



MAINTENANCE INSTRUCTION

TESTING AND/OR SETTING AUTOMATIC TRANSITION SD9 LOCOMOTIVES

DESCRIPTION

Automatic transition is applied to locomotives to enable them to operate within the voltage and amperage limitations of the main generator. When properly adjusted and maintained, automatic transition will provide trouble free and satisfying performance of the locomotive throughout its entire designed range of operation.

This instruction covers the testing and setting of automatic transition as applied to EMD Model SD9 locomotives. The three principle relays involved are:

1. FTR - Forward Transition Relay
2. FTS - Forward Transition Relay
3. BTR - Backward Transition Relay

The first two of these relays, FTR and FTS, Fig. 1, are sensitive to main generator voltage and when energized, initiate circuit changes for forward transition. The BTR relay, Fig. 2, is designed for operation on main generator current and will function to cause backward transition.

The forward transition relays are located on the upper left hand corner of the electrical equipment rack and are accessible from the cab of the locomotive. The resistors for relay pickup and dropout adjustment are located in the engineroom side of the electrical equip-

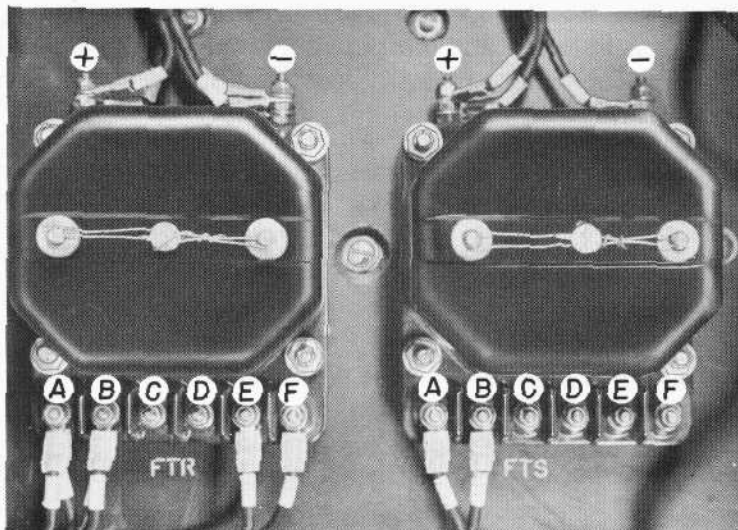


Fig. 1 - FTR And FTS Relays

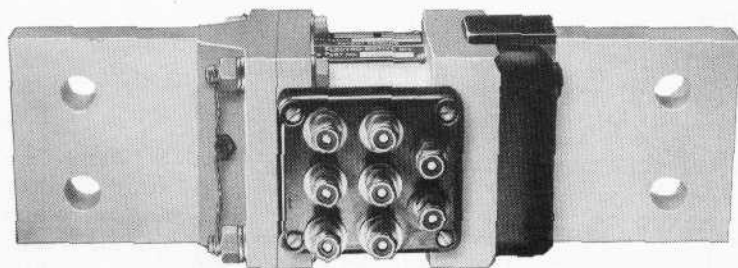


Fig. 2 - BTR Relay

ment rack, upper right hand corner. The BTR relay is also accessible from the engineroom being located near floor level on the left hand side.

OPERATION

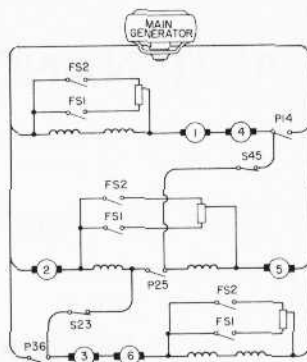
SD9 locomotives are basically equipped with four stages of automatic transition. The traction motor to generator circuits established by these transition steps are described in Fig. 3.

When the locomotive is standing still, the traction motors offer little resistance to the input of current from the main generator. After the locomotive speed increases after starting in transition 1, the counter-electromotive force developed by the traction motors builds up causing the main generator voltage to rise. The main generator is designed to operate over a wide range of voltage and amperage, however, there are limitations on each. Transition is thus necessary to stay within these limitations.

As locomotive speed increases in transition 1 and generator voltage rises, its maximum limit would soon be reached and if transition did not occur, the power output of the generator and engine would begin to drop off. Thus, to prevent this loss of power, the FTR relay, sensitive to voltage, is set to pick up and initiate transition to step 2 just before the generator voltage limitation and power drop-off point is reached.

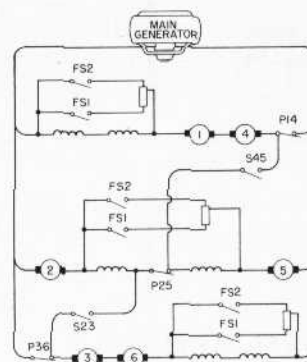
Transition circuit No. 2, Fig. 3, will result in a reduction of counter-electromotive force due to rearrangement of the traction motors, thus allowing the generator voltage to drop. After this transition and a further increase in speed, the voltage again rises to the pickup value of FTR which initiates a circuit change to transition 3. This establishes traction motor field shunting through closure of the FS1 contactors, and reduces the counter-electromotive force again allowing the generator voltage to drop. The last transition to step 4 is similarly initiated but now by pickup of the FTS relay, which in this instance closes the FS2 contact for additional motor field shunting. The locomotive now can accelerate to its maximum designed speed limit consistent with tonnage being handled.

As speed reduces, the generator voltage drops allowing FTS and FTR to drop out returning transition from step 4 to 3, and 3 to 2. Further reduction in speed accompanied by the generator



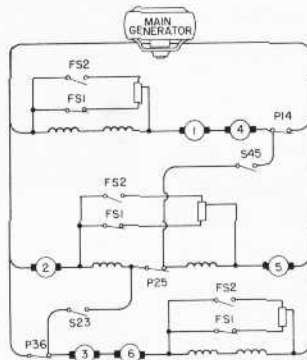
Transition 1

Two groups of three motors connected in series, each group paralleled across the main generator, (S23 and S45 closed).



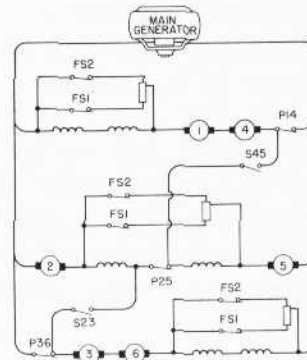
Transition 2

Three groups of two motors connected in series, each group paralleled across the main generator, (P14, P25 and P36 closed).



Transition 3

Same as Transition 2 except that the three FS1 contactors close to shunt the traction motor fields.



Transition 4

Same as Transition 3 except that the three FS2 contactors close to establish additional shunting of the traction motor fields.

Fig. 3 - Traction Motor Power Circuits

current rising (voltage still dropping) will cause pickup of the BTR which initiates the final transition from 2 to 1. The locomotive now is in a slow speed, heavy pulling circuit with the generator fully protected for such service.

MAINTENANCE

MANUAL SEQUENCE TEST

A manual sequence test of the automatic transition control circuit should be made at intervals specified in Maintenance

Instruction 1704, Scheduled Maintenance Program. Such tests will insure the proper functioning of the various relays and contactors that are used in conjunction with the FTR, FTS and BTR relays to provide automatic transition. This test will also serve to check the proper functioning of associated interlocks and the inter-related circuits they establish. These transition control circuits are illustrated in Fig. 4.

The manual sequence test can be performed with the Diesel engine running or shut down as desired. The following safety precautions should be attended to prior to making the test.

1. Check to make sure locomotive brakes are set.
2. See if sufficient electric-control air is available (90 ± 3 lbs).
3. Remove battery field fuses from all units.
4. Place isolation switches on other than unit being tested in START position.
5. If engine on unit being tested is shut down, block in the NVR relay to prevent alternator failure alarm from functioning.

CAUTION: Be sure to remove blocking from NVR relay after test to insure proper functioning of this safety device in operation.

The locomotive may now be set up to simulate operating conditions by establishing the necessary control and excitation circuits from the cab of the lead unit:

1. Place control and fuel pump circuit breaker ON.
2. Place generator field circuit breaker ON.
3. Move selector (transition) lever to No. 1 or RUN position.
4. Move reverse lever to either FORWARD or REVERSE position.
5. Move throttle lever to No. 1 position.

(Fuel pumps in individual units may be stopped if desired by using the fuel pump switch on the engine starting panel.)

FORWARD TRANSITION CHECK

Transition 1

Having followed the above procedure, a check can now be made to see if the proper contactors have closed for transition 1.

1. Series power contactor S23 should be closed.
2. Series power contactor S45 should be closed.
3. Shunt field contactors (SF) should be closed.
4. Battery field contactor (BF) should be closed.

NOTE: The above check should be repeated with the controller reverse lever in the opposite position, FORWARD or REVERSE. After checking in both positions, it may remain in either for the remaining tests.

Transition 1 to 2

To initiate this transition step, it will be necessary to momentarily jumper or short circuit the "A-B" terminals of the FTR relay, Fig. 1. An insulated wire or short circuiting bar can be used.

The following transition 2 circuit arrangement has now been established:

1. Transition relay (TR) is energized.
2. Parallel power contactor P14 should be closed.
3. Parallel power contactor P25 should be closed.
4. Parallel power contactor P36 should be closed.
5. Shunt field contactor (SF) should be closed.
6. Battery field contactor (BF) should be closed.

In addition to checking the end result of the transition, it is important to observe the sequence in which the change occurred and the functioning of additional important devices. Referring to Fig. 4, the following sequence of operation occurred during the change from transition 1 to 2.

On placing the jumper wire across the "A-B" terminal studs of the FTR relay, the TR and the TDO relays pick up. The TDO relay picks up to energize the ORS; while the pickup of the TR relay results in the opening of the SF and BF contactors and the closing of the P25 power contactor. When the P25 contactor closes, the S23 and S45 power contactors drop out. When the S45 power contactor drops out, the P14 and P36 power contactors close; while the dropout of the S23 power contactor results in the TDO relay being de-energized. With the closing of P14 power contactor, SF and BF contactors pick up to complete transition 2.

NOTE: When the S23 power contactor drops out, the TDO relay coil is de-energized, but the relay does not drop out until a time delay of 2 to 2-1/2 seconds has elapsed. On dropping out, the relay de-energizes the ORS. It is important that this function be observed. In addition, check to see that the S23 and S45 power contactors have dropped out.

Transition 2 to 3

Continuing from the previously established transition 2 circuit, again place a jumper across the "A-B" terminals of FTR. This time, the jumper should be left in place to keep the circuits in transition 3 and make it possible to progress to transition 4 in the next step.

Observe that the FS1 contactor and field shunting delay relay FSD are now closed in addition to those previously closed in transition 2, items 1 through 6 above. The unit is now in transition 3.

NOTE: The FSD relay will pick up after a time delay of 2 to 3 seconds.

Transition 3 to 4

Continuing from the previously established transition 3 circuit, place a jumper wire across the "A-B" terminals of FTS relay, Fig. 1. The jumper should be left in place to establish the transition 4 circuit.

Observe that the traction motor field shunting contactor (FS2) and the time delay relay (TDR) are now closed in addition to the items mentioned for transition 3. The unit is now in transition 4 which is the last step in forward transition.

BACKWARD TRANSITION CHECK

Transition 4 to 3

Remove the jumper from across the "A-B" terminal studs of the FTS relay. Check to see that the FS2 contactor and the TDR relay drop out. The unit is now in transition 3.

NOTE: The TDR relay interlocks will not open until after a time delay of 2 to 2.5 seconds. It is important that the operation of the TDR relay be observed.

Transition 3 to 2

Remove the jumper wire from across the "A-B" terminal studs of the FTR relay. Check to see that the FS1 contactor and the FSD relay drop out. The dropout of the FS1 contactor places the unit in transition 2.

Transition 2 to 1

Backward transition 2 to 1 can be accomplished by placing the throttle lever back in the IDLE position and then

advancing it to the No. 1 position or by disconnecting the wires from either the "A" or "B" terminal studs of the BTR relay, Fig. 2. The sequence of operation using the throttle lever is as follows:

When the throttle lever is placed in the IDLE position, the TR relay drops out to open the SF, BF, P14, and P36 contactors. With the P14 and P36 contactors and TR relay dropped out, the S23 and S45 contactors close. The closing of the S23 contactor results in the opening of the P25 contactor. Advancing the throttle lever to the NO. 1 position, closes the SF and BF contactors; thus completing the change from transition 2 to 1.

Check to see that the P14, P25, and P36 contactors are open and that the S23, S45, SF, and BF contactors are closed.

On completion of test, return the locomotive to its normal operating condition. Make certain block is removed from the NVR relay.

CHECKING AND CALIBRATION OF FTR AND FTS TRANSITION RELAYS

The operating values of the relays used in the automatic transition should be checked at periods as scheduled in Maintenance Instruction 1704; also, whenever any difficulty is reported in road operation.

The following is the procedure for checking and properly adjusting the operating values of the relays used in automatic transition; also, the procedure for sequence checking the unit with the aid of a motor-generator (M-G) set. Refer to Maintenance Instruction 5352 for procedures used in checking and/or setting the operating values of the FSD, TDR and TDO relays.

In the preparation for the test, place the isolation switch in the unit under test in the START position and shut down the

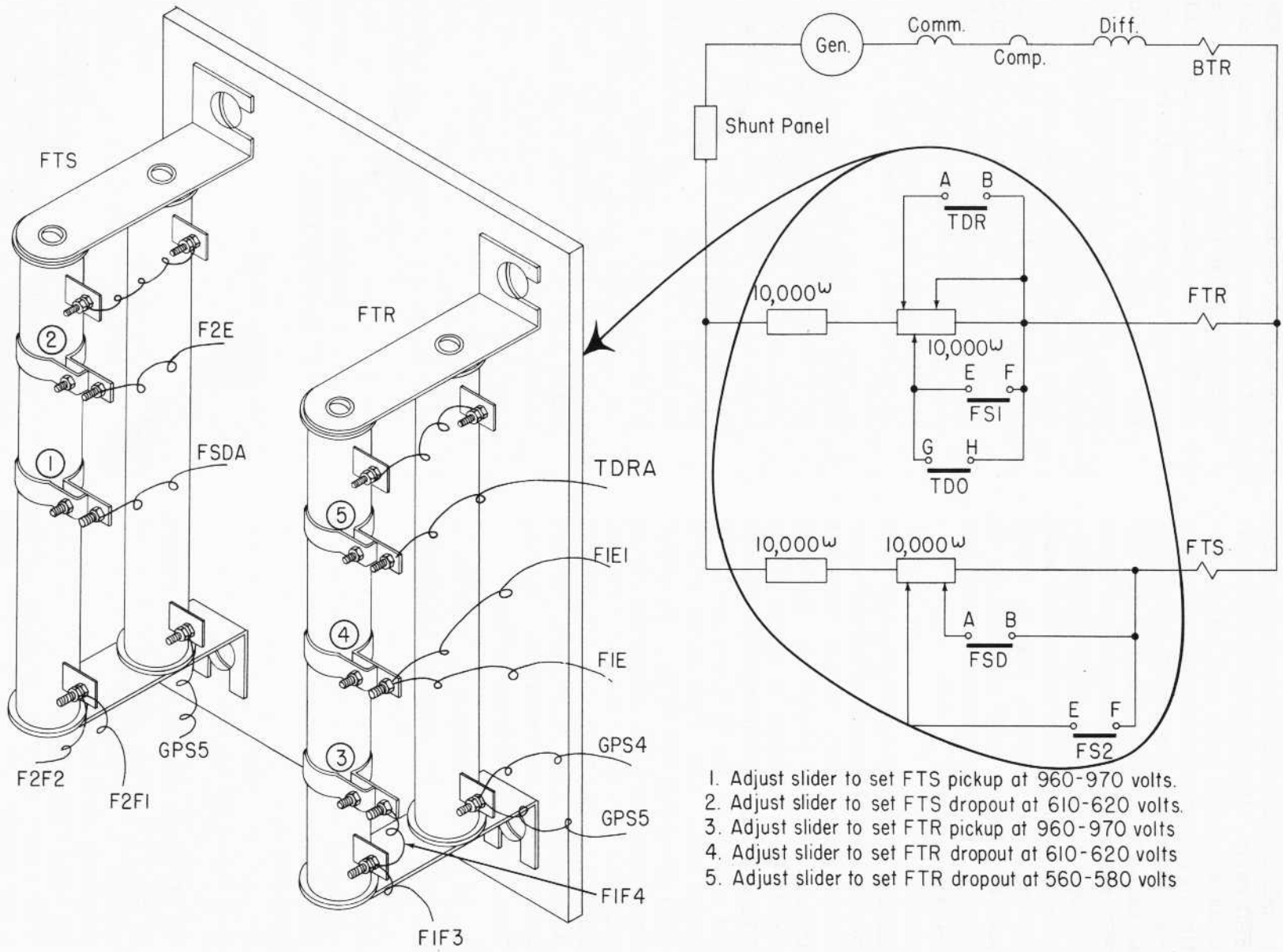
engine. Disconnect the jumper cables between the test unit and any adjacent units. As a safety precaution, remove the battery field fuse. Make certain the locomotive brakes are set, then proceed with the test.

1. Disconnect the GPS4 feed wire from the bottom terminal of the rear 10,000 ohm resistor of the FTR resistor assembly, Fig. 5. This GPS wire must be disconnected in order to remove the main generator from the circuit, thus preventing an overload of the M-G set. Be sure to leave the GPS5 wire intact so that both the FTR and FTS circuits are connected in parallel across the M-G set. Connect the positive (+) output lead of the M-G set and the positive (+) lead of a 0-1000 DC voltmeter having $\pm 1\%$ full scale accuracy to the terminal from which the GPS wire was removed. Connect the negative (-) lead to the GNR1 terminal on either the FTS or FTR relays, Fig. 1. Connect the input leads of the M-G set to the battery knife switch. Observe proper polarity. (LEFT POST IS POSITIVE.)

NOTE: If desirable, connect two test lights per Fig. 4 to give a visual indication of FTR and FTS pickup. The control and fuel pump switch in the cab must be closed. Be sure to remove the S2E2 wire from the FTR "B" terminal stud and the F1G wire from the FTS "B" terminal stud before connecting the test light leads to these studs.

2. To check or set the operating values of the FTS relay, raise the output voltage of the M-G set to about 1000 volts and note that the FTS relay does not pick up. Then reduce the M-G set voltage to zero (0) volts.

NOTE: The FTR relay should pick up, but the adjustment of the FTR relay will be dealt with later.



1. Adjust slider to set FTS pickup at 960-970 volts.
2. Adjust slider to set FTS dropout at 610-620 volts.
3. Adjust slider to set FTR pickup at 960-970 volts
4. Adjust slider to set FTR dropout at 610-620 volts
5. Adjust slider to set FTR dropout at 560-580 volts

Fig. 5 - Transition Relay Adjustments

Next, place an insulated jumper wire or shorting bar across the "A-B" terminal studs (A-B interlock) of the FSD relay. Raise the M-G set output voltage to 900 volts and allow sufficient time for the resistors to warm up. Next, raise the M-G set voltage to 960-970 volts at which point the FTS relay should pick up. To adjust the operating voltage of the FTS relay, vary the position of the slider band on the left resistor, Fig. 5, which has the FSDA wire attached to it. Moving the band down will raise the pickup voltage.

3. Reduce the M-G set voltage to zero (0) volts, and apply an additional insulated jumper wire across the E-F interlock of FS2 contactor. Increase the M-G set voltage to again pickup FTS and then slowly reduce the output voltage of the M-G set until FTS drops out. The FTS relay should drop out at 610-620 volts. To adjust the dropout of FTS, adjust the slider band on the left resistor, Fig. 5, which has the F2E wire attached to it. Moving the slider band upward will decrease the resistance, thereby decreasing the dropout voltage.

NOTE: Refer to Maintenance Instruction 5360 for the internal adjustment of the FTS relay.

After satisfying the pickup and dropout values of the FTS relay, remove the jumper wire from across the "A-B" terminal studs of the FSD relay and the jumper wire from across the E-F interlock of the FS2 contactor.

4. To check or set the operating values of the FTR relay, raise the M-G set voltage to 960-970 volts at which point the FTR relay should pick up. To adjust the operating voltage of the FTR relay, vary the position of the lower slider band on the right hand resistor, Fig. 5. This band has the F1F4 wire attached to it. Moving the band in the downward direction will raise the pickup voltage.

5. Reduce the M-G set voltage to zero (0) volts and apply an insulated jumper wire across the E-F interlocks of the FS1 contactor. Increase the M-G set voltage to again pick up FTR and then slowly reduce the output voltage of the M-G set until FTR drops out. The relay should drop out at 610-620 volts. To adjust this dropout of FTR, adjust the middle slider band on the right hand pair of 10,000 ohm resistors, Fig. 5. This slider band has the F1E and F1E1 wires connected to it. Moving the band downward will increase the resistance in the circuit and increase the value of the voltage at which FTR will drop out.
6. Reduce the M-G set voltage to zero (0) volts and place an additional insulated jumper across the A-B interlocks of the TDR relay. Increase the M-G set output voltage to again pick up FTR and then slowly reduce the output voltage of the M-G set until FTR drops out. FTR should now drop out at 560-580 volts. To adjust this dropout of FTR, adjust the upper slider band on the right hand pair of 10,000 ohm resistors, Fig. 5. This band has the TDRA wire connected to it. Moving the band downward will increase the resistance in the circuit in order to raise the dropout voltage value. After satisfying this second dropout value of the FTR relay, remove the jumper wires from across the FS1 E-F and TDR A-B interlocks.

NOTE: Refer to Maintenance Instruction 5360 for the internal adjustment of the FTR relay.

SEQUENCE CHECK OF AUTOMATIC TRANSITION USING M-G SET

A sequence check of the automatic transition should be performed with the motor-generator set after the relay operating values have been checked or set. In preparation for the test, carry out the following preliminary steps if not already done. Place the isolation switch in the

unit under test in the START position and shut down the engine. Disconnect the jumper cables between the unit under test and any adjacent units. As a safety precaution, remove the battery field fuse. Make certain the control air pressure is set at a minimum of 90 psi. Make certain the locomotive brakes are set, then proceed with the test.

1. Connect the M-G set, if not already done, as per procedure listed under test for checking and calibrating the operating values of the FTS and FTR relays.
2. At the engineman's control panel, close the control and generator field circuit breakers. Insert the reverse lever into the controller and place it in the FORWARD position. Place the selector (transition) lever in the RUN position on units so equipped. Next, place the isolation switch in the RUN position; the S23 and S45 power contactors should close. Advance the throttle lever to the NO. 1 position and SF and BF contactors should close completing transition 1.

NOTE: To prevent the alarm bell from ringing, close the fuel pump circuit breaker on the engineman's control panel and block IN the NVR relay.

3. Repeat Step 2 with reverse lever in the REVERSE position, then proceed with the test with reverse lever in either position.
4. To place the unit in transition 2, raise the M-G set voltage to 900 volts to allow the resistors to warm up, and then raise the voltage to the pickup value (960-970 volts) of FTR relay. The FTR relay picks up to bring in the TR and TDO relays. The TDO relay picks up to energize the ORS while the TR relay picks up to drop out the SF and BF contactors. Next, lower the M-G set voltage to the dropout value (610-620 volts) of the FTR relay. When the FTR relay drops out, the P25 power contactor

closes to drop out the S23 and S45 power contactors. With the dropping out of the S45 power contactor, the P14 and P36 power contactors close. With the closing of the P14 power contactor, the SF and BF contactors pick up to complete transition 2.

NOTE: The dropout of the S23 contactor results in the TDO relay coil being de-energized. The relay drops out after a 2 to 2-1/2 second delay to de-energize the ORS.

5. To place the unit in transition 3, once again raise the M-G set voltage to the pickup value (960-970 volts) of the FTR relay and immediately reduce the M-G set voltage to 900 volts after pickup of FTR relay.

NOTE: The M-G set voltage should be reduced to 900 volts before the FSD relay completes its 2 to 3 second delay to pick up; otherwise the FTS relay will pick up, placing the unit in transition 4.

The FTR relay picks up to close the FS1 contactor, placing the unit in transition 3. The FSD relay picks up after a 2 to 3 second delay to lower the pickup value of the FTS relay to 960-970 volts. Likewise, the dropout value of the FTR relay is lowered to 610-620 volts when the FS1 contactor closed.

NOTE: The FTR and FSD relays and the FS1 contactor must remain picked up in order to proceed from transition 3 to 4.

6. To place the unit in transition 4, raise the M-G set voltage to the pickup value (960-970) of the FTS relay (with A-B interlock FSD relay closed). The FTS relay picks up to close the FS2 contactor, placing the unit in transition 4.
7. To place the unit back in transition 3, reduce the M-G set voltage to the dropout value (610-620 volts) of the FTS relay (with E-F interlock FS2

relay closed). The moment the FTS relay drops out, raise the M-G voltage immediately to approximately 700 volts to keep the FTR relay from dropping out. The FTS relay drops out to open the FS2 contactor, placing the unit in transition 3.

8. To place the unit in transition 2, reduce the M-G set voltage to the dropout value (610-620 volts) of the FTR relay (with E-F interlock of FS1 contactor closed). The FTR relay will drop out after a 2 to 2.5 second delay to de-energize the FSD relay and to open the FS1 contactor, placing the unit in transition 2.
9. To place the unit in transition 1, place the throttle in the IDLE position. The TR relay and the SF, BF, P25, P14, and P36 contactors drop out, and the S23 and S45 contactors close. Advancing the throttle to the NO. 1 position picks up the SF and BF contactors to complete transition 1. On completion of test, return the locomotive to its normal operating condition.

CHECKING AND CALIBRATION OF BTR RELAY

The most convenient and accurate method for checking and/or setting the

BTR relay is by the standstill test outlined below.

1. Unit under test must be coupled to two (2) other units to provide sufficient additional braking.
2. If possible, disconnect jumpers to units other than the one under test. If it is necessary to run the engines in other units, remove the battery field fuse in the units and place the isolation switches in START position. Tag each isolation switch with a warning sign of test being made.
3. Remove main generator copper bus bar at shunt panel and insert a suitable test shunt, such as a 2000 ampere 50 or 100 millivolt shunt or a 3000 ampere 100 millivolt shunt, Fig. 6. Connect the proper millivolt meter with calibrated leads to the test shunt.

NOTE: On some locomotives without a shunt panel, the bus bar attached to the generator side of the BTR relay must be removed in order to apply the test shunt.

4. Close main battery switch; close control switch and start engine.
5. Close generator field switch and place isolation switch in RUN.

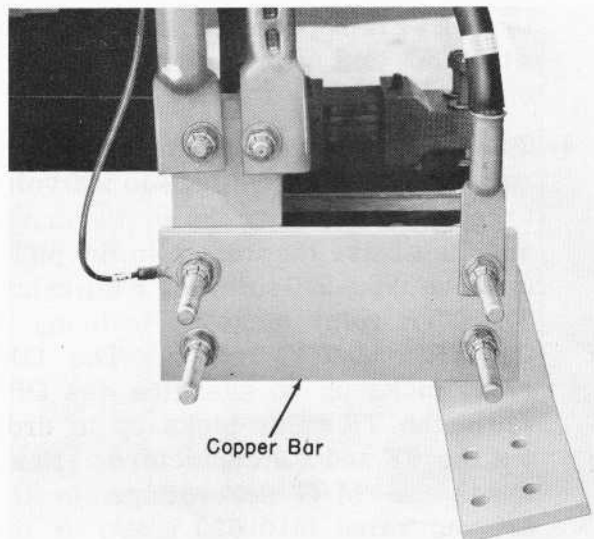
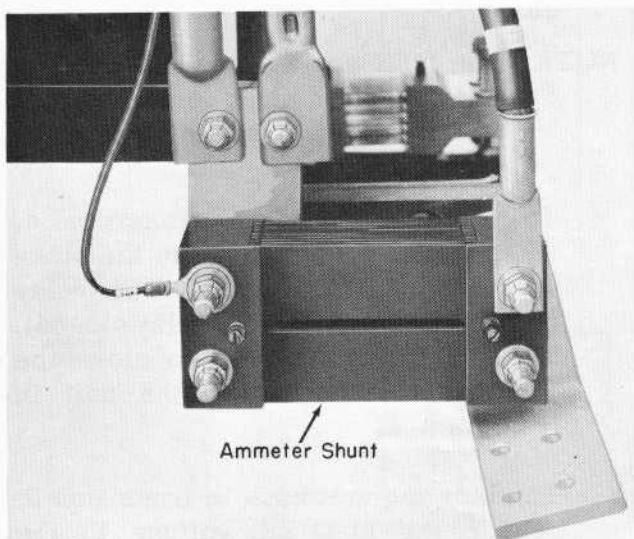


Fig. 6 - Ammeter Shunt Application

6. Place reverse lever in FORWARD or REVERSE position and transition lever in NO. 1. Apply locomotive brakes and place throttle in RUN 1.
7. Jumper TR relay A-B interlock momentarily to place unit in transition 2.
8. Advance throttle to RUN 2 (or higher if operating value of relay is not reached). This will cause load regulator to advance, through normal pilot valve action, towards maximum field. Current buildup as read on millivolt meter is somewhat rapid at first, but will slow down as the current becomes higher. When pickup value of BTR is reached, TR relay is de-energized, dropping the field contactors. This causes current to drop off abruptly. When the current reaches the dropout value of the relay, the parallel power contactors will come in. The pickup value of the relay is the highest current value reached during this test. The relay should pick up at 2225-2275 amperes.

After the backward transition sequence is made and the pickup value noted, quickly reduce the throttle to IDLE. The pickup value used should be the average of three readings. For each reading the throttle must be reduced to IDLE and then brought back to RUN 1 for the succeeding reading. The throttle must not be in power position longer than is necessary to obtain a single reading.

In the event that the particular locomotive unit or units being worked on are equipped with traction motor cutout switches, a recalibration circuit is used in conjunction with the BTR relay. When a pair of traction motors are cut out through action of a cutout switch, a cutout relay (COR) becomes energized and a pair of its interlocks close to allow the recalibration coil of the BTR relay to become energized. This coil operates in the same direction as the main operating coil to reduce the amount of current

necessary to pick up the BTR relay and consequently protect the main generator from overload.

Before making any adjustments to the BTR relay, check its operation both with and without the recalibration coil energized. Proceed as follows:

1. Place an insulated jumper across the C-D interlocks of BTR to pick up the recalibration coil.
2. Perform the same check as outlined in Step 8 above when the recalibration coil was not energized. The relay should now pick up at 1800-1850 amperes.

If it is necessary to adjust the pick-up value, one of the molded neoprene snap-on covers which protects the adjustment knobs should be removed, Fig. 7, and the US&S or EMD seal on the knob broken. The pickup value may be raised by turning the knob clockwise or lowered by turning counterclockwise, using a 3/8" socket wrench or an offset box wrench. A change in adjustment of one position (ten adjustment positions equal one full turn) will change the pickup approximately one-fourth of one per cent (approximately 5.6 amperes at 2250 amperes). For a major adjustment involving one turn or more, both adjustment knobs (on top and bottom of relay) should be turned in the same manner and approximately the same amount. Since both adjustments are of

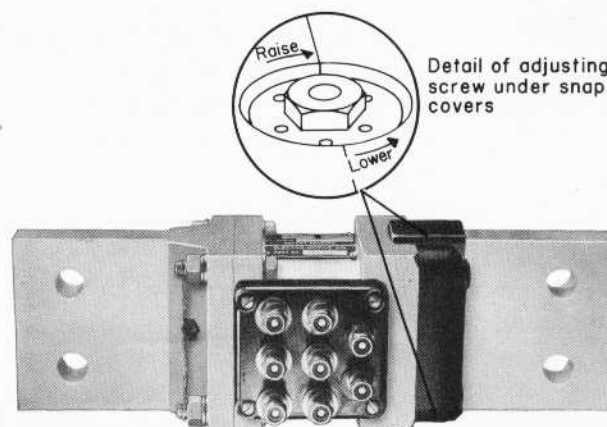


Fig. 7 - BTR Relay Adjustments

the micrometer type, care should be taken that pressure is not used which is great enough to damage the threads or twist the parts. It is recommended that the relay be returned to Electro-Motive when repairs are needed.

recalibration, the adjustment screw should be locked in position by a seal wire or equivalent.

CAUTION: If any pickup adjustment has been made, immediately after

The dropout value is inherent and can not be adjusted. Return circuit to normal operating conditions upon completion of the test.

MAINTENANCE DATA

TRANSITION RELAY SETTINGS

FTS

Pickup (FSD A-B closed) 960-970 Volts
 Dropout (FS2 E-F closed) 610-620 Volts

FTR

Pickup 960-970 Volts
 Dropout (TDO G-H or FS1 E-F closed) 610-620 Volts
 Dropout (TDR A-B closed) 560-580 Volts

BTR

Pickup 2225-2275 Amperes
 Pickup (calibrating coil energized) 1800-1850 Amperes
 Dropout Inherent 83% of Pickup Min.

FSD 2-3 sec. DELAY on Pickup
 TDO 2-2.5 sec. DELAY on Dropout
 TDR 2-2.5 sec. DELAY on Dropout
 TDS 8-10 sec. DELAY on Dropout