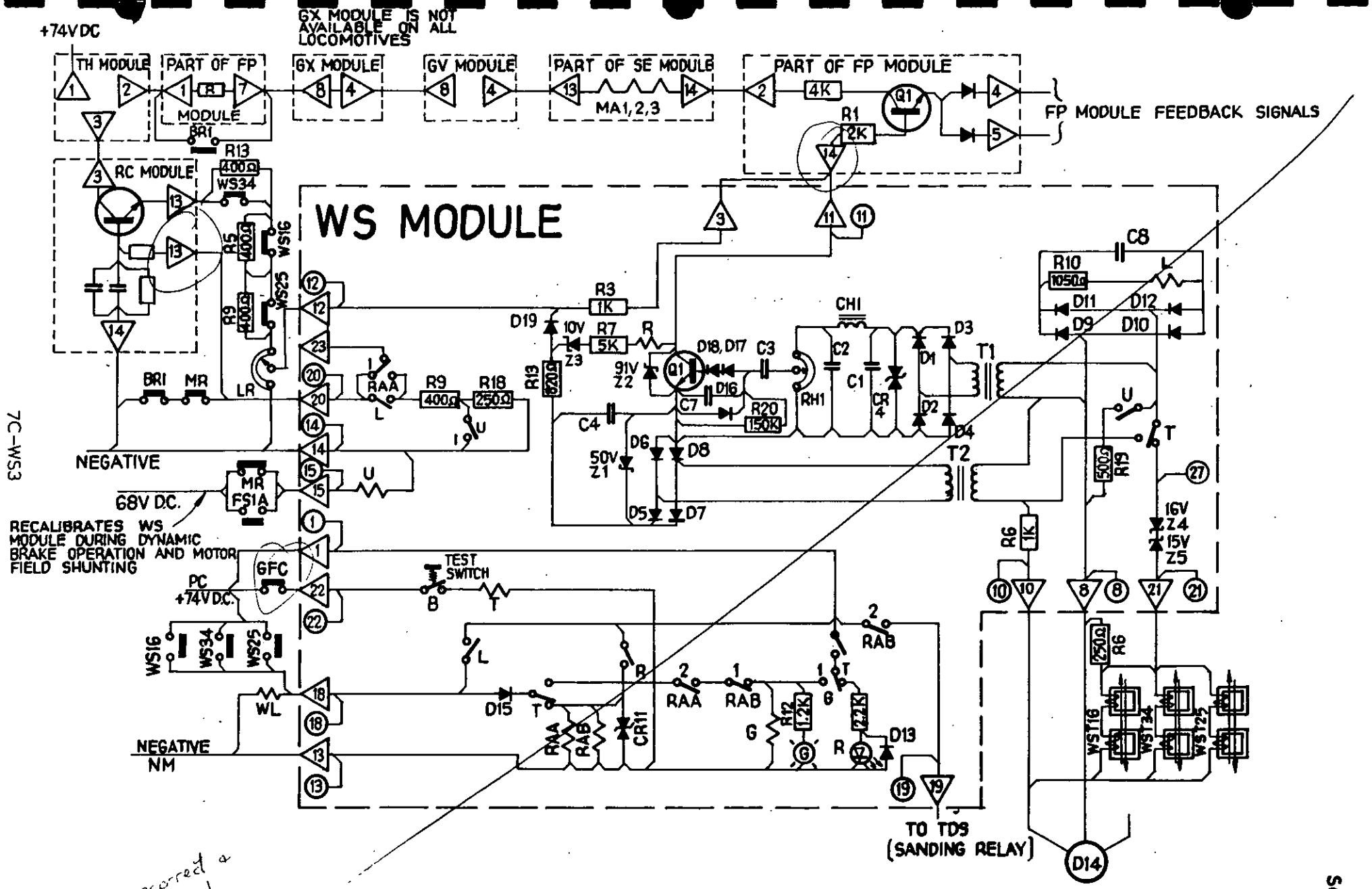

Fig. WS-1 — Wheel Slip Module, Simplified Schematic Diagram

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After the wheelslip is corrected, C3 and C7 discharge through the lower portion of RH1, to the small steady state value. Discharging C7 removes forward bias from Q1 which stops the current flow and allows the voltage applied to the base of Q1 on the FP module to return to its normal value.

SECOND STAGE CORRECTION

A second stage of wheelslip correction occurs if the wheelslip signal from the wheelslip transductors exceeds a predetermined value. During the second stage of wheelslip correction sand is applied to the rails and the rate control capacitors on the RC module are discharged at a controlled high rate.

The wheelslip signal that brings about the second stage of correction causes a large forward bias to be applied to transistor Q1. This large forward bias results in an increase of current flow through resistor R3. Reverse current will flow through zener diode Z3 when the voltage across R3 rises above 10 volts. The current through Z3 results in pickup of the R relay.

Pickup of the R relay provides a feed to the RAA and RAB relays. Pickup of RAA provides a fast discharge path for the rate control capacitors through R9 and R18 to negative. Pickup of RAB provides a sanding signal to the TDS relay.

Discharging the rate control capacitors reduces generator excitation which results in a decrease of output power from the main generator. The decreased power and sanded rails improves traction which causes a reduction in forward bias on Q1. The reduced forward bias results in less current flow through R3. When the voltage across R3 drops below 10 volts, zener diode Z3 blocks current flow through the R relay causing the R relay to drop out. Dropout of the R relay removes the feed to RAA and RAB. Dropout of RAA removes the discharge path for the rate control capacitors and allows the capacitors to charge at their normal rate for smooth reapplication of power. Dropout of RAB removes the sanding signal from the TDS relay. Sanding continues for a timed interval after the sanding signal is removed. Dropout of RAB also removes the feed from ORS.

THIRD STAGE CORRECTION

Output of the wheelslip detectors is applied to the wheelslip level detector circuit consisting of diodes D9 through D12, capacitor C8, resistor R10, and level detector relay L. The L relay responds to the magnitude of level of a wheelslip signal instead of responding to the rate of increase of the wheelslip signal. The L relay picks up when the wheelslip signal increases above a predetermined value.

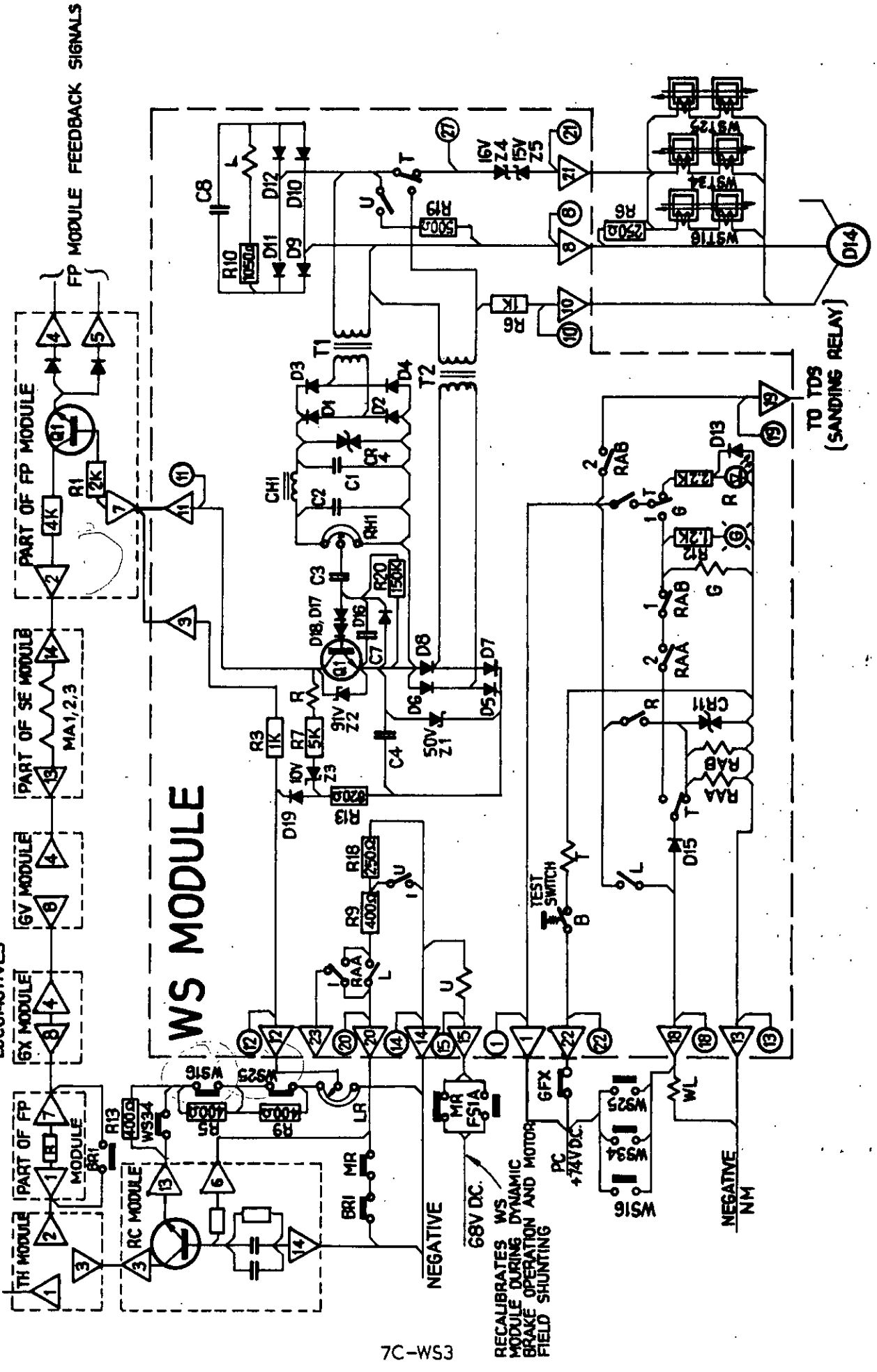

Fig WS-1 — Wheel Slip Module, Simplified Schematic Diagram

After the wheelslip is corrected, C3 and C7 discharge through the lower portion of RH1, to the small steady state value. Discharging C7 removes forward bias from Q1 which stops the current flow and allows the voltage applied to the base of Q1 on the FP module to return to its normal value.

SECOND STAGE CORRECTION

A second stage of wheelslip correction occurs if the wheelslip signal from the wheelslip transductors exceeds a predetermined value. During the second stage of wheelslip correction sand is applied to the rails and the rate control capacitors on the RC module are discharged at a controlled high rate.

The wheelslip signal that brings about the second stage of correction causes a large forward bias to be applied to transistor Q1. This large forward bias results in an increase of current flow through resistor R3. Reverse current will flow through zener diode Z3 when the voltage across R3 rises above 10 volts. The current through Z3 results in pickup of the R relay.

Pickup of the R relay provides a feed to the RAA and RAB relays. Pickup of RAA provides a fast discharge path for the rate control capacitors through R9 and R18 to negative. Pickup of RAB provides a sanding signal to the TDS relay.

Discharging the rate control capacitors reduces generator excitation which results in a decrease of output power from the main generator. The decreased power and sanded rails improves traction which causes a reduction in forward bias on Q1. The reduced forward bias results in less current flow through R3. When the voltage across R3 drops below 10 volts, zener diode Z3 blocks current flow through the R relay causing the R relay to drop out. Dropout of the R relay removes the feed to RAA and RAB. Dropout of RAA removes the discharge path for the rate control capacitors and allows the capacitors to charge at their normal rate for smooth reapplication of power. Dropout of RAB removes the sanding signal from the TDS relay. Sanding continues for a timed interval after the sanding signal is removed. Dropout of RAB also removes the feed from ORS.

THIRD STAGE CORRECTION

Output of the wheelslip detectors is applied to the wheelslip level detector circuit consisting of diodes D9 through D12, capacitor C8, resistor R10, and level detector relay L. The L relay responds to the magnitude of level of a wheelslip signal instead of responding to the rate of increase of the wheelslip signal. The L relay picks up when the wheelslip signal increases above a predetermined value.

Pickup of the L relay provides a feed to the WL relay, the RAA relay, and the RAB relay. Pickup of the WL relay provides a feed to the wheelslip light WS. Pickup of RAA and RAB relays provide the same corrective action that takes place during the second stage of wheelslip correction. The L relay remains picked up until the wheelslip is corrected or until power reduction causes a decrease in the wheelslip signal which permits dropout of the L relay.

Dropout of the L relay removes the feed to WL, RAA, and RAB. Dropout of WL removes the feed to the WL light. Dropout of RAA removes the discharge path for the control capacitors and allows the capacitors to charge at their normal rate for smooth reapplication of power. Dropout of RAB removes the sanding signal from the TDS relay. Sanding continues for a timed interval after the sanding signal is removed.

If a slip persists, the three stages of correction are repeated. The wheelslip light will blink on and off as the cycle repeats or it will burn continuously if the throttle is advanced far enough to hold the L relay picked up.

TEST CIRCUIT FUNCTION

With the isolation switch in RUN position and the throttle opened, the GFC contactor picks up. Pickup of GFC opens the positive feed to terminal 22 of the WS module which prevents pickup of the test relay T in case the test switch is closed when operating under power. This prevents application of high voltage from the D14 alternator to transformer T1.

When the locomotive is isolated or throttle placed in idle position, the GFC relay drops out to allow application of positive feed to terminal 22 of the WS module. Closing the test switch with positive voltage applied to terminal 22 results in pickup of the test relay T.

Pickup of the T relay connects one phase from the D14 alternator to transformer T1 and to the wheelslip level detector circuit. The output of the D14 alternator is approximately 75 volts when the throttle is in idle position. Pickup of the T relay also provides a feed to the red test light on the WS module.

Output from the secondary of T1 provides a signal to RH1. This signal places a large forward bias on Q1 which causes the R relay to pick up. Pickup of the R relay provides a feed to the RAA and RAB relays. Pickup of RAB provides a sanding signal to the Time Sanding Relay. Pickup of RAA provides a discharge path for the rate control capacitors. However, the charge on the capacitors is very small since the throttle is in idle position.

Pickup of the L relay provides a feed to the WL relay causing the WS light on the locomotive control stand to go on. Pickup of the L relay also provides a feed to the G relay and the green test light. Pickup of the G relay drops the feed to the red test light and provides a holding circuit for the G relay and also provides a feed to the green test light.

The R relay drops out when capacitor C3 is fully charged and Q1 turns off, but the green test light and G relay remain energised through the holding circuit. Dropout of the R relay drops the feed to RAA and RAB which removes the sanding signal from the SA module. The green test light will remain on as long as the test switch is held in the closed position. The circuits of the WS module return to normal when the test switch is released.

WHEEL SLIP BRIDGE CIRCUIT

The wheel slip bridge circuit is designed to detect wheel slip during dynamic braking. A typical bridge circuit is shown below. The bridge circuit consists of two traction motors, two 2K resistors, and a bridge relay WS. The wheel slip system includes three such bridge circuits, one circuit for each pair of traction motors.

The bridge circuit is balanced during normal operation. However, the bridge circuit will become unbalanced if a set of wheels skid during dynamic braking. This unbalanced condition is detected by the WSR relay. Pick-up of WSR results in reduced excitation and application of sand to the rails. Refer to the description of the WS module for explanation of this corrective action.

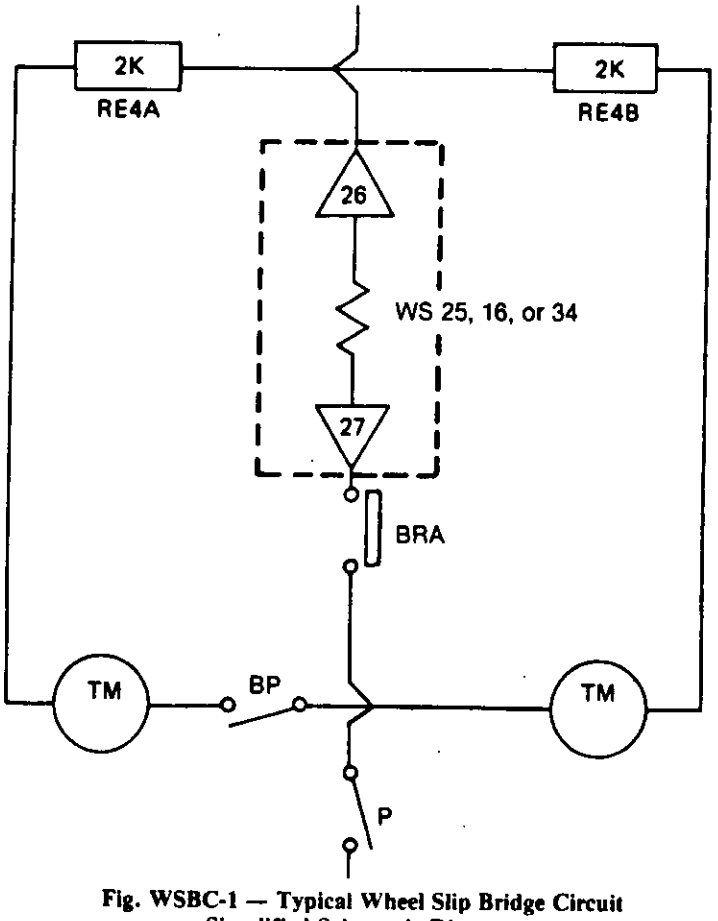

Fig. WSBC-1 — Typical Wheel Slip Bridge Circuit Simplified Schematic Diagram

DYNAMIC BRAKING SYSTEM EXCITATION AND CONTROL

INTRODUCTION

This section provides a general description of the dynamic braking system excitation and control. Description of the system is followed by a detailed description of typical modules and components used in the system. Simplified schematic diagrams of the system modules and components are provided in this section for convenient reference. The locomotive wiring diagram should be used when performing troubleshooting or maintenance on the dynamic braking system.

GENERAL DESCRIPTION

Locomotive dynamic braking is a system which is used to retard locomotive speed through the conversion of kinetic energy to electrical energy. This energy conversion is accomplished by connecting the traction motors as separately excited generators with field current being provided by the main generator. The motor armatures are geared to the axles and rotate whenever the locomotive is moving. Loading is provided by connecting the traction motor armature circuits to the dynamic braking grids. Armature current (grid current) is determined by the speed at which the armatures rotate (track speed) and by the amount of excitation applied to the motor fields. The motor field connections during dynamic braking are shown in Fig. 7D-1 and the motor armature connections are shown in Fig. 7D-2.

With maximum field excitation (approximately 370 amperes with braking lever in position 8) braking effort increases from minimum at zero km per hour to maximum at approximately 38 km per hour. Maximum braking effort for the lower braking lever positions is progressively lower and is attained at progressively higher track speeds as the braking lever position is decreased. After maximum braking effort is attained, an increase in track speed results in a decrease in braking effort. High braking effort is maintained at low track speeds on locomotives equipped with extended range dynamic brakes.

Refer to description of the extended range dynamic brake module DE for description of the extended range dynamic brakes.

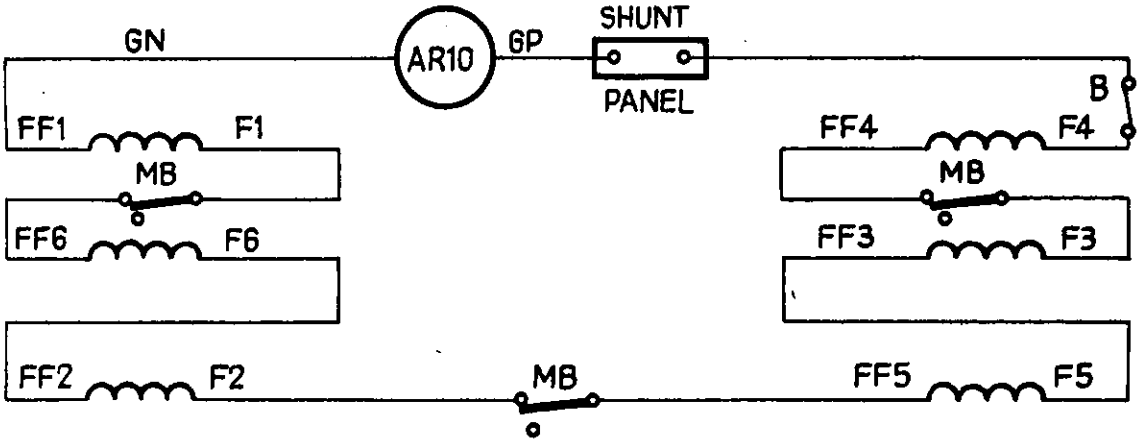

Fig. 7D-1 — Motor Field Connections During Dynamic Braking, Simplified Schematic Diagram.

The amount of kinetic energy that is converted into electrical energy is proportional to I^2R where I is braking grid current and R is the effective resistance of the braking grids. The increase in braking effort from zero to maximum results from increased motor armature grid current as track speed increases. This results in an increase of I^2R and consequently an increase in braking power since power is equal to I^2R. The armature or grid current increases to its maximum value at the speed where maximum braking effort is attained and remains at the maximum value at all higher speeds.

The reason for a decrease in braking effort at higher track speeds may be explained as follows. It is important to remember that braking power remains constant at the higher track speeds. Braking effort may be defined as the amount of retarding force in Newtons that is applied to decrease the track speed. The power formula often used in railroad work is given as follows:

1 Kilowatt = weight in Kilograms x speed in Kilometres per hour divided by 2738.

Retarding force in newtons (braking effort in newtons) may be substituted for weight in the above formula thus:

Kilowatts = braking effort in newtons x speed in kilometres per hour divided by 277.

As braking power remains constant the product of braking effort (in Newtons) and speed (in kilometres per hour) must remain constant. If speed increases, the retarding force or braking effort must decrease in order for braking power to remain constant.

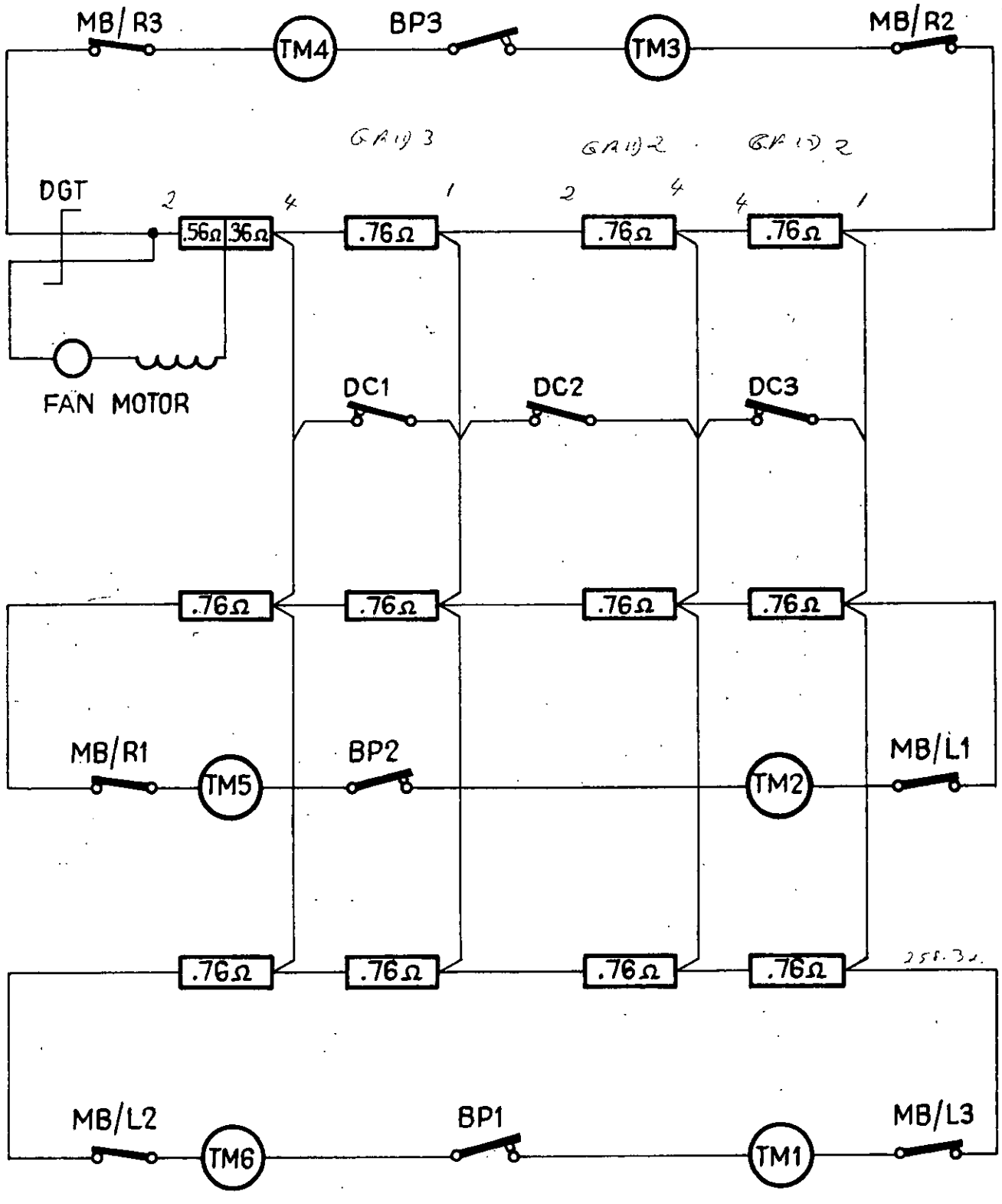

Fig. 7D-2 – Motor Armature Connections During Dynamic Braking, Simplified Schematic Diagram

Excitation current to the motor fields is controlled by the braking lever position and by the dynamic braking regulator module DR. The DR module senses a voltage across a portion of one braking grid which is proportional to braking grid current. The DR module operates to limit the excitation current to a value that prevents armature or grid current from increasing above the maximum safe current carrying capacity of the braking grids. Refer to description of the DR module for a detailed description of this regulating action.

The braking grids are cooled by an exhaust blower to prevent overheating. The blower motor is connected across a portion of one braking grid. The blower, located above the grids, draws outside air through a grill, circulates it around the grids, and exhausts to atmosphere. The DG module provides protection by dropping the feed to the brake relay B in case the blower motor fails to operate. Refer to description of the DG module for description of this protective action.

The DP module contains a motor field protection circuit MFP and a brake warning circuit BWR. The motor field protection circuit operates to protect the motor fields, if a fault in the excitation circuit permits motor field excitation current to rise above a safe value. The brake warning circuit is provided for backup protection of the braking grids. If a fault develops in the DR module, grid current may tend to rise and cause failure of the grids. If grid current increases above a safe value, the BWR circuit operates to decrease excitation which results in a decrease in grid current. Refer to description of the DP module for description of this protective action.

If a braking grid opens, the open circuit protection relay OCP detects an unbalance and operates to drop the feed to brake relay B. Dropping this feed disables the dynamic braking system. This prevents opening of the grid shorting contactors while carrying high current and it also protects the traction motors from excessively high voltages. After pickup, the OCP relay mechanically latches in and should not be reset until the braking grid circuit has been repaired.

The brake current transductor BCT provides a signal, to transformer T4, which is proportional to braking grid current. The output of T4 is used as an input to the DE module where it is compared with the field current signal. If the grid current signal is smaller than the field current signal, the DE module initiates pickup of a grid shorting contactor. If the grid current is larger than the field current signal, the DE module initiates dropout of a grid shorting contactor. Refer to description of the DE module for further details.

CONTENTS

The contents of Section 7 Part D are arranged in the following order:-

DE - Extended Range Dynamic Brake Module

DG - Dynamic Brake Grid Protection System

DP - Dynamic Brake Protection Module

DR - Dynamic Brake Regulator Module

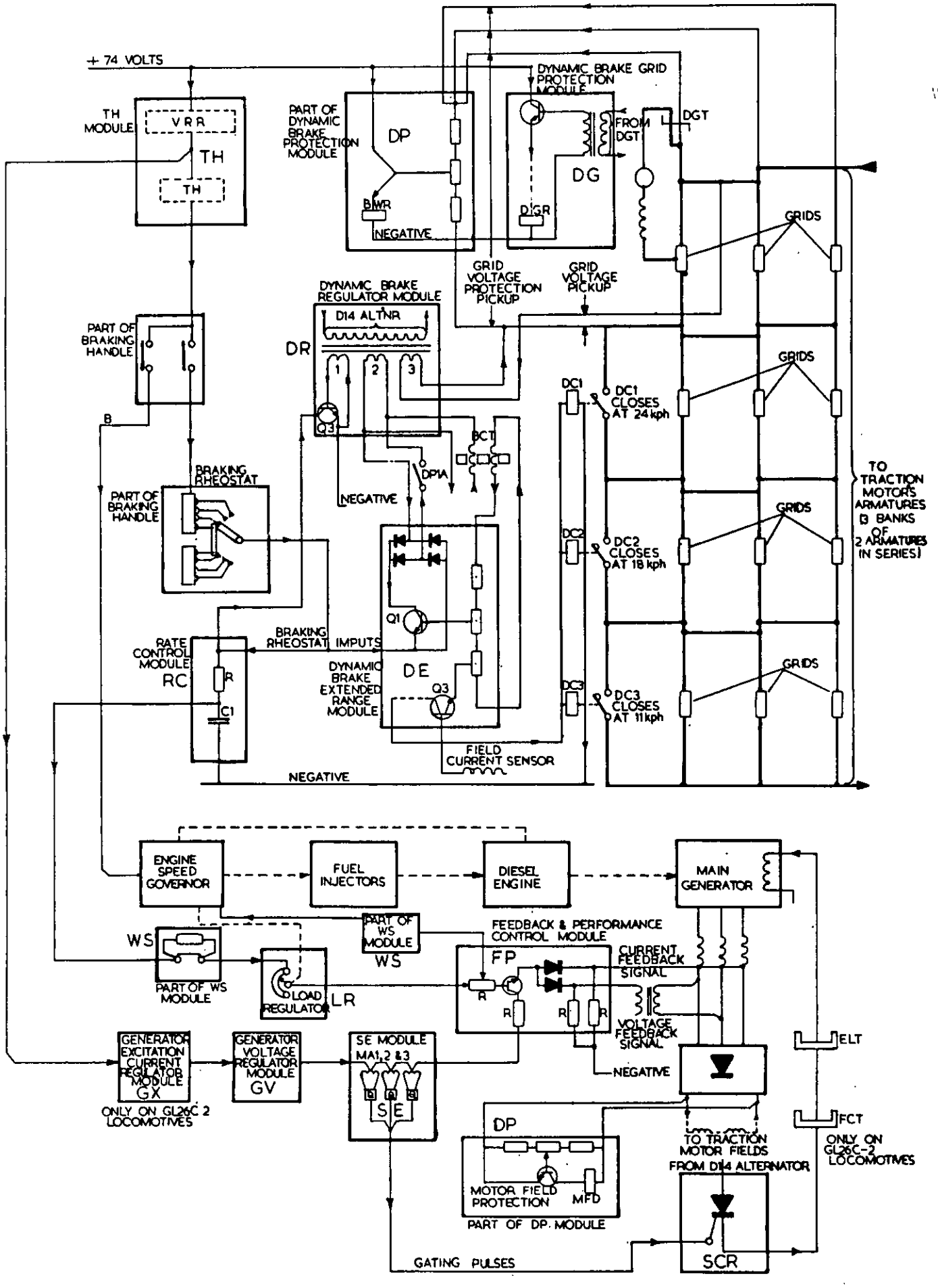

Fig 7D-3— Excitation and Braking Control System, Simplified Flow Diagram

GENERAL CIRCUIT DESCRIPTION OF MODULE OPERATION IN THE DYNAMIC BRAKING MODE

NOTE: The following description relates to components shown on the diagram opposite (7D-3).

1. In braking the diesel engine speed is kept constant at 645 rpm by energisation of the 'B' valve in the Engine Governor.

2. Excitation of the main generator is controlled by a signal received from the braking rheostat via the RC module, the WS module and the Load Regulator. This signal enters the Feedback and Performance Control Module, FP. This module effectively controls locomotive excitation.

3. The DR and DG Modules (shown opposite) provide protection for the high tension braking circuit;

   i. The DG module ensures that the Grid Fan is operating correctly via the DGT transductor. DGR relay in the DG module is energised causing Braking to cease if there is an abnormality.

   ii. The DR module reduces excitation if a strong signal is received in Winding 2 in the DR module in the case of high current via the BCT transductor or in Winding 3 in the DR module in the case of high voltage.

   iii The DP Module provides backup protection in the case of DR failure when the BWR relay in the DP module is energised due to Grid Voltage Buildup.

4. In EXTENDED RANGE DYNAMIC BRAKING MODE the DE Module and the DR Module combine to regulate the braking operation as follows:-

   (a) i. Interlock DP1A closes between the DR and DE Modules closing the circuit between winding 2 in the DR module and transistor Q1 in the DE module. This enables DE and DR modules to monitor grid current during Extended Range Dynamic Braking

   ii. Grid Voltage is monitored by the DR module in Winding 3. Windings 2 and 3 in the DR module affect Winding 1 which controls transistor Q1. Transistor Q1 controls capacitative discharge from Capacitor 1 in the RC module and this action regulates excitation signals to the FP module, thereby controlling locomotive excitation.

   (b) The DE module energises DC1, DC2 and DC3 contactors on separate impulses from the DE module transistor Q3. DE Q3 compares field current and grid current and switches on when grid current starts to fall as field current remains steady.

EXTENDED RANGE DYNAMIC BRAKE MODULE, DE (SPECIAL ORDER)

INTRODUCTION

On locomotivesequipped with basic dynamic brakes, maximum braking effort normally drops off rapidly at track speed below approximately 27 km per hour on locomotives equipped with 1.52 ohm dynamic braking grids.

However, on locomotives equipped with extended range dynamic brakes, the braking effort remains high until track speed decreases to approximately 8 to 11 kms per hour. High braking effort is maintained by shorting out a portion of the dynamic braking grids as track speed decreases.

The extended range dynamic brake module DE consists of comparison circuits and control circuits as necessary to short out the braking grids at the proper time to maintain high grid current and high braking effort. The DE module also contains a comparison circuit that operates to limit braking grid current to a value that is proportional to braking lever position while operating in the extended range dynamic braking mode.

GENERAL DESCRIPTION

GRID CURRENT CONTROL

An input signal proportional to braking lever position is applied to terminal 2 of the DE module. This signal is applied to the emitter of Q1, through resistor R3. Forward bias is applied to Q1 when the grid current signal rises above the braking lever signal. Turn on of Q1 connects terminal 4 to terminal 5 on the DE module.

Terminal 5 on the DE module is connected to terminal 5 on the DR module. Terminal 4 on the DE module is connected to terminal 4 on the DR module when the DP1A contacts at terminal 4 are closed. The DP1A contacts are closed during extended range dynamic brake operation. Therefore, during extended range dynamic brake operation, terminals 4 and 5 on the DE module are connected to terminals 4 and 5 on the DR module when Q1 on the DE module is turned on.

Connecting terminals 4 and 5 of the DE module to terminals 4 and 5 on the DR module results in forward bias to Q3 on the DR module. Turn on of Q3 discharges the rate control capacitors on the RC module. Refer to description of the DR module for a more detailed description of grid current regulation. Discharging the capacitors reduces excitation to the main generator field and results in less grid current. The grid current decreases until the grid current signal applied to the base of Q1 on the DE module is equal to or less than the braking lever signal applied to the emitter of Q1. Regulation of grid current to a value proportional to braking lever position is available at all track speeds as well as during extended range dynamic brake operation by shorting out the DP1A contacts to provide a direct connection from terminal 4 on the DE module to terminal 4 on the DR module and shorting DP1A contacts between terminal 6 on the DR module and terminal 8 on the RC module.

370 AMPERE – 1·52 OHM EXTENDED RANGE DYNAMIC BRAKES

The following general description applies to extended range dynamic brake operation for locomotives equipped with 1.52 ohm dynamic braking grids and braking lever in maximum brake position. The same general description is applicable when the braking lever is moved away from maximum brake position. However, braking effort, grid current, and field current decreases as the braking lever is moved away from maximum brake position. The braking grids are shorted out at a different track speed for each braking lever position. Refer to braking effort, grid current, and field current curves, Fig. DE-1.

At track speeds above approximately 27 km per hour, the field current is regulated by the dynamic brake regulator module DR as necessary to limit braking grid current to a maximum of 370 amperes. Refer to description of the DR module for description of this regulating action. Braking grid current is limited to a maximum of 370 amperes to prevent overheating of the braking grids. Regulation of grid current to a value proportional to braking lever position is available by special order from the customer.

Field current is limited to a maximum of 370 amperes, therefore, a decrease in track speed below 27 km per hour results in a decrease in grid current and a decrease in braking effort. This decrease is shown between point B and area C of Fig. DE-1. With basic dynamic brakes, braking effort would decrease rapidly along a line from point B to O on the braking effort curve as track speed decreases from 27 km per hour to standstill.

However, with extended range dynamic brakes a high level of grid current and braking effort is maintained until track speed decreases to approximately 11 km per hour. This improved braking effort with extended range dynamic brakes is obtained by shorting out a portion of the dynamic braking grids as track speed decreases. Shorting out a portion of the braking grids results in maintaining braking grid current near 370 amperes. Otherwise, braking grid current would decrease rapidly from point B to O as track speed decreases from 27 km per hour to standstill. Shorting out of the braking grids is controlled by the DE module.

The DE module consists of the necessary comparison circuits and control circuits to short out the braking grids at the proper time to maintain high grid current. A step by step operational description of the DE module is provided in Fig. DE-2. A simplified schematic diagram of the DE module, Fig. DE-3 is included for reference only. The applicable locomotive wiring diagrams should be used when performing troubleshooting or maintenance of the extended range dynamic braking system.

The grid current decreases from 370 amperes at 27 km per hour to approximately 310 amperes at 24 km per hour. This grid current decrease is shown by the line from point B to area C on the grid current curve of Fig. DE-1. The DE module senses this decrease in grid current and initiates pickup of grid shorting contactor DC1 and also places a fast discharge path across the rate control capacitors located on the rate control module RC. This permits partial discharge of the RC capacitors and results in a reduction of excitation to the main generator field. The reduced excitation results in fast reduction of field current as shown at area C of the field current curve in Fig. DE-1. This reduction in field current prevents excessive grid current when a portion of the braking grids are shorted out.

Pickup of DC1 shorts out a portion of the braking grids. Pickup of DC1 also removes the fast discharge path from the rate control capacitors. Removing the fast discharge path allows field current to increase to a maximum of 370 amperes as necessary to maintain a grid current of 370 amperes. This increase in field current is shown between area C and point D of the field current curve in Fig. DE-1.

Shorting out a portion the braking grid reduces the total/braking grid resistance by 25%. This results in a fast increase of grid current to 370 amperes, as shown at area C of the grid current curve in Fig. DE-1. The braking effort increases as track speed decreases from approximately 24 km per hour at area C to approximately 21 km per hour at point D, as shown by the braking effort curve in Fig. DE-1. This increase in braking effort is the result of maintaining constant power (I^2R) and a decrease in track speed. When power is constant, the retarding force or braking effort increases as track speed decreases.

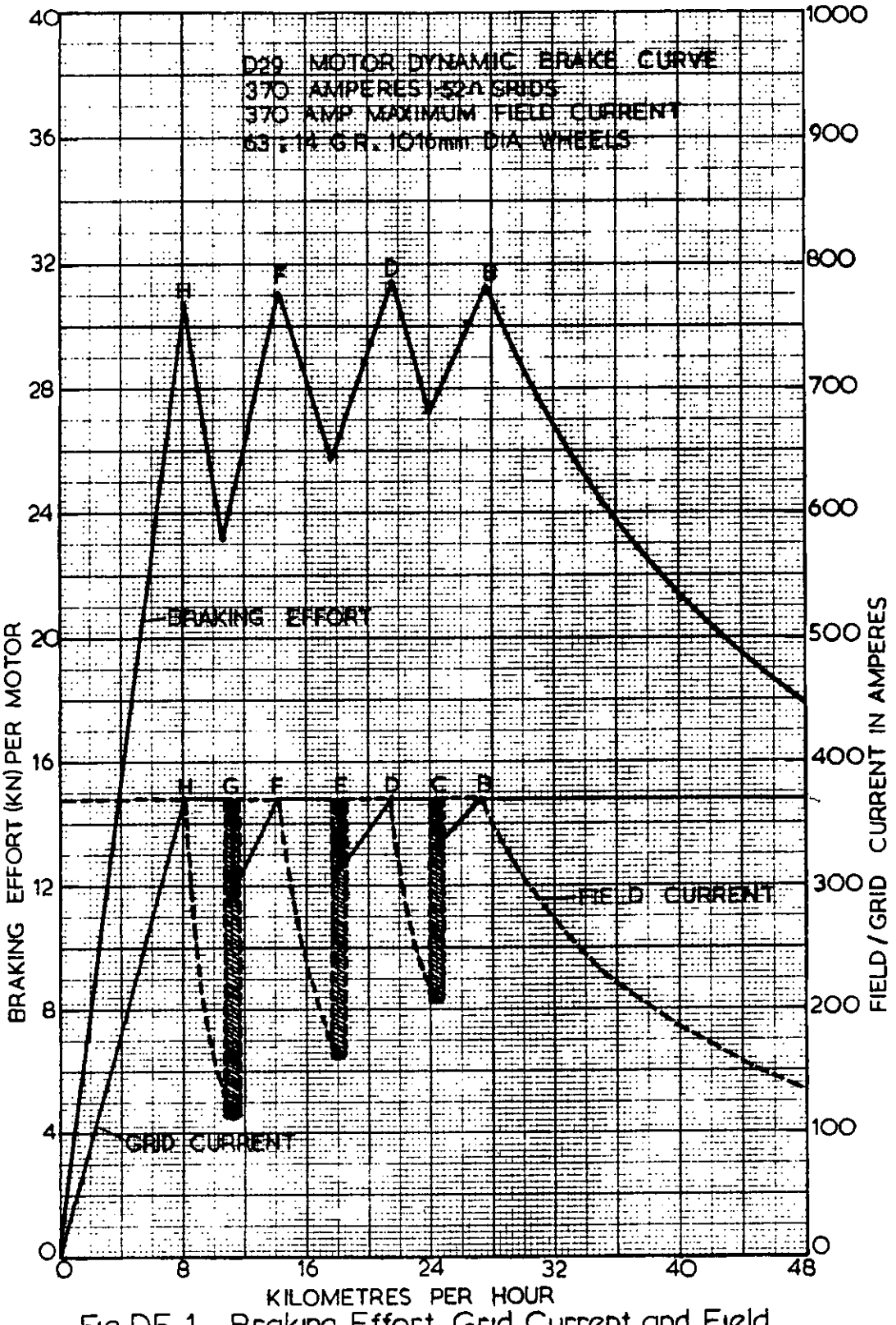

Fig DE 1 Braking Effort Grid Current and Field Current Curves for Extended Range Dynamic Brakes with 1·5ngrids

Field current and braking effort reach their maximum value at approximately 21 km per hour as shown at point D on the field current and braking effort curves in Fig. DE-1. A further decrease in track speed from approximately 21 km per hour at point D to approximately 18 km per hour at area E results in a decrease in grid current and braking effort. At area E the grid current has decreased to approximately 290 amperes. The DE module senses the decrease in current and initiates pickup of grid shorting contactor DC2 and also places a fast discharge path across the rate control capacitors. This results in partial discharge of the capacitors and reduces excitation to the main generator. The reduced excitation results in a fast reduction in field current as shown at area E of the field current curve in Fig. DE-1. The reduction in field current prevents excessive grid current when DC2 picks up.

Pickup of DC2 shorts out a second portion of the braking grid and also removes the fast discharge path from the rate control capacitors. Removing the fast discharge path allows field current to increase to a maximum of 370 amperes as necessary to maintain a grid current of 370 amperes. This increase in field current is shown between area E and point F of the field current curve in Fig. DE-1.

Shorting out the second portion of the braking grid reduces the remaining braking grid resistance by approximately 33%. This results in a fast increase of grid current to 370 amperes as shown at area E of the grid current curve in Fig. DE-1. The braking effort increases as track speed decreases from approximately 18 km per hour at area E to approximately 14 km per hour at point F as shown by the braking effort curve in Fig. DE-1. This increase in braking effort is the result of constant horsepower and a decrease in track speed.

Field current and braking effort again reach their maximum value at approximately 14 km per hour as shown at point F on the field current and the braking effort curves in Fig. DE-1. A further decrease in track speed from approximately 14 km per hour at point F to approximately 11 km per hour at area G results in a decrease in grid current and in braking effort. At area G the grid current has decreased to approximately 260 amperes. The DE module senses the decrease in current and initiates pickup of grid shorting contactor DC3 and also places a fast discharge path across the rate control capacitors which permits partial discharge of the capacitors and reduces excitation to the main generator field. The reduced excitation results in a fast reduction in field current as shown at area G of the field current curve in Fig. DE-1. The reduction in field current prevents excessive grid current when DC3 picks up.

Pickup of DC3 shorts out a third portion of the braking grid and also removes the fast discharge path from the rate control capacitors. Removing the fast discharge path allows field current to again increase to a maximum of 370 amperes as necessary to maintain a grid current of 370 amperes.

This increase in field current is shown between area G and point H on the field current curve in Fig. DE-1.

Shorting out the third portion of the braking grid reduces the remaining braking grid resistance by approximately 50%. which results in a fast increase of grid current to 370 amperes as shown at area G of the grid current curve in Fig. DE-1. The braking effort increases as track speed decreases from approximately 11 km per hour at area G to approximately 8 km per hour at point H as shown by the braking effort curve in Fig. DE-1. This increase in braking effort is the result of maintaining constant horsepower as track speed decreases.

The field current and braking effort again reach their maximum value at approximately 8 km per hour as shown at point H on the field current and braking effort curves in Fig. DE-1. A further decrease in track speed below 8 km per hour results in a decrease in grid current and in braking effort as shown between points H and O on the grid current and braking effort curves in Fig. DE-1.

OPERATION OF THE DE MODULE

An input signal, from transformer T4, which is proportional to braking grid current is applied between terminals 7 and 11 of the DE module. This signal is rectified and applied to a voltage divider consisting of resistors R5, R6, R7, R8, R9, R10, and R11. A portion of the grid current signal from the voltage divider is applied to the emitter of solid state switch Q3. A smaller portion of the grid current signal is applied to the base of solid state switch Q2.

A feedback signal, from the performance control module, which is proportional to traction motor field current is applied between terminals 6 and 14 of the DE module. The traction motor field current signal is applied to the base of Q3 and to the emitter of Q2. Therefore, the grid current signal is compared with the traction motor field current signal by solid state switches Q3 and Q2.

The power supply for solid state switches Q3 and Q2 is provided by transformer T1. The D14 alternator input to transformer T1 is applied between terminals 8 and 10 of the DE module. Transformer T1 contains two secondary windings, one for each solid state switch. The voltage applied to the primary of T1 is limited to 10 volts by zener diodes Z1 and Z2 along with resistors R1 and R2.

The traction motor field current signal is constant at all speeds for a given braking lever position. The signal increases as the braking lever is advanced. The grid current signal increases with speed, until the maximum value of grid current allowed by the DR module is attained.

Assume that the braking lever is in maximum brake position and track speed is above 29 km per hour. Under these conditions, the grid current signal applied to the emitter of Q3 is larger than the field current signal applied to the base of Q3. This keeps Q3 cut off and no current flows through T1A secondary or T3 primary.

The sequence of events that occur during extended range dynamic brake operation for locomotives equipped with 1.52 ohm braking grids is given in Fig. DE-2.

Shorting out the different braking grid sections occurs at different track speeds for different braking grid resistance values. A simplified schematic diagram of the DE module, Fig. DE-3 is provided for reference only. The applicable locomotive wiring diagrams should be used when performing troubleshooting or maintenance on the extended range dynamic braking system.

Step	Procedure or Condition	Result of Procedure or Condition
	OPERATION OF DE MODULE DURING DECREASING TRACK SPEED	
1	Assume that braking lever is in maximum brake position and track speed is above 27 km per hour.	The grid current signal at emitter of Q3 is larger than the field current signal at the base of Q3. Q3 is reverse biased.
2	Assume that track speed decreases to 24 km per hour.	The grid current signal decreases while field current signal remains the same. Q3 is forward biased.
3	Q3 forward biased.	Current flows through T1A secondary and primary of T3.
4	T3 energised.	Q4 is forward biased by rectified output of T3. Refer to sheet 2 of 2, Fig. DE-4.
5	Forward bias on Q4.	Current flows from terminal 1 of DE module, through Q4, D9, and R32 to negative. C3 charges through R33 until voltage across C3 is sufficient to cause reverse conduction through zener diode Z6. Breakdown voltage of Z6 is 47 volts.

FIG. DE-2 — OPERATION OF THE DE. MODULE (SHEET 1 OF 8)

Step	Procedure or Condition	Result of Procedure or Condition
6	Charge on C3 causes Z6 to conduct.	Forward bias applied to Q11. Q12 is forward biased through R37.
7	Q11 and Q12 turned on.	Forward bias applied to Q8 by connecting base of Q8 to negative through D8, R36, Q11 and Q12.
8	Forward bias on Q8.	Current flows from terminal 1 of DE, through Q4, Z4, Q8, D14, and coil of relay DP1. DP1 picks up. NOTE: Charging of C3 in Step 5 provides a short time delay which prevents pickup of DP1 from transient voltages in T3.
9	DP1 picked up.	Provides holding feed to DP1 (1NC-1NO) through forward biased Q10. Places forward bias on Q13 and provides charging path for C4 and C5 (3C-3NO) through A-B of DC1. Provides feed to DP1A (3C-3NO) Provides feed to DC1 (2C-2NO). DC1 picks up after a short inherent time delay.
10	Forward bias on Q13.	Provides fast discharge path for rate control capacitors (on RC module) to prevent excessive spikes in grid current when DC1 picks up to short out one braking grid.
11	Charge placed on C4 and C5 (Step 9).	Places forward bias on Q6 when charge on C4 and C5 rises above breakdown value of zener diode. Z8.
12	Forward bias on Q6.	Provides feed to TD relay and places reverse bias on Q12.
13	DC1 picked up (Step 9).	Removes forward bias from Q13 which opens fast discharge path for RC capacitors on the RC module (A-B). These contacts also remove charging current from C4 and C5.

FIG. DE-2-OPERATION OF THE DE MODULE (SHEET 2 OF 8)

Step	Procedure or Condition	Result of Procedure or Condition
13	(Cont'd)	Shorts out one dynamic braking grid (main contacts). Provides feed to DC1A and DC1B (E-F). These contacts also provide a feed to light emitting diode DC1 on the DE module.
14	TD relay energised (Step 12).	Disables grid overcurrent detector circuit on DP module to prevent operation of BWR due to grid current spikes when braking grid is shorted out by pickup of DC1 (2). Provides a fast charging path for the RC capacitors on the RC module for fast recovery of grid current (1).
15	Reverse bias on Q12.	Provides open circuit to base of Q8. This prevents a feed to DP2 when DC1B picks up. This forces a short time delay between pickup of DC1 and DC2.
16	Open circuit to base of Q8	Drops main feed to DP1. DP1 remains picked up by holding feed.
17	Dynamic braking grid shorted out (Step 13).	Grid current increases due to reduced resistance in braking grid circuit. Grid current increase results in maintaining high braking effort.
18	DC1A picked up (Step 13)	Recalibrates the grid current signal applied to emitter of Q3. This provides reverse bias to Q3.
19	Reverse bias on Q3.	Blocks current flow through T1A secondary and T3 primary. This results in turn off of Q4.
20	DC1B picked up (Step 13).	Sets up circuit to DP2 in preparation for shorting out a second braking grid in case track speed decreases.

FIG-DE2—OPERATION OF THE DE MODULE (SHEET 3 OF 8)

Step	Procedure or Condition	Result of Procedure or Condition
21	Assume that track speed decreases to approximately 21 km per hour.	Grid current signal decreases while the field current signal remains the same. This places forward bias on Q3.
22	Procedures and conditions of Steps 3 through 17 are repeated except:- a. Substitute DP2 for DP1: b. Substitute DC2 for DC1: c. Substitute DC2A for DC1A d. Substitute DC2B for DC1B e. Substitute light emitting diode DC2 for emitting diode DC1.	
23	DC2A picked up.	Q3 turned off by recalibrating grid current signal applied to emitter of Q3. Recalibrates grid current signal to base of Q2. This prevents turn on of Q2 until track speed increases.
24	DC2B picked up.	Sets up circuit to DP3 and provides a holding circuit to DP1 to ensure that DP1 remains picked up until DC2B drops out.
25	Assume that track speed decreases to approximately 18 km per hour.	Grid current signal decreases while the field current signal remains the same. This places forward bias on Q3.
26	Procedures and conditions of Steps 3 through 17 are repeated except:- a. Substitute DP3 for DP1: b. Substitute DC3 for DC1: c. Substitute DC3A for DC1A d. Substitute light emitting diode DC3 for light emitting diode DC1.	

FIG-DE-2-OPERATION OF THE DE MODULE (SHEET 4 OF 8)

Step	Procedure or Condition	Result of Procedure or Condition
27	DC3A picked up.	Recalibrates grid current to base of Q2. This prevents turn on of Q2 until track speed increases. Provides holding circuit for DP2 to ensure that DP2 remains picked up until DC3A drops out.
	OPERATION OF DE MODULE DURING INCREASING TRACK SPEED	
1	Assume that braking lever is in position 8 and track speed is below 8 km per hour.	All DP and DC relays and contactors are picked up.
2	Assume that track speed increases to approximately 11 km per hour.	Grid current increases to 370 amperes to about 8 km per hour. The DR module limits grid current to 370 amperes by decreasing excitation. The increase in grid current and decrease in field current places forward bias on Q2 and reverse bias on Q3.
3	Forward bias on Q2.	Current flows through T1B secondary and T2 primary.
4	T2 energised.	Q5 is forward biased by rectified output of T2.
5	Forward bias on Q5.	Current flows from terminal 1 of DE module, through Q5, D11 and R32 to negative and capacitor C3 is charged through R33 until voltage across C3 is sufficient to cause reverse conduction through zener diode Z6. Breakdown voltage of Z6 is 47 volts.
6	Reverse conduction through Z6.	Forward bias is placed on Q11. Q12 is normally forward biased through R37.
7	Forward bias on Q11	Places forward bias on Q9.

FIG-DE2—OPERATION OF THE DE MODULE (SHEET 5 OF 8)

Step	Procedure or Condition	Result of Procedure or Condition
8	Forward bias on Q9.	Current flows from terminal 1 of DE, through Q5, Q9, and R30. This places reverse bias on Q10 which is normally forward biased.
9	Reverse bias on Q10.	Drops feed to DP3. Feed to DP1 and DP2 is maintained by DC2B and DC3A.
10	DP3 drops out.	C4 and C5 charge through R40. This places forward bias on Q6 when the charge rises above 27 volts. DC3 drops out after a short inherent time delay.
11	Forward bias on Q6.	Places reverse bias on Q12 which removes forward bias from Q9. Cut off of Q9 places forward bias on Q10. TD relay picks up which prevents operation of BWR in the DP module and also provides a fast charging path for the RC capacitors in the RC module. This fast rate of charge provides for fast increase in excitation. TD contacts remain picked up for a short time after C4 and C5 discharge to cut off Q6.
12	Forward bias on Q10.	Provides holding circuit for DP2.
13	DC3 drops out after a short inherent time delay (Step 10).	Removes short circuit from one braking grid which increases effective braking grid resistance and decreases grid current. Removes charging current from C4 and C5 causing Q6 to cut off when charge on C4 and C5 falls below 27 volts. Removes feed from DC3A causing DC3A to drop out. Light emitting diode DC3 on DE module goes out.

FIG-DE2—OPERATION OF THE DE MODULE (SHEET 6 OF 8)

Step	Procedure or Condition	Result of Procedure or Condition
14	Q6 cuts off.	TD drops out. Dropout of TD enables BWR to operate in a normal manner and also removes fast charging path for RC capacitors on the RC module.
15	DC3A drops out (Step 13).	Recalibrates grid current signal to base of Q2 which places reverse bias on Q2 until grid current signal increases. Drops DP2 holding feed from terminal 1 of DE. Holding feed for DP2 is maintained through Q10.
16	Assume that track speed increases to approximately 24 km per hour.	Grid current increases to 370 amperes at about 21 km per hour. The DR module limits grid current to 370 amperes by decreasing excitation as speed increases. The decrease in field current and increase in grid current places forward bias on Q2.
17	Procedures and conditions of Steps 3 through 14 are repeated except: a. Substitute DP2 for DP3: b. Substitute DC2 for DC3: c. In Step 9 feed is not maintained to DP2: d. Substitute DC2A and DC2B for DC3A.	
18	DC2A Drops out.	Recalibrates grid current signal applied to Q2 and Q3. This places reverse bias on Q2 until grid current signal increases.
19	DC2B drops out.	Drops DP1 holding feed from terminal 1 of DE. Holding feed for DP1 is maintained by Q10.
20	Assume that track speed increases to approximately 34 km per hour.	Grid current increases to 370 amperes at about 29 km per hour. The DR module limits grid current to 370 amperes by decreasing excitation as speed increases. The decrease in field current signal places forward bias on Q2.

FIG-DE2 - OPERATION OF THE DE MODULE (SHEET 7 OF 8)

Step	Procedure or Condition	Result of Procedure or Condition
21	Procedures and conditions of Steps 3 through 14 are repeated except: a. Substitute DP1 for DP3: b. Substitute DC1 for DC3: c. In Step 9, feed is not maintained to DP1 and DP2: d. In Step 12, feed is not provided to DP2: e. Substitute DC1A and DC1B for DC3A.	
22	DC1A drops out.	Recalibrates grid current signal applied to Q3.
23	DC1B drops out.	This prevents pickup of DP2 relay until DC1 again picks up.

FIG-DE2—OPERATION OF THE DE MODULE (SHEET 8 OF 8)

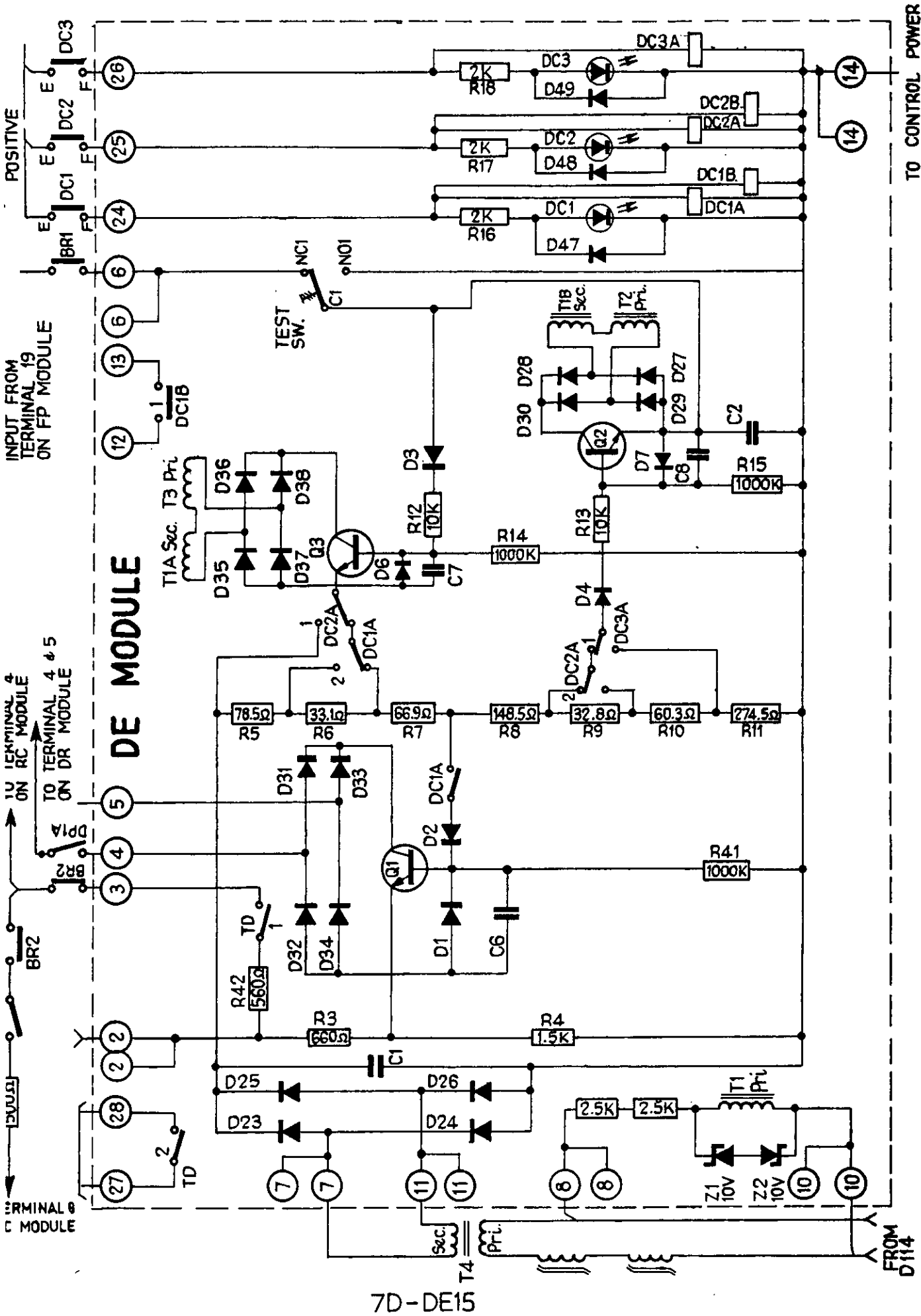

Fig. DE3 - Extended Range Dynamic Brake Module DE, Simplified Schematic Diagram (Sheet 1 of 2)

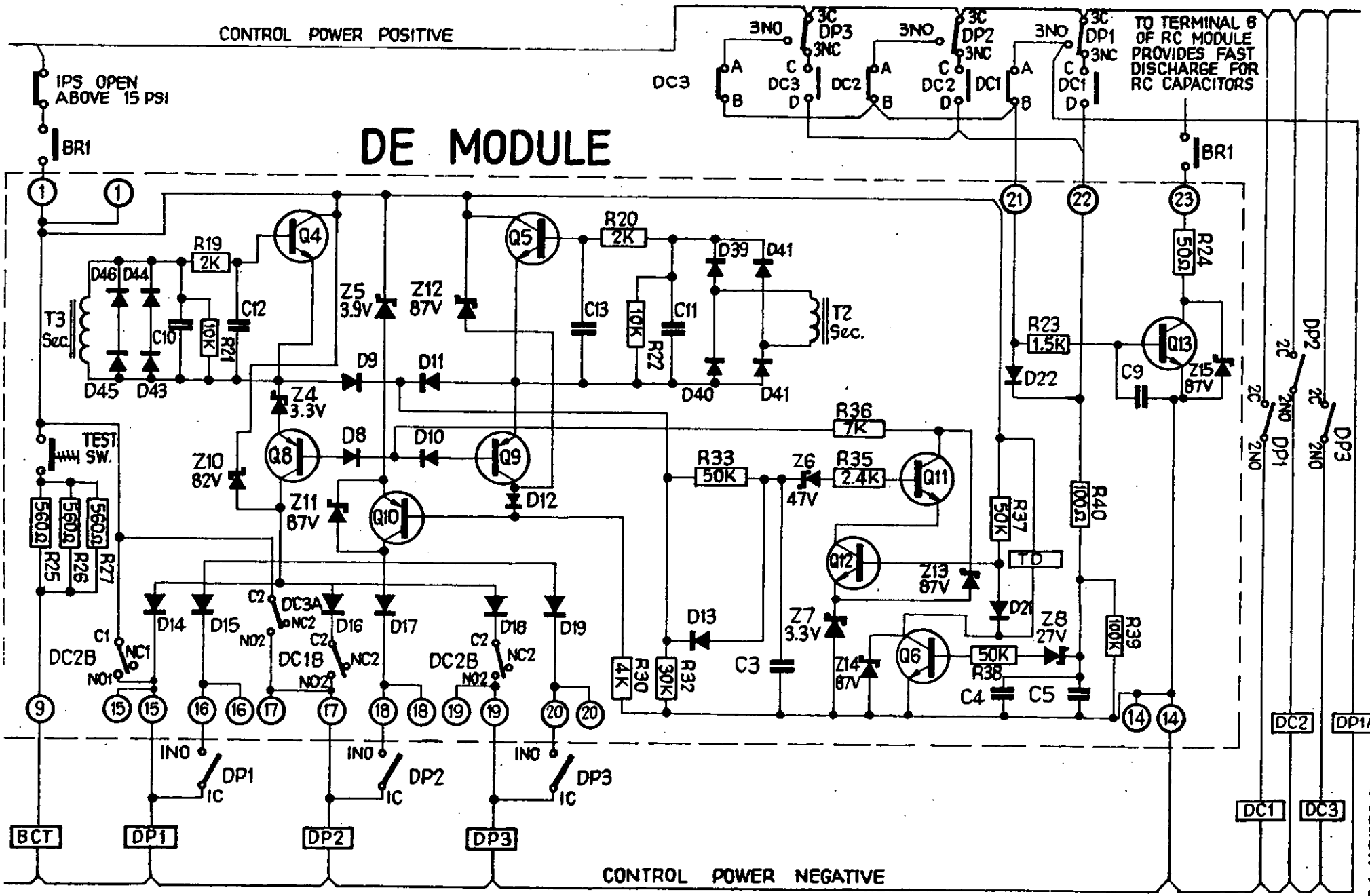

Fig. DE-3 – Extended Range Dynamic Brake Module DE, Simplified Schematic Diagram (Sheet 2 of 2)

DYNAMIC BRAKING GRID PROTECTION SYSTEM (SPECIAL ORDER)

INTRODUCTION

The purpose of this section is to describe the operation of the dynamic braking grid protection system consisting of the dynamic braking grid protection module DG10 and the dynamic braking grid transductor DGT.

The dynamic braking grid protection module DG10 provides protection for the dynamic braking grids by dropping the feed to the generator field contactor GFC, in case of failure in the grid blower motor circuit, during dynamic brake operation or when performing self load test on the dynamic braking grids. Simplified schematic diagrams of the protection system are provided for convenient reference only. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance on the system.

DYNAMIC BRAKING GRID TRANSDUCTOR, DGT

The dynamic braking grid transductor DGT consists of two laminated iron cores, two AC windings, a test winding, and two bias windings. The two cores are magnetically isolated from each other by an air gap and each core contains an AC winding. The test winding and both bias windings are common to both cores. A simplified schematic diagram of the DGT is provided in Fig. DG-1.

The two AC windings are connected series opposing so that the magnetic lines of force in the two cores travel in opposite directions. The AC windings in series with the primary of transformer T1 on the DG module, are energised by current from the D14 alternator.

The reactance of the AC windings is much larger than the reactance of T1. Therefore, during normal operation, practically all of the input AC voltage is developed across the AC windings and very little voltage appears across T1.

Transformer T1 provides an input signal to the DG module. Consequently, the input signal to the DG module is very small during normal operation.

GP MODEL LOCOMOTIVES (GL22C-2 & GL26C-2)

The blower motor bias winding consists of five turns connected in series with the blower motor. The grid current bias winding consists of 2 turns passing through both cores and connected in series with the braking grids.

During normal operation, the flux lines set up by the blower motor bias winding and the grid current bias winding are equal and opposite in both cores, so that the resultant flux lines set up by the two bias windings is near zero. However, if an open circuit develops in the blower motor windings, no current would flow through the blower motor bias winding and the flux lines set up by the two bias windings would be unbalanced.

An increase in blower current without a corresponding increase in grid current would result in an unbalance in flux lines set up by the two bias windings. This condition could result from a frozen bearing or from locked fan blades in the blower motor. Either of these conditions would probably result in burning out the blower motor windings.

OPERATION

During any unbalance in bias, the resultant flux lines would aid the flux lines from the AC winding in one core and oppose the flux lines from the AC windings in the other core. The core in which the flux lines aid would move toward magnetic saturation which would reduce the reactance of the AC winding on this core to near zero.

The core in which the flux lines oppose would move away from saturation, but the reactance of the winding on this core would be affected by only a very small amount. The resultant reactance of the two AC windings would be only about one-half of the reactance that exists during normal operation. This causes a large increase in current through the two AC windings and through the primary of transformer T1 on the DG module. The increase in current through T1 provides a signal to the DG module which results in dropping the brake contactor B. Dropout of the B contactor removes braking current from the braking grids.

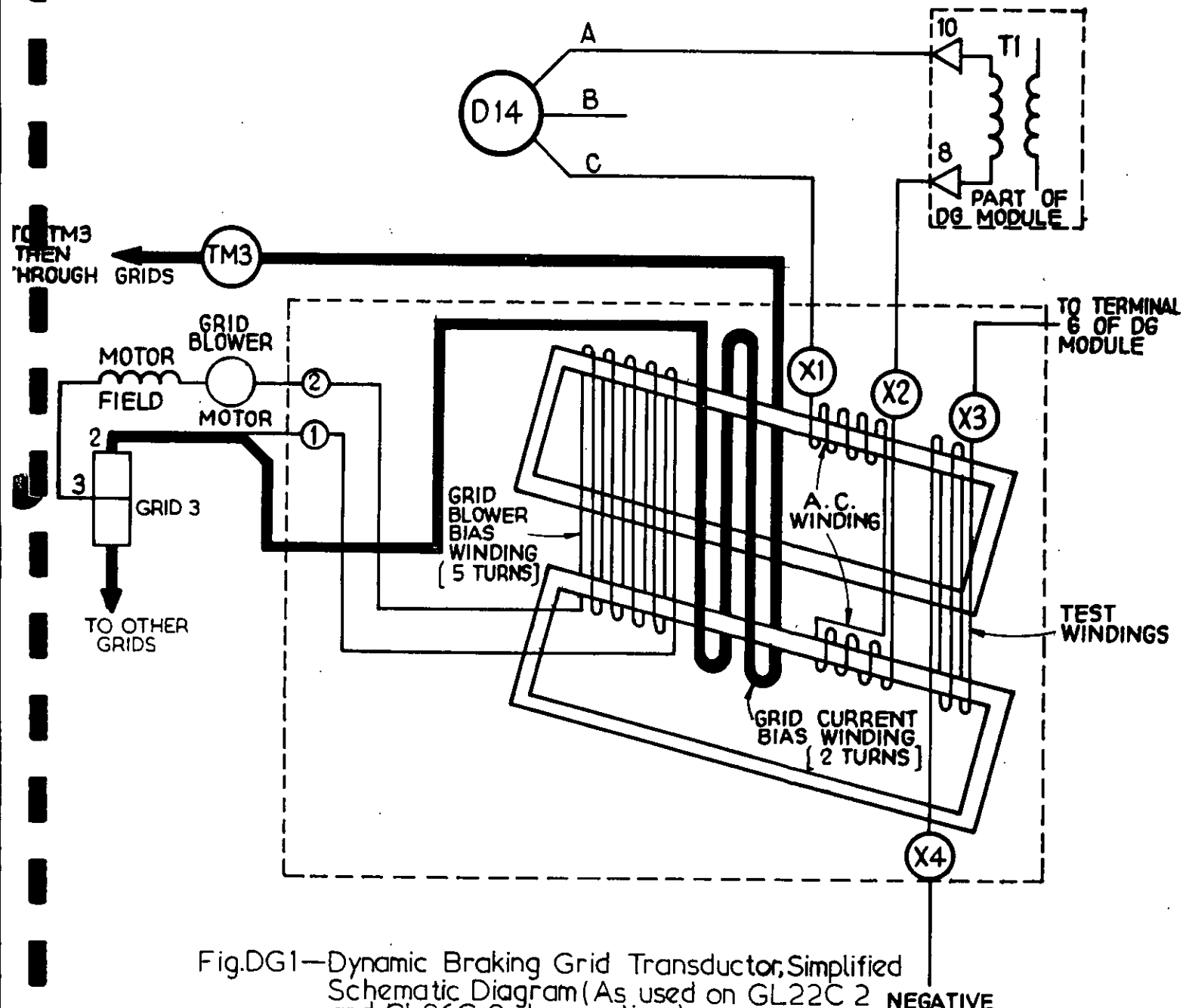

Fig.DG1—Dynamic Braking Grid Transductor, Simplified Schematic Diagram (As used on GL22C 2 and GL26C 2 locomotives)

The test winding on DGT is provided for testing the dynamic braking grid protection system. Closing the test switch on the DG module allows current to flow through the test windings. Current flow through the test windings causes an unbalance of flux lines in the two cores and a signal to T1 results.

DYNAMIC BRAKING
GRID PROTECTION MODULE DG 10

A simplified schematic diagram of the DG module is provided in Fig. DG-2 for convenient reference only. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance on the system.

The output voltage of transformer T1, which is proportional to the amount of unbalance between the bias windings on DGT, is rectified and applied to rheostat RH1. Capacitor C2 suppresses transient surges in the output of T1. The voltage at the wiper arm of RH1 is applied to the series combination of resistor R4B, R4A, and capacitor C1. The junction of R4A and C1 is connected to the base of transistor Q1 so that the voltage across C1 is applied to the base of Q1.

Forward bias is applied to transistor Q1 when the charge on C1 exceeds 6.2 volts. The RC circuit consisting of R4B, R4A, and C1 provides a time delay in applying forward bias to Q1. This time delay prevents turn on of Q1 from transient bias unbalance of DGT.

Turn on of Q1 provides a path for current flow from terminal 1 of the DG module through R7, R10, D7, from collector to emitter of Q1, then through zener diode Z1 to negative. The voltage developed across R7 provides forward bias for Q2. Turn on of Q2 provides a path for current flow from terminal 1 of the DG module through R9, from collector to emitter of Q2, then through the DGR relay to negative. Pick up of DGR provides a holding feed through the reset switch and DGR-2 contacts. Pickup of DGR also opens DGR-1 contacts between terminals 5 and 4 of the DG module and closes DGR-1 contacts between terminals 5 and 3 on the DG module. Closing DGR-2 contacts between terminals 5 and 3 provides a feed to the annunciator module.

Opening DGR-1 contacts between terminals 5 and 4 on the DG module drops the feed to the DGX relay during dynamic brake operation or when performing self load test on the dynamic braking grids. Dropout of DGX drops the feed to the B contactor and to the generator field contactor GFC. Dropout of GFC removes excitation from the main generator field. Dropout of the B contactor opens the circuit to the motor fields.

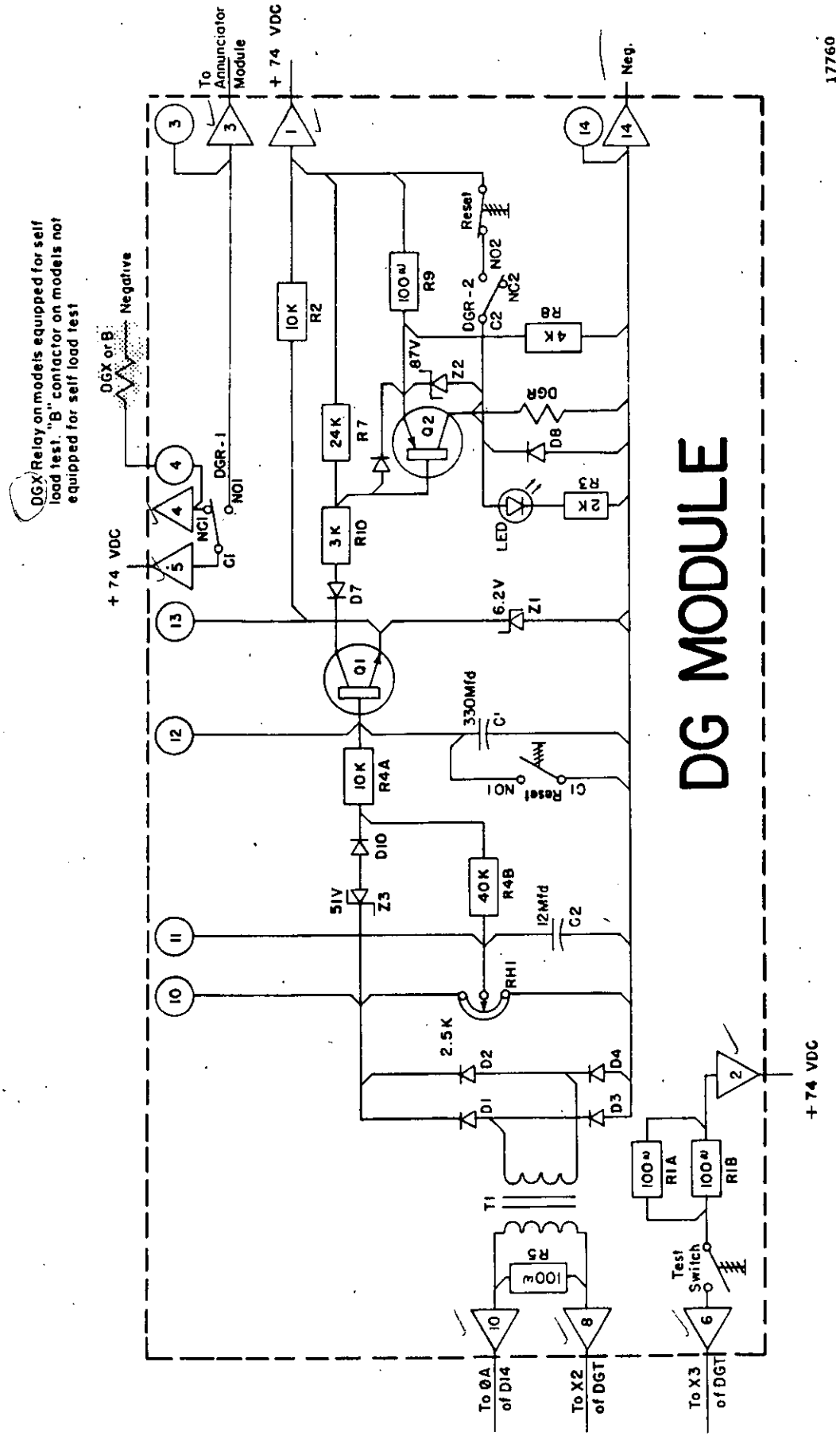

Fig. DG-2 – Dynamic Braking Grid Module DG, Simplified Schematic Diagram

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LOCOMOTIVES NOT EQUIPPED FOR SELF LOAD TEST

Opening DGR-1 contacts between terminal 5 and 4 on the DG module drops the feed to the B contactor during dynamic brake operation. Dropout of the B contactor opens the circuit to the motor fields and drops the feed to the generator field contactor GFC. Dropout of GFC removes excitation from the main generator field.

TEST CIRCUIT

A test switch and a reset switch are provided on the DG module. The test switch, when pressed energises the test winding on the DGT which unbalances the flux lines in the two cores of DGT. This provides an input to transformer T1 and causes DGR to pickup. This provides a means of performing a functional test of the DG module and also of DGT. The reset switch provides a means of resetting the DGR relay after a test or after pickup of DGR due to a blower motor fault. However, the reset switch should not be operated, after pickup of DGR due to a fault, until the dynamic braking system has been checked and repaired as necessary.

DYNAMIC BRAKE PROTECTION MODULE, DP

INTRODUCTION

The dynamic brake protection module DP11 provides backup protection for the traction motor fields and the dynamic braking resistor grids in case a fault develops in the dynamic braking regulator module DR. The DP module operates to remove excitation from the main generator field in case motor field excitation or the dynamic braking grid current rises above a safe value.

A simplified schematic diagram of a typical dynamic brake protection module is provided in Fig. DP-1 for convenient reference. The function of components located on the DP module is given in Fig. DP-2 and the function of terminals located on the DP module is given in Fig. DP-3. The applicable locomotive wiring diagram should be used when performing troubleshooting or maintenance.

MOTOR FIELD PROTECTION CIRCUIT

The motor field protection circuit, Fig. DP-1, is connected across the main generator, in parallel with the traction motor fields, during dynamic braking. Therefore, the motor field protection circuit detects any change in excitation voltage applied to the traction motor fields.

During dynamic braking, zener diode Z8, in series with resistors R15 and R19, maintains 6.2 volts on the emitter of transistor Q5. Current flows from terminal 3 of DP through the voltage divider consisting of resistors R19, R16, R17, R18, and rheostat RH2, then to terminal 12 of DP. The base of Q5 is connected to the wiper arm of RH2 so that the voltage applied to the base of Q5 is directly proportional to the excitation voltage applied to the traction motor fields. Transistor Q5 is reverse biased during normal operation. However, if a fault develops in the dynamic braking regulator module DR, the excitation voltage applied to the traction motor fields may tend to rise above a safe value. Any increase in excitation voltage results in an increase in voltage at the wiper arm of RH2. Transistor Q5 will become forward biased if the excitation voltage rises above a safe value.

With forward bias on Q5, current flows through the motor field protection relay MFP causing pickup of MFP. Pickup of MFP opens the normally closed contacts of MFP1, and closes the normally open contacts of MFP1 and MFP2.

Opening the normally closed contacts of MFP1 drops the feed to the equipment protection relay EQP. Closing the normally open contacts of MFP2 recalibrates the motor field protection circuit by shorting out resistor R16. Closing the normally open contacts of MFP1 provides a positive potential to the motor fieldannunciator relay MFA and to resistor R21.

Drop out of EQP drops the feed to the generator field contactor GFC which removes excitation voltage from the main generator field and results in a drop in the main generator output voltage. The inductance of the main generator field windings prevent an immediate collapse of current through the field. The decrease in output voltage of the main generator results in a reduction of voltage applied to the base of Q5. This reduction in voltage causes Q5 to become reverse biased. Reverse bias on Q5 blocks the current flow through MFP causing MFP to drop out. Dropout of MFP re-establishes the feed to EQP and results in re-applying excitation voltage to the main generator field. If the fault persists and excitation voltage to the traction motor fields rises above a safe value, Q5 will again be forward biased causing pickup of MFP. This results in removing excitation voltage from the main generator field causing a reduction in the excitation voltage to the traction motor fields. This pickup and dropout of MFP continues as long as the fault persists with dynamic brakes applied. Operation of the dynamic brakes may be continued, but the regulation will be very coarse. The fault should be corrected as soon as practical.

Recalibrating the motor field protection circuit, by shorting out R16, applies a larger forward bias to Q5 so that MFP will remain picked up until the excitation voltage to the traction motor fields drops several volts below the safe value. Therefore, the recalibration prevents rapid cycling of the MFP relay, the EQP relay, and the GFC contactor.

GRID OVERCURRENT PROTECTION CIRCUIT

The grid overcurrent protection circuit, Fig. DP-1, consists of a detector circuit and a trigger circuit. The detector circuit, connected across a portion of one dynamic braking resistor grid, turns on the trigger circuit if a grid overcurrent condition is detected. The trigger circuit then operates to remove excitation from the main generator field.

The input voltage, from the dynamic braking resistor grid, to the detector circuit is applied through blocking rectifiers D11 through D14 to two voltage divider circuits. One of the voltage dividers consists of resistors R11, R12, R13, and rheostat RH1. The other voltage divider consists of resistor R8 and zener diode Z6.

The voltage applied to the emitter of transistor Q4 is limited to 49.6 volts by zener diode Z6. The base of Q4 is connected to the wiper arm of RH1 so that the voltage applied to the base of Q4 is directly proportional to the input voltage from the dynamic braking resistor grids. During normal operation, the voltage applied to the base is less than 49.6 volts and reverse bias is applied to Q4. However, if the braking resistor grid current rises above a safe value, the voltage applied to the base of Q4 increases above 49.6 volts and forward bias is applied to Q4.

When Q4 turns on, current flows through the secondary of transformer T1 in series with the primary of transformer T2. The rectified output of T2 applied forward bias, through resistor R1, to transistor Q1. With forward bias on Q1, current flows from terminal 1 of the DP module to the collector of Q1, from collector to emitter of Q1, then through the BWR relay to negative. Current also flows through diode D1 and resistor R2 to charge capacitor CA2. Forward bias is applied to the base of transistor Q3 when the charge on CA2 is sufficient to cause reverse condition through zener diode Z2.

Forward bias on Q4 results in immediate pickup of BWR, but the time delay provided by R2 and CA2 is sufficient to prevent turn on of Q3 by a single short-time duration spike in the grid current. However, three or more short-time duration spikes that are closely spaced will result in turn on of Q3. Any grid overcurrent condition lasting longer than approximately one or two seconds will result in turn on of Q3.

Pickup of BWR drops the feed to the EQP relay. Dropout of EQP drops the feed to the generator field contactor GFC which removes excitation voltage from the main generator field. The inductance of the main generator field windings prevents an immediate collapse of current through the field. Removing excitation voltage from the main generator field results in a decrease of braking grid current. The decrease in braking grid current tends to apply reverse bias on Q4 as the current decreases below the maximum safe value. However, pickup of BWR recalibrates the detector circuit so that forward bias on Q4 is maintained until the braking grid current decreases to several amperes below the maximum safe value. This recalibration prevents rapid cycling of the detector circuit, BWR, EQP, and the GFC contactor.

Pickup of BWR and forward bias on Q3 allows current flow from terminal 1 of the DP module, through the BWA relay coil, from collector to emitter of Q3, then to negative at terminal 14. Pickup of BWA provides a feed to the brake warning light and to terminal 17 of the DP module. The feed to terminal 17 may be applied to a brake warning annunciator circuit.

Voltage Spikes occur in the braking grids when shorting contactors close during extended range dynamic brake operation. Pickup of time delay relay TD on the DE module recalibrates the DP module, by connecting terminal 20 to terminal 28 on the DP module. This recalibration disables the grid current protection circuit to prevent turn on of Q4 by transient voltage spikes during pickup and for a short time after pickup of the grid shorting contactors. This time delay provides time for grid voltage spikes to dissipate. For further details refer to description of the DE module.

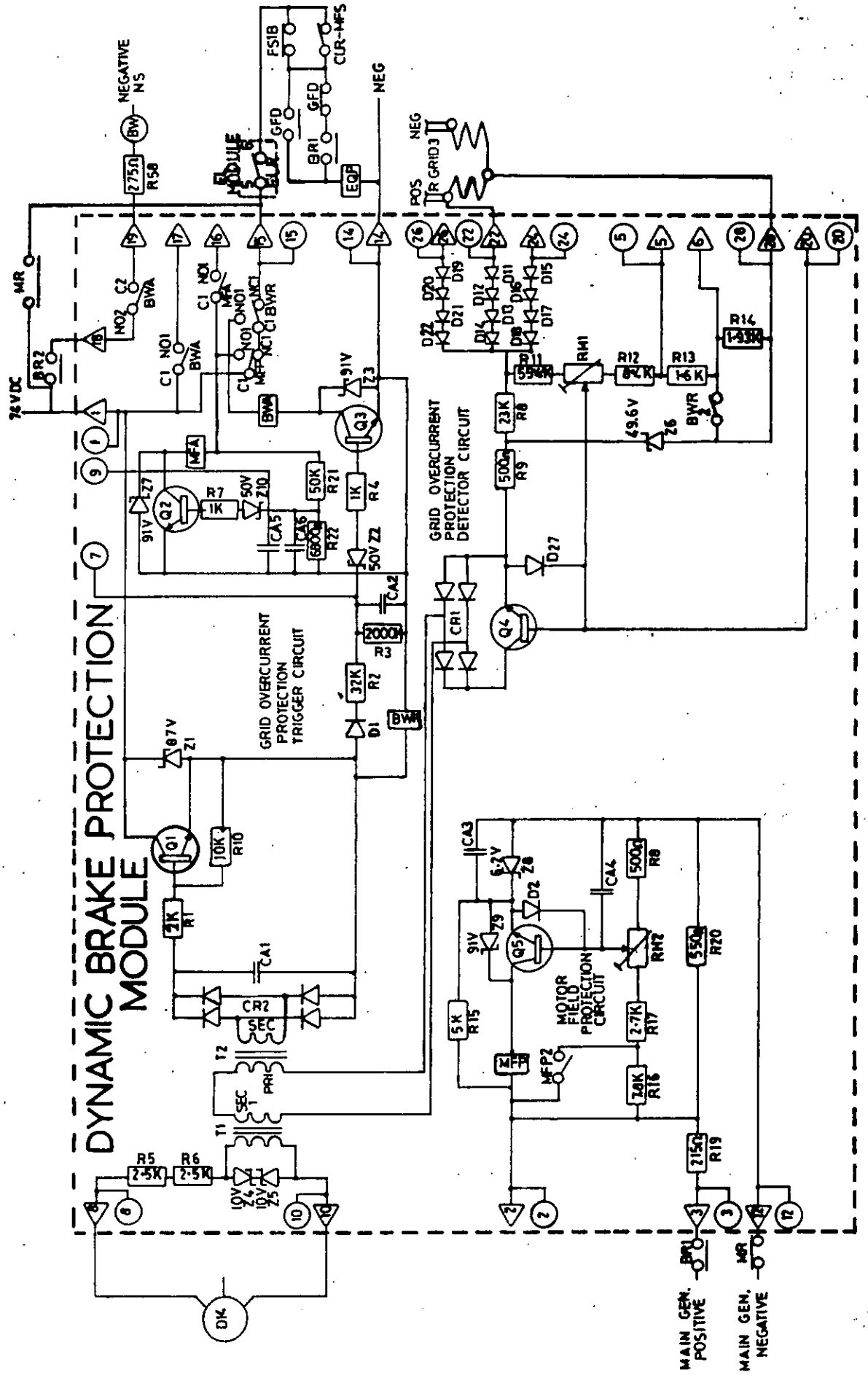


FIG DP-1 DYNAMIC BRAKE PROTECTION MODULE SIMPLIFIED SCHEMATIC DIAGRAM

COMPONENT	FUNCTION
BWA Relay	This relay is energised by a delay circuit which is energised whenever BWR is energised. The delay circuit will time out by steady application of potential or upon application of several rapid pulses. Pickup of BWA provides a feed to the train-lined brake warning and wheelslip indicator light. Pickup of BWA also provides a positive feed to terminal 17 of DP. This positive feed may be used for a brake warning annunciator.
BWR Relay	This relay is energised when the dynamic brake grid current exceeds a predetermined level. Pick up of BWR opens the feed to the equipment protection relay EQP and also recalibrates the grid overcurrent protection detector circuit. Dropout of EQP removes excitation from the main generator field. Recalibration of the grid overcurrent protection detector circuit prevents dropout of BWR until dynamic brake grid current decreases to a value several amperes below the maximum safe value.
MFA Relay	This relay is energised by a delay circuit which is energised whenever MFP is energised. The delay circuit will time out by steady application of potential or upon application of several rapid pulses. Pickup of MFA provides a positive feed to terminal 16 of DP. This positive feed may be used for a motor field annunciator.
MFP Relay	This relay is energised, during dynamic braking, when main generator voltage applied to the traction motor fields exceeds a predetermined value. Pickup of MFP opens the feed to the equipment protection relay EQP and provides a feed to the motor field annunciator MFA delay circuit. Pickup of MFP also recalibrates the motor field protection circuit. Dropout of EQP removes excitation from the main generator field. Recalibration of the motor field protection circuit prevents dropout of MFP until the voltage applied to the motor fields decreases to a value several volts below the maximum safe value. The motor field annunciator MFA delay circuit operates to provide a positive feed to terminal 16 of DP, if MFP is energised long enough for the MFA delay circuit to time out. The positive feed applied to terminal 16 of DP may be used for a motor field annunciator circuit.

FIG.DP2-DP MODULE COMPONENT FUNCTIONS (SHEET 1 OF 4)

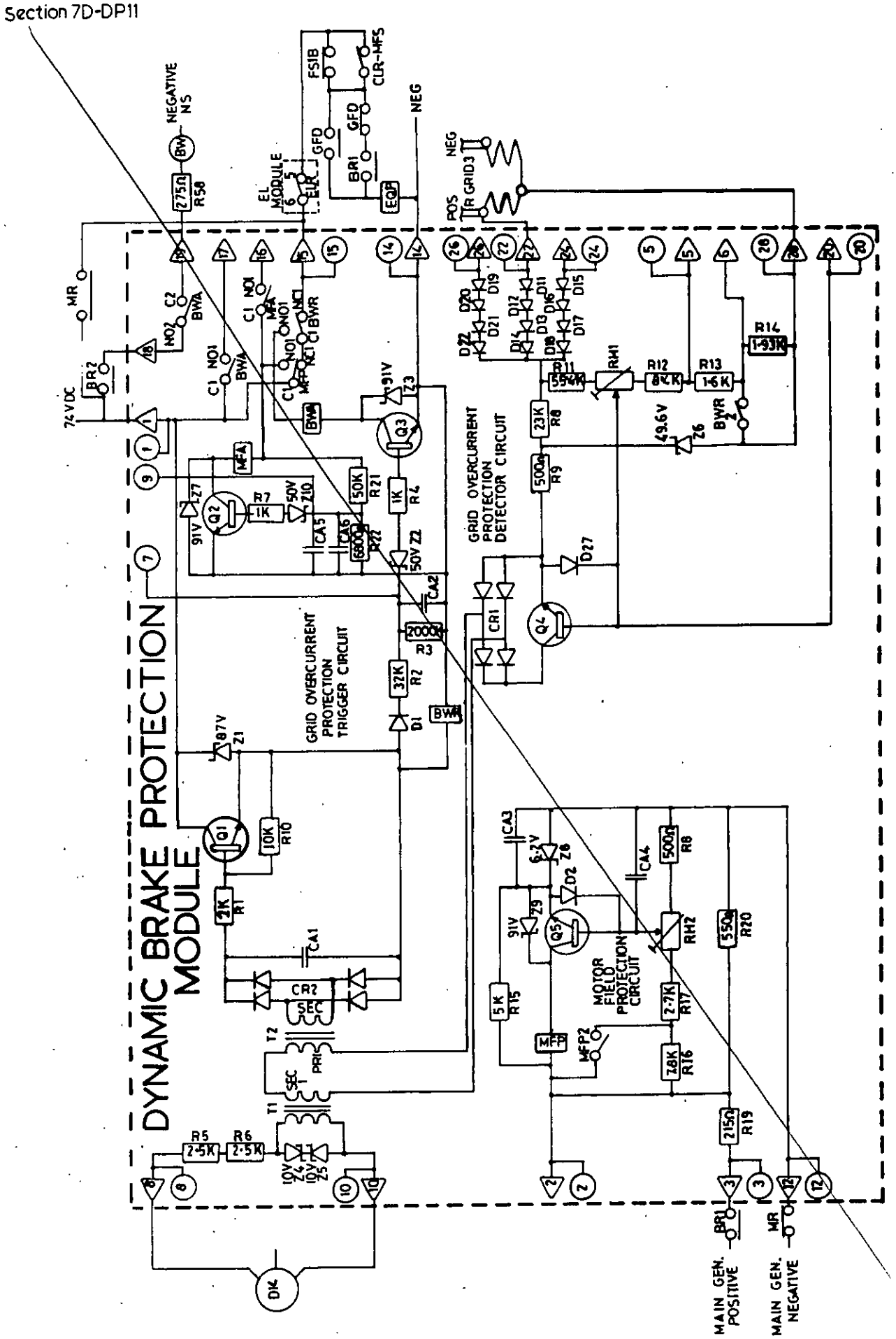


FIG DP-1 DYNAMIC BRAKE PROTECTION MODULE SIMPLIFIED SCHEMATIC DIAGRAM

COMPONENT	FUNCTION
BWA Relay	This relay is energised by a delay circuit which is energised whenever BWR is energised. The delay circuit will time out by steady application of potential or upon application of several rapid pulses. Pickup of BWA provides a feed to the train-lined brake warning and wheelslip indicator light. Pickup of BWA also provides a positive feed to terminal 17 of DP. This positive feed may be used for a brake warning annunciator.
BWR Relay	This relay is energised when the dynamic brake grid current exceeds a predetermined level. Pick up of BWR opens the feed to the equipment protection relay EQP and also recalibrates the grid overcurrent protection detector circuit. Dropout of EQP removes excitation from the main generator field. Recalibration of the grid overcurrent protection detector circuit prevents dropout of BWR until dynamic brake grid current decreases to a value several amperes below the maximum safe value.
MFA Relay	This relay is energised by a delay circuit which is energised whenever MFP is energised. The delay circuit will time out by steady application of potential or upon application of several rapid pulses. Pickup of MFA provides a positive feed to terminal 16 of DP. This positive feed may be used for a motor field annunciator.
MFP Relay	This relay is energised, during dynamic braking, when main generator voltage applied to the traction motor fields exceeds a predetermined value. Pickup of MFP opens the feed to the equipment protection relay EQP and provides a feed to the motor field annunciator MFA delay circuit. Pickup of MFP also recalibrates the motor field protection circuit. Dropout of EQP removes excitation from the main generator field. Recalibration of the motor field protection circuit prevents dropout of MFP until the voltage applied to the motor fields decreases to a value several volts below the maximum safe value. The motor field annunciator MFA delay circuit operates to provide a positive feed to terminal 16 of DP, if MFP is energised long enough for the MFA delay circuit to time out. The positive feed applied to terminal 16 of DP may be used for a motor field annunciator circuit.

FIG.DP2-DP MODULE COMPONENT FUNCTIONS (SHEET 1 OF 4)

COMPONENT	FUNCTION
CA1 Capacitor	This filter capacitor smooths out the signal applied to the base of transistor Q1.
CA2 Capacitor	Capacitor CA2, zener diode Z2, and resistors R2 and R3 form the time delay circuit for operation of the brake warning annunciator relay BWA.
CA3 and CA4 Capacitors	These filter capacitors smooth out the ripple in the signal to the motor field protection circuit.
CA5 and CA6 Capacitors	Capacitors CA5 and CA6, zener diode Z10, and resistors R21 and R22 form the time delay circuit for operation of the motor field annunciator relay MFA.
CR1 Rectifier	Single phase full wave bridge rectifier which prevents transfer of power from T1 to T2 until Q4 is turned on in the brake warning circuit.
CR2 Rectifier	Single phase full wave bridge rectifier to convert AC signal from T2 into a usable DC signal to turn on transistor Q1 and pickup the BWR relay when an overcurrent condition is detected by the grid overcurrent protection detector circuit.
D1 Diode	This blocking diode prevents capacitor CA2 from discharging through the BWR coil.
D2 Diode	Protective diode used to prevent reverse current through the emitter of Q5.
D11 thru D22 Diodes	Blocking diodes which supply the input signal to the grid overcurrent protection detector circuit from terminals 22, 24, or 26 as applicable.
Q1 Transistor	Provides feed to the BWR relay and the BWA relay time delay circuit when a grid overcurrent condition is detected.
Q2 Transistor	Provides feed for the MFA relay after a short time delay when the MFP relay picks up.
Q3 Transistor	Provides feed for the BWA relay after a short time delay when the BWR relay picks up.
Q4 Transistor	Provides path for current flow from secondary of T1 to primary of T2 when a grid overcurrent condition is detected.
Q5 Transistor	Provides feed for the MFP relay when excessive excitation is applied to the traction motor fields during dynamic braking.

FIG. DP2 – DP MODULE COMPONENT FUNCTIONS (SHEET 2 OF 4)

COMPONENT	FUNCTION
R1 Resistor	Current limiting resistor for base current of transistor Q1.
R2 and R3 Resistors	These resistors form part of the RC time delay circuit for operation of Q3. Refer to function of CA2.
R4 Resistor	Current limiting resistor for base current of transistor Q3.
R5 and R6 Resistors	Resistors R5 and R6 in conjunction with zener diodes Z4 and Z5 provide voltage regulation so that 10 volts AC will be applied to the primary of transformer T1.
R7 Resistor	Current limiting resistor for base current of transistor Q2.
R8 Resistor	Resistor R8 in conjunction with zener diode Z6 provides voltage regulation so that 49.6 volts is applied to the junction of R8 and R9. Resistor R8 and zener diode Z6 establishes the set point of the grid overcurrent protection detector circuit.
R9 Resistor	Current limiting resistor for emitter current of transistor Q4.
R10 Resistor	Stabilising resistor to prevent thermal runaway of transistor Q1.
R11, R12, and R13 Resistors	These resistors and rheostat RH1 form a voltage divider circuit for the grid overcurrent protection detector circuit.
R14 Resistor	Pick up of BWR inserts resistor R14 in the voltage divider circuit established by R11, R12, R13, and RH1. The addition of R14 recalibrates the grid overcurrent protection detector circuit to prevent dropout of BWR until dynamic brake grid current decreases to a value several amperes below the maximum safe value.
R15 Resistor	Resistor R15 in series with zener diode Z8 forms a voltage regulator so that a constant 6.2 volts is applied to the emitter of transistor Q5.

FIG. DP2-DP MODULE COMPONENT FUNCTIONS (SHEET 3 OF 4)

COMPONENT	FUNCTION
R16, R17, R18, R19, and R20 Resistors	These resistors and rheostat RH2 form a voltage divider circuit for the motor field protection circuit. R16 is shorted out when MFP picks up. Shorting out R16 recalibrates the motor field protection circuit to prevent dropout of MFP until the voltage applied to the motor fields decreases to a value several volts below the maximum safe value.
R21 and R22 Resistors	Resistors R21 and R22 in conjunction with capacitors CA5 and CA6 form an RC time delay circuit so that pickup of MFP will energise MFA after a short time delay.
RH1 Rheostat	This rheostat is used to set the operating point for the grid overcurrent protection detector circuit.
RH2 Rheostat	This rheostat is used to set the operating point for the motor field protection circuit.
T1 Transformer	Input transformer which supplies AC power from the D14 alternator to the grid overcurrent protection circuit.
T2 Transformer	Isolation transformer which supplies the bias signal to transistor Q1 in the grid overcurrent protection trigger circuit.
Z1, Z3, Z7, and Z9 Zener Diodes	Transient suppression zeners to protect against transistor collector to emitter breakdown.
Z4 and Z5 Zener Diodes	These zener diodes are used to provide a 10 volt square wave input to the primary of transformer T1.
Z6 Zener Diode	This reference zener diode is used to establish the operating point of the grid overcurrent protection detector circuit.
Z8 Zener Diode	This reference zener diode in conjunction with R15 and R19 provides a constant 6.2 volts at the emitter of transistor Q5. This allows the setting of RH2 to establish the operating point of the motor field protection circuit.
Z10 Zener Diode	This zener diode is used to prevent turn on of Q2 until the change on capacitors CA5 and CA6 exceeds 50 volts.

FIG DP2-DP MODULE COMPONENT FUNCTIONS (SHEET 4 OF 4)

TERMINAL	FUNCTION
1 and 14	Supplies 74 volt DC input to the module.
3 and 12	Supplies main generator DC voltage to the motor field protection circuit.
5 and 6	These terminals are provided for use on locomotives equipped with extended range dynamic brakes when it is desired to recalibrate the grid overcurrent protection detector circuit for extended range dynamic brake operation.
8 and 10	Supplies AC voltage from the D14 alternator to the module. This voltage is rectified and used to provide forward bias for transistor Q1 when a grid overcurrent condition is detected.
15	Provides 74 volt DC output from the DP module to the EQP relay. There is a normally closed interlock of the MFP and the BWR relay in this output circuit. Regulation of main generator output in dynamic braking under fault conditions is accomplished by dropping the feed to the EQP relay which drops the generator field contactor GFC and also discharges the rate control capacitors located in the rate control module.
16	This terminal is provided to supply an output from the DP module to a motor field annunciator relay, if desired. This output is present only when the MFP relay is picked up.
17	This terminal is provided to supply an output from the DP module to a brake warning annunciator relay, if desired. This output is present only when the BWA relay is picked up.
18 and 19	Provides 74 volts DC to the trainlined brake warning light circuit. This output is present only when the BWA relay is picked up.
20	This terminal is used only on locomotives equipped with extended range dynamic brakes, and connects the base of transistor Q4 to negative during the closing of the extended range D contactors. This prevents a brake warning operation during the closing of the D contactors.
22	Positive input to the DP module grid overcurrent protection detector circuit from the dynamic braking grids.
24 and 26	Same as 22 except 24 and 26 are used on different types of locomotives.
28	Negative input to the DP module grid overcurrent protection detector circuit from the dynamic braking grids.

FIG DP3—DP MODULE COMPONENT FUNCTIONS (SHEET 1)

DYNAMIC BRAKE REGULATOR MODULE, DR

INTRODUCTION

Dynamic brake regulator module DR11 is designed to protect the dynamic braking grids by limiting braking grid current to a maximum value of 370 amperes. DR11 may also be used to limit dynamic braking grid current to a value proportional to braking lever position. This limiting action is accomplished by reducing excitation to the main generator field. Excitation to the main generator field is reduced, as necessary to limit braking grid current to the desired value, by discharging the rate control capacitors on the RC module through a solid state circuit on the DR module.

The DR module may be used on locomotives equipped with any one of the following dynamic braking systems.

1. Basic Dynamic Brakes.
2. Basic Dynamic Brakes with Trainlined Grid Current Control.
3. Extended Range Dynamic Brakes. (Used on GL22C-2 and GL26C-2 locomotives).
4. Extended Range Dynamic Brakes with Full Time Trainlined Grid Current Control.

A description of the DR11 module as used on GL22C-2 and GL26C-2 locomotives is provided in the following paragraphs on extended range dynamic brakes.

BASIC DYNAMIC BRAKES

A voltage signal proportional to braking grid current through R GRID 3. to terminals 13 and 2 of the DR11 module on units equipped with 1.52 ohm dynamic braking grids.

The signal provided between terminals 13 and 2 is applied to a voltage divider consisting of rheostat RH1 and resistors R1, R2, R3, and R4. This same voltage is also applied to resistor R7 in series with zener diodes Z1 through Z9. The zener diodes provide a constant reference signal to the emitter of Q2.

A signal proportional to braking grid current is applied to the base of transistor Q1 by a voltage divider consisting of R5 and R6 connected between the wiper arm of RH1 and the emitter of Q2. When braking grid current is less than 370 amperes, the voltage at the wiper arm of RH1 is less than the reference signal applied to the emitter of Q2. This places reverse bias on transistors Q1 and Q2.

When braking grid current rises above 370 amperes, the voltage at the wiper arm of RH1 is larger than the reference signal applied to the emitter of Q2. This causes current flow from the wiper arm of RH1 to the zener diodes. This current flow results in placing forward bias on Q1 and Q2.

Output voltage of the D14 alternator is connected to terminals 8 and 10 of the DR module. The voltage applied to the primary of transformer T1 from terminals 8 and 10 is limited to 64 volts by zener diodes Z10, Z11, Z12, and Z13 in conjunction with resistor R10 and diodes D11, D12, D13, and D14. Secondary T1-A is open until transistors Q1 and Q2 turns on.

With forward bias on Q1 and Q2, current flows through the secondary winding of transformer T1-A and through the primary winding of transformer T2-A, then from collector to emitter of Q1 and Q2. The current flow through the primary T2-A induces a voltage into secondary T2-A. This voltage is rectified and applied to a voltage divider consisting of R8 and R9. Transistor Q3 is forward bias by the voltage developed across R9.

With forward bias on Q3, the braking lever signal is removed from the rate control capacitors in the RC module. The signal passes through a resistance, in the RC module, to terminal 4 of the RC module, through BR2 contacts to terminal 6 of the DR module, from collector to emitter of Q3 on the DR module, then to negative at terminal 14 of the DR module. The rate control capacitors in the RC module discharge through a resistor in the RC module to negative at terminal 14 of the RC module. Excitation to main generator field decreases as the rate control capacitors discharge. This reduced excitation results in a decrease in braking grid current.

When braking grid current decreases below 370 amperes, the signal at the wiper arm of RH1 decreases and places a reverse bias on Q1 and Q2. Reverse bias on Q1 and Q2 stops the current flow through T1-A secondary and T2-A primary which removes forward bias from Q3. With Q3 turned off, the braking lever signal is again applied to the rate control capacitors and allows an increase in excitation to the main generator field. This regulating action limits braking grid current to a maximum of approximately 370 amperes regardless of braking lever position.

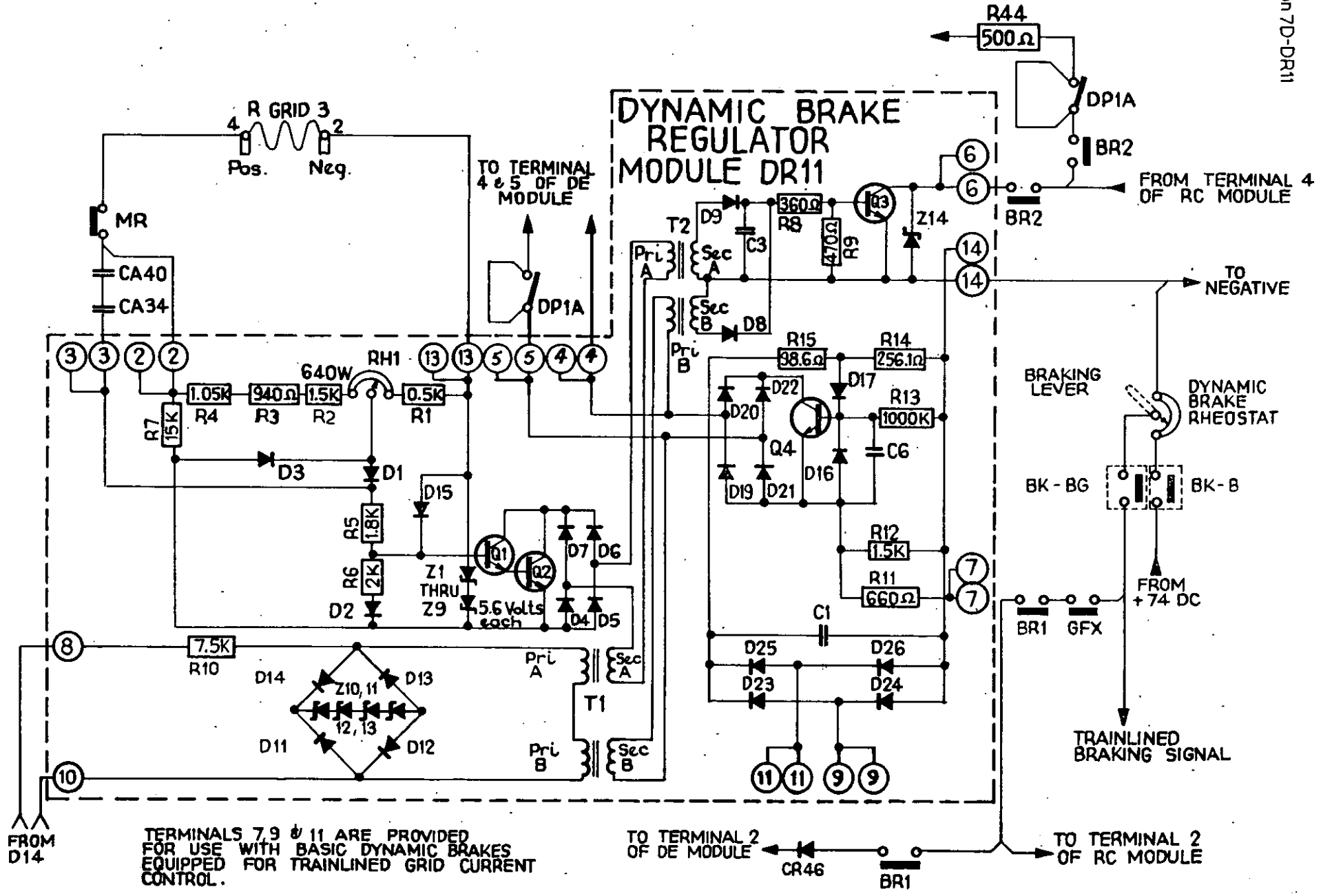


Fig. DR-11— Dynamic Brake Regulator Module DR, Simplified Schematic Diagram (Extended Range Dynamic Brakes)

ANTICIPATION CIRCUIT

An additional function of the DR module is to produce smooth braking by providing a slow buildup of the braking effort. Grid current buildup is controlled through the operation of the "anticipatory" circuit, made up of capacitors CA34 and CA40 which are connected to DR module terminal 3.

Current flows through CA34 and CA40 only when there is a change in voltage at the positive grid terminal. The amount of current flow is proportional to the rate of voltage increase (expressed in volts per second). A sudden increase in grid current causes a current flow through CA34, CA40, and through DR module resistors R5 and R6. This current flow and resulting voltage drop across R6 forward biases and turns on Q1 and Q2. The DR then operates to discharge the rate control capacitors on the RC module which decreases main generator field excitation and results in a decrease in braking grid current.

EXTENDED RANGE DYNAMIC BRAKES

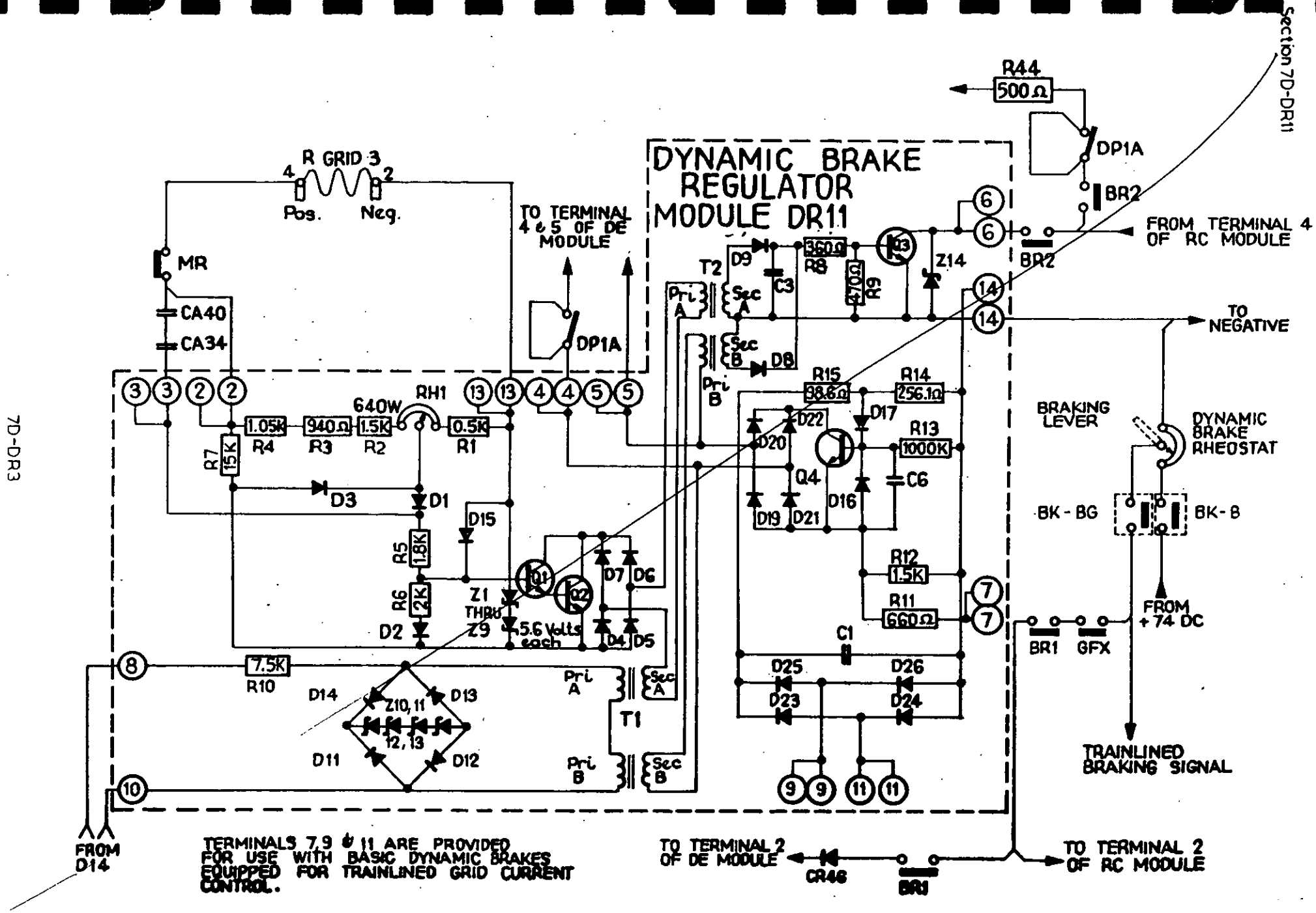
A voltage signal proportional to braking grid current through a portion of dynamic braking grid B is applied between terminals 13 and 2 of the DR11 module on units equipped with 1.52 ohm dynamic braking grids.

The signal applied between terminals 13 and 2 is used to limit dynamic braking grid current to a maximum value of 370 amperes. Refer to description of basic dynamic brakes for this limiting action and for operation of the anticipation circuit consisting of CA40 and CA34.

The DR module limits maximum dynamic braking grid current to 370 amperes on units equipped with basic dynamic brakes and on units equipped with extended range dynamic brakes. However, when operating units equipped with extended range dynamic brakes below approximately 27 km per hour on units with 1.52 ohm braking grids, the DR module in conjunction with the DE module limits braking grid current to a value proportional to the braking lever position.

A signal proportional to dynamic braking grid current is applied to the DE module. Another signal, the braking lever signal, which is proportional to braking lever position is also applied on the DE module. A comparison circuit on the DE module compares the dynamic braking grid current signal to the braking lever signal. A solid state switch on the DE module turns on if the braking grid signal is larger than the braking lever signal.

Turn on of the solid state switch provides a path for current flow between terminals 4 and 5 on the DE module. The DP1A relay picks up when using dynamic brakes below approximately 27 km per hour on units with 1.52 ohm grids.



7D-DR3

Fig. DR-11— Dynamic Brake Regulator Module DR, Simplified Schematic Diagram (Extended Range Dynamic Brakes)

ANTICIPATION CIRCUIT

An additional function of the DR module is to produce smooth braking by providing a slow buildup of the braking effort. Grid current buildup is controlled through the operation of the "anticipatory" circuit, made up of capacitors CA34 and CA40 which are connected to DR module terminal 3.

Current flows through CA34 and CA40 only when there is a change in voltage at the positive grid terminal. The amount of current flow is proportional to the rate of voltage increase (expressed in volts per second). A sudden increase in grid current causes a current flow through CA34, CA40, and through DR module resistors R5 and R6. This current flow and resulting voltage drop across R6 forward biases and turns on Q1 and Q2. The DR then operates to discharge the rate control capacitors on the RC module which decreases main generator field excitation and results in a decrease in braking grid current.

EXTENDED RANGE DYNAMIC BRAKES

A voltage signal proportional to braking grid current through a portion of dynamic braking grid B is applied between terminals 13 and 2 of the DR11 module on units equipped with 1.52 ohm dynamic braking grids.

The signal applied between terminals 13 and 2 is used to limit dynamic braking grid current to a maximum value of 370 amperes. Refer to description of basic dynamic brakes for this limiting action and for operation of the anticipation circuit consisting of CA40 and CA34.

The DR module limits maximum dynamic braking grid current to 370 amperes on units equipped with basic dynamic brakes and on units equipped with extended range dynamic brakes. However, when operating units equipped with extended range dynamic brakes below approximately 27 km per hour on units with 1.52 ohm braking grids, the DR module in conjunction with the DE module limits braking grid current to a value proportional to the braking lever position.

A signal proportional to dynamic braking grid current is applied to the DE module. Another signal, the braking lever signal, which is proportional to braking lever position is also applied on the DE module. A comparison circuit on the DE module compares the dynamic braking grid current signal to the braking lever signal. A solid state switch on the DE module turns on if the braking grid signal is larger than the braking lever signal.

Turn on of the solid state switch provides a path for current flow between terminals 4 and 5 on the DE module. The DP1A relay picks up when using dynamic brakes below approximately 27 km per hour on units with 1.52 ohm grids.

Therefore, turn on of the solid state switch on the DE module results in connecting terminal 4 to terminal 5 on the DR module and permits current flow through transformer T1-B secondary and T2-B primary on the DR module.

The output of T2-B secondary is rectified and applied to a voltage divider consisting of R8 and R9. The voltage developed across R9 provides forward bias for Q3 on the DR module. Forward bias on Q3 results in discharge of the rate control capacitors on the RC module. Excitation to the main generator field decreases as the rate control capacitors discharge. This reduced, excitation results in a decrease in braking grid current until the braking grid current signal decreases to a value equal to or less than the braking lever signal. The approximate maximum value of braking grid current for each position of the braking lever when operating below approximately 27 km per hour on units with 1.52 ohm grids, is the same as that provided in the description of basic dynamic brakes with trainlined grid current control.

DYNAMIC BRAKING GRID OPEN CIRCUIT PROTECTION SYSTEM FIG. DR-2

The dynamic braking grid open circuit protection system is designed to protect the traction motors from excessively high voltages in case an open circuit develops in one of the dynamic braking grids. The system also provides protection against excessive current through the remaining braking grids in case an open circuit develops in one of the dynamic braking grids.

The open circuit protection relay OCP is connected across a bridge circuit consisting of the dynamic braking grids and traction motors TM1 and TM6 on GL22C-2 and GL26C-2 locomotives. The bridge is balanced during normal operation. Pickup of grid shorting contactors DC1 and DC3 unbalances the bridge, but this unbalance is not sufficient to cause pickup of OCP. However, an open in one of the dynamic braking grids results in an unbalance sufficient for pickup of OCP.

Pickup of OCP drops the feed from braking contactor B and provides a feed to the open circuit protection fault light on the annunciator module. After pickup, the OCP relay mechanically latches in and should not be reset until the braking grid circuit has been checked and repaired. Dropout of the B contactor removes excitation from the main generator and disables the dynamic braking system.

INDICATING LIGHTS AND DEVICES

INTRODUCTION

Various indicating lights and devices are located on the engine control panel and on the locomotive control stand to provide information to the operator. A description of these indicating lights and devices will be found in the Operator's Manual and in Section 6 of the Locomotive Service Manual.

The annunciator module, located in the module compartment, contains indicating lights to provide information for maintenance personnel. A description of the annunciator module is provided in the following paragraphs.

ANNUNCIATOR MODULE

Each annunciator module contains a TEST/RESET switch and four or more identical annunciator circuits. The AN module is equipped with one positive and one negative input terminal. A fault signal input terminal is provided for each annunciator circuit on the module. A simplified schematic diagram showing one annunciator circuit is provided in Fig. AN-1.

The annunciator table identifies the fault signals that may be applied to AN modules. The table also identifies the input terminal for each fault. When one of the faults listed in the table is detected, a signal is applied to the applicable input terminal. This signal is applied to the applicable magnetic latching annunciator relay ANR. Pickup of ANR provides a feed to the applicable light emitting diode LED. The light emitted by LED provides a visual indication of the fault. The specific fault is identified on the face plate of the AN module. After pickup, ANR remains in the latched position until the fault signal is removed and the TEST/RESET switch is moved to the RESET position.

HOT ENGINE

The engine temperature switch ETS closes to provide a feed to the THL relay when a hot engine fault is detected. Pickup of THL provides a positive feed to terminal 2 on the AN module.

GOVERNOR SHUTDOWN

The LOS switch closes to provide a feed to GSR relay. Pickup of GSR provides a positive feed to terminal 2 on the AN module.

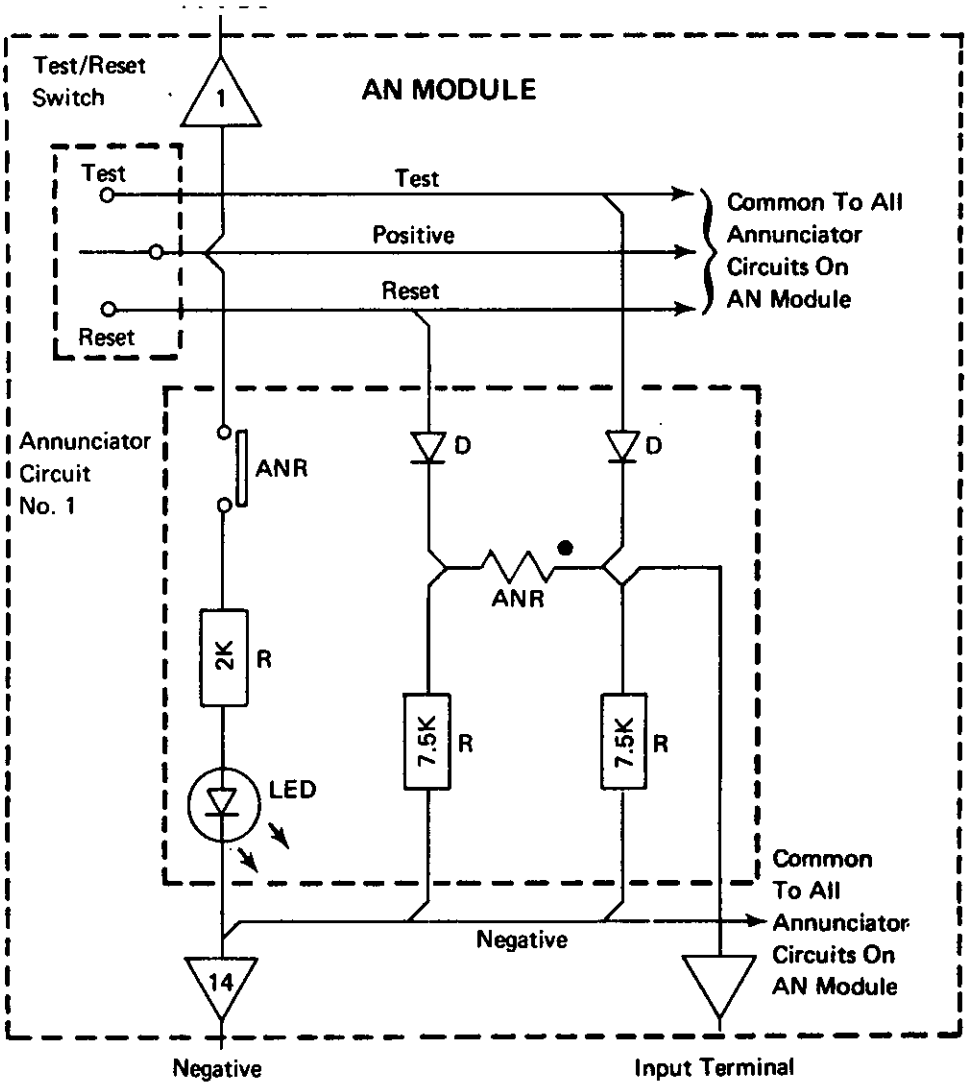


FIG. AN-1 Annunciator Module, Simplified Schematic Diagram

GROUND RELAY

The ground relay picks up to provide a feed to input terminal 4 when a high voltage ground fault is detected, and when a group of 5 main generator diodes have failed.

EXCITATION LIMIT

Excitation current to the main generator field is monitored by the excitation limit module EL.

The EL module provides a signal to terminal 5 if excitation current rises above a safe value.

GRID OVERCURRENT

Dynamic brake grid current is monitored by the dynamic brake protection module DP. The DP module provides a signal to terminal 6 if braking grid current rises above a safe value.

MOTOR EXCITATION

Traction motor field excitation voltage is monitored by the dynamic brake protection module DP during dynamic brake operation. The DP module provides a signal to terminal 7 if traction motor field excitation voltage rises above a safe value.

GRID OPEN CIRCUIT

On locomotives equipped with extended range dynamic brakes, the grid open circuit protection relay OCP picks up if an open circuit develops in a braking grid. Pickup of OCP provides a signal to terminal 8.

GRID BLOWER FAILURE

Grid blower motor current is monitored by the dynamic brake grid current transductor DGT and the DG module. The DG module provides a signal to terminal 9 if grid blower motor current becomes abnormal.

TABLE OF ANNUNCIATOR (AN26) INDICATIONS

INPUT TERM.	FAULT SIGNAL
2	HOT ENGINE
3	GOVERNOR SHUT DOWN
4	GROUND RELAY
5	EXCITATION LIMIT
6	GRID OVERCURRENT
7	MOTOR EXCITATION
8	GRID OPEN CIRCUIT
9	GRID BLOWER FAILURE
10	TMCO OPERATION
11	EMERGENCY SWITCH
12	FIRE ALARM

TMCO OPERATION

Each time MCO SEL. SW is operated, COR relay will be energised. Pickup of COR will provide a positive feed to terminal 10 on an AN module.

EMERGENCY SWITCH

When emergency switch is placed in either V. R. FAIL or A. G. ALT. FAIL position, a positive feed to terminal 11 on AN module is provided.

FIRE ALARM

When fire detectors FAS1 or FAS2 are triggered, they provide a feed to pickup FAR relay. Pickup of FAR provides a positive feed to terminal 12 on the AN module.

TEST/RESET SWITCH

Placing the TEST/RESET switch to TEST position places positive potential on the TEST LINE. This allows current flow from the marked terminal to the unmarked terminal of all ANR relays on the AN module. Current in this direction causes the ANR relay contacts to close and provides a feed to all lights on the AN module. This performs a functional check of all lights and relays on the AN module. The lights will remain on until the TEST/RESET switch is moved to RESET position.

Placing the TEST/RESET switch to RESET position places positive potential on the RESET LINE. This allows current flow from the unmarked terminal to the marked terminal of all ANR relays on the AN module. Current in this direction causes the ANR relay contacts to open and all lights on the AN module will go out.

MISCELLANEOUS CONTROL CIRCUITS AND DEVICES

This section provides a description of miscellaneous locomotive control circuits and devices. The simplified schematic diagrams used in the description are provided for convenient reference only. The applicable locomotive wiring diagrams should be used when performing troubleshooting or maintenance.

The contents of Section 7 Part F are presented in the following order:

1. Automatic Ground Relay Reset Limiter Assembly 8408360 - ARL

   The automatic ground relay reset limiter assembly resets the ground relay within 10 to 20 seconds after the first, second, third, and fourth pickup of the GR relay. The fourth pickup of the ground relay GR results in recalibration of the GV module for a maximum generator output voltage of 600 volts. The fifth pickup of GR results in lockout of the ground relay. The automatic ground relay reset limiter contains a 35 minute timer which advances the reset counter to zero in case the time between successive pickups of GR exceeds 30 to 50 minutes. Advancing the reset counter to zero returns the operating sequence to the starting point.

2. Hot Engine Power Reduction System - PR

   The hot engine power reduction system is used to reduce excitation and engine RPM, when operating in some thorttle positions, in case a hot engine is detected.

AUTOMATIC GROUND RELAY RESET LIMITER 8408360 (SPECIAL ORDER) Fig. AGRL-1

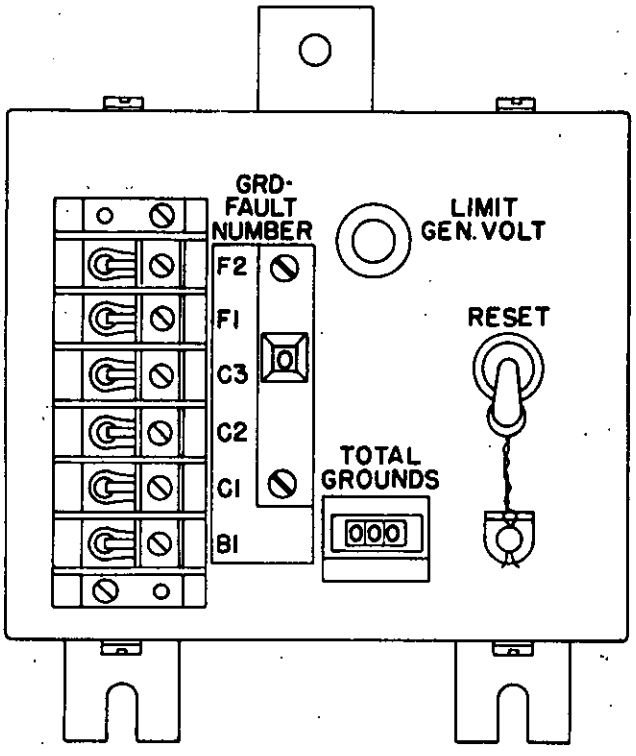


Fig. AGRL-1 – Automatic Ground Relay Reset Limiter Assembly 8408360

The basic locomotive is equipped with a manual reset pushbutton for the ground relay GR. However, automatic reset circuits are available as an extra when requested by the customer. The automatic ground relay reset limiter 8408360 resets the ground relay within 10 to 20 seconds after pickup of first, second, third, and fourth pickup of the ground relay GR. The fourth pickup of the ground relay GR also provides a feed to the generator voltage limit relay GVL and to the generator voltage limit indicator on the automatic ground relay reset limiter.

Pickup of GVL recalibrates the GV module so that generator voltage is limited to a maximum voltage of approximately 600 volts. This reduced voltage reduces the possibility of GR pickup due to insulation leakage in the presence of minor moisture grounds.

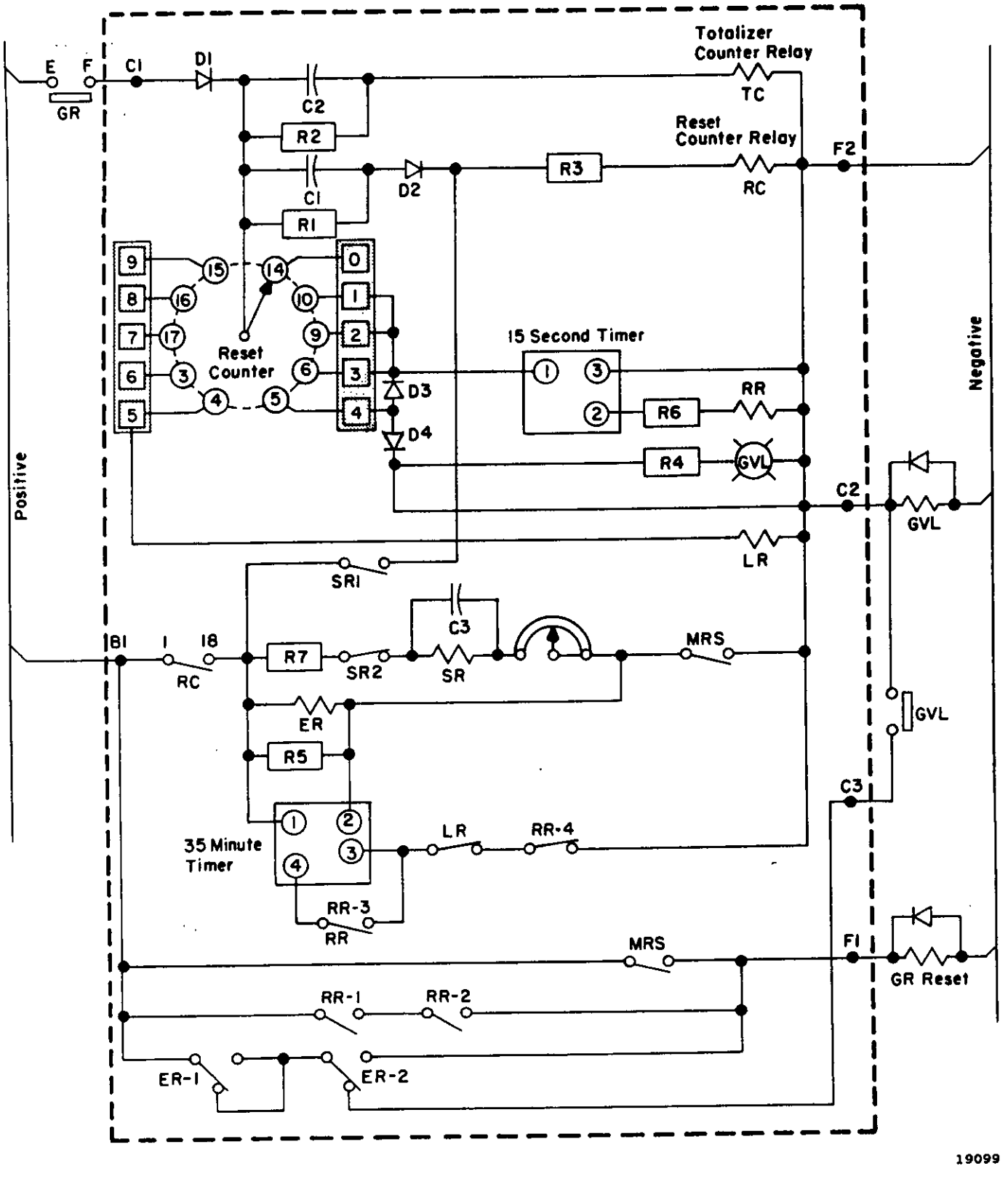


Fig. AGRL-2 – Automatic Ground Relay Reset Limiter 8408360,
Simplified Schematic Diagram

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This allows the locomotive to operate at reduced output until the moisture dissipates. If GR pickup occurs while operating at reduced voltage, the lockout relay LR will be energised. Pickup of LR disables the automatic reset feature and the system is locked out. After lockout, the system can be reset only by operating the manual reset switch MRS located on the ground relay reset limiter assembly.

A ground fault number indicator is provided to visually indicate the number of GR pickups in a sequence. The ground fault number indicator advances one count each time GR picks up. Operating the manual reset switch MRS resets the reset counter and the ground fault number indicator to zero. A total grounds indicator which advances one count each time the GR relay is reset, provides a visual indication of the total number of GR resets. This indicator has a count capacity of 999. Operating the manual reset switch MRS does not reset the total grounds indicator.

The automatic ground relay reset limiter assembly contains a 35 minute timer which advances the reset counter to zero in case the time between successive pickups of GR exceeds 30 to 50 minutes. Advancing the reset counter to zero returns the operating sequence to the starting point. Operation of the 35 minute timer does not advance the total grounds indicator. A simplified schematic diagram of the automatic ground relay reset limiter assembly is provided in Fig. AGRL-2.

FIRST GROUND RELAY PICKUP

Assume that the reset counter is set to zero. Pickup of GR provides + 74V DC, through E-F contacts of GR, to terminal C1 of the automatic ground relay reset limiter. This provides a current flow through diode D1, capacitor C1 and resistor R1, diode D2, resistor R3, and reset counter relay RC. Current also flows from D1 through C2 and R2 to totaliser counter relay TC. Pickup of RC advances the reset counter wiper arm to terminal 10 and the ground fault number indicator displays the numeral 1. Pickup of RC also closes contacts 1-18 of RC which applies +74V DC to terminal 1 of the 35 minute timer. Contacts 1-18 of RC remain closed until the reset counter advances to zero. Pickup of TC does not advance the total grounds indicator. However, the total grounds indicator will advance one count when the E-F contacts of GR open to drop the feed to TC.

When the reset counter wiper arm advances to terminal 10, a feed is provided to terminal 1 of the 15 second timer. Within 10 to 20 seconds, the 15 second timer provides a feed through R6 to reset relay RR. Pickup of RR provides a feed through RR-1 and RR-2 contacts to the GR reset relay. Pickup of RR also closes the RR-3 contacts and opens the RR-4 contacts. Closing RR-3 contacts connects terminal 3 to terminal 4 on the 35 minute timer which discharges a timing capacitor in the 35 minute timer. Opening RR-4 contacts removes the negative feed from the 35 minute timer which prevents the timer from starting the 35 minute countdown.

Pickup of the GR reset relay opens the E-F contacts of GR which removes the feed from the C1 terminal and allows the TC and RC relays to drop out. Opening the E-F contacts also removes the feed from reset relay RR. Dropout of RR opens RR-1, RR-2, and RR-3 contacts and closes RR-4 contacts. Opening RR-1 and RR-2 contacts removes the feed from the GR reset relay. Opening RR-3 contacts removes the discharge path of the timing capacitor. Closing RR-4 contacts provides a negative feed to the 35 minute timer which allows the 35 minute timer to start timing.

Dropout of TC advances the total grounds indicator one count. The reset counter wiper arm remains connected to terminal 10 until the next pickup of GR relay or until the reset counter is reset to zero.

OPERATION OF 35 MINUTE TIMER

The 35 minute timer times out if the next GR pickup does not occur within 30 to 50 minutes. Time out of the 35 minute timer provides a path from terminal 2 to terminal 3 on the 35 minute timer. This results in pickup of the excitation relay ER and the sequence relay SR. Pickup of ER provides a feed to the GR reset relay. However, GR has already been reset and ER provides no function at this time. The function of ER will be discussed in a later paragraph.

Pickup of sequence relay SR closes SR-1 contacts and opens SR-2 contacts. Closing SR-1 contacts provides a feed to the reset counter relay RC which results in advancing the reset counter and ground fault number indicator one count. Blocking diode D2 prevents pickup of TC. Therefore, the total grounds indicator will not advance. Opening SR-2 contacts removes the feed from the SR relay. However, C3 provides a short time delay in dropout of SR. This short time delay provides sufficient time for positive operation of RC before dropout of SR. SR dropout occurs after the short time delay provided by C3. Dropout of SR closes SR-2 contacts and opens SR-1 contacts. Closing SR-2 contacts provides a feed to the SR relay. Pickup of SR results in a repeat of the action described in this paragraph. Each pickup of SR provides a feed to the reset counter relay RC. Each pickup of RC advances the reset counter and ground fault number indicator one count.

This pickup and dropout of SR continues until the reset counter and ground fault indicator advances to zero. Contacts 1-18 of RC open when the reset counter has advanced to zero. This removes the feed from the SR relay which stops the sequence.

SECOND GROUND RELAY PICKUP

If a second ground relay operation follows the first ground relay operation before timeout of the 35 minute timer, the sequence of events will occur as specified, for the first ground relay pickup, except the reset counter wiper arm will advance to terminal 9 and the ground fault number indicator will display the numeral 2.

This indicates the second ground relay operation in the sequence. The 35 minute timer is reset to zero and will not time out until 30 to 50 minutes after the second ground relay reset.

THIRD GROUND RELAY PICKUP

If a third ground relay operation follows the second ground relay operation before time out of the 35 minute timer, the sequence of events will occur as specified for the first ground relay operation, except the reset counter wiper arm will advance to terminal 6 and the ground fault number indicator will display the numeral 3. This indicates the third ground relay operation in the sequence. The 35 minute timer is reset to zero and will not time out until 30 to 50 minutes after the third ground relay reset.

FOURTH GROUND RELAY PICKUP

If a fourth ground relay operation follows the third ground relay operation before time out of the 35 minute timer, the sequence of events will occur as specified for the first ground relay operation, except the reset counter wiper arm will advance to terminal 5 and the ground fault number indicator will display the numeral 4. This indicates the fourth ground relay operation in the sequence. The following additional events will also result from the fourth ground relay operation in a sequence.

A feed is provided through diode D4 to the generator voltage limit relay GVL and to the generator voltage limit indicator. Pickup of GVL recalibrates the GV module so that generator output voltage is limited to a maximum voltage of approximately 600 volts. Pickup of GVL also provides a holding feed for GVL from terminal B1 through ER-1 and ER-2 contacts of the excitation relay ER and the GVL contacts. Therefore, generator voltage will be limited to a maximum of 600 volts until the excitation relay picks up to drop the holding feed to GVL.

The excitation relay ER will pick up if the 35 minute timer times out before the next ground relay operation or if the manual reset switch MRS is operated. Pickup of ER drops the feed to GVL. Dropout of GVL permits generator voltage limit to return to the normal value. Time out of the 35 minute timer or closing MRS will also advance the reset counter and the ground fault number indicator to zero.

FIFTH GROUND RELAY PICKUP

If a fifth ground relay operation follows the fourth ground relay operation before time out of the 35 minute timer, the reset counter wiper arm advances to terminal 4 which provides a feed to lockout relay LR and the ground fault number indicator displays the numeral 5, which indicates the fifth ground relay operation in the sequence. No positive feed is provided to the 15 second timer. Therefore, the automatic reset feature is disabled.

Pickup of LR removes the negative feed from terminal 3 of the 35 minute timer. This prevents time out of the timer so that ER and SR does not pick up and the reset counter does not advance to zero. Therefore, the E-F contacts of GR remain closed and the system is locked out.

The generator voltage limit relay GVL picked up and locked in during the fourth ground relay operation. During the fifth ground relay operation, excitation to the main generator is removed and GVL remains locked in. After the fifth ground relay operation, the system will remain locked out and GVL will remain locked in until the manual reset switch MRS is operated.

MANUAL RESET SWITCH OPERATION

After the fifth ground relay operation, the system will remain locked out until the manual reset switch MRS, located on the automatic ground reset limiter assembly, is operated.

Holding MRS closed provides a negative feed to ER and SR and provides a positive feed to the GR reset coil. Pickup of the GR reset coil opens the E-F contacts of GR. This results in advancing the total grounds indicator one count. Pickup of ER removes the holding feed from GVL which removes the recalibration circuit from the GV module. Pickup of SR results in advancing the reset counter and the ground fault number indicator to zero. The lockout relay LR drops out and provides a negative feed to terminal 3 of the 35 minute timer. Contacts 1-18 of the reset counter open when the reset counter advances to zero. This removes the positive feed from the 35 minute timer.

When resetting the counter, MRS should be held closed until the reset counter advances to zero. Otherwise, lockout will occur on the next GR pickup.

HOT ENGINE AND ENGINE FILTER POWER REDUCTION

An engine temperature switch ETS is installed in the water manifold on the equipment rack. Excessive water temperature causes the ETS contacts to close. Closing these contacts provides a feed to the HOT ENGINE light and to the throttle limit relay THL. Pickup of THL provides a feed to the alarm and to the annunciator module. Pickup of THL also provides a feed to the TH module and to the governor DV solenoid when operating in throttle positions 5 through 8.

Pickup of the TH module causes a reduction of approximately 10 to 12 volts in TH module output voltage to the RC module for some throttle positions. This reduction in output voltage results in reduced excitation. Pickup of the governor DV solenoid results in decreasing engine speed by approximately 165 RPM at some throttle positions. Refer to Fig. PR-1 for typical values.

Throttle Position	Governor Solenoid Energized		Engine Speed R.P.M.		TH Module Output Volts	
	Normal	Hot Engine	Normal	Hot Engine	Normal	Hot Engine
5	BV-CV-DV	BV-CV-DV	650	650	51.2	51.2
6	AV-BV-CV-DV	AV-BV-CV-DV	735	735	57.3	57.3
7	BV-CV	BV-CV-DV	815	650	63.2	51.2
8	AV-BV-CV	AV-BV-CV-DV	900	735	68.0	57.3

Fig. PR-1 – Throttle Position, Normal Engine Speed, And Reduced Power Speed

INSPECTION AND REPLACEMENT OF CONTACT TIPS FOR CONTACTORS AND MOTOR OPERATED TRANSFER SWITCH

MAINTENANCE OF CONTACT TIPS – GENERAL

Only skilled personnel familiar with electrical equipment and the hazard involved should be permitted to service contactors and transfer switches. All safety precautions must be observed.

Minimum maintenance is required to keep the switchgear in serviceable condition. Moving mechanical parts should be free from excess friction and should also be checked for excessive wear. The bearing surfaces are designed to operate without lubrication. Do not oil or grease at any time.

Main contact and arc chute parts are normally oxidized and smoked from regular service. Other parts should not show visible damage from high temperatures.

Contact tips used on all EMD switchgear are made of alloy material. The contacting surfaces of these alloy tips take on irregularities during the first few operating cycles. It is during this initial operation that the majority of contact wear occurs. The discoloration on the surfaces of the contact tips, which results from repeated cycling, does not affect contact operation.

ALLOY CONTACTS WILL OPERATE SATISFACTORILY EVEN THOUGH BLACKENED, PITTED, AND ERODED. DO NOT CLEAN, DRESS, OR FILE CONTACT SURFACES. REPLACE CONTACTS WHEN ANY PORTION OF THE ALLOY MATERIAL IS WORN TO THE BASE METAL.

The contactor must be kept clean, connections tight, and inspected and serviced at intervals as specified in the Scheduled Maintenance Program.

SAFETY PRECAUTIONS

The following safety considerations should always be carefully observed in the application, operation, and servicing of the equipment.

1. ELECTRICAL RATINGS of the equipment are values that should be considered to be EXTREMELY DANGEROUS to personnel.

2. EQUIPMENT SHOULD ALWAYS BE COMPLETELY DE-ENERGIZED BEFORE HANDLING OR PERFORMING ANY SERVICE OPERATIONS. De-energizing the operating coil is not sufficient to render the equipment safe. The power lines must also be disconnected or otherwise de-energized. If power lines are not de-energized, all parts of the device should be considered to be at the maximum system voltage.

3. IF INSPECTION OF ENERGIZED EQUIPMENT IS NECESSARY, DO NOT TOUCH OR HANDLE ANY PARTS. DO NOT STAND IN FRONT OF THE EQUIPMENT OR AT CLOSE RANGE TO PERFORM VISUAL INSPECTIONS. The discharge of hot gases and particles is always likely when the contactor is operated in an energized circuit.

4. NEVER ATTEMPT TO OPERATE THE POWER CONTACTOR WITHOUT HAVING THE ARC CHUTE PROPERLY IN PLACE.

5. NEVER ATTEMPT TO REMOVE THE ARC CHUTE WHILE THE POWER CONTACTOR IS IN AN ENERGIZED OR CLOSED POSITION. Such action is extremely dangerous and would likely result in extensive damage.

6. Operating temperatures for the contactors and switches are high. Some parts of these devices may normally reach temperatures in excess of 200° F. SERIOUS BURNS CAN RESULT FROM HANDLING THE EQUIPMENT AFTER IT HAS BEEN IN SERVICE AND BEFORE IT HAS BEEN ALLOWED TO COOL.

INSPECTION AND REPLACEMENT OF POWER CONTACTOR CONTACTS

INSPECTION OF CONTACTS

1. Press arc chute latch spring, Fig. 8-1, and remove arc chute by pulling forward.

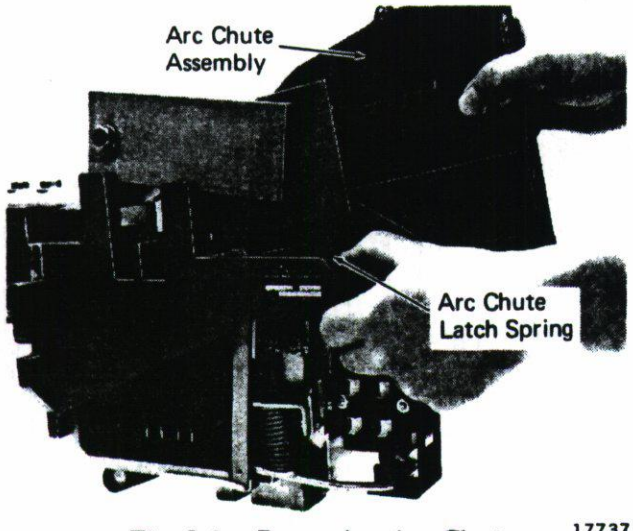


Fig. 8-1 – Removing Arc Chute 17737

2. Inspect the three stationary contact tips and the movable contact. The contacts will operate satisfactorily even though blackened, pitted, or eroded as shown in Fig. 8-2. If any tip is eroded beyond wear limits of Fig. 8-3, replace all three stationary contacts and the movable contact.

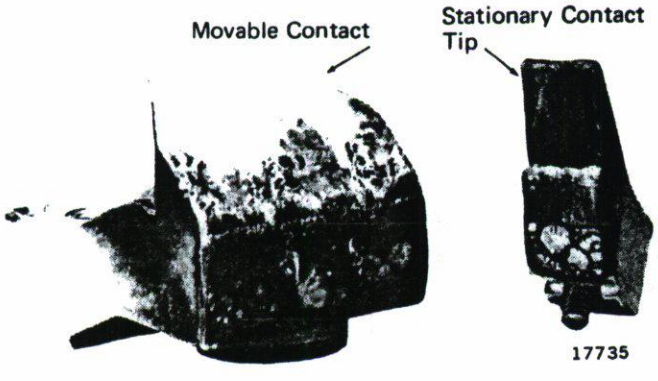


Fig. 8-2 – Usable Blackened And Pitted Contacts

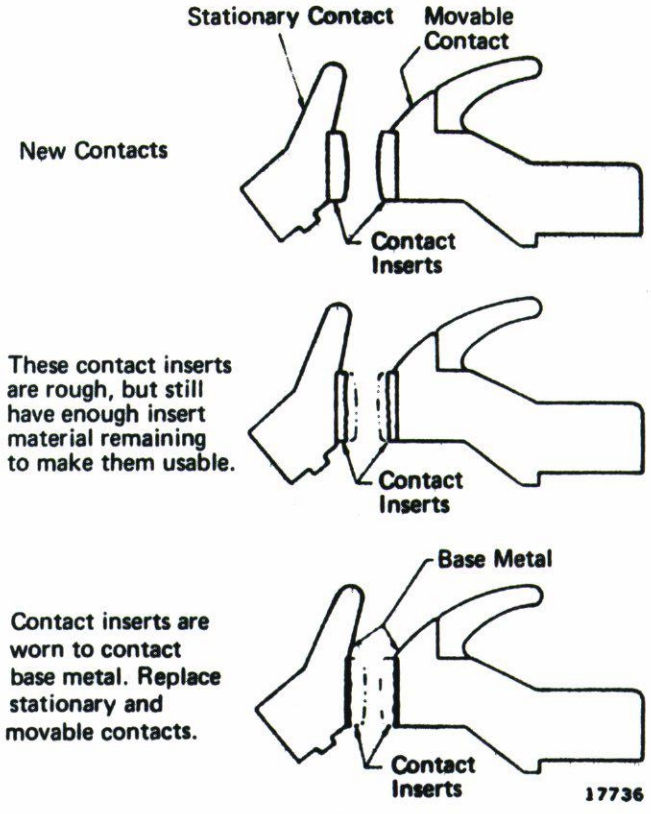


Fig. 8-3 – Contact Wear Limits

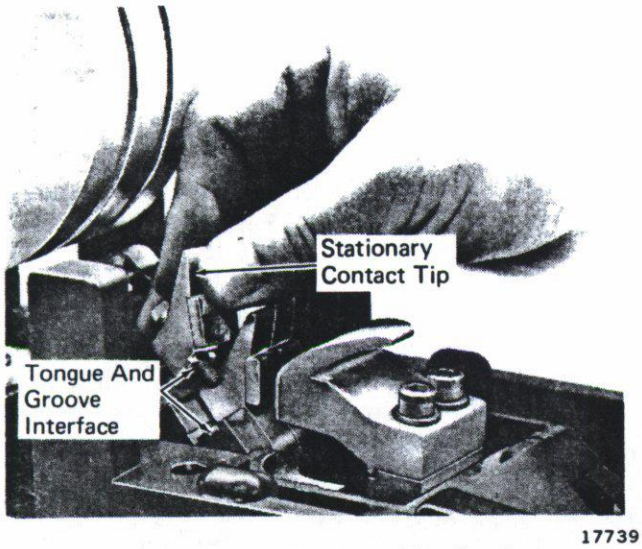
NOTE: When arc chute is removed or not fully engaged, an interlock spring, Fig. 8-4, interferes with motion of the interlock to prevent closing of the contactor.

Fig. 8-4 – Contactor With Arc Chute Removed

REPLACEMENT OF MAIN CONTACTS

1. Remove three screws and carefully remove stationary contact tips as shown in Fig. 8-5.

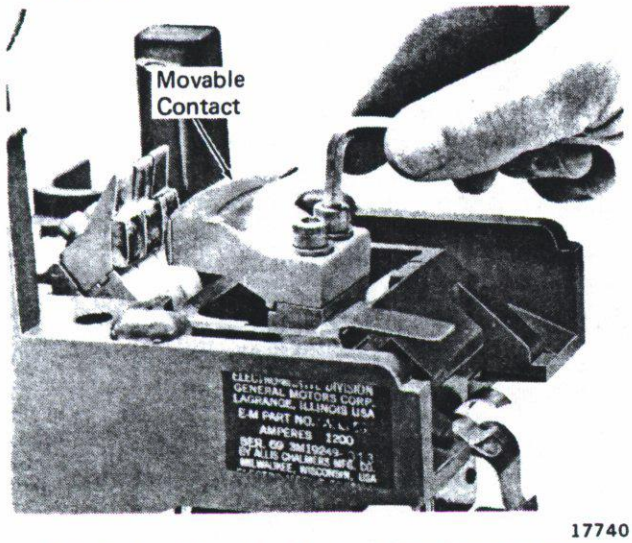
2. Align new stationary contacts at tongue and groove interface, Fig. 8-5, and secure with screws and lockwashers.



17739

Fig. 8-5 -- Stationary Contact Tip Replacement

3. Remove movable contact by removing two screws as shown in Fig. 8-6. Apply new contact which is self-aligning. Secure with screws.

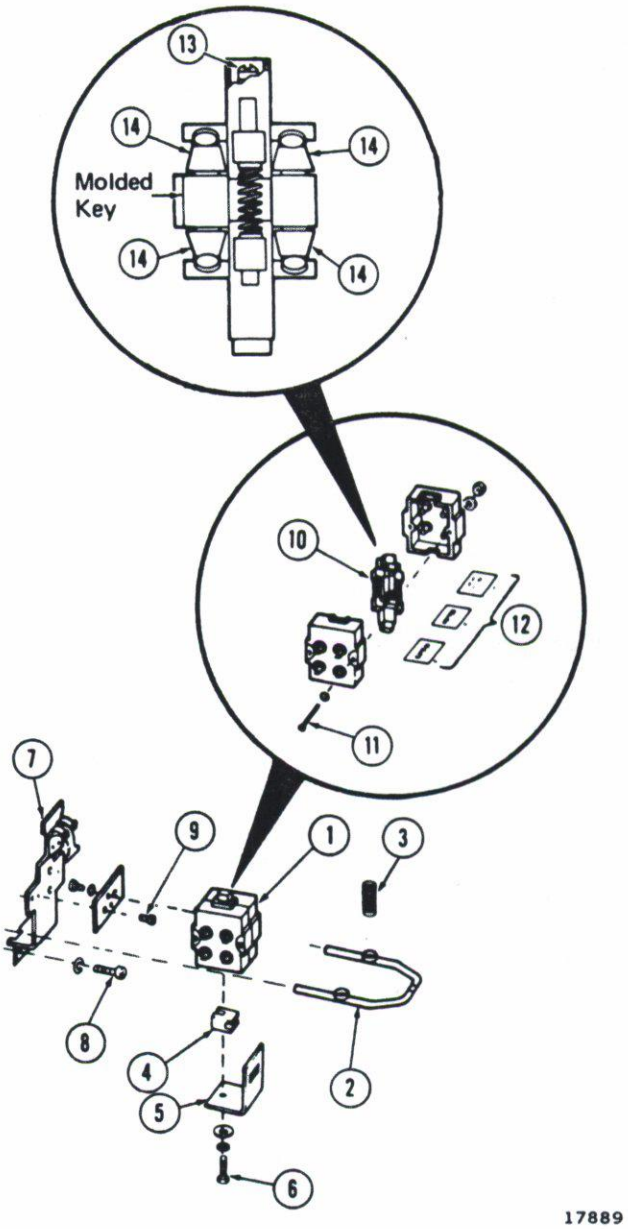


17740

Fig. 8-6 – Movable Contact Tip Replacement

INSPECTION OF INTERLOCK CONTACTS

1. Remove screw (6, Fig. 8-7) and washer from bottom of contact carrier (10), and remove slider (5) and interlock operator (4).



17889

1. Interlock Assembly	8. Screw
2. Operating Lever	9. Screw
3. Return Spring	10. Contact Carrier Assembly
4. Interlock Operator	11. Screw
5. Slider	12. Labels
6. Screw	13. Screw
7. Support Bracket	14. Contact Bridge

Fig. 8-7 – Interlock Assembly, Exploded View

2. Slit labels (12) along parting line between the two interlock covers.

3. Remove two screws (11) from interlock covers and carefully remove the left-hand interlock cover, exposing interlock contacts. Interlock contacts do not require replacement until they are worn 0.060" per mating pair, when compared to new contact dimensions. Refer to Fig. 8-8 to determine if contacts are usable or require replacement.

NOTE If the contacts in the contact carrier are worn beyond the tolerances in Fig. 8-8, the contact bridges should be replaced. If the stationary contacts located within the interlock covers are defective or loose, the interlock assembly should be replaced.

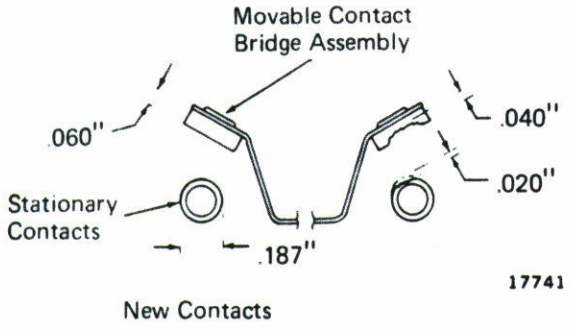


Fig. 8-8 – Interlock Contacts Wear Limits

REPLACEMENT OF INTERLOCK ASSEMBLY

If inspection determined that interlock assembly should be replaced, proceed as follows:

1. Remove return springs (3, Fig. 8-7) with screw driver.

2. Remove two screws (8) from bottom terminal assembly and swing the support bracket (7), with interlock assembly attached, forward until disengaged from top terminal molding, Fig. 8-9.

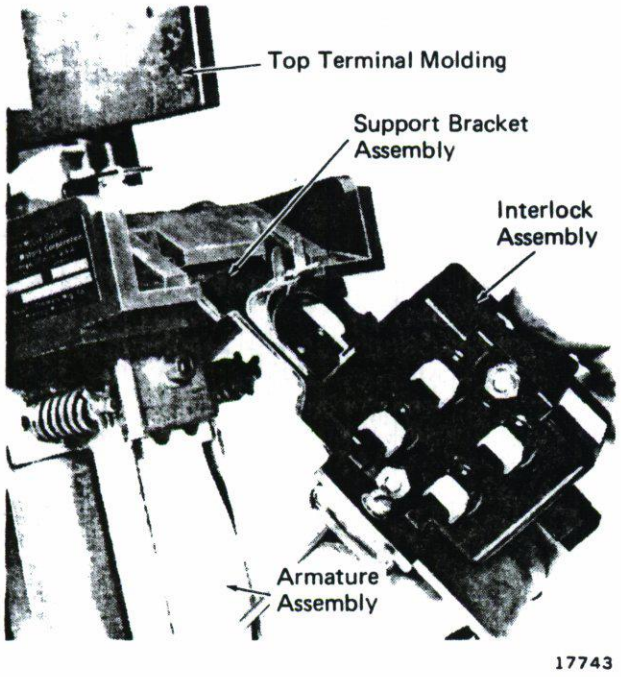


Fig. 8-9 – Removing Support Bracket And Interlock Assembly

3. Remove two screws (9, Fig. 8-7) and remove interlock assembly from support bracket.

4. Attach new interlock assembly to support bracket with screws.

5. Position top end of interlock support bracket under front end of top terminal molding.

6. Attach interlock support bracket (7) loosely to bottom terminal assembly with two screws and lockwashers. Center bracket in the opening of top terminal molding and tighten screws.

7. Insert both return springs between cups on operating lever (2) and spring location buttons on return spring bracket. Springs must be fully seated in cups.

8. Attach interlock operator and slider to bottom of contact carrier (10) with screw, Belleville washer, and lockwasher. Flattened portion of operating lever must be nested inside recess in interlock operator.

NOTE: Ensure slider (5) does not interfere with motion of interlock movable contact carrier.

REPLACEMENT OF INTERLOCK CONTACTS

If inspection determined that interlock contacts should be replaced, proceed as follows:

1. Remove movable contact carrier (10, Fig. 8-7) from interlock assembly cover half.

NOTE: Work on movable contact carrier in an area where small parts will not be lost if dropped.

2. Hold contact carrier in palm of hand and loosen screw (13) so that the top, center, and bottom elements of the carrier can be separated sufficiently to remove an upper and lower set of contact bridges (14). Insert a new set of upper and lower contact bridges.

CAUTION: Ensure that each contact bridge is positioned properly and not inverted since this could cause malfunction of the contactor. See Fig. 8-7 for correct position of contact bridges.

3. Turn over contact carrier in palm of hand and repeat Step 2 for remaining two contact

bridges and tighten screw (13). Ensure brass sleeves on all four contact bridge assemblies are free after screw is tightened.

4. Place the contact carrier (10) into the interlock cover remaining on the contactor. Ensure that screw (13) in the contact carrier is at the end of the interlock cover stamped C-D and that molded key is outside the cover. Move contact carrier from end to end to ascertain that the contact bridge assemblies are correctly related to the stationary contacts inside the interlock cover. Align bottom and top elements of the contact carrier rotationally, if required, so they do not bind in the square bearing hole of the interlock cover.

5. Apply other cover half to the interlock assembly and secure with two screws (11), lockwashers, and nuts. Lockwashers are to be used under screw heads and under nuts.

INSPECTION AND REPLACEMENT OF BRAKING CONTACTOR CONTACTS

INSPECTION OF MAIN CONTACTS

1. Pull arc chute latch spring, Fig. 8-10, forward and remove arc chute assembly by lifting front end of arc chute away from main body of contactor.

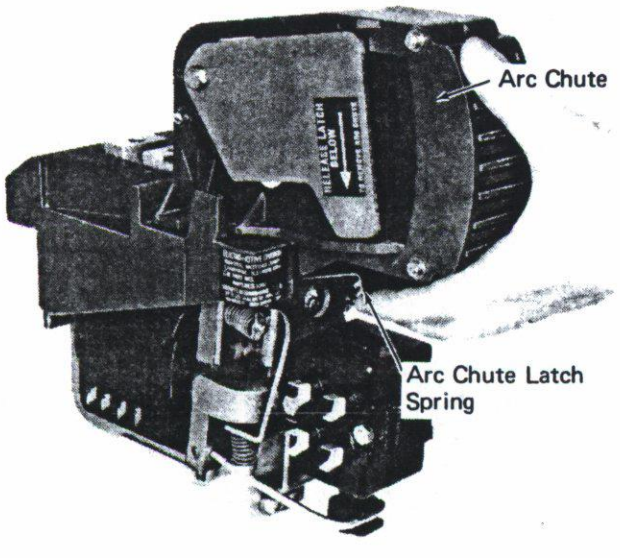


Fig. 8-10 – Braking Contactor

2. Inspect the two stationary contact tips and the movable contact tip. Refer to Fig. 8-11 to determine if contacts are usable or require replacement. If one is eroded beyond wear limits of Fig. 8-11, replace stationary contact tips and movable contact tip.

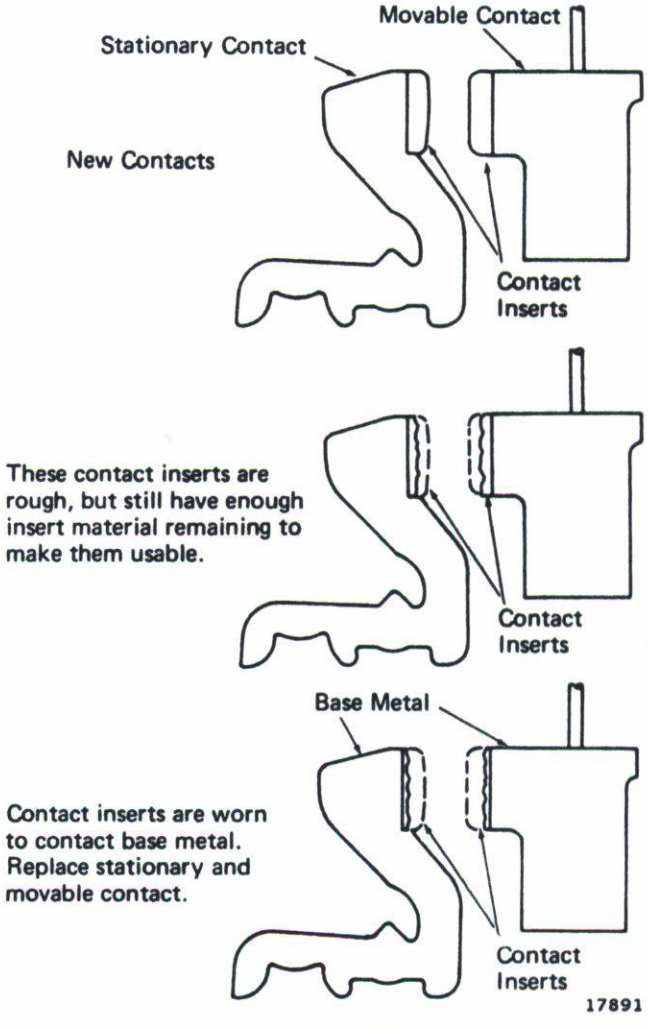


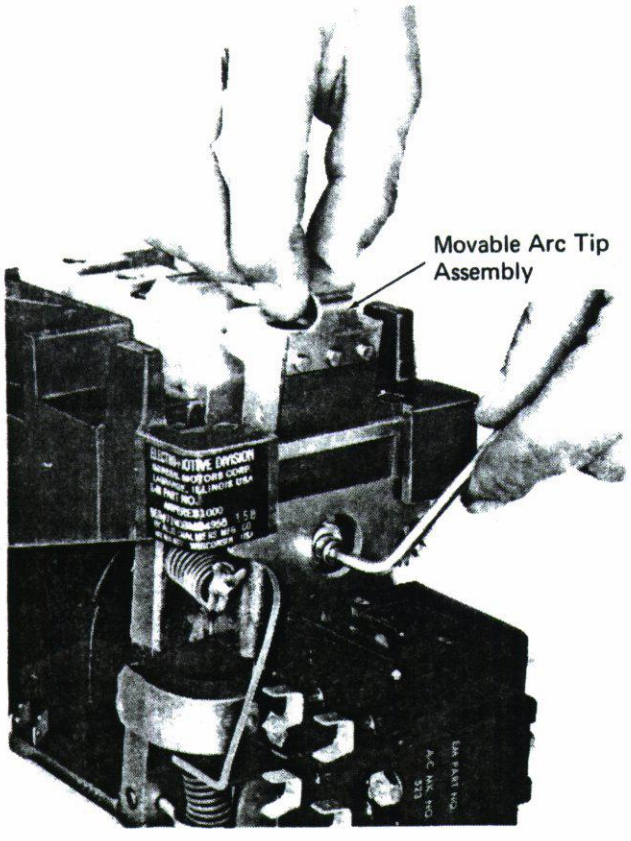
Fig. 8-11 – Contact Wear Limits

REMOVAL OF MOVABLE ARC TIP ASSEMBLY

NOTE: If arc chute assembly has not been removed for inspection, remove per Step 1 of Inspection Of Main Contacts paragraph.

1. Remove screw and lockwasher, Fig. 8-12, holding the movable arc tip assembly to the movable main contact assembly.

2. Remove arc tip from slot between movable contact support and the hold-on magnet bracket by pulling up on the movable arc tip, while moving the movable arc tip slightly from side to side.

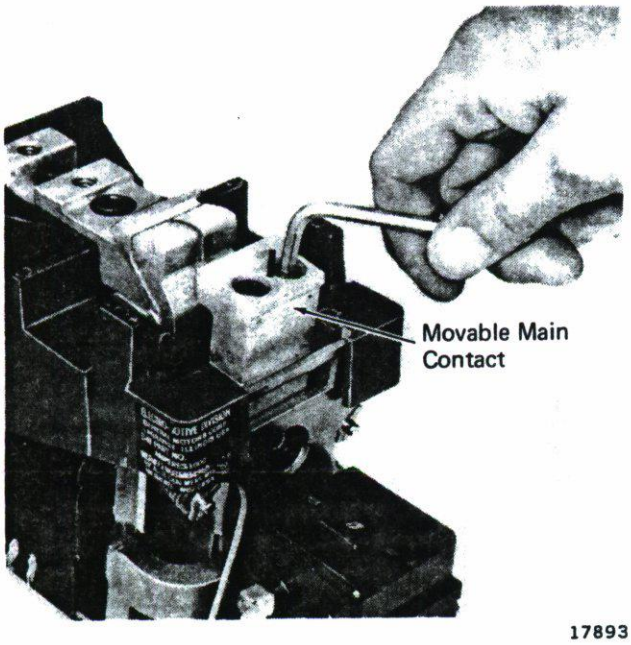


17892

Fig. 8-12 – Removal Of Movable Arc Tip Assembly

REPLACEMENT OF MOVABLE CONTACT ASSEMBLY

1 Remove two screws and lockwashers, Fig. 8-13. holding movable contact assembly in place. Remove movable contact assembly and replace with a new contact assembly.



17893

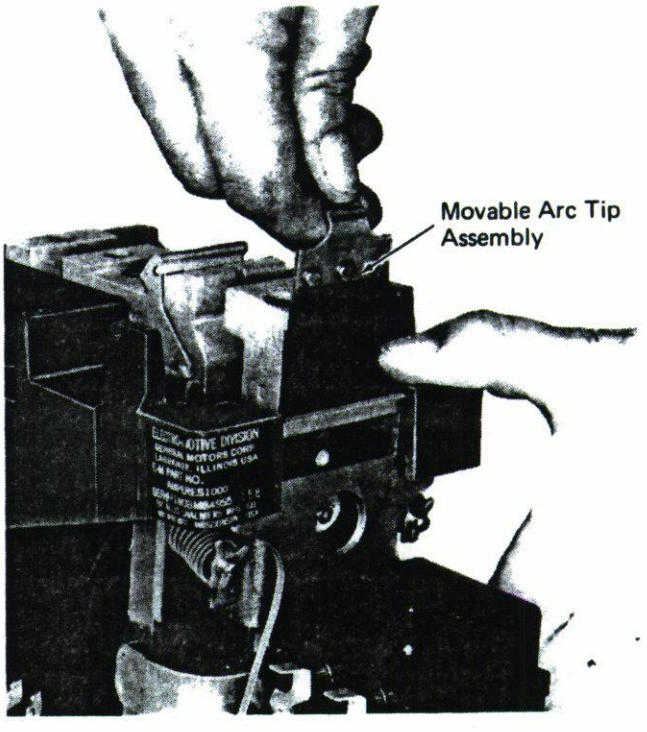
Fig. 8-13 – Removing Movable Contact

Secure new contact assembly with screws and lockwashers, but do not tighten screws at this time.

2. Ensure that the movable contact assembly is properly seated, then tighten screws. Recheck seating of the contact after screws are tightened.

REPLACEMENT OF MOVABLE ARC TIP ASSEMBLY

1. Insert new movable arc tip assembly into slot between movable main contact support and the hold-on magnet bracket, Fig. 8-14.



17894

Fig. 8-14 – Insertion Of Movable Arc Tip Assembly

CAUTION: Arc tip assembly must be inserted between the hold-on magnet bracket and the movable main contact support, not in front of the hold-on magnet bracket.

2. Align the hole in the movable arc tip assembly and the hole in the movable main contact support with the hole in the hold-on magnet bracket. Insert screw and tighten securely.

REPLACEMENT OF STATIONARY ARC TIP ASSEMBLY

The stationary arc tip assembly is located in the arc chute assembly.

1. Remove two screws and lockwashers holding the stationary arc tip assembly to the arc chute. Fig. 8-15.

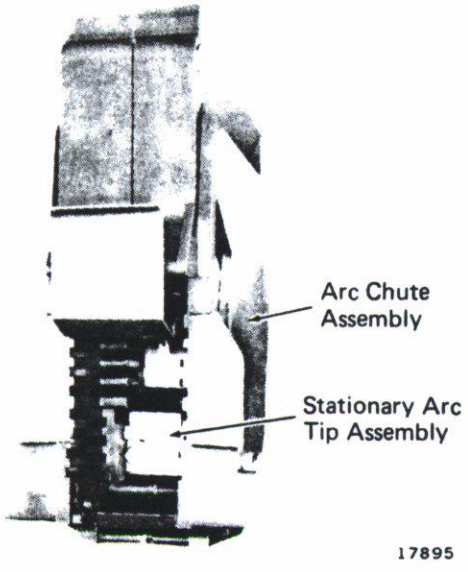


Fig. 8-15 – Replacement Of Stationary Arc Tip Assembly

2. Lift out stationary arc tip assembly.

3. Place new stationary arc tip in proper position and install two screws and lockwashers. Tighten screws securely.

REPLACEMENT OF STATIONARY CONTACT ASSEMBLIES

1. Remove the top stationary contact assembly and two stationary contacts and spacer by removing two screws and lockwashers, Fig. 8-16.

2. Position spacer on the top terminal molding, with the short leg of the "L" down between the pivot springs and the long leg extending back between the wipe springs.

3. Place new stationary contacts over wipe springs and pivot springs. Spring caps must be firmly seated on pivot springs.

4. Insert pointed nose of the top stationary contact assembly into the cavity in back of the stationary contact, engaging the mating pivots.

5. With pivots engaged and the top stationary contact assembly held back against the stop in the top terminal molding, secure with two screws and lockwashers.

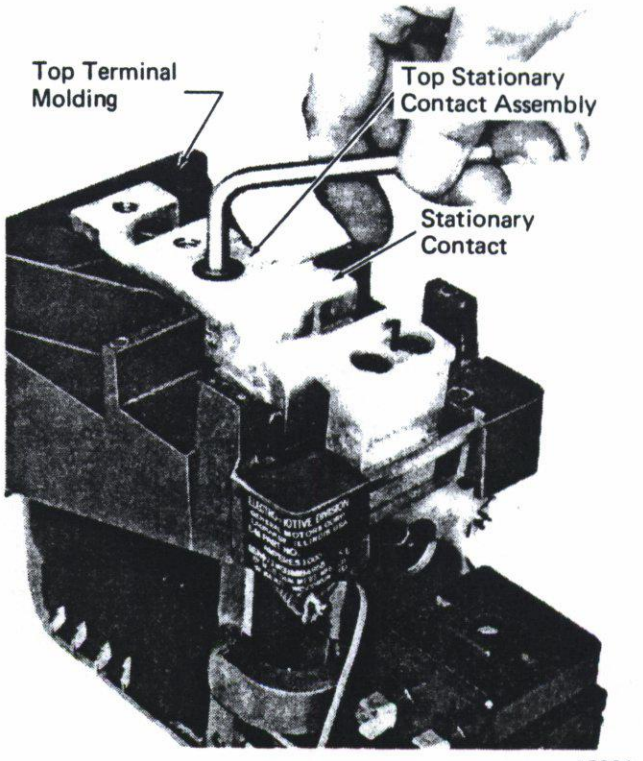


Fig. 8-16 – Removing Stationary Contact Assemblies

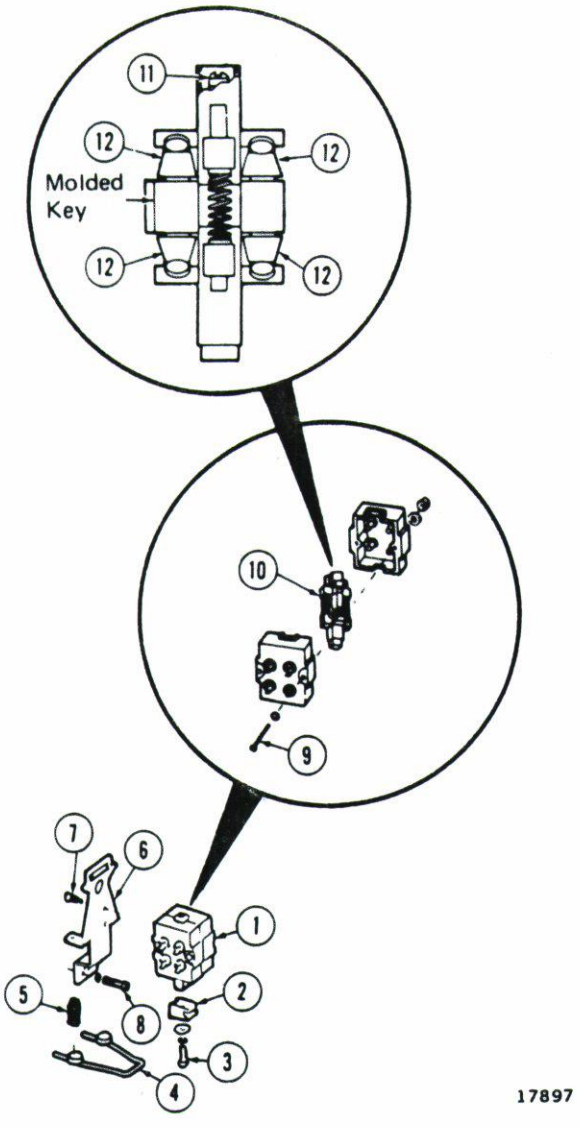
6. Check for freedom of movement of both stationary contact assemblies. Refer to Service Data for contact gap.

INSPECTION OF INTERLOCK CONTACTS

1. Remove screw (3, Fig. 8-17), lockwasher, and washer from bottom of interlock assembly and remove interlock operator (2).

2. Remove two screws (9) from interlock assembly and carefully remove the left-hand cover exposing interlock contacts. Interlock contacts do not require replacement until they are worn .060" per mating pair, when compared to new contact dimensions. Refer to Fig. 8-18 to determine if contacts are usable or require replacement.

NOTE: If the contacts in the movable contact carrier are worn beyond the tolerances in Fig. 8-18, the contact bridges should be replaced. If the stationary contacts located within the interlock covers are defective or loose, the interlock assembly should be replaced.



1 Interlock Assembly
2 Interlock Operator
3 Screw
4 Operator Lever
5 Return Spring
6 Support Bracket
7. Screw
8. Screw
9. Screw
10. Contact Carrier Assembly
11. Screw
12. Movable Contact Bridge

Fig. 8-17 – Interlock Assembly, Exploded View

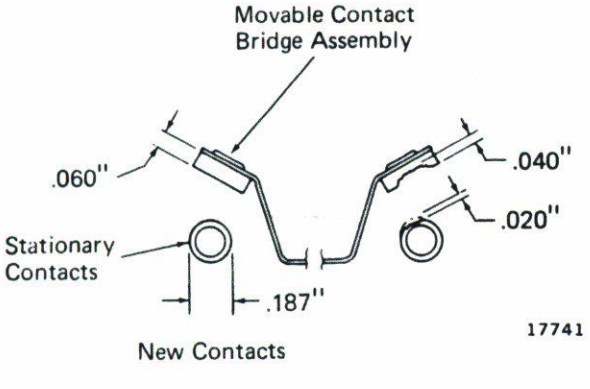


Fig. 8-18 -- Interlock Contacts Wear Limits

REPLACEMENT OF INTERLOCK ASSEMBLY

If inspection determined that interlock assembly should be replaced, proceed as follows:

1. Remove return springs (5, Fig. 8-17), with screw driver.

2. Remove two screws (8) from bottom terminal assembly and swing the interlock support bracket (6), with interlock assembly attached, forward until disengaged from top terminal molding.

3. Remove two screws (7) and remove interlock assembly from support bracket.

4. Mount new interlock assembly to support bracket with screws.

5. Position top end of interlock support bracket under front end of top terminal molding.

6. Attach interlock support bracket to bottom terminal assembly with two screws and lockwashers. Center bracket in the opening of top terminal molding and then tighten screws.

7. Insert both return springs between cups on operating lever (4) and spring location buttons on return spring bracket. Springs must be fully seated in cups.

8. Attach interlock operator to bottom of movable contact carrier (10) with screw, Belleville washer, and lockwasher.

REPLACEMENT OF INTERLOCK CONTACTS

If inspection determined that the interlock contacts must be replaced, proceed as follows:

1. Remove contact carrier (10, Fig. 8-17) from interlock assembly cover.

NOTE: Work on contact carrier in an area where small parts will not be lost if dropped.

2. Hold contact carrier in palm of hand and loosen screw (11) so that the top, center, and bottom elements of the contact carrier can be separated sufficiently to remove an upper and lower set of contact bridges (12). Insert a new set of upper and lower contact bridges.

CAUTION: Each contact bridge must be positioned properly and not inverted since this could cause malfunction of the contactor. See Fig. 8-17 for correct position of contact bridges.

3. Turn over contact carrier in palm of hand and repeat Step 2 for remaining two contact bridges and tighten screw (11). Ensure brass sleeve on each contact bridge assembly is free after screw is tightened.

4. Place contact carrier (10) into the interlock cover half remaining on the contactor. Ensure the screw (11) in the movable contact carrier is at the end of the interlock cover stamped C-D and the molded key is outside the cover. Move contact carrier from end to end to ascertain that the contact bridge assemblies are correctly related to the stationary contacts within the covers.

5. Mate the left cover half to the interlock assembly and secure with two screws, lockwashers, and nuts. Lockwashers are to be used under screw heads and under nuts.

REPLACEMENT OF DYNAMIC BRAKE GRID SHORTING CONTACTOR CONTACTS

INSPECTION OF MAIN CONTACTS

Under normal circumstances, main contacts should not need replacement. If the following inspection procedure does determine main contacts require replacement, replace the dynamic brake grid shorting contactor with a new contactor. Replacement of main contacts is a bench type operation and not possible on the locomotive.

1. Rotate spring-loaded latch on the left side, upper rear of the arc chute, Fig. 8-19, out of the way of the arc chute latch post, and lift arc chute vertically.

2. With the operating coil of the contactor energized, push the top and bottom contact retaining screws in with one hand, so that the movable main contact is firmly held against the stationary main contact, Fig. 8-20. With the other hand, check the gap between the rear of locknut and the front of the spacer. Main contacts must be replaced if the original gap of .035" (wear allowance) has been reduced to .010". Do not disturb original adjustment.

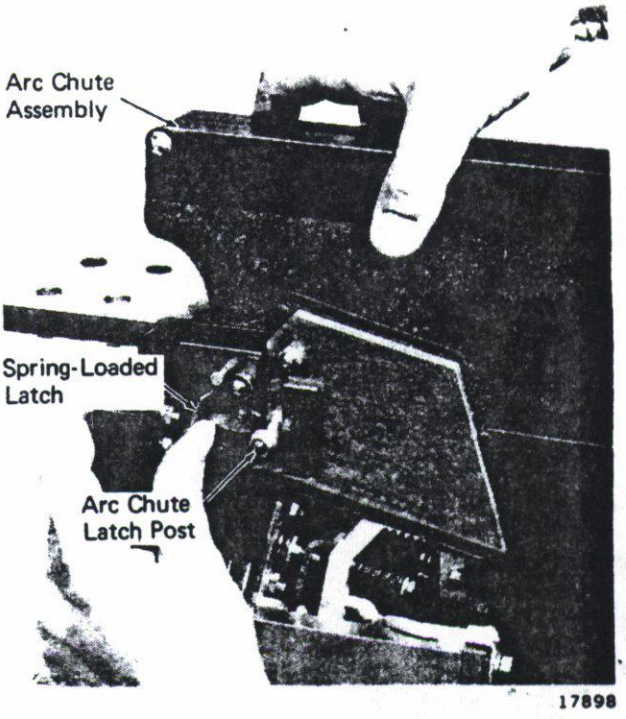


Fig. 8-19 – Removing Arc Chute

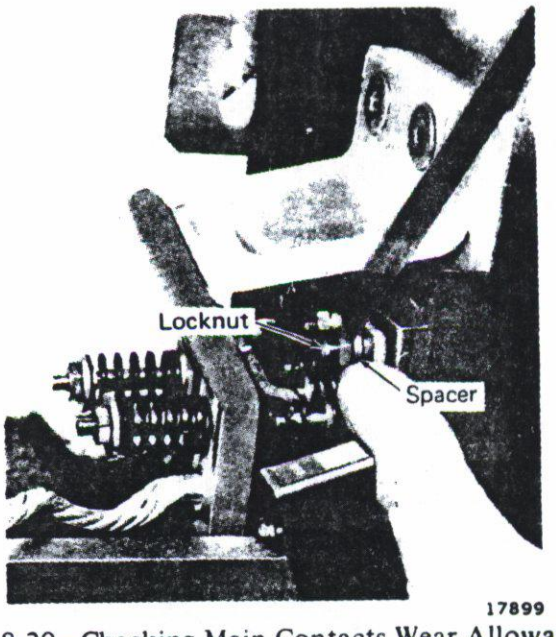


Fig. 8-20 - Checking Main Contacts Wear Allowance

NOTE: When main contacts are being measured to determine if they need replacement, the arcing contacts and other parts need not be removed. Two of the eight measuring points will be hidden, but need not be checked.

INSPECTION OF ARCING CONTACTS

Replacement of arcing contacts is required when the silver contact insert in the stationary arcing

contact is eroded to the copper base at the lower edge of the insert. Replace both movable and stationary arcing contacts as a set.

REPLACEMENT OF MOVABLE AND STATIONARY ARCING CONTACTS

NOTE If arc chute is not removed, remove per Step 1 of Inspection Of Main Contacts.

1. Remove two bolts holding the two flexible wires to the movable contacts, Fig. 8-21.

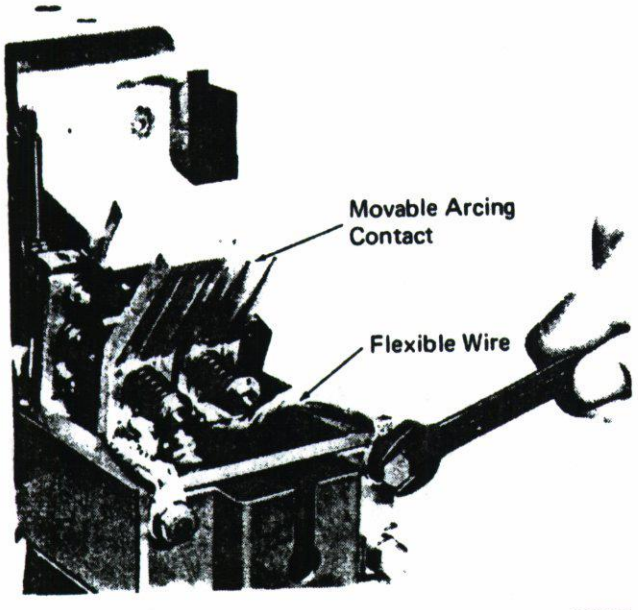


Fig. 8-21 – Removing Flexible Wires To Movable Arcing Contacts

2. Remove the two locknuts and spring glands, holding the pressure springs and the movable arcing contacts to the armature, Fig. 8-22, and remove the movable arcing contacts.

3. Remove two flathead hex socket screws from the stationary arcing contacts, Fig. 8-23, and remove stationary arcing contacts.

4. Install two new stationary arcing contacts with new lockwashers and screws.

5. Install two new movable arcing contacts, two pressure springs with spring glands, and two locknuts.

6. Tighten the two arcing contact locknuts so that the nut is advanced until a flat area filed on the threads of the screw is just fully visible.

7. Replace the two bolts holding the flexible wires.

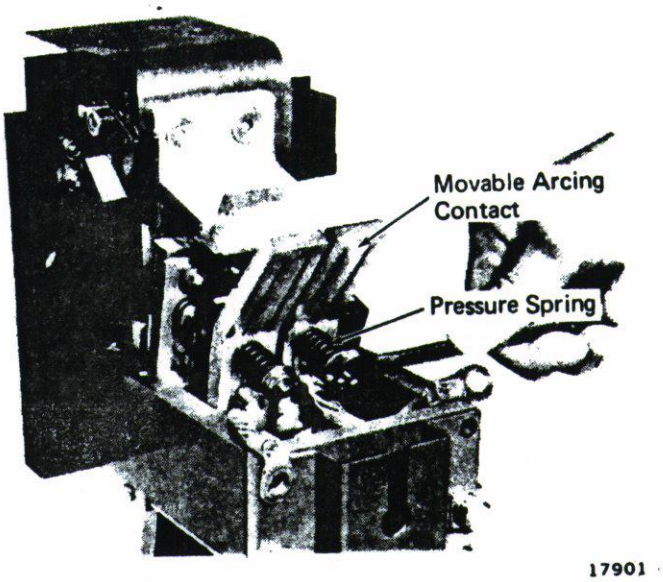


Fig. 8-22 – Removing Movable Arcing Contacts

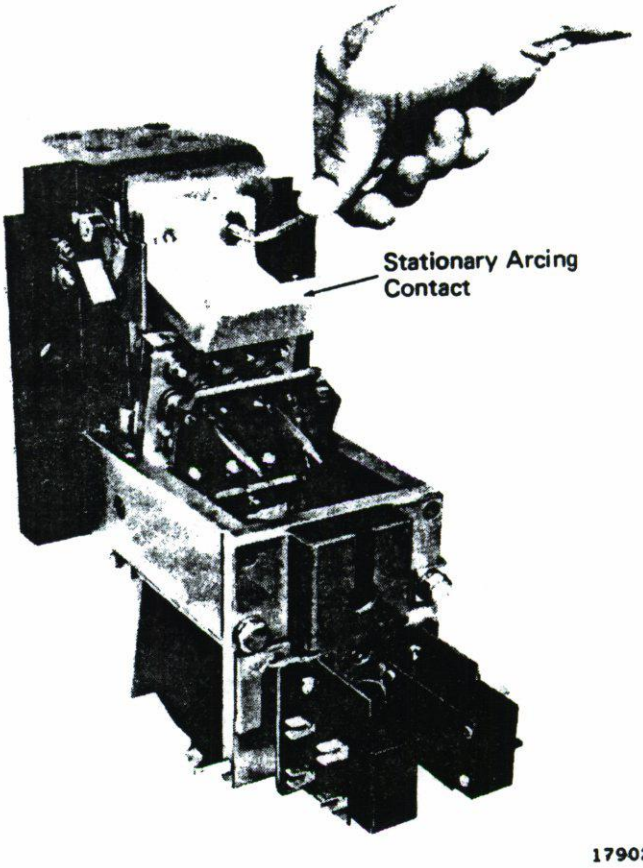


Fig. 8-23 – Removing Stationary Arcing Contact

REPLACEMENT OF CONTACT ASSEMBLIES AND ADJUSTMENTS OF MOTOR OPERATED SWITCHES

The motor operated switch is a composite of one motor module driving a maximum of six switch modules through a segmented shaft.

MOTOR MODULE

AUXILIARY INTERLOCK CONTACT ADJUSTMENT

1. Disconnect all wires from interlock terminals.

2. Remove retaining ring and link pin from link assembly, Fig. 8-24.

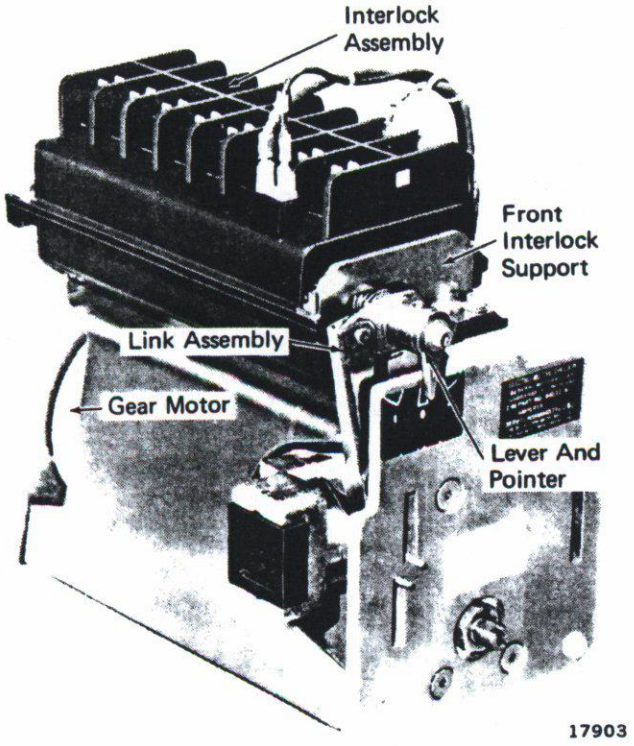


Fig. 8-24 – Motor Module

3. Remove three screws and remove the front interlock support.

4. Separate interlock assembly from gear motor by lifting front end of interlock assembly and sliding forward out of rear interlock support.

5. Remove three screws from interlock cover and open interlock assembly.

6. Place interlock cover in the inverted position. Place the cam shaft with bearing liners and wrap-around bearings into bearing sockets of the cover.

7. With drilled lever pointing up, check contact gaps on the front two circuits, V-Y and X-W, as shown in Fig. 8-25. Gaps must be between .172" and .187". If required, adjust by bending stationary contact finger between the second bend and point of contact with cover molding, Fig. 8-26.

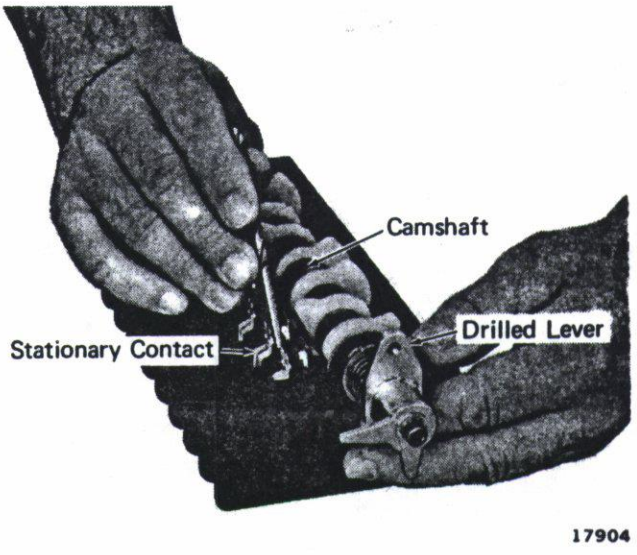


Fig. 8-25 – Auxiliary Interlock Adjustment

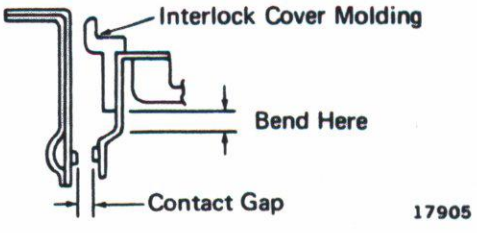


Fig. 8-26 – Interlock Contact Adjustment

8. Rotate camshaft clockwise until drilled lever points to the right. Contact gaps on the six rear circuits must be between .172" and .187". If required, adjust by bending as described in Step 7.

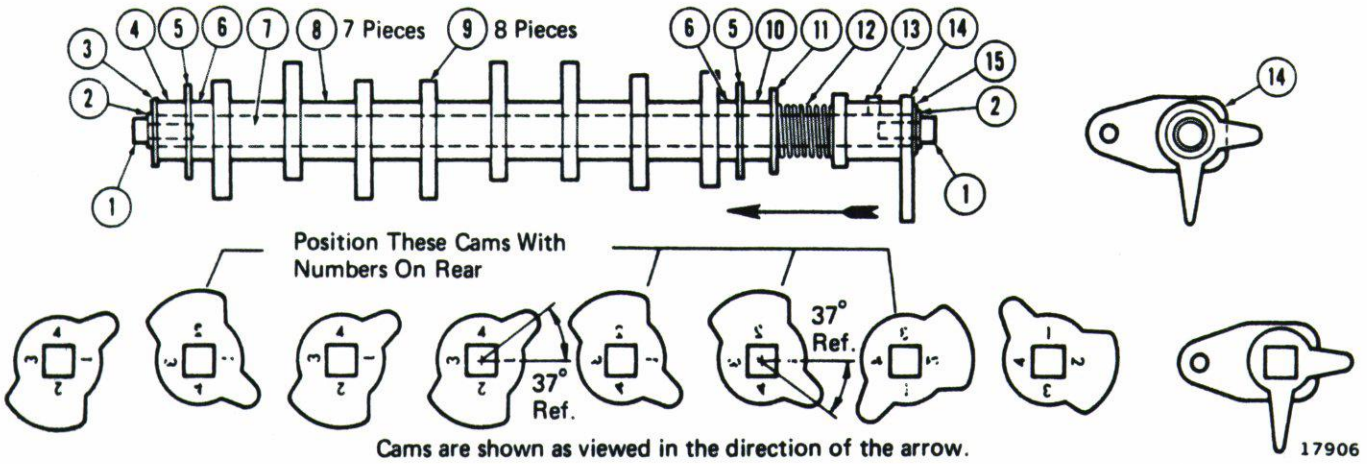
9. Place base assembly over the cover and cam assembly. Invert and secure with three screws and washers.

10. Slide the interlock assembly into the rear interlock support, over the gear motor assembly, with the cam shaft pointer in front. Position the front interlock support and secure with three screws and lockwashers.

GEAR MOTOR MAINTENANCE

The gear motor assembly, Fig. 8-24, is lubricated for the life of the gear motor.

The brushes should be replaced in the conventional manner when worn down to 1/4" length.



1 Cap Screw
2 Lockwasher
3 Plain Washer, .75" O.D.
4. Interlock Bearing, 13/32" lg.
5. Creepage Washer
6. Spacer Tube, 15/64" lg.
7. Camshaft
8. Spacer Tube, 21/32" lg.
9. Cam
10. Interlock Bearing, 21/64" lg.
11. Washer
12. Spring
13. Set Screw
14. Lever And Pointer
15. Plain Washer, .219" O.D

Fig. 8-27 – Camshaft Assembly

CAMSHAFT ASSEMBLY

If it becomes necessary to rebuild the camshaft interlock assembly, refer to Fig. 8-27 for sequence of parts and the proper orientation of the cams.

SWITCH MODULE

REPLACING MOVABLE CONTACT ASSEMBLY

1. Remove operating head, Fig. 8-28, by removing screws.

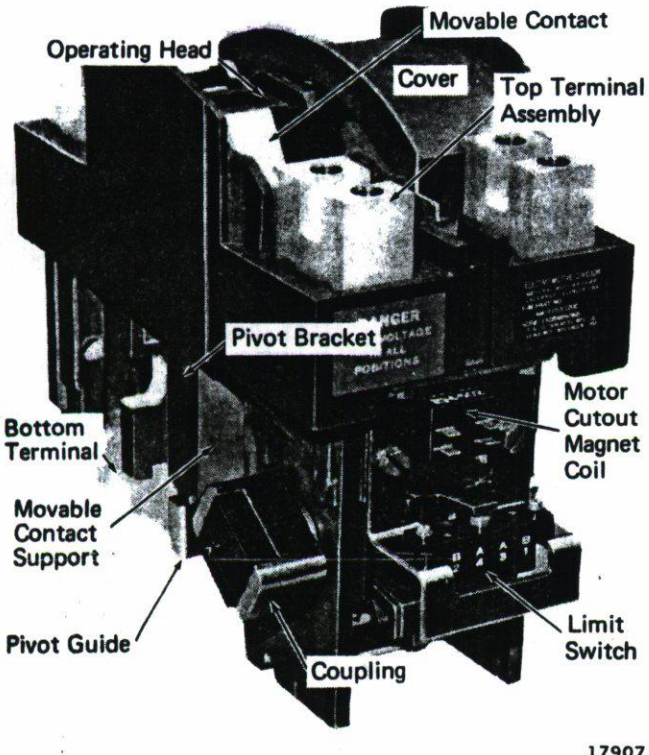
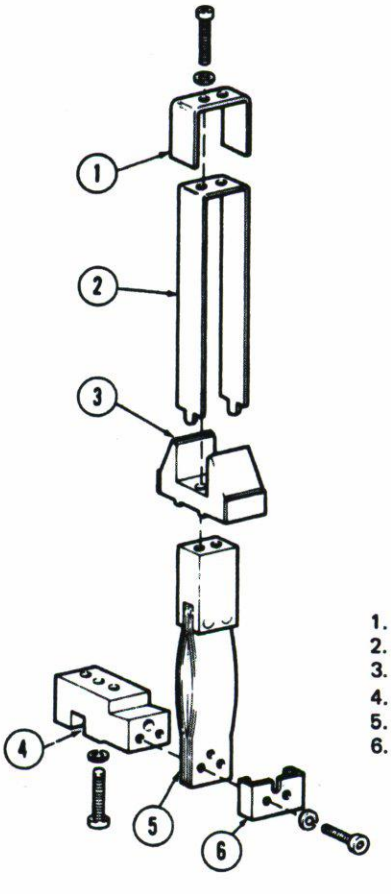


Fig. 8-28 – Switch Module

2. Remove two screws, hold-on iron (1, Fig. 8-29), pivot bracket (2), and movable contact (3).

3. Remove two screws, hold-on iron, pivot bracket, and movable contact from the other side.



1. Hold-On Iron
2. Pivot Bracket
3. Movable Contact
4. Bottom Terminal
5. Movable Contact Support
6. Pivot Guide

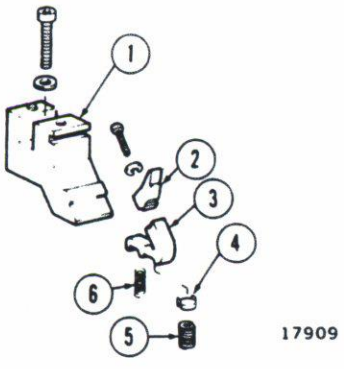
Fig. 8-29 – Movable Contact Assembly, Exploded View

4 Place two new movable contacts on movable contact supports, reassemble pivot bracket and hold-on iron and secure with two screws.

REPLACING STATIONARY CONTACT ASSEMBLIES

If inspection has determined that any one of the three stationary contacts requires replacement, replace all three to maintain proper contact pressure distribution.

1 Remove screw, releasing top terminal assembly (1, Fig. 8-30) with the three stationary contact assemblies (2 and 3)



1 Top Terminal Assembly
2 Stationary Contact Tip
3 Stationary Contact Support
4 Pivot Spring Cap
5 Pivot Spring
6 Wipe Spring

Fig. 8-30 – Stationary Contact Assembly, Exploded View

2 Remove three wipe springs (6) and three pivot springs (5) with spring caps (4) from the base molding.

3 Repeat Steps 1 and 2 to remove the stationary contact assemblies in the remaining three locations.

4 Mate new stationary contact tips (2) to new contact supports (3). Secure the halves with screws and lockwashers making certain that the halves are centered on each other.

5 Ensure that support areas for wipe springs and pivot springs are free of all foreign particles.

6 Place a wipe spring (6) over each of the three small pins in one of the four contact pockets.

7 Place a pivot spring (5) over each of the three larger pins in the same contact pocket.

8 Attach a pivot spring cap (4) to the bottom of each of the three stationary contact assemblies by the spring tension of the two ears on spring cap. Bend ears inward if necessary to bind on support half.

9 Place one contact assembly with attached spring cap over wipe spring and pivot spring making certain that the spring cap is firmly seated over the top of pivot spring. Position the remaining two contact assemblies in the same manner.

10 Insert the pointed nose of top terminal (1) into cavity in back of the stationary contact assemblies, engaging the pivots of the mating parts.

11 Secure top terminal to base molding with screw and lockwasher. Be certain that the pivots remain engaged and that the rear end of the top terminal touches the base molding.

12 Check for freedom of motion at each stationary contact. A clearance of 0.020" to 0.045" shall be maintained behind the top edge of each stationary contact. Fig. 8-31.

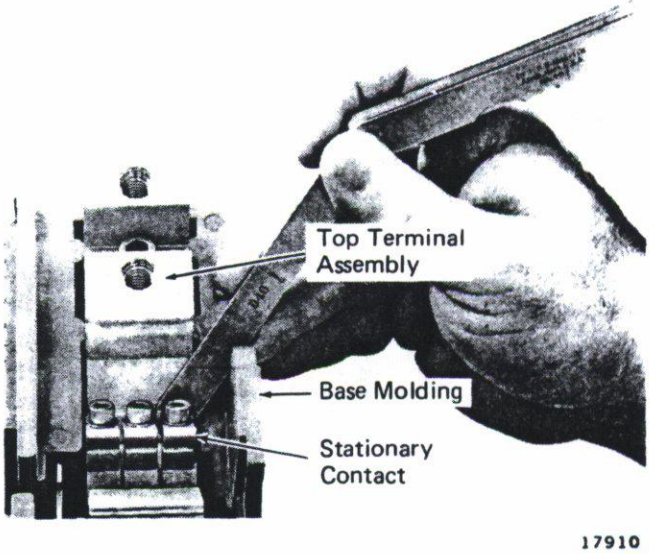


Fig. 8-31 – Checking Stationary Contact Clearance

13 Install the remaining three sets of stationary contacts and top terminals using the same procedure.

SERVICE DATA
INSPECTION AND REPLACEMENT OF CONTACT TIPS FOR CONTACTORS AND MOTOR OPERATED TRANSFER SWITCH

REFERENCES

Power Contactors – 8416134 and 8458534	M.I. 5422
Braking Contactors – 8461331, 8461332, and 8461333	M.I. 5424
Dynamic Brake Grid Shorting Contactors – 8416136, 8436326, and 8459697	M.I. 5406
Motor Operated Switch – Motor Module 8453176, Switch Module 8453175	M.I. 5421

SPECIFICATIONS

POWER CONTACTOR 8458534

MAIN CONTACTS

Contact Rating (Continuous Duty)	1200 amps
Contact Wear Allowance (Total)	1/8"
Contact Opening (Nominal)	0.484"
Initial contact pressure	15-25 lbs.

INTERLOCK CONTACTS

Contacts A-B, C-D	Normally closed
E-F, G-H	Normally open
Contact Spring Pressure (at 3/32" deflection)	0.25 lbs.
Contact Opening	3/16"
Contact Lift	3/32"
Contact Wear Allowance (Total)	0.060"

MAGNET COIL

Resistance (at 20°C)	120 ohms (±10%)

OPERATION

Working Voltage (Continuous)	24 V DC
Pickup (at 20°C)	48 V DC
Dropout (at 20°C)	5-28 V DC

HI-POT

	60 Hz, 1 Minute
Magnet Coil To Mounting	600 V RMS
Magnet Coil To Main Contacts	
Main Contacts To Mounting	
Main Contacts To Interlocks	5400 V RMS
Between Open Main Contacts	
Interlocks To Mounting	
Interlock To Interlock	

BRAKING CONTACTOR 8461331

MAIN CONTACTS

Contact Rating	1000 amps
Contact Pressure (New Contacts)	9-10 lbs.
Contact Wear Allowance (Each Contact)	1/16"
Contact Opening (New Contact, Min.)	15/32"

INTERLOCK CONTACTS

Contacts A-B, C-D	Normally closed
E-F, G-H	Normally open
Contact Lift, Short Wipe (at 3/32" deflection)	0.25 lbs.
Contact Lift, Long Wipe (at 1/4" deflection)	0.30 lbs.
Movable Contact Assembly Travel	0.375"
Contact Wear Allowance (Total)	0.060"

MAGNET COIL

Resistance (at 20°C)	120 ohms (±10%)

OPERATION

Working Voltage (Continuous)	74 V DC
Pickup (at 20°C)	48 V DC
Dropout (at 20°C)	5-28 V DC

HI-POT

	60 Hz, 1 Minute
Magnet Coil To Mounting	600 V RMS
Magnet Coil To Main Contacts	
Main Contacts To Mounting	
Main Contacts To Interlocks	2400 V RMS
Between Open Main Contacts	
Interlocks To Mounting	
Interlock To Interlock	

DYNAMIC BRAKE GRID SHORTING CONTACTOR 8459697

MAIN CONTACTS

Contact Rating	2250 Amps
Contact Wear Allowance Gap	0.035"
Contact Replacement Gap Limit	0.010"
Contact Spring Pressure	6.25-6.5 lbs.

INTERLOCK CONTACTS

8332487 Contacts A-B, C-D	Normally open
8332489 Contacts E-F	Normally open
G-H	Normally closed

ARCING CONTACTS

Contact Spring Pressure	3.75-4.0 lbs.
Wear Limit	Silver insert eroded to copper base at lower edge of insert

MAGNET COIL

Resistance	123 ohms (±10%)

SERVICE DATA
INSPECTION AND REPLACEMENT OF CONTACT TIPS FOR CONTACTORS AND MOTOR OPERATED TRANSFER SWITCH

OPERATION

Working Voltage (Continuous)	74 V DC
Pickup (From -40° to +100°C)	48 V DC
Dropout (From -40° to +100°C)	5-28 V DC

HI-POT

	60 Hz, 1 Minute
Magnet Coil To Mounting	600 V RMS
Magnet Coil To Main Contacts	
Main Contacts To Mounting	
Main Contacts To Interlocks	3200 V RMS
Between Open Main Contacts	
Interlocks To Mounting	
Interlock To Interlock	

SWITCH MODULE 8453174 OR 8453175

MAIN CONTACTS

Contact Rating (Continuous)	1200 amps
Interruption Rating	100 amps
Contact Wear Allowance (Total)	1/8"

MOTOR CUTOUT SWITCH

Coil Resistance (at 20°C)	190 ohms (±10%)
Coil Pickup (at 20°C)	48 V DC
Coil Dropout (at 20°C)	5-28 V DC

MOTOR MODULE 8453176

INTERLOCK CONTACTS

Contact Rating	10 amps
Contact Gap	0.172-0.187"

Contact Position

	Interlock Camshaft Pointer Position		
Contacts	1	0	2
Y-V	Open	Closed	Closed
X-W	Closed	Closed	Open
A-B	Open	Open	Closed
C-D	Open	Open	Closed
E-F	Closed	Open	Open
G-H	Closed	Open	Open
N-P	Open	Open	Closed
Q-R	Closed	Open	Open

LOAD TEST AND HORSEPOWER STANDARDIZATION

INTRODUCTION

This section contains procedures for load test and power standardisation. Accurate and standardised power data can be used to evaluate performance of the engine and auxiliary equipment and to indicate possible malfunction or excessive power output. Correction of malfunctions will improve engine performance, and operation at normal power will minimise engine wear.

The following information is provided in this section:-

1. Preliminary preparation for load test.
2. Test setup for load testing on dynamic braking grids.
3. Loading the unit.
4. Power calculation and standardisation.

The service Data pages included at the end of this section provide the following information:-

1. References to drawings and other publications relating to equipment and procedures covered in this section.
2. A list of routine maintenance parts and equipment recommended for use with the procedures provided in this section.
3. Specifications covering components and circuits.
4. Power and loading resistance graphs, and power correction factors.

PRELIMINARY PREPARATION FOR LOAD TEST

1. Stop the diesel engine and remove the starting fuse. Open the generator field circuit breaker.
2. Check that fuel tank contains sufficient fuel (minimum 1136 litres) for the period of the load test (about 4 hours). Fuel should be in accordance with specifications listed in M.I. 1750.
3. Check oil level at:-
   a. Engine oil pan
   b. Air Compressor
   c. Governor
   d. Engine air filter.

4. Check that coolant level, is at the STOP/FULL mark on the water tank sight glass gauge.

5. Make an engine air box inspection. Check condition of piston rings and cylinder walls.

6. Make a generator air box inspection. Replace any blown fuses and shorted diodes.

NOTE: The inertial air filter compartment door is to remain closed during the testing.

7. Suspend a thermometer for measuring ambient air temperature. The thermometer may be hung at the radiator air inlet grill.

8. Remove the plug in the engine mounted fuel filter and install a dial thermometer to read fuel oil temperature.

9. A thermometer well is located in the water pump discharge elbow. Fill the well with oil, and in it place a glass thermometer for measuring engine water inlet temperature.

10. Suspend a caged glass thermometer, approximately 75 mm below the oil level in the lube oil strainer housing. This will measure engine oil inlet temperature.

TEST SETUP

The test setup for loading the locomotive is determined by the type of loading equipment that is available. The following paragraphs provide test setup procedures and must be read in conjunction with applicable locomotive wiring diagram.

SETUP FOR LOADING ON DYNAMIC BRAKING GRIDS(FIG9-1)

(Units Not Equipped for Automatic Loading).

1. Remove the generator shunt panel busbar.

2. Reconnect between terminals D, G, H & C.

3. Install a 4000 Amp Shunt between terminals A & D.

4. Connect two 1100/.24 cables between terminals E & F.

5. Connect 0-1200V Voltmeter positive to TP3 and the negative to TP4 on the test panel.

6. Connect 0-100 millivolt meter to a 4000 Amp shunt.

7. Connect a 300 V A.C. voltmeter across two phases of the D14 alternator.

8. Turn the test switch to the load test position.

9. Move the reverser to neutral.

10. Remove 6F1 wire from DGX-3 NO and replace on DGX-3NC.

11. Refer to procedures for loading the unit.

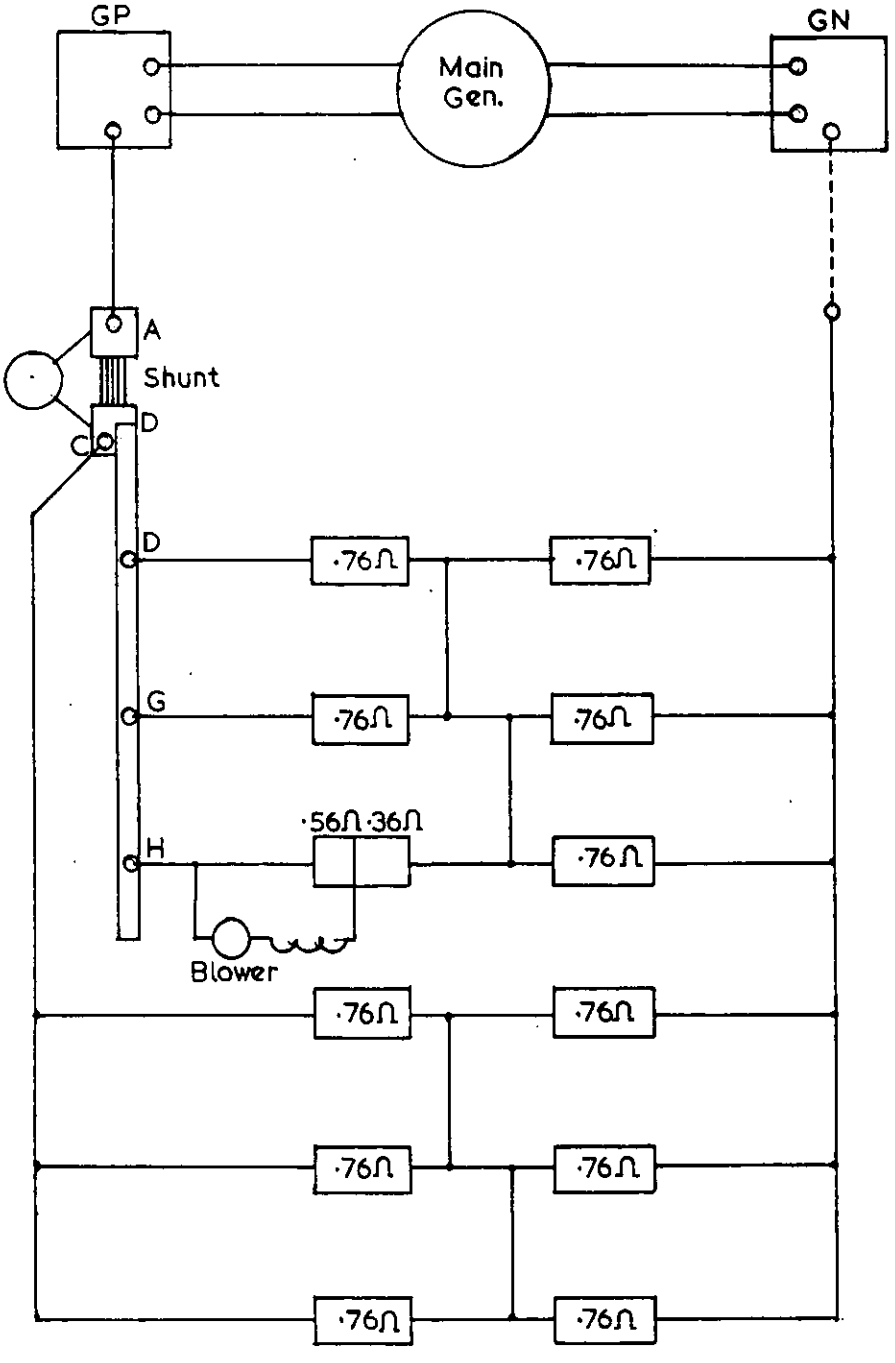


Fig 9-1 Test Setup for Loading on Dynamic Brake Grids – GL22C 2 & GL26C 2

LOADING THE UNIT

When the load test setup is checked and in order, perform the load test as follows:-

1. Make certain that the generator field and AC control circuit breakers are closed. Replace the starting fuse, start the diesel engine, and allow the engine time to warm up.

CAUTION: Do not apply load until water temperature reaches at least 49°C. If the engine has been idling in extremely cold weather, apply load gradually to increase engine temperature.

2. Set the locomotive controls for operation under power, but allow the throttle to remain in IDLE position.

3. Centre the reverser handle.

4. Place the load test switch in LOAD TEST position.

5. Place the throttle in Notch 1 position. Check the following:-

   a. Engine oil pressure satisfactory.

   b. No fuel oil or water leaks.

   c. Dynamic brake grid blower operating.

   d. Generator volts and amperes registering.

6. Advance throttle one step at a time to full engine speed and load. When at full speed and load, check radiator fan. A test button is located on each engine temperature switch.

7. With throttle in Notch 8 position, check that the load regulator is at a balance point and is not at maximum field position.

8. Operate test switch on the TH module. Load regulator should move quickly to the minimum field position. After releasing the test switch the load regulator should return to a balance point.

9. Close all engine room doors and allow the engine to run at full load until conditions stabilise (about one half hour if power only is being checked and at least 60 minutes if the oil cooler performance is being checked).

10. Check engine water temperature periodically until there is no difference between one temperature reading and another taken 15 minutes later.

NOTE: Opening the engine room doors to take temperature readings can effect the stability of conditions. Always allow time for conditions to stabilise before taking a second reading.

11. When the stability of conditions is verified, observe and record valves and conditions as indicated on the form shown on the Service Data page. Take a second set of readings in 10 or 15 minutes, and a third set 10 or 15 minutes after the second.

CALCULATION AND POWER STANDARDIZATION

1. From the observations, calculate the corrected total engine power using the formulas, correction factors and auxiliary power values that appear in the Service Data.

2. If the total power adjusted to standard conditions does not fall within the allowable limits listed on the Service Data page, the rack settings, injector timing, valve timing, governor settings, injector calibration, air filter cleanliness, power assembly condition, and generator excitation, should be checked to find the reason for the power discrepancy.

3. If the engine lube oil inlet temperature is higher than the maximum indicated by the lube oil cooler performance base line graph shown in the Service Data pages in Section 2 of this manual, the oil cooler should be cleaned.

CAUTION

On units not equipped for automatic self loading, the LOAD TEST position of the test panel rotary switch will open circuit the main generator unless an external load is applied.

Never return the test switch to the NORMAL position while operating under load.

LOAD TEST AND POWER STANDARDIZATION

REFERENCES

Locomotive "Charts and Graphs" drawing, which includes setting values for systems and components is referenced in the Circuit Diagram Index. An electrical parts list is included in the "Locomotive Running List".

645E3 Engine Maintenance Manual.

Lube Oil Coolers..... M.I. 927

THERMOMETERS REQUIRED

Dial indicating thermometer 0° - $66^{\circ}C$

Glass thermometer 0° - $66^{\circ}C$

Glass thermometer 38° - $121^{\circ}C$ Bulb 6.35 mm maximum diameter.

Caged Glass thermometer 38° - $121^{\circ}C$.

SPECIFICATIONS

odel	Governor Rack	Engine RPM	Total Power Adjusted to Standard Conditions GL22C-2	Total Power Adjusted to Standard Conditions GL26C-2
	0.83	900-908	1119 kW	1492 kW

ɔrmulas: Input to Generator=Generator Output Power= $\frac{\text{Main. Gen. Volts x Main Gen Amps}}{.935}$

AR10 Efficiency is 93.5%

Power Adjusted to Standard Conditions = $\frac{\text{Main Gen. Power + Auxiliary Power}}{\text{A x B x C x D}}$

Where in the formula -

A - Is the correction factor for air temperature (Standard is 17.8°C)

B - Is the correction factor for altitude. (Standard at sea level is 1012.53 millibars)

C - Is the correction factor for fuel density. (Standard is 0.845 specific gravity).

D - Is the correction factor for fuel temperature. (Standard is 17.8°C).

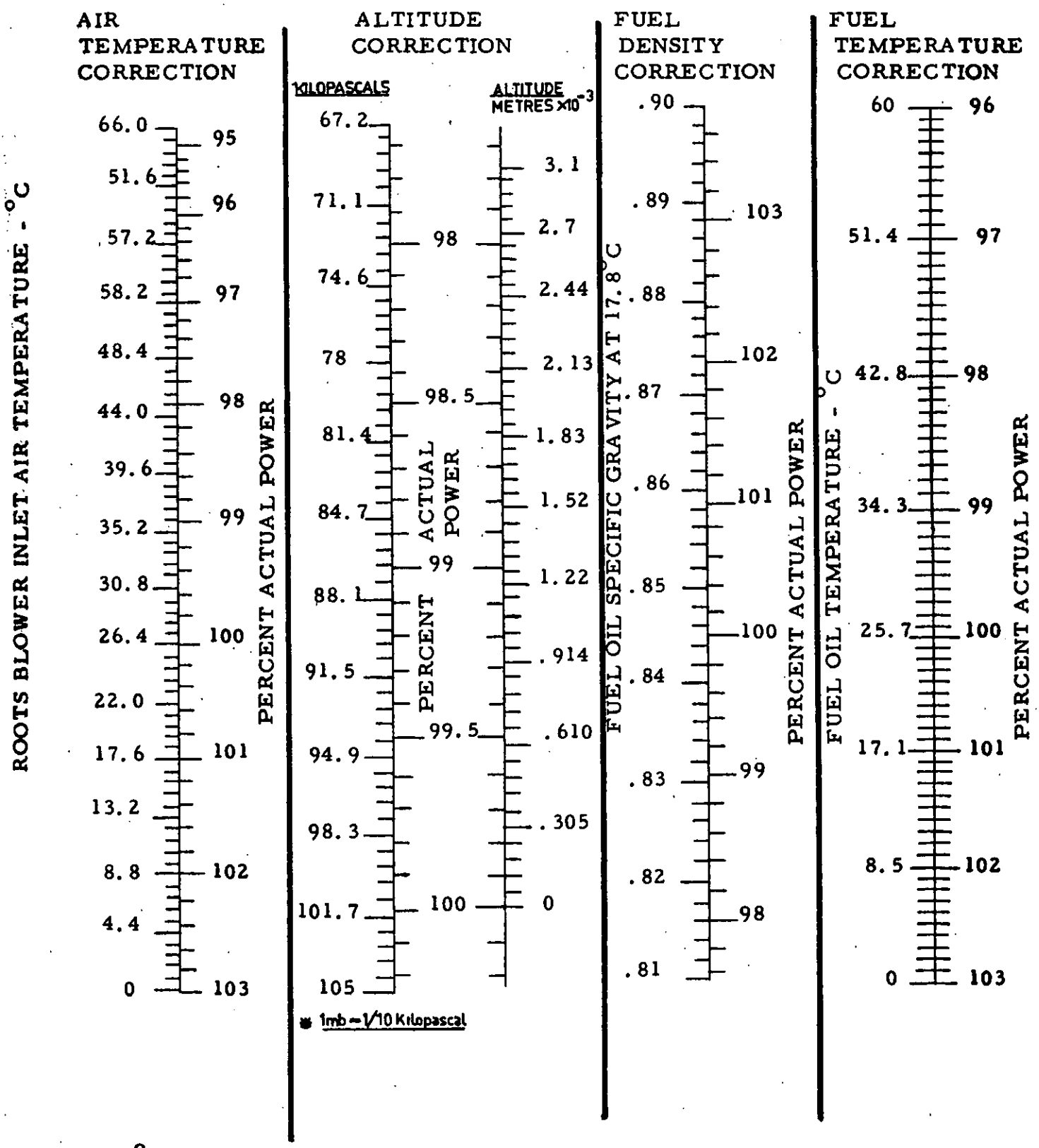
Reference the table of correction factors on the other side of this data sheet

TABLE OF AUXILIARY POWER	GL22C-2	GL26C-2
Auxiliary Generator	7	7
Traction Motor Blower	52	52
2 x 48" Cooling Fans (GL26C-2)		60
1 x 48", 1 x 36" Cooling Fans (GL22C-2)	42	
WBO Compressor - Unloaded	11	11
TOTAL	112	130

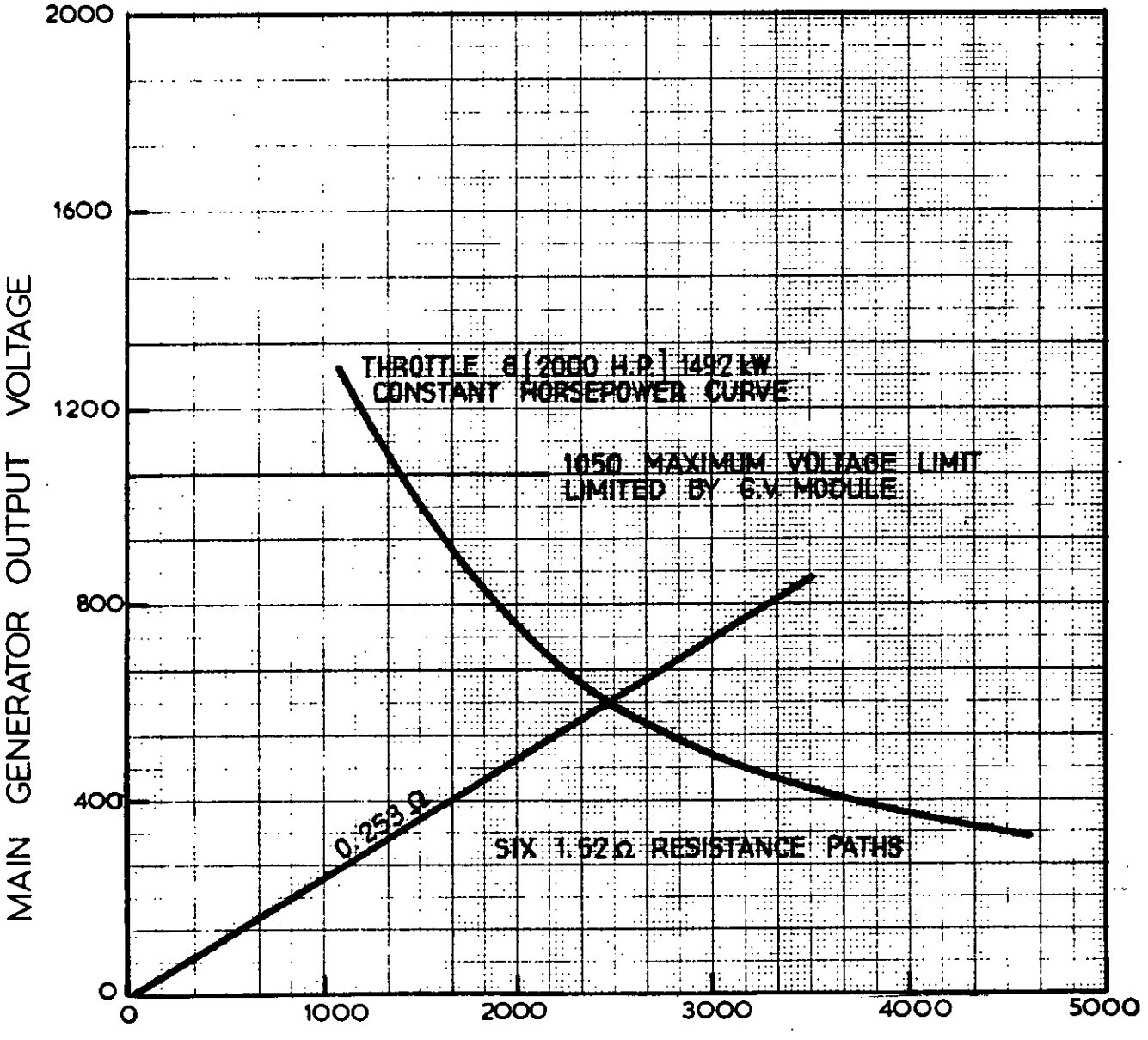
NOTE: 1. 36" 10 blade fan Part No. 5526269 Produces 12.1 kW at 1780 RPM.
48" 9 blade fan Part No. 8379212 Produces 29.8 kW at 1780 RPM.

2. Auxiliary Generator Power must be calculated for each locomotive as follows:-
Aux. Gen Output = Volts x Amps
Aux. Gen Input = Aux. Gen Output + Copper Loss + Iron loss + windage + friction.
Copper loss full load = 6% full load power.
Iron loss + W & F = 6% Power used

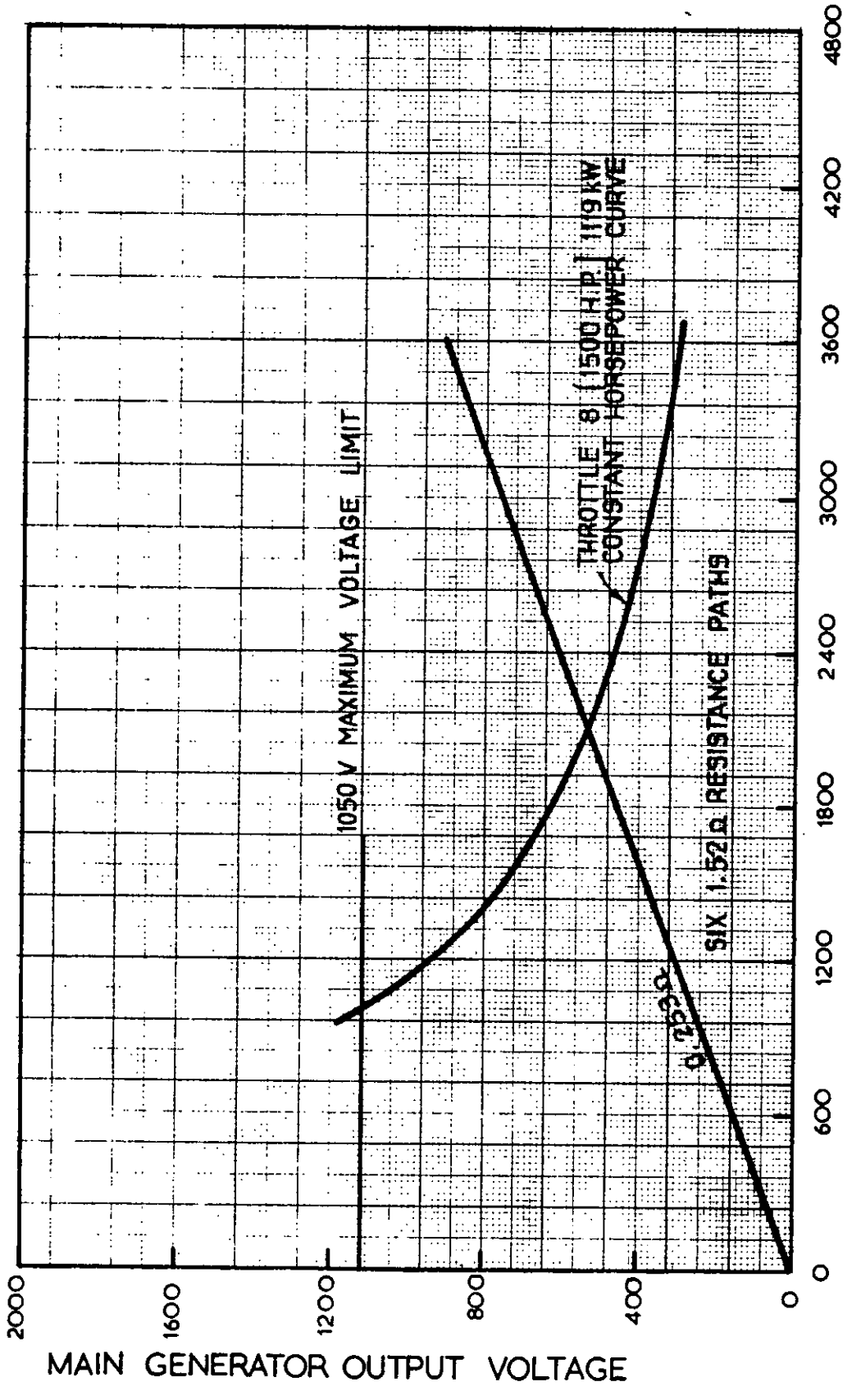
CORRECTION FACTORS FOR 12 &16 CYLINDER 645E ENGINES



*Add 3°C to Ambient to obtain Inlet Temperature



GL26C-2 1492kW Generator Loading Graph
(Dynamic Brake Grid Load)



GL22C - 2 1119kW Generator Loading Graph (Dynamic Brake Grid Load)

LOAD TEST AND HORSEPOWER STANDARDIZATION

INTRODUCTION

This section contains procedures for load test and power standardisation. Accurate and standardised power data can be used to evaluate performance of the engine and auxiliary equipment and to indicate possible malfunction or excessive power output. Correction of malfunctions will improve engine performance, and operation at normal power will minimise engine wear.

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PRELIMINARY PREPARATION FOR LOAD TEST

1. Stop the diesel engine and remove the starting fuse. Open the generator field circuit breaker.
2. Check that fuel tank contains sufficient fuel (minimum 1136 litres) for the period of the load test (about 4 hours). Fuel should be in accordance with specifications listed in M.I. 1750.
3. Check oil level at:-
   a. Engine oil pan
   b. Air Compressor
   c. Governor
   d. Engine air filter.

4. Check that coolant level, is at the STOP/FULL mark on the water tank sight glass gauge.

5. Make an engine air box inspection. Check condition of piston rings and cylinder walls.

6. Make a generator air box inspection. Replace any blown fuses and shorted diodes.

NOTE: The inertial air filter compartment door is to remain closed during the testing.

7. Suspend a thermometer for measuring ambient air temperature. The thermometer may be hung at the radiator air inlet grill.

8. Remove the plug in the engine mounted fuel filter and install a dial thermometer to read fuel oil temperature.

9. A thermometer well is located in the water pump discharge elbow. Fill the well with oil, and in it place a glass thermometer for measuring engine water inlet temperature.

10. Suspend a caged glass thermometer, approximately 75 mm below the oil level in the lube oil strainer housing. This will measure engine oil inlet temperature.

TEST SETUP

The test setup for loading the locomotive is determined by the type of loading equipment that is available. The following paragraphs provide test setup procedures and must be read in conjunction with applicable locomotive wiring diagram.

SETUP FOR LOADING ON DYNAMIC BRAKING GRIDS(FIG 9-1)

(Units Not Equipped for Automatic Loading).

1. Remove the generator shunt panel busbar.

2. Reconnect between terminals D, G, H & C.

3. Install a 4000 Amp Shunt between terminals A & D.

4. Connect two 1100/.24 cables between terminals E & F.

5. Connect 0-1200V Voltmeter positive to TP3 and the negative to TP4 on the test panel.

6. Connect 0-100 millivolt meter to a 4000 Amp shunt.

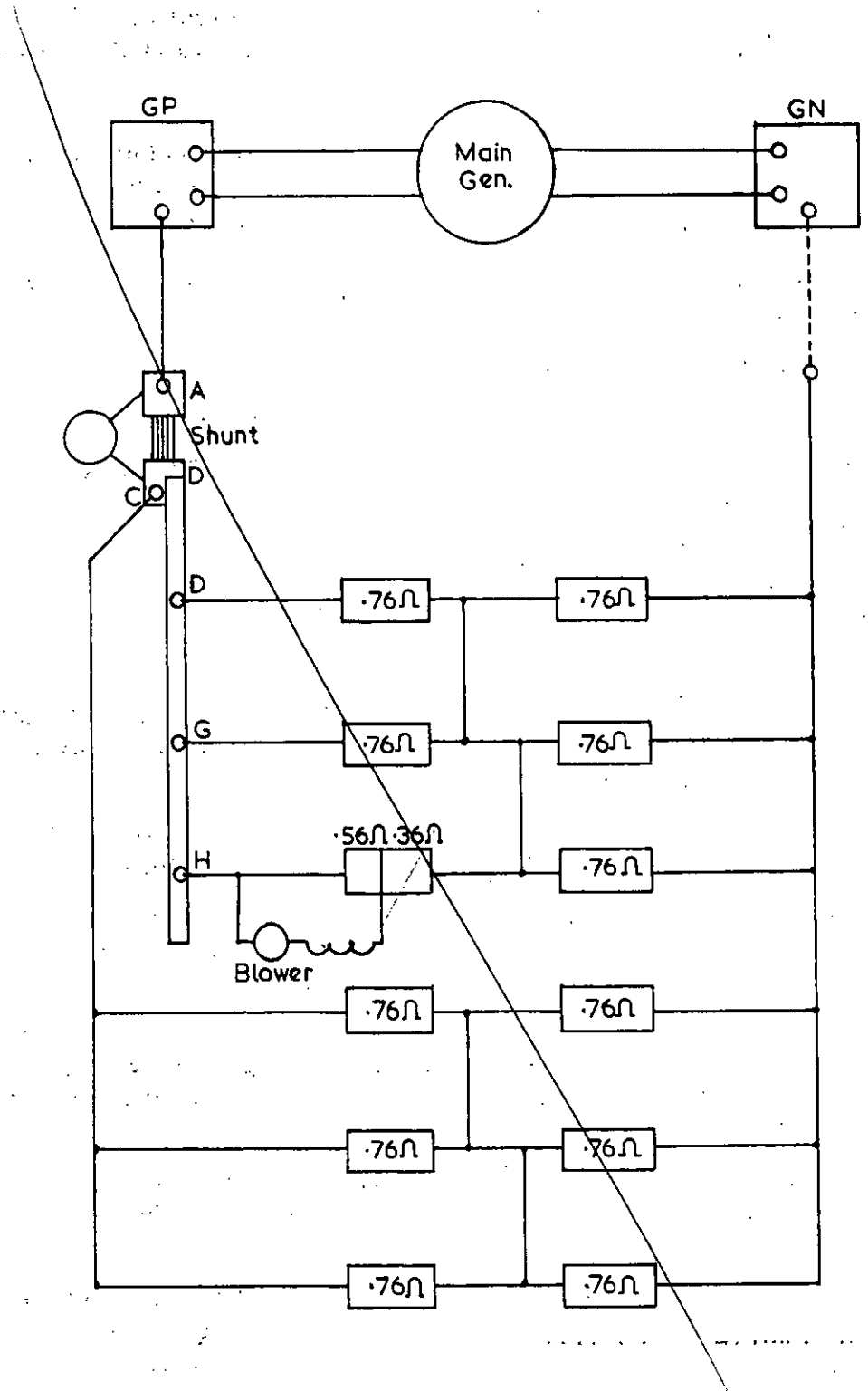
7. Connect a 300 V A.C. voltmeter across two phases of the D14 alternator.

8. Turn the test switch to the load test position.

9. Move the reverser to neutral.

10. Remove 6F1 wire from DGX-3 NO and replace on DGX-3NC.

11. Refer to procedures for loading the unit.



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LOADING THE UNIT

When the load test setup is checked and in order, perform the load test as follows:-

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2. Set the locomotive controls for operation under power, but allow the throttle to remain in IDLE position.
3. Centre the reverser handle.
4. Place the load test switch in LOAD TEST position.
5. Place the throttle in Notch 1 position. Check the following:-
   a. Engine oil pressure satisfactory.
   b. No fuel oil or water leaks.
   c. Dynamic brake grid blower operating.
   d. Generator volts and amperes registering.
6. Advance throttle one step at a time to full engine speed and load. When at full speed and load, check radiator fan. A test button is located on each engine temperature switch.
7. With throttle in Notch 8 position, check that the load regulator is at a balance point and is not at maximum field position.
8. Operate test switch on the TH module. Load regulator should move quickly to the minimum field position. After releasing the test switch the load regulator should return to a balance point.
9. Close all engine room doors and allow the engine to run at full load until conditions stabilise (about one half hour if power only is being checked and at least 60 minutes if the oil cooler performance is being checked).
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645E3 Engine Maintenance Manual.

Lube Oil Coolers..... M.I. 927

THERMOMETERS REQUIRED

Dial indicating thermometer 0° - 66°C

Glass thermometer 0° - 66°C

Glass thermometer 38° - 121°C Bulb 6.35 mm maximum diameter.

Caged Glass thermometer 38° - 121°C.

SPECIFICATIONS

Model	Governor Rack	Engine RPM	Total Power Adjusted to Standard Conditions GL22C-2	Total Power Adjusted to Standard Conditions GL26C-2
	0.83	900-908	1119 kW	1492 kW

Formulas: Input to Generator = Generator Output Power = $\frac{\text{Main. Gen. Volts x Main Gen Amps}}{.935}$

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Where in the formula -

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(Standard at sea level is 1012.53 millibars)

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(Standard is 17.8°C).

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WBO Compressor - Unloaded	11	11
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NOTE: 1. 36" 10 blade fan Part No. 5526269 Produces 12.1 kW at 1780 RPM.
48" 9 blade fan Part No. 8379212 Produces 29.8 kW at 1780 RPM.

2. Auxiliary Generator Power must be calculated for each locomotive as follows:-
Aux. Gen Output = Volts x Amps
Aux. Gen Input = Aux. Gen Output + Copper Loss + Iron loss + windage + friction.
Copper loss full load = 6% full load power.
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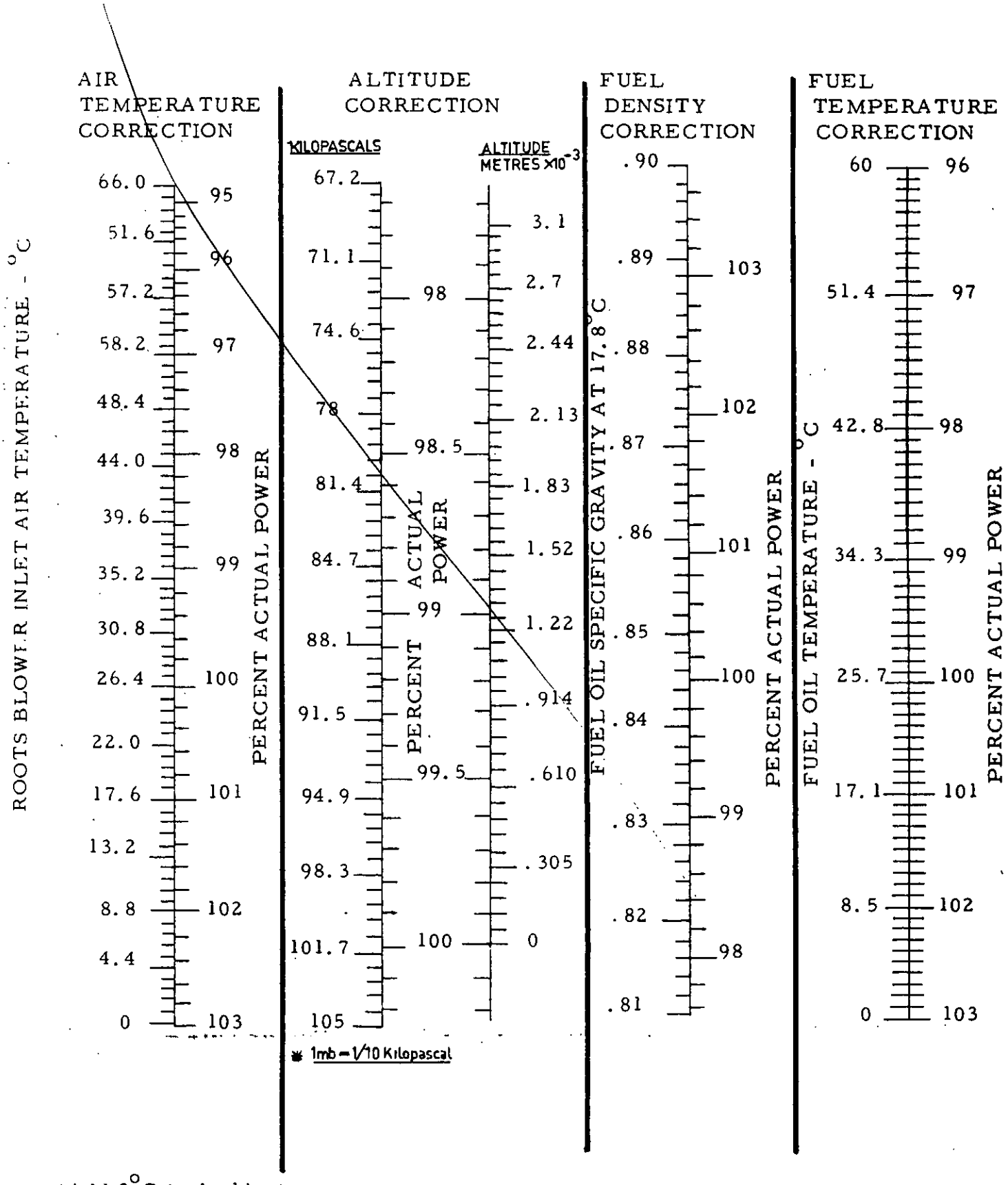
CORRECTION FACTORS FOR 12 &16 CYLINDER 645E ENGINES



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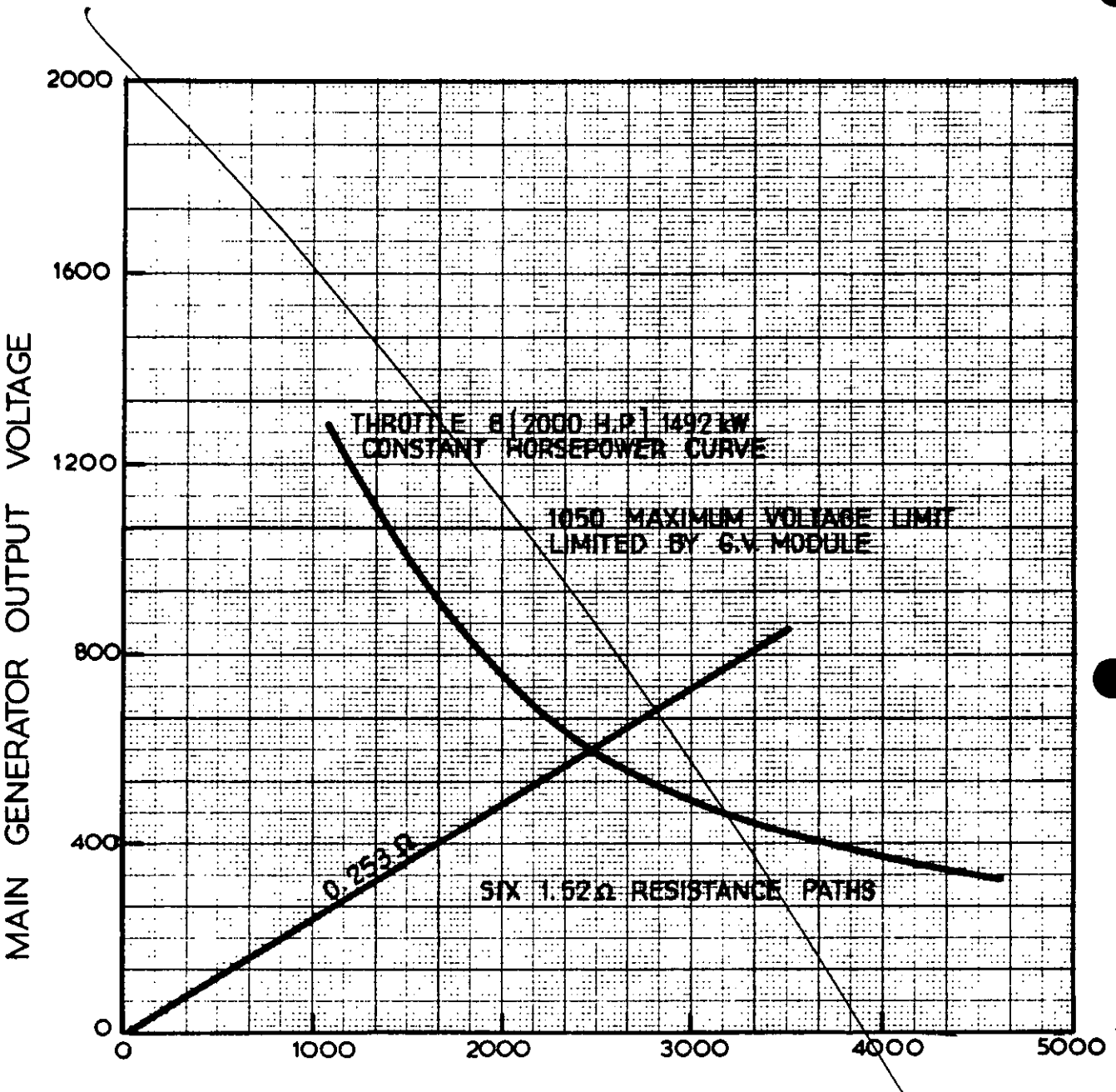
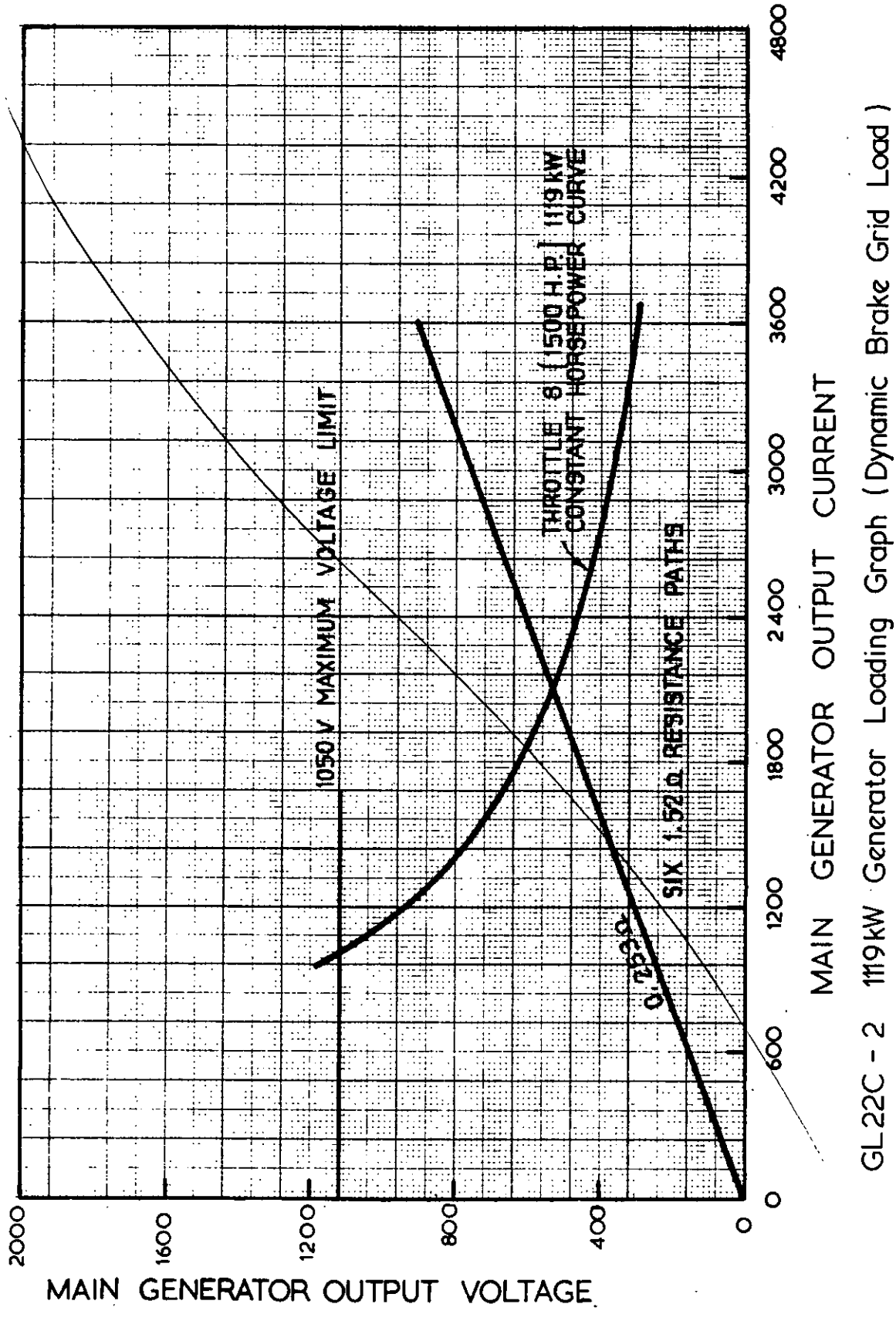


GL26C-2 1492kW Generator Loading Graph
(Dynamic Brake Grid Load)



GL22C - 2 1119 kW Generator Loading Graph (Dynamic Brake Grid Load)

HIGH POTENTIAL TESTS FOR LOCOMOTIVES IN SERVICE

INTRODUCTION

Locomotive electrical circuits and equipment are sufficiently well insulated to withstand potentials far in excess of those experienced in normal operation. This insulation dielectric strength should, however, be periodically checked to verify that this margin of safety remains in existence. High potential tests provide the means for making this check.

During high potential testing, wiring and equipment are subjected to voltage or potentials that are higher than normal. These potentials are applied for a specific period of time. For the circuit to qualify, there must be no breakdown of insulation to ground. The dielectric strength of the insulation is then considered satisfactory. On the other hand, a breakdown to ground indicates the need for improved insulation on the circuit or device tested.

This section provides a guide for high potential testing of locomotive wiring and equipment. Service Data indicates recommended procedures to prevent accidential destruction of circuit components that may be unable to withstand the test potential should a fault exist in the tested circuit.

TEST EQUIPMENT

It is of the utmost importance that a reliable high potential testing machine is used. The machine should be in verified good condition so that adequate tests can be made safely, without unnecessarily overstressing insulation during testing.

The machine to be used for high potential testing should have the following characteristics.

1. Wave Form

   The voltages specified for high potential testing are root-mean-square voltages, and the wave form should be such as to have a limit of 5% third harmonic. This limitation fixes the peak voltage for any RMS voltage. The wave form may be influenced by the capacity of the testing apparatus relative to the size of the equipment being tested.

2. Surges

   The means employed to change voltage on the primary must be such that harmful surges do not occur.

3. Regulation

   The secondary voltage drop should not exceed 20% under actual test conditions.

SAFETY PRECAUTIONS

1. Whenever possible, high potential tests should be performed by one man. All others should be kept off the locomotive and away from the test area.
2. A thorough knowledge of the circuits, equipment, and procedures involved is essential. Extreme care should be taken to make certain that tests are properly made. Before making any high potential tests, a 500-volt megger test should be applied for one minute to determine the condition of the circuit. Circuits containing static electronic components such as transistors and silicon rectifiers must be disconnected or shorted during the tests.
3. To prevent dangerous overvoltage surges, test electrodes must be firmly connected to the circuit or item before the voltage is applied. Similarly, the voltage should be removed before the electrodes are removed.
4. After the tester has been removed from the item being tested, clear the item of possible residual voltage by discharging to ground with a suitable insulated conductor.

TESTS OF LOCOMOTIVES IN SERVICE

To comply with established regulations, it is necessary to perform high potential tests on locomotive high voltage (DC), and alternating current (AC) circuits. It is also good practice to megger the low voltage control circuits. Preparations for tests should be made as indicated in Service Data that follows this instruction.

1. High Voltage DC Circuits

   High voltage circuits include all equipment and wiring connected to the output of the main generator, plus the dynamic brake grid resistors and circuits (where used).

2. Alternating Current (AC) Circuits

   The alternating current circuits include the D14 alternator, cooling fans, inertial filter blower motor, various control circuit transductors and transformers, excitation equipment, and associated wiring.

3. Low Voltage (DC) Circuits

   The low voltage circuits include all control, equipment, and wiring connected to the locomotive auxiliary generator and storage battery. High potential tests are not required for low voltage circuits and equipment, however, it is good practice to check insulation resistance to ground. This may be done using a megohmmeter (500 V DC maximum) after grounding the high voltage DC and AC circuits. A reading of one megohm or better indicates satisfactory insulation resistance to ground. Perform protective steps indicated in Service Data before performing the checks.

TEST PROCEDURE

The preferable time to perform high potential tests is right after a locomotive has completed a run. In such instances, the equipment is warm and dry, thus eliminating the possibility of moisture that might be present in units that have been shut down for an extended period of time.

Prior to making a high potential test, the circuit insulation resistance should be checked with a suitable megohmmeter. Readings of less than one megohm should be viewed with suspicion, as applying a high potential test in such instances may cause a breakdown of the insulation. To reduce the risk of this possibility, the cause of low megohmmeter readings should be determined and corrected. This may be done by reducing the complete circuit concerned into individual circuits which are then isolated and checked separately. In this way, the circuit portion or equipment causing the low reading can be found. Correction may often be made by thorough cleaning and drying of the affected areas.

Refer to Service Data for data regarding protective procedures before making high potential tests.

When preparations have been completed, apply the high potential test as follows:

1. Make certain that the tester is not connected to the power supply, the control knob is set at zero (0), and the control switch is off.
2. Place one electrode firmly in contact with the insulated conductor of the circuit being tested. Refer to wiring diagram for suitable points of connection.
3. Place the other electrode firmly in contact with ground, such as locomotive underframe.
4. Make certain that circuits other than the one being tested have been isolated and grounded.
5. Connect the high potential tester to a power supply and turn the control switch on.
6. Press ON button firmly down, and while holding in this position, slowly turn control knob to specified test voltage.
7. After applying specified voltage for the required period of time, and while still holding the ON button down, slowly turn the control knob back to zero (0).
8. Release ON button and place control switch OFF.
9. Discharge tested circuit to ground before removing electrodes.
10. Repeat the preceding tests for other circuits involved in the test.

HIGH POTENTIAL TESTS FOR LOCOMOTIVES IN SERVICE

High Voltage DC Circuits . . . . . 1050 Volts RMS For 1 Minute
Maximum Output Current - 330 Milliamperes

Alternating Current AC Circuits . . . . . 400 Volts RMS For 1 Minute

Low Voltage DC Circuits . . . . . Megohmmeter Test Only
(500 Volt DC Maximum Megger)

PRELIMINARY MEGGER CHECK

Before making high potential checks of the high voltage DC and AC circuits, make a preliminary check of circuit condition with a 500 or 1000 volt megohmmeter. These megohmmeter readings should be recorded in a locomotive maintenance log. The readings are most useful when compared to previous readings. The low voltage control circuits may be checked at the same time, using a maximum 500 volt megohmmeter.

Before starting the checks, take the following protective measures.

1. Open main battery switch and ground relay cutout switch.
2. Jumper main battery switch blades from negative to positive.
3. Place all circuit breakers in the ON position.
4. Close all control switches.
5. Pull out all circuit modules half way to fully disconnect the circuit modules from locomotive circuitry.
6. Completely remove the PF module; at the rack, jumper pins 15 and 16 to pin 17.
7. Connect a jumper wire from positive terminal to negative terminal of CR17.
8. Jumper positive to negative at the battery charging rectifier CRBC.
9. Jumper from left-yellow to right-yellow on ground relay CRGR.
10. At the SCR assembly, jumper AC1 to AC2, AC2 to AC3, AC3 to negative bus, negative bus to positive bus, and positive bus to DC+.
11. At main generator output, jumper all positive and negative buses together.
12. Disconnect or jumper out any electronic equipment such as radio, train control, speed indicator, automatic reset devices, and fault counters.

13. High Voltage DC Circuits

    Ground the main battery switch blades, and ground the D14 alternator. Perform high potential tests on high voltage DC circuits and equipment. Reference locomotive schematic diagram. Do not perform high potential tests on cranking motors.

14. High Voltage AC Circuits

    Remove the ground from the D14 alternator, and connect the ground to the main generator output. Perform high potential tests on high voltage AC circuits and equipment.

15. Low Voltage DC Control Circuits

    Remove the ground from the main battery switch, and connect the ground to the D14 alternator. Perform megohmmeter check on low voltage DC circuits and equipment, including the engine cranking motors.

16. When the tests are completed, be certain to remove all shorting and grounding jumpers.

17. Return controls and switches to normal standby condition. Use procedure for applying jumpers as a check list to make sure that all jumpers have been removed.

TROUBLESHOOTING

The material in this publication is to be used as a guide in qualifying and troubleshooting the locomotive. It is presented in the following parts.

A. TROUBLESHOOTING GUIDE - POWER CONTROL SYSTEM

1. Qualification

This guide lists checks that can be performed when no specific trouble is reported or indicated. The checks can be performed to qualify a locomotive for service.

2. Troubleshooting

These guides are intended for only the most probable and easiest to locate types of electrical trouble. It should be understood that various types of trouble can occur that will require more thorough investigation than the procedures covered in this guide.

B. TROUBLESHOOTING OUTLINES

Text in outline form provides a guide to finding and correcting trouble reported of a specific nature. Letter symbols generally similar to an abbreviation of the word or words commonly used to describe a component or a trouble are provided to aid in locating the applicable text.

For example:

"CT" Indicates current transformer.

"FIL" Indicates filter.

"OL" Indicates overloading

A column for publication references is provided on the right hand side of the troubleshooting guide outlines. The references are provided to identify publications that may be of help in identifying and correcting troubles.

Examples of the references follow:

M.I. 000	General Motors - EMD Maintenance Instruction.
LSM-9	Locomotive Service Manual - Section 9
EMM-6	Engine Maintenance Manual - Section 6

MODULAR ARRANGEMENT OF CIRCUITS

Most of the locomotive control and protective circuits are designated with solid state components and small relays that allow placement of essential circuit components and wiring on a standard size circuit board. The circuit boards are fitted with a handle and with a standard arrangement of terminal receptacles. When the circuit board is fitted into the appropriate guideway in the electrical cabinet of a locomotive and pressed into place, the receptacles on the board make contact with stationary pins that are fastened firmly in the electrical cabinet. Faston terminals connected to wires complete circuits to other pins or components.

A faceplate is also fastened to the terminal board. Receptacles that accept the standard 0.185" banana plug are located on the faceplate. These receptacles are connected to specific circuit points for test purposes. The receptacles are colour coded to identify the type of voltage appearing at the test point.

Orange 72-76V DC positive.

Blue Control circuits. Generally low DC voltage.

Yellow AC voltage, either from the D14 or from the main generator feedback transformer.

Red Main generator AC output,or dynamic brake motor armature output.

Black Control circuit 74V DC negative.

Green Main generator field.

The module face plates may also contain switches and test lights.

WARNING: Never disconnect a module during locomotive operation. Do not operate test switches during locomotive operation without thorough familiarity with the circuits involved and a firm understanding of the results of such action.

Always consider the particular set of conditions the locomotive is operating under before performing tests on a moving locomotive.

When performing standstill tests, always disconnect control jumper cable between units. When extensive checking of control circuit voltages is to be done, it is recommended that the ER relay be disabled whenever possible during high-throttle no-load testing.

The Circuit Check and Load Test positions of the test panel rotary switch do not preclude excitation on the main generator .The load test position will open circuit the main generator on units not equipped for automatic self loading. Do not exceed Throttle No. 1 with main generator open circuit. Never return test switch to normal position while unit is being loaded.

TROUBLESHOOTING INSTRUMENTS

VOLTMETERS-OHMMETERS

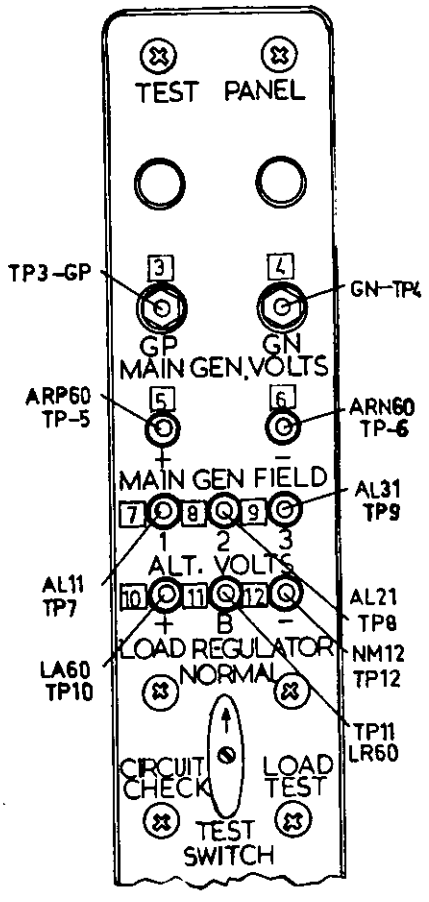
In general a voltmeter and an ohmmeter will be the only tools necessary for basic electrical troubleshooting. These meters and any shunts should be at least 0.5% accuracy, and all readings should be taken at the upper 1/3 of the meter scale.

Sensitivity of the voltmeter should be a minimum of 20,000 ohms per volt. Verify accuracy of voltmeter 0-100 range by reading voltage from TH-TP10 to TH-TP14, with locomotive engine running. Voltmeter should indicate 68 ± 0.2V DC.

MANOMETER

A simple water manometer will be required to measure air pressure drops across various devices.

CAUTION: Never use a test lamp, bell ringer, or megohmeter for troubleshooting modular or solid state control circuits. A lamp may overload the circuits, and a bell ringer or megohmmeter may produce destructive voltages.



Note: Load Regulator Plus is not + 74 VDC.

TEST SWITCH			
TERM.	CKT. CHECK	NORM	LOAD TEST
1-2			X
1-3		X	
4-6		X	
5-6	X		
7-8	X		X
7-9	X	X	
10-11			X
10-13		X	
12-13	X		
14-15			X
14-17		X	
16-17	X		

WARNING: Circuit check position does not prevent excitation of the main generator. On units NOT equipped for automatic self loading, load test position will open circuit the main generator. Do not exceed throttle No.1 with AR10 open circuit.

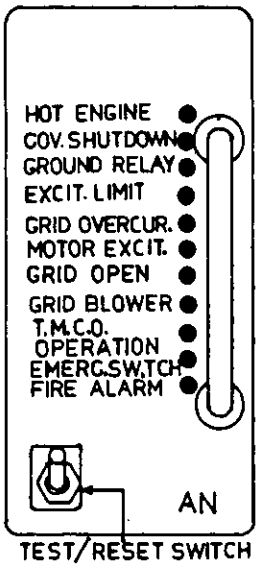
Do not return test switch to normal position while unit is under Load.

Refer back to the excitation system block diagram for location of test points in the system.

TEST PANEL

OPERATING FUNCTIONS AT TEST POINTS

Not Drawn to Scale

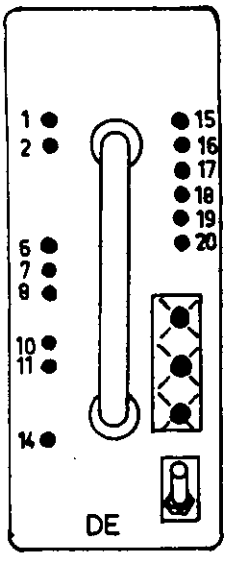


AN The annunciator module receives signals from various fault detecting devices. When a fault signal has been received, the applicable fault light remains on until the reset switch is operated after the fault signal has ceased.

The basic AN module contains only the first four indications shown below. When the unit is equipped with dynamic brakes, the fifth and sixth lights are provided with a seventh light functional if the unit has extended range dynamic brakes. As special extras, the eighth light is provided on units equipped with dynamic brakes, a ninth light is provided on units equipped for traction motor cutout operation, a tenth also available on units to indicate the use of the emergency switch and an eleventh available to indicate fire alarm.

In order from top to bottom, the annunciator indications are as follows:-

HOT ENGINE	Temperature at engine coolant inlet over 98°C.
GOV.SHUT DOWN	Engine oil pressure is low.
GROUND RELAY	High voltage path to locomotive ground or a group of failed diodes in the main generator.
EXCIT. LIMIT	Excessive main generator field current.
GRID OVERCUR.	Excessive current in the dynamic braking resistor grids.
MOTOR EXCIT.	Excessive current in motor fields or excessive voltage across the motor fields during dynamic braking.
GRID OPEN	Open resistor grid on unit equipped with extended range dynamic brakes only.
GRID BLOWER	Current unbalance due to an open or short, or due to a stalled grid blower motor.
T.M.C.O. OPERATION	Traction motors cut out.
EMERG.SWITCH	Operation of emergency switch in response to VR fail or AG/ALT failure.
FIRE ALRAM	Fire detectors FAS1 or FAS2 triggered.



DE Receives a signal from FP module and compares it to a signal proportional to brake current from BCT. When brake current drops below a given level because of low train speed, the module picks up the "DC" contactor at the proper time. It also drops out the "DC" contactors at the proper time as train speed increases. There is a built-in time delay between steps.

During extended range operation a signal proportional to grid current is compared in the DE circuitry with a signal from the dynamic braking rheostat, and grid current is limited at a level proportional to braking handle position. On special order, the grid current control function of the DE module is operative over the full range of dynamic braking.

1- Control circuit DC pos; PM feed thru BR interlocks and IPS switch.

2- Input from dynamic brake rheostat.

6- Main generator current feedback signal input from performance control module FP.

7) Armature current signal input from BCT and T4; AC voltage.
11)

Test lamps DC1, DC2, DC 3 -indicate pickup of grid shorting contactors DC1, DC2, DC3 respectively.

Test switch- operate to sequence dropout of grid shorting contactors.

8) AC power supply from D14.
10)

14- Control circuit DC negative; Nm.

15- Output to pick up pilot relay DP1 and grid shorting contactor DC1.

16- Output to hold DP1 picked up.

17- Output to pickup pilot relay DP2 and grid shorting contactor DC2.

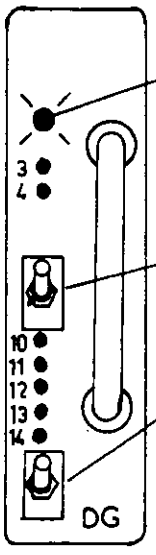
18- Output to hold DP2 picked up.

19- Output to pickup the pilot relay DP3 and grid shorting contactor DC3.

20- Output to hold DP3 picked up.

OPERATING FUNCTIONS AT TEST POINTS

DG Receives signal from DGT, which is a transductor that senses grid blower current. Provides protection against a non-operating grid blower, since it will drop out the "B" contactor on either no blower motor current or excessive blower motor current.



Red test lamp - Indicates that a current unbalance has occurred between the dynamic brake grid blower bias winding and the grid current bias winding causing the DG module to dropout the DGX relay. This usually indicates that the grid blower motor is not operating correctly.

Reset Switch - Must be pressed to reset the DG module and allow the "B" contactor to pickup.

Test switch - Applies control circuit current to a test winding on the DGT transductor to simulate current unbalance to obtain a signal from the transductor. The signal fires the DG circuit, the red test lamp comes on, the "B" power contactor drops out, and the GRID BLOWER light latches on.

3- Output to annunciator to register DG module operation.

4- Normally closed contacts of DGR pilot DGX relay to interrupt feed to "B" contactor coil.

10- Voltage in DG circuit proportional to the instantaneous value of grid-motor unbalance.

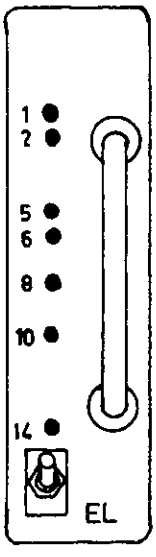
11) Voltage in DG module which monitors a time delay circuit.
12)

13- Zener reference voltage to which firing of the DG circuit is calibrated.

14- Control circuit DC negative NM.

EL Receives an input signal from ELT at terminals 8 & 10 to generator field current. If excessive field current is reached, EQP feed is interrupted.

Provides back-up protection against excitation control failure.



1- Control circuit DC positive, PM feed to ELR and ELRA coils within the EL module.

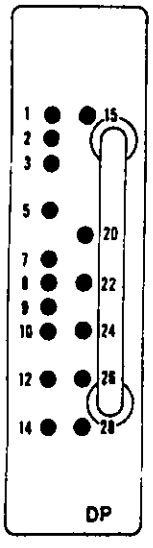
2- PM feed through test button to energise test coil ELT transductor.

5- Interlock in circuit to equipment protective relay EQP coil.

6- Same as TP5.

8-) Input, generator field current signal from ELT transductor;
10) AC Voltage.

14- Control circuit DC negative NM.



DP — First function receives voltage signal from braking grids and interrupts feed to EQP coil when limiting value is reached. Provides back-up protection against a DR or control circuit failure.

Second function receives voltage from generator during dynamic brake. Interrupts feed to EQP coil when limiting value is reached. Provides protection against hot motor fields, open field circuit, or control circuit failure.

1- Control circuit DC positive input; feed to EQP relay operating coil thru protective interlocking.

2- Same as TP3, but used on four-motor unit.

3- Main generator DC pos. during braking. Motor field protective circuit input, six-motor unit.

5) 7) 9) Used only for standstill test as indicated in qualification section of this handbook.

8) 10) D14 AC voltage power supply to BWR circuit.

12 - Main gen. DC neg. during braking. Motor field protective circuit input.

14- Control circuit DC negative NM.

15- 74V DC output to EQP coil. NC interlocks of MFP and BWR, under fault conditions, regulate the main generator output by dropping the gen. field and discharging the rate control capacitors.

20- On units with extended range dynamic brakes, negative input from dynamic brake grids provided only during pickup of grid shorting contactors to disable grid protection circuitry.

22- Pos. input from traction motor armature and brake grids to brake warning circuit.

24- Same as TP22.

26- Same as TP22.

28- Negative input from traction motor armature and dynamic brake grids to the brake warning circuit.

DR The DR module receives a signal (from braking grids) proportional to braking current. Provides grid current limit by reducing RC Module output (reference voltage) when grid signal indicates maximum permissible grid current.

On units with extended range dynamic brakes, the DE module receives a separate signal (from brake current BCT) proportional to braking grid current and compares it to a signal established by braking handle position. A signal resulting from the comparison is directed to the DR module to provide grid current limit at a value established by braking handle position. The signal is basically applied to DR only during extended range braking; however, on special order the signal may be applied to DR during the entire braking range.

On special order, units without the DE module may have the BCT signal compared to the braking handle position signal directly at the DR module to limit grid current to a value established by braking handle position.

1- Provision only (when provided).

2- Positive high voltage input from dynamic braking grids.

3- Input from anticipation capacitor that functions to smooth out regulation and minimise overshoot.

4- On units with extended range dynamic brakes, receives input from DE module for grid current control related to braking handle position.

5- Same as 4.

6- Output from DR which shunts the Brake Handle signal at the base of the rate control transistor to negative when DR operates. This brings about discharge of the rate control capacitors at a predetermined rate not related to braking handle position.

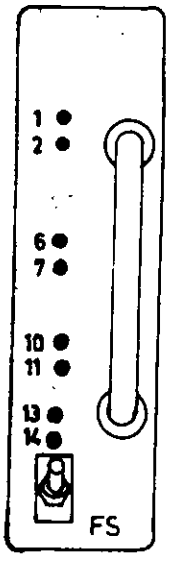
7- Functional on units equipped for grid current trainline control and not equipped with extended range dynamic brakes. 24T input from brake rheostat. Signal is at a value related to braking handle position. It is matched with BCT signal (TP9-11 below).

9) Not used on units equipped for extended range dynamic
11) brakes. On units equipped for grid current trainline control, AC signal from brake current transductor BCT is compared to signal from braking rheostat (see TP7) to regulate maximum braking current to a value related to braking handle position.

13- Negative high voltage DC input from dynamic braking grids.

14- Control circuit DC negative NM.

OPERATING FUNCTIONS AT TEST POINTS



FS — Receives FP Module signal proportional to main generator current and voltage. FS output controls relays to initiate forward and backward field shunting sequence.

1- Input, 74V DC; supply to FSR operating circuit within the module.

2- DC voltage proportional to AR10 voltage.

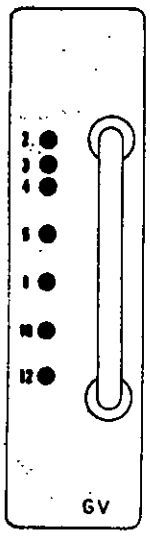
6)
7) Normally open FSR interlock.

10)
11) Normally open OSR interlock

13- 0-50 V DC input signal from module. Signal is proportional to AR10 current.

14- NM Negative.

GL22C-2 module FS14 does not have terminal 10 or 11 as there is no OSR on these locomotives.



GV — Provides a limit to the generator voltage by interrupting the current at the SE control winding. Receives a signal from the GPT (generator potential transformer) proportional to main generator voltage.

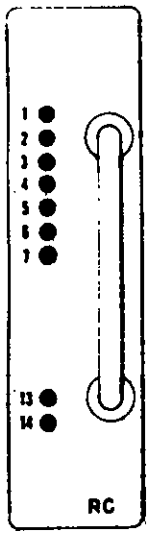
2)
3) Input, generator voltage signal from generator
6) potential transformer GPT.

10)
12) AC power supply from D14.

4- Sensor current output to sensor control windings.

8- Sensor current input from TH Module thru. GX.

OPERATING FUNCTIONS AT TEST POINTS



RC - Receives a step input voltage from the TH module or the brake rheostat. Provides a reference voltage to the load with a time rate of build-up.

Shuts off the reference voltage when terminals 4 or 6 are connected to NM.

1- Input, 74V DC to pre bias the transistor before braking.

2- Input variable DC from brake rheostat.

3- Input, variable DC from TH module.

4- Input, brake regulation by DR module.

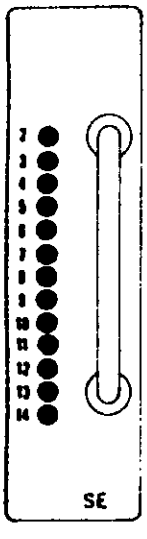
5- Provisional Function only.

6- Output, discharge of rate capacitor at wheelslip and when DC Contactors operate.

7- Rate capacitor discharge at EQP dropout.

13- Output, reference voltage to load reg.

14- Control circuit DC negative NM.



SE Provides gating pulses to the SCR at the proper time determined by the current in the control windings. Primary control windings are connected to terminals 13 & 14.

2- Provision for biasing coil. Not used on GL22C-2 and GL26C-2 locomotives.

3- Input from AR10 positive during dynamic braking.

4- Provision for biasing coil. Not used on GL22C-2 and GL26C-2 locomotives.

5- Output to gate of SCR1.

7- Output to gate of SCR2.

9- Output to gate of SCR3.

6)
8) AC power supply from D14.
10)

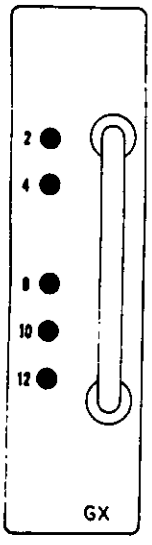
11- Common point for gate outputs; cathodes of SCR's.

12- AR10 negative during dynamic braking.

13- Input, excitation control windings.

14- Input, excitation control windings

OPERATING FUNCTIONS AT TEST POINTS



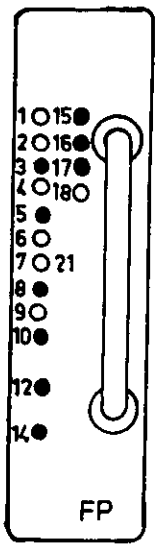
GX — Provides a limit to the generator field current by interrupting the current to the SE control winding. Receives a signal proportional to field current from the FCT (field current transductor).

2) Input, generator field current signal from FCT
12) transductor; AC voltage.

10) AC power supply from D14.
12)

4- Sensor current output to sensor control windings by way of GV Module.

8- Reference voltage from TH module.



FP — Receives signals proportional to generator voltage from GPT1 and GPT2 on special extra) and generator current from CT's. The sum of these voltages at terminal 21 is compared to the reference voltage.

1) The voltage level produced at the emitter of Q1 by the performance control characteristic i.e. higher current and lower voltage.

3) On units equipped for traction motor lockout, these
5) points are connected across a voltage dropping resistor in the reference voltage connection between TH and RC modules.

2) AC feedback signal from generator potential transformer
4) GPT2 on units equipped for special performance control.
6)

7) Input from the LR. This signal at the base of Q1 should be greater than the signal from the Performance Control part of the module for the Generator Field.

9) Input from SE module. This signal should be 68V DC.

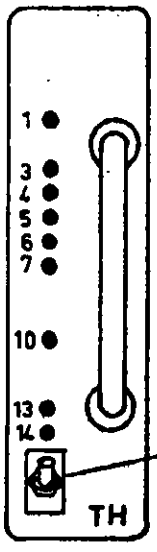
8) A.C. Feedback signal from generator potential transformer
10) GPT1.
12)

14 Control Circuit DC Negative,NM.

15) AC Feedback signal from AR10 current transformers CTA,
16) CTB, CTC.
17)

18 The voltage level produced by the power control characteristic i.e. higher voltage & lower current.

21 The voltage level at the emitter of transistor Q1 from either the performance control or the power control voltage - divide resistances.



TH Provides a closely regulated voltage (68V D.C.) at terminal 10 for use as a reference.

Optoisolators put a fixed resistance in series output so that output voltages increases to 68V D.C. in Notch 8.

1- Input, 74V D.C. to VRR.

3- Output, variable D.C. from TR.

4- Input to TR from THS 2,4,6,8

5- Input to TR from THS 5 thru 8.

Operate to drive load regulator toward minimum field position.

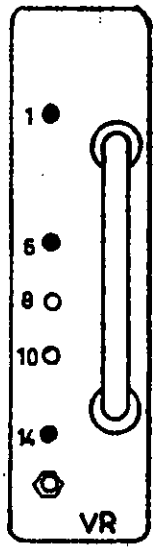
6- Input to TR from THS 3 thru 8.

7- Input to TR from THS stop 5,6

10- 68V D.C. output from VRR.

13- "NM" negative - TR relays.

14- "NM negative - VRR circuit.



VR Regulates auxiliary generator voltage to 74V D.C. by controlling the auxiliary generator field current.

1- Aux. Gen. Positive.

6) Single Phase A.C. input from Aux. Generator Output.
10)

14- Aux. Gen. Negative.

CAUTION: Do not install or remove VR module in locomotive unless engine is completely stopped.

Battery charging Voltage Adjust.

8- Output to Aux. Gen. Field.

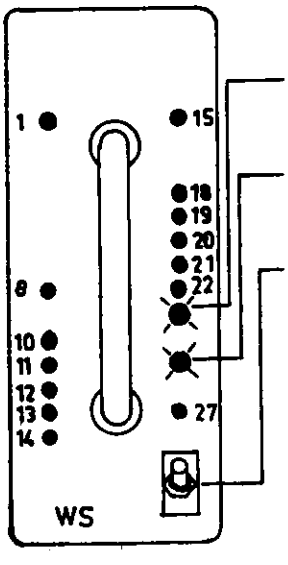
WS — Receives signals from WST and from motor voltage bridge circuit. Provides various corrections to reference voltage; actuates sanding, wheel slip light, and ORS under some conditions.

1- Control circuit DC positive.

8- A.C. input from wheelslip transductors, and AC power supply from D14.

10- A.C. power supply from D14.

11- Output to base of FP transistor.



Green test lamp indicates satisfactory WS module when it remains lit while test switch operated and held.

Red test light comes on to indicate faulty WS module when switch is operated.

Test Switch. With throttle idle or unit isilated, switch actuates WS test circuits and test lamps.

12- Output from the Load Regulator Wiper.

13- Control Circuit DC negative;N.

14- Control circuit DC negative ;NM

15- Used to recalibrate the wheelslip control at moderate and high track speed on some locomotives.

18- Output to wheelslip light relay WL operating coil.

19- Output to sanding relay and ORS.

20- RC capacitor discharge by WS action.

21- AC input from wheelslip transductors.

22- 74V D.C. input to test switch.

27- Test point for zener breakdown voltage of 16V A.C.

GL22C-2 & GL26C-2

ELECTRICAL QUALIFICATION AND TROUBLESHOOTING GUIDE

ELECTRICAL QUALIFICATION AT STANDSTILL

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
Checking excitation System response to throttle.	Power setup: Engine running; Reverse Fwd;Air brake set.	Place throttle in No. 1	Load current indicating meter rises slowly to between 100A and 140A and stops.
		Momentarily place throttle in No. 2 position	No wheel slip indication should occur.
		Return throttle to IDLE, change reverser handle position, and repeat tests.	Same response as above.
Checking WS module response and wheel slip correction		With throttle in IDLE, engine running, operate WS module test switch.	Red lamp flashes on and off. Green test lamp comes on and remains on while switch is held, and wheelslip light comes on and remains on while switch is held.Continue to hold WS test switch; TDS relay picks up. Sand is applied to rail in proper amount at proper location. Load regulator moves toward minimum field.
		NOTE: Control CB must be closed.	
		Release WS test switch.	Wheelslip light and WS module test light go out. TDS relay drops out after a 3-5 second delay.
		Change reverser position and repeat test.	Same response as above.
Checking power response to WS test		Connect jumper from WS-TP1 to WS-TP22.	
		Throttle Notch 1. Operate WS module test switch.	Load indicating meter needle dips slightly. Also same response as above.

PURCHASE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
Checking power response to WS test. (Cont'd)	Release	Release WS test switch and throttle to idle. Remove jumper wire.	CAUTION: Do not exceed Notch 1 with jumper in place.
Checking reference voltages, rate, and engine speed response to throttle	Power setup; Engine running; Gen. field circuit breaker OFF; Test panel test switch in CIRCUIT CHECK position; Reverser Fwd.	Connect voltmeter positive to FP-TP21; negative to TH-TP14. Connect voltmeter positive to VR-TP1; negative to TH-TP14.Throttle Notch 1.	Meter must indicate 68 ± 1 V DC. If reading is incorrect replace meter with a qualified meter. Meter should indicate between 71 and 77V DC (74V DC is recommended minimum)
		Connect voltmeter positive to RC-TP3; Negative to TH-TP14. Open throttle in steps from idle to Notch 8.	Voltage should increase in steps; Zero volts at idle, and above 65 volts in Notch 8. Engine speed increases with each step 2 thru 8. (See setting chart for specific voltage checks with FP module pulled).
		Return throttle to idle.	
		Connect voltmeter positive to RC-TP13; negative to TH-TP14. Wipe throttle to Notch 8.	Voltage should increase with rate. Zero volts at idle, and from 40 to 50 V DC in Notch 8. (About 18 to 36 seconds build up time).
		Return throttle to idle.	Note: If FP module has been pulled, 50V DC will be present in Notch 8.

WARNING

Do not close the traction generator field circuit breaker until the throttle is in idle position. The circuit check position of the test panel test switch does not prevent excitation of the main generator.

Checking load regulator response.	Power setup; Engine running; Generator field circuit breaker OFF; Test panel test switch in CIRCUIT CHECK position; Reverser Fwd.	Connect voltmeter positive to WS-TP12; negative to TH-TP14. Place throttle in No.8. Operate test switch on TH module to energise ORS and drive the load regulator to minimum field position. Release TH test switch Return throttle to IDLE	Voltmeter indicates between 40 and 50 V. DC. Voltage drops to zero. Voltage increases slowly to above value. Voltage drops to zero.
EL module field current limit protection; Main generator current limit protection by GX module. GX module is only on the GL26C-2 Model locomotives.	Pull out FP module. Engine running; Power setup; Air brake set; Throttle IDLE; Reverser Fwd. Ohmmeter positive at GX-TP8 negative at GX-TP4.	Operate and hold the EL module test switch. Release EL test switch. Reset AN module.	EQP relay drops out. AN module EXCIT. LIMIT light comes on. Ohmmeter indication goes from low to high resistance. (Ohmmeter indication only on GL26C-2 locomotives) Ohmmeter goes to low resistance; EQP picks up. EXCIT. LIMIT light goes out.
Checking GV module for high generator voltage protection.	Engine running; Power setup; Generator field circuit breaker OFF; Test panel test switch in CIRCUIT CHECK position; Reverser Fwd; Throttle IDLE.	Pull out to disconnect FP module. Ohmmeter on low resistance (R x 100) scale.Lead of positive polarity at GV-TP8; lead of negative polarity at GV-TP4. Pull out to disconnect GV module. Disconnect ohmmeter. Reinstall GV and FP modules.	Ohmmeter should show low resistance. Ohmmeter indicates high resistance.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
Checking ground relay protective circuit.	Power setup; Engine running; Gen Field circuit breaker ON. Reverser centered; Test panel test switch in LOAD TEST. 0-500 DC voltmeter spade lugs tightly secured at test panel GP (3) and GN (4) terminals.	Connect 5 amp fused jumper wire from generator positive to locomotive ground. Open throttle to Notch 1. Throttle idle; Move jumper from main generator positive to main generator negative; Repeat check. Throttle idle; Remove jumper and meter; Return test panel test switch to NORMAL position.	Ground relay should pick up between 75 and 125 volts.
CAUTION: Main generator is open circuited. Do not exceed throttle Position 1			
Checking FS module.	Generator field circuit breaker OFF; test switch in CIRCUIT CHECK Position; controls and switches set up for power; Reverser Fwd. or Rev. Throttle 1. Throttle idle; Return test switch to NORMAL; Close generator field circuit breaker.	Operate and hold the FS module test switch. Release FS test switch.	FSRA and FS1A, FS1B pick up. (in GL26C-2 locomotives OSRA, WL, Wheelslip light Indication pick up) FSRA and FS1B, FS1B drop out. (in GL26C-2 locomotives ORSA, WL Wheelslip light Indication drop out.

Checking DP module for motor excit. protection during dynamic braking.	Throttle idle; Engine running; Reverser Fwd. One RV switch module centered. (Reference procedure on page MFP-1). Braking handle in SET UP position. ER switch off.	Jumper DP-TP9 to DP-TP14 to discharge a capacitor. Connect a 0-100 DC voltmeter positive at DP-TP3; negative at DP-TP12.	
		Disconnect jumper and advance the dynamic braking handle.	MFP relay in the DP module picks up as generator voltage rises. MFP pickup and EQP dropout occur between 70 and 80V DC. DP-TP3 to DP-TP12. EQP cycles in and out. MOTOR EXCIT. light on AN module may come on, after a number of cycles.
		Return braking handle to OFF and reset.AN module. Operate reverser handle to Reverse and Fwd.	
Checking for grid overcurrent protection.	Engine running; Controls set up for dynamic braking; Braking handle in SET UP position.	Remove the jumper and connect it from DP-TP14 to DP-TP5.	
		Apply another jumper from DP-TP1 to DP-TP20.	EQP relay will drop out after the BWR relay in the DP module picks up. After a time delay of between 1 and 2 seconds, the BWA relay in DP will pick up and the brake warning light will come on. GRID OVERCUR. light on the AN module may come on.
		Remove jumpers. Reset AN module.	

PURCHASE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
Checking main generator volts during dynamic braking.	Engine running; Air brakes set; Controls and switches set up for dynamic braking; 0-100 DC voltmeter pos. at DP-TP3 neg. at DP-TP12	Wipe braking handle to maximum.	Voltage DP-TP3 to DP-TP12 immediately surges, then decays to between 20 and 60 V DC in a few seconds.
Checking grid current control	Above test setup remains.	Connect jumper from DR-TP4 to DR-TP5.	Voltage slowly drops to zero or near zero. NOTE: Refer to BCT, GL, DE, or DR pages of Troubleshooting Outlines for further checks.
Checking DE module for control of contactors for high braking current at low speeds.	Engine running: Controls and Switch set for dynamic braking; independent air brakes released. Reverser Fwd.	Place braking handle in position 3. Operate and hold the DE test switch. Release test switch. Apply independent brake. Release independent brake. Return braking handle to SET UP position. Return braking handle to OFF position.	Engine speed increases to Notch 5 speed. DE module test lamps indicate in sequence DC1, DC2, DC3, with an interval between indications. DE test lamps go out in sequence DC3, DC2, DC1 with an interval between steps. Sequence repeats; lamps on. Test lamps go out all at once. Sequence repeats; lamps on. Engine goes to idle speed; lamps remain on. Test lamps go out all at once.

Checking extended range dynamic brake open circuit protection.	Engine running; Reverser centered, Test panel switch in LOAD TEST position. Dynamic brake cutout switch in Dynamic Brake position. <u>Units without automatic self loading</u>:0-1000 DC voltmeter connected at test panel GP to GN. Jumper from E1 to E2 of BR2. Jumper from OCP "P" to main.gen. neg.	Open throttle to obtain required voltage.	OCP should pickup and the GRID OPEN light on the AN module should come on at approximately 550 volts.
		Throttle IDLE. Reverser forward. Disconnect jumpers and meter. Move braking handle to SET UP position.	The " B" contactor will <u>not</u> pick up.
CAUTION: Do not allow main generator voltage to exceed 800.		Return test switch to NORMAL position. Reverser Fwd. Operate OCP reset switch. Reset the annunciator.	The "B" contactor picks up when OCP resets.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
Checking DG module protection against no grid cooling.	Engine running; controls and switches set up for dynamic braking.	With braking handle at position 4, operate and hold the DG test switch in test position. Release test switch. Return braking handle to SET UP. Operate DG module reset switch. Reset annunciator	After 1 to 15 seconds, "B", GFC, and GFX contactors drop out. Annunciator GRID BLOWER light on: DG test lamp on. DG test lamp goes out. GRID BLOWER light goes out.

TROUBLESHOOTING GUIDE

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
OVERLOADING	FAILED COMPONENT IN EXCITATION SYSTEM.	NOTE: The following must be performed in sequence to be valid. THROTTLE (1) MOTOR STALL CURRENT HIGHER THAN 220 AMPERES (GL26C-2) 150 AMPERES (GL22C-2). If locomotive is at a safe test site, momentarily place throttle in Notch 2 position to verify that wheelslip will not occur. Return throttle to idle. a. Remove SE module; Place throttle in Notch 1. If load current is over 50 amperes, replace SCR with a qualified SCR and retest. b. Return throttle to idle,Remove FP module and reinstall SE. Throttle Notch 1. 'If load current is over 50 amperes replace SE module with a qualified SE and retest. c. Return throttle to idle. Remove WS module and reinstall FP module. Throttle Run 1. If load current is over 50 amperes, replace FP module with a qualified FP and retest. d. Return throttle to idle. Reinstall WS module. Throttle Notch 1. With stall current over 220 amperes, read voltage from FP-TP7 to FP-TP10and from FP-TP7 to FP-TP1. If either reading is over 5 volts, check AC voltage balance between FP-TP15 to FP-TP16; TP16 to TP17;TP17 to TP15. If all readings are not within 5V AC of each other check wiring to AR10 current transformers CTA, CTB, CTC. If readings are in balance replace FP module with a qualified FP and retest. e. With throttle in Notch 1, operate and hold the test switch on the TH module. Load current should go to zero in about 2 to 5 seconds as the load regulator goes to minimum position. If load current remains over 50 amperes, check for load regulator open on the negative side. f. If Steps a thru e above indicated no failure, and throttle 1 stall current is still over 220 amperes, replace TH module with a qualified TH and retest.
	ENGINE OR GOVERNOR PROBLEMS	An incorrectly adjusted governor or engine can cause overloading.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
UNDERLOADING OR NOT LOADING	COMPONENT FAILED IN EXCITATION SYSTEM	NOTE: The following must be performed in sequence to be valid. PART 1 OF 3 PARTS Engine running; Controls and switches set up for power operation; Test panel test switch in CIRCUIT CHECK position; Generator field circuit breaker open. 0-75 DC voltmeter positive at WS-TP12; negative at TP14. Place throttle in Notch 8. a. About 46 V DC: Momentarily pull out FP module. If voltage rises perform Part 2 of 3 parts. If voltage does not rise perform G of Part 2. b. Zero or much less than 46V DC; Perform Part 3 of 3 parts. PART 2 OF 3 PARTS Air brakes set; Control and switches set up for power operation. Test panel test switch in CIRCUIT CHECK position; Generator field circuit breaker open. Throttle Notch 8. Obtain voltages test point to test point. The first test point is positive. If the voltages obtained indicate failure, replace the affected module with a qualified module and test. a. FP-TP21 to FP-TP14 should be 68 V DC. If less than 65V DC; Failed TH module. b. GX-TP8 to GX-TP4 GV-TP8 to GV-TP4 - If more than 5V DC; Failed GX or GV. c. SE-TP13 to SE-TP14 - If more than 5V DC; Failed SE. d. FP-TP9 to FP-TP18 - If more than 35V DC; Failed FP. e. FP-TP9 to FP-TP1 - If more than 35V DC; Failed FP.

g. FP-TP21 to FP-TP14 -
FP-TP18 to FP-TP14 -
Voltages less than 10 V DC. If voltage is 50V DC, Failed FP . If voltage is more than 50V DC; Failed FP. If there is no voltage; Failed WS.

h. Check for equal voltages (approximately 75V AC with engine at idle speed) SE-TP6 to SE-TP8; SE-TP8 to SE-TP10; SE-TP10 to SE-TP6. If voltages do not balance; failed SE.

WARNING: Do not place generator field circuit breaker in the ON position until the throttle is in IDLE position. The CIRCUIT CHECK position of the test panel test switch does not prevent excitation of the main generator

PART 3 OF 3 PARTS - Zero or much less than 46V DC; WS-TP12 to FP-TP14.

Controls and switches set up for power operation; Test panel test switch in CIRCUIT CHECK position. Generator field circuit breaker open. Throttle Notch 8.

a. TH-TP1 to TH-TP14 - If not 74V DC, check wiring to TH-TP1.

b. TH-TP10 to TH-TP14 - If less than 65V DC, failed TH.

c. TH-TP3 to TH-TP14- If less than 65V DC, failed TH, or wiring error from TH-TP10 to TH-TP2.

d. RC-TP3 to TH-TP14 - If less than 65V DC, check wiring between TH and RC.

e. RC-TP13 to RC-TP14 - If less than 40V DC, remove WS. If voltage increases to more than 65V DC, go to Step f. If voltage does not increase,make certain that RC-TP6, TP4, TP7, to negative are open. If they are open, RC is failed.

f. Replace WS. Check WS-TP12 to RC-TP14-If less than 40V DC, failed WS or shorted load regulator, bad load regulator brushes, jammed load regulator.

g. Check voltage RC-TP6 to RC-TP14-If less than 40V DC, failed WS.

h. Dynamic Unit - WS-TP12 to WS-TP11-If more than 15 volts, failed WS.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
NO DYNAMIC BRAKING	FAILED DP MODULE	Engine running; Controls set up for dynamic braking; Dynamic brake handle in maximum brake position. Main generator volts GP to GN should be 20 to 60V DC. If no voltage is obtained, pull out DR module. If no voltage is obtained, check for pickup of EQP. If EQP is not picked up,connect a jumper from C1 to C2 of MR. If EQP picks up voltage is obtained when jumper is applied, check voltage at DP-TP15 to negative. If this is not close to 74V replace DP module with a qualified DP module and test again.
LOSS OF POWER REPORTED UNDER SEVERE TRACK AND GRADE CONDITIONS.	NORMAL CORRECTIVE ACTION BY WHEEL SLIP CONTROL SYSTEM	No action required. The wheel slip control system responds under severe conditions to maintain power at an optimum level for adhesion conditions. The lowering of the power level under severe conditions should not be misinterpreted as a fault.
LACK OF ADHESION AND NO WHEELSLIP CORRECTION REPORTED.	WS MODULE FAILURE	Refer to General Qualification procedures to verify WS Module function. Refer to Troubleshooting Outlines for WST and WS qualification.
GROUND/FAULT		To find a ground fault the circuit is broken into sections, which are open circuited one from each other, and tested with a megger - if the reading is high i.e. high resistance no breakdown to earth that section has no fault. If the reading is low the ground is located there and by eliminating smaller and smaller sections of the circuit the actual fault or faults can be isolated.
	GROUNDED CABLE OR DEVICE MOISTURE GROUND TRACTION MOTOR FLASHOVER	Repair or replace. Dry out wet area. Inspect, clean,and repair flashed motor if required. Refer to General Qualification procedures to verify GV module action. Refer to General Qualification procedures to verify WS module action; Troubleshooting Outlines for WS and WST function.
	MAIN GENERATOR FAULT	Inspect main generator for blown fuses and shorted diodes, Inspect for bad capacitors and resistors. M.I. 3317-2. Qualify GV module in the event of multiple diode failure. Refer to Grid Load Checks in Troubleshooting Outlines.

FAULT LIGHTS MOTOR EXCIT. AND GRID OVERCURRENT	DR MODULE FAILURE	Engine running; Controls set up for dynamic braking; Dynamic brake handle in maximum braking position; Voltage into module from D14 Alternator should be 135V - 165V Measure voltage RC-TP13 to RC-TP14, then connect a jumper from DR-TP4 to DR-TP5. Voltage should decrease very slowly to near zero. If voltage does not decrease, check BR2 relay and wiring. If wiring seems intact and BR2 picks up, replace DR with a qualified DR and retest.
EXCESSIVE BRAKING AT LOWER DYNAMIC BRAKE HANDLE POSITIONS	DR MODULE	Engine running; Controls set up for dynamic braking; Dynamic brake handle at maximum position. Measure voltage RC-TP13 to RC-TP14. Connect jumper from DR-TP4 to DR-TP5. Voltage should decrease slowly to zero or near zero. If voltage does not decrease, check BR2 relay. If wiring is intact and BR2 picks up, replace DR with a qualified module and recheck. NOTE: On units with DE modules refer to GL, BCT, DE or DR pages of troubleshooting outlines for grid current control functional check.

GENERAL TROUBLE GUIDE

OPERATING OR TEST CONDITION	ENGINE SPEED	HP $\frac{V \times A}{700}$	GOVERNOR RACK POSITION INDICATOR	LOAD REGULATOR POSITION	TYPE OF TROUBLE TO SUSPECT
Load test or road operation th 8 over 25 MPH.	Normal	LOW or NO LOAD	LONG	Max. Field	ELECTRICAL
Load test or road operation.	Possibly Variable	Variable	HUNTING	HUNTING	ELECTRICAL OR MECHANICAL
Load Test or road operation th 8	Normal	LOW	NORMAL	BALANCED	MECHANICAL
Load test or road operation th 8.	Normal	LOW	LONG	Balanced, but toward min. field.	MECHANICAL - Gov. ENGINE AIR
Load test or road operation th. 8	Normal	LOW or HIGH	SHORT	BALANCED	MECHANICAL - Gov.
Load test or road operation th. 8	LOW	LOW or HIGH	SHORT	MINIMUM	ELECTRICAL

GOVERNOR AND GOVERNOR RELATED TROUBLESHOOTING

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
Insufficient travel of injector adjusting link to obtain correct injector rack setting.	1. Wrong terminal shaft lever applied to governor	1. Change terminal shaft lever. Lever should measure 106.36mm between hole centers.
	2. Terminal shaft lever improperly applied to governor.	2. If lever has no double serration, apply new lever, Lever should have double width serration matched with missing serration of terminal shaft.
	3. Wrong terminal shaft on governor.	3. Replace governor. Missing serration should be at 3 O'clock position.
	4. Wrong terminal shaft scale on governor.	4. Replace governor. Scale should be graduated from 1.96" to .62".
	5. Terminal shaft scale quadrant mislocated.	5. Scale should indicate 1.96" with engine shut down.
Governor low oil plunger trips when starting engine.	1. Governor low oil time delay too short, or engine slow in developing oil pressure.	1. Reset governor low oil plunger immediately, and crank engine again. With engine operating at idle, check and reset time delay, if necessary. See EMM Governor Section.
	2. Low water or crankcase pressure detector tripped.	2. Check detector reset buttons to ensure they are in the set position.
	3. Engine oil pressure line to governor broken or crimped.	3. Replace oil line.
	4. Hot oil shutdown valve stuck open or leaking.	4. Replace valve if defective. See LSM Lubricating Oil Section.
	5. True low engine oil pressure.	5. See EMM Lubricating Oil Section.
Governor fails to control engine speed when starting.	1. Insufficient fuel. (Terminal shaft goes to full-fuel position).	1. Replace fuel filter elements. Clean fuel strainer element.
	2. Insufficient oil in governor (Terminal shaft goes to no-fuel position).	2. Check governor sight glasses for proper oil level. See EMM Governor Section for procedure and M.I. 1754 for correct lubricating oil.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
	3. Governor shutdown nuts too tight.(Terminal shaft goes to no-fuel position).	3. Remove governor cover and check to see that shutdown rod and nuts are free, and that speed indicator pointer is at IDLE.
	4. Defective governor. (Terminal shaft goes to no-fuel position).	4. Remove governor cover and check to see that speed indicator pointer moves from STOP to IDLE position when cranking engine. Replace governor if speed indicating pointer does not move.
	5. Incorrect injector rack setting.	5. Reset injector racks. See EMM Fuel Section.
Idle Speed approximately 50 rpm low.	The cap under the "D" solenoid is cocked or the spring around the "D" solenoid plunger is not installed correctly.	Install parts correctly. See EMM Governor Section.

Governor hunts	1. Compensating needle valve not properly adjusted.	1. See EMM Governor Section.
	2. Too much or too little oil in governor.	2. See EMM Governor Section for procedure, and M.I. 1754 for correct oil.
	3. Governor hunts for a short time when engine oil and governor oil are cold.	3. Run engine for a short period of time to warm the oil.
	4. Insufficient fuel.	4. Fuel return sight glass must be full and relatively clear at all speeds and loads. Replace fuel filter elements and clean fuel strainer element. Check that fuel pump is of adequate capacity.
	5. Binding injector control shaft linkage or sticking injector.	5. Make certain that all control shaft linkage is free. (Replace sticking injector or free up linkage).
	6. Wheelslip action due to variations in locomotive wheel diameter.	6. Match wheel diameters.
Governor hunts only at full load	1. Insufficient fuel to maintain engine speed at full load. Partial fuel restriction.	1. Replace fuel filter elements. Clean fuel strainer element. Fuel return sight glass must be full.
	2. Defective load regulator rheostat.	2. Qualify rheostat.
	3. Other electrical problems.	3. See LSM Section 11A - Electrical Qualification.
Engine overloaded. Governor terminal shaft at full fuel position, but engine speed bogs down. Load regulator in minimum field position.	1. Insufficient fuel.	1. Check fuel filter and strainer. Return fuel sight glass must be full.
	2. Over excitation of main generator. Fault in power control circuits.	2. See LSM Section 11A- Electrical Qualification.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
Engine under-loaded. (Not producing proper horsepower).Engine at rated speed. Governor terminal shaft at longer than specified rack,and load regulator in maximum field position.	Underexcitation of the main generator. Fault in power control circuits.	See LSM Section 11A - Electrical Qualification.
Engine is loaded, but governor terminal shaft is at longer or shorter than specified rack length. Load regulator is balanced.	1. Improperly set governor.	1. Reset governor balance point. See EMM Governor Section.
	2. Governor terminal shaft quadrant off location.	2. With engine shutdown, quadrant scale should indicate 1.96". Relocate quadrant.
Load regulator stays in minimum field position with the engine at idle.	1. Insufficient fuel.	1. Check fuel filter and strainer. Return fuel sight glass must be full.
	2. One or more injectors defective.	2. Qualify injectors. See EMM Fuel Section.
	3. Governor overriding solenoid stuck, or spring under overriding solenoid plunger broken.	3. Correct or replace. See EMM Governor Section.
	4. Injector rack length not properly set at 1.00" on governor terminal shaft scale.	4. Reset injector rack length. See EMM Fuel Section.

Governor fills with oil	1. Ruptured low oil pressure diaphragm.	1. Replace diaphragm or change out governor.
	2. Defective seal on load control pilot valve plunger	2. Change out governor.
	3. Porous column casting.	3. Change out governor.
Governor loses oil.	Defective drive shaft seal.	Replace drive shaft seal.
Governor does not change speed when throttle is changed.	1. Loose governor plug.	1. Check governor plug for looseness. Change out electrical equipment assembly (power pack) or replace governor.
	2. Solenoids do not respond to throttle setting. Governor speed setting is not obtained.	2. Change out electrical equipment assembly (power pack) or replace governor. Make certain that control circuits are providing power to energize solenoids.
	3. Locomotive in consist does not reduce engine speed for corresponding throttle reduction. Low voltage feed in trainline holds solenoid(s) in once energised.	3. Correct control circuit problem.

TROUBLESHOOTING OUTLINES

LEGEND OF REFERENCE SYMBOLS

The reference symbols used in this troubleshooting guide consists of one or more letters generally similar to the common words describing a component or trouble.

BATT	Battery
BCT	Brake Current Transductor
CB	Circuit Breaker
CP	Crankcase (Oil Pan) Pressure
CT	Current Transformer
DE	Extended Range Dynamic Brake
DP	Dynamic Brake Protection
DG	Grid Blower Protection
DR	Dynamic Brake Regulation
EL	Main Generator Field Excitation Limit
EMM	Engine Maintenance Manual
FP	Feedback and Performance Control
FS	Field Shunting
FZ	Fuse
GOV	Governor
GTP	Generator Potential Transformer Suspected Defective
GR	Ground Relay
GV	Generator Voltage Module
GX	Generator Excitation Module
HOT	Hot Engine
LR	Load Regulator
MFP	Motor Field Protection
NVR	No Voltage Relay (Aux. Gen; Aux. Alt)

RC	Rate Control
SCR	Main Generator Excitation Controlled Rectifier
SE	Sensor
TEM	Temperature Switches
TH	Throttle Response (And Reference Voltage Regulator)
UL	Underloading – Unloading
UL-D	Unloading - Dynamic Brakes
VR	Voltage Regulator
WS	Wheelslip
WST	Wheelslip Transductors

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk indicates Most Probable Fault-*	Instruction Reference

BATT EXCESSIVE USE OF BATTERY WATER:

Test Procedure

Check voltage at auxiliary generator fuse clip and right side of main battery switch.

Normal Indication

Between 71 and 78V DC

Fault Indication

If voltage is higher than allowed range, manipulate adjustment screw on face of VR module to obtain voltage within tolerance. If voltage cannot be brought within tolerance, replace VR module with a qualified module and retest.

Reset new regulator to the voltage required by the railroad for battery charging characteristic desired.

CAUTION: Auxiliary generator voltage of less than 74V may result in marginal excitation of the D14 auxiliary alternator, and the desired fast speed pickup of cooling fan motors may not be obtained.

BATT BATTERY CHARGE LOW

Battery charging indicator indicates high charging rate.

Test Procedure

Check specific gravity. (See battery manufacturers manual).Check voltage at auxiliary generator fuse clip and right side of main battery switch.

Normal Indication

Between 71 and 78V DC

Fault Indication

With adjustment on face of VR module, adjust charging voltage as required to obtain a satisfactory charging rate.

CAUTION: Do not remove or install VR module unless the diesel engine is completely stopped.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault- *	Instruction Reference
BCT	BCT SUSPECTED FAULTY (Units with grid current trainline control with extended range dynamic brakes).	GL

Test Procedure

Engine running; Controls and switches set up for dynamic brake operation; Brake handle at maximum position. Measure voltage RC-TP13 to TP14 or GP to GN.

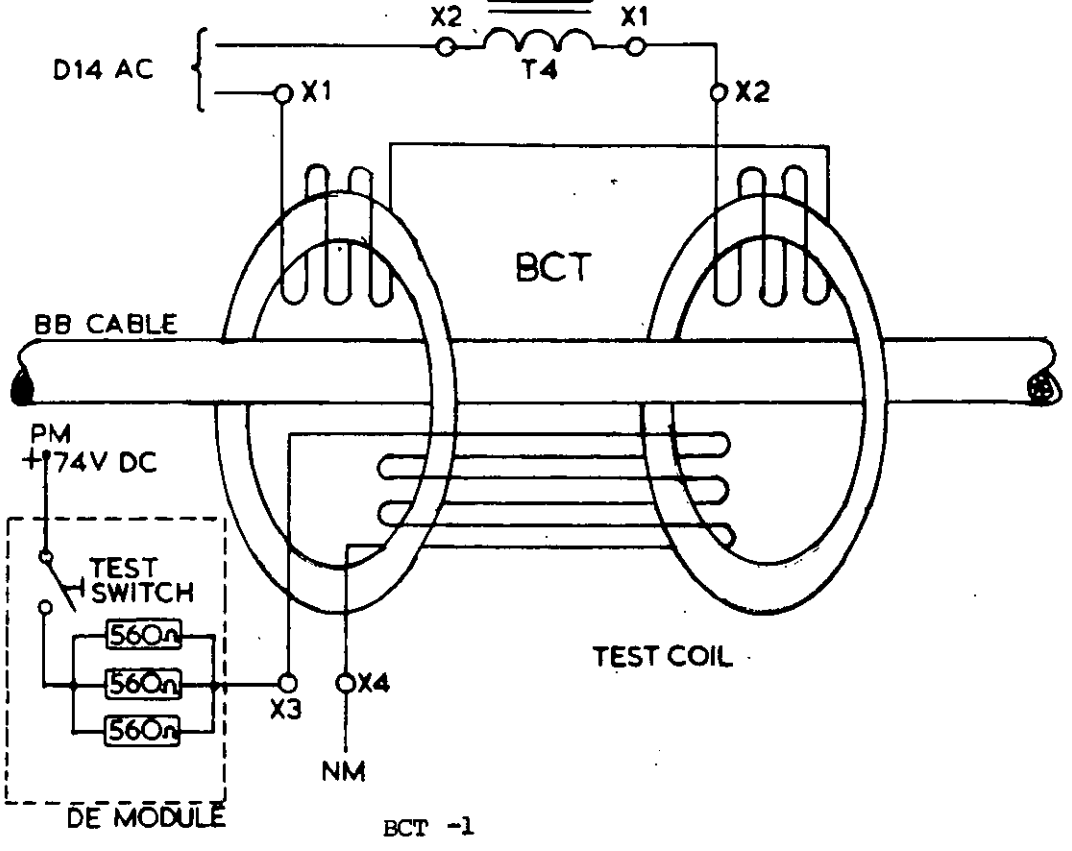
Connect BCT test coil terminal X3 in series with the equivalent of 186 ohms 3(560 ohm) resistors already in parallel in the DE module) to 74V DC (PM) connect BCT terminal X4 to negative (NM)

Normal Indication

Voltage RC-TP13 to TP14 or GP to GN should fall to zero or nearly zero.

Fault Indication

If improper indication is obtained, and DR checks are satisfactory DR replace BCT with qualified BCT and retest.



Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

CB AUX. GEN. FIELD BREAKER TRIPPED

Test Procedure

Engine shutdown and isolated. Pull out the VR module and open the auxiliary generator output circuit breaker. Check the auxiliary generator for shorts and grounds.

Normal Indication

Possible causes of a tripped breaker are an auxiliary generator ground or short *

Fault Indication

If the auxiliary generator tests good, replace the voltage regulator VR with a qualified module and retest. VR

Also check the Auxiliary Generator Circuit Breaker

CAUTION: Engine must be completely stopped when removing or installing the VR module.

CB GEN. FIELD CIRCUIT BREAKER TRIPPED

Check the following defects:-

a. Defective SCR assembly SCR*
b. Defective sensor SE SE
c. Defective excitation limit circuit EL. EL
d. Defective voltage regulator GV GV
e. Incorrect wiring from D14 to SCR panel

NOTE: The D14 Alternator Field is fed via a 60 Amp Alt. Field Fuse.

TROUBLE - POSSIBLE CAUSE AND SYMPTOM
Test Procedure
Normal Indication for Test Setup or Operating Condition
Fault Indication and Corrective Step
Asterisk Indicates Most Probable Fault -*

Reference Symbol

Instruction Reference

CP CRANKCASE PRESSURE DETECTOR SUSPECTED DEFECTIVE-

Any time a true crankcase pressure trip has occurred, or is suspected to have occurred.

Test Procedure

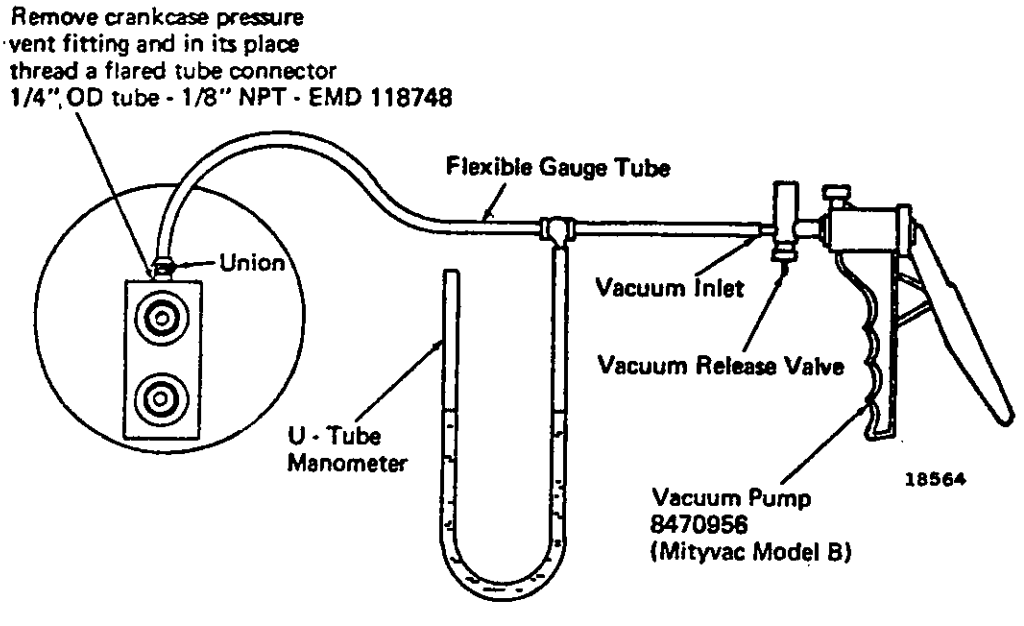
Check crankcase (oilpan) pressure detector trip valve, using metering device comparable to that illustrated below.

Normal Indication

Shut engine down. Operate the device to trip the detector, then reset the detector. Ignore the first trip value. Slowly operate the vacuum metering device again. Crankcase pressure detector trip button should pop out at a maximum of 63.50 mm (2.5")of water pressure or less to a minimum of 20.32 mm (.8"). On new or rebuilt engines of less than 3 months service these limits of pressure are 45.72 - 20.32 mm (1.8" - .8") pressure.

Fault Indication

If the detector does not trip when maximum value is reached, replace the detector with a qualified detector. The detector may be qualified with bench apparatus. MI 259



TROUBLE - POSSIBLE CAUSE AND SYMPTOM

Test Procedure

Normal Indication for Test Setup or Operating Condition

Fault Indication and Corrective Step

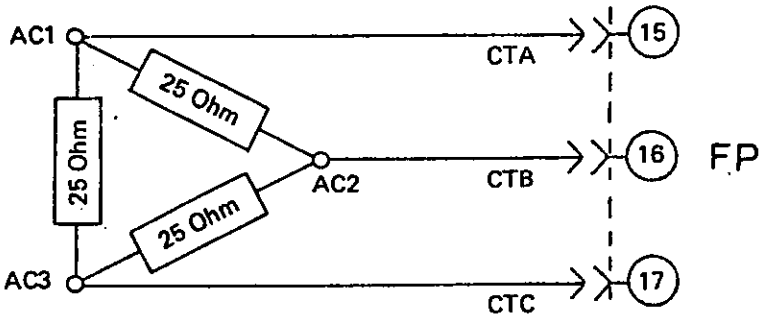
Asterisk Indicates Most Probable Fault -*

CT CTA, CTB, CTC, CURRENT TRANSFORMERS SUSPECTED DEFECTIVE - UL

Underloading.

Test Procedure

Grid Load or Short circuit; Connect three 25 ohm resistors in delta fashion to CTA, CTB, and CTC, at FP-TP15,16 and 17.



Close traction generator field circuit breakers and place throttle in Run 1. Check voltage drops across the resistors. They should be within 2 volts.

Fault Indication

If the voltages are out of balance, replace FP module with a qualified module, and test. If voltages are still out of balance; At back of the electrical cabinet, connect three 25 ohm resistors in delta fashion and connect the CTA, CTB, and CTC wires to the delta. FP

If the voltage readings are out of balance; Open traction Gen Fld CB. Verify that the CTA, CTB, CTC wires in the main generator airbox are connected to the X1 terminals of the current transformers, and the X2 terminals are connected common by jumpers AB and BC.

If connections are in order, determine which current transformer CT is defective, and replace it with a qualified transformer. (Resistance CTA to CTB, CTB to CTC, CTC to CTA, 22 $\pm$ 2.2 ohms. Greater variation indicates shorted turns or open windings).

CAUTION: Do not excite the main generator with wires CTA, CTB and CTC disconnected.Extremely high and damaging voltage will result.

If current transformers are not defective, verify that there is no fault in generator wiring.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

DE DE MODULE SUSPECTED FAULTY

Checking generator excitation and DE sequence function.

Test Procedure

Engine running; Controls and switches set up for dynamic braking; Reverser forward; Independent air brake released; 0-75 DC voltmeter connected at test panel GP and GN terminals.

Advance dynamic braking handle to maximum braking position.

Normal Indication

Engine speed increases to Notch 5 speed. Illumination of DE module test lamps indicate the sequence DC1, DC2, DC3 with an interval between indications. After sequence, voltmeter settles between 20 and 60V DC.

Test Procedure

Operate and hold the DE test switch.

Normal Indication

Test lamp sequence repeats with lamps going out in reverse order to illumination.

Test Procedure

Release test switch.

Normal Indication

Sequence repeats; lamps on.

Test Procedure

Apply independent brake fully to open IPS switch.

Normal Indication

Test lamps go out all at once.

Test Procedure

Release independent brakes.

Normal Indication

Sequence repeats; lamps on.

Test Procedure

Return braking handle to SET UP.

Normal Indication

Engine goes to idle speed; lamps remain on.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

DE DE MODULE SUSPECTED FAULTY
Checking generator excitation and DE sequence function.

Test Procedure

Move braking handle to OFF position.

Normal Indication

Test lamps go out all at once.

Fault Indication

If indications are incorrect, replace DE module with a qualified module and repeat tests. If indications are still incorrect, check circuitry at DP relays and DC contactors.

If independent brake application does not cause sequencing, check IPS switch.

DE DE MODULE SUSPECTED FAULTY
Checking DE module grid current control function.
Apply independent brake.

Test Procedure

Return dynamic braking handle to maximum position. After the meter reading stabilises, connect jumper across terminals 3C and 3NO of DP3 relay.

Normal Indication

Voltmeter Indication drops quickly to near zero.

Test Procedure

Remove jumper from DP3 relay.

Normal Indication

Voltage returns to between 20 to 60V DC.

Test Procedure

Connect a jumper wire from 1c to 1NO of relay DP1A on units so equipped.

Connect a voltage source of approximately 45V volts to DE-TP7. A convenient source of voltage is the headlight circuit where a wire can be connected between a headlight and its ballast resistor to tap offavoltage divider setup. The ballast resistor can be adjusted to give the right voltage, as can be the "dimming" resistor.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

DE DE MODULE SUSPECTED FAULTY

Checking DE Module grid current control function

Reduce dynamic brake handle one number at a time, allowing voltage to settle at each position.

Normal Indication

Voltage will settle at a lower value for each handle position, until at some lower position, voltage will continue falling to zero.

Fault Indication

If faulty response is obtained, check DR function. DR

If DR is satisfactory, replace DE module with a qualified DE module and retest.

GENERAL TROUBLESHOOTING OUTLINE

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault-*	Inst. Reference

DG DG MODULE SUSPECTED FAULTY

Checking grid protection after grid blower failure.

Test Procedure

Engine running; Controls and switches set up for dynamic braking; Reverser forward; Independent air brake released.

Advance dynamic braking handle to maximum braking position.

Operate and hold the DG test switch.

Normal Indication

Locomotive goes out of dynamic brake; DGX and B contactor dropout.

Annunciator panel "Grid Blower" shows an indication.

Fault Indication

If there is no response or a faulty response from the DG module, replace the DG module with a qualified DG module.

GENERAL TROUBLESHOOTING OUTLINE

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference
DP	DP MODULE SUSPECTED FAULTY Test Procedure At the back of the electrical cabinet, disconnect the BB273 wire from terminal 22 of the DP terminal strip. In the cab, connect a 0-100 DC voltmeter to test panel GP and GN terminals. Using a motor generator set, connect DC positive at DP-TP22; negative at DP-TP28. Engine running; Controls and switches set up for dynamic braking; Move dynamic braking handle to maximum braking position. Voltmeter at GP-GN will jump, then settle to a lower value within a few seconds. (20-60V). Slowly apply and increase MG set voltage. Normal Indication The DP module should regulate and main generator voltage drop off when MG set voltage is between 270 and 330 volts, with cold grids (Nominally 310 volts when grids are hot). Fault Indication If correct regulation does not occur, replace the DP module and repeat the test.	GL
	If retest fails, qualify the RC module.	RC
DP	DP MODULE SUSPECTED FAULTY Check motor field protection. NOTE: The above instructions for checking only. Settings are to be made only with bench test equipment.	MFP

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference
DR	DR MODULE SUSPECTED FAULTY	GL
	Test Procedure Engine running; Independent brake fully set (to open IPS switch when applicable); Controls and switches set up for dynamic brake operation; Brake handle at maximum position. Measure the voltage RC-TP13 to TP14, then connect a jumper from DR-TP4 to TP5. Normal Indication Voltage should decrease very slowly to less than 1V DC. Fault Indication If voltage RC-TP13 to TP14 does NOT decrease, replace the DR module with a qualified DR module and retest. If retest fails, qualify the RC module	RC
	NOTE: A satisfactory indication on the above test does not by itself qualify the DR module. Various portions of the DR circuits are not tested by the above test. Refer to the other tests.	DR-2 DE GL
DR	DR MODULE SUSPECTED FAULTY	
	Test Procedure Disconnect BB373 wire from DP-TP24 and connect MG set positive to DR-TP2. Connect the MG set negative to DP11-TP28.Connect a 0-100 volt DC voltmeter at test panel GP and GN terminals. Engine running; Controls and switches set up for dynamic braking; Move the dynamic braking lever to maximum braking position. Voltmeter at GP-GN will jump, then settle at a lower value within a few seconds. Slowly apply MG set voltage. Normal Indication The DR module should regulate and main generator voltage should drop off when MG set voltage is between 295 and 310 volts.	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference
DR	DR MODULE SUSPECTED FAULTY	
	Test Procedure	
	Return MG set voltage to zero.	
	Normal Indication	
	Main generator volts will return to the former value.	
	On units equipped for "Grid Current Trainline Control" of dynamic brakes or with extended range dynamic brakes, reference DR and DE pages covering grid current control checks.	DR DE
	Fault Indication	
	If correct indications do not occur, replace DR module with qualified module and repeat the tests. If retest fails, qualify the RC module.	RC GL
	NOTE: The above instructions are for checking only. Settings are to be made only with bench test equipment.	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

EL EL MODULE SUSPECTED FAULTY

Test Procedure

With isolation switch in RUN, generator field switch OFF, reverser handle in NEUTRAL, and throttle at IDLE, operate the EL test switch.

Normal Indication

EXCIT. LIMIT light on AN module comes on. The EQP relay drops out.

Fault Indication

If EQP relay fails to drop out and AN light fails to come on, advance throttle to No. 2 (or No. 3 if necessary) and again operate the test switch. If EQP relay fails to drop out and annunciator light fails to come on, replace EL module with a qualified module and retest. If replacement module fails to respond to test switch, qualify excitation limit transductor ELT.

Reset AN module.

EL EL MODULE OR ELT TRANSDUCTOR SUSPECTED FAULTY

Test Procedure

Remove the generator bus at the rear of the electrical cabinet, and short circuit the main generator. Disconnect the ARP1 wire from the front negative terminal GFD and bolt one side of a 300 ampere 75 millivolt shunt to the terminal. Bolt the ARP1 to the other side of the shunt. Connect a 0-75 millivolt meter to the shunt. Connect jumper from GX-TP8 to GX-TP4.

With the engine running and controls set up for power operation, advance throttle as required.

Normal Indication

The ELR relay in the EL module should pick up to drop out EQP and GFC when main generator field current is at EL pickup value indicated on the setting chart. Field current will rise and fall as EL picks up and drops out. (Peak at nominally 114 amperes).

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

EL EL MODULE OR ELT TRANSDUCTOR SUSPECTED FAULTY

Test Procedure

Pull out the GX-TP8 to TP4 jumper.

Normal Indication for

Current will hold steady at a lower value. (Nominally 108 amperes).

Fault Indication

If improper regulation is obtained, replace the EL module with a qualified EL module and retest.

If retest fails, replace the ELT transductor with a qualified transductor and retest.

Reset AN module.

TROUBLE - POSSIBLE CAUSE AND SYMPTOM

Reference Symbol				Instruction Reference
Ohmmeter Polarity		Nominal (ohms) Reading FP16	Nominal (ohms Reading FP15	
Pos.	Neg.			
5	3	302	450	
18	19	579	510	
18	11	608	582	
18	13	643	617	
18	14	1734	1617	
8	19	1006.8+	1000.6+	
10	19	1006.8+	1000.6+	
12	19	1000.8+	1000.6+	
18	8	579 +	510 +	
18	10	579 +	510 +	
18	12	579 +	510 +	
Ohmmeter Polarity		Nominal (ohms) Reading FP16	Nominal (ohms) Reading FP15	
Pos	Neg.			
2	18	1656 +	1597 +	
4	18	1656 +	1597 +	
6	18	1656 +	1597 +	
18	2	655.8 +	597.2 +	
18	4	655.8 +	597.2 +	
18	6	655.8 +	597.2 +	
15	13	140.8+	194.2 +	
16	13	140.8 +	194.2 +	
17	13	140.8 +	194.2 +	
19	15	1155 +	1107 +	
19	16	1155 +	1107 +	
19	17	1155+	1107 +	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

FP — FP MODULE SUSPECTED FAULTY

Faulty feedback signal causes overloading or underloading.

Test Procedure

Pull out FP module and test with an ohmmeter.For correct resistance readings see overpage.

Fault Indication

Low reading indicates shorted components.

Infinite reading indicates open component

NOTE: Verify polarity of ohmmeter leads (See overpage) + indicates that uncertain forward resistance of diodes must be added to the reading. Diode forward resistance will vary with the meter scale used and with the individual diode.

On straight resistance readings allow 5 to 10% meter tolerance.

FP — FP MODULE SUSPECTED FAULTY

High Starting Current

Test Procedure

Power setup; Air brake set; Throttle 1; Motors stalled.

Normal Indication

Load indicating meter indicates between 100 - 140A (GL22C-2) and 170 - 210 A (GL26C-2). Advance throttle to Notch 2 position to verify that wheelslip light does not come on, then return throttle to idle. If wheelslip is indicated in Notch 2, check wheelslip and motor circuits

Fault Indication; WS

If excessive amperes (150A GL22C-2) and 220A (GL26C-2) show on the indicating meter with throttle in Notch 1, remove the RC module. Full 68V DC should appear across FP-TP9 to FP-TP14. If it does not, replace FP with a qualified module and retest.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
FP	FP MODULE SUSPECTED FAULTY (Cont'd) Abnormal voltage feedback signal.	
	Normal Indication	
	The three readings from a single GPT should be within 10% of each other.	GPT
	Fault Indication	
	Voltage readings differ by more than 10%,use an ohmmeter to check the FP module. Verify accuracy of connections to GPT.	
	Qualify GPT	GPT

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

FS FS MODULE SUSPECTED FAULTY

Test Procedure

Engine running; Generator Field Circuit Breaker OFF; Test switch in CIRCUIT TEST position; Controls and switches set up for power operation; Reverser forward or reverse; Throttle 1.

Operate and hold the FS module test switch.

Normal Indication

FSRA relay and the FS1A and FS1B contactors pick up.

Test Procedure

Release FS test switch.

Normal Indication

FSRA relay and the FS1A and FS1B contactors drop out.

Fault Indication

If indications are incorrect, replace FS module with a qualified module and retest.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference
FZ	AR10 RECTIFIER FUSES BLOWN Check for the following defects:-	
	a. Defective GV module	GV
	b. Defective SCR assembly	SCR
	c. Bad commutation resistors or capacitors	M.I. 3317-2*
	Refer to specific instructions for the component.	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

GOV LOAD REGULATOR TIMING SUSPECTED FAULTY -

Test Procedure

Engine running and warm; Generator field circuit breaker open. Throttle 3. Load regulator in Max. position; Governor cover removed. Press and release test switch on TH module several times to obtain warm oil in lines.

Insert and twist screwdriver blade to lift pilot valve and uncover unloading ports fully, but do not uncover the overriding solenoid dump slots. (Pilot valve pointer just at the top of the letter "T" of the word "START").

Normal Indication

Load regulator travels from maximum to minimum position in 2 to 5 seconds.

Test Procedure

Quickly release the screwdriver and withdraw.

CAUTION: Make certain that the pilot valve scale pointer operator does not slip under the washer on the pilot valve operator.

Normal Indication

Load regulator travels from minimum to maximum in 16 to 25 seconds.

Fault Indication

Governor timing incorrect. Replace governor with a qualified governor and retest.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

GTP GENERATOR POTENTIAL TRANSFORMER(S) SUSPECTED DEFECTIVE

Test Procedure

Place the test panel rotary test switch in LOAD TEST position and center the reverser. Engine running and controls set up for power operation; Place throttle in Notch 1.

CAUTION: Do not exceed Notch 1 on units not equipped for automatic self loading.

Measure AC voltage with a 0-300 AC voltmeter; FP-TP8 to TP10; TP8 to TP12: TP10 to TP12.

Normal Indication

The three readings should balance within 10% of each other.

Test Procedure

Also read from FP-TP2 to TP4; TP2 to TP6; TP4 to TP6

Normal Indication

The three readings should balance within 10% of each other.

Fault Indication

Voltage readings differ by more than 10%; Verify accuracy of connections to GPT. Check continuity of GPT and wiring.

Isolate various GPT inputs to circuit modules and repeat voltage balance checks.

CHECKING FOR FAULT IN GV

Test Procedure

Pull out the GV module; Connect a jumper from GX-TP4 to SE-TP13. Open throttle as required.

Check voltage balance; FP-TP8 to TP10; TP8 to TP12; TP10 to TP12.

Fault Indication

If voltage readings balance when GV is isolated, replace GV with a qualified GV and retest.

If voltage readings are still unbalanced, allow test setup to remain, and perform FS checks GPT-2

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

(GPT checks continued from preceding page).

CHECKING FOR FAULT IN FS

Test Procedure

Pull out the FS module. Open throttle as required. Check voltage balance; FP-TP2 to TP4; TP2 to TP6; TP4 to TP6.

Fault Indication

If voltage readings balance when FS is isolated, replace FS with a qualified FS and retest.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
GR	GRD FAULT LIGHT -	
	Traction motor flashover; Moisture ground; Insulation breakdown; Loose component; Multiple AR10 diode failure; leaking capacitor.	
	Test Procedure	
	Inspect motors for flashover indication or damage.	
	Normal Indication	
	No heavy carbon tracks on motor commutator or riser; Brush "pigtail" leads intact; Brushes in acceptable condition.	
	Fault Indication	
	If flashover indication is observed, repair flashover damage and clean motor as required.	
	Test Procedure	
	Visually inspect switchgear for burns, cuts, evidence of moisture.	
	Fault Indication	
	Repair defects as required.	
	Test Procedure	
	Visually inspect for multiple blown fuses in AR10 rectifier assembly. Visually inspect for burned commutation resistors and damaged capacitors.	M.I. 3317-2
	Normal Indication	
	No pins protrude from fuse indicators; Capacitors not bulged; Resistors not burned; Wires not burned or broken.	
	Fault Indication	
	Test fuses and diodes for shorts and opens wherever blown fuses are indicated. Renew all faulty diodes and fuses. Check for defective GV, SE or FP modules. Check SCR.	M.I. 3317-2
	Check for grounded or shorted suppression capacitors and open or shorted resistors.	M.I. 3317-2

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

GR GRD FAULT LIGHT -
Insulation breakdown suspected.

Test Procedure

Isolate and stop the unit under test. Remove jumper cables between units, Perform megger or high potential tests for insulation failure and electrical ground.

a. Open main battery switch and ground relay switch.
b. Connect a jumper from AR10 negative to AR10 positive.
c. Connect jumpers to short out AR10 and D14 slip rings.
d. Refer to schematic wiring diagram wiring strings and isolate circuits as desired.
e. With a minimum of 3 inches movement of each module, displace (but do not withdraw completely) all modules to disconnect module receptacles from cabinet mounted contact pins.
f. Disconnect or jumper out electronic equipment.

Test suspected circuits and components with a 500 volt megohmmeter for one minute to determine condition of circuits before making high potential tests.

Normal Indication

Normal megohmmeter indication is 1 megohm or more.

Fault Indication

Under 1 megohm the circuit is suspected.

Test Procedure

Test suspected circuits (except control circuits and cranking motors) and components with high potential tester. 1050 volts for 1 minute.

Normal Indication

Less than 1/3 ampere leakage.

Fault Indication

1/3 ampere leakage or more.

WARNING: Observe personal safety precautions when working with high voltage. Do not subject static electronic components to megohmmeter or high potential tests.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

GR GRD FAULT LIGHT FAILS TO COME ON

GRD FAULT LIGHT COMES ON UNNECESSARILY

Test Procedure

Locomotive controls set up for power operation; Air brakes set; Engine running; Reverse lever centered; Test panel test switch in LOAD TEST POSITION.

WARNING: The AR10 will be open circuited on units not equipped for automatic self loading. Do not exceed Notch 1 and do not allow main generator volts to exceed 250V DC with the main generator open circuited.

If the main generator contains a ground, hazardous conditions can exist if the test ground is made by an unfused heavy connector.

Connect a 5 ampere fused jumper from generator positive to locomotive ground. Connect a 0-500V DC voltmeter from GP to GN. Press the test button on the TH module for five seconds to drive the load regulator to minimum field position, then open the throttle to Notch 1 and release the TH test button.

Return throttle to idle, move the grounding jumper from generator positive to generator negative, and repeat the test.

Normal Indication

The ground relay should pick up between 75 and 125 volts DC across the main generator.

Fault Indication

If ground relay action is faulty, check out ground relay resistors, rectifiers, and coil. Replace faulty components as required.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
GV	GV MODULE SUSPECTED FAULTY -	
	Unit not loading.	GPT
	AR10 diodes failing.	
	Test Procedure	
	Power setup; Air brakes set; Throttle 1; Motors stalled.	
	Normal Indication	
	Normally zero or very low voltage appears between GV-TP8 and GV-TP4.	
	Fault Indication	
	If above normal voltage (over 10V DC) appears at GV-TP8 to GV-TP4, a fault may exist in the GV, or FP modules.	
	Test Procedure	
	FP module pulled out; Engine running; throttle idle. Ohmmeter at low resistance scale. Positive at GV-TP8; negative at GV-TP4.	
	Normal Indication	
	Ohmmeter should show very low resistance. Pull out the GV module. Ohmmeter should show very high resistance.	
	Fault Indication	
	If resistance remains low when the GV module is pulled out, a shorted GV is indicated. Replace with a qualified GV and retest.	
	Test Procedure	
	Throttle idle; Disconnect ohmmeter; Reinstall FP and GV; Open the AC control circuit breaker to isolate D14 from transductor coils; Bell rings A.G./ Alt Fail light.ON. Power setup; Air brakes set; Throttle 1.	
	Normal Indication	
	With throttle in Notch 1, full 68V DC appears between GV-TP8 and TP4. No load current.	
	Fault Indication	
	Low voltage(less than 10V DC) between GV-TP8 and TP4 indicates shorted GV. Replace GV with qualified GV and retest.	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
GX	GX MODULE SUSPECTED FAULTY (only applied on GL26C-2 locomotives)	
	Unit not loading.	
	Excitation limit annunciator light reported.	EL
	Test Procedure	
	Connect jumper from C1 to C2 of GFX and from EL-TP5 to EL-TP6.	
	Connect a 0-74 DC voltmeter from GX-TP4 to FP-TP14.	
	Controls set up for power operation; Throttle No. 1; Motors stalled.	
	Operate EL test switch.	
	Normal Indication	
	Voltmeter reading should drop to zero or near zero, and load meter at control stand should drop to zero or near zero.	
	Fault Indication	
	If readings are incorrect:	
	a. Check AC input at GX-TP10 to TP12.	
	b. Check AC input at GX-TP2 to TP12, and again press the EL test switch. AC voltage reading should increase. If it does not, perform FCT checks	GX-2
	c. If AC inputs are correct, replace GX with a qualified GX and retest.	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
GX	GX MODULE OR FCT TRANSDUCTOR SUSPECTED FAULTY -	

Test Procedure

Remove the generator bus at the base of the electrical cabinet, and short circuit the main generator. Disconnect the wires from the front negative terminal of GFD contactor and bolt one side of a 300 ampere 75 millivolt shunt to the terminal. Bolt the wires to the other side of the shunt. Connect a 0-75 millivolt meter to the shunt.

Connect a jumper from EL-TP5 to EL-TP6.

With the engine running and controls set up for power operation, advance throttle as required.

Normal Indication

Generator field current should regulate at nominally 103 amperes (with 5 and 6 terminals unjumpered).

Fault Indication

If regulation is not correct, check AC input at GX-TP2 to TP12 and at GX-TP10 to TP12. If AC input appears correct, replace GX with a qualified GX and retest.

If retest fails, replace FCT transductor with a qualified transductor and retest.

CAUTION: Hold high field current levels for as short a time as practicable.

Test Procedure

Return throttle to idle.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

HOT HOT ENGINE TEMPERATURE

Test Procedure

Check water level on tank sight glass.

Normal Indication

Water level satisfactory. No evidence of water loss.

Fault Indication

If water is low, inspect for leaks or overheating.

a. Check oil level.

b. Press test buttons on temperature switches to verify fan operation.

c. Visually inspect piping, pumps, and radiators for leaks.

d. Visually inspect engine top deck and air box for evidence of water leaks.

e. Visually inspect exhaust stack for evidence of chromate in the exhaust system.

f. Test oil for presence of water.

If standard checks fail to reveal source of repeated water loss, extended engine loading, system pressurisation, and engine strip down may be required to reveal the source of the leak.

WARNING: Do not subject the water tank to pressure greater than 50 psi. If pressure in excess of 50 psi is required to test the engine, isolate the engine by using blanking plates at water pump connections and at the discharge "Y". As an added safety precaution, maintain the greatest volume of water and the smallest volume of air practicable in the system or engine during testing.

If water level is low, verify operation of engine low water detector, and low oil shutdown plunger operation on engine governor.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

HOT HOT OIL DETECTOR QUALIFICATION TEST

Remove detector from engine and test as follows:

1. Connect air lines to and from valve so that flow is in direction of arrow.
2. Place valve in thoroughly agitated liquid bath so that half the valve body is immersed. (Dow glycerine, USP grade 96% recommended).
3. Heat the bath. After 235°F. is obtained, the rate of rise must not exceed 1°F. per minute.
4. Apply 50 psi air pressure and observe for leaks. No leaks between valve body and cap are acceptable.
5. At 250°F., maximum rate of leakage to be 10 SCFH. (Standard cubic feet of air per hour).
6. Turn off air to avoid chilling.
7. Raise temperature to 258°F.
8. Turn air on. Minimum rate of flow to be 20 SCFH.

Reference Symbol | TROUBLE - POSSIBLE CAUSE AND SYMPTOM
Test Procedure
Normal Indication For Test Setup or Operating Condition
Fault Indication And Corrective Step
Asterisk Indicates Most Probable Fault-* | Instruction Reference

LR LOAD REGULATOR SUSPECTED DEFECTIVE.

Test Procedure

With engine running and controls and switches set up for power operation, but with Gen. Field Circuit Breaker open and Test Panel Test Switch in CIRCUIT CHECK position,place throttle in Notch 8. Connect a 0-75V DC voltmeter positive at test panel Load Reg. B; negative at Loading Reg.-

Normal Indication

Voltage at test panel should be between 40 and 50V DC.

Fault Indication

Voltage less than 40V DC. Check for -

a. Open load regulator connections.

b. Bad load regulator brush.

c. Jammed load regulator.

Test Procedure

Return throttle to idle; Pull out to disconnect the FP, RC, and WS modules. Connect a jumper from test panel Load Reg.+ to a convenient 74V D.C. source. Press the test switch on the TH module. Meter needle falls to zero in about 5 seconds. While observing meter closely, release the TH test switch.

Normal Indication

Meter indication will increase slowly from zero to 74V D.C.

Fault Indication

Momentary meter needle deflection toward zero to any time after the TH module test switch is released indicates an open load regulator rheostat contact button. Replace load regulator rheostat with a qualified rheostat.

A sudden jump in the meter reading from zero to 74V D.C. at any time after the TH test switch has been released indicates an open load regulator rheostat.

CAUTION: Remove the 74V D.C. source before reinstalling the RC, FP, and WS modules.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

MFP MOTOR FIELD PROTECTION SUSPECTED FAULTY

Test Procedure

Engine running; Throttle idle; Dynamic brake OFF; Reverser in reverse position.

Apply upward pressure on the tip of transfer switch RV contact carrier, Fig. MFP-1, and operate the reverser handle to forward position. The contact carrier will disengage from the main lever assembly as the transfer switch operates. The movable contact assembly of that switch module is left in a centered position. Other RV switch modules complete their travel.

Place braking handle in SET UP position. Open engine run switch to prevent engine speed increase.

Connect a jumper from DP-TP9 to DP-TP14 to discharge a capacitor. Connect a 0-150 DC voltmeter positive at DP-TP3; negative at DP-TP12. Remove jumper, then advance dynamic braking handle slowly as required.

Normal Indication

MFP relay in the DP module picks up as generator voltage rises. MFP pickup along with EQP dropout should occur between 73 and 79 V DC. EQP cycles in and out.

CAUTION: Immediately wipe handle to OFF if meter goes to full scale.

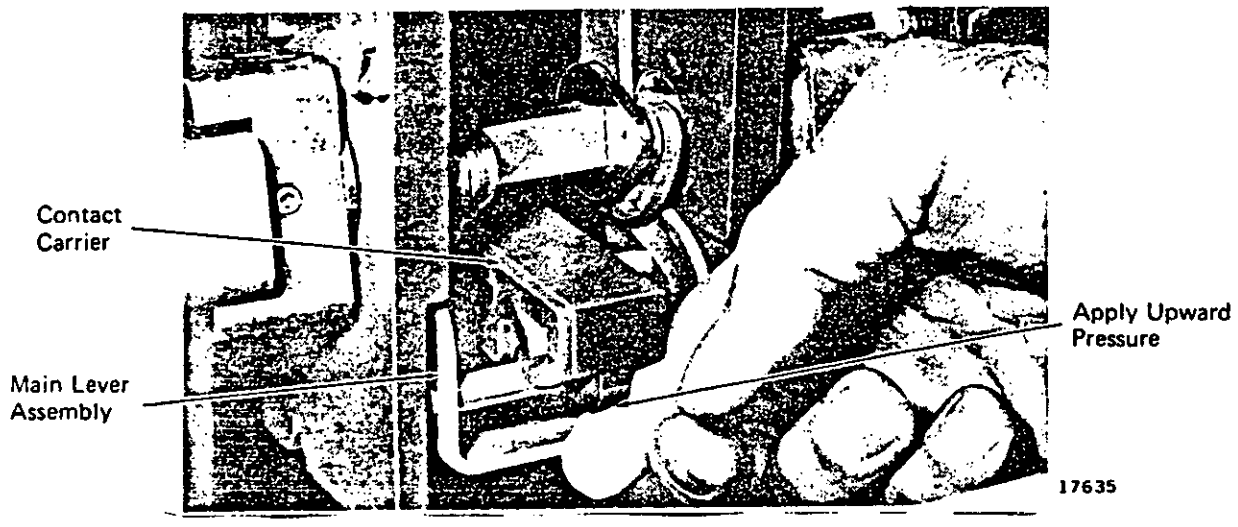
Fault Indication

If pickup is incorrect, replace DP module with a qualified DP and retest.

After the test operate the reverser to re-engage the contact carrier and the main lever assembly. Open the dynamic braking handle to verify that voltage then settles at a smaller value.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication for Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

MFP MOTOR FIELD PROTECTION SUSPECTED FAULTY (Cont'd)



Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
NVR	NO AC VOLTAGE RELAY NVR DROPPED OUT Alarm sounds, AG/ALT Fail light on; Engine Running.	
	Test Procedure	
	Check for tripped Generator Field CB. If tripped, turn test panel test switch to CIRCUIT CHECK position.	
	Normal Indication	
	NVR picks up; D14 output is satisfactory.	
	Fault Indication	
	Check for shorted SCR.	SCR*
	Test Procedure	
	Check for tripped AC Control CB.	
	Fault Indication	
	AC Control Breaker tripped. Pull out circuit modules SE,DR, GV, EL, DP, GX and WS and visually inspect for evidence of fault.	
NVR	NO AC VOLTAGE RELAY DROPOUT REPORTED Alarm sounds AG/ALT Fault light on; Engine running. Hot Engine	HOT
	Test Procedure	
	Check for locked or binding fan motor rotor causing low D14 voltage.	
	Check for shorted CR17 or grounded field.	
NVR	NO AC VOLTAGE RELAY DROPPED OUT Alarm sounds; AG/ALT Fail Light on; Engine stopped.	
	Test Procedure	
	Check for tripped Aux. Gen. Field CB.	
	Check for tripped Aux. Gen. Output circuitbreaker. If circuit breaker tripped, check for burned out headlights and for shorted CR-BC.	
	Fault Indication	
	If CR-BC is not shorted, replace VR with a qualified VR and check auxiliary generator voltage.	VR
	CAUTION: Make certain that the engine is completely stopped before removing or inserting a VR module.	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

RC RC MODULE SUSPECTED DEFECTIVE
Rate Control function suspected defective.

Test Procedure

Engine running and warm; Throttle idle; Controls and switches set up for power operation; Generator field circuit breaker open; Test panel test switch in CIRCUIT CHECK position. Pull out the FP module.

Move throttle rapidly to Notch 8 position.

Normal Indication

Voltage RC-TP13 to RC-TP14 should increase from zero to about 50V DC in from 18 to 36 seconds time.

Test Procedure

When voltage is up, connect jumper from RC-TP4 to RC-TP14 to check the discharge rate.After a jumper is connected and the discharge rate observed, remove the jumper and allow voltage to return to full value.

Normal Indication

Voltage decays very slowly to zero (1 to 4 minutes). Remove jumper and allow voltage to become stable.

Test Procedure

Jumper from RC-TP7 to RC-TP14.

Normal Indication

Voltage decays at a rapid rate to 3 to 7V DC. Remove jumper and allow voltage to become stable.

Test Procedure

Jumper from RC-TP6 to RC-TP14.

Normal Indication

Voltage decays at a rapid rate to near zero.

Test Procedure

Return throttle to idle and remove jumper. Place braking handle in SET UP position. Move braking handle rapidly to No. 8 position.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication and Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
RC	RC MODULE SUSPECTED FAULTY (Cont'd)	

Normal Indication

Voltage RC-TP13 to RC-TP14 increases from zero to about 49V DC within 4 to 11 seconds.

Fault Indication

If incorrect indications are obtained, replace RC module with a qualified RC and retest.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
SCR	MAIN GENERATOR EXCITATION RECTIFIER SCR SUSPECTED FAULTY	
	NOTE: Most SCR failures involve a short circuit. This will be seen as a tripped Generator Field Circuit Breaker, or will be seen as a lack of power control. If doubt about the condition of the SCR exists, perform SE checks.	SE-2

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
SE	SE MODULE SUSPECTED DEFECTIVE	
	AC failure.	UL
	Test Procedure	
	Engine running; Throttle idle or unit isolated.	
	Normal Indication	
	SE voltage TP6 to TP8 to TP10, TP10 to TP6 balanced at a value between 65 and 80V AC.	
	Fault Indication	
	Voltage incorrect or out of balance.	
	a. AC control or Gen. Field CB open.	
	b. Open wiring or defective connection.	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

SE SE MODULE SUSPECTED DEFECTIVE -

Unbalanced output.

Test Procedure

Engine running; Air brakes set; Control and switches set up for power operation.

Using a three terminal jumper with banana plugs, perform the following at the SE module.

a. Jumper TP9 to TP7 to TP11 in order to check output to SCR G1. Place throttle in No. 1; Record current; Return throttle to IDLE and remove jumpers.

b. Jumper TP9 to TP5 to TP11 to check output to SCR G2. Place throttle in No. 1; Record current; Return throttle to IDLE and remove jumpers.

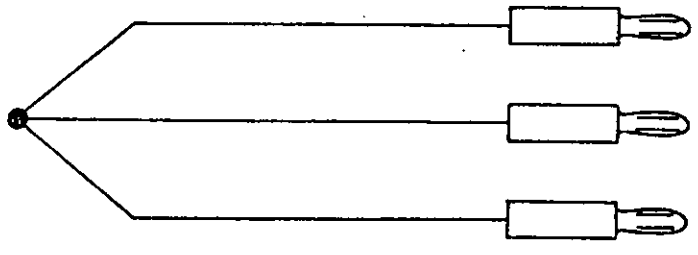
c. Jumper TP7 to TP5 to TP11 to check output to SCR G3. Place throttle in No. 1; Record current; return throttle to IDLE and remove jumpers.

Normal Indication

AR10 current as seen on the load indicating meter should be nominally equal in each of the three tests above.

Fault Indication

If AR10 current is significantly unequal, replace defective SE with qualified SE module and retest. If retest fails, replace SCR.



Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
TEM	COOLING SYSTEM TEMPERATURE SWITCHES SUSPECTED DEFECTIVE	
	Hot Engine Alarm	HOT
	Large movement of governor rack scale pointer as fans come in. D14 failure. Test Procedure Place thermometer in well of temperature switch manifold. Road or loading grid operation under full power. Normal Indication Temperature switches operate fan contactors in sequence. TA - FC1 - 155° ± 1½°F Verify temp indicated TB - FC2 - 171° ± 1½°F on switch nameplate. ETS - THL - 208° ± 1½°F Fans come up to full speed within 15 seconds. Fault Indication	
	Two fan contactors pick up within a few seconds of each other. Shut the unit down immediately. Inspect and megger the D14, the fan motors, and fan cables. Check temperature switch part numbers. Replace any switch suspected defective.	HOT
	Second fan fails to come up to speed within 15 seconds. Verify that voltage output from the auxiliary generator is 72V DC minimum.	

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference
TH	TH MODULE THROTTLE RESPONSE OR REFERENCE VOLTAGE REGULATION SUSPECTED FAULTY	
	Test Procedure	
	Engine running and warm; Open the Generator Field circuit breaker; Place test panel rotary switch in CIRCUIT CHECK position; Set up controls for power operation; Throttle Notch 1.	
	Normal Indication	
	Voltage TH-TP2 to TP14; 67.8 to 68.2 V DC	
	Voltage TH-TP3 to TP14; Approx 9 V DC	
	Advance throttle to Notch 8. Voltage TH-TP3 to TP14 increases in steps to 67.8 to 68.2 V DC.	
	Fault Indication	
	Voltage out of tolerance; Qualify VR module	VR
	If voltage TH-TP1 to TP14 is satisfactory (71 to 77V DC) but voltage TH-TP3 to TP14 is out of tolerance, replace TH module with a qualified module and retest.	
	Test Procedure	
	Throttle Notch 8, operate the TH test switch.	
	Normal Indication	
	Voltage - load regulator "B" to minus at the test panel terminals drops to zero as load regulator goes to minimum field position in from 2 to 5 seconds.	
	Fault Indication	
	Incorrect timing or voltage, qualify the load regulator governor, or rate control module RC.	LR RC GOV

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

UL UNDERLOADING

No AR10 Output or Output Lower Than Normal

1. Check GFC, GFD, EQP contactor pickup, and generator field circuit breaker closed.
2. Check output voltage at TH and RC at all throttle positions. Reference the setting chart or the description of the TH module, Section 7B of this manual.
3. Check position of load regulator. Should be at a balance point with AR10 current between 1200 and 4500 amperes. Notch 8, 63:14 Gearing. At maximum field position with AR10 current higher than 4500 amperes.

NOTE: These are nominal values for checking purposes only.

4. Resistance of load regulator should be 1500 ± 0.25% ohms. Check continuity of all contact buttons. — LR
5. Check wiring to all terminal boards.
6. Check for proper AC supply to all modules.
7. Check AR10 and D14 slip ring brushes.
8. Check for correct engine speed and for correct governor power piston balance point. — EMM
9. Check for plugged fuel filters — LSM-1
10. Perform NOT LOADING OR UNLOADING checks in troubleshooting guide.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

UL-D UNLOADING

Unit reported not loading or unstable in dynamic brake.

Test Procedure

Engine running; Controls and switches set up for dynamic brake operation; Brake handle in maximum dynamic braking position. Voltage RC-TP2 to TP14 verified. RC

Normal Indication

Voltage RC-TP13 to TP14, 42 to 52 V DC. If this voltage is correct, the DR module is satisfactory. The excitation system should be checked.

Fault Indication

Voltage RC-TP13 to TP14 lower than 42V DC or at zero.

Withdraw to disconnect the DR module. If voltage increases to the correct value, perform the following:-

1. Replace the defective DR. Voltage should decrease slowly. If voltage dumps immediately, replace the RC module with a qualified RC before replacing DR with a qualified module.
2. Replace the defective DR module with a qualified module and retest. DR

   If disconnecting the DR module did not correct the RC-TP13 to TP14 voltage, the excitation system should be checked.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

VR VOLTAGE REGULATOR VR SUSPECTED DEFECTIVE -

NOTE: The VR module does not provide reference voltage for the excitation system. The reference voltage regulator is part of another module.

Test Procedure

Gen. Field CB open; Power setup; Air brake set; 0-100 DC voltmeter positive connected at auxiliary generator output circuit breaker negative at main battery switch.

With engine running, read voltage at Notch 1 speed and Notch 8 speed.

Normal Indication

Voltage at Notch 8, at value within the 71 - 77 V DC range desired by the railroad for battery charging purposes.

Voltage at Notch 1 within 1 volt of Notch 8 voltage.

Fault Indication

Voltage at any throttle position not within 1 volt of selected value within 71 - 77 volt range. Replace VR module with a qualified module if adjustment cannot be made.

WARNING: Do not close the Gen. Field CB until the throttle is in idle position. Do not remove or install VR module until engine is completely stopped.

VR VOLTAGE REGULATOR VR SUSPECTED DEFECTIVE

Test Procedure

Locomotive idling or in service.

Normal Indication

Voltage measured from positive at auxiliary generator output circuit breaker negative at main battery switch; 71 - 77 V DC.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

VR VOLTAGE REGULATOR VR SUSPECTED DEFECTIVE - (Cont'd)

Fault Indication

Replace VR with qualified module if any of the following conditions are observed.

Voltage fluctuates between 20 and 40V DC.

No regulation. Auxiliary generator output circuit breaker.

No voltage.

Voltage oscillates between 80 and 85 volts.

Low voltage can not be brought up by adjusting screw.

GENERAL TROUBLESHOOTING OUTLINE

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

WS EXCESSIVE WHEEL SLIP ACTION REPORTED
Check for fault in motor circuits.

Test Procedure

Position the unit under test against other locomotive units, against a bumping post, or against some other restraining arrangement. Set air brake on all units.

Engine running and warm; Controls and switches set up for power operation; Advance throttle one step at a time to Notch 3. As soon as current stabilises in Notch 3, return throttle to idle.

Normal Indication

No wheel slip action will occur if motor circuits are in balance.

Fault Indication

If wheel slip action occurs, the motor circuits are out of balance. Open the AC Control circuit breaker, and disconnect the following:-

AK1 from WST25

AK2 from WST34

AK52 from WST16

Insulate wire ends.

Reconnect one of the above wires independently to its proper terminal. Close the AC Control CB, and repeat the stall current checks. Perform the checks for each transductor independently connected. Wheel slip response with a given transductor connected will narrow the fault down to one of the motor circuits. Inspect motors, contactors, cables.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

WST WHEELSLIP TRANSDUCTOR SUSPECTED FAULTY

CAUTION: Use the following recommended method for obtaining differential current at the transductors.

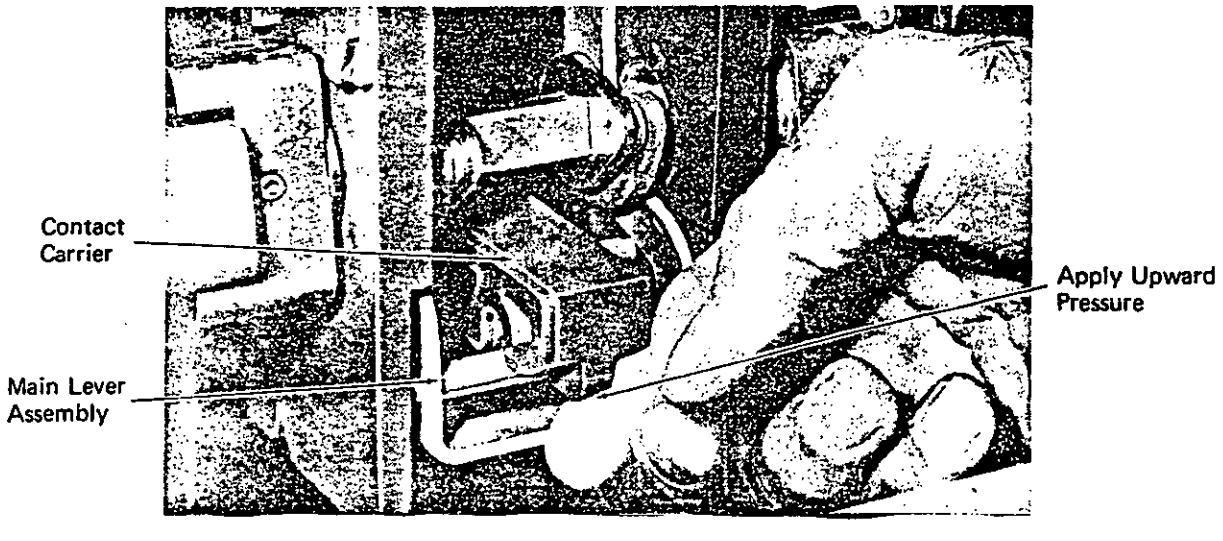
Do not place insulating material between power contactor or transfer switch main contact tips. The presence of foreign material at contact tips will lead to failure of the device.

Procedure for centering individual transfer switch modules to open a motor circuit.

Engine running; Controls and switches set up for power operation; Reverser handle in reverse position.

Apply upward pressure on the tip of one transfer switch module contact carrier, Fig. WST-1, and operate the reverser to forward position. The contact carrier will disengage from the main lever assembly as the transfer switch operates. The movable contact assembly of that switch module is left in a centered position. Other switch modules in the same assembly will complete their travel.

Proceed with WST Transductor checks.



Reference Symbol | TROUBLE - POSSIBLE CAUSE AND SYMPTOM | Instruction Reference

Test Procedure
Normal Indication For Test Setup or Operating Condition
Fault Indication And Corrective Step

Asterisk Indicates Most Probable Fault -*

Test Procedure

Engine running; Locomotive controls and switches set up for power operation; Air brakes set; Throttle idle. Open the AC Control CB and disconnect the following wires:

AK1 from WST 25
AK2 from WST 34
AK52 from WST 16

Insulate wire ends

WST 25 CHECK

Test Procedure

Reconnect wire AK1 to WST25. Using the procedure given on page WST-1, center switch module RV4/R3.

Close the AC control CB.

Place throttle in Notch 1.

Normal Indication

Current rises to a level.

Throttle Notch 2.

Load current rises to a level, then falls off as wheel slip control system operates. Current then rises again and cycling continues.

Throttle Notch 3.

Same response as for Notch 2.

Test Procedure

Throttle idle. Return reverser handle to reverse position. Center RV3/R2. Repeat above throttle 1, 2, and 3 checks.

Fault Indication

If response is incorrect, check cabling thru transductors, and qualify the transductors. WST-4 WST-6

TROUBLE - POSSIBLE CAUSE AND SYMPBOM

Test Procedure
Normal Indication For Test Setup or Operating Condition
Fault Indication And Corrective Step

Asterisk Indicates Most Probable Fault -*

Reference Symbol

Instruction Reference

WST34 CHECK

Test Procedure

Throttle idle; Open the AC Control CB. Disconnect the AKl wire from WST25. Insulate the end. Reconnect the AK2 wire to WST34. Close the AC Control CB. Centre RV5/Rl.

Open throttle to Notch 1, 2, 3

Normal Indication

Same response as for WST25 check.

Test Procedure

Throttle idle. Move reverser handle to reverse position. Center RV2/Ll. Move throttle to Notches 1, 2 3.

Fault Indication

If response is incorrect, check cabling thru transductors, and qualify the transductors WST-4

WST 16 CHECK

Test Procedure

Throttle idle; AC Control CB open. Disconnect the AK2 wire from WST34. Insulate the wire end. Reconnect the AK52 wire to WSTl6 RV 6/L2 is centered. Close the AC Control CB. Open throttle to Notches 1, 2 3.

Normal Indication

Same Response as for WST35 check.

Test Procedure

Throttle idle. Return reverser handle to reverse position. Center RVl/L3. Repeat throttle Notches 1, 2 3 checks.

Fault Indication

If response is incorrect, check cabling thru transductors WST-4
and qualify the transductors. WST-6
Return circuits to normal operating condition.

TROUBLE - POSSIBLE CAUSE AND SYMPTOM

Test Procedure
Normal Indication For Test Setup or Operating Condition
Fault Indication And Corrective Step

Asterisk Indicates Most Probable Fault-*

WST WST QUALIFICATION CHECK

Test Procedure

Engine running; throttle idle; air brakes set; controls and switches set up for power operation; AC Control breaker OFF.

Pull out the WS module and connect an AC voltmeter to WS receptacle pins 21 and 8. Meter should have a scale to accept 100 volts and a scale to accurately measure low voltage.

Disconnect wires AK1, AK2, and AK52 wires from WST25,WST34 and WST16 respectively. Insulate wire ends.

WST16 CHECK

Test Procedure

Reconnect AK1 wire to WST16 and close the AC control CB.
Voltmeter on high scale.
Place throttle in Run 2 position.

Normal Indication

Voltmeter should indicate between 1 and 5 V AC.

Fault Indication

More than 80 volts indicates open R14 or shorted WST.
Zero volts indicates open circuit. If result is not conclusive, retest at Run 8. Return throttle to idle.

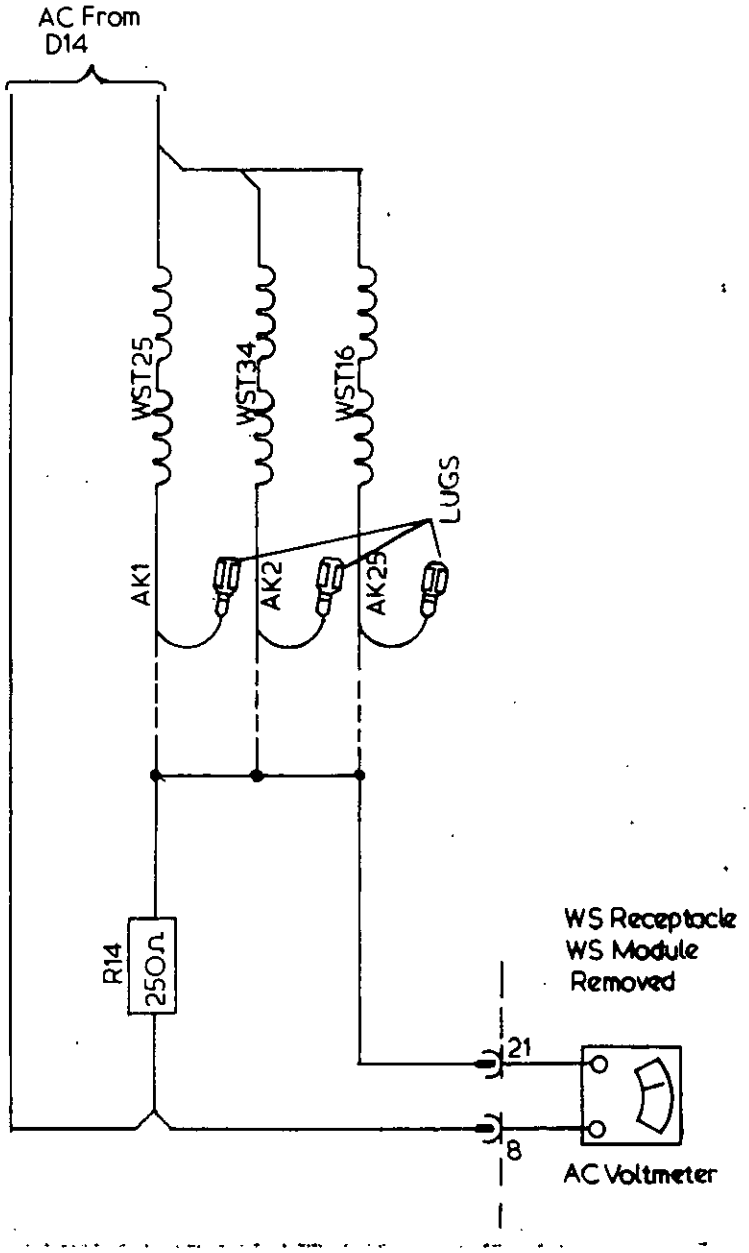
WST25, WST34 CHECKS

Test Procedure

Reference the drawing on the reverse side of this sheet and perform checks for each transductor with other transductors isolated.
Return controls and circuits to normal standby condition after tests are completed.
Reference WST - for further transductor qualification checks. WST-6

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault-*	Instruction Reference

WST QUALIFICATION CHECK (Cont'd)



Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

WST TRANSDUCTOR CHARACTERISTICS CHECKS

CHECK 1

Test Procedure

Engine running; Generator field circuit breaker open; Test panel rotary test switch in CIRCUIT CHECK position.

Place throttle in Notch 3, Measure and compare AC voltage from X1 to C and from X2 to C at each transductor under test.

Normal Indication

A sizeable voltage difference can exist between measurements taken on a good transductor. If the voltage difference appears significant, perform further checks indicated below.

Fault Indication

If the voltage drop across one coil is three times greater than the voltage drop across the second coil, replace the transductor with a qualified transductor and retest.

CHECK 2

Test Procedure

Throttle idle; Engine run switch off; Open the AC Control circuit breaker, and disconnect wires AK1, AK2 and AK52 from the WS transductors; Insulate wire ends.

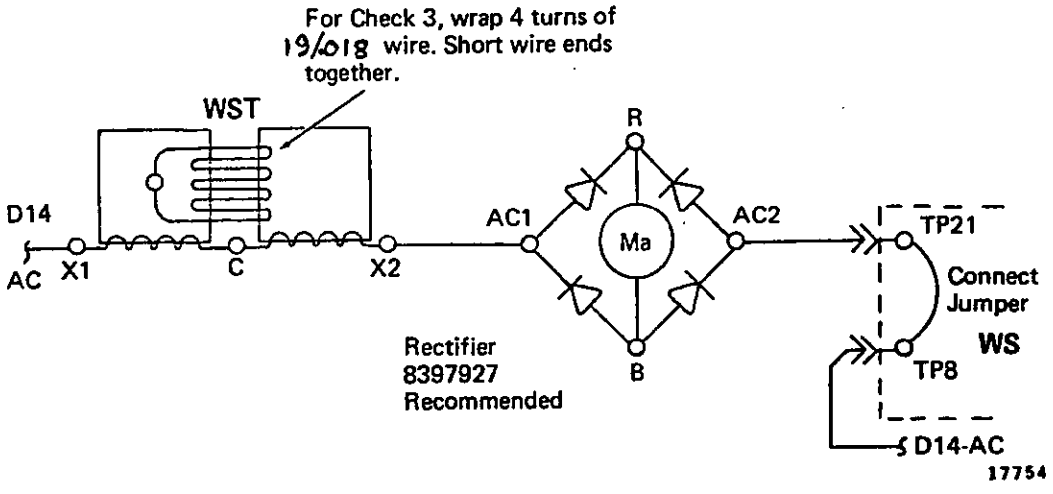
Connect a jumper from WS-TP21 to WS-TP8 to short out the WS module and R14.

Connect a small rectifier bridge and a DC milliameter in series with the transductor under test as indicated in the illustration below.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

WST CHARACTERISTICS (Cont'd)

CHECK 2 (Cont'd)



Test Procedure

Close engine run switch, and AC Control circuit breaker.

Place throttle in Notch 3.

Normal Indication

If milliammeter reading is less than 0.020 ampere, proceed to Check 3.

Fault Indication

If milliammeter reading is 0.020 or more, replace the transductor under test with a qualified transductor.

Check 3 may be performed to verify transductor condition before replacement is undertaken.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

WST TRANSDUCTOR CHARACTERISTICS CHECKS

CHECK 3

Test Procedure

Throttle idle; Open engine run switch and AC Control circuit breaker.

Wrap four turns of 19/.018 wire around both transductor cores. This is done to compensate for meter tolerances and test conditions.

Close engine run switch and AC Control circuit breaker; Place throttle in Notch 3.

Normal Indication

Milliammeter reading should be less than 0.020 ampere.

Fault Indication

If milliammeter reading is 0.020 or more, replace the transductor under test with a qualified transductor and retest.

Reference Symbol	TROUBLE - POSSIBLE CAUSE AND SYMPTOM Test Procedure Normal Indication For Test Setup or Operating Condition Fault Indication And Corrective Step Asterisk Indicates Most Probable Fault -*	Instruction Reference

UL UNDERLOADING

Difficult to obtain High Current Readings (such as when using low resistance position on a loading resistor grid or when checking settings under short circuit conditions). LSM-9

1. Check current thru terminal 13 to 14 at the SE module. This current should not exceed 1.4 milli-amperes at 4000 amperes in Notch 8.
2. If current 13 to 14 at SE is high, check phase rotation with the engine at idle speed using the following test setup. The lamp must be bright. If the light is dim or not lit, there are faulty wiring connections.
3. Check phase rotation at SCR and terminals boards.
4. Check SCR assembly . SCR