

# Schematic Connection Diagram



ALCO DIESEL-ELECTRIC LOCOMOTIVE SCHOOL  
INSTRUCTION SERIES  
No. 805

## THE SCHEMATIC CONNECTION DIAGRAM

Each device and component part of a device has a particular function. It is necessary to represent these parts on a wiring diagram in a manner that aids in trouble shooting. Trouble in the electrical circuits is caused by the failure of a certain function, usually caused by the failure of a device or devices.

In the Schematic Connection Diagram, the devices are broken up into component parts. The diagram is sectionalized by function and each component part placed in that section to which it applies. For example: The connection diagram has sections named Propulsion Control, Motors 2 and 4, Motors 1 and 3, Generator and Excitation Circuits, Limit Circuits, and so on.

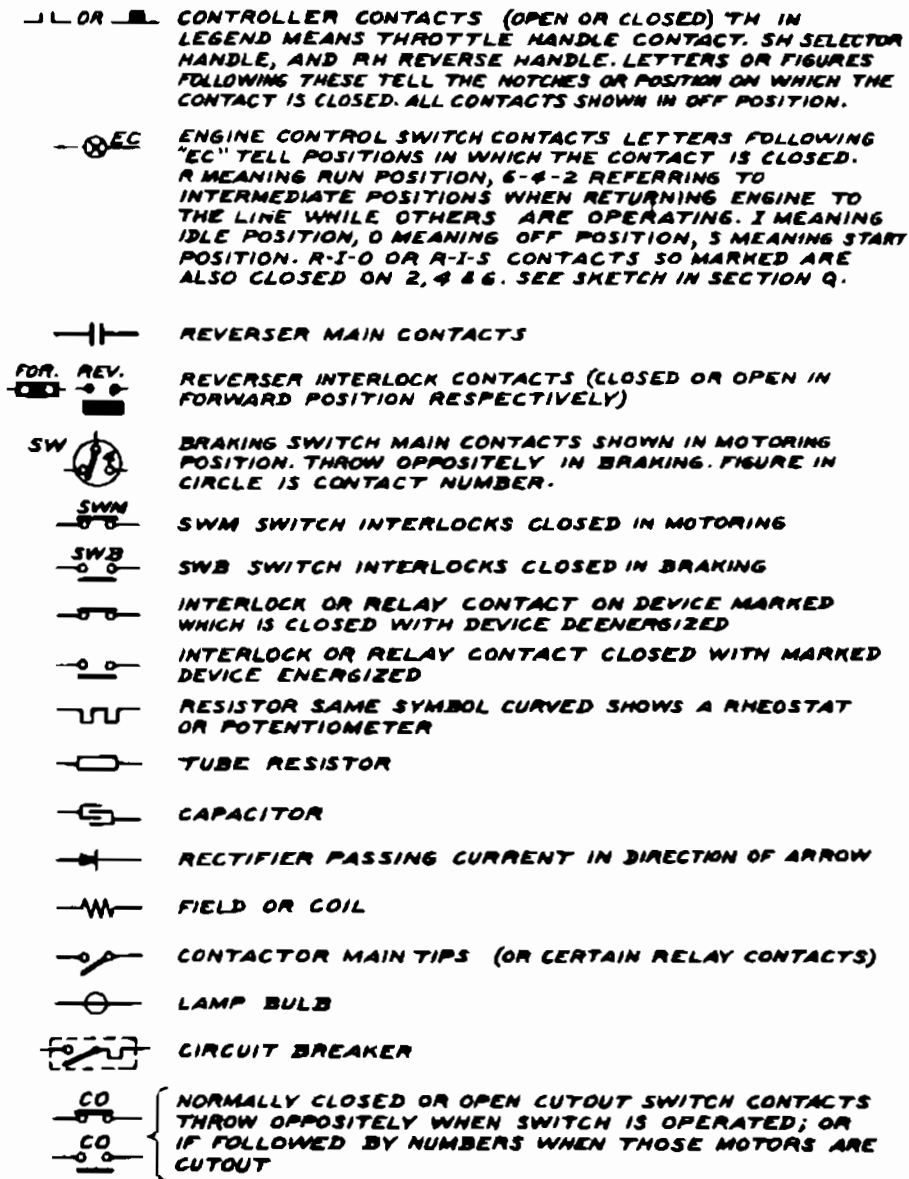
A power contactor has an operating coil, a main contact and several auxiliary control contacts called interlocks. The operating coil is placed in the propulsion control section, the main contact is on one of the motor sections, and the interlocks in a controlling circuit which would be located in a particular section by its function. For example: A power contactor interlock may control an alarm bell although the main function of the contactor may be to close the circuit to a motor. When the bell fails to ring, it is readily found that an interlock of this contactor controls the alarm bell, because this interlock appears in the alarm circuit section of the diagram. The wiring diagram now becomes an organized arrangement with a minimum number of lines or wires connecting devices.

When using the diagram, certain assumptions must be made and followed.

1. Everything on one diagram is for one locomotive unit only.
2. Everything on the diagram is shown de-energized. All switches, contactors, relays and other devices are shown in the shut down position.
3. All devices involving reverser action have no shut down position, so are shown set up for forward locomotive motion.
4. All dynamic braking devices are shown set up for motoring.

### SYMBOLS

Two types of symbols are used, one system for pre-1950 and the other for 1950 locomotives. The one for pre-1950 is shown in Fig. 1. The symbols for the 1950 type are shown in Fig. 2.

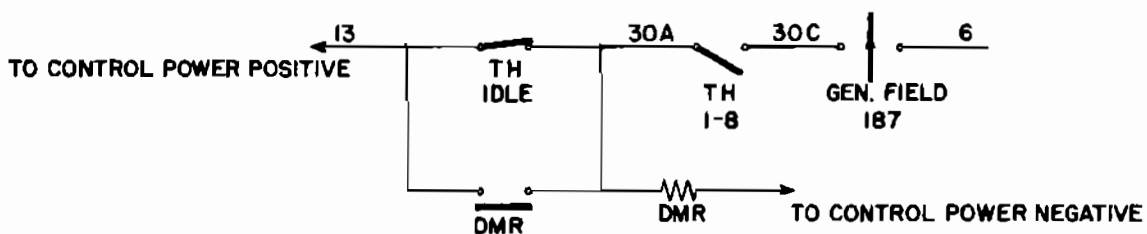


SYMBOLS

FIG. 1

READING THE DIAGRAM

Conditions must be set up in reading a wiring diagram. Consider the following circuit for an example.


























To follow this section of the wiring diagram from wire 13 to wire 6, the following conditions exist:

Two paths are possible from wire 13 to wire 30A. Start from the top line through the throttle handle contact (TH Idle). It is apparent that the throttle handle must be in the idle position. But to proceed from wire 30A to 30C, it is necessary to have the throttle handle in some position other than idle (TH 1-8). As this is one and the same throttle handle and cannot be in two positions at the same time, this circuit cannot exist. Again start from wire 30A and follow the other path through operating coil of DMR to control power negative to energize DMR. When DMR relay picks up, its contacts (also marked DMR) close and complete a circuit from wire 13 to wire 30A. A path from wire 30A to wire 30C is now possible by operating the throttle in some position other than idle and from wire 30C to wire 6 by manually closing the generator field switch 187. In other words, to establish a circuit from wire 13 to wire 6, the DMR re-

lay must be energized by first placing the throttle handle in the idle position. After this the circuit is completed by placing the throttle handle in some position from 1 through 8 and closing switch 187. Remember that whenever a circuit is traced through a device or part of a device, the condition or position of that device must be firmly established and adhered to.

INDEX TO THIS DIAGRAM			
ITEM	SECTIONS	ITEM	SECTIONS
A-N CONNECTOR WIRE TABLE	X	EXCITATION CONTROL	F-G
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ASSOCIATED DIAGRAMS	Y	LIGHTING	M-N
BATTERY AND AUX. CIRCUITS	H-J	PROPULSION CONTROL	A-C
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ENGINE CONTROL	K-L	TRACTION MOTORS	D-E

EXPLANATION OF SYMBOLS			
<b>NORM. CONTACTS</b> NORM. OPEN  NORM. CLOSED  FINGER TYPE  BRIDGING TYPE 		<b>RESISTORS</b> GRID TYPE  TUBE TYPES FIXED WITH TAP  WITH SLIDER 	
THE ABOVE SYMBOLS APPLY TO CONTACTORS, RELAYS, INTERLOCKS AND ALL MANUALLY OPERATED DEVICES EXCEPT KNIFE-BLADE AND SNAP SWITCHES AND CIRCUIT BREAKERS		<b>RHEOSTATS AND POTENTIOMETERS</b> FULL TRAVEL  LIMITED TRAVEL  TWO-SECTION INACTIVE SECTION  ACTIVE SECTION 	
 REVERSER MAIN CONTACTS  BRAKING SWITCH MAIN CONTACTS (FIGURE IN CIRCLE IS CONTACT NO.)		<b>OPERATING AND FIELD COILS</b> OPER COIL  FIELD COILS COMPENSATING  COMMUTATING 	
 CIRCUIT BREAKERS  KNIFE BLADE SWITCHES  SNAP SWITCHES		<b>CAPACITOR</b>  ONE SYMBOL SHOWS ONE OR MORE CAPACITORS IN PARALLEL <b>RECTIFIER</b>  CURRENT FLOW IS IN DIRECTION OF ARROW	
 MOTOR CUTOUT SWITCH CONTACTS. IF MARKED CO, THROW OPPOSITELY WHEN ANY MOTOR IS CUT OUT. IF MARKED CO FOLLOWED BY A NUMBER, THROW OPPOSITELY ONLY WHEN MOTOR SO NUMBERED IS CUT OUT		<b>LAMP</b> 	
<b>LETTER POSITION</b> O OFF I IDLE S START R RUN 2,4,6 2,4,6		<b>EC SWITCH</b> CONTACTS ARE MARKED TO SHOW POSITIONS ON WHICH THEY ARE CLOSED	

SYMBOLS

FIG. 2

OPERATION	MOTOR CONNECTION	SELECTOR HANDLE POSITION SH	THROTTLE HANDLE POSITION TH	EC-ENG. CONT. SW. SW-BRAKING SW.	CONTACTORS										RELAYS														
					S1	P2	S21	P22	TDR	M1	M2, M3, M4	TR	G51, G52	FPC	EP	DMR	AVF, AVS	BVS	CVF, CVS	DVS	BR1, BR2	OPR	ESR						
SHUT DOWN	CONT. SW. OPEN	OFF	IDLE	0																									
ENG. START	CONT. SW. CLOSED	OFF	IDLE	5																									
IDLING	CONT. SW. CLOSED	OFF	IDLE	1																									
MOTORING	SERIES	1	1	RM																									
			2	RM																									
			3	RM																									
			4	RM																									
			5	RM																									
			6	RM																									
			7	RM																									
			8	RM																									
	SERIES FS2	2	8	RM																									
				RM																									
	FORWARD TRANSITION (2 TO 3)	3	8	RM																									
				RM																									
				RM																									
				RM																									
RM																													
PARALLEL	3	8	RM																										
			RM																										
			RM																										
PARALLEL FS2	4	8	RM																										
			RM																										
BACKWARD TRANSITION (3 TO 2)	2	8	RM																										
			RM																										
			RM																										
			RM																										
SERIES FS2	2	8	RM																										
SERIES FS1	1	8	RM																										
IDLING		1 TO 4	IDLE	RM																									
CUTOUT MOTORING	#1 & #4 MOTORS CUTOUT	1	1	RM																									
			2	RM																									
			3	RM																									
			4	RM																									
	#2 & #3 MOTORS CUTOUT	1	1	RM																									
			2	RM																									
			3	RM																									
			4	RM																									
ELECTRIC BRAKING			B	IDLER	B																								
M. & ENG. STOP	ANY	ANY	ANY	RM																									
ENG. STOP BY EC SWITCH	ANY	ANY	ANY	0																									

SEQUENCE TABLE

FIG. 3

ENGINE CONTROL SEQUENCE TABLE

CONDITION	CONTROL BREAKER POSITION	SELECTOR HANDLE POSITION	THROTTLE HANDLE POSITION	EC-ENG. CONT. SW.	CONTACTORS & RELAYS																	
					GS1	GS2	FFC	OPR	SAR	AVS, AVF	BVS	CVS	DVS	ESR								
SHUT DOWN	OFF	OFF	IDLE	0																		
ENG. START	ON	OFF	IDLE	S	•	•	•	•	•													
→ ENG. START	ON	OFF	IDLE	S	•	•	•	•	•													
IDLING	ON	ANY	IDLE	I																		
ENGINE SPEED CONTROL ABOVE IDLING	ON	1-4	1	R																		
			2	R																		
			3	R																		
			4	R																		
			5	R																		
			6	R																		
			7	R																		
			8	R																		
M.U. ENG. STOP	ON	ANY	ANY	R																		
SINGLE ENG. STOP	ON OR OFF	ANY	ANY	0																		

LOCOMOTIVE CONTROL SEQUENCE TABLE

OPERATION	MOTOR CONNECTIONS	SELECTOR HANDLE POSITION	THROTTLE HANDLE POSITION	EC-ENG. CONT. SW.	CONTACTORS, RELAYS & OTHER DEVICES																				
					SI, SR1	P1	P2	P21	P22	MI, M2, M3, M4	EF, GF	TDR	TR	DMR	CR1	CR2	CR3	BR1, BR2	SW (BRK. SW.)						
MOTORING	SER. PAR. FS1	1-4	1-8	R	•																				
	FS2	2-4			•																				
	PAR. FS1	3-4			•																				
	FS2	4			•																				
						•																			
ELECTRIC BRAKING		OFF	IDLE	R	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				
CUTOUT MOTORING (NO ELECTRIC BRAKING IN CUTOUT POSITIONS)	MOT. 1 C.O.	1-4	1-8	R	•																				
	MOT. 2 C.O.				•																				
	MOT. 1 & 2 C.O.				•																				
	MOT. 3 C.O.				•																				
	MOT. 4 C.O.				•																				
MOT. 3 & 4 C.O.	•																								

SEQUENCE TABLES

FIG. 4

SEQUENCE TABLE

This table indicates what happens when. The sequence table shown in Fig. 3 is for the pre-1950 model, and the dot signifies that for a particular condition of control handles the device is closed. If by observation it is found that the device does not close, that apparently is the trouble, and the circuit for that particular device can easily be traced.

The table shown in Fig. 4 is for the 1950 model and is similar except that the devices dependent upon throttle handle position are tabulated separately.

SYMBOL	TYPE	OPERATING COIL CAT. NO.	RES.	INTERLOCK CAPACITOR	* SECTION	FUNCTION
B	17CM15AV77	4739477	185	17AF14K5	CP E-N	BATTERY
FPC	17CM15AL77	4739477	185		GR F	FUEL PUMP
GS1, 2	17CM63C1	4739365	27.5	17AF14J3	CP C-H-J-Q	CRANKING
M1, 2 M3, 4	17CM12AL34	4739346	237	17AF14H1 17AF14H2 17AF14H3 17AF14H4	CP B-J-K-Q A-J	FIELD SHUNTING
P1	17CP2N3	3122101	775	17AF21A4	CP A-B-EE-K-P	PARALLEL MOTORS
P2	17CP2N3	3122101	775	17AF21A4	GR A-B-J-K-P	
P21	17CP2N3	3122101	775	17AF21A4	CP A-CC-N-J-K-P	
P22	17CP2N3	3122101	775	17AF21A12	CP A-EE-J-J-K-P	
S1	17CP2N3	3122101	775	17AF21A4	CP B-EE-J-K-P	SERIES MOTORS
S2	17CP2N3	3122101	775	17AF21A4	CP A-N-J-K-P	
SW	17GP5J1	3122101	775	INCL.	CP A-B-C-J-K-Q	BRAKING
GF	17CM15AL77	4739477	185	17AF14K7	CP C-J-K-Q	GEN. FLD.
-R	17DP13H1	3122101	775	INCL.	CP A-B-N-J-Q	REVERSER
B1, B2	17CM43L5	8827035	184		CP A-B-I	BRAKING
AVF	17LV53C1	4739351	762		CR CC-I-N	SEQUENCE
AVS	17LV53C1	4739351	762		EP D-I-N	
BVS	17LV53C1	4739351	762		EP CC-B-I-N	
BVA, BVB	17LV53C1	4739351	762		CR CC-E-J-K-N	
BWR	17LV53M5	4739412	684		CR A-N-N	BRAKE OVERLOAD
CVF	17LV53C1	4739351	762		CR CC-I-N	SEQUENCE
CVS	17LV53C1	4739351	762		EP D-I-N	
DMA	17LV53C901	4739351	762		CS I-J-N-R-X	SAFETY CONTROL
DVS	17LV53C1	4739351	762		EP CC-D-I-N	SEQUENCE
EF	17LV53C1	4739351	762		CR C-CC-J-Q	EXCITER FIELD
ESA	17LV53C1	4739351	762		EP D-I-Q	ENGINE STOP
GR	17LV53L25	4739412	684		CR B-D-N-J-K-Q	GROUND
OPR	17LV53C1	4739351	762		EP D-Q	OIL PRESSURE CONT.
OS	17HM30A1				E D-Q-X-Y	ENGINE OVERSPEED
AC	17LC19D14	4739205	29.4	SHUNT	CP E-R	REVERSE CURRENT
		4739206	279	DIFF.		
		8823217	.001	SERIES		
SAR	17LV53AB113	4739407	11.8		EP D-P	SAFETY
SA	17LV533115	4739407	11.8	1-0.1 MFD	EP H-P	SIGNAL
TDR	17LV53C139	4739351	762	1-0.1 MFD	CR J-K-Q	TIME DELAY
TR	17LV53C39	4739351	762		CR J-K-N	TRANSFER
WS1	17LV53E15	8827018	0.6		CR A-N-J-P	WHEEL SLIP
WS2	17LV53E19	8827015	0.6		CR A-N-J-P	
X	17LNE2B2	4739452	1.58	COMP.	CP E-X-Y	VOLTAGE REGULATING
			2.30	OPN. FX		
			1.82	SHUNT		
		4739398	10.22	SHUNT		
		.21	SERIES	FL		
		0.037	SERIES	CL		
		36.7	STABIL.			
BLA	17LV53W16	4739351	762		CR EE-N-Q	BLOWER STOPPED
GOV.	17M63C1	M3CR66	16.0	SPEED	E C-D-X SEE ALSO 185-125A-131	ENGINE GOVERNOR
			55.0	STAB.		
		M3CR66	16.0	FUEL LIM.		
			55.0	NOT USED		
				CAT. R-7A		MICRO SWITCH
		4739396	342.0			CLUTCH
SMV	17ME1A20				F-X	NOT IN SCHEMATIC

INDEX  
FIG. 5

APPARATUS TABLE

The Apparatus Table lists other necessary information concerning the devices and equipment. Each device is listed alphabetically and the following information can be found for each item.

1. Symbol
2. Type
3. Cat. No. and resistance of operating coil, if any.

\* SYMBOL IN THIS COLUMN REFER TO LOCATION OF APPARATUS IN LOCOMOTIVE IN ACCORDANCE WITH THE FOLLOWING :-  
 CP CONTROL COMPARTMENT  
 CR 17LE34A18 RELAY EQUIP. (IN CONTROL COMPARTMENT)  
 CS CONTROL STAND IN ENGINEMAN'S CAB  
 E ON ENGINE  
 EP 17FM76DI ENGINE CONTROL PANEL  
 EX 17FM64B1 PANEL (IN CONTROL COMP'T.)

FIG. 6

4. Type of interlock, if any.
5. Where the device is located on the locomotive.
6. In what section of the wiring diagram can be found all the component parts of the device.
7. Recommended adjustments or settings, if any.
8. Function of devices.

APPARATUS TABLE SYMBOL KEY FOR SHOWING DEVICE LOCATIONS ON LOCO.	
SYMBOL	LOCATION ON LOCO.
AB	AIR BRAKE SYSTEM
CP	CONTROL COMPARTMENT
CS	CONTROL STAND
E	DIESEL ENGINE
ER	ENGINE ROOM
58	17LES8 PANEL
59	17LES9 PANEL
105	17FM105 PANEL
110	17FM110 PANEL

} THESE PANELS ARE LOCATED IN THE CONTROL COMPARTMENT

FIG. 7

Fig. 5 is the Apparatus Table or Index and Fig. 6 the Location Symbol Key for pre-1950 models. Fig. 7 is the Key and Fig. 8 the Table for 1950 models.

SYMBOL	TYPE OR CAT. NO.	RESISTANCE DATA CAT. NO. OR FUNCTION 25°C. RES.	INTERLOCK OR OTHER DATA	LOCATION ON LOCO. FEET OF TRACK	FUNCTION
GR	17LV53L25	4739412	684	58 BCFJLT	GROUND RELAY
GS1	17CM43C1	4739365	27.5	17AF14J3	CP BFKT ENGINE STARTING CONTACTORS
GS2				17AF14J9	CP BFKU
K1	56Y29C1	FIELD	0.063	MOSE	I TRACTION MOTOR BLOWERS
K2		ARM.	0.0403	ER	
K3	56Y19A2	FIELD	0.021	ER	EW BRAKING RESISTOR BLOWER
		ARM.	0.034		
L03	CR-2791-C 104-F66		2400	CS	ABCO SPEED SENSITIVE RELAYS
LS1,LS11					
LS2					
LS3,LS3A,LS4					
M1,M5	17CM12CC34	4739366	237	17AF14H2	AEU FIELD SHUNTING CONTACTORS
M2,M6				17AF14H1	CP ACDU
M3,M7					CP ADE
MG	SATB75M49	SHUNT FLD	110	ER	GJ 400 CYCLE MOTOR ALTERNATOR SET
		SER. FLD	0.0345		
		ARM.	0.071		
		STATOR A,B,C	0.4		
OPR	17LV53C1	4739351	762	110	JKLU OIL PRESS. RELAY
OPS1,2	450E24	123368		ER	KU OIL PRESS. SWITCHES
OS	17MM16A1			E	KU ENG. OVERSPEED SW
OSM	FA4	527702	387	AB	B LOCO OVERSPEED SW
Q1,2,2E	17CP2N3	3122101	775	17AF21A4	CP ABCDEKUV PARALLEL CONTACTORS
PCS	FI	91092		AB	LU POWERCUTOFF SWITCH
R	17DP13J1	3122101	775	CP	BDEINV REVERSER
R1,R2	6RS5C1B			105	FG EXCITATION CONTROL RECTIFIERS
R3	20F6RS5C23				G
RFC	56DY32A1		5.7	ER	J RAD. FAN CLUTCH
RC	17LC19D26	4739205	29.9	SHUNT	CP NV REVERSE CURRENT RELAY
		4739206	279	DIFF.	
		8062464		SERIES	
RH	17MC66F1	CONTROLLER		CS	BQ REVERSE HANDLE
RPM	MIP-61F			110	L ENG. SPEED RECEPT
S1,S21	17CP2N3	3122101	775	17AF21A4	CP ABCDEKUV SER.-PAR. CONTACTS
SAR	17LV53AB113	4739407	11.8	110	KLV SAFETY RELAY
S6	56YA17A1				O AXLE GENERATOR
SH	SEE RH			CS	ABC6Q SELECTOR HANDLE
SR	17LV53S115	4739407	11.8	110	JV SIGNAL RELAY
SW	176P19A1	3122101	775	CP	BCDFIV BRAKING SWITCH
T1	846256			105	G TRANSFORMER
TDR	17LV53C139	4739351	762	105	BCW SEQUENCE RELAY
T6	17MM16A1	PER PHASE	14.45	E	L ENG. TACH. GEN.
TH	SEE RH			CS	L THROTTLE HANDLE
TR	17LV53C39	4739351	762	105	ABCW TRANSITION RELAY
W3Y,2	17LV53E19	8027015	0.6	58	DGKW WHEEL SLIP RELAYS

APPARATUS TABLE

FIG. 8



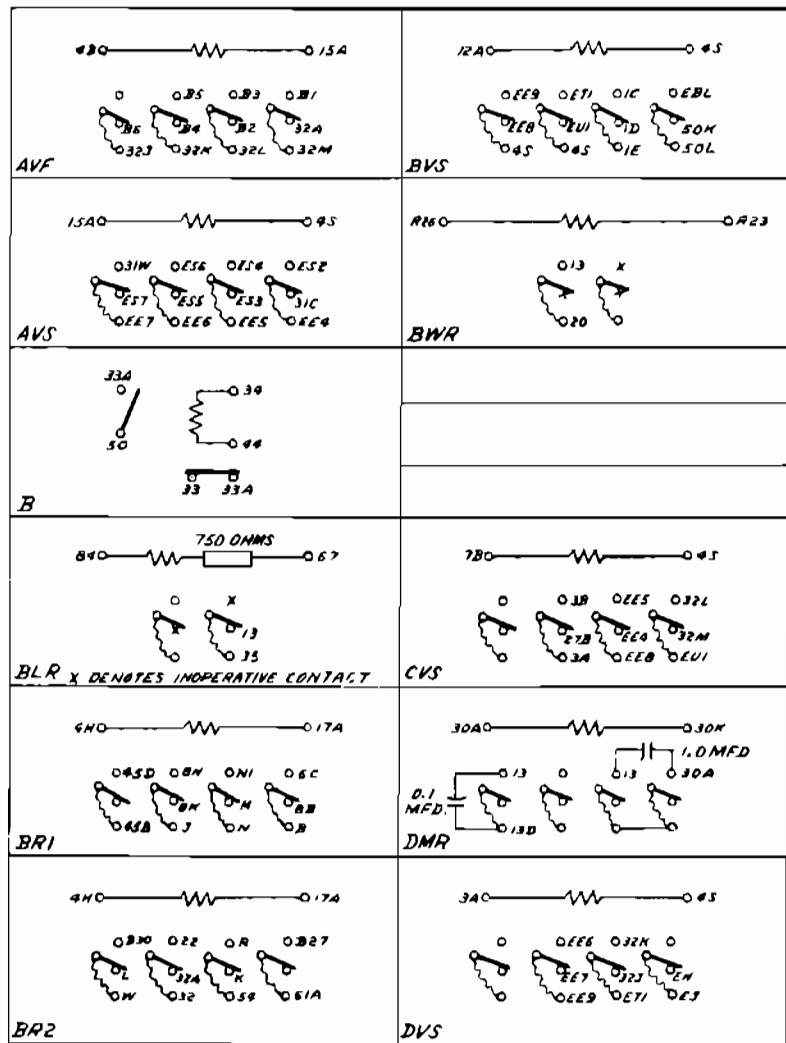
RELAY AND INTERLOCK SKETCHES

It is also necessary to know the physical location of an interlock on any contactor or relay having a number of interlocks. This is obtained from the section on the diagram titled Relay and Interlock Sketches (Pre-1950) or Device Sketches (1950). For example: In Figure 9, it is seen that the fourth contact from the left on AVF causes a circuit from wires B1 to 32M when AVF is energized and from 32A to 32M when AVF is de-energized.

DEVELOPMENT

The Development shows when throttle, reverser and selector handle control contacts open and close in various positions of these handles. Development sketches such as Figure 10 are used to locate the physical positions of these contacts and possibly to check the wiring on the diagram.

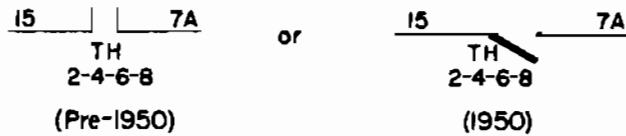
The contacts are shown in the shut down position. This is "off" for the reverser handles, "idle" for the throttle handles and "off" for the selector handle.



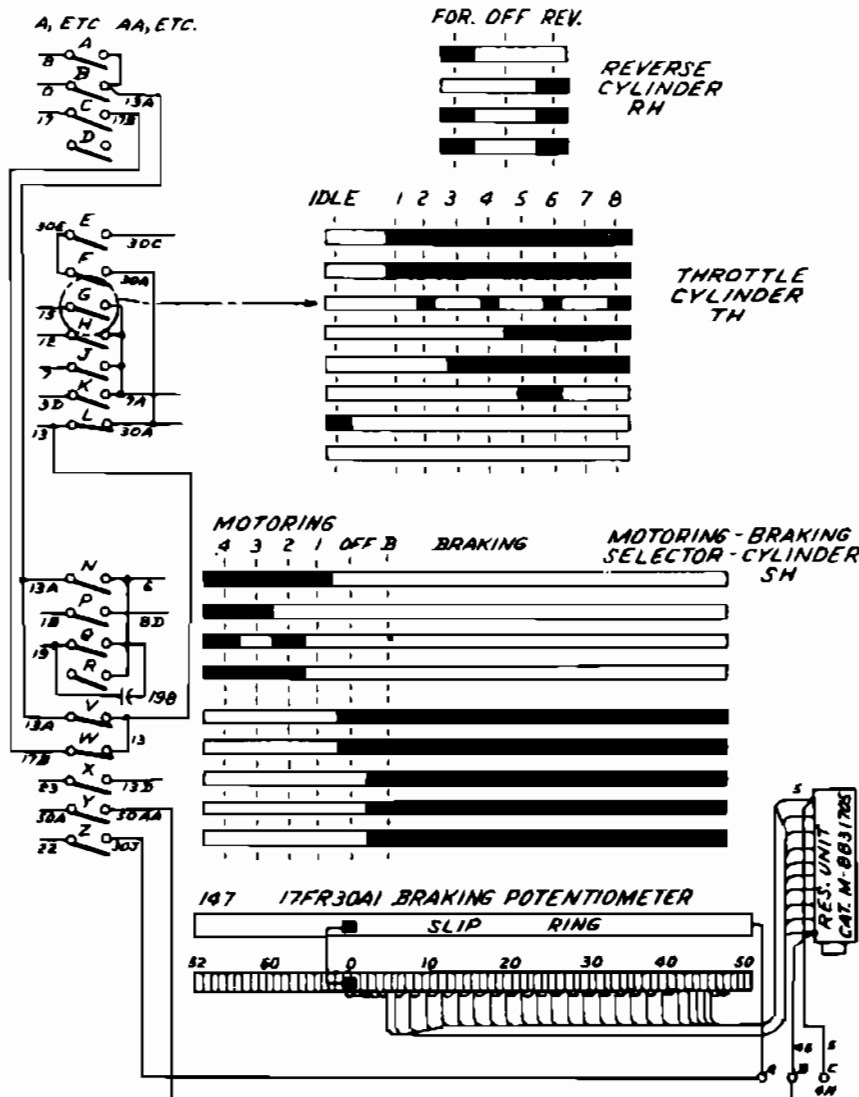
DEVICE SKETCHES

FIG. 9

Assume that the following is shown on the diagram:



How can this contact be found on the locomotive? When referring to Fig. 10 it is seen that contact 15-7A is open in the idle position. The rectangular portion opposite this contact shows an unshaded area in the idle position, while at positions 2, 4, 6 and 8, the shaded or black portions show that this contact closes at these throttle positions. Furthermore, the physical location of this contact can be determined by counting down the contactor drum. The contact in question, is the seventh from the top.

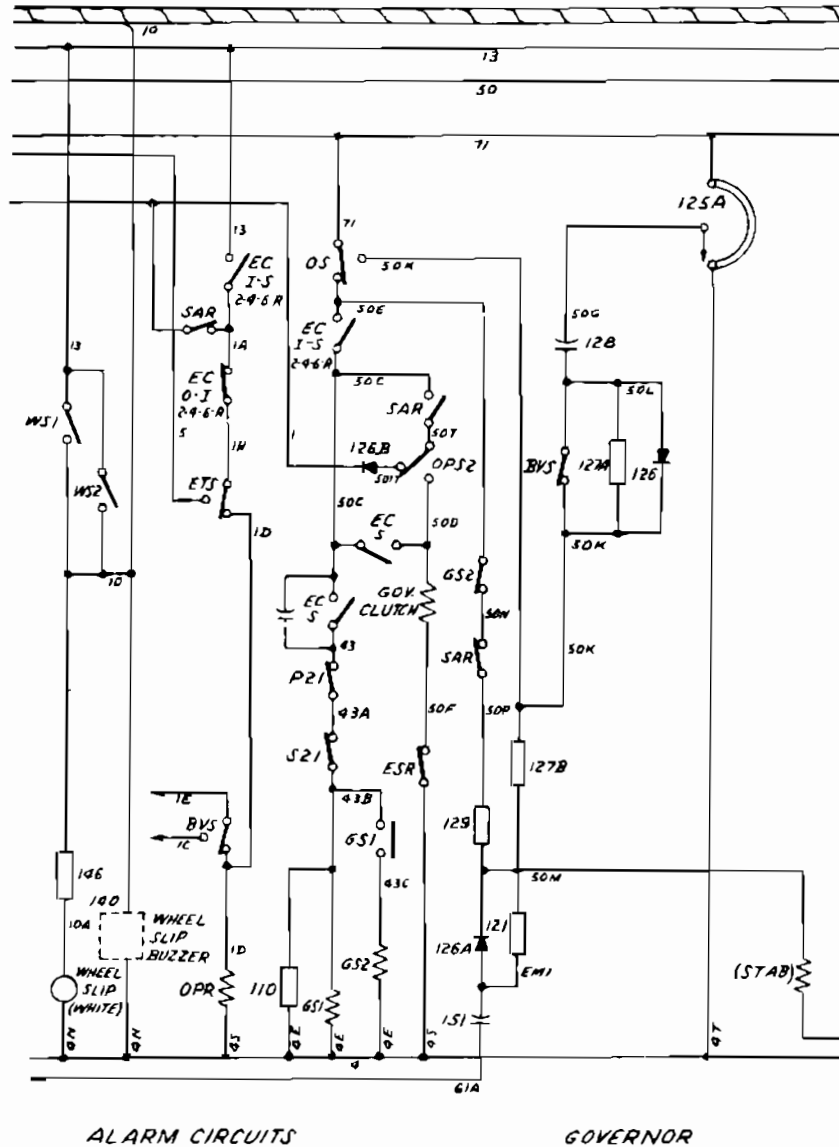


CONTROLLER DEVELOPMENT

FIG. 10

**TROUBLE SHOOTING**

To better understand trouble shooting, set up a case of trouble and follow through the various steps in its analysis. Assume the diesel engine does not crank over, and the fault is due to an interlock on P21.



**FIG. 11**

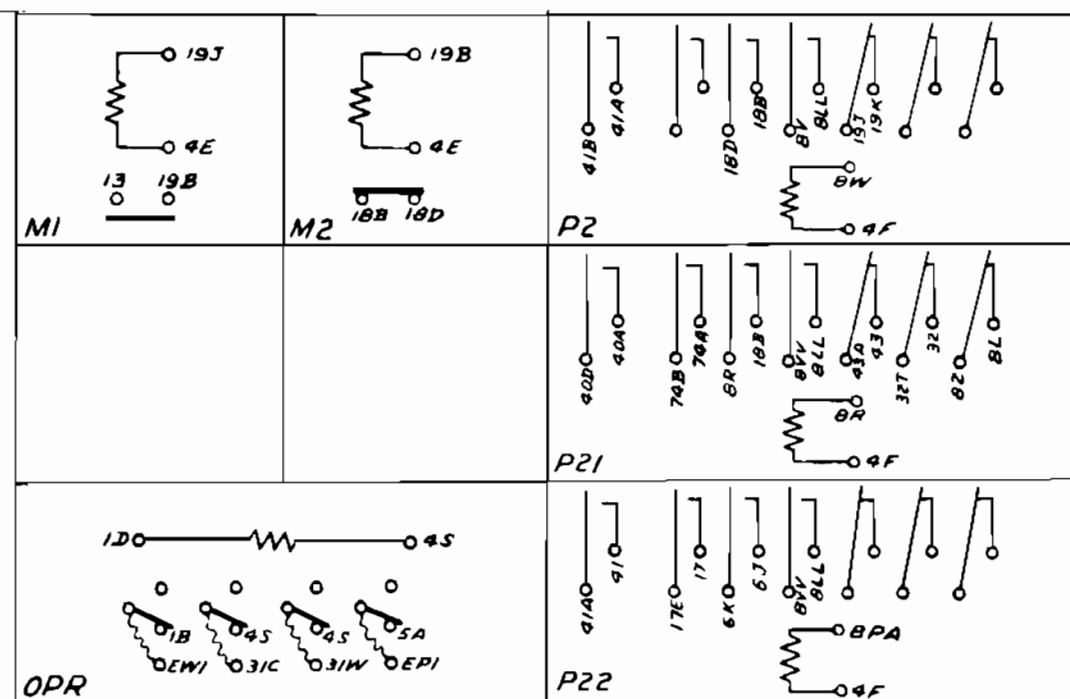
The first step is to determine what is supposed to happen when the start switch is turned. "What happens when", is seen from the Sequence Chart. Refer to Figure 4 and note that GS1 and GS2 contactors should be closed. To find

the location of GS1 and GS2 on the locomotive, see Fig. 8, which places them in CP. Fig. 7 explains that CP is the control compartment. The location of GS1 is now known. Observation will show that GS1 and GS2 have not closed. The next step is to find the coil of GS1 and GS2 on the wiring diagram and attempt to determine why these coils are not energized from control power. From the Apparatus Table, Fig. 8, note that GS1 parts are found in Sections B, F, K and T. The coil is found in Section K, Fig. 11, and the problem now consists of an examination of all equipment in this circuit. It is seen that a normally closed interlock on P21 is in this circuit. Again refer to the Apparatus Table to locate this interlock on the locomotive.

The diagram indicates that the interlock that has 43 and 43A wires, is normally closed. If the wire numbers cannot be identified, the Device Sketch, Fig. 12, will show that this interlock is the third from the right. By cleaning or repairing this contact, the trouble is corrected.

By following this method any type of trouble can be traced to its source and corrected.

This type of diagram, with a little practice and experience, provides a very efficient means of trouble shooting.



DEVICE SKETCHES

FIG. 12



**AMERICAN LOCOMOTIVE COMPANY**  
**Schenectady, N. Y.**