BREDA COSTRUZIONI FERROVIARIE

REPAIR AND MAINTENANCE MANUAL

METRO RED LINE OPTION CAR I

PASSENGER VEHICLE

Issue: April 2000

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SECTION 1

INTRODUCTION

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SECTION 1

INTRODUCTION

1-2 ARRANGEMENT

This Repair and Maintenance Manual consists of 1 volume which includes the following Sections:

Section	1	-	Introduction
Section	2	-	Car Body
Section	4	-	Trucks and Vehicle Suspension System
Section	6	-	High Voltage Power Distribution
Section	7	-	Propulsion and Control System
Section	10	-	Low Voltage Power Distribution
Section	11	-	Lighting Circuit and Destination Signs
Section	15	-	Integrated System Troubleshooting
Section	16	-	Periodic Inspections and Preventive Maintenance Requirements

1-3 APPLICABILITY

This Repair and Maintenance Manual is applicable to the Metro Red Line Option Car I - - Passenger Vehicles manufactured by BREDA COSTRUZIONI FERROVIARIE S.P.A. Whenever a system, sub-system, assembly, component is applicable to a particular vehicle configuration, its applicability is clearly indicated in the title of each paragraph.

This manual only contains sections, paragraphs and subparagraphs relative to systems, subsystems and components which have been modified with respect to the base car.
Refer to the base car documentation for those systems, subsystems and components which have been left unchanged.

1-9 ABBREVIATIONS, ACRONYMS AND SYMBOLS

The following abbreviations, acronyms and symbols are used throughout this Repair and Maintenance Manual:

Abbreviation	Definition
A or amp	Ampere
AC	Alternating Current
ADA	Americans with Disabilities Act of 1990
AISI	American Iron and Steel Structure
ANSI	American National Standards Institute
APS	Auxiliary Power System
ASR	Automatic Speed Regulation
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
AWG	American Wire Gauge
BC	Battery Charger
BLF	Battery Line Filter
BM	Car Wiring Terminal Board
CB	Circuit Breaker
CCF	Central Control Facility
CCU	Communications Control Unit
CDRL	Contact Data Requirements List
CE	Connection End
CM	Chopper Module
dB	Decibel
DBS	Dead Battery Start
DC	Direct Current
DC/DC	DC to DC Converter
DE	Drive End
DFE	District-Furnished Equipment
DSSR	Door Sensing Switch Relay
DTE	Diagnostic Test Equipment
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EMO	Emergency Manual Operation
FCC	Filter Charging Contactor
FDR	Filter Discharge Resistor
GDPS	Gate Driver Power Supply
GFD	Ground Fault Detector
GND	Ground
GTI™	Global Transit Information (registered trade mark)
GTO	Gate Turn-Off
HEX	Hexagonal (six sided)
HVAC	Heating, Ventilation and Air Conditioning
HVPS	High Voltage Power Supply
IC	Intercommunications

Abbreviation	Definition
IGBT	Insulated Gate Bipolar Transistor (Used as Power Switches)
KB	Q2 Relay Panel
KBAT	Battery Disconnect Contactor
KNE	Non Essential Contactor (Load Shed)
KNSW	Knife Switch
KQ	Auxiliary Relay Panel
KR	Interface Auxiliary Box (Console)
KT	Interface Auxiliary Box (Annunciator Panel)
KV	Console Auxiliary Power Supply
LACMTA	Los Angeles County Metropolitan Transportation Authority
LB	Line Breaker
LBRR	Line Breaker Overload Reset
LED	Light Emitting Diode
LEM	Hall Effect Devices for Current and Voltage Measurements Manufactured by LEM in Switzerland
LFR	Line Filter Reactor
LLRU	Lowest Level Replaceable Unit
LRU	Lowest Replaceable Unit
LVPS	Low Voltage Power Supply
M16	“A” Car (Base Car)
M17	“B” Car (Base Car)
M26	“A” Car (Option Car I)
M27	“B” Car (Option Car I)
MD	Motoring Diode
MOV	Metal Oxide Varistor
MRT	Mean Restoration Time
MTBF	Mean Time Between Failures
MTO	Manual Train Operation
MTTR	Mean Time to Repair
MTU	Memory Transfer Unit
NE	Non Essential (Loads)
OPT	Optional
PA	Public Address
PECE	Propulsion Electronic Control Equipment
PM	Phase Module
PSC	Pulse System Controller
PSS	Programmed Station Stopping
PTU	Portable Test Unit
PWM	Pulse Width Modulation
RCC	Rail Control Center
SCU	Sign Control Unit
SYM	Input Voltage In Range (From German)
TB	Terminal Board
THD	Total Harmonic Distortion
TICU	Train Interface Control Unit
V	Volts
VAM	Voltage Attenuation Module
VPI	Vacuum Pressure Impregnation

Abbreviation	Definition
VVVF	Variable Voltage Variable Frequency
W/	With
&	And
#	Number

SECTION 2

CAR BODY

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SECTION 2

CAR BODY

For removal and assembly procedures of carbody components refer to the corresponding section of Workshop Manual. Periodic inspection and preventive maintenance procedures are listed in section 16 of the Repair & Maintenance Manual.

2-1 VEHICLE (GENERAL)

2-1.1 Clean

2-1.1.1 General Information

The primary cleaning problem of the vehicle exterior surface is the removal of iron oxide deposits from the surface. These deposits can be satisfactorily controlled by the use of acid base cleaners. Alkaline base cleaners are ineffective in the removal of iron oxide stains. The following procedure is to be followed for cleaning of car shell produced in austenitic stainless steel.

2-1.1.2 Procedure

The cleaning procedure and the cleaning product to be used must be selected according to the following conditions:

- Substances to be removed.
- Presence of other materials that can be affected by the cleaning product.
- Surface finish.

a. Substances to be removed
The cleaning product must be selected according to the type and nature of the substances to be removed. Table 2-1 indicates the type of cleaner for removing particular substances. Other equivalent products can be used depending on the local suppliers. Always read and follow recommended manufacturer procedure for application of cleaning products.

b. Presence of other materials
Other materials besides the stainless steel like paint, rubber, tin-lead solder, etc. can be affected by the cleaning products. Strong alkaline cleaners (usually include sodium hydroxide), can be used safely to clean stainless steel surfaces, but will attack non-ferrous metals. Tin-Lead solder, used at roof sheet seams, and paint may be attacked by strong alkaline cleaners.

Mild alkaline solutions are commonly made with trisodium phosphate.

Sodium metasilicate may attack paint.

c. Surface finish
Hard cleaners may scratch or modify polished surfaces of stainless steel. Special care must be taken to avoid hard cleaners for polishing surfaces of the carshell.

CAUTION: USE CARE IN THE APPLICATION OF A SOLVENT. SOME CLEANERS MAY BE HAZARDOUS FOR HEALTH: SAFETY RECOMMENDATIONS INDICATED BY THE CLEANING PRODUCT MANUFACTURER INSTRUCTIONS/DIRECTIONS MUST BE CAREFULLY READ AND FOLLOWED. ALTHOUGH NOT TOXIC TO MOST INDIVIDUALS, SOME INDIVIDUALS MAY BE ALLERGIC TO COMPONENTS WITHIN THE SOLVENT. IF THE SOLVENT CONTACTS THE SKIN, THE AREA SHOULD BE THOROUGHLY FLUSHED WITH CLEAR WATER. SHOULD THE SOLVENT GET INTO THE EYES, FLUSH IMMEDIATELY WITH CLEAR WATER AND A SUITABLE EYE WASH. OBTAIN MEDICAL ASSISTANCE SHOULD A CONTINUING IRRITATION RESULT.

The cleaning procedure apply to interior and exterior of the car, according to instructions of Table 2-1.

2-1.1.3 Cleaning Procedures

Table 2-1 Stainless Steel Carshell Cleaning Procedure

Substance to remove	Cleaner	Application	Remarks
Common deposits of *grease, dirt*, and *similar substances*.	Commercial Deter-gent.	Flush with water-detergent solution, rub with cloth or sponge, rinse and wipe dry.	Does not affect the finish if gritty substances are first removed before rubbing.
Tightly adhering local deposits of *food, oil, grease stains, oxide stains* or *other light discolorations.*	Grade FFF Italian Pumice, Whiting, or Talc.	Rub with damp cloth.	Satisfactory for all finishes.

(Cont'd)

Table 2-1 Stainless Steel Carshell Cleaning Procedure - Continued

Substance to remove	Cleaner	Application	Remarks
Tightly adhering local deposits of *food, oil, grease stains, oxide stains* or *other light discolorations.*	Liquid NuSteel.	Rub with small amount of dry cloth.	Satisfactory for all finishes if rubbing pressure is light.
	Household cleaners, such as Bon Ami, Old Dutch, Lighthouse, Sunbrite, or Bab-O.	Rub with damp cloth.	Will scratch finish slightly.
	Grade FFF Italian Pumice, Zud, Stell Bright, or Restoro.	Rub with damp cloth.	Will scratch finish slightly.
Tenacious deposits on large areas, rusty discolorations, and industrial atmospheric stains.	Oakite N° 33, Flash-Klenz, Dilac, Teno 12, or Temony.	Swab and soak with clean cloth or sponge, let stand as directed, rinse and dry.	No effects on finish. Observe recommended safety precautions when using.
Heat tint, heavy discolorations, or water deposits.	Household cleaners.	Scour with damp cloth.	Very good for heat tint removal.
	5% Oxalic acid (use warm), vinegar or 5-15% phosphoric acid. Always followed with a 5% Sodium Carbonate or neutralizer rinse.	Swab or immerse.	Good discoloration remover. Good removers of hard water deposits or heavy lime scale.
Fingerprints.	Glass Wax, Lumin Wash, or Lac-O-Nu.	Rub with cloth as directed.	No effect on finish; leave transparent film on surface reducing tendency to fingerprint.

(Cont'd)

Table 2-1 Stainless Steel Carshell Cleaning Procedure - Continued

Substance to remove	Cleaner	Application	Remarks
Grease, oil, fatty acids, or oxide stains.	5-15% Caustic soda (hot or cold).	Can be used where swabbing or rubbing is not practical.	Will remove grease, oxide stains, etc.
Grease, oil, fatty acids, or oxide stains.	0.1 - 0.2% Solution of sodium metasilicate, trisodium phosphate, sodium hexametaphosphate or sodium tropolyphosphate.	Can be used where swabbing or rubbing is not practical.	All excellent removers of grease, oil, and oxide stains.
Oil and grease.	Carbon tetrachloride, trichlorethylene, kerosene, gasoline, or alcohol.		No effect on finish. These organic solvents should not be used for cleaning food containers unless followed by washing with detergent. Observe recommended safety precautions when using.

2-1.1.4 Cleaning Frequency

It is recommended that normal maintenance cleaning to remove light grease and dirt be done within a period no longer than 3 days.

2-1.1.5 Cleaning Products Not Recommended

Certain cleaning products are considered dangerous to the external surfaces of the car and are not recommended.

a. Vehicle skins and extrusions can be attacked by:

   (1) Fluoride acid brighteners.

   (2) Strong sodium hydroxide cleaners.

   (3) Strong potassium hydroxide cleaners.

   (4) Ammonia cleaners, such as Windex, or similar household ammonias.

(5) Dishwashing cleaners, such as Lux, etc., will cause a black staining effect.

(6) Rust strippers having a hydrochloric acid base will attack and stain.

b. Window glass can be attacked by:

(1) Fluoride acid brighteners.

(2) Strong sodium hydroxide cleaners.

(3) Strong potassium hydroxide cleaners.

c. Rubber seals can be weakened by:

(1) Methylene chloride solvents.

(2) Commercial paint strippers.

2-2 CARBODY STRUCTURE (Figure 2-1)

2-2.1 Description

2-2.1.1 <u>Main Underframe (Sheet 1)</u>

The main underframe consists of two side sills connected together by cross members. The entire structure is made of stainless steel.

2-2.1.2 <u>End Underframe (Sheet 1)</u>

The underframe ends are made of steel and consist of a cross member, a central member and a body bolster all welded together to form a single body. An anti-climber device, made of steel, is provided. This device prevents a car from climbing the mating one when both are under compression. The front end underframe is provided with two jacking pads, as is the rear end underframe. All the undercar components are secured to the floor beams and intercostals.

2-2.1.3 <u>Sidewalls (Sheet 2)</u>

The sidewalls consist of stainless steel panels. These panels are welded to the side structure’s vertical framing member which are, in turn, welded to the side sills. The car ends incorporate two collision posts, designed to provide adequate strain strength to compression.

2-2.1.4 Roof (Sheet 3)

The roof consists of beams extending the full length of the car, carline cross members which also support ceiling-mounted equipment, and exterior corrugated sheeting.
The roof will withstand the concentrated loads applied by two men working in any concentrated area on the roof.

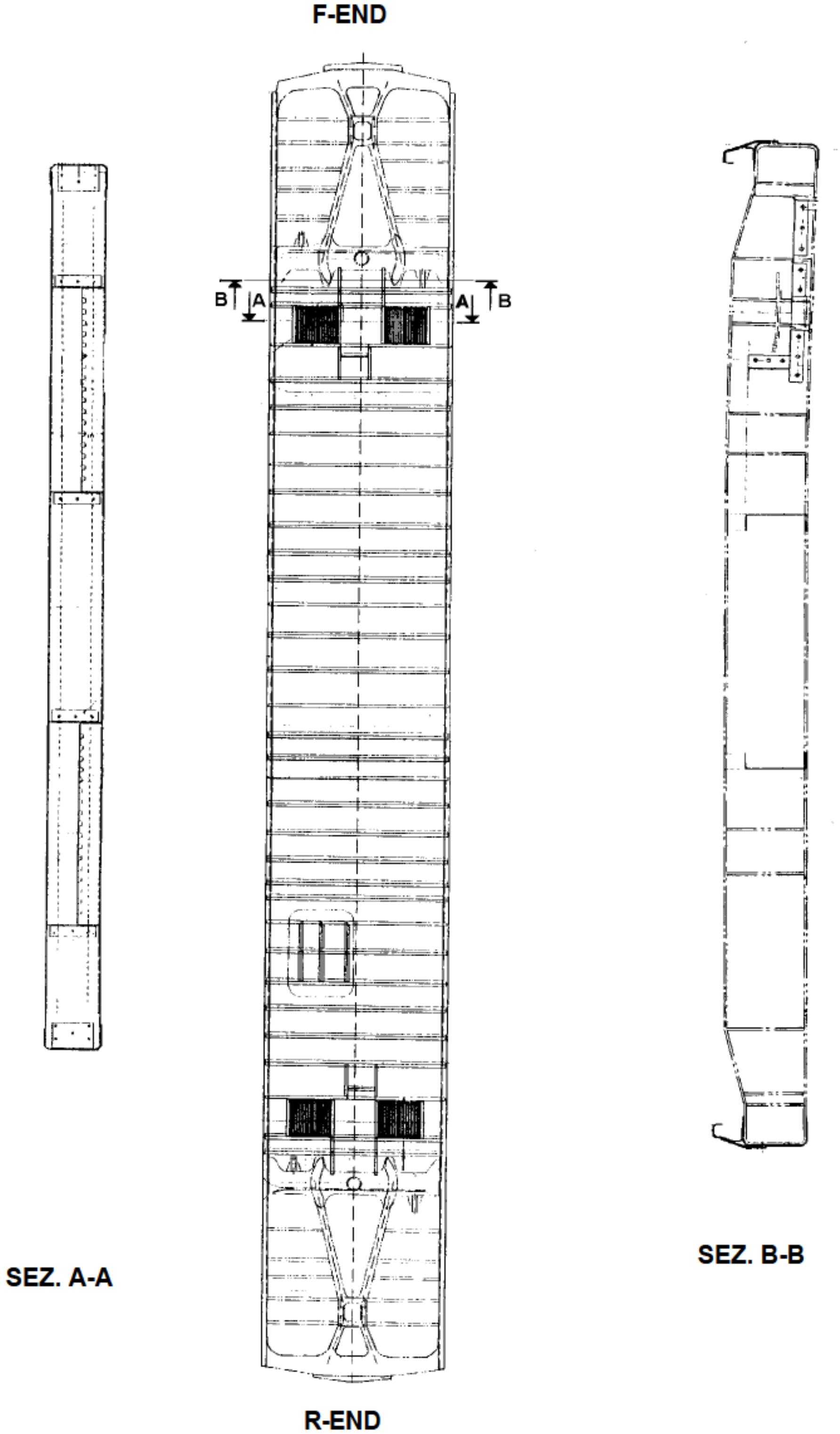

Figure 2-1. (Sheet 1 of 3). Car Body Structure

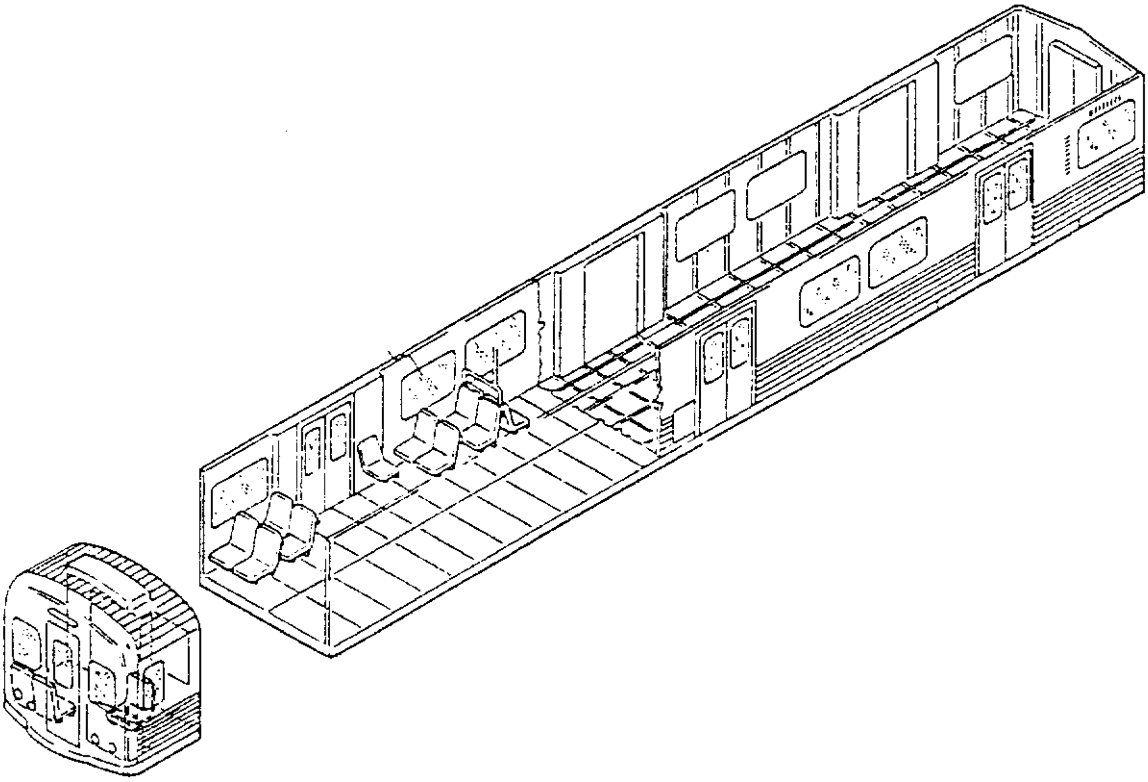

Figure 2-1. (Sheet 2 of 3). Car Body Structure

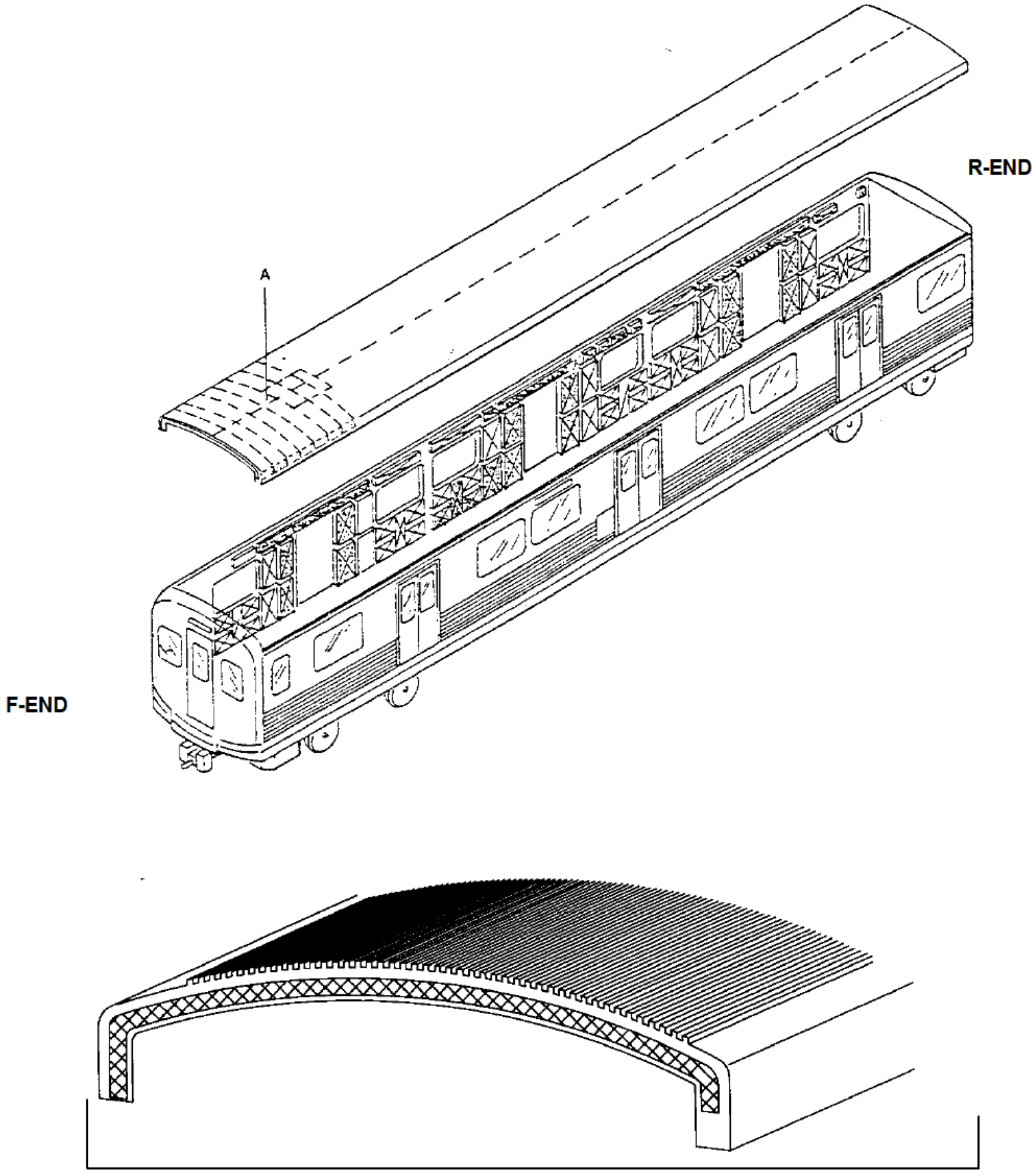

Figure 2-1. (Sheet 3 of 3). Car Body Structure

2-3 DOORS

2-3.1 Side Doors Description

The car side doors are composed of inside frames and interior and exterior skins with provision for installing windows. Each door panel is suspended from a supporting rail by two carriages equipped with nylon rollers.

The lower edge of the door is equipped with a non-metallic insert which slides on the threshold profile to maintain the lateral position of the door and insure watertightness.

The mating vertical edges of each door panel are equipped with neoprene closure extrusions. The rear vertical edge of each panel is equipped with a neoprene lipped seal.

Each side door is provided with two door closing annunciation luminous indicators which start flashing as the “Door Close” command is given and flash until the door is closed and locked.

The luminous indicators are located on the lower surface of the respective door operator valance (see Figure 2-2).

Door operator installation, adjustment and repair instructions are contained in Section 9 of this manual.

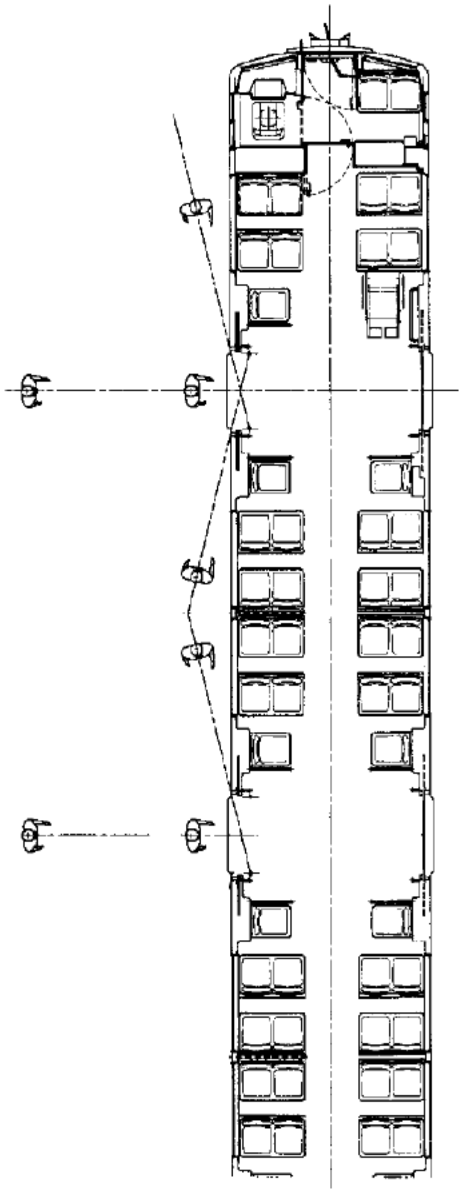

Figure 2-2. Side Door Details (Door Closing Annunciation Indicators)

2-6 SEATS

2-6.1 Description and Operation

2-6.1.1 General Description

All passenger seat models (except the double seat, located in the F-end passenger cab area) are of wall-attached (cantilevered) construction, without floor support, allowing a pedestal-free car floor. The seats are fitted with an internal self-supported tubular frame, which is covered by a plastic shell supporting the seat bottom and back upholstered inserts. Grabrails are installed on top of the seat shells to provide handholds for passengers, and crash-pads are installed on the back of the seats, providing crash protection to passengers. The operator seat located in the operator cab is a pedestal supported seat fitted with soft seat and back cushions fully adjustable in height, back reclination angle, front-and-back positioning and 90° swivel control. Also the double transverse seat in the F-end passenger cab area is pedestal supported.

All passenger seat models are configured in right and left hand versions, (except the double transverse seat in the F-end passenger cab area) and are arranged in the car interior as shown in Figure 2-4.

2-6.1.2 Identification of Seat Models

a. Transverse seat assembly
The transverse seat is a double seat (two seating places) positioned transverse to the centerline of the car, attached to the wall through three mounting studs placed at the seat’s side face. The transverse seat is provided with a grabrail, a back crash-pad and upholstered inserts.

b. Bulkhead seat assembly
The bulkhead seat is a double seat (two seating places) positioned at each end of the carset with its back facing the car bulkhead. It is attached to the side wall through its side face. The bulkhead seat presents the same general characteristics as the transverse seat, except for the absence of a grabrail and a crash-pad.

c. Longitudinal seat assembly
The longitudinal seat is a single seat (one seating place) positioned longitudinal to the car centerline, at each side of the car by side doors. It is attached to the car wall through the back face. Longitudinal seats are not provided with grabrails and crash-pads.

d. Back-to-back seat assembly
The back-to-back seat is a doubled version of the transverse seat, and presents four seating places. It is positioned between the car doors and it is attached to the side wall through its side face. It is provided with a grabrail and upholstered inserts.

e. Back-to-back seat assembly (with extinguisher housing)
This seat has the same general characteristics as the regular back-to-back seat, except for the presence of a fire extinguisher housing located between the seats back. The car is fitted with only one seat with this configuration.

f. Operator seat assembly
The operator seat is placed in the operator cabin and is fixed to the floor by four screws. It can freely rotate around its vertical axis and is provided with the following adjustment devices:

- A handle control lever for adjusting the seat height from 13.2” to 17.13” with respect to the car floor.

- A handle for displacing the seat horizontally by 3.54” forwards and 3.15” backwards with respect to the central position.

- A handle for adjusting the seat back reclination angle by 15°.

The seat’s bottom and back surfaces are covered by upholstery fabric over foam padding.

g. Transverse seat assembly (Passenger cab area only)
This transverse seat is a double seat (two seating places) positioned transverse to the longitudinal centerline of the car. The seat frame is welded to a double pedestal, in turn fixed by four screws to the car floor. The emergency ladder is located in a compartment beneath the seat.

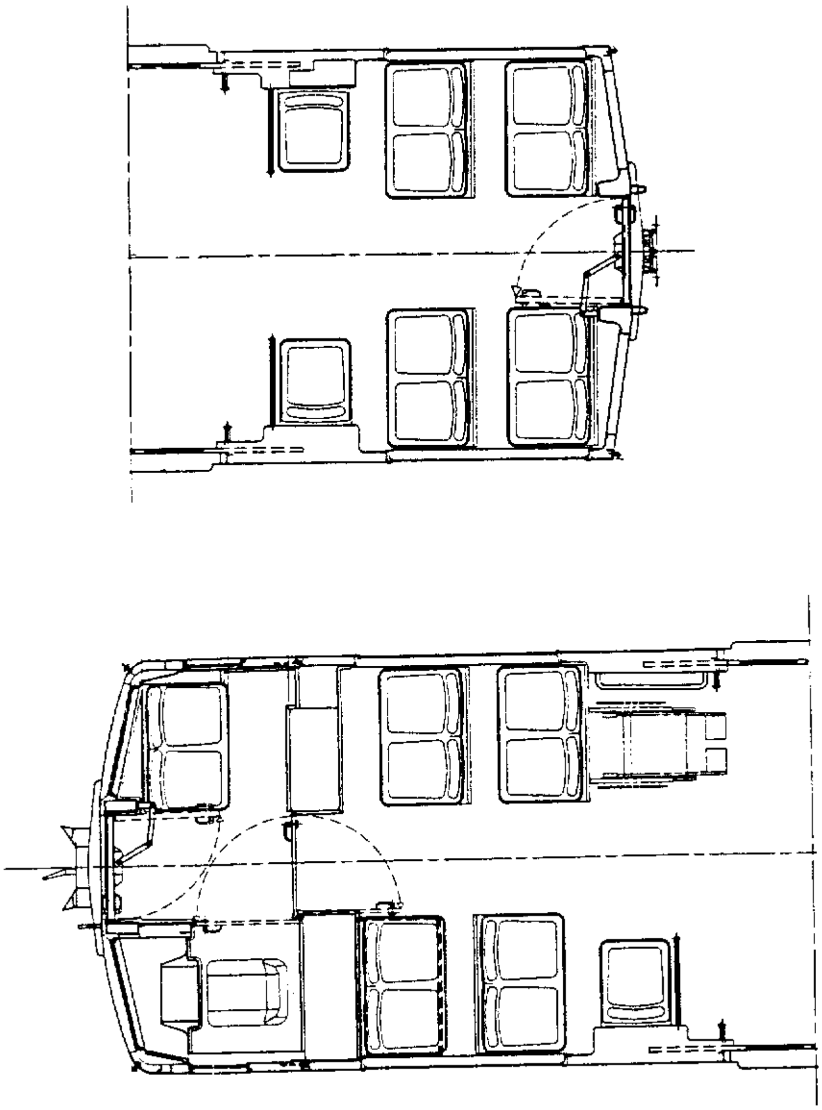

Figure 2-4. Seats Arrangement

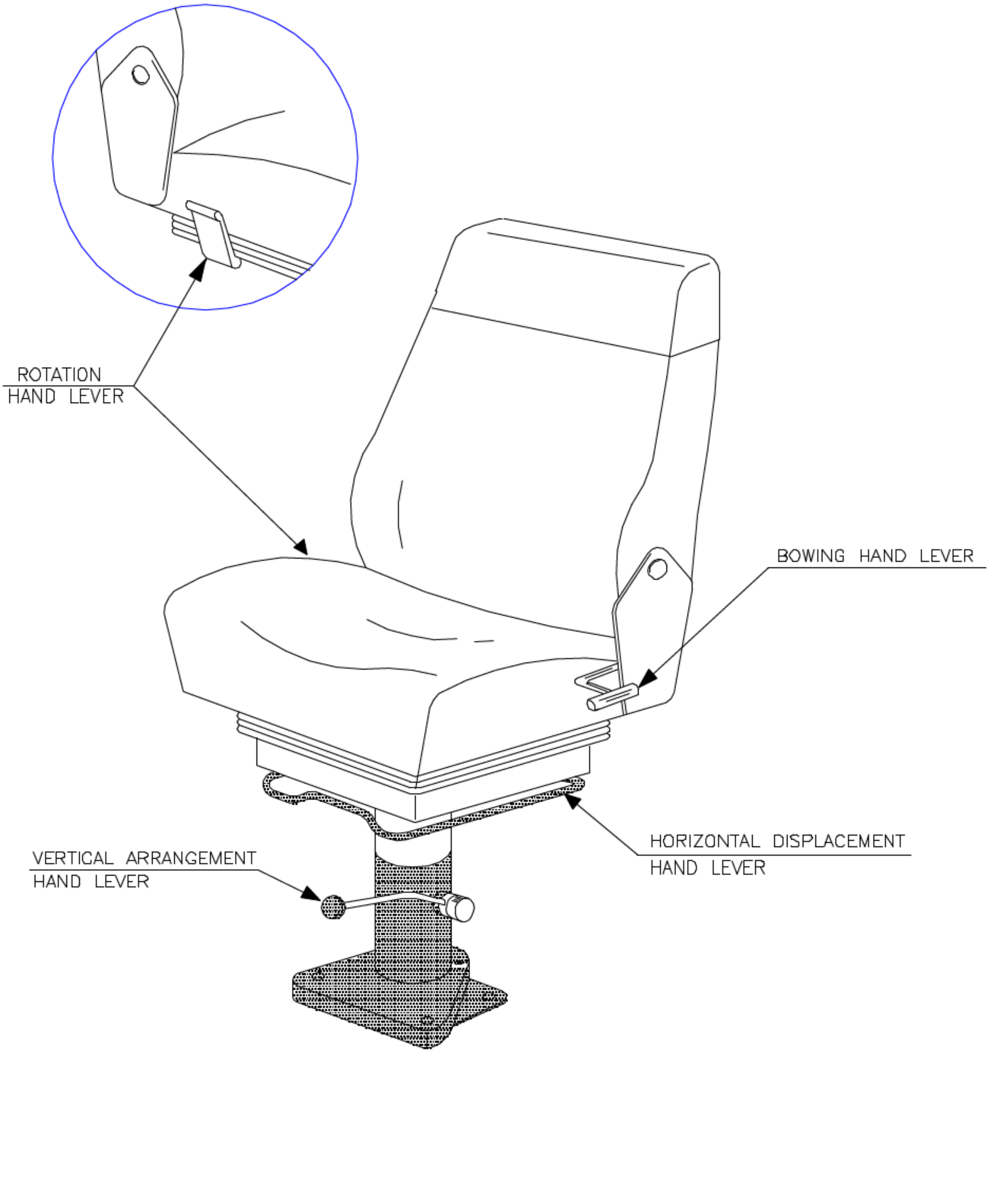

Figure 2-5. Operator Seat

2-7 MISCELLANEOUS ACCESSORIES

2-7.2 Emergency Ladder

The emergency ladder is located in the passenger area opposite the cab beneath the transverse seat. The ladder is housed in a box, with a hinged door (see Figure 2-6) and is secured to the floor by one retaining pin.

2-7.2.1 Removal

The ladder is to be used only for emergencies and should not be removed unless necessary.

To remove the ladder:

a. Open the door of the box located beneath the transverse seat.

b. Extract the retaining pin to have the ladder cleared for removal.

c. Remove the ladder from the box as shown in Fig. 2-6.

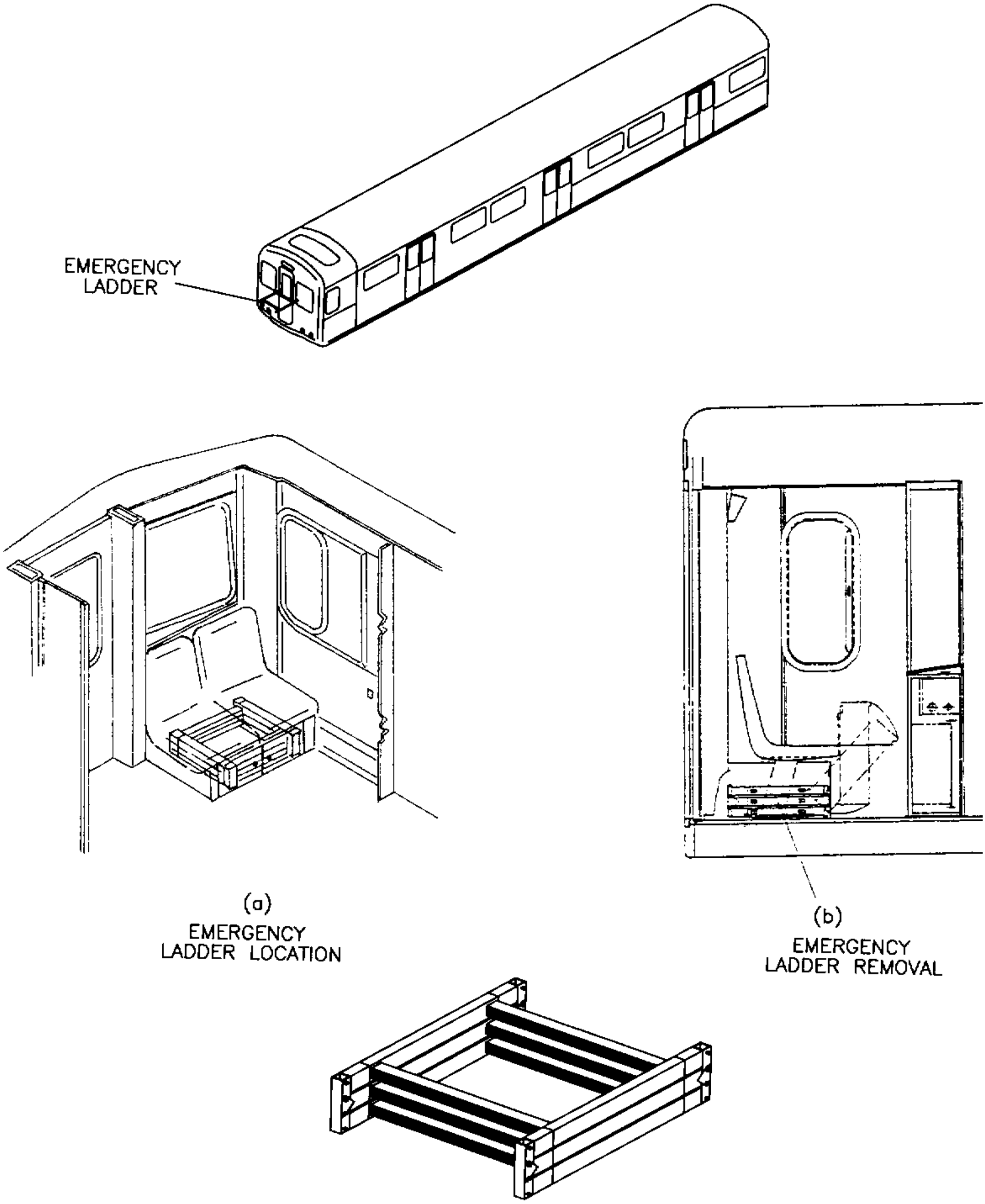

Figure 2-6. Emergency Ladder

2-7.4 Intercar Barriers

2-7.4.1 General Arrangement

To comply with ADA standards, intercar barriers are provided for preventing passengers on the platform from falling between two coupled cars.

The devices consist of pairs of chains, mounted on A car and B car. Chains have different lengths according to location between cars of the same dependent pair or between cars of different dependent pairs (see Fig. 2-9).

- Long chains (see Fig. 2-9, detail A)

  When the train consists of more than one dependent pair these chains are hooked between the F-end of two coupled cars.

  When the train consists of only one dependent pair, the long chains are stowed in a cabinet, in the passenger area opposite the cab.

- Short chains (see Fig. 2-9, detail B)

  Two short chains are mounted between A car and B car of the same dependent pair. The chain ends are hooked between the R-ends of the two coupled cars, platform side. The chains are connected between the two cars as long as the cars are in “married pair“ configuration.

2-7.4.2 Chains Configuration

- Short chains length 16.48” (5 links)
- Long chains length 26.54” (13 links)

Spiral springs, covered with corrugated rubber hose and provided with a spring catch, are fixed to the ends of both types of chain (see Fig. 2-9, detail C).

The spring catches are used for hooking the chains between two coupled cars, to eyebolts screwed into threaded holes, in the car exterior.

2-7.4.3 Long Chains Removal/Installation

a. Removal

To remove the long jack chains

(1) Unhook both spring catches (1) and have the chain free (see Fig. 2-10)

(2) Stow the chains in the cabinet located in the passenger cab area, in front of the double transverse seat.

If required:

- unscrew eyebolts (2) and remove together with relative hexagon nuts (3), washer seals (4), washer (5), seals (6).

b. *Installation*

(1) Remove the chains from cabinet unhooking the spring catches from the supports.

(2) Hook the chains between the F-end of the coupled cars by relative spring catches.

If required:

- screw nut (3) on eyebolts (2)
- install washer seal (4), washer (5), seals (6) on the eyebolt
- screw eyebolt into the threaded hole on the car F-end
- tighten nut (3).

2-7.4.4 <u>Short Chains Removal/Installation</u>

a. *Removal*

It should be noted that the short chains are removed seldom since “A” and “B” car of the same married pair are generally never uncoupled.

However, to remove the short chains.

- Unhook spring catches and have the chains free.

b. *Installation*

Hook the chains between the R-End of the coupled cars (“A” and “B” car) by relative spring catches.

2-7.4.5 <u>Chains Disassembly/Reassembly (See Figure 2-10)</u>

a. *Disassembly*

- Unhook quick links (12) and have chain (13) free.
- Unscrew end spring (11) from spiral spring (9) (on both ends).
- Remove clamps (7).

- Withdraw spiral spring (11) from guard (8)

b. *Reassembly*

Execute in reverse order operations listed at paragraph a. above

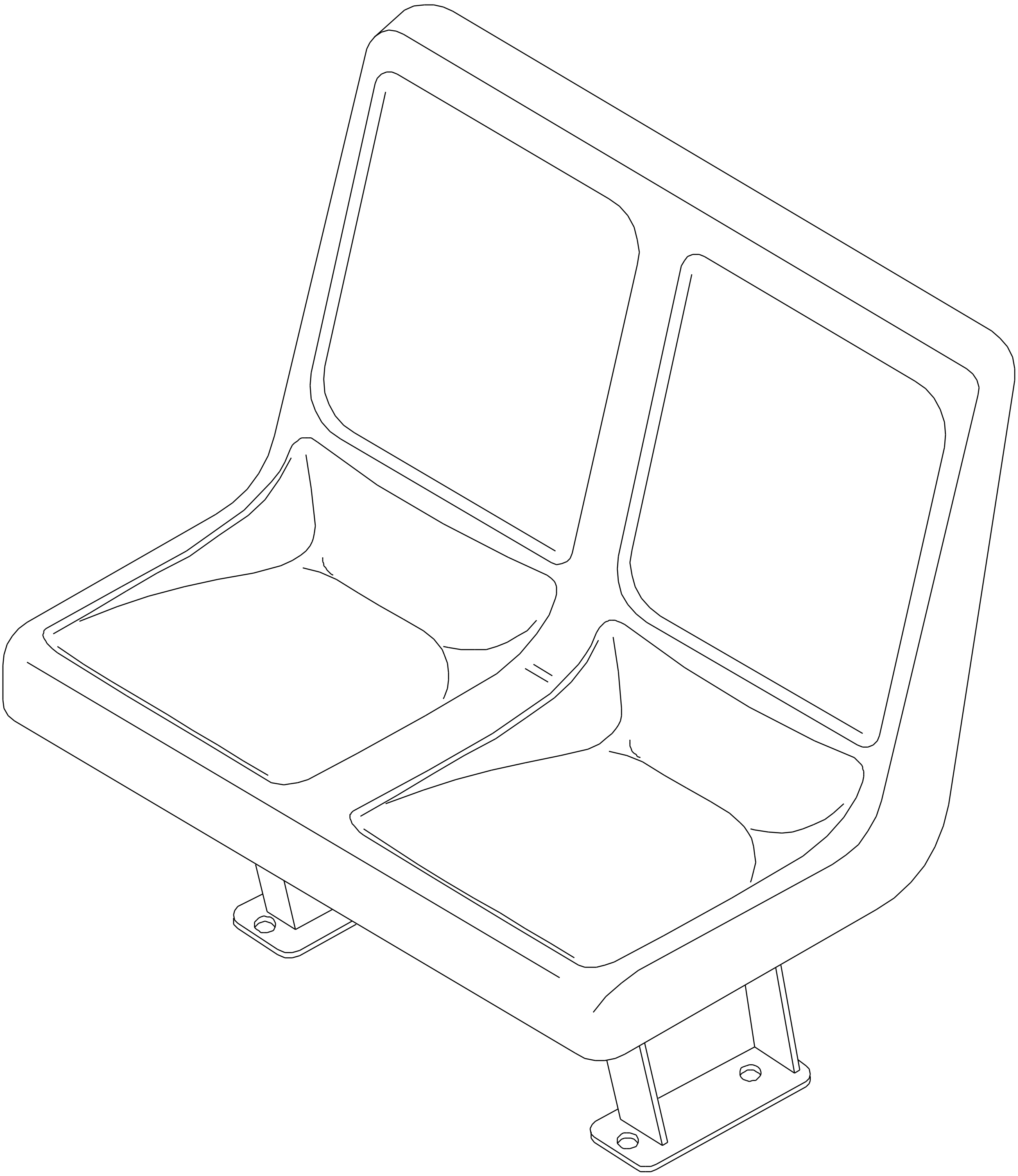

Figure 2-8. Transverse Seat Assembly (Passenger Cab Area Only)

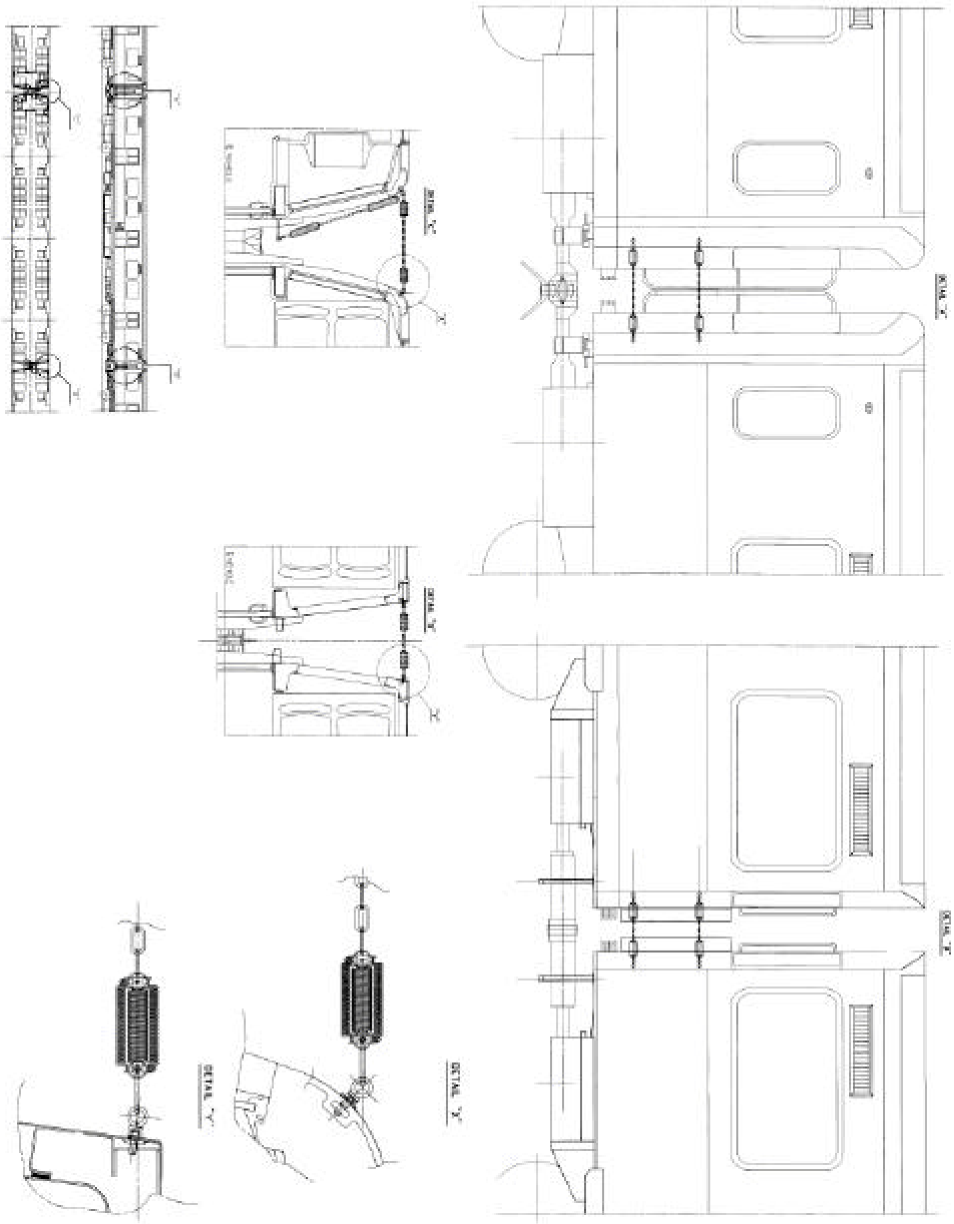

Figure 2-9. Intercar Barriers

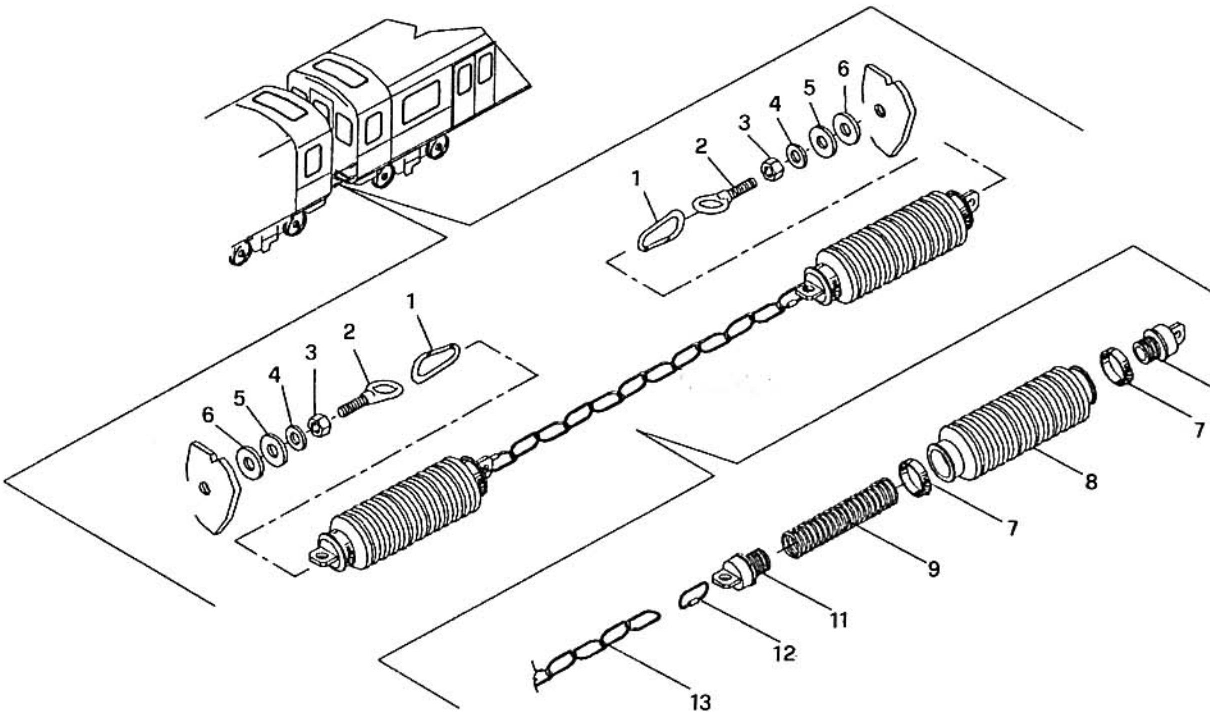

Figure 2-10. Intercar Barriers Installation/Removal/Disassembly/Reassembly

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SECTION 4

TRUCKS AND VEHICLE SUSPENSION SYSTEM

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TRUCKS AND VEHICLE SUSPENSION SYSTEM

4-1 TRUCKS AND VEHICLE SUSPENSION SYSTEM

4-1.1 Introduction

Each car is equipped with two trucks which are designed to support and guide it when running on the track, as well as to supply the wheels tractive and braking forces.

The truck described herein is the front truck. The rear truck is the same as the front except that it excludes the following equipment: pilot bars, parking brake, trip switch, and ATO receivers.

4-1.2 Truck Assembly (See Figure 4-1)

The truck consists of a frame (2) made of steel cross members welded together and provided with supports for fastening parts to it.

The truck is provided with two axles (12) integral with rolling wheels (16) driven by two A.C. traction motors. The motor voltages range from Ø to 525 V_{rms} line to neutral (910 V_{rms} line to line). The stator frequency ranges from Ø to 150 Hz and the inverter switching frequency from Ø to 650 Hz.

Each motor unit is provided with a single reduction gear box (3) firmly secured to the frame (2). The reduction gear box is also provided with an auxiliary 98-tooth gear for driving speed sensors (14).

In addition, each traction motor has a speed sensor mounted opposite the drive end.

Frame and axles are connected via the primary suspension system (9), consisting of four Chevron springs to support the vertical, transverse and longitudinal loads transmitted to the bearing housing (10) and thus to the axles.

The primary suspension system's vertical displacements (lower or upper) are dampened by suitable rubber pads.

The car frame transmits static and dynamic loads to the truck via direct impact on the sliding and support shoes (5) and/or by means of the center pin and bushing (11); the latter, which is self-lubricated, is housed in the hole machined in the truck bolster beam (6).

The bolster beam and frame are connected together via the secondary suspension system (18) consisting of two air valves which are supplied by the air compressor, via pneumatic pipes (21) and two air reservoirs (19) on the truck frame.

The secondary suspension system (18) can support, safely and completely, the vertical static and dynamic loads which the bolster beam transmits to the truck frame, and also maintains maximum passenger comfort while the train is running.

Two leveling valves (23) allow the secondary suspension system to compensate for possible bolster beam misalignments brought about by load differences on the air springs because of variations in passenger distribution throughout the car.

Lateral bumpers (7) are designed to limit the bolster beam transverse shifting, and longitudinal shifts are prevented by two horizontal connecting rods hinged, at both ends, to the beam and the truck frame.

Lower rubber pads, which are housed inside the air springs, are designed to limit the secondary suspension systems vertical give, while its upright range is limited by two vertical rods with slots at both ends; these rods are pinned to the truck frame and the bolster beam.

Two steel tension cables (13) connect the truck frame to the car frame in order to prevent the center pin from slipping out of the bushing (11) housed in the central hole machined in the bolster beam.

The bolster beams vertical and transverse oscillations about its own balance position are dampened by two vertical hydraulic shock absorbers (20) as well as by two lateral shock absorbers (4), which are connected to the bolster beam as well as to the truck frame.

The truck is equipped with two brake assemblies, one with parking brake (17) and one without parking brake (24). The brake assemblies are supplied with compressed air via pneumatic pipes (21) secured to the truck frame.

The air pressure, which is controlled by the braking system, allows the brake pneumatic pistons to exert proper thrust on the brake shoes, which, by acting directly on the wheels, develop the braking force for stopping the car.

Moreover, the truck is equipped with speed sensors (14), ATO receivers (15), trip switch (25), two pilot bars (1) and two current collectors (22).

The Rear Truck (equal to the Front Truck) is not provided with parking brake, trip switch, ATO receivers and pilot bars.

On the truck frame are electric cables which, when connected to the corresponding cables on the car frame, allow all the truck electrical devices to be supplied with power.

Pneumatic supply of the components installed on the truck takes place via hoses connecting the pipes on the truck frame to the pipes on the car.

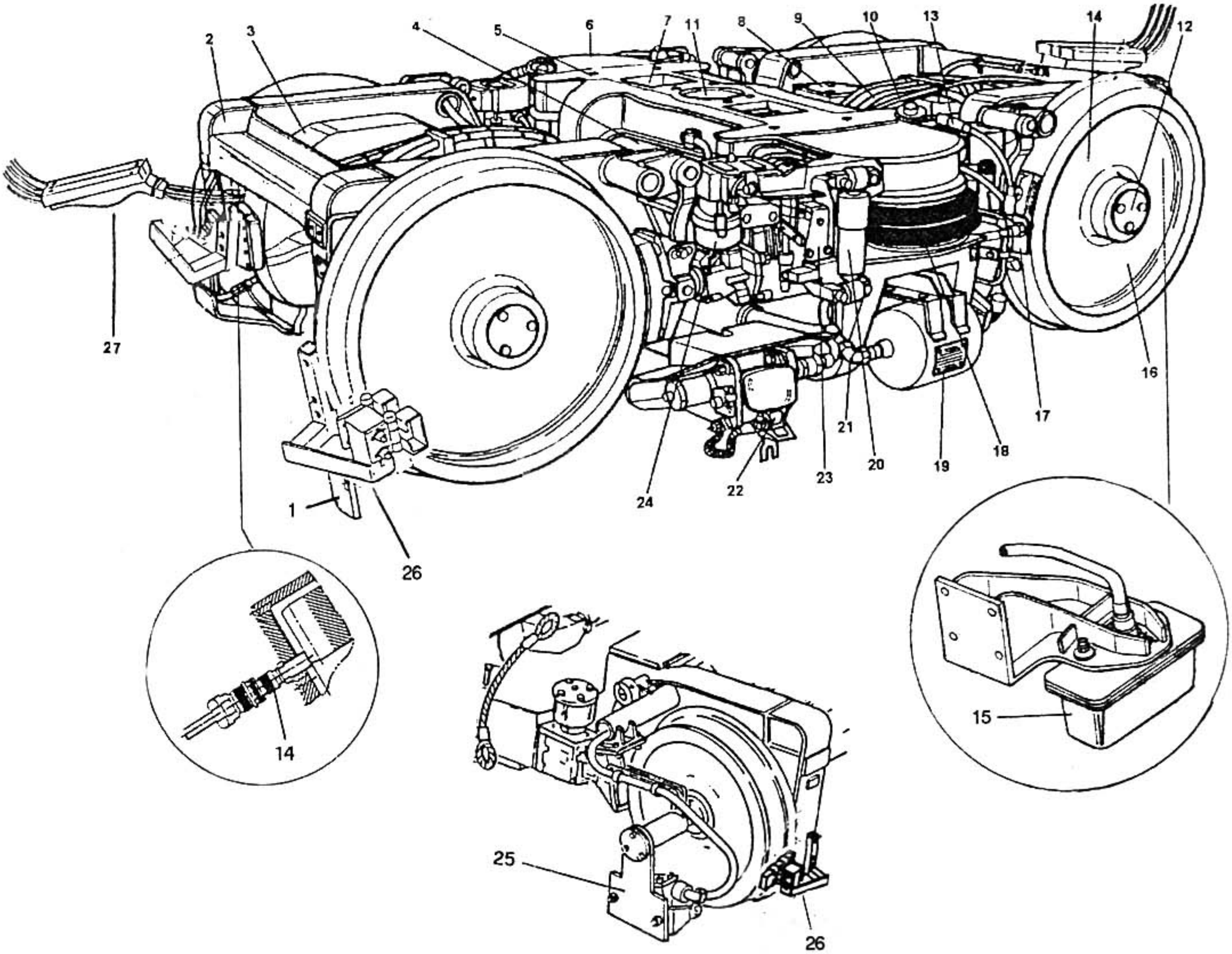
Wheel flange lubricators (26) are located on the trucks i.e. (see Fig. 4-14):

- There are four wheel flange lubricators on the car “A” and car “B” F-end trucks. Two are mounted on brackets fastened to the pilot bars, and two are mounted on brackets fastened to the ATO sensor supports.

- There are two wheel flange lubricators on the car “A” and car “B” R-end trucks, which are mounted on supports fastened to the frame.

The wheel flange lubricators (see Fig. 4-15) are mainly made up of cassette (1) containing a bar of lubricating material (graphite) (2) which is maintained pressed against the wheel flange by a spiral spring device housed in sliding drawer (3) in the cassette itself.

Sliding drawer (3) is blocked with transverse pin (4) in turn blocked by clip (5).



LEGEND

1. PILOT BAR (F-TRUCK ONLY)
2. FRAME
3. REDUCTION GEAR BOX
4. LATERAL SHOCK ABSORBER
5. SUPPORT SHOES
6. TRUCK BOLSTER BEAM
7. LATERAL BUMPER
8. TRACTION MOTOR
9. PRIMARY SUSPENSION
10. BEARING HOUSING
11. CENTER PIN BUSHING
12. AXLE
13. STEEL TENSION CABLES
14. SPEED SENSOR (TWO LOCATIONS) (FOUR SPEED SENSORS "A" CAR REAR TRUCK)
15. ATO RECEIVER (F-TRUCK ONLY)
16. ROLLING WHEELS
17. BRAKE ASSEMBLY WITH PARKING BRAKE (F-TRUCK ONLY)
18. SECONDARY SUSPENSION (AIR SPRING)
19. AIR RESERVOIR
20. VERTICAL HYDRAULIC SHOCK ABSORBER
21. PNEUMATIC PIPES
22. CURRENT COLLECTOR
23. LEVELLING VALVE
24. BRAKE ASSEMBLY WITHOUT PARKING BRAKE
25. TRIP SWITCH (F-TRUCK ONLY)
26. WHEEL FLANGE LUBRICATOR (FOUR LOCATIONS)
27. JUNCTION BOX

Figure 4-1. Truck Assembly ("A" Car Front Truck)

4-2.12 Gearbox (Figure 4-12)

a. Visually inspect the exterior of the gearbox to check whether it is damaged or there are lubricating oil leaks either from it or from the seals.

b. Clean the reduction gearbox outside using brushes and rags or, if necessary, steam and compressed air.

> **WARNING:** **ALWAYS OBSERVE SAFETY PRECAUTIONS TO AVOID POSSIBLE DANGER TO PERSONNEL.**

c. Check that the box is firmly secured to the electric motor.

d. Check integrity and cleanliness of the air vent which is installed on the gearbox upper part.

e. Remove the lubricating oil filler plug and check the oil level: it must be between the upper and the lower limit of the pour-hole; add or remove oil (Mobil SHC 80 W 140, or equivalent), as required.

f. To replace the lubricating oil, remove the oil drain plug, set a can under the drain and let the old oil drain until empty. Replace the drain plug after making sure that seal condition is acceptable, then fill the reservoir with about 6 l. (1.6 gallons) of oil mentioned above.

g. Install the filler plug after making sure that its seal is not damaged.

For further details, see Section 7 of this manual.

4-2.14 Graphite Bar Replacement in the Wheel Flange Lubricator (Figure 4-15)

To replace the graphite bar (2)

- remove clip (5)
- extract transverse pin (4) from cassette (1)
- remove spring device sliding drawer (3)
- insert a new graphite bar in spring device sliding drawer (3)
- insert spring device sliding drawer (3) in cassette (1) and block it by transverse pin (4) and clip (5)

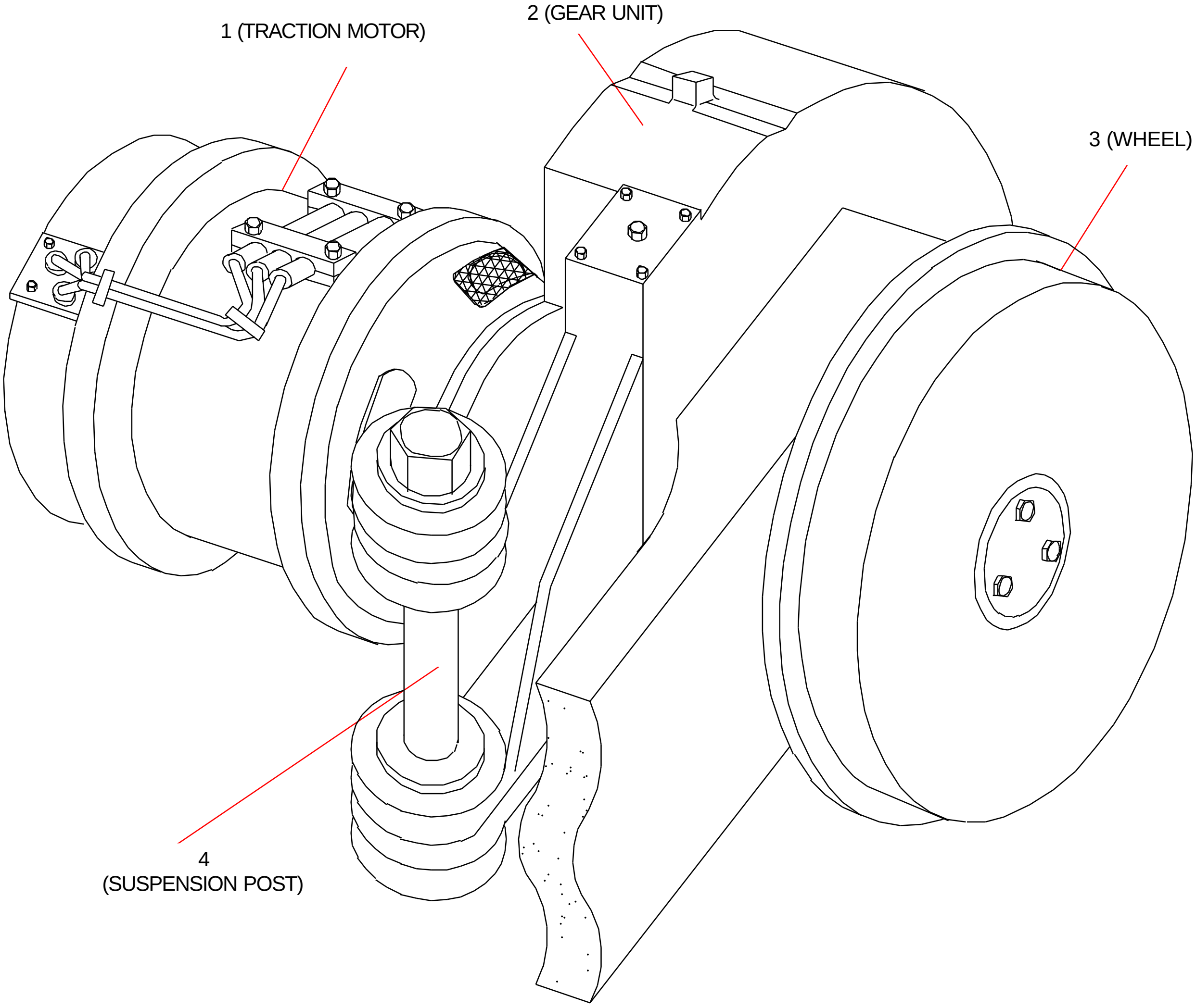


Figure 4-12. Gear Box

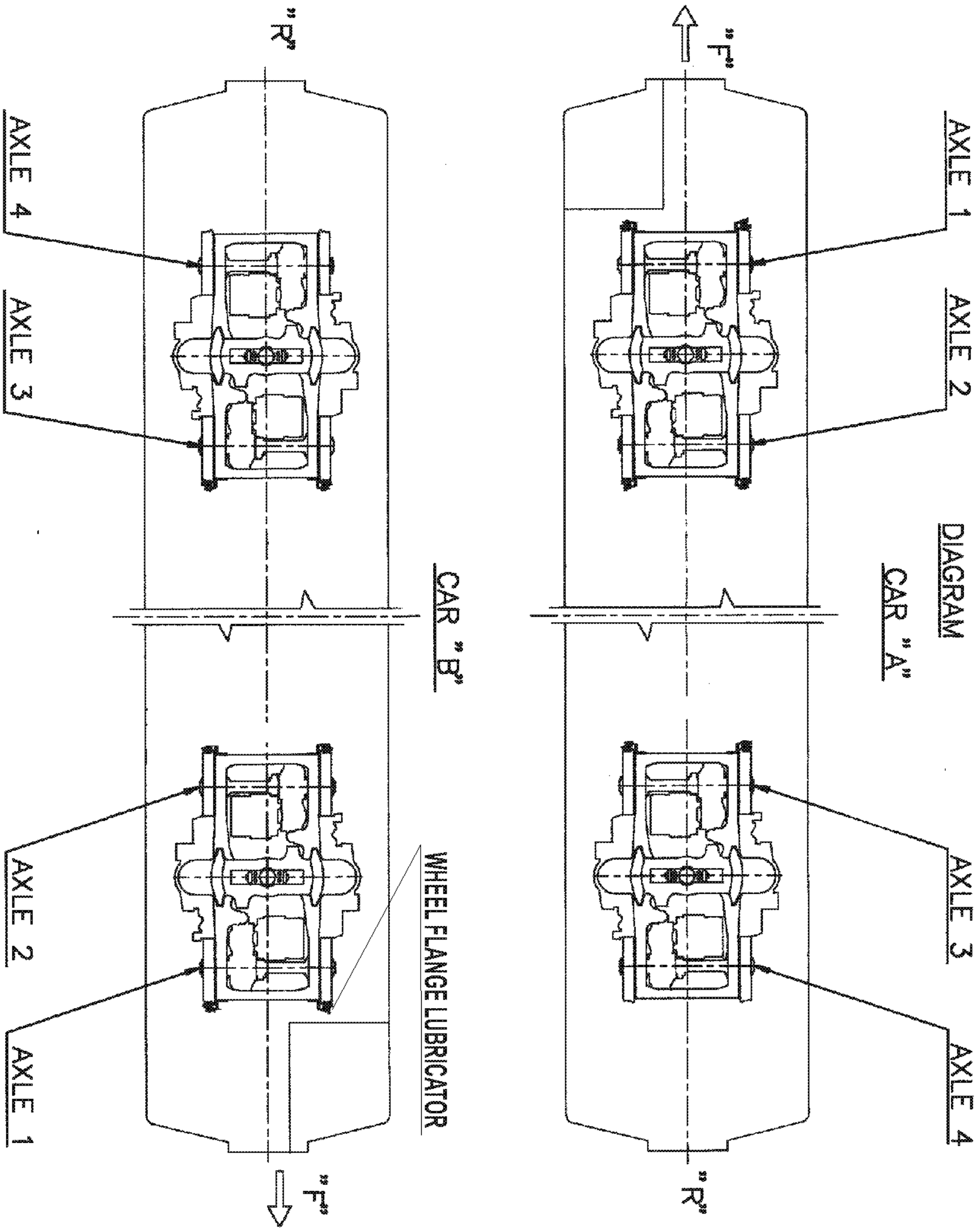
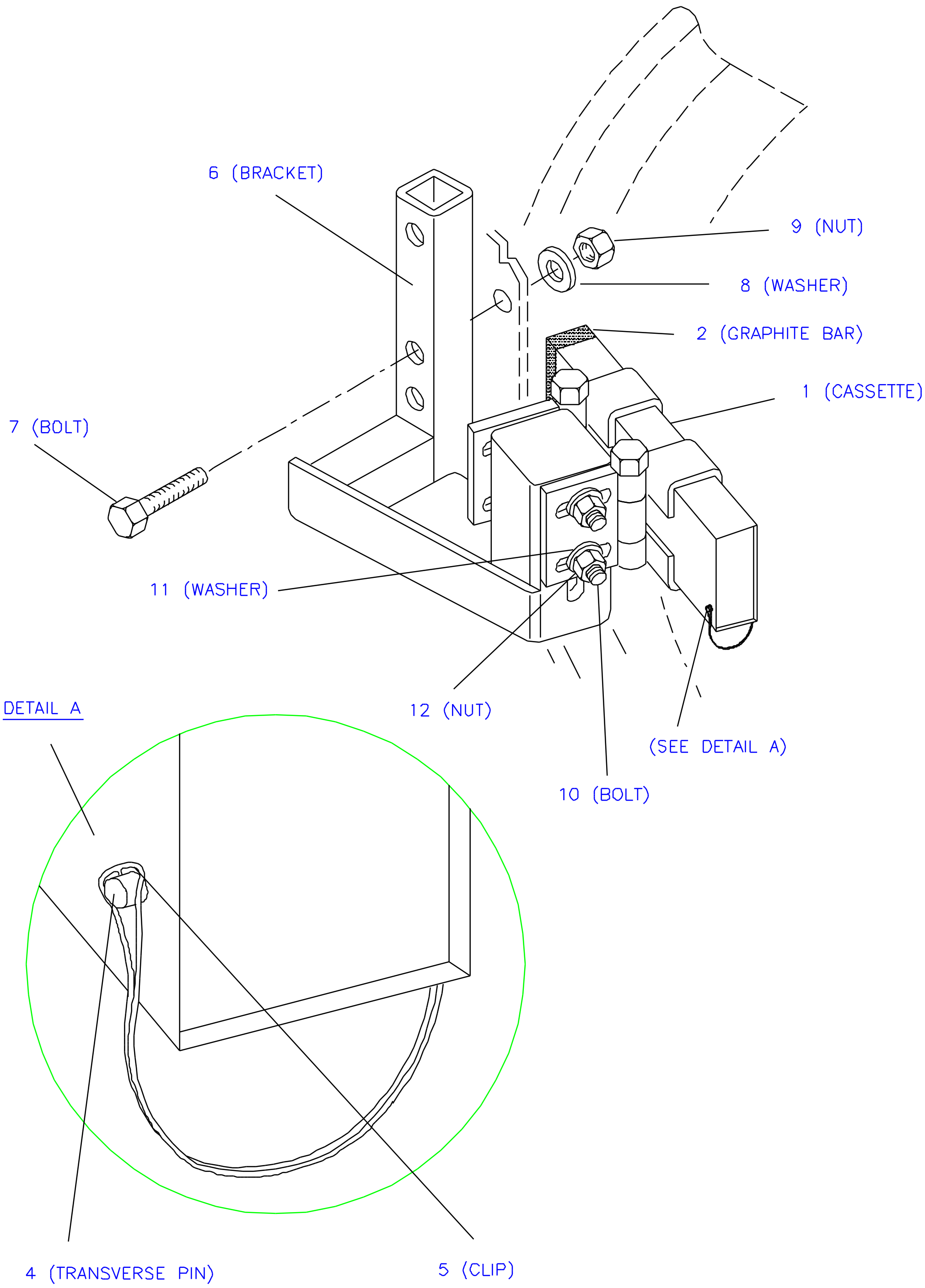


Figure 4-14. Flange Lubricators Location



LEGEND

1)	CASSETTE	4)	TRANSVERSE PIN
2)	GRAPHITE BAR	5)	CLIP
3)	SLIDING DRAWER		

Figure 4-15. Wheel Flange Lubricator

SECTION 6

HIGH VOLTAGE POWER DISTRIBUTION

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SECTION 6

HIGH VOLTAGE POWER DISTRIBUTION

WARNING:	**WHEN ANY CURRENT COLLECTOR ON A CAR IS IN CONTACT WITH CONTACT RAIL ALL CURRENT COLLECTORS ON THAT CAR CARRY 750 VDC HIGH VOLTAGE. ALL COLLECTORS MUST BE ISOLATED FROM THE CONTACT RAIL AND ANY OTHER POWER SOURCE BEFORE WORKING ON THE HIGH VOLTAGE SYSTEM. USE APPROVED LACMTA PROCEDURES TO REMOVE CONTACT RAIL POWER FROM TRACK SECTION AND PLACE APPLICABLE WARNING FLAGS OR LIGHTS AT EACH END OF TRAIN. ADDITIONAL PRECAUTIONS MAY BE TAKEN BY PADDLING OR REMOVING CURRENT COLLECTORS AND OPENING THE KNIFE SWITCH AND APPROPRIATE CIRCUIT BREAKERS. TO ISOLATE THE CURRENT COLLECTORS FROM THE CONTACT RAIL, INSERT WOODEN PADDLES (LOCATED IN A CABINET, IN THE PASSENGER CAB AREA) BETWEEN THE COLLECTORS AND THE CONTACT RAIL. FAILURE TO HEED THIS WARNING COULD RESULT IN SEVERE INJURY OR DEATH.**

6-1 DESCRIPTION AND OPERATION

The system takes the 750 Vdc from the third rail and converts it into VAC ranging from 0 to 525 V_{rms} line to neutral (910 V_{rms} line to line) for supplying the traction motors located on the trucks.

The functional block diagram of the High Voltage Power Distribution System is shown in Fig. 6-1.

The system is composed of the following components:

- Current Collector (MB)

- Rail Gap Group (MS) including:

- Knife Switch

- Main Fuse
- Auxiliary Fuse

- Line Breaker (MI)

- Line Filter Reactor (MK)

- Filter Charging Resistor (MP)

- Filter Charging Contactor (FCC)

- Main Inverter (MN)

- Traction Motor (MT)

- Braking Resistor Assembly (MQ)

- H.V. Circuit Breaker Panel (KP)

The 750 Vdc current is collected from the third rail by the current collector (MB), located on the truck, and is sent, through cable MCM 535, to the Rail Gap Group (MS), the Line Breaker (MI), the Line Filter Reactor (MK) and is applied to the Main Inverter (MN) which generates the AC current to power the traction motors.

6-2 DESCRIPTION OF THE COMPONENTS

6-2.1 Rail Gap Group (MS)

WARNING: HIGH VOLTAGE MAY BE PRESENT. THE KNIFE SWITCH SHOULD BE USED ONLY BY AUTHORIZED PERSONNEL.

The knife switch is a four-position manually operated switch:

- In position 1 (RUN) the rail power is connected to the main fuse to supply power to the car and, through the auxiliary fuse, to the circuit breaker panel.

- In position 2 (RAIL TEST) supplies third rail power to the auxiliary circuit only.

- In position 3 (OFF) disconnects power from all circuits.

- In position 4 (SHOP TEST), third rail power is disconnected from all main circuits. A plug connection at this position may be used to apply shop power to the auxiliary circuits when the car is in the shop for maintenance purposes.

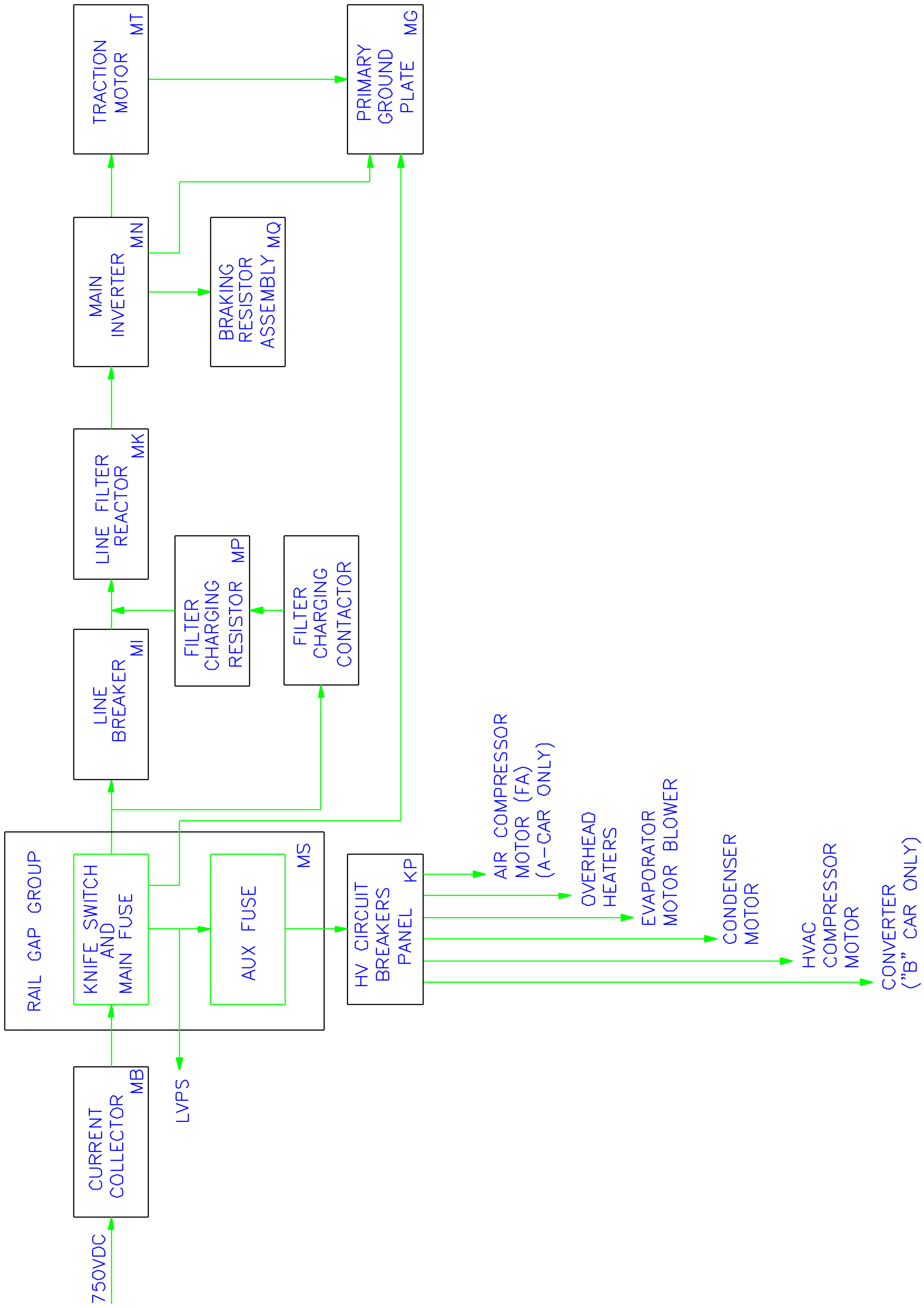

Figure 6-1. Primary Power Distribution

The main fuse interrupts high voltage application to the vehicle in case of short within the power system. The auxiliary fuse protects the circuit breakers in the KP box and opens if a circuit breaker has experienced an overload and fails to trip.

6-2.2 Line Breaker (MI)

The Line Breaker (MI), mounted on both cars (“A” and “B”) controls the 750 Vdc line input to the main inverter (MN).

6-2.3 Line Filter Reactor (MK)

The Line Filter Reactor (MK) mounted on both cars (“A” and “B”), filters the 750 Vdc input to the main inverter and reduces the noise induced by the inverter onto the line.

6-2.4 Filter Charging Resistor (MP)

The Filter Charging Resistor (MP), mounted on both cars (“A” and “B”), limits the charging rate of the main inverter filter capacitors through the Filter Charging Contactor.

6-2.5 Filter Charging Contactor

The Filter Charging Contactor closes upon application of high power, and the capacitors are charged. At that time, the Line Breaker (MI) closes and the Filter Charging Contactor opens, removing the Filter Charging Resistor (MP) from the circuit.

6-2.6 Main Inverter (MN)

The Main Inverter (MN) (one for each car) is an electronic device which transforms the 750 Vdc into VVVF power for the traction motors. It receives commands from ATO and MASTER CONTROLLER and converts them into VVVF signals for driving the traction motors with the correct traction effort or with the correct electrical braking percentage.

In dynamic braking, the kinetic energy of the vehicle is converted into electrical energy by the motors and the inverter system. This generated voltage is regulated by the braking choppers and the energy is recovered as current flow back into the third rail as regenerative power. If the supply is not fully receptive, the energy is then dissipated by the braking resistors.

6-2.7 Braking Resistor Assembly (MQ)

The Braking Resistor Assembly (MQ) mounted on both cars (“A” and “B”), includes the resistors which dissipate any excessive energy generated during electrical braking not utilized by the system.

6-2.8 HV Circuit Breaker Panel (KP)

The HV Circuit Breaker Panel, mounted on both cars (“A” and “B”), includes circuit breakers for the components listed in Table 6.1 where the relative amperage is also given.

WARNING: HIGH VOLTAGE MAY BE PRESENT, THE HIGH VOLTAGE CIRCUIT BREAKER PANEL IS TO BE USED ONLY BY AUTHORIZED PERSONNEL.

Table 6.1 H.V. Circuit Breakers

CURRENT	USER
20A	HVAC FRONT COMPRESSOR MOTOR
20A	HVAC REAR COMPRESSOR MOTOR
3A	HVAC REAR CONDENSER MOTOR
3A	HVAC REAR EVAPORATOR MOTOR
3A	HVAC FRONT EVAPORATOR MOTOR
3A	HVAC FRONT CONDENSER MOTOR
20A	HVAC FRONT HEATER
20A	HVAC REAR HEATER
5A	AIR COMPRESSOR MOTOR (“A” CAR ONLY)
50A	LVPS CONVERTER (“B” CAR ONLY)

6-3 TOTAL POWER LOSS

WARNING: WHEN ANY CURRENT COLLECTOR ON A CAR IS IN CONTACT WITH CONTACT RAIL ALL CURRENT COLLECTORS ON THAT CAR CARRY 750 VDC HIGH VOLTAGE. ALL COLLECTORS MUST BE ISOLATED FROM THE CONTACT RAIL AND ANY OTHER POWER SOURCE BEFORE WORKING ON THE HIGH VOLTAGE SYSTEM. USE APPROVED LACMTA PROCEDURES TO REMOVE CONTACT RAIL POWER FROM TRACK SECTION AND PLACE APPLICABLE WARNING FLAGS OR LIGHTS AT EACH END OF TRAIN. ADDITIONAL PRECAUTIONS MAY BE TAKEN BY PADDLING OR REMOVING CURRENT COLLECTORS AND OPENING THE KNIFE SWITCH AND APPROPRIATE CIRCUIT BREAKERS. TO ISOLATE THE CURRENT

(cont’d)

(cont'd)

WARNING:	**COLLECTORS FROM THE CONTACT RAIL, INSERT WOODEN PADDLES (LOCATED IN A CABINET, IN THE PASSENGER CAB AREA) BETWEEN THE COLLECTORS AND THE CONTACT RAIL. FAILURE TO HEED THIS WARNING COULD RESULT IN SEVERE INJURY OR DEATH.**

A complete power loss (see Fig. 6-1) can result only from one or more of the following conditions:

a. Current collectors not on contact rail or fuses blown.

b. Knife switch open.

c. Both main fuse and auxiliary fuse blown.

6-4 MAIN FUSE BLOWN

Refer to the Workshop Manual, Section 5, Para. 5-7.6.

6-5 AUXILIARY FUSE BLOWN

The auxiliary fuse, if not defective, can blow only if a circuit breaker in the KP box has experienced an overload and failed to trip. It is very likely that there will be visible damage at the site of the malfunction.

a. Look for signs of intense heat, fire, smoke, and/or melted insulation on the items listed below. The Operator's report may identify the system which originally malfunctioned.

   (1) Converter.

   (2) Air Compressor (A-Car).

   (3) Compressor-Condensers.

   (4) Overhead Heaters.

   (5) Evaporator Blower motors.

b. If the malfunctioning system is identified in step "a", perform the following:

   (1) Remove and replace fuse.

   (2) Remove and replace failed circuit breaker.

(3) Remove and replace damaged equipment.

c. If the malfunctioning system cannot be identified in step “a”, perform the following:

(1) Remove and replace fuse.

(2) Remove and bench test each circuit breaker at its rated capacity until the faulty one is found.

(3) Troubleshoot the associated system per the appropriate section of this manual.

WARNING: BEFORE WORKING ON OR NEAR CURRENT COLLECTORS, ALL COLLECTORS MUST BE ISOLATED FROM THE CONTACT RAIL OR/ANY OTHER POWER SOURCE. TO ISOLATE THE CURRENT COLLECTORS FROM THE CONTACT RAIL, INSERT WOODEN PADDLES (LOCATED IN A CABINET IN THE PASSENGER CAB AREA) BETWEEN THE COLLECTORS AND THE CONTACT RAIL.

6-6 REPLACING THE AUXILIARY FUSE

Refer to Workshop Manual, Section 5, Para 5-7.6.

6-7 PREVENTIVE AND CORRECTIVE MAINTENANCE

Detailed information about preventive and corrective maintenance of the high voltage power distribution components can be found in Section 7 of this Manual.

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SECTION 7

PROPULSION AND CONTROL SYSTEM

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7–1 THEORY OF OPERATION

7–1.1 OVERVIEW

7–1.1.1 Scope

This document explains the functioning of the Metro–Red Line–Passenger Vehicle AC–Drive propulsion system. Treatment of the equipment includes a detailed description of propulsion components supplied by General Electric Transportation Systems and that equipment supplied by others to the extent that it interfaces with the GE equipment. It also discusses a limited discussion of the PTU (Portable Test Unit). It also includes a limited discussion of the theory, functions, and diagnostic capabilities of the propulsion system.

7–1.1.2 Definitions and Abbreviations

Name	Schematic Section	Description
"A" Car		The half of a married pair without a converter.
ACG	102	Auxiliary Contactor Group, P/N 17KG511
Ambient Air		The air surrounding the object of interest.
AMBT	34A	Ambient Temperature Sensor; Sends ambient temperature reading from electronics panel to the Analog I/O Card. Power removed and event logged if AMBTS > 70°C or AMBTS < −35°C, PTU regulated. Resistance at 25°C = 100 kΩ; P/N 17FM602A1.
Auxiliary Equipment		Any mechanism or structure, other than the car body, traction motor or propulsion system gearing, which functions during car operation; e.g. car door operation and car lighting.
AUX	33A	Auxiliary Trainline Relay: Used to disable Low Voltage Power Supply
AUXS	33A	Auxiliary Trainline Relay Suppression Module; Used to reduce transient voltage levels which occur when coil is energized or de–energized; P/N 41B566971G1
AWG		American Wire Gauge.
AW0		Empty transit vehicle weight. (Ref. only, 80,000 lbs.)
AW1		Empty transit vehicle weight plus passenger seated load. (Ref. only, 89,086 lbs.)
AW2		Empty transit vehicle weight plus passenger seated load and normal rated standing load. (Ref .only, 107,720 lbs.)
AW3		Empty transit vehicle weight plus passenger seated load and full rated standing load. (Ref. only, 126,354 lbs.)
AF	1A	Auxiliary Fuse; Protects Auxiliary Equipment; P/N 41A296321BBP1
"B" Car		The half of a married pair with the converter.
Blended Braking		The electronic system provides the operational feature of blending of the friction and dynamic brake systems to achieve a commanded deceleration rate.

Table 7–1 Metro–Red Line Passenger Vehicle Propulsion System Devices

Name	Schematic Section	Description
BLF	23A	Battery Line Filter; Provides filtering and protection for low voltage (37 VDC) electronics in the 17FL337 Electronics Panel (CCUB Power input filter); P/N 17FM311M1
BLFD	23A	Battery Line Filter Diode; Provides reverse voltage protection for the Battery Line Filters. P/N 41A26304DB2
Braking Chopper	2A ,3A	Electrical device used to transfer electrical energy (current) to a resistive network, whenever the braking energy of the train cannot be directed into regenerative braking. Also regulates link voltage at a PTU–adjustable level (default 890V). Also CM1 and CM2.
Braking Effort		Retarding force developed by the propulsion subsystem, friction braking subsystem, or a combination of both subsystems.
Braking, Emergency		An irretrievable braking effort to fully stop a transit vehicle which is obtained from the friction brake subsystem, but with no braking effort provided by the propulsion subsystem.
Braking, Full Service		Full service braking occurs when the master controller handle is in the B_{max} position resulting in a deceleration of 3.0 mphps.
C1		Rail Gap Snubber Capacitor; Provides 1 µF of voltage transient protection for the Rail Gap Device; P/N 41A296302AHP2
CBBF	23B	Battery Line Filter Circuit Breaker; 10 A; pulling black button out kills power to the CCU/INV cards. P/N 41A267871P11
CIF11–19	9A, 9B	Inverter #1 Filter Capacitor Modules; 3600 µF, 1250V per module; 32,400 µF the bank; Provides energy storage and filtering for the inverter; P/N 41C668431G4
CIF20–28	10A, 10B	Inverter #2 Filter Capacitor Modules; 3600 µF, 1250V per module; 32,400 µF for the bank; Provides energy storage and filtering for the inverter; P/N 41C668431G4
CLF1–8	8A, 8B	Line Filter Capacitor Modules; 3600 µF, 1250V per module; 28,800 µF for the bank; Provides energy storage and filtering for the inverter; P/N 41C668431G4
CMIN	1A, 34B	Current Measuring Module – IN; Measures current going to Inv 1&2. Used with CMOUT in the detection of ground faults in the group, and to monitor 60 and 100 Hz current ripple as an integrity check for the filter. Logs fault if absolute value of (CMIN – CMOUT) >90A. Current ratio is 3000:1; P/N 41A296328AKP1
CMUT	2A, 34B	Current Measuring Module – OUT; See CMIN (no ripple detection); P/N 41A296328AKP1
CM1	2A	Braking Chopper GTO Module #1; Provides switching across the inverter #1 filter to dissipate energy through the Dynamic Braking Resistor group for Dynamic Braking and to regulate link voltage; Operates at 196 Hz, 180 degrees out of phase from CM2. P/N 17FM668A1
CM2	3A	Braking Chopper GTO Module #2; Provides switching across the inverter #2 filter to dissipate energy through the Dynamic Braking Resistor group for Dynamic Braking and to regulate link voltage; Operates at 196 Hz, 180 degrees out of phase from CM1. P/N 17FM668A1

Table 7–1 Metro–Red Line Passenger Vehicle Propulsion System Devices (Cont)

Name	Schematic Section	Description
CM1A	4A, 12A	Current Measuring Module – A Phase Inverter #1; Used to measure the inverter #1 phase A current. The A phase current is added to the B phase current to calculate the C phase current which is not measured. Current ratio is 3000:1. P/N 41A296328AKP1
CM1B	4B, 12B	Current Measuring Module – B Phase Inverter #1; See CM1A. P/N 41A296328AKP1
CM2A	5A, 16A	Current Measuring Module – A Phase Inverter #2; Used to measure the inverter #2 phase A current. The A phase current is added to the B phase current to calculate the C phase current which is not measured. Current ratio is 3000:1. P/N 41A296328AKP1
CM2B	5B, 16B	Current Measuring Module – B Phase Inverter #2; See CM2A. P/N 41A296328AKP1
CNA, CNB, CNC, CND	52 – 55	Connectors; These four 104–pin connectors bring all wiring into and out of the electronics panel; Located at the four corners of the EP
DBF	23A	Battery Filter Diode; Provides back feed isolation between the low voltage supply and the control electronics; P/N 41A296304DBP2
DCLF	2A	Line Filter Diode; Provides reverse voltage protection for line filter capacitors; P/N 41C660210G1
DL	1A	Main Line Diode; Provides Third Rail Power isolation; P/N 84D704327G1
DS	1A	Snubber Diode; Protects Rail Gap Device; P/N 41A296304ALP2
DIT1A,B,C	4A,4B	Inverter #1 di/dt Reactors for Phases A,B,C; provides current transient protection for the inverter GTO's; 500A and 5.5 μF. P/N 41A281874P1
DIT2A,B,C	5A,5B	Inverter #2 di/dt Reactors for Phases A,B,C; As above
Dynamic Braking		Electric Braking when all the braking energy is dissipated by the braking resistors.
EDM	28A,B	Event Display Monitor; Two digit display used to indicate events which have occurred in the system; Event code descriptions may be found on the Electronics Panel cover or in the PTU section of this manual; P/N 17FM532A1
Electric Braking		Braking by means of employing traction motors as generators to convert mechanical energy of the vehicle into electric energy to be dissipated by resistors (Dynamic Braking), or to be returned to the third rail or combination of both.
EMR3	40A	Emergency Relay; Existing emergency relay located in the KA box which drops out upon emergency. P/N (this part is supplied by others)
EP		Electronic Panel; Contains the 6 microprocessor–controlled cards of the Propulsion System Controller and the 5 cards of the Inverter Controller. P/N 17FL337
EPG	23B	Electronic Panel Ground; Electrical common point of the Electronics Panel; EPG is electrically tied to CCU low ground CCUN
F74	102A	Load Shed Fuse; Located in the Auxiliary Contactor Group; P/N 41A296321BGP1
FAN	32A	Inverter Group Cooling Fan; 32VDC–300CFM; P/N 41A281928P1
FANC	32A	Inverter Cooling Fan Contactor; P/N 17LV66A1

Table 7–1 Metro–Red Line Passenger Vehicle Propulsion System Devices (Cont)

Name	Schematic Section	Description
FANCS	32A	Fan Contactor Suppression Module; Used to reduce transient voltage levels which occur when coil is energized or de−energized; P/N 41B566971G1
FCC	1B, 30B	Filter Charging Contactor; Used to apply power to the filter capacitor bank when the difference between the line voltage and filter voltage is greater than 70V; charge currents pass through filter charging resistor FCR; P/N 41A296327ANP3
FCCS	32A	Filter Charging Contactor Suppression Module; Used to reduce transient voltage levels which occur when coils are energized or de−energized; P/N 41B566971G1
FCR	1B	Filter Charging Resistor; 1.04 ohm resistor used to limit line filter currents on charge up of the Line Filter Capacitors; P/N 17EM121AC1
FDC1	32A, 2B, 39A	Filter Discharge Relay #1; Used to discharge the inverter #1 filter capacitors when inverter #1 is isolated via ICO1, and to contribute in discharging the line filter capacitors when not isolated via ICO1; P/N 17LV66EB1
FDC2	32A, 3B, 39A	Filter Discharge Relay #2; Used to discharge the inverter #2 filter capacitors when inverter #2 is isolated via ICO2, and to contribute in discharging the line filter capacitors when not isolated via ICO2; P/N 17LV66EB1
FDC1S	32A	Filter Discharge Relay #1 Suppression Module; Used to reduce transient voltage levels which occur when coils are energized or de−energized; P/N 41B566971G1
FDC2S	32A	Filter Discharge Relay #2 Suppression Module; See FDR1S; P/N 41B566971G1
FDR	2B, 3B	Filter Discharge Resistors; Used in conjunction with FDC1 and FDC2 to discharge Filter Capacitors; P/N 84C614707G1
FIBER OPTIC CARD	21, 22	Fiber Optic Driver Card; Receives GTO firing signals from the both inverter CPUs and converts them to fiber optic light signals to command inverter and chopper GTO's on and off; Receives status and temperature feedbacks from GTO driver cards; Mounted on the outside of the 17FL337 panel; P/N 41C666382G6.
FLSWD	32B	Low Fan Speed Warning Detector
GBLF	23A	Gate Drive Battery Line Filter; Provides filtering and protection for low voltage (37 VDC) electronics of the Gate Drive Power Supplies GDPS1 and GDPS2; P/N 41C669184G1
GDCB1	102A	Circuit Breaker; Used to protect Gate Drive Power Supply #1; Located in the Auxiliary Contactor Group; P/N 41A296335AKP1
GDCB2	102A	Circuit Breaker; Used to protect Gate Drive Power Supply #2; Located in the Auxiliary Contactor Group; P/N 41A296335AKP1
GDPS1	19A, 19B	Gate Drive Power Supply for Inverter #1; Provides power to commutate on and off the inverter and braking chopper GTO's;. Input is 37V unfiltered, output is 25 kHz, 200V peak−to−peak (103VAC measured with Fluke) P/N 17FM589A3
GDPS2	20A, 20B	Gate Drive Power Supply for Inverter #2; See above. P/N 17FM589A3
GEAR UNIT	6A, 6B	Transfers motive power to the axle. Single reduction (121:19) parallel drive unit with a 6.3684:1 ratio. P/N 7GA81A1/A2

Table 7−1 Metro−Red Line Passenger Vehicle Propulsion System Devices (Cont)

Name	Schematic Section	Description
GFM	29B	Gate Firing Module. Used to gate the regen SCR
GROUND BRUSH	6A,6B	Ground brush passes electrical energy from the car components to the axle and running rail. P/N – part of gear unit
HG	2A	High Ground; The electrical return path for the main inverter group currents; Electrically connected to the Car Body Ground; P/N not applicable
High Voltage		Voltage level, of primary power, usually between 430 and 780 VDC.
HVAC		Heating, Ventilating and Air Conditioning.
HVLT–1	2B	Capacitor Voltage Indicator; Used to indicate Inverter #1 high filter voltage.
HVLT–2	3B	Capacitor Voltage Indicator; Used to indicate Inverter #2 high filter voltage.
HVLTP	2B, 3B	Indicator Resistors; Current limiting resistors for the HVLT #1 and #2 Indicators; P/N 84B108800G1
Inverter		A direct current to alternating current solid state device.
INVERTER CPU CARD	11,15	Inverter CPU Card (#1 and #2); Provides the inverter GTO firing, voltage regulation , torque regulation and self diagnostics necessary for the operation of the system; located in connector slots CN9,11; P/N 17FB138B1
INVERTER I/O CARD	12,13,14, 16, 17,18	Inverter I/O Card (#1 and#2); Receives the inverter speed, voltage, and current feedback for the Inverter CPU operations as well as outputs this information onto the CCU; located in connector slots CN10,12. P/N 17FB134A1
KNE	102A, 102B	Non–essential Load Contactor; Located in the Auxiliary Contactor Group; Controls non–essential bus; P/N 41B569857G2
KNSW	1A, 24A	Knife Switch; Used to manually connect and disconnect main power; Located in the Rail Gap Group P/N 41A327724P1
LB	1A,24B,32B, 39B	Line Breaker; High speed electromagnetic circuit breaker connecting the third rail power to the inverter line filter; The LB will trip if current exceeds the level set by the factory (approximately 2400A), and will pull in at 10Ω, and hold at 62Ω. Includes an arc chute and blowout coil to assist in opening under load and an air puffer circuit for low–current tip separation. P/N 41A296327AFP6
LBG	1A	Line Breaker Group; Consists of the LB Line Breaker, CMIN Current Measuring Module, VAM5 Voltage Measuring Module and the FCC Filter Charging Contactor; see LB, CMIN, FCC. P/N 17KG510
LBOLR	32B	Line Breaker Overload Relay; 30A relay which resets the line breaker when commanded to do so by the LBRR. P/N – part of line breaker assembly.
LBOLRS	32B	Line Breaker Overload Relay Suppression Module; Provides transient voltage protection for the LBOR
LBRR	32B, 39A	Line Breaker Reset Relay; Energizes LBOLR when the Line Breaker has been overloaded, unless the reset lockout count has been reached. P/N 17LV66CY53
LBRRS	32B	Line Breaker Reset Relay Suppression Module; Suppresses transients for the LBRS. P/N41B566971G1

Table 7–1 Metro–Red Line Passenger Vehicle Propulsion System Devices (Cont)

Name	Schematic Section	Description
LFR	1B	Line Filter Reactor; Provides impedance and filtering for the inverter and reduces the amount of transients passing to and from the inverter and the third rail. P/N 41A281970P1
LG	16A	Low Ground or CCUN; The electrical return path for the low voltage (37 VDC) power distribution; P/N not applicable
Low Voltage		Voltage level at which most auxiliary subsystems operate, nominally 37.5 VDC. Cards operate between 32 and 45 VDC.
LVPS		Low Voltage Power Supply; 750 VDC converted to 37.5 VDC. P/N 17KG512
LWIP	25A, 37B	Load Weigh; Receives signal from load weigh transducer in Friction Brake System of a voltage proportional to the weight of the car to the Analog I/O Card; P/N 17FM672B1
MD1	2B	Motoring Diode #1; Allows return current to flow freely during motoring, and causes regen currents to pass through the Series Resistor RS1 (0.451 ohm) during regeneration; P/N 17FM592A1
MD2	3B	Motoring Diode #2; As above
MIG	VARIOUS	Main Inverter Group; Physical grouping which contains the main inverter group components. P/N 17KG497
MPF	1A	Main Fuse; fuse between knife switch and line breaker. P/N 41A296321TP1
MOTOR	6A	Three Phase AC Traction Motor; converts 3–phase electricity which enters through the stator, to mechanical energy which causes the rotor, followed by the gear box quill and pinion gears, the axle, and the wheels to turn. P/N GEB–17A1
PM1A+, PM1A–	4A	Inverter #1 Phase A GTO Power Modules; Solid state switching device used as a main switch component in the power inverter bridge; P/N (+) 17FM590B1; P/N (–) 17FM591B1
PM1B+, PM1B–	4B	Inverter #1 Phase B GTO Power Modules; As above; P/N (+) 17FM590B1; P/N (–) 17FM591B1
PM1C+, PM1C–	4B	Inverter #1 Phase C GTO Power Modules; As above; P/N (+) 17FM590B1; P/N (–) 17FM591B1
PM2A+, PM2A–	5A	Inverter #2 Phase A GTO Power Modules; As above; P/N (+) 17FM590B1; P/N (–) 17FM591B1
PM2B+, PM2B–	5B	Inverter #2 Phase B GTO Power Modules; As above; P/N (+) 17FM590B1; P/N (–) 17FM591B1
PM2C+, PM2C–	5B	Inverter #2 Phase C GTO Power Modules; As above; P/N (+) 17FM590B1; P/N (–) 17FM591B1
POWER SUPPLY CARD	23B	System Power Supply Card; Provides regulated +/–5, +/–15 volts DC and Electronic Panel Ground to the CCU; located in connector Electronic Panel slot CN1 and CN2 (double card); P/N 17FB120A1
PRIMARY GROUND PLATE	6A	Connects motors and inverter to system ground through wheels. P/N this part is supplied by the car builder
PSC		Propulsion System Controller. Consists of 6 of the 11 cards in the Electronic Control Panel.

Table 7–1 Metro–Red Line Passenger Vehicle Propulsion System Devices (Cont)

Name	Schematic Section	Description
PTU	25A	Portable Test Unit; Computer based tester used to monitor functions, record event information, and perform tests on the CCU.
RCS1	2B	Chopper Module #1 Snubber Capacitor; Used to reduce voltage transients produced by the chopper module; P/N 41B569438G2
RCS2	3B	Chopper Module #2 Snubber Capacitor; Used to reduce voltage transients produced by the chopper module; P/N 41B569438G2
RG1	2A	Inverter #1 Grid Resistors; Contains Dynamic Brake Series Grids (1); Used during dynamic braking to dissipate energy as heat. Used during regenerative braking to elevate the inverter filter voltage. P/N 17EM128K1
RG2	3A	Inverter #2 Dynamic Braking Grid; As above.
RGG	1A	Rail Gap Group
Regenerative Braking		Process of returning the kinetic braking energy of the car to the third rail power system through the conversion of kinetic energy to electrical energy by using the traction motors as generators together with the inverter drive to produce the D.C. current returned to the power system.
R1	1A	Snubber Resistor; Used as a Rail Gap Device Snubber; 10Ω 25W; P/N 41A281418P1
R2	1A	Snubber Resistor; Used as a Rail Gap Device Snubber; 2 10Ω resistors in parallel; P/N 41C668644G1
R3	1A	Snubber Resistor; Uses as a Rail Gap Device Snubber; 80KΩ; P/N 41C668977G1
RS1A	4A	Inverter #1 Phase A Snubber Resistor; Used to reduce voltage transients caused by the switching on and off of the associated GTO's; P/N 41C669323G2
RS1B	4B	Inverter #1 Phase B Snubber Resistor; See description for RS1A; P/N 41C669323G2
RS1C	4B	Inverter #1 Phase C Snubber Resistor; See description for RS1A; P/N 41C669323G2
RS2A	5A	Inverter #2 Phase A Snubber Resistor; Used to reduce voltage transients caused by the switching on and off of the associated GTO's; P/N 41C669323G2
RS2B	5B	Inverter #2 Phase B Snubber Resistor; See description for RS2A; P/N 41C669323G2
RS2C	5B	Inverter #2 Phase C Snubber Resistor; See description for RS2A; P/N 41C669323G2
RSN1	2B	Chopper #1 Snubber Resistor; Provides 0.25 μF of voltage transient protection for the breaking chopper GTO. P/N 41C669323G1
RSN2	3B	Chopper #2 Snubber Resistor; Provides 0.25 μF of voltage transient protection for the breaking chopper GTO. P/N 41C669323G1
SC1	2B	Chopper #1 Snubber Capacitor; Provides 3 μF of voltage transient protection for the snubber GTO; P/N 41B569438G2
SC2	3B	Chopper #2 Snubber Capacitor; As above

Table 7–1 Metro–Red Line Passenger Vehicle Propulsion System Devices (Cont)

Name	Schematic Section	Description
SCRL	1A	Regen SCR Assembly, used to control regen braking.
SS1	13A	Speed Sensor #1; Sends Truck 1, Motor 1 speed information to the Inverter I/O Card; P/N 41A296328BAP1
SS2	13A	Speed Sensor #2; Sends Truck 1, Motor 2 speed information as above; P/N 41A296328BAP1
SS3	17A	Speed Sensor #3; Sends Truck 2, Motor1 speed information as above; P/N 41A296328BAP1
SS4	17A	Speed Sensor #4; Sends Truck 2, Motor 2 speed information as above; P/N 41A296328BAP1
SYSTEM ANALOG I/O CARD	34–37	System Analog I/O Card; Provides various analog I/O channels between the CCU and peripheral system hardware; located in connector slot CN6; P/N 17FB157A1
SYSTEM BATTERY I/O CARD	38,39,40	System Battery Level Digital Input Card; Receives and generates 37 V commands. P/N17FB128A2
SYSTEM CPU CARD	25	System CPU Card; Provides the system control and sequencing logic for system contactors and inverter operations according to system commands and feedback from the various car systems and the CCU I/O cards. Located in connector slot 3; P/N 17FB141A1
SYSTEM DIGITAL I/O CARD	28,29,30,31	System Digital I/O Card; Provides various digital I/O channels between the CCU and peripheral system hardware. Located in connector slot CN5. P/N 17FB125A1
Trainline		The means of sending a signal to all cars in a consist via a continuous electrical circuit connected through appropriate coupling devices.
SYSTEM CUSTOM CARD	26,27	Custom I/O Card; Located in slot 4. Communicates with the trainlines and friction brake system. P/N 17FB156B1
VAM1	35A	Voltage Attenuation Module #1; Used to measure the third rail voltage, VLF (DCP to HG); The signals are attenuated (201:1) at the VAM and sent on to the Analog I/O card; P/N 17FM559A1
VAM2	16A	Voltage Attenuation Module #2; Measures Inverter #1 phase voltages 1A,1B, and 1C; also measures the inverter filter voltages DC1P to DC1N; these signals are sent on to the Inv1 I/O card; P/N 17FM560A1
VAM3	12A	Voltage Attenuation Module #3; Measures Inverter #2 phase voltages 2A,2B, and 2C; also measures the inverter filter voltages DC2P to DC2N; these signals are sent on to the Inv2 I/O card; P/N 17FM560A1
VAM4	35A	Voltage Attenuation Module #4; Used to measure the Chopper #1 and #2 Voltages; The signals are attenuated (201:1) at the VAM and sent on to the Analog I/O card; P/N 17FM559A1
VAM5	35B	Voltage Attenuation Module #5–Line Breaker; Used to measure voltages on the line side of the Line Breaker (LB). The signals are attenuated (201:1) at the VAM and sent on to the Analog I/O card; P/N 17FM559A1

Table 7–1 Metro–Red Line Passenger Vehicle Propulsion System Devices (Cont)

7–1.1.3 'AC' Propulsion System

GE has supplied an AC propulsion system for the Metro–Red Line–Passenger Vehicle cars. These cars are in a married pair configuration with each car having two powered trucks. There may be up to three married pairs in a consist.

The Metro–Red Line–Passenger Vehicle AC Transit Propulsion system takes nominal 750 Volts DC, obtained from the third rail, and converts this source into a variable voltage variable frequency AC power supply. The inverter uses GTO silicon controlled rectifiers for the power inversion process. Each inverter feeds two AC traction motors, one per powered axle. The traction motors are the three phase asynchronous, self–ventilated type. This tractive effort is the sum of the force required to overcome friction and windage and the tractive effort needed to accelerate the vehicle.

The AC propulsion system incorporates a diagnostic system to aid in the troubleshooting and maintenance of the propulsion equipment. The diagnostic system has three parts: the system controller for event logging, a 2–digit display panel for annunciation, and a portable test unit for analyzing data and troubleshooting. The diagnostic system has the capability to log up to 200 events that can occur in the propulsion system. A fault light in the operator's cab will be annunciated if a restrictive event occurs and the lockout count has been reached.

Figure 7–1 shows a basic Propulsion System block diagram. These two inverters and the rest of the propulsion system are controlled by the System Controller, which in turn is controlled by the Trainline Commands from the operator (via the Master Controller) or via the Automatic Train Control System (ATCS).

Figure 7–1 Basic Propulsion Block Diagram

7–1.1.3.1 Married Pair

Figure 7–2 displays the major components of the propulsion system on each car. Each includes a Car Control Unit, two Inverter Controllers, four AC motors, and Power Inverters #1 and #2, which are all supplied by GE. The Master Controller, Automatic Train Control System and Friction Brake System are also integral parts of the propulsion system, but are not GE supplied items.

The Portable Test Unit (PTU) may be connected to the electronics panel or cab connection for diagnostic functions.

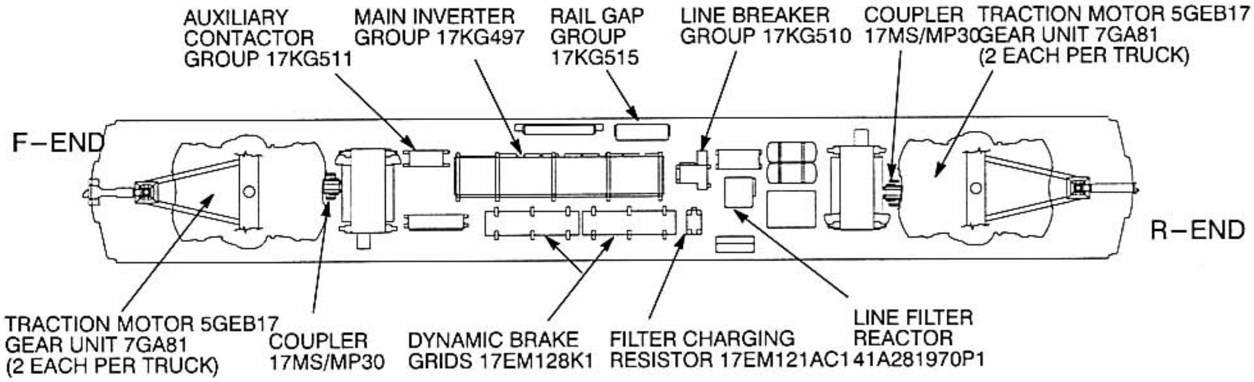
Figure 7–2 Married Pair Configuration

7–1.1.3.2 GE and Non–GE Supplied Equipment

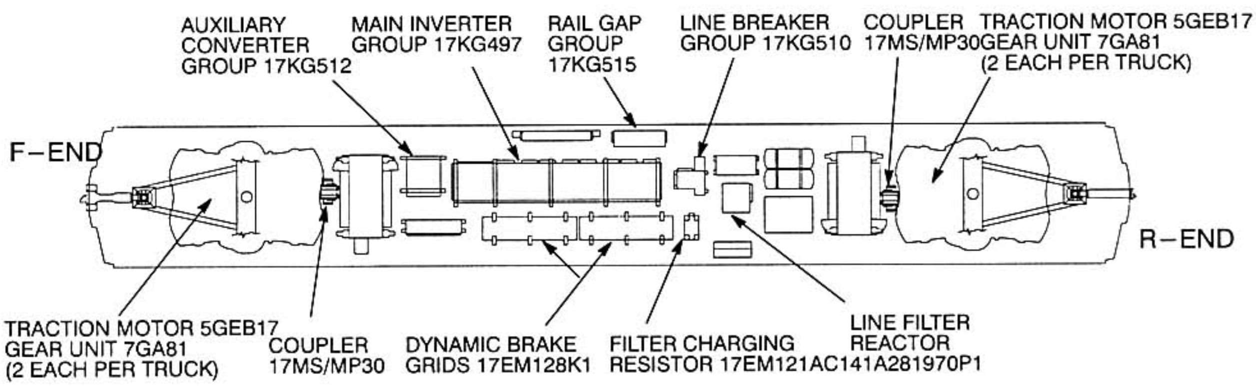
Table 7–2 lists the GE and non–GE equipment supplied for each car.

ITEM	DESCRIPTION	QTY./CAR
1.	17KG515A1 Rail Gap Group	1
2.	17KG510B1 Line Breaker Group	1
3.	Filter Charging Resistor 17EM121AC1	1
4.	41A281970P1 Line Filter Reactor (1.5 mH Air Core)	1
5.	17KG497A1 Main Inverter Group	1
6.	Braking Resistors 17EM128K1	2
7.	Truck Cable Quick Disconnects (4 cable, clam shell type)	1
	17MS30D2 Car Mounted Socket	4
	17MP30D2 Mating Plug Conn.	4
8.	AC Traction Motors (+ Speed Sensor)5GEB17A1	4
9.	Single Reduction Gear Units 7GA81A1 (6.368 G.R.)	4
10.	Couplings 7GAC9E1	4
11.	Gear Unit Suspension Pads , Bolt, Post + Spacers	2
12.	Auxiliary Contactor Group 17KG511 (A car only)	1
13.	Auxiliary Converter Group 17KG512 (B car only)	1
14.	Loadweigh Interface Panel (17FM672)	1
15.	Four PTU's, one power module shop tester, and one control module shop tester total.	
These items are not supplied by GE, but are necessary for proper propulsion operation:		
1.	Automatic Train Control	1
2.	Master Controller	1
3.	Friction Brake System	1
4.	Rear Motor Suspension Bracket , Misc Bolts + Shims	2

Table 7–2 GE Supplied Equipment



A – CAR



B – CAR

Figure 7–3 GE Propulsion/Auxiliary Equipment Arrangement

7–1.2 AC INDUCTION MOTORS

7–1.2.1 AC vs DC Propulsion Systems: DC System

Transit DC motor drives have been in service since the late 1800's. The series field DC motor was used because it provides a high acceleration torque at low speed and excellent speed control over a wide speed range. The controllers for most of these DC motor powered vehicles insert resistance in series with the motors at low speeds to limit starting current. (See Figure 7–4.)

As the motor back emf (internally generated voltage) increases at higher speeds, the series resistance is reduced in steps, until the motors are directly across the power source. To achieve still better high speed performance, a circuit path is provided to by–pass some of the motor armature current away from the field; this is called field shunting or weakening. Initially, much of the switching of resistors was done manually. Later, controllers operating motor driven cam shafts were used to control contact closures and cycle resistors in or out of the motor circuit. These have been the state–of–the–art throughout the world for many decades.

Figure 7–4 DC Motor Transit Propulsion System

The characteristic speed–acceleration curves obtainable with DC systems are shown in general form in Figure 7–5.

In mode 1 from zero speed to speed S1 of Figure 7–5, the motor current for maximum acceleration is held constant, thereby allowing a constant maximum torque and acceleration. At speed S1, the entire series resistance is shorted out and the motors are directly across the line. Between the speeds S1 and S2 (mode 2), field shunting/weakening is generally provided to hold essentially constant horsepower. Beyond speed S2 (mode 3), no further field weakening takes place and the motor torque follows the DC motor curve. In braking, the motors are connected as cross–excited DC generators and the power generated is fed into resistors to provide electric braking of the vehicle.

DC motors have proved to be very satisfactory in supplying the performance needed for transit drive applications. The principal disadvantage of these systems is that the motor requires substantial maintenance. DC motor brushes wear during normal operation. Carbon dust from the brushes can accumulate on the commutator of the motor and create a conductive path which shorts out windings in the motor. This is often accompanied by large arcing currents which create a brilliant flash of light, or a "flashover." Flashovers can accelerate commutator wear, which increases the maintenance on them.

Brushes also wear, requiring that they be replaced at regular intervals.

Aside from motor maintenance, the motor cam controllers used in these DC control systems also require attention. The power contacts used to open and close under load require regular maintenance to replace eroded contact tips and to avoid failures and flashovers in the under–car control groups.

All of this adds up to relatively high costs for DC system maintenance.

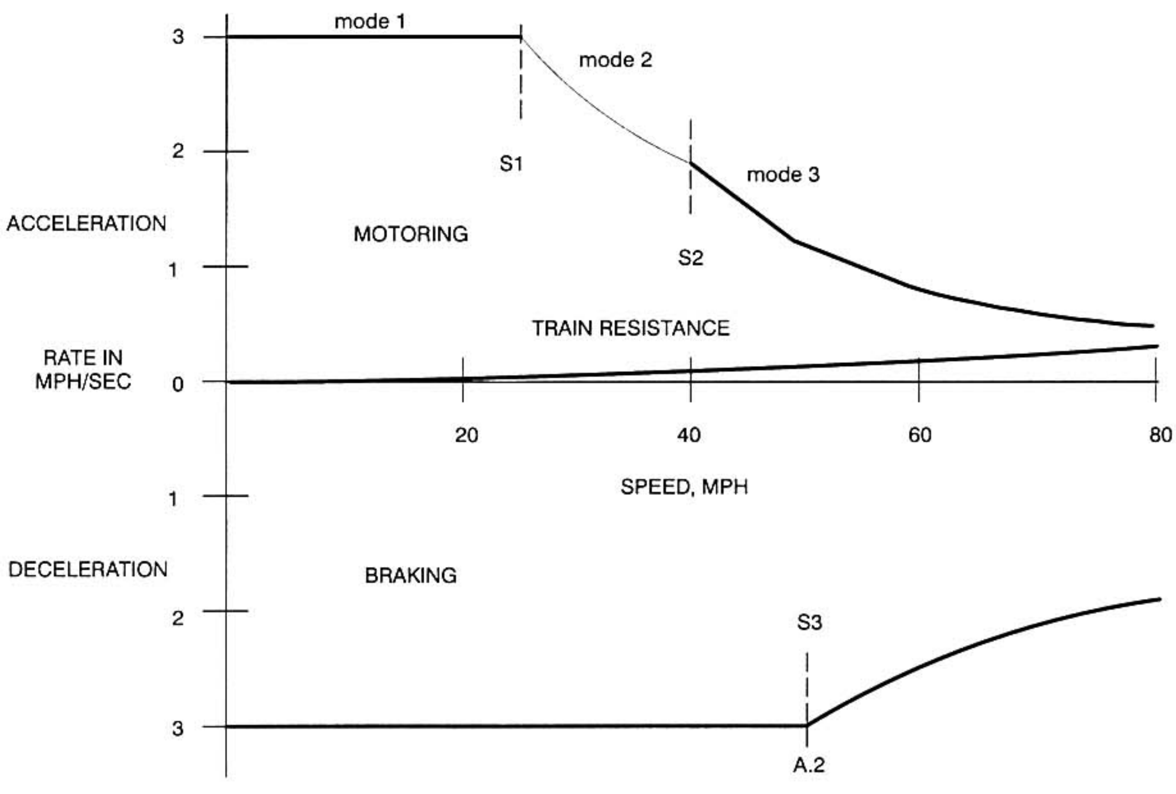


Figure 7–5 Transit DC Motor Acceleration vs Speed Profile Using Cam Control

7–1.2.2 AC vs DC Propulsion Systems: AC System

For the above reasons, system designers have been looking at the possibility of replacing DC motors with AC motors, which are designed to require less maintenance. The induction motor is particularly attractive since it is simple in construction and eliminates brush and rotor maintenance entirely. The AC induction motor has no commutator or brushes. Also, a three phase induction motor of a given horsepower will be physically smaller than a DC motor of the same horsepower.

Given a three phase power supply of a single frequency and voltage, the AC induction motor will produce a torque vs frequency curve as shown in Figure 7–6. On this graph, the units on the x–axis are in "per unit frequency." In other words, 1.0 corresponds to 100% of the applied frequency. Note that the speed of an induction motor is directly proportional to frequency.

Figure 7–6 illustrates that if an AC voltage source of a given frequency (say 460 VAC, 60 Hz) is applied to an AC induction motor, it will be capable of producing the maximum torque defined by the curve in Figure 7–6 over the range from 0.0 to 1.0 per unit frequency (0% to 100% speed).

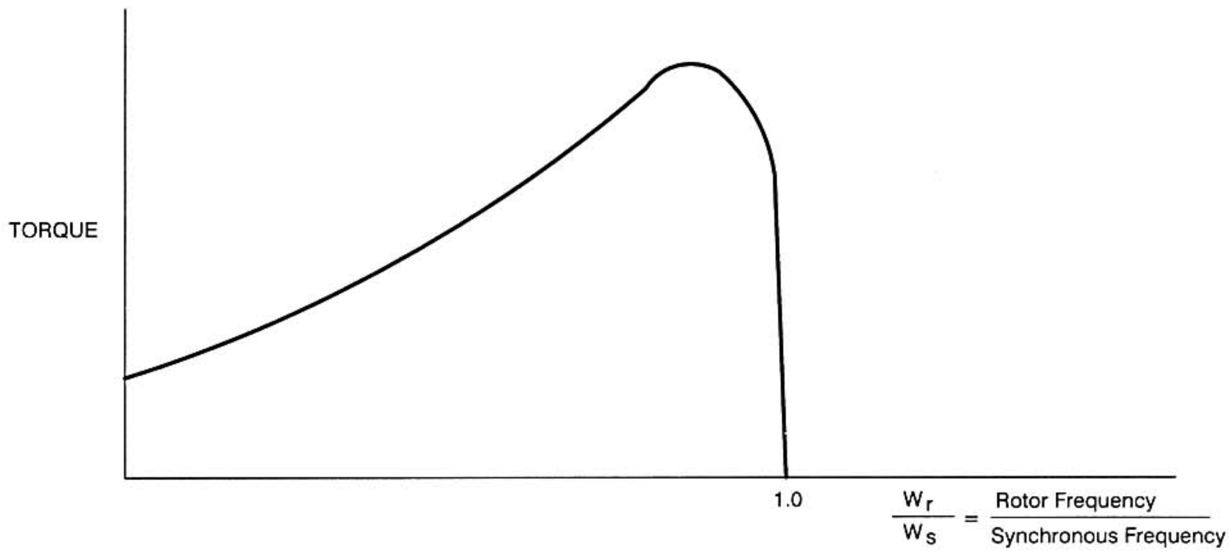


Figure 7–6 Torque vs Frequency for AC Induction Motor

The problem with this curve is that it provides a low torque value at low speeds. To apply the induction motor to the variable speed transit vehicles, an AC power inverter must be used. The AC power inverter, or simply "inverter", receives a DC voltage supply and inverts it to deliver variable voltage and variable frequency AC power for the AC induction motor. (Refer to AC Induction Motor Theory section 7–1.2.3 for more detailed information.) The inverter uses GTO silicon controlled rectifiers as switches for the power inversion process. These have no moving parts to wear out. Also, the output provided allows the induction motor to obtain nearly identical operating characteristics to the DC system. (See Figure 7–7.)

In short, the AC propulsion system offers the best of both worlds: rugged low maintenance equipment and high performance control.

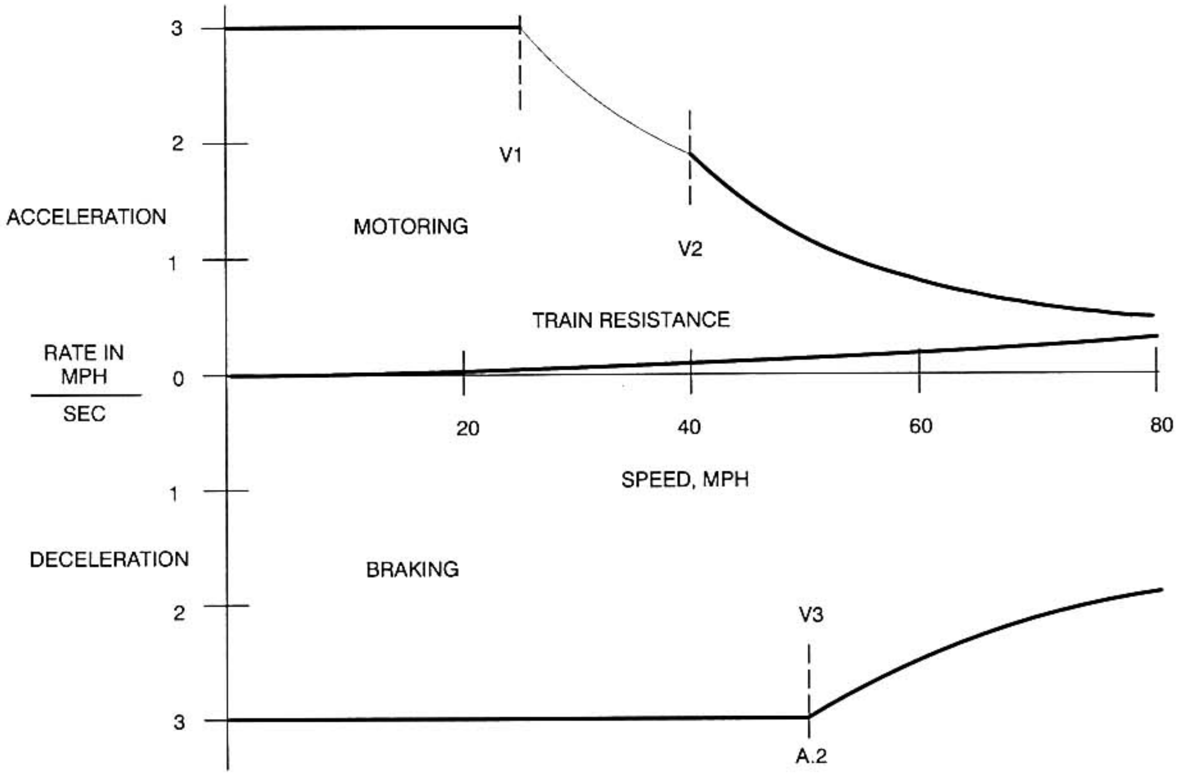


Figure 7–7 Transit AC Motor Acceleration vs Speed Profile Using AC Inverter Control

7–1.2.3 AC Induction Motor Theory

7–1.2.3.1 Three Phase Induction Motors

Currents in conductors such as copper wires produce magnetic fields. The greater the current passing through the conductor, the stronger the magnetic field emanating from the conductor. Magnetic fields are intensified by forming the conductor into coils. The greater number of turns in a coil, the stronger the magnetic field. The magnetic field produced by the coil has polarity, called north (N) and south (S) poles. When current changes direction, the polarity of the coil reverses, i.e., the N and S poles exchange places.

When an AC current is applied to the coil, the magnetic field increases then decreases with the current during the first half of the AC cycle, as shown in Figure 7–8. During the second half of the cycle the polarity in the coil reverses and the magnetic field again increases and decreases with the current. This is repeated for each cycle of AC current.

With three phase AC, there are three AC currents occurring 120 degrees out of phase with each other. Each current is connected to a separate set of coils. In Figure 7–9, phase B starts 1/3 of the way into phase A; phase C starts 2/3 of the way into phase A; and A starts its second cycle 1/3 of the way into phase C.

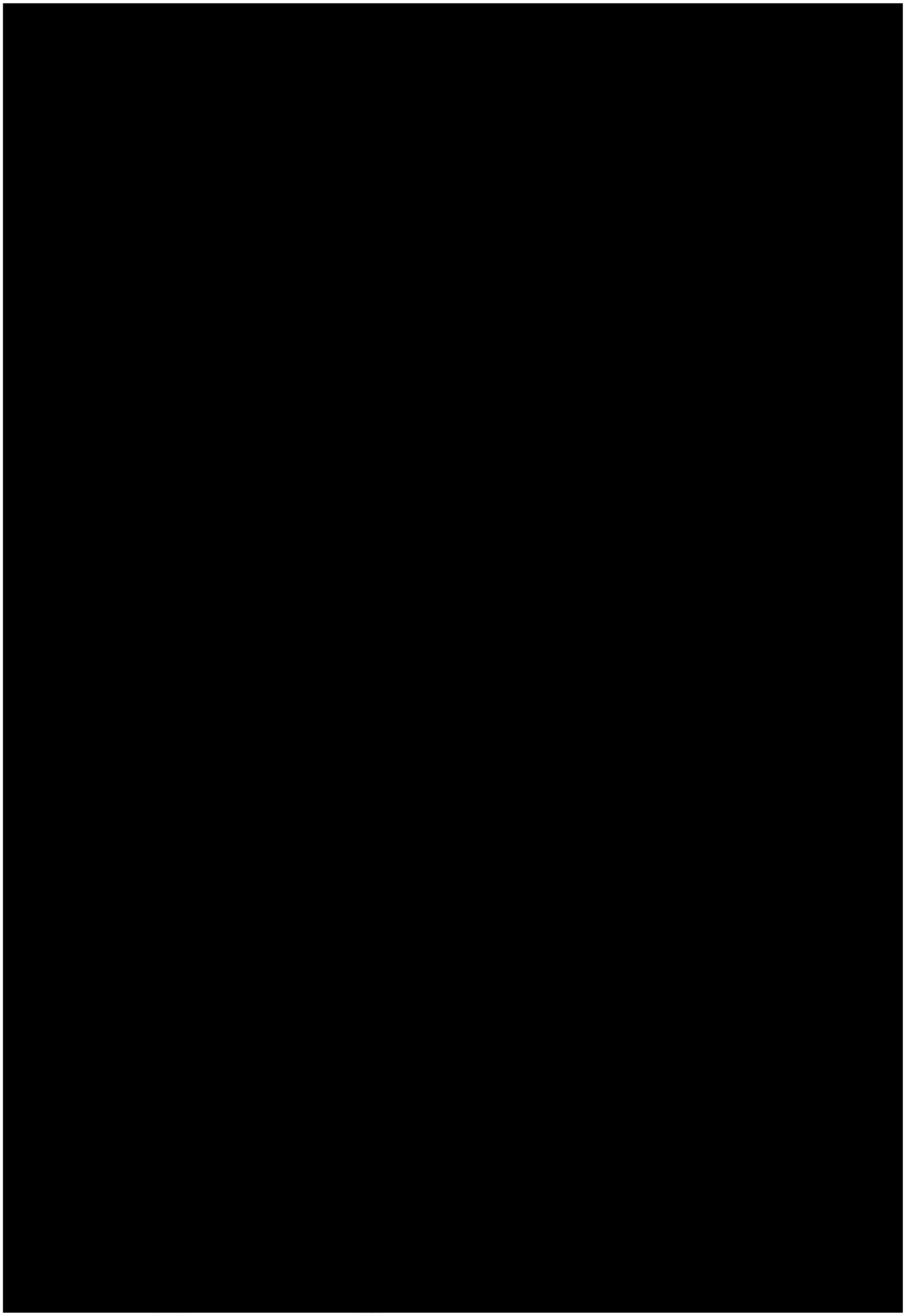


Figure 7–9 Three Phase Currents and Stator Coils (2–pole)

The induction motor used in AC transit applications consists of a stator, rotor, shaft, and frame, with an air gap between the stator and rotor. (See Figure 7–10.)

The stator consists of copper wire which is held in stator punching slots in close proximity to the air gap. The windings are grouped such that the voltages applied to them generate alternately north and south magnetic poles, at a given point in time. These magnetic poles will rotate around the inner surface of the cylinder in the air gap between the stator and the rotor. This is known as the *air gap flux.* The number of poles in the stator can be any factor of two (i.e., 2, 4, 6, 8, etc... poles per motor). This is determined by the way the stator windings are wound and distributed when the motor is manufactured. Excitation is applied to the stator via leads which are brought out to a junction box on the motor frame. Each lead is connected to a separate set of coils. The center of these coils are spaced geometrically 60° apart on a 4–pole motor.

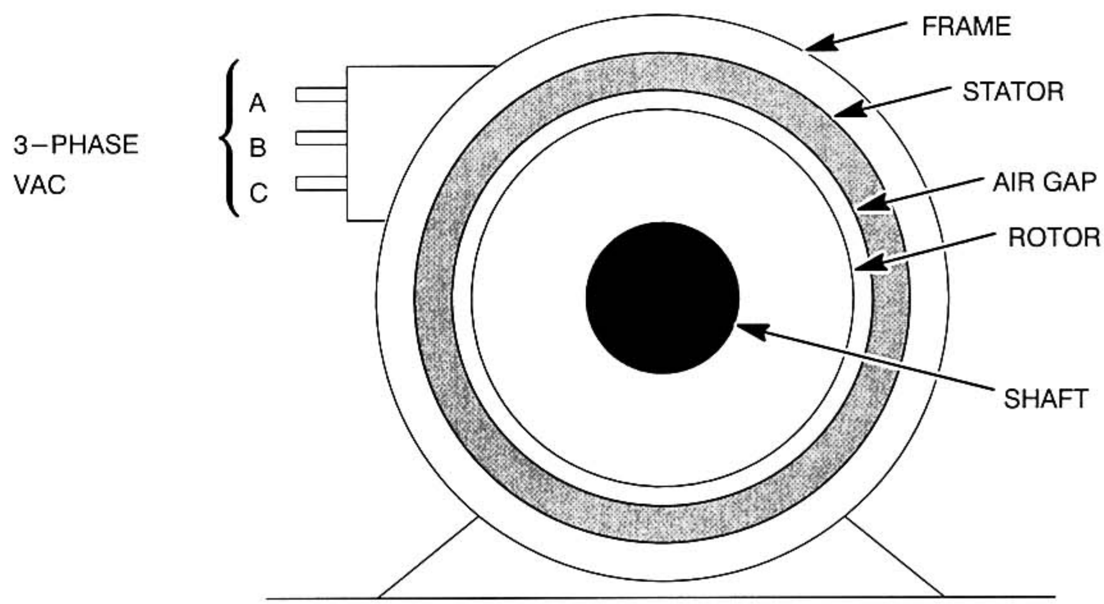


Figure 7–10 AC Induction Motor (End View)

When three phase currents are applied to one of the coils, a rotating magnetic field is produced in the stator. This magnetic field rotates because the N and S poles become stronger in the different phases at different times. For example, looking at the 3 phase AC current diagram, Figure 7–11, we can see that at time t=0, phase C voltage is very positive, phase A voltage is 0, and phase B voltage is somewhat negative. Using N and S for a very strong pole, n and s for weak poles, and 0 for no change, you can see that, at time =0, the magnetic field of the stator would look like Figure 7–12.

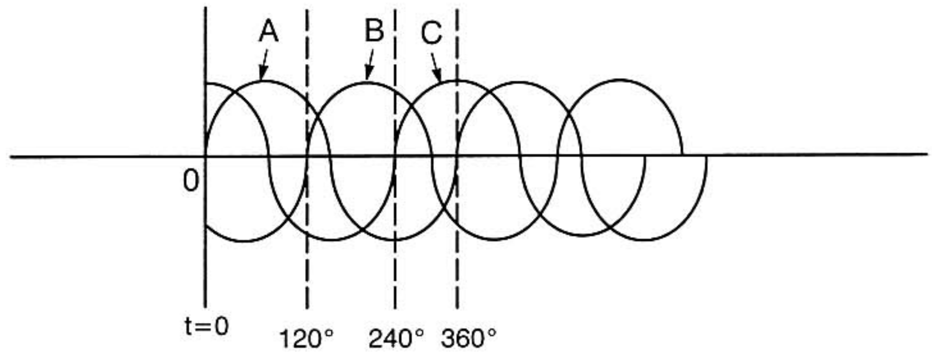


Figure 7–11 Three Phase AC Voltage

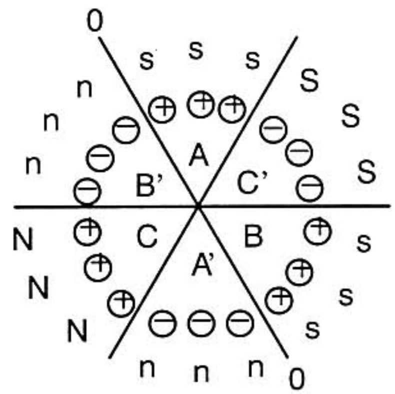


Figure 7–12 North and South Poles In a 2–Pole Motor

Remember that for each north pole, there must also be a south pole, since the stators are wound in a circular fashion. If B is the positive pole, B' would be the negative pole that carries the same current as B, but in the opposite direction.

The induction motor works under the same principal as a transformer. When alternating current is passed through the primary winding of the transformer (the stator), an alternating magnetic field is created. This alternating magnetic field travels around the air gap between the stator and rotor. When the secondary windings of the transformer (the rotor) are exposed to the rotating magnetic field, a voltage is induced. Because the rotor squirrel cage bars are shorted on each end, current flows in the rotor. This current creates a magnetic field in the rotor which is attracted to and repulsed from the stator flux. This attraction causes the rotor to turn, see Figure 7–13.

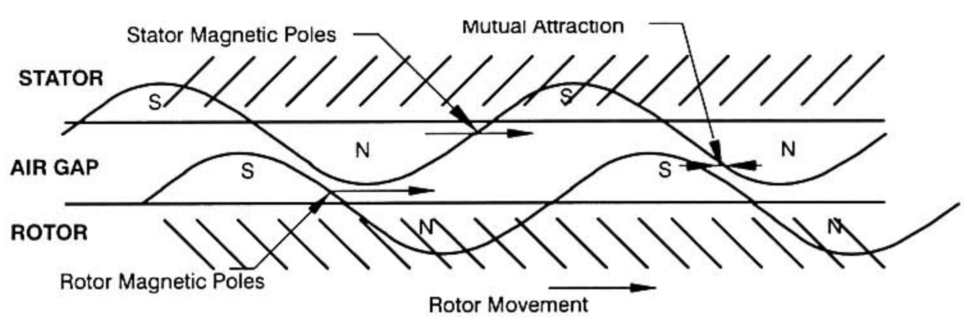


Figure 7–13 AC Induction Motor Air Gap Action

Two things must be known to determine the slip of a motor. These are the rotor speed and the synchronous speed. Slip can be expressed several different ways.

Slip may be expressed in RPM as the *slip speed* (n_s):

$$n_s = n_1 - n_2$$

where n_1 = synchronous speed in RPM
n_2 = rotor speed in RPM

Slip may also be expressed in *percent slip* (% slip) as:

$$\% \text{ slip} = \frac{(n_1 - n_2)}{n_1} \times 100 \text{ or } \% \text{ slip} = \frac{n_s \times 100}{n_1}$$

Finally, the slip may be expressed in *per unit slip* (s). In per unit, a value of 1.0 equals 100%. Per unit slip may be expressed as:

$$s = \frac{n_s}{n_1}$$

As an example, if we had a slip speed of 54 RPM and a synchronous speed of 1800 RPM, our per unit slip would be 0.03.

Under normal loaded conditions the AC induction motor is sized to operate with slip values between 0.02 and 0.05 per unit slip.

Torque– It can be shown that at low values of slip (to the right of point A on Figure 7–15), torque is proportional to the applied voltage, the frequency, and the slip as seen in the expression,

$$T \propto (V_a / f)^2 \times s$$

where V_a is the applied voltage
f is the frequency of the applied voltage
s is per unit slip
($\propto$ means "proportional to")

For a given voltage and frequency, the AC induction motor has the characteristic torque vs speeds curve as shown in Figure 7–15. Two items are of interest in this curve:

a. Torque at low speed is much less than the maximum torque of the motor.

b. Torque falls off dramatically as the motor reaches synchronous speed.

In the transit application it is desirable to have high torque capabilities at low speed. The above torque equation tells us that while changing the frequency to change the speed, torque can be held constant throughout the frequency range if the slip is held constant and the voltage is changed to keep the V_a/f ratio constant.

It would be as if we could generate an identical curve to Figure 7–15 for each point along the frequency range. The resultant series of speed vs torque curves are represented in Figure 7–16.

The dashed line indicates a possible 100% torque value which could be used under the above scenario. Note that the torque line falls off after the one per unit frequency point. Beyond this point, voltage remains constant and frequency continues to increase. Torque decreases as the speed increases. This is the CONSTANT HORSEPOWER range. In this region the inverter control causes an increase in the motor slip, which weakens the field, but causes a slower decay in torque with speed. Finally in the highest speed region, the slip is not increased further and the torque falls off in accordance with the torque equation:

$$T \propto (V_a / f)^2 \times s$$

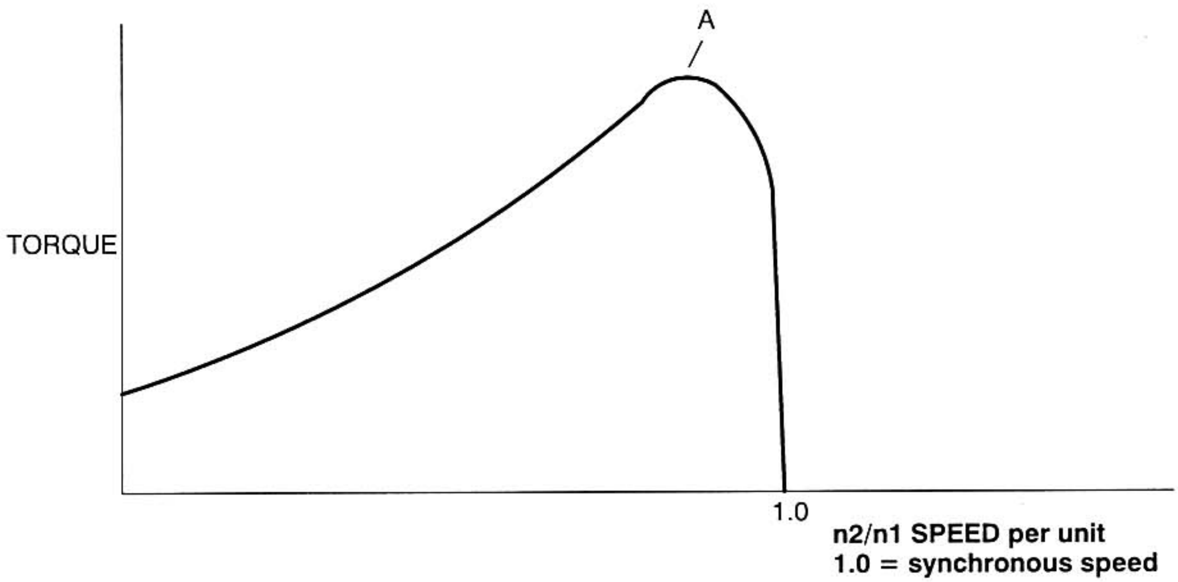


Figure 7–15 Torque vs Frequency for AC Induction Motor
(Curve is for a given voltage and frequency)

The CONSTANT TORQUE region is analogous to the DC motor running at base speeds. The CONSTANT HP region is analogous to the DC motor in weak field. Compare the dashed line in Figure 7–16 with Figure 7–17, and note the similar torque vs speed profile.

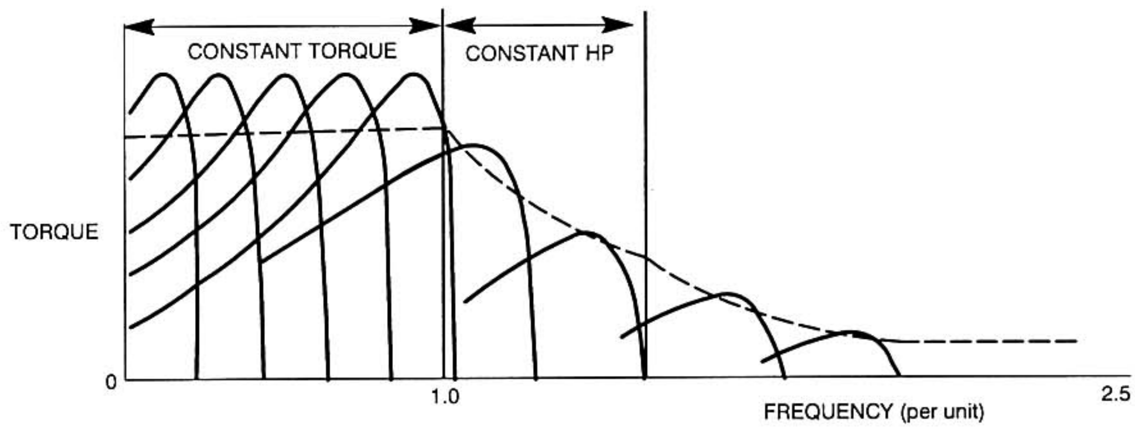


Figure 7–16 AC Motor Torque vs Frequency Curves

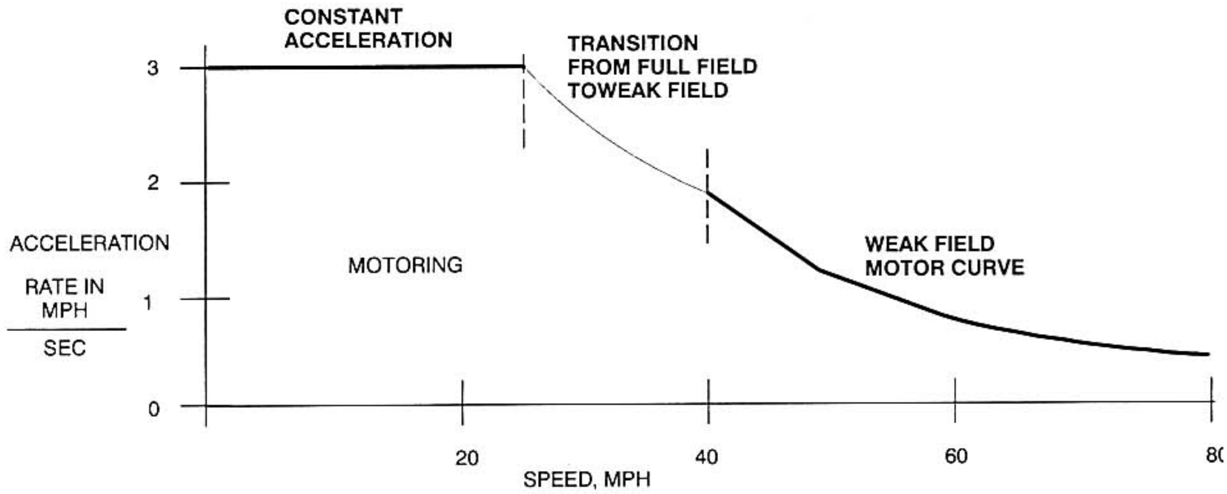


Figure 7–17 Transit DC Motor Acceleration vs Speed Profile

Torque Output– The curve of Figure 7–18 shows the acceleration vs speed (torque vs frequency) operating curve of the transit AC motor, supplied by the inverter. In the mode 1 region, constant torque is supplied by increasing the voltage (V_a) proportionally to frequency (SPEED) and holding the slip (s) constant. PWM exclusively is used from zero to approximately eighty per cent of the S1 speed on Figure 7–18. A combination of PWM and square wave called "patterns" is used from that point to the S1 mark.

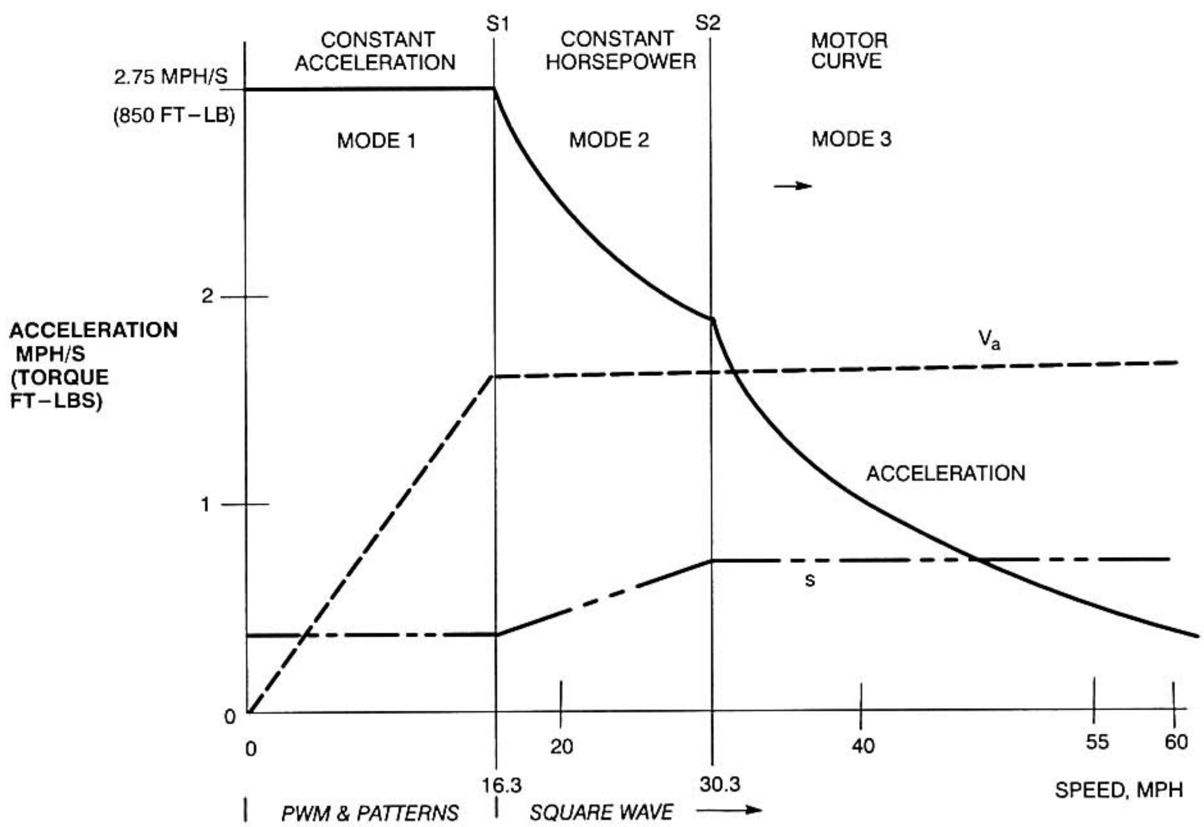


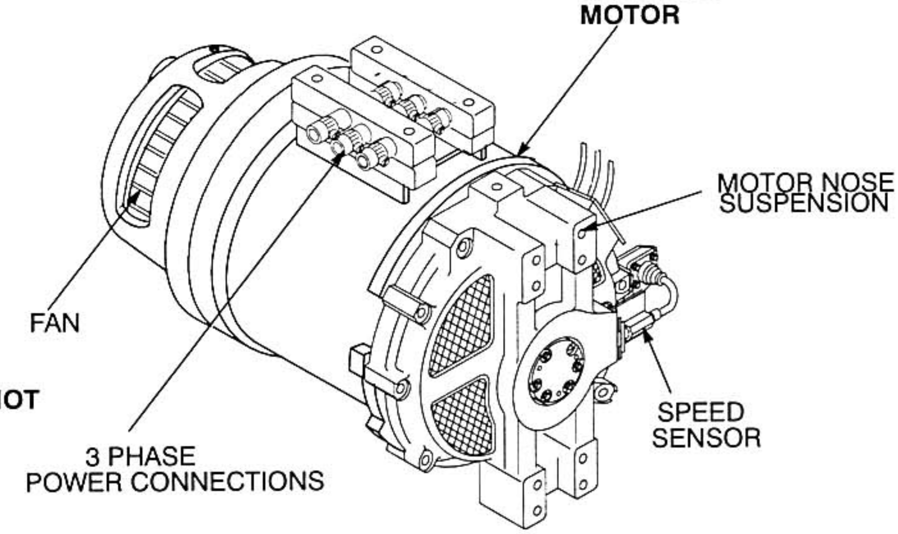
Figure 7–18 Motoring Acceleration vs Speed Profile

During mode 2 of Figure 7–18, the inverter puts out a constant voltage and continues to increase the frequency. Slip is increased to offset the reduction of the V_a/f ratio of the motor torque equation. Torque in this region decreases by 1/SPEED. Although not shown, horsepower is constant in this region. Square wave operation is used for all speeds above S1.

Finally, at still higher speeds (mode 3), the slip is again held constant and the torque above speed S2 falls off to match the existing DC motor drive. Since the GE inverter is designed to control the torque output of the AC motor, virtually any equivalency to the DC drive can be made.

7–1.2.4 Metro–Red Line Passenger Vehicle Induction Motor

Ratings– The propulsion system utilizes a three phase, four pole, asynchronous, induction motor. It has a top speed of 4800 RPM, which drives the cars to the designated speed of 70 mph. It has a torque rating of 1050 ft.–lbs. and a nominal horsepower rating of 250 HP. The motor is self ventilated by a shaft mounted radial blade fan.



NOTE:
THE GEAR UNIT IS NOT SHOWN.

Figure 7–19 AC Traction Motor

Suspension– The motor/gear assembly is attached to the car by a two point suspension system. This uses vertical, rigid shock mounts which attach directly to the motor and the car body (supplied by others). These support the speed sensor end of the motor. The traction motor is attached to the gear box by five resilient bushings between the motor and the gear unit to provide an interface between the coupling end of the motor and the gear box.

Speed Sensor– The Metro–Red Line–Passenger Vehicle motor uses a digital speed sensor mounted on each motor to send speed information to the inverter. The speed sensor consists of a 96–tooth gear mounted to the motor shaft and an active sensor device mounted to the motor housing. The speed sensor counts the number of teeth which pass the sensor in a given period of time. The speed sensor detects direction as well as speed.

Wiring to the sensor is as follows:

a. SC–A [+12 VDC] – RED

b. SC–D [COMMON] – BLACK

c. SC–B [DIRECTION] – GREEN (not used)

d. SC–C [CHANNEL 1 FREQ.] – WHITE

e. SC–F [CHANNEL 2 FREQ.] – ORANGE

f. SC–E [SHIELD] – BARE

The square wave speed signal is sent to the inverter controller. The relationship between speed sensor signals and speed with 34.5 in. wheels are as follows:

with 99.25 Hz/MPH ➔ 62.03 MOTOR RPM = 1.0 MPH

The speed information is used to limit the car to a software adjustable maximum speed (70 MPH). This speed limit may be adjusted using the PTU. It is also used for wheel slip control by the CCU, as well as acceleration and deceleration control.

If one of the two inverter motor speed sensor fails, the other takes over, and a fault is generated. If both fail, a no power condition will be imposed, regardless of the feedback of the other inverter.

Motor Connection– The inverter three phase output connects to the AC traction motor at the motor disconnect MD, where wires then go to the motor cable cleat assembly. The cable cleat assembly is mounted on top of the motor housing. See Figure 7–20.

Figure 7–20 Motor Connection

Gear Unit–7GA81A1 – This gear unit is a single-reduction, parallel-drive unit which transfers motive power from the traction motor to the car axle by means of two gears and shafts. See Figure 7–21. The pinion gear shaft is coupled to the traction motor through the 7GAC9E1 flexible coupling, which is a gear-coupled, self-aligning, grease-lubricated device, see Figure 7–21. The pinion (high speed) gear drives the low-speed (quill) gear. The gear box provides a reduction of 6.368 to 1.

The quill-end of the gear unit is pressed on to the axle. The integral flange on the gear unit provides for mounting and alignment of five resilient bushings between the motor and the gear unit.

The motor end of the gear unit is attached to the truck by means of a gear unit suspension mount that provides cushioning between the gear unit and the truck.

The gear box consists of a fabricated steel case which houses the helical gear train and quill. Roller bearings and gears are gravity-lubricated by oil from a reservoir located under the inspection covers on top of the gear box. The inspection cover on the quill end of the box provides access to the gears.

The gear box structure includes a safety hanger which provides independent support for the gear unit in the event of suspension system distress.

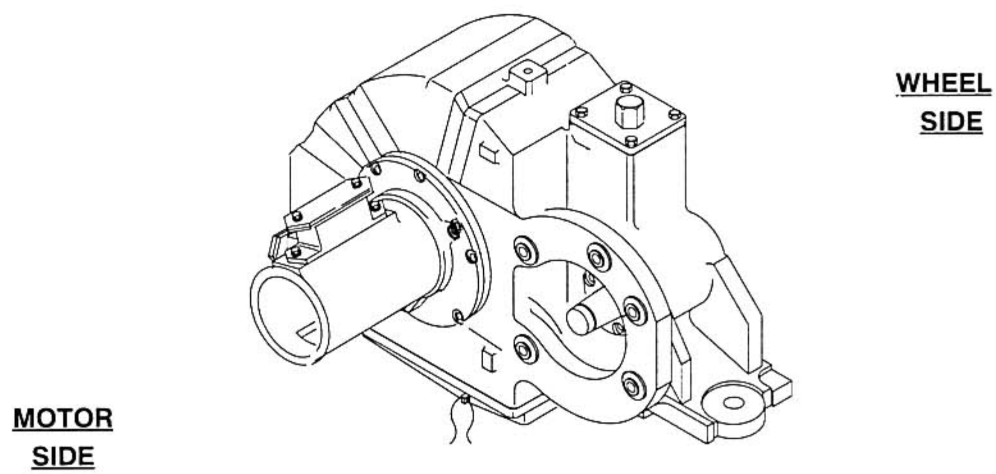


Figure 7–21 7GA81A1 Gear Unit

7–1.3 INVERTER

7–1.3.1 Inverter Theory

Before discussing the operation of the inverter, a brief overview of the AC inverter switching operation and power switches is presented.

7–1.3.1.1 AC Inverter Switching Operation

See Figure 7–22 thru Figure 7–24.

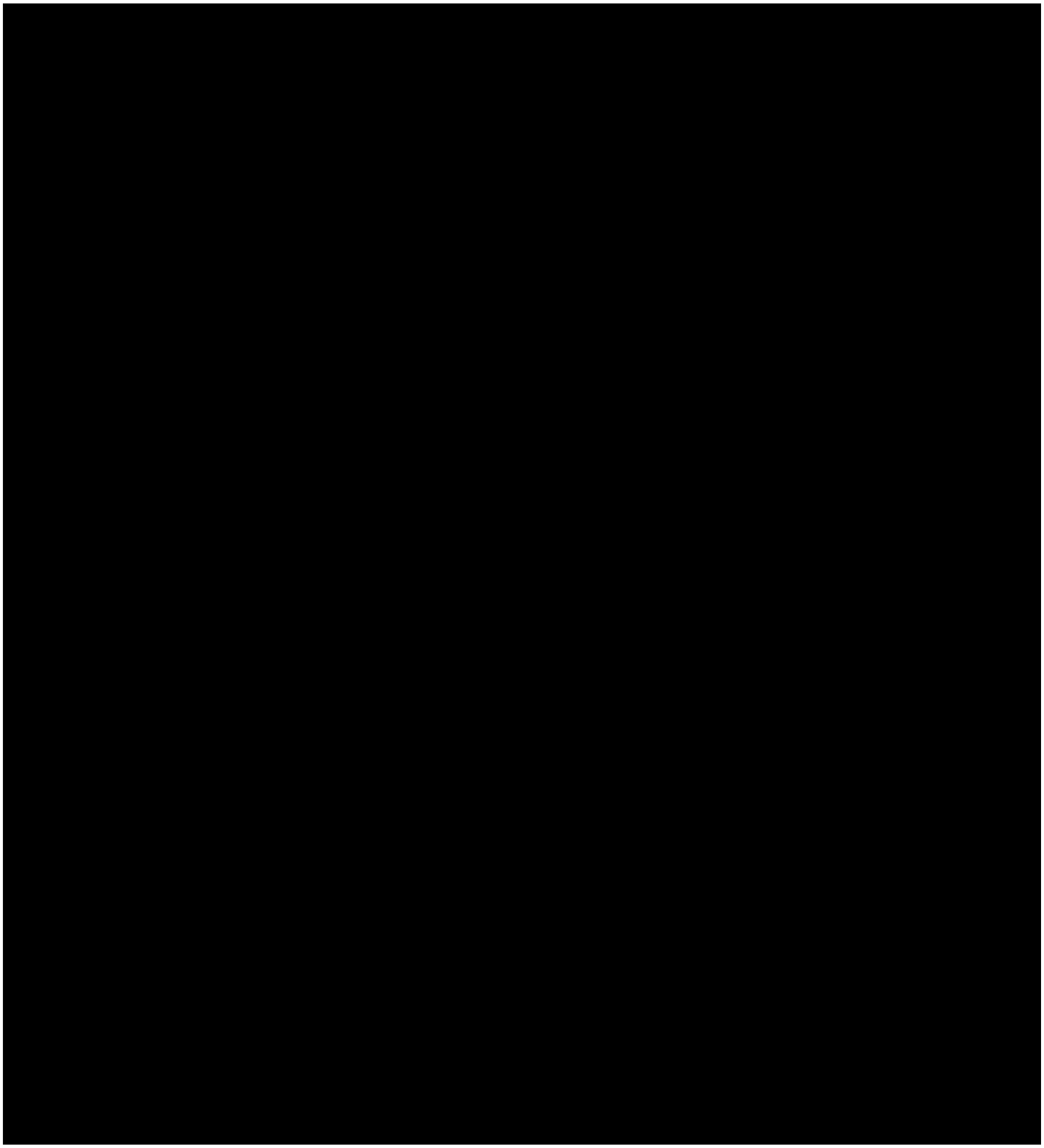


Figure 7–22 AC Inverter Switching (Part 1)

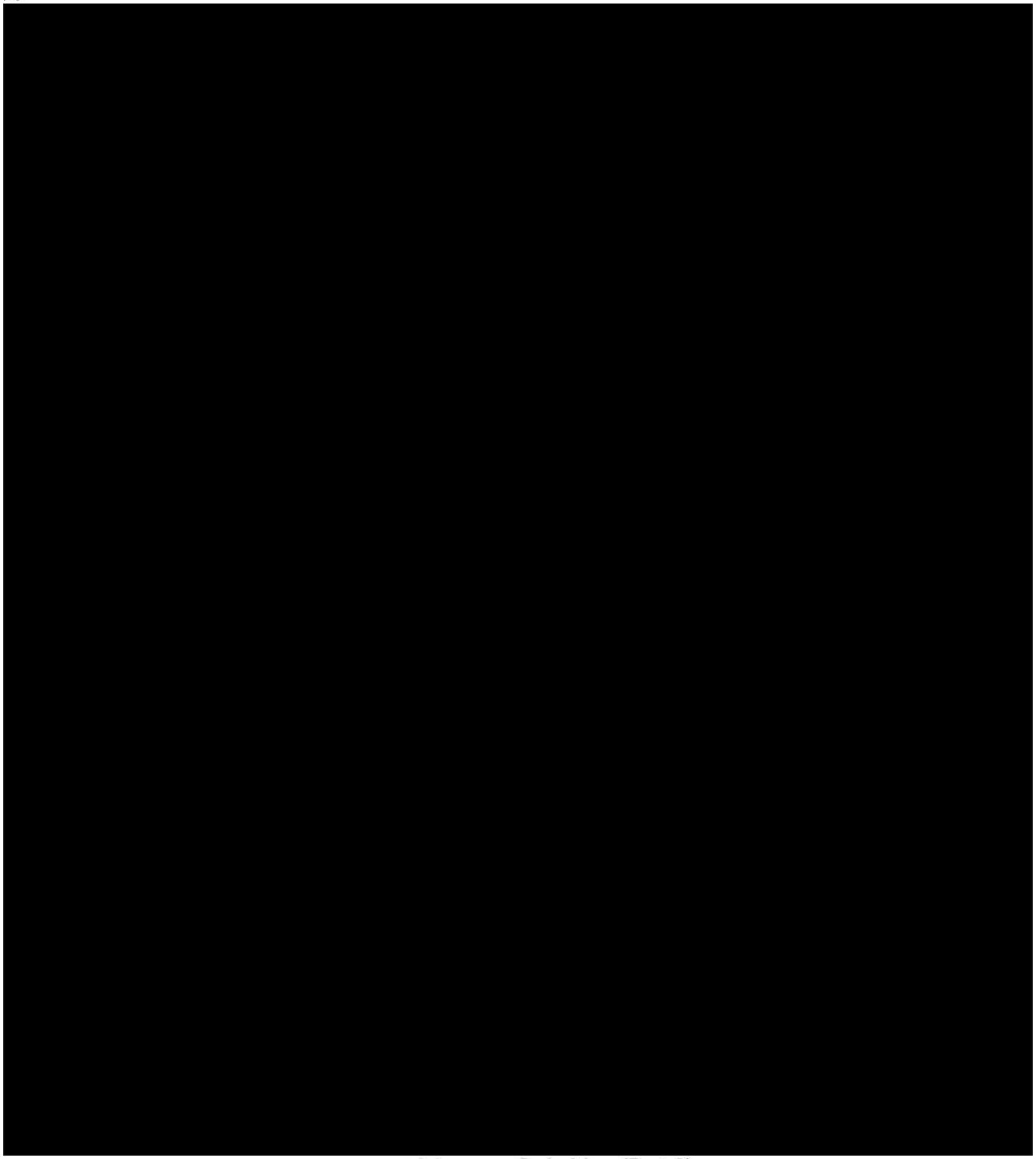


Figure 7 – 23 AC Inverter Switching (Part 2)

Figure 7–24 AC Inverter Switching (Part 3)

7–1.3.1.2 Power Switches: SCR's and GTO's

Silicon Controlled Rectifier (SCR)– The SCR is a four layered, PNPN semiconductor device. It is similar to a diode in that it will block current in one direction. However, an SCR will block the flow of current in both directions in a circuit, and can be made to conduct current when needed in one direction only.

SCR's used in converter and inverter applications provide the function of an efficient high speed power switch. The SCR is capable of turning on in as little as 1 μs, and turning off in 10 to 50 μs. It is used in applications conducting anywhere from very few amperes to over one thousand amperes of current.

When a voltage is applied to the anode and cathode of an SCR as shown in Figure 7–25, and a small gate current is applied (I_g), then current (I_{ak}) is allowed to flow in the direction of the arrow through the main body of the SCR. Once (I_{ak}) current is flowing, it will continue to flow even if the gate current is removed. To stop the (I_{ak}) current, it must be reduced to be less than the small amount of current known as the holding current. This is done a number of different ways. One is to reverse the voltage polarity at the SCR anode and cathode. Another is to reduce the (I_{ak}) current by shunting the SCR with a low impedance L–C circuit. In either case (I_{ak}) must be brought below the holding current level. The latter technique is normally used for inverter applications. The problem with this style of circuit switching is that large commutating currents are required to flow in the SCR commutation circuit. This current can often cause induced currents in the vehicle running rails and can become a potential problem to the train occupancy signalling system. This problem is avoided by use of a newer power switch called the GTO (Gate Turn–Off) thyristor.

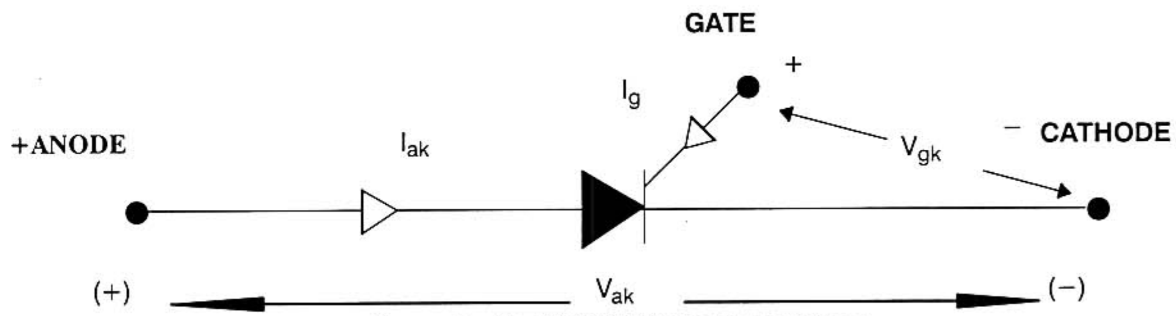


Figure 7–25 SCR/GTO Representation

Gate Turn Off Thyristor (GTO)– The GTO is a four–layer PNPN device which was invented soon after the standard SCR in the later 1950's. The turn–on of the device is essentially identical to the standard SCR and requires only a small positive gate current to occur. However, the GTO device is constructed so that if a large negative current is drawn from the gate of the GTO for a short time, the GTO will turn off. The turn–off gain is much lower than the turn on gain and therefore the amount of negative gate current needed to turn it off is relatively large. Where perhaps 2A of gate current can turn the GTO switch on, gate currents of minus 500A may be needed for a short time to turn the GTO off. The total power consumption is relatively small, due to the short (≈ 90 ms) time duration of the actual switching.

The ability to simply command the GTO off and its ability to conduct large currents make the GTO the best choice for power switch for the transit vehicle.

GTO's must be protected from several concerns for dependable operation. The first concern is heat. The switching on and off (or commutating on and off) of a GTO creates heat in the device. If temperature is allowed to rise unchecked, the GTO will reach a point where gating is no longer required to allow current to flow in the device. GTO's are always mounted to a heatsink to conduct the heat away from the GTO cell. It is very important that the heat sink assembly is ventilated according to the manufacturer's instruction to insure proper operation.

Another concern is transient voltages which occur in the normal operation of power conversion (or inversion in this case). Switching a GTO on or off in an energized inverter circuit creates large transient voltages which appear across the GTO. The greater the magnitude of the voltage with respect to the time period of the transient, the greater the likelihood that the GTO will be caused to transition into a conductive state. This can occur regardless of the GTO gate circuit state. An R–C snubber is used to reduce the transient effects and allow the GTO to operate properly.

High current transients can also produce damaging effects in GTO's, causing localized heating within the GTO itself. This can cause degraded operation and shorten the life span of the device. A saturable reactor is used to protect the GTO from this problem. The reactor impedance will be high for large current transitions, but will decrease once a "steady state" current is attained.

7–1.3.1.3 Inverter Basics

The power distribution available to a transit system is either DC or AC of a single frequency. To use the induction motor as discussed above would require a controller which could generate a continuous range of voltages and frequencies to allow the motor to produce high torque over the entire speed range. This cannot be done with any simple controller similar to that of the DC motor controller.

However, this can be done with a device called an *AC power inverter,* or simply *inverter.* In fact, by using an inverter, the induction motor can obtain the same characteristics as that of a DC motor. One type of inverter is a motor–generator set, which is a rotating power inverter. This is quite heavy and requires much equipment maintenance in itself. The better solution is to use powered semiconductor devices in a "static" power inverter.

In its simplest form, there are very few primary components in the static inverter. It is comprised of a DC voltage supply, an L–C filter for energy storage and filtering, six power switches, and the controls which cause the switches to open and close in the necessary sequence.

Figure 7–26 shows a simple inverter power circuit. This inverter feeds a three phase induction motor. For simplicity, mechanical switches are used in the drawing to represent the semiconductors.

There are several different methods of power inversion which can be employed in the inverter system. The two that are used in the GE inverter are Pulse-Width Modulation and Square Wave (also known as 6-Step). Both of these voltage inverter methods are used.

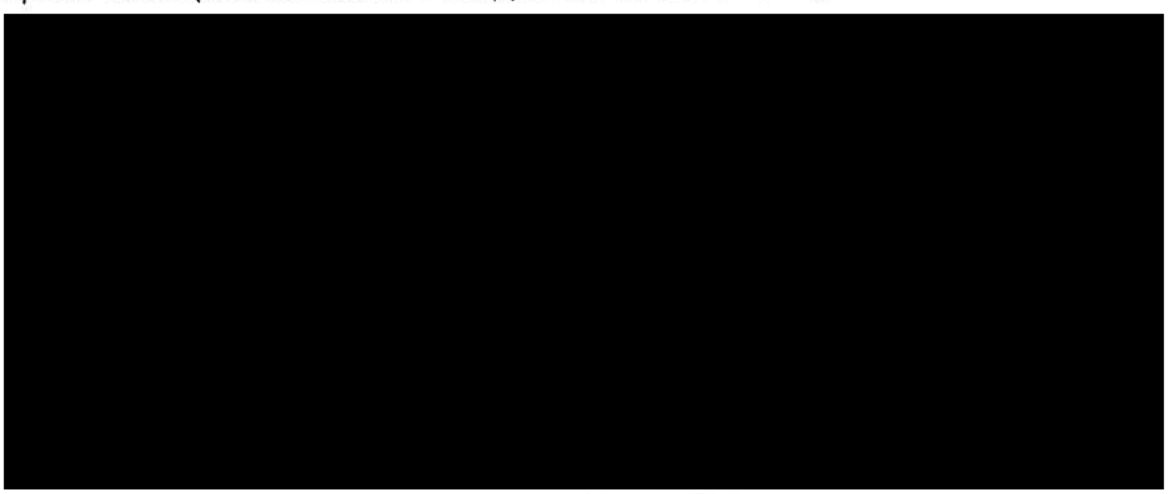


Figure 7–26 Simple AC Inverter

With either method, each motor leg will be alternately connected to the positive or negative side of the inverter DC filter. At any given time, two motor legs will be positive and one will be negative, or vice versa. As a motor leg is switched from positive to negative, the current flowing through the winding is reversed. This provides the method of alternating current flow, which allows the transformer action to occur, as discussed in the AC Induction Motors section. See AC Inverter Switching Operation Section to see the switching sequencing.

The semiconductor devices which are used as switches are GTO's which are described further in GATE TURN OFF THYRISTOR (GTO) section. These switches have very low losses and can be switched many times per second without damage or appreciable wear.

7–1.3.1.4 PWM METHOD

Pulse Width Modulation (PWM) operation requires the inverter to connect each leg of the motor to the high and low side of the DC voltage source (as do all inverter methods). The switching rate is limited to approximately 540 Hz, in order to keep from overheating the devices. The time duration each phase is connected to either the high or low side of the DC supply will determine the amount of current rise and/or fall in that winding of the motor. The switching is digitally regulated to provide a roughly sinusoidal current to the motor. Figure 7–27 shows the line to ground and line to neutral voltages produced by PWM.

The digital controller uses a comparison of two waveforms, shown as comparator voltages above, to determine when to switch each phase of the motor to the positive or negative side of the DC supply. The reference voltage wave V_A is the fundamental frequency and is representative of the voltage amplitude we are trying to produce on the motor. The triangle wave V_T occurs at the chopping frequency of the inverter. The amplitude and frequency of these signals are determined by the inverter controller. The inverter is made to connect each motor phase to either the positive or negative supply each time the sine wave signal and the triangle signal for that phase intersect.

[redacted]

Figure 7–27 PWM Voltage Wave Forms

The average voltage applied to the motor can be decreased (or increased) by decreasing (or increasing) the amplitude of the reference voltage V_A with respect to the triangle wave V_T. A lower reference voltage amplitude will cause the switches to be closed for a shorter period of time and opened for a longer period of time. This results in a lower average voltage output and therefore lower current from the inverter. The PWM inverter is effective in controlling motor operations from zero to close to the rated frequency of the motor.

One problem with real world inverters is that each time a switching device closes or opens a circuit, harmonic currents are created in the system which produce heating losses. Also, switching itself causes power loss in the switching device. For these reasons, it is desirable to keep the number of switch operations to a minimum, which is why we prefer to switch from the PWM to the square wave inverter once a high enough frequency is reached.

At high frequencies, the PWM switching patterns are optimized to smooth the transition to the "Square Wave" switching method. This subset of PWM switching is call "patterns" mode.

7–1.3.1.5 Square Wave METHOD

Figure 7–28 illustrates the square wave voltage output. Each is offset by 120° and are measured from the positive inverter output bus to the negative bus. The 3 phase motor is shown very simply in a wye configuration (center to neutral) with each leg drawn as a resistive unit (for this explanation). Figure 7–29 displays output voltages for each phase as measured from positive to negative inverter bus, from phase to phase on the motor and from line to neutral on the motor.

The square wave inverter, also known as a 6–step inverter, uses the same switch configuration as PWM, but works at a much slower switching frequency. While in PWM each switch may operate many times for each cycle of the fundamental frequency being output to the motor, in square wave operation each switch will operate only twice per cycle. Each switch will close for 180 electrical degrees of the fundamental frequency, and then open for 180 electrical degrees.

The disadvantage of slower switching of square wave is that the current and voltage waves seen by the motor are much choppier than for PWM. However, at high frequencies the AC motor may use a square signal and still function correctly.

The advantage of square wave operation is that it has much less loss of power from switching and parasitic harmonic currents, which are problems with PWM. Square wave operation is used only at the higher speed (near rated frequency and above) because it does not have the ability to vary the voltage. We may still control torque however, by controlling the motor slip, and the frequency of switching.

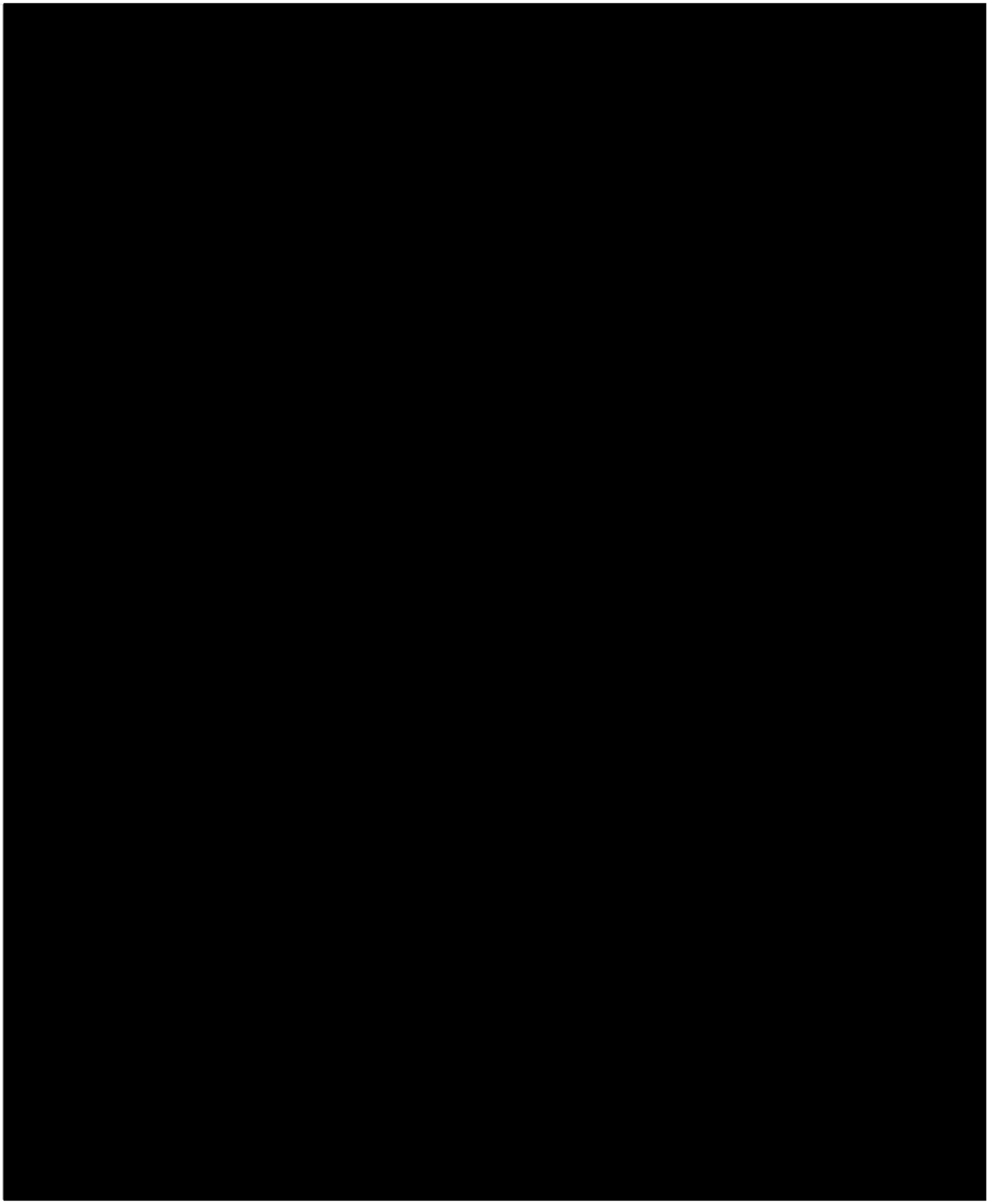


Figure 7–29 Square Wave Inverter Various Voltage Wave Forms

To determine the voltage at each leg of the motor in square wave operation, two points will be viewed at six successive periods in time (Figure 7–30 thru Figure 7–35):

a. Phase A to Phase B.

b. Phase A to Neutral.

Figure 7–30 Square Wave Inverter 0°–60°

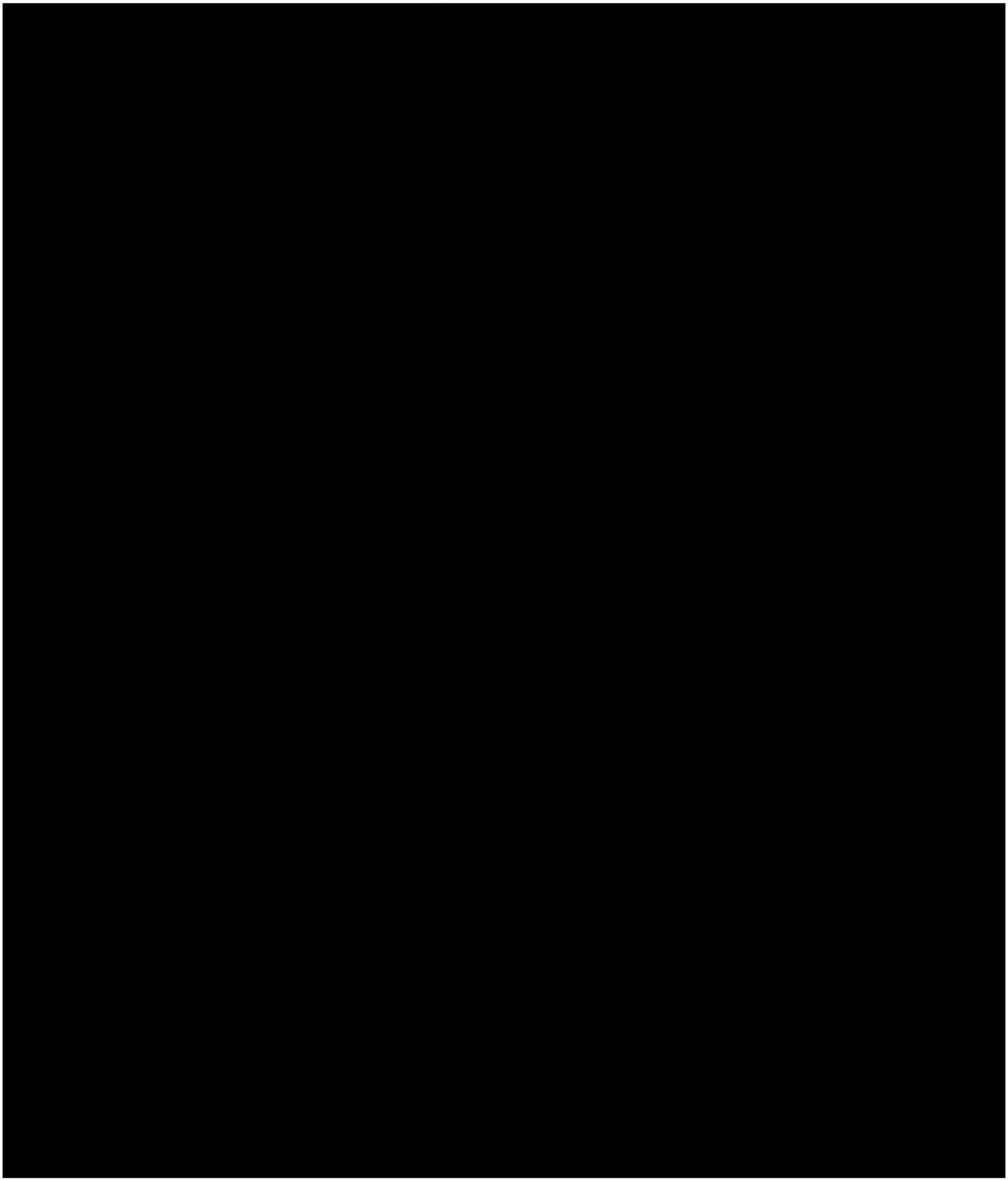


Figure 7–32 Square Wave Inverter 120° –180°

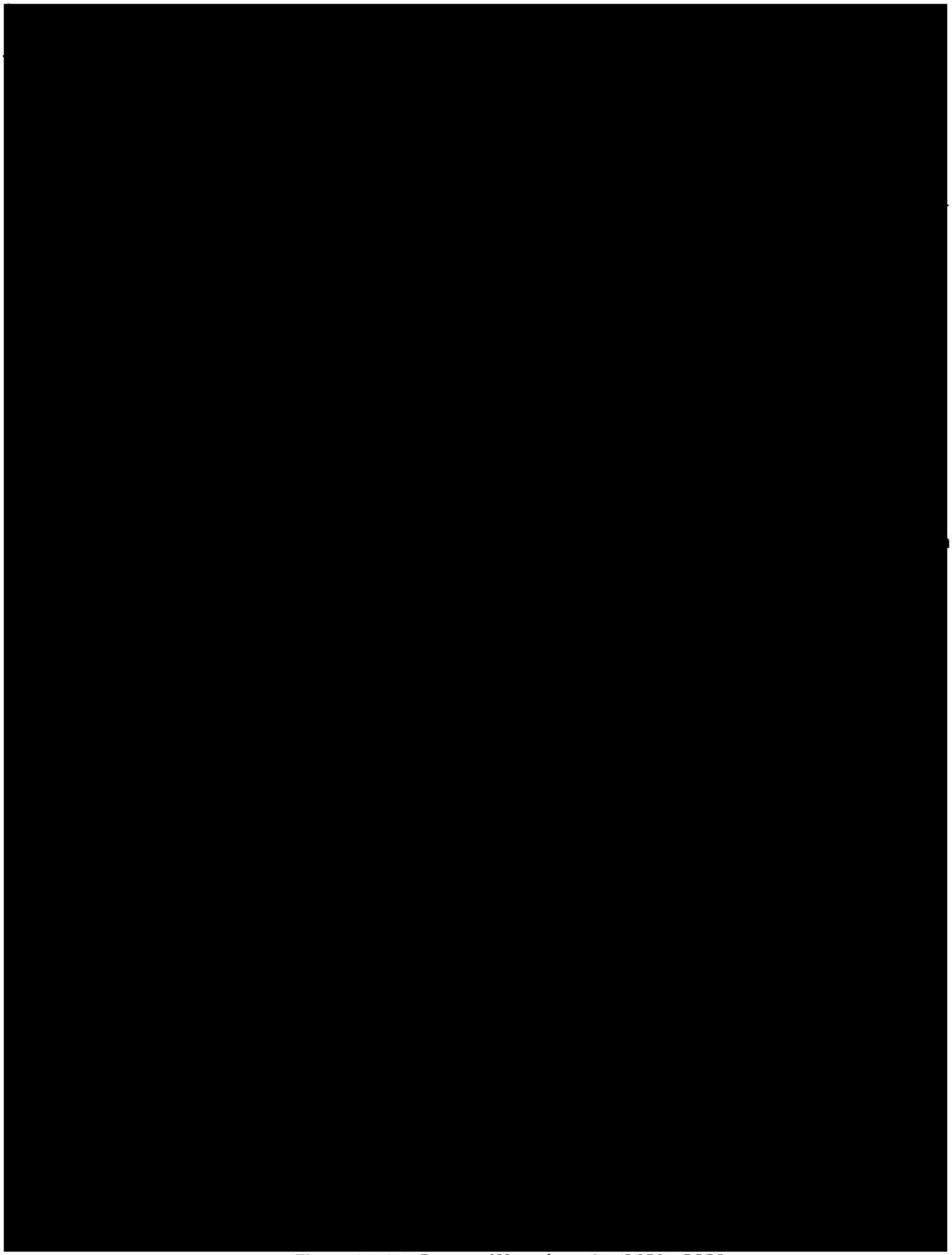


Figure 7–34 Square Wave Inverter 240°–300°

Figure 7–35 Square Wave Inverter 300°–360°

7–1.3.2 Inverter Applications

7–1.3.2.1 Motoring/DC to AC Conversion

During motoring, the inverter converts the DC voltage to AC by sequencing the power switches (GTOs) to produce AC for the traction motors. The inverter electronically alters the phase sequence of the power sent to the motor to change the rotation of the vehicle for forward and reverse operation. To produce positive (motoring) torque, the inverter sequences the switches so that the stator frequency "leads" the induced motor frequency.

7–1.3.2.2 Electrical Braking/AC to DC Conversion

During electrical braking, the AC motors are used as generators to produce a negative torque. To produce negative (braking) torque, the inverter sequences the switches so that the stator frequency "lags" the induced motor frequency. This causes a transfer of power from the motors, through the GTO's (which act as rectifiers in this case), to the line filter capacitors. This DC power is either dissipated in braking resistors, called dynamic braking, or returned to the third rail to help supply other accelerating vehicles on the line. The return of the DC power to the third rail during braking is called regenerative braking and its use can result in power savings to the transit authority. Both forms of braking extend the life span of the friction brake equipment. The line filter capacitors and reactor smooth the ripple currents caused by the GTO switching to provide "cleaner' DC power to the third rail during regeneration.

7–1.3.3 Inverter Parts

The main assemblies of the Inverter are the DC Filter and the Inverter Bridge. A typical inverter bridge is shown in Figure 7–36.

Figure 7–36 Typical Inverter Power Bridge

7–1.3.3.1 DC Filter

The DC Filter consists of:

a. Filter Charging Resistor (FCR)

b. Line Filter Reactor (LFR)

c. Filter Discharge Contactors (FDC1, FDC2)

d. Filter Discharge Resistors (FDR)

e. Line Filter Diode (DCLF)

f. Line Filter Capacitors (CLF)

g. Inverter Filter Capacitors (CIF)

7–1.3.3.2 Inverter Bridge

The Inverter Bridge consists of:

a. GTO Phase Modules (PMA+, PMA–, PMB+, PMB–, PMC+, PMC–)

b. Snubber Resistors (RS)

c. DI/DT Reactors (DIT)

7–1.3.3.3 Additional Components

a. Chopper Modules (CM)

b. Motoring Diode (MD)

c. Voltage and Current Monitoring Devices (VAM, CM)

d. Gate Driver Power Supplies (GDPS)

e. Inverter Controller

f. Dynamic Braking Resistors (RG)

Each of these components will be examined in more detail in the following sections.

7–1.4 COMPONENT OPERATION

7–1.4.1 Third Rail Power and Main Fuse

The inverter is furnished with power through the third rail shoes. The nominal third rail voltage is 750 VDC. The input from the Third Rail Shoes is fused with the1000A Main Fuse (MPF) which feeds thru the Main Line Diode Assembly into the Knife Switch, then into the Line Breaker Group and Auxiliary Power Group. During regen braking power flow will be from the Knife Switch thru the Regen SCR Assembly back to the third rail shoes.

7–1.4.2 Knife Switch

As described above the power from the Third Rail Shoes enters the Knife Switch (KNSW) assembly. The knife switch will apply power to both the inverter and auxiliary power system when in the normal operating position. When in the TEST position, the knife switch will allow shop power to be applied to the auxiliary power system only.

7–1.4.3 Line Breaker Group

7–1.4.3.1 Line Breaker (LB)

The 17KG510B1 Line Breaker Group (MB) contains the Line Breaker (LB). This device is an electromagnetic line breaker, with automatic over-current protection by a series trip coil.

7–1.4.5 Filter Capacitors/Resistors

7–1.4.5.1 Filter Capacitors

There are two types of filter capacitors: the line filter capacitors (CLF) and inverter filter voltage capacitors (CIF). Both sets serve the purpose of filtering the line voltage coming through the Line Filter Reactor. The line filter capacitors have eight trays connected in parallel CLF 1–8 (total = 28,800 µF, 1250V). These are supplemented by two inverter capacitor banks each with nine trays labeled CIF 11–19 (total=32,400 µF, 1250V – for Inverter #1) and CIF 20–28 (total=32,400 µF, 1250V – for Inverter #2). These add energy storage capacity for each inverter individually. Each capacitor tray is made up of 5 capacitor cans connected in series with each can having a 20K ohm resistor across its terminals (for redundant bleed discharge). These capacitor trays are fused with a special fuse that provides visible indication that a fuse has blown.

7–1.4.5.2 Filter Discharge Resistors

In addition to the bleed resistor located in each of the capacitor trays, filter discharge circuits have been supplied to discharge all capacitor banks. This occurs whenever battery power is removed from the System Controller, or when commanded from the System Controller. The circuit will discharge the capacitors through the normally closed FDC1 and FDC2 Filter Discharge Contactor relay contacts and the FDR resistors. Note the Capacitor Voltage Indicators, HVL T1 and HVL T2, located on the outside of the Main Inverter Group enclosure, will be illuminated if the Inverter Filter Capacitors are not discharged.

7–1.4.6 Braking Chopper

The circuit used for dynamic braking consists of one chopper module and two resistor grids placed across each of the two inverter DC filters. The chopper modules are labeled CM1 for inverter #1 and CM2 for inverter #2. (See system schematic GE dwg 84B108121 sheets 1 and 2.)

The inverter is equipped to provide two types of electric braking. The first, and probably the most familiar is dynamic braking. Dynamic braking is accomplished by firing a pair of GTO's across the system DC voltage supply and into a resistor grid (See Operating Modes – Dynamic Brake Mode section. These GTO devices are known as "chopper modules" and are labeled CM1 for inverter #1 and CM2 for inverter #2. To synchronize the firing of the choppers, one inverter controller (typically #1) controls both GTOs. The choppers operate at 189 Hz, 180° out of phase to eliminate possible harmonic interferences with the track signaling system.

The second type of electric braking is regenerative braking. This is accomplished when the inverter allows the motor to return power to the third rail by closing the Line Breaker, and firing the regenerative SCR in the Rail Gap Group. In this case the chopper modules would only be used to suppress transients or to provide blended resistive and regenerative braking if the filter voltage on the third rail rises above 850V.

The function of the choppers is to regulate the DC link voltage to various voltage levels as determined by the inverter controller, whether in motoring, regenerative braking, or rheostatic braking.

7–1.4.7 Resistor Grids

7–1.4.7.1 Dynamic Braking Resistors

The chopper modules are used to control the current flow through the braking resistors. The dynamic braking resistor grids, RDB1 and RDB2 have a total impedance of 1.06 ohms each.

7–1.4.7.2 Series Resistors

During electric braking, the series resistors RS1 and RS2 are in the inverter power circuit. The voltage drop across these resistors causes the inverter (link) voltage to be higher than the line voltage. This higher voltage allows the motors and inverters to produce a given braking energy at a lower current. The resistance of each series resistor is .431 ohms.

7–1.4.8 Motoring Diode

This module bypasses the Series Resistor during motoring and provides a freewheeling diode for the braking grid. It is mounted on an electrically isolated heatsink and keyed to prevent incorrect installation.

7–1.4.9 Inverter Bridge

As described earlier, the inverter is comprised of six power switching devices which are used to connect each leg of the AC motor, in turn, to either the high or low side of the inverter filter supply voltage to produce alternating currents in the motor windings. The power switching devices used are GTO thyristor modules. The GTO receives gate signals from the Inverter Controller (via fiber optic light signals) which turn the device on, and also turn it off, very quickly. The ability to quickly turn on and off, plus the high current carrying capabilities of the GTO make for a relatively simple, highly reliable inverter design

7–1.4.9.1 GTO Phase Modules

Each GTO Phase Module has a GTO, an electronic Gate Driver Card, and part of a snubber circuit to form a fully integrated driver/power package. The switching on and off (or commutating on and off) of a GTO creates heat in the device. If temperature is allowed to rise unchecked, the GTO will reach a point where gating is no longer required to allow current to flow in the device. GTO's are always mounted to a heatsink to conduct the heat away from the GTO cell. This electrically isolated heat sink is cooled by air movement generated from car motion. A temperature sensor is also incorporated in these modules and this information is also sent back to the inverter via fiber optic signals. Circuit modules include a free–wheeling diode which allows commutation and regeneration currents to flow around the inverter GTO (see Figure 7–36). The module also includes some of the snubber circuitry which protects the GTO from damaging current and voltage transients which are normal occurrences in inverter operation. A positive (+) and negative (–) switch module make up 1 phase of the 3 phase AC output. The GTO's used in these modules are 2500V, 2000A devices.

7–1.4.9.2 GTO Firing Signals

The Gate Driver Card located in the GTO module transmits and receives information over fiber optic lines to the Fiber Optic Driver Card. The Fiber Optic Driver Card produces a signal to turn the GTO on or off. It is sent over the transmit connector on the Fiber Optic Card to the receive fiber optic connector on the Gate Driver Card. Once this signal is received, the Gate Driver card produces a pulse of gate current to either turn the GTO on or off. The Gate Driver Card returns a signal indicating the state of the GTO. This state information indicates whether the GTO is on or off. It is sent over the transmit fiber optic connector on the Gate Driver Card to the receive fiber optic connector on the Fiber Optic Card. This process of checking the status of the GTO will help to insure against shoot–through and other failures. Temperature information is superimposed on this same fiber optic cable.

7–1.4.9.3 Snubber Resistors

Switching a GTO on or off in an energized inverter circuit causes large transient voltages to appear across the GTO. The greater the magnitude of the voltage with respect to the time period of the transient, the greater the likelihood that the GTO will be caused to transition into a conductive state. An R–C snubber is used to reduce the transient effects and allow the GTO's to operate properly. Snubber Resistors (RS) are part of the R–C snubber and are located outside of the phase module.

7–1.4.9.4 DI/DT Reactors

High current transients can produce damaging effects in GTO's, causing localized heating within the GTO itself. This can cause degraded operation and shorten the life span of the device. Non–saturable inductors called DI/DT reactors are used to protect the GTO from this problem. The reactor impedance will be high for large current transitions, but will decrease once a "steady state" current is attained.

7–1.4.9.5 Gate Drive Power Supply

In order to produce the relatively large currents required to commutate the GTO's off, all of the Gate Driver Cards receive power from the Gate Drive Power Supply units. There is one Gate Drive Power Supply for inverter #1 and one for inverter #2. The Gate Drive Power Supply provides 25 KHZ power with all channels rated for 1KW peak.

7–1.4.9.6 Inverter Voltage Measurement

Phase A, B, and C voltages and currents are measured and sent as feedback to the respective inverter controller. Inverter #1 voltages are sent to the inverter controller via VAM2, and inverter #2 voltages are sent via VAM3.

7–1.4.9.7 Inverter Current Measurement

Phase A and B currents are measured and sent as feedback via CM1A, B (for inverter #1) and CM2A, B (for inverter #2). The algebraic sum of these two currents provides the value of the phase C current, so it is not directly measured. These values are used by the inverter controllers to regulate motor torque and detect inverter events.

7–1.4.9.8 Filter Current Measurement

Filter currents are measured using current measuring module CMIN (located in the Line Breaker Group) for current coming into the inverter and CMUT (located in the Inverter Group) for current leaving the inverter. The signals are sent to the Propulsion System Controller. If the difference between the input and output currents is greater than 90A, an event (Ground Fault) is registered and a NO POWER restriction is imposed.

7–1.4.9.9 Filter Voltage Measurement

The Line Filter Voltage is measured at the DCP BUS (Third Rail input) and HG BUS (High Voltage Ground return) points of the propulsion system. These are measured through the VAM1 voltage measuring module and sent to the System Controller. These are used by the system to regulate the line filter voltage, filter charging logic, etc.

7–1.4.10 Propulsion System Controller (PSC)

The System Controller is responsible for determining how the car is to be run. The Metro–Red Line–Passenger Vehicle PSC interfaces with the following: (Figure 7–37)

a. Master Controller and ATC (via Trainlines)

b. Fault Lights and Operator Switches

c. Friction Brake System

d. Two Digit Diagnostic Event Display

e. Inverter Controllers (high speed serial link via backplane wiring)

f. Portable Test Unit (PTU) for advanced troubleshooting and system adjustments

g. Numerous analog and digital I/O

Figure 7–37 System Control Architecture

The System Controller receives Trainline information (from the Master Controller or ATC) and acts upon it according to many variables including rail gap detection, fault status, current feedbacks, voltage feedbacks, and contactor states. In response to these inputs, the CCU's microprocessor determines torque command outputs and reference outputs to the inverter controller, relay operation, and software mode state changes.

Each car in the married pair has an Electronic Control Panel, which houses the CCU and the Inverter Controllers. The Electronic Control panel is responsible for the control of the propulsion, and consists of the following eleven circuit cards:

Type	Function	Electronics Panel Slot
17FB120	Power Supply Card	2
17FB141	System CPU Card	3
17FB156	System Custom I/O Card	4
17FB125	System Digital I/O Card	5
17FB157	System Analog I/O Card	6
17FB128	System Digital Battery Level I/O Card	7
17FB138	Inverter #2 CPU Card	9
17FB134	Inverter #2 I/O Card	10
17FB138	Inverter #1 CPU Card	11
17FB134	Inverter #1 I/O Card	12
41C666382G2	Fiber Optic Card Inv #1 & #2	13

The cards are all contained in the Electronic Control Panel (EP), shown in Figure 7–38, except for the Fiber Optic Driver Card which is mounted on the exterior of the EP.

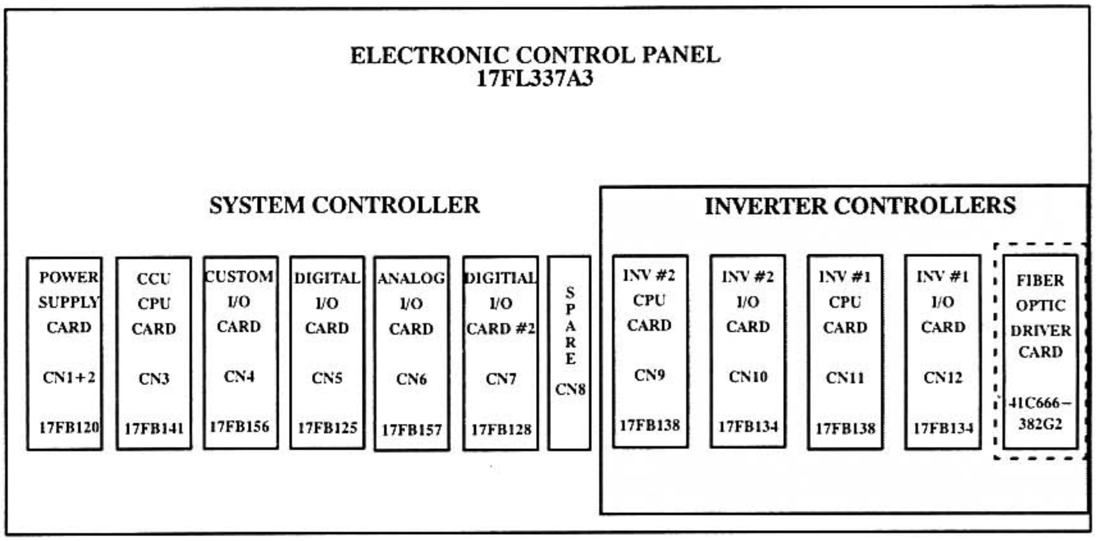


Figure 7–38 Propulsion Electronic Control Panel

PSC operations include the following:

a. Operating mode changes

b. Torque reference generation

c. Contactor control

d. Rail gap detection

e. Wheel slip/slide reaction

f. System diagnostics/self tests

g. Event Sensing

h. Data storage

i. Electric/Friction brake communication

j. Independent torque and run commands to each of the two inverter controllers (uses a 400K baud high speed serial link)

The Metro–Red Line–Passenger Vehicle AC–Drive Inverter is made up of not only power components, but also a controller. The Metro–Red Line–Passenger Vehicle Inverter #1 is shown in Figure 7–39. The Inverter #1 is a microprocessor-based control system which provides the interface between the PSC and the power section. The Inverter Controller shown in Figure 7–39 performs the following tasks:

a. Receives PSC torque commands via a high speed serial communication link

b. Sends fiber optic GTO firing signals to the inverter and chopper GTO modules

c. Receives fiber optic GTO ON/OFF state and temperature feedback information

d. Receives speed sensor signals from each speed sensor

e. Receives inverter filter voltage, phase (A&B) currents, phase (A,B&C) voltages

f. Regulates all inverter functions

g. Performs diagnostic self tests

h. Detects inverter events

[redacted]

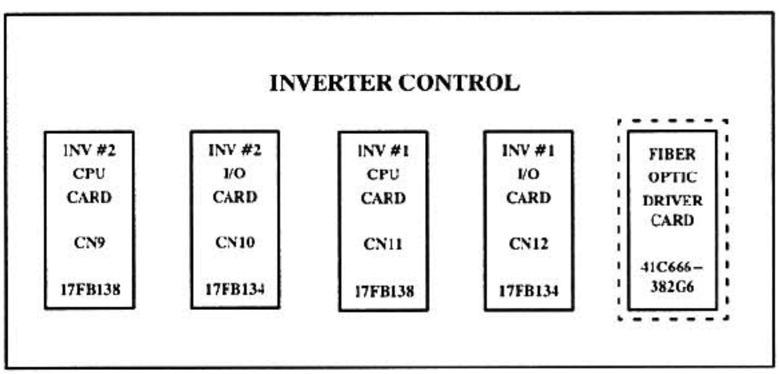
Figure 7–39 Inverter Control Architecture

The inverter controller is comprised of the following five circuit cards (see Figure 7–40):

a. Two CPU cards (one for each inverter)

b. Two I/O cards (one for each inverter)

c. One Fiber Optic Driver card (for both inverters) attached to the control group housing.



(Located in the 17FL337 Electronics Panel)

Figure 7–40 Inverter Control Cards

7–1.4.10.1 Power Supply Card (CN2), 17FB120

Converts +37.5V supplied power to regulated +5VDC and +15VDC for control logic.

7–1.4.10.2 System CPU Card (CN3), 17FB141

The CPU Card is the brains of the System Controller. It contains an 80960 microprocessor which is responsible for the error detection, calculations, self–tests, and PTU communication. It interfaces to the Inverter #1 and #2 CPU cards over a high speed serial channel and uses RS232 to interface to PTU's.

7–1.4.10.3 System Custom I/O Card (CN4), 17FB156

Receives inputs from the master controller and operator switches and outputs to Friction Brake, Trainline, and ATC System.

7–1.4.10.4 System Digital I/O Card (CN5), 17FB125

The digital I/O card commands most of the system's power contactors, such as LB, FCC, and FDR1 & 2. The Gate Drive Power Supplies are turned on from a Digital I/O card signal.

7–1.4.10.5 System Analog I/O Card (CN6), 17FB157

The system analog I/O card interfaces to read and monitor ambient temperature, Third Rail voltage and current, Inverter Bridge voltage and current, and Load Weight voltage, sends outputs to analog test channels (on connector M4).

7–1.4.10.6 System Battery Level Digital I/O Card (CN7), 17FB128

The battery level digital I/O card receives inputs from the following: Friction Brake Wheel Slip, Emergency circuit, Tach signals from Inverter #1 & 2. It receives feedback from the Line Breaker, Filter Discharge Contactors, and Filter Discharge circuits.

7–1.4.10.7 Inverter #2 CPU Card (CN9), 17FB138

The Inverter CPU Card receives inputs from the Inverter #1 Chopper circuit for GTO On/Off, Status, and Temperature; Inverter #1 GTO's On/Off, Status, and Temperature; and Serial High Speed Interface to System CPU and Inverter #2 CPU Cards.

7–1.4.10.8 Inverter #2 I/O Card (CN10), 17FB134

The Inverter #2 I/O Card reads and monitors Motor #1 and 2 three phase voltages and currents, Motor #1 and 2 speeds and directions, Inverter #1 Filter voltage. Shares C_{min} and V1 (current and voltage signals) with System Analog Card. Output tach reading to Digital I/O Card #2.

7–1.4.10.9 Inverter #1 CPU Card (CN11), 17FB138

The Inverter #1 CPU Card receives inputs from: Inverter #2 Chopper circuit for GTO On/Off, Status, and Temperature; Inverter #2 GTO's On/Off, Status, and Temperature; and Serial High Speed Interface to System CPU and Inverter #1 CPU Cards.

7–1.4.10.10 Inverter #1 I/O Card (CN12), 17FB134A1

The Inverter #1 I/O Card reads and monitors Motor #3 and 4 three phase voltages and currents, Motor #3 and 4 speeds and directions, Inverter #2 Filter voltage. Shares CMIN and V1 (current in and link voltage signals) with System Analog Card. The tach #3 signal is shared with the Digital I/O Card #2.

7–1.4.10.11 Fiber Optic I/O Card, 41C666382G2

The Fiber Optic I/O Card sends light signals to the Phase Modules' Gate Driver Card that are used to indicate when the GTO should turn on or off. The signal is approximately 680 Hz and is not corruptible by AC ripple current or RFI. The Gate Driver Card returns the on/off status of the GTO with a short 100 kHz indication of GTO temperature.

7–1.5 CAR OPERATING MODES

7–1.5.1 General Description of the Control State Logic

Referencing the first few pages of the Metro–Red Line–Passenger Vehicle System Schematic illustrates the propulsion power portion of the Metro–Red Line–Passenger Vehicle System. Note the different power contactors. These contactors will be energized and de–energized in various modes.

Generally, Propulsion System Control is structured so that there are several discrete control logic states. These States are shown on the Figure 7–41 Metro–Red Line–Passenger Vehicle State Diagram.

Three states (START, POWER–UP, READY) are initialization and restrictive fault retreat states. Four states (BRAKE, BRAKE REGEN, COAST, POWER) are used to respond to different Master Controller calls and changing Line Voltage and receptivity conditions.

Figure 7–41 State Diagram

7–1.5.2 Reset Condition

Whenever low voltage control power is first applied to the control, or System CPU has RESET, the control automatically goes to the first state known as START. Any battery power interruption is treated as a Reset to insure the System Devices are not left in any undesirable state from the previous operation.

7–1.5.3 Operating States

START STATE: START is the first state System enters when Battery Voltage is applied to the control circuits. It is also the "lowest" System state during the normal operation. Generally, System returns to the start state when either: (1) The Master Controller is turned off and the system is in POWER UP; or (2) A restrictive fault occurs and an "ALL STATES" fault restriction is called for.

Whenever System enters the START state, an attempt to perform a ripple filter test is made. This test will verify the filters for the frequencies measured by the system.

The ripple filter test will be repeated at least every eight hours. Speed must be zero to run the ripple self test:

WHILE IN START (or SLEEP) The system is initialized as follows;

a. TORQUE REQUEST shall be set to ZERO, so that Torque Call will be immediately set to zero.

b. INVERTER RUN COMMAND = OFF.

No power is applied to motors either for braking or motoring.

a. FCC = OPEN (Do this before opening LB).

b. LB = OPEN (Do this before dropping out FDR 1 & 2).

c. FDR1 + FDR2 = Dropped Out (Will discharge the filter capacitors).

d. Power to Inverter Gate Driver turned off.

POWER UP STATE: This state is the next initialization state entered. Once in higher states, this state is re–entered during emergency brake applications, or when filter discharge is required, or a more restrictive fault occurs where READY state is not allowed (i.e. LB needs to open).

While in Power Up:

a. Further initialization and certain reset sequences that are to run automatically on power–up are taken care of here. No power is applied to motors either for braking or motoring.

b. Inverter POWER UP tests are initiated.

c. TORQUE REQUEST is set to zero, so Torque Call is immediately set to zero.

d. INVERTER RUN COMMAND = OFF.

e. FCC = OPEN (Filter Charging Contactor dropped out).

f. LB = OPEN (Line Breaker dropped out).

g. FDR's = DROPPED OUT (Discharge filter capacitors).

h. Inverter Gate Driver power is turned on.

READY STATE: This is final initialize type mode and the mode most often returned to handle restrictive type faults (no power restriction). The filter discharge relays are energized here (to disable filter discharge). From READY state transitions are allowed to various higher states.

While in Ready:

a. This is a "safe mode". No power is applied to motors either for braking or motoring.

b. TORQUE REQUEST is set to zero, so Torque Call is immediately set to zero.

c. INVERTER RUN COMMAND is turned off.

d. FCC = OPEN.

e. LB = OPEN.

f. FDRs are picked up (energized) so that capacitor discharge is disabled.

COAST STATE: This is the state where the filter is charged and the Line Breaker is closed. Power or Brake states can not be entered until the filter is charged.

While in Coast:

a. The TORQUE REQUEST is equal small positive or small negative value.

b. If the system is coming from START mode and is in COAST for the first time, the Inverter High Voltage Test is performed by each of the two inverters.

c. The PSC will perform CHOPPER SELF–TEST, if conditions are correct. Also, it will check for shorted and open braking resistors, and filter charging resistors.

d. The filter will be charged if Line Volts – Filter Volts > 70V at which time FCC will close, until line volts – filter volts < 50V, then LB = CLOSED and FCC = OPEN.

e. The system will maintain the charge on capacitors. It will not exit Coast to Brake or Power unless the capacitors are charged.

f. The INVERTER RUN COMMAND will be in whatever state it was before entering COAST.

BRAKE STATE: The inverter is equipped to provide two types of electric braking. These are Dynamic Braking and Regenerative Braking.

When in dynamic braking the kinetic energy of the moving car is converted to electrical energy by the control of the inverter on the AC motor. The inverter is used to generate a stator excitation frequency which is slower than the rotation of the rotor. This difference in stator excitation and rotor speed creates a negative torque on the motor. The AC rotor now acts as an AC generator, which causes the AC voltage at the motor terminals to rise. The free–wheeling diodes in the main propulsion inverter GTO modules provide a path from the AC motor stator lead to the inverter filter. The diodes rectify the AC voltage and allow the DC inverter filter voltage to rise.

When a load in the form of a braking resistor grid is placed across the inverter filter, current flows through the resistor and power is consumed. The electrical energy is turned into heat and dissipated to the ambient air. When kinetic energy is transformed to heat energy and released in this way, there is less kinetic energy left in the system. The kinetic energy in the system is represented by the train moving at a given speed. When the kinetic energy decreases, the speed of the train decreases as well. Thus the train undergoes braking by electrical means.

Regenerative braking works exactly as dynamic braking with one exception. After the power is produced by the AC motors and stored in the inverter DC filter, it is passed back to the third rail instead of being consumed in the resistor grid. This power can then be used by any load (other vehicles) on the same section of third rail as the regenerating car.

BRAKE mode is the dynamic (rheostatic) electric braking state. Regeneration into third rail is not permitted, therefore Line Breaker is open. Neither BRAKE nor BRAKE REGEN state is allowed if Brake Cut–Out switch is in cut–out position is off.

> **NOTE:** Because the Friction Brake Control can only blend with Electric Braking on a per car basis, the propulsion system may need to exit BRAKE state and return to COAST if one inverter is disabled so that the braking effort is not applied unequally.

While in Dynamic Brake:

a. INVERTER RUN COMMAND = ON.

b. FCC = OPEN.

c. LB = OPEN.

d. TORQUE REQUEST is set to BRAKING so Torque Call provides braking torque.

BRAKE REGEN STATE: This is the Electric Braking state where the motors are turned into generators and energy is fed back to the third rail.

Neither BRAKE nor BRAKE REGEN state is allowed if ELECTRIC BRAKE CUTOUT switch is in the cutout position.

If VLB < 650 VDC (lowest full BRAKE REGEN performance voltage), the System will switch to BRAKE to maintain full Electric Braking Effort level.

While in Brake Regen:

a. The filter must be charged

b. Check for direction.

c. INVERTER RUN COMMAND = ON.

d. Set TORQUE REQUEST to BRAKING so Torque Call will provide BRAKING TORQUE.

Upon the completion of BRAKE REGEN mode, all events that are not locked–out will be reset.

POWER STATE: As the name implies this is the state used to perform the Power (or motoring) functions. Before performing the normal Power commands the following will be checked:

a. Forward–Reverse Change – The system shall respond to the (FWD) and (REV) commands from the trainlines, and a signal shall be sent to Inverters #1 and #2 calling for the proper direction. Direction of movement will be monitored and a fault will be logged (by the Inverters) if a motion direction mismatch is detected. No change in direction is acknowledged unless the car speed is below ZERO SPEED (2 MPH).

b. If a third rail power gap is encountered at the moment POWER is called for or during motoring, the System acknowledges the loss of 700 volt third rail voltage by going to Resistive Brake state, which opens the Line Breaker. The inverters are reduced to minimum torque, and will regulate the filter voltage to a minimum operating level if required. Once the gap has passed and the live third rail section is encountered, the system charges the Filter (if necessary), closes the Line Breaker, and reverts back to motoring (POWER state).

While In Power:

a. Establish direction desired.

b. LB will already be closed.

c. INVERTER RUN COMMAND = ON.

d. Set TORQUE REQUEST to POWER, so that the Torque Call can be derived from trainline call and load weigh signals.

MANUAL TEST STATE: The System may be put in the MANUAL TEST state when there is less than 50 VDC on the filter, the vehicle speed is less than the zero speed of 2 MPH, and the KNIFE SWITCH is open. PTU must be connected to one of two designated PTU receptacles on the car and PTU software must be activated and in a self test screen to make the transition to TEST. System will accept various self test commands in this state. Certain state transitions and some other sequencing are permitted without filter voltage present, etc. The system will revert back to normal operation if the PTU is disconnected.

7–1.5.4 Car Control Requirements

The propulsion system controller provides the following operating characteristics.

7–1.5.4.1 Acceleration Requirement

AW0	80,000 Lbs	40.00 Tons
AW1	89,086 Lbs	44.54 Tons
AW2	107,720 Lbs	53.86 Tons
AW3	126,354 Lbs	63.18 Tons

Table 7–3 Car Weight Table

For car weights AW0 to AW2, Initial Acceleration is 3.0 MPHPS. Up to AW2, it is maintained up to 23.5 MPH. For car weights above AW2 and up to AW3, car tractive effort is maintained at the AW2 level. Therefore Initial Acceleration decreases proportionally from 3.0 MPHPS to the weight increase.

7–1.5.4.2 Jerk Limit

Jerk limit for all acceleration applications shall be 2.0 mphps ±10%

Jerk limit for all motoring tractive effort reductions shall be −2.0 mphps ±10%, except for:
- Power removal due to emergency braking request
- Power removal due to the loss of Line Voltage
- Power removal due to propulsion failure
- Power reduction due to spin control activity

For these cases, tractive effort reduction shall not be jerk limited.

7–1.6 SYSTEM INTERFACES

7–1.6.1 Trainline Information Decoding

7–1.6.1.1 Direction Selection

[redacted]

Figure 7–42 DIRECTION_CALL Selection Logic

Direction of the car motion is determined by propulsion control from the following sources:
- FRWD trainline input
- RVRS trainline input

Absence of both FRWD and RVRS signals indicates that the master controller is in shutdown position (power/brake handle of the controller is interlocked with direction selector). The propulsion system reads this condition as "NEUTRAL" and remains in the deenergized state.

Presence of either one of the signals indicates that the car is expected to move in the selected direction. Once car speed exceeds 2.0 mph, this direction is "locked in" and no further direction change is recognized until the speed is reduced to below 2.0 mph. The propulsion system reads this condition as either "FORWARD" or "REVERSE" and allows operation in the selected direction.

Simultaneous presence of both FRWD and RVRS signals at any time constitutes a fault condition. If the car speed is below 2.0 mph, the propulsion system reads this condition as "NEUTRAL" and remains in the deenergized state. If the car speed is above 2.0 mph, torque is removed and the last valid direction is retained until the speed of 2.0 mph is reached.

7–1.6.1.2 Power/Braking Mode and Rate Selection

Master Controller development settings are presented in Figure 7–43.

Trainline Rate Call is determined by propulsion control from the following sources:
- FBON digital trainline input
- BRK digital trainline input
- EBCT digital trainline input
- EMRG digital trainline input
- PWRE analog trainline input
- DIRECTION call (as specified above)
- VLNE line voltage measurement

Trainline Modes are defined as follows:

TL_SHUTDOWN	–Master Controller is OFF. No action is expected from propulsion
TL_EMERGENCY	–Emergency Brake (Friction only, irretrievable till Zero Speed).
TL_MISMATCH	–Same as Emergency, but restorable to normal operation at any speed.
TL_BRAKE	–Brake Call at a particular deceleration rate (referred to 3.0 mphps).
TL_COAST	–Coast Call at near 0 tractive effort.
TL_POWER	–Power Call at a particular acceleration rate (referred to 3.0 mphps)

NOTE: Trainline modes are not to be confused with System Modes which are described elsewhere.

The flow diagram in Figure 7–44 represents the propulsion system response to the trainline inputs.

7–1.6.2 Trainline System

The GE propulsion system provides an interface to communicate with Trainline system.

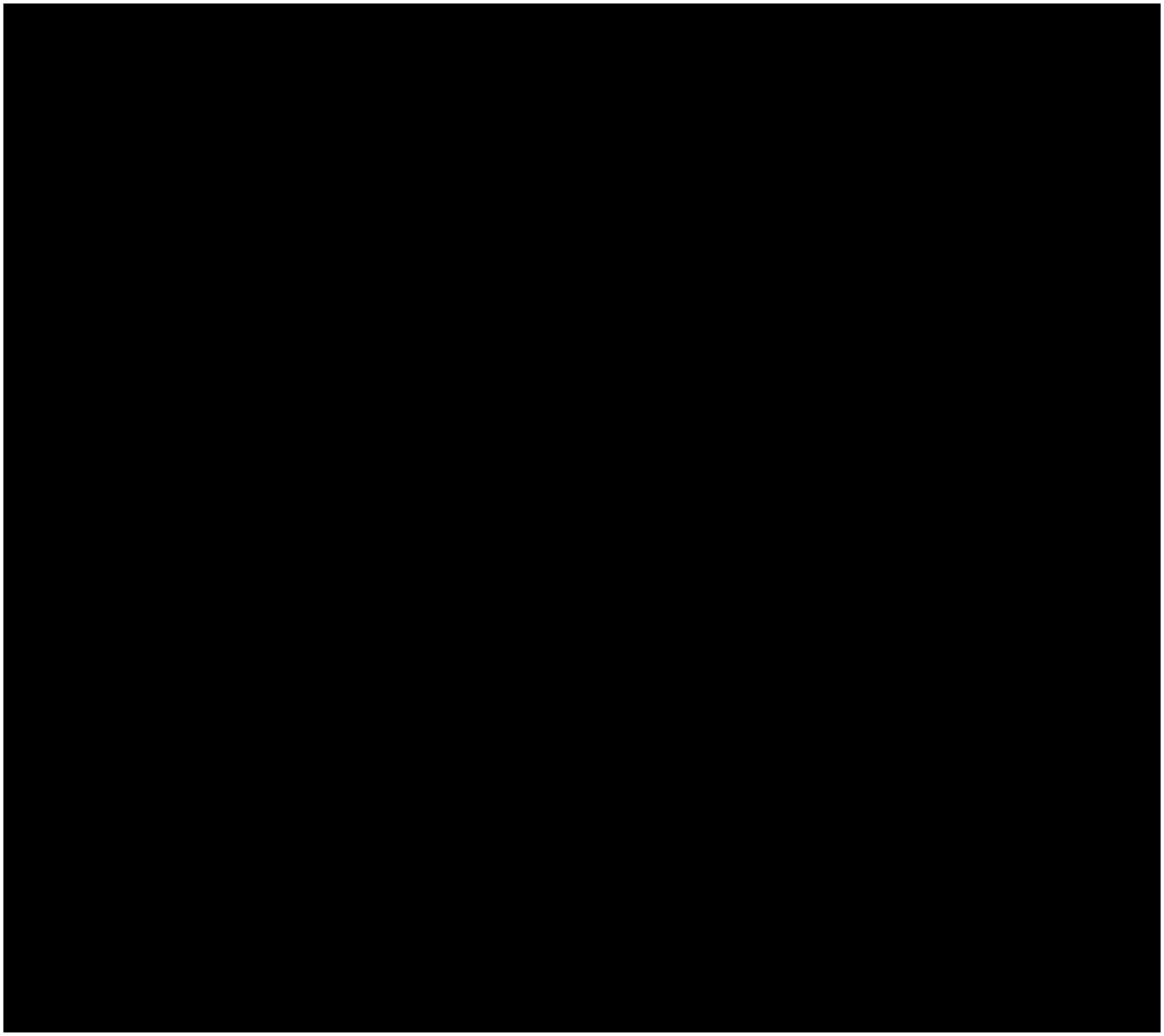


Figure 7–43 P–Wire vs. Master Controller Tolerances

Figure 7–44 TRAINLINE_CALL and RATE Selection Logic

Figure 7–45 TRAINLINE_CALL and RATE Selection Logic (Cont)

7–1.6.3 Friction Brake Interface

7–1.6.3.1 Dynamic Braking Effort Feedback

The Propulsion system and the Friction Brake each read the Trainlines. The Friction Brake compares how much total braking effort is being called for, to how much the propulsion system is providing, and then makes up the difference with friction braking.

The braking effort on the cars, as well as the tractive effort, is controlled by the Master Controller. The PSC on each car transmits to the friction brake system on that car electric braking effort feedback being produced on that car. This signal is in the form of a DC current loop. The calibration for this signal is 0 to –1 mA, which corresponds to0 to 20,000 lbs. of tractive or braking effort.

7–1.6.3.2 Wheel Spin Slide

This is a signal from the friction brake system which upon receipt of this signal in braking, the Dynamic Braking Effort is reduced without jerk rate limit. When this indication is removed, the Dynamic Braking Effort is built up to the commanded level under Jerk limitations.

7–1.6.3.3 Load Weigh

This is a 0.1 to 5.1 volt analog signal coming from the Friction Brake System. It is read by the PSC via the 17FM672 loadweigh interface panel.

7–1.6.4 Emergency

The GE Propulsion system interfaces to the Emergency interface through the EMR1 relay (see Figure 7–46).

[redacted]

Figure 7–46 Emergency Circuit

7–1.7 MAINTENANCE/TROUBLESHOOTING

The microprocessor controlled Propulsion System Controller (PSC) and its microprocessor controlled inverters have been incorporated with very powerful diagnostic capabilities. The PSC constantly monitors the system for any abnormalities. In addition, automatic self–tests are performed periodically on various parts of the system to insure its integrity.

The diagnostic system is comprised of three parts:

a. The PSC for detection, event logging, data storage, and fault light indications.

b. A two digit display panel or Event Display Monitor (EDM) located in the Main Inverter Group for event annunciation to maintenance personnel.

c. A portable test unit (PTU) for retrieval of stored fault information, real time car status, troubleshooting etc.

The PTU can be attached to the PSC in either the operators cab or inside the electronics portion of the main inverter group. The diagnostics is also complemented with a plug containing eight programmable brush recorder test points, and on the M4 connector. These test points can be used to monitor currents and voltages inside the main inverter group while the group is in operation. The operator can select which data is to be monitored via the PTU.

7–1.7.1 Events

Events are system faults or abnormalities that are detected by the various sensors on the car, and registered by the CPU Card in the EP. There are two types of faults/events (hereafter called events): non–restrictive and restrictive events. Non–restrictive events are a notice by the system that there is a problem, and it should be investigated the next time the car is in the shop. Non–restrictive events will show up on the EDM, but will not effect the operation of the car. Restrictive events are considered more serious, and prevent the Propulsion System from entering certain Mode States.

RESTRICTION	DEFINITION OF STATES RESTRICTED
ALL STATES	POWER_UP, READY, BRAKE, BRAKE_REGEN, COAST, POWER
ALL STATES (exc POWER UP)	READY, BRAKE, BRAKE_REGEN, COAST, POWER
NO POWER	BRAKE, BRAKE_REGEN, COAST, POWER
INV. DISABLED	NO_POWER first, then NO_POWER on the inverter that is DISABLED. The other inverter will resume operation as before DISABLED.
NO BRAKING	BRAKE, BRAKE_REGEN
NO REGEN	BRAKE_REGEN
NONE	No restrictions (Non–Restrictive Event)

Table 7–4 Restrictive Events

7–1.7.1.1 Event Logging

A buffer of 250 entries is provided to be filled with events occurring in chronological order (event number 1 is the first to have occurred). Also included in this buffer are all the input and output values, time the event occurred, reset time, mode information, controller status, etc. for each event. This buffer is filled continuously and the first event may be overwritten if necessary. Since logging of the previously logged, non–reset events is not allowed, any overwrite possibilities are minimized. It is intended that this data be downloaded and cleared at each maintenance interval.

7–1.7.1.2 Event Lockout Counter

A counter for each event is used to determine if the system is to be locked out. This counter, when incremented, is compared with a fixed, but modifiable lockout count. If the counter reaches the lockout count, the event and its restriction can be reset only by two digit display or the PTU and cannot be reset any longer automatically or by the operator. If not locked out, these counters are reset to zero when the car changes direction or on power up.

7–1.7.1.3 Event Stored Counter

This counter is used to indicate how many and which events occurred, since last cleared during a previous maintenance interval. This counter also refers to the number of events with stored event data information (1 snapshot of all inputs, outputs, time etc. per event). This stored event data may only be cleared by the PTU.

7–1.7.1.4 Event Historical Counter

This counter contains historical data for the cars. It contains three columns of information:

a. CNT – the number of times the event may occur before being locked–out.

b. CNTR – the number of times the event has occurred since last being reset.

c. HIST – the event history for each event (i.e. event #10 has occurred 25 times since the car was put in service).

This counter may only be cleared by the PTU and it is intended to be cleared only once, when the cars enter revenue service.

7–1.7.1.5 Event Shutdown/Reset Procedures

If the event is a restrictive one, the system will be shutdown or performance will be limited. The restriction will cause a fault light indication after lockout is reached. This event may be automatically reset if a system lockout has not occurred.

The auto reset is permitted for a limited number of times where the number may be different for each type of event. When the number of resets is equal to the events lockout count for any given event, the event is considered locked out and no auto resets are to be permitted.

An automatic reset of the system occurs either during ready state when vehicle speed is less then 2 mph, or after a certain time, which is typically set at five seconds. The event counters are reset at the end of any run when the system is shut down and repowered or reversed. This allows the system to have the maximum number of events before a system lockout, even if some faults had occurred on the previous runs.

The propulsion manual reset switch is located on the 2–Digit Event Display Monitor (EDM) in the Main Inverter Group. It must be pressed twice in ten seconds to reset an event.

7–1.7.2 Event Display Monitor (EDM)

The Event Display Monitor is a digital display used to report real or potential problems to the maintenance personnel. The events are displayed as a two digit hexadecimal number. See Figure 7–47. The number indicates a problematic part, module, card, or area in the propulsion system. The user must refer to Inverter Group 17KG497A1 section. to determine the best course of troubleshooting any displayed events.

All events are logged by the display, but may be cleared after an automatic or manual reset. Reset of an event removes any restrictions imposed on the vehicle by that event and clears the event number from the Event Display Monitor, but does not remove the event from the system battery backed up RAM memory. This allows maintenance personnel to reset events, but still be able to retrieve and store information with the PTU when convenient. Only the PTU (or battery back up RAM battery failure) can be used to erase stored event information. The unit will save multiple events in chronological order and allow the user to scroll through the list to identify all events. The unit is located in the Main Inverter Group and is shown in Figure 7–47.

The monitor uses two LED's labeled FIRST and LAST to indicate the status of the unit and the chronological position of the event displayed. If the FIRST and LAST LED's simultaneously pulse every 5 seconds, but no two digit number is displayed, then the unit is operating, but there are no events recorded since last being reset. If the FIRST LED is on steady, the unit is indicating that the event number in the display is the first to have occurred since all events were last reset. If the LAST LED is on steady, the unit is indicating that the event number in the display is the last to have occurred. If both the FIRST and LAST LED's are on steady, then there is only one event active (it is both the first and the last event in the active event list). Whenever an LED is said to be on steady, it will flash off and the other LED will flash on once every 5 seconds to indicate that communication is established with PTU.

If an event is displayed and neither the FIRST or the LAST LED is displayed, then the event falls chronologically between the first and last event.

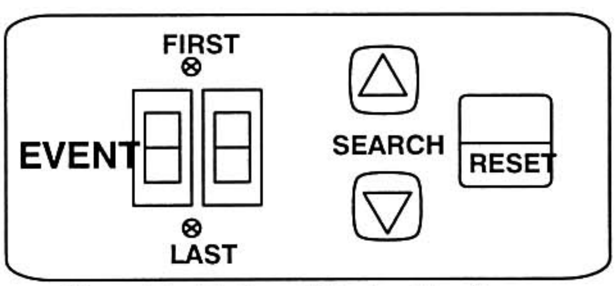


Figure 7–47 Event Display Monitor

To view all events use the up and down arrow SEARCH keys. The up arrow will display prior events and may be depressed repeatedly to scroll to the first event to have occurred. The down arrow will scroll to the last event to have occurred.

The RESET button can be used to reset the event displayed on the monitor. Depress the RESET button twice within ten seconds to reset the event.

7–1.7.3 Portable Test Unit (PTU)

The PTU is a computer based test, data storage, and monitoring system which may be used by maintenance personnel to investigate problems which may require more information than is provided by the Event Display Monitor.

The PTU is portable and communicates to the PSC via RS232 serial communication cable, which can be connected to the controller at either the car cab or Section C of the Inverter Control Group Assembly, near the Event Display Monitor. The PTU can access real time and stored system information including contactor states, voltage and current levels, temperatures, event codes and much more. It may also be used to change system operating parameters and force contactor operation.

The PTU program is menu driven and includes "HELP" information for many screens to make using the system as easy as possible. For complete information on using the PTU, refer to Portable Test Unit (PTU) section.

7–1.7.4 Troubleshooting Techniques

The diagnostic equipment supplied with this system may be used to quickly identify failed components. The following general procedures may be employed to isolate problems using the PTU or Event Display Monitor.

7–1.7.4.1 Troubleshooting Using the PTU

If an event is displayed on the Event Display Monitor, it means that the event is active and that all restrictions associated with that event, if any, are imposed on the system. If a Portable Test Unit is available, plug the communication cable into the PTU plug either at the propulsion system Electronics Panel (EP) or in the cab of the car. Refer to Portable Test Unit (PTU) section for instructions on using the PTU and section 7–2.4.7.

7–1.8 SCHEMATIC DIAGRAM

NOTE: A copy of the system schematic is provided as an aid to the propulsion system overview and may not be to the latest revision. Maintenance personnel should always refer to the actual schematic drawing (GE 84B108121) for the latest revision.

See Page 7–66 thru Page 7–128 for details.

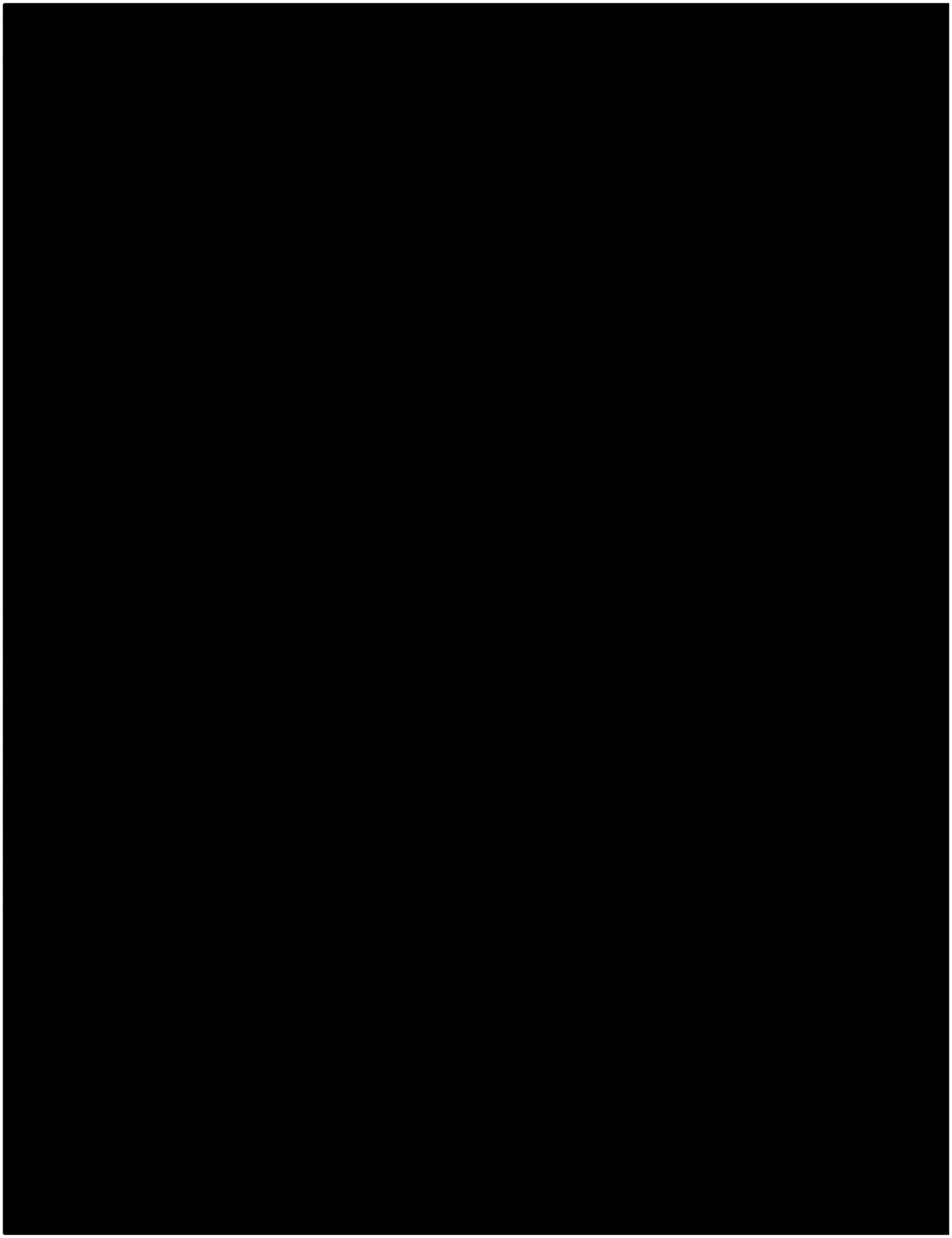
84B108121
CONT. ON SH. 0A SH. NO. 0 TITLE SHEET SECT. 0A SECT. 0B TITLE SHEET REV NO. G

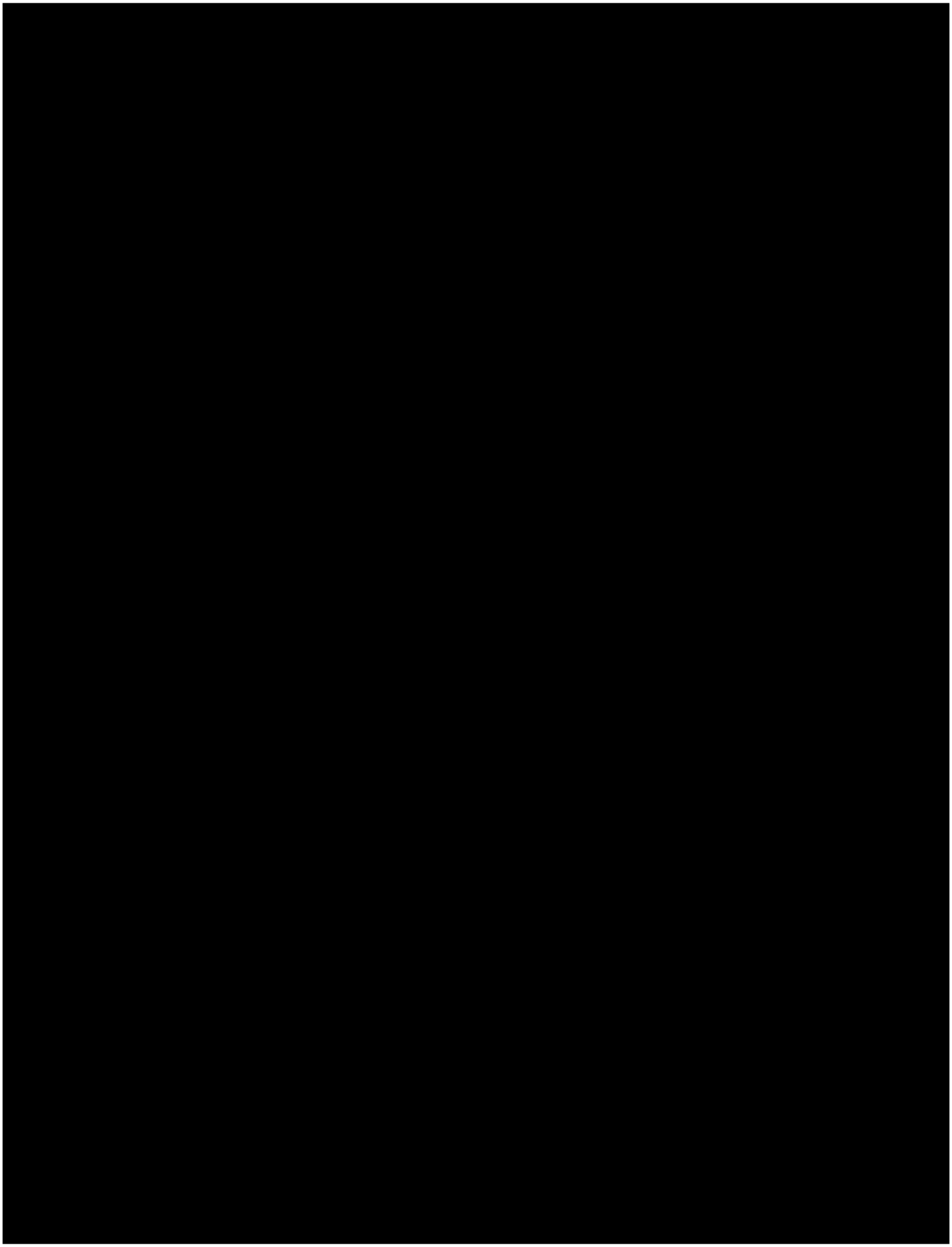
GENERAL ELECTRIC TRANSPORTATION SYSTEMS
2901 EAST LAKE ROAD, ERIE PA. 16531

LA RED PROPULSION
AND LOW VOLTAGE
POWER SYSTEM SCHEMATIC

84B108121
CONT. ON SH. 1 SH. NO. 0A INDEX SHEET SECT. 0A A SECT. 0A B INDEX SHEET REV. NO. G

SHEET	DESCRIPTION	REV.	SHEET	DESCRIPTION	REV.
0	TITLE SHEET	G	35	SYSTEM ANALOG CARD – VOLTAGE ATTENUATION INPUTS : MISC INPUTS	E
0A	INDEX SHEET	G	36	SYSTEM ANALOG CARD – ANALOG TEST SIGNALS	E
1	HIGH VOLTAGE INPUT : INPUT POWER BREAKER, RAIL GAP GROUP AND CONTACTORS	F	37	SYSTEM ANALOG CARD – LOAD WEIGHT INPUT	F
2	HIGH VOLTAGE INPUT : CHOPPER #1	E	39	DIGITAL INPUTS – BATTERY LEVEL TYPE	E
3	HIGH VOLTAGE INPUT : CHOPPER #2	E	44	TERMINAL BLOCKS TB1 AND TB2	E
4	INVERTER TRUCK #1 (FRONT)	G	45	TERMINAL BLOCKS TB3 AND TB4	F
5	INVERTER TRUCK #2 (REAR)	G	46	TERMINAL BLOCK (MBTB1) – AMBTB, GDATB, HCATB, FANTB AND CTB1 LOCATIONS	E
6	MOTOR CONNECTIONS (TRUCKS #1 AND #2)	F	47	M1 CONNECTOR	F
8	LINE FILTER CAPACITORS	E	48	M2 CONNECTOR	F
9	INVERTER #1 FILTER CAPACITORS	E	49	M3 CONNECTOR	F
10	INVERTER #2 FILTER CAPACITORS	E	50	M4 CONNECTOR	E
11	INVERTER #1 CPU	E	51	MBCN CONNECTOR AND RGCN CONNECTOR	F
12	INVERTER #1 INPUT / OUTPUT CARD	E	52	CNA CONNECTOR	E
13	INVERTER #1 INPUT / OUTPUT CARD	E	53	CNB CONNECTOR	E
14	INVERTER #1 INPUT / OUTPUT CARD	E	54	CNC CONNECTOR	E
15	INVERTER #2 CPU	E	55	CND CONNECTOR	E
16	INVERTER #2 INPUT / OUTPUT CARD	E	56	DEVICE TABLE – MAGNETICS	E
17	INVERTER #2 INPUT / OUTPUT CARD	F	57	DEVICE TABLE – CAPACITORS	E
18	INVERTER #2 INPUT / OUTPUT CARD	E	58	DEVICE TABLE – POWER DEVICES	E
19	INVERTER #1 GATE DRIVER POWER SUPPLY	E	59	DEVICE TABLE – ELECTRONIC CARDS	E
20	INVERTER #2 GATE DRIVER POWER SUPPLY	E	60	DEVICE TABLE – ELECTRONIC MODULES	E
21	FIBER OPTIC INPUT / OUTPUT INVERTER #1	E	61	DEVICE TABLE – MISCELLANEOUS DEVICES	E
22	FIBER OPTIC INPUT / OUTPUT INVERTER #2	E	62	DEVICE TABLE – MODULES	A
23	BATTERY LINE FILTER : SYSTEM / INVERTER CPU POWER SUPPLY	E	63	DATA TABLE	G
24	EMERGENCY CIRCUITS : PROPULSION CUTOUT AND EMR1	F	64	LEGEND	E
25	SYSTEM CPU CARD – RS232 COMMUNICATIONS	E	65	LEGEND	E
26	EXTERNAL SYSTEM INPUTS	E	66	LEGEND	E
27	CUSTOM I/O COMMUNICATIONS	E	102	AUXILIARY CONTACTOR GROUP	G
27A	CUSTOM I/O COMMUNICATIONS	E			
28	EVENT DISPLAY MODULE	E			
29	DIGITAL INPUTS – GROUNDED TYPE : SCR GATE DRIVER	E			
30	DIGITAL INPUTS – 15 VOLT TYPE	E			
31	DIGITAL OUTPUTS – FET DRIVERS	E			
32	DIGITAL OUTPUTS – CONTACTORS / RELAYS	E			
33	AUX TRAINLINE RELAY	E			
34	SYSTEM ANALOG CARD – TEMPERATURE INPUTS : CURRENT INPUTS	E			





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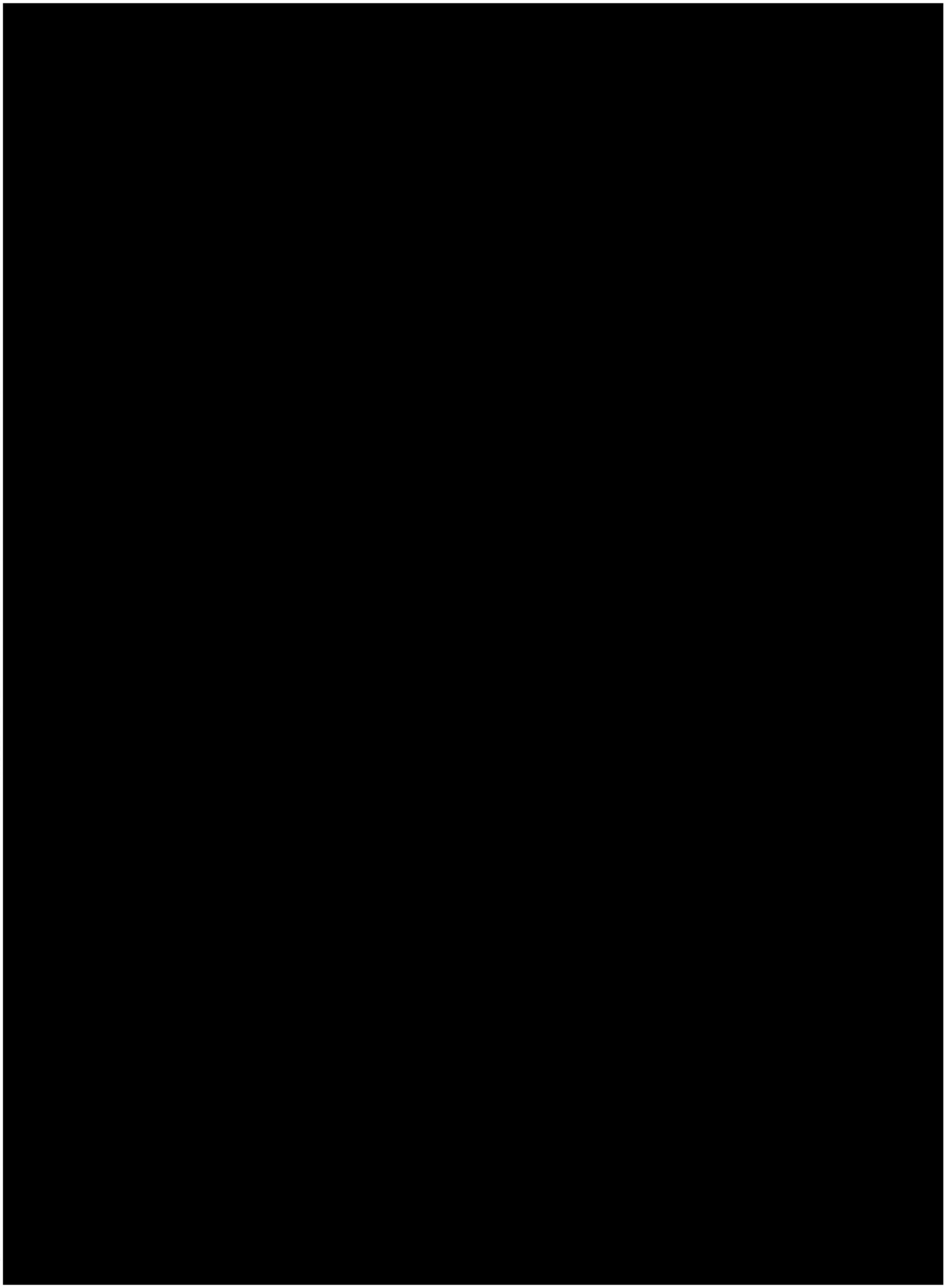

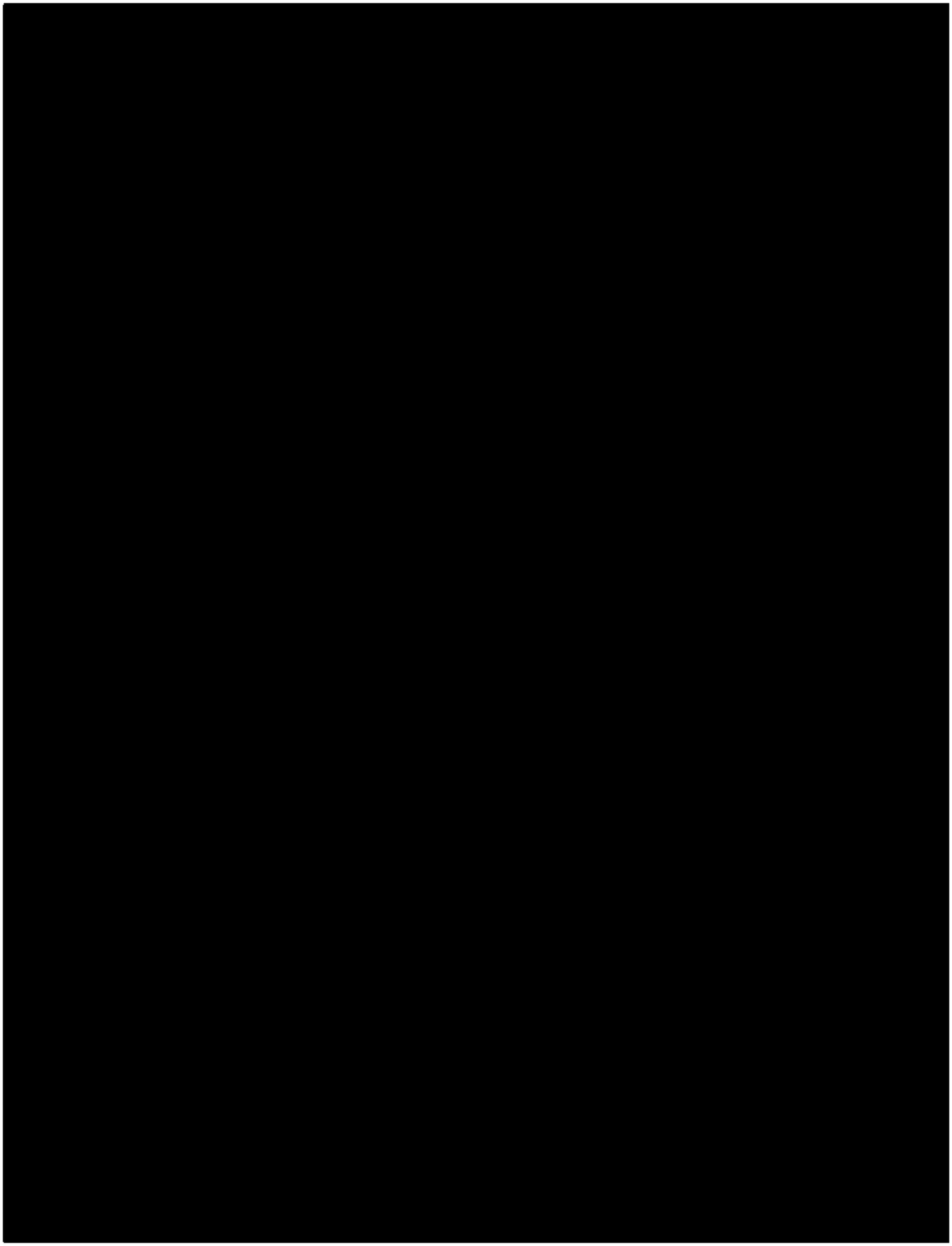

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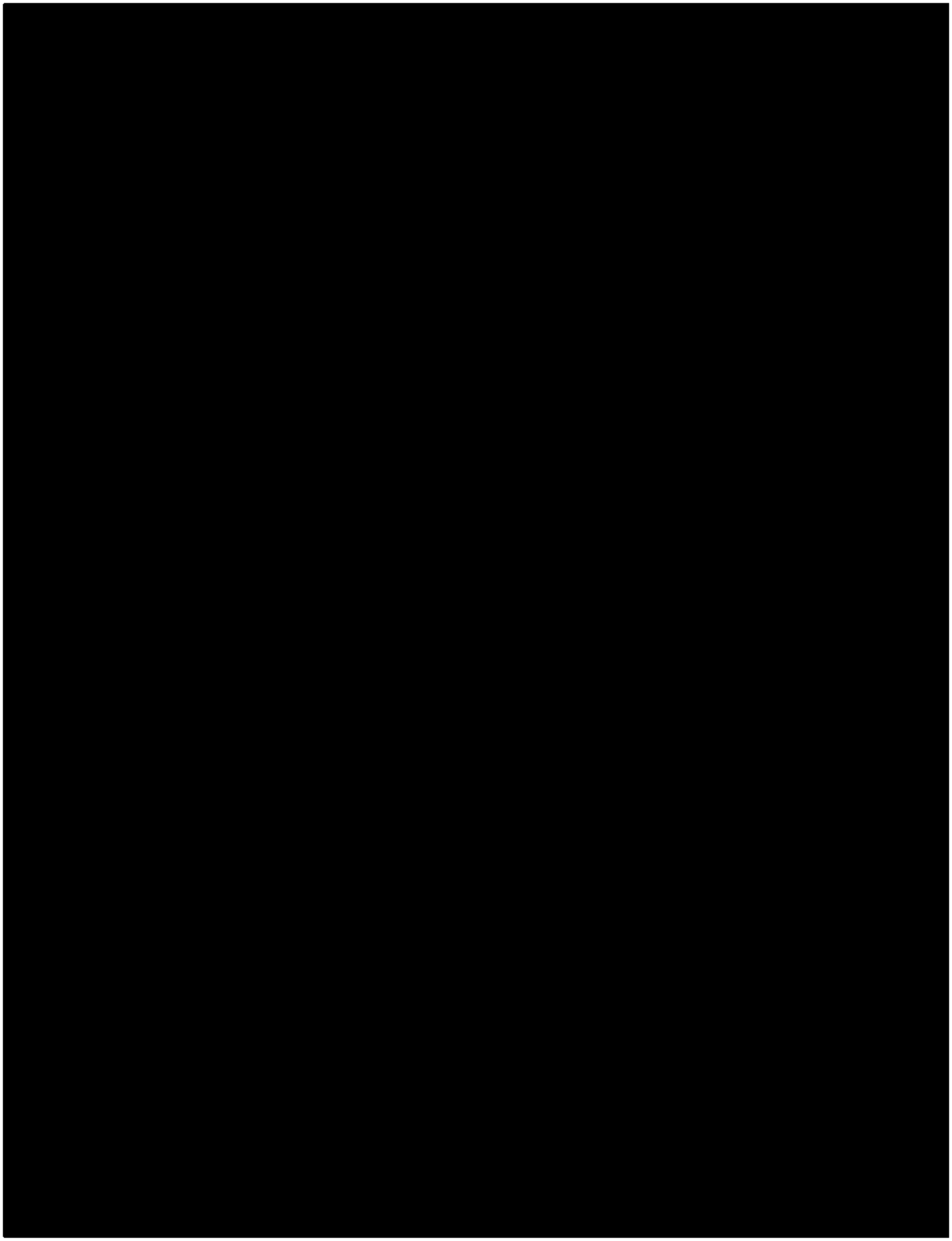

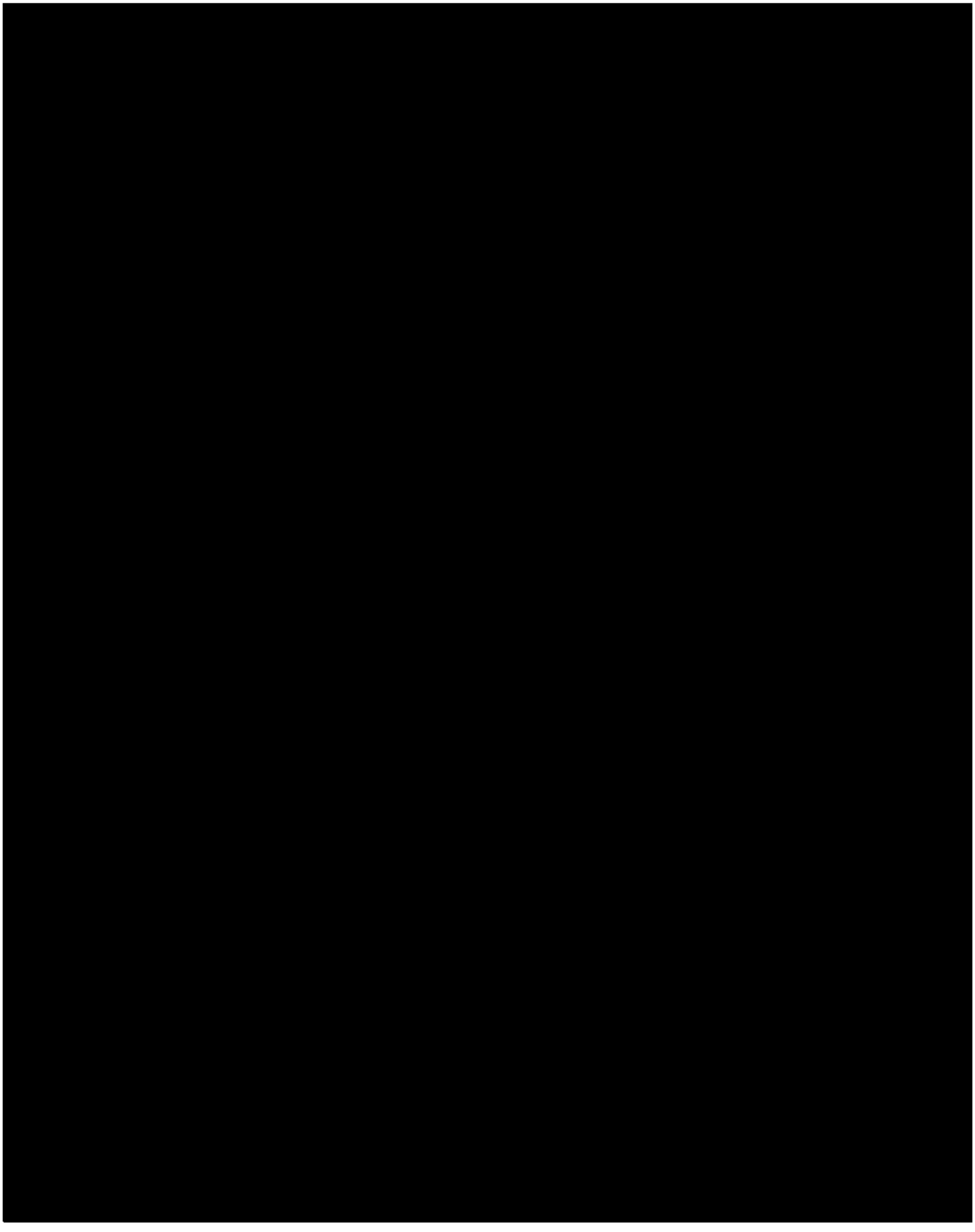

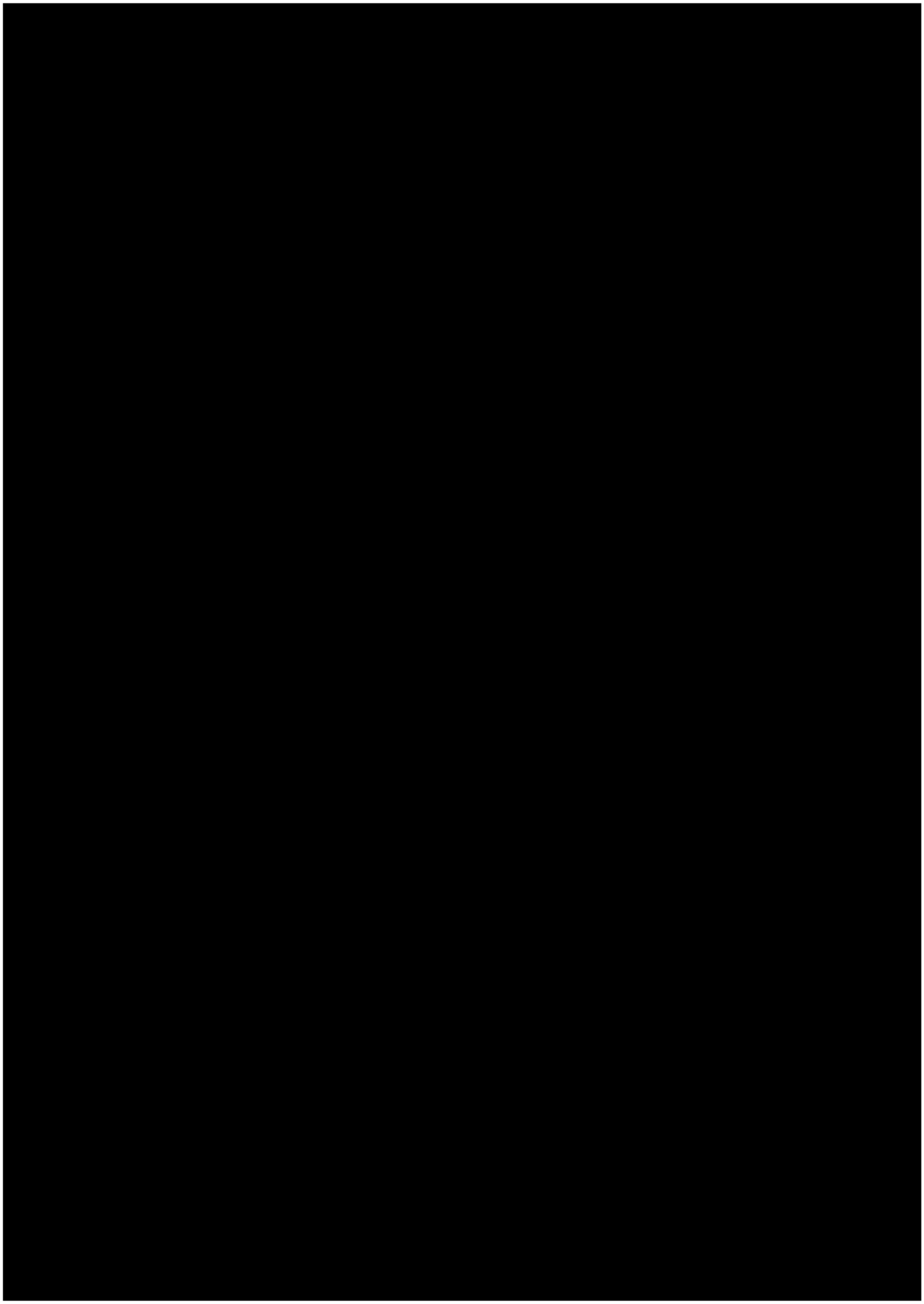

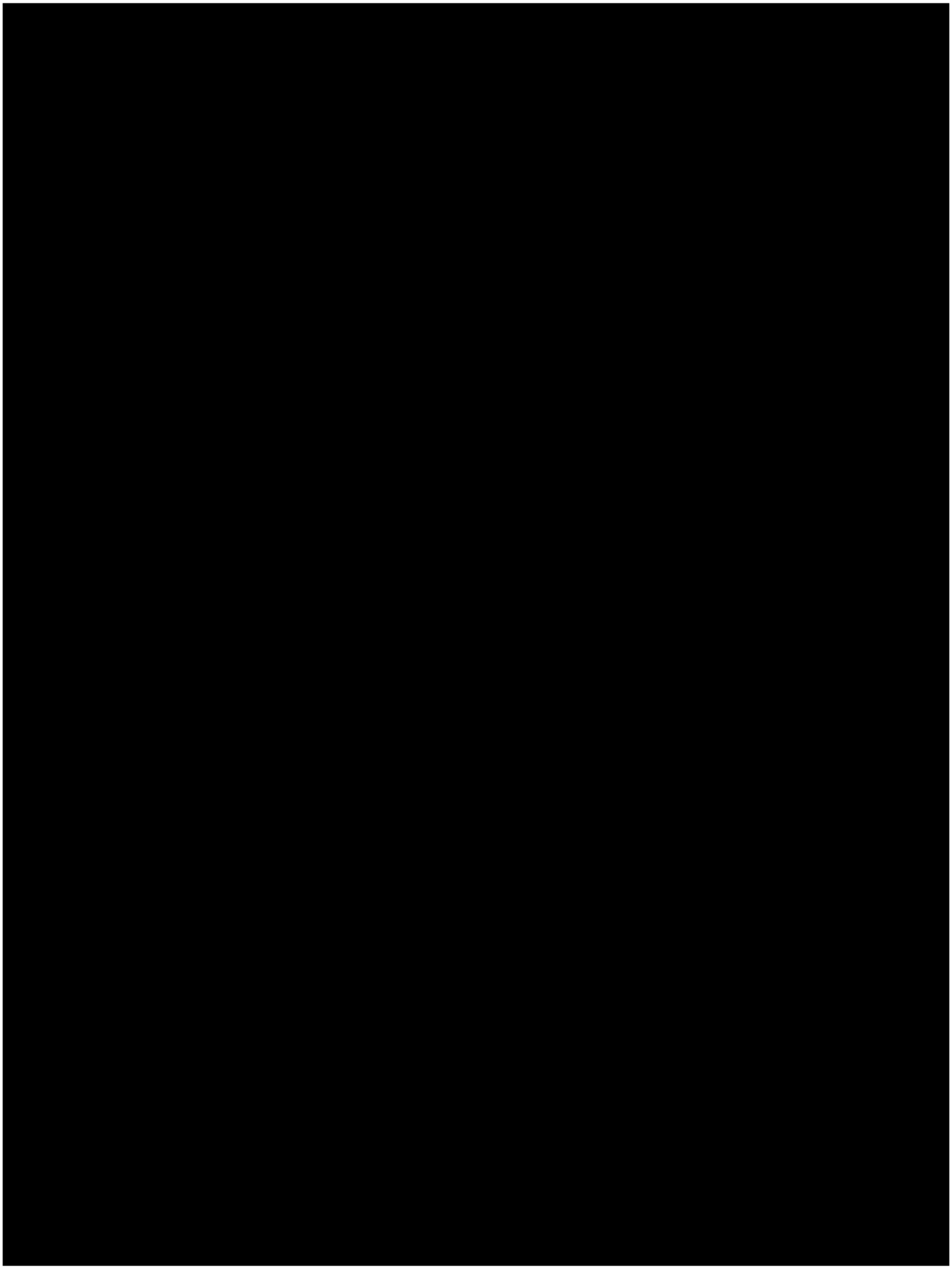

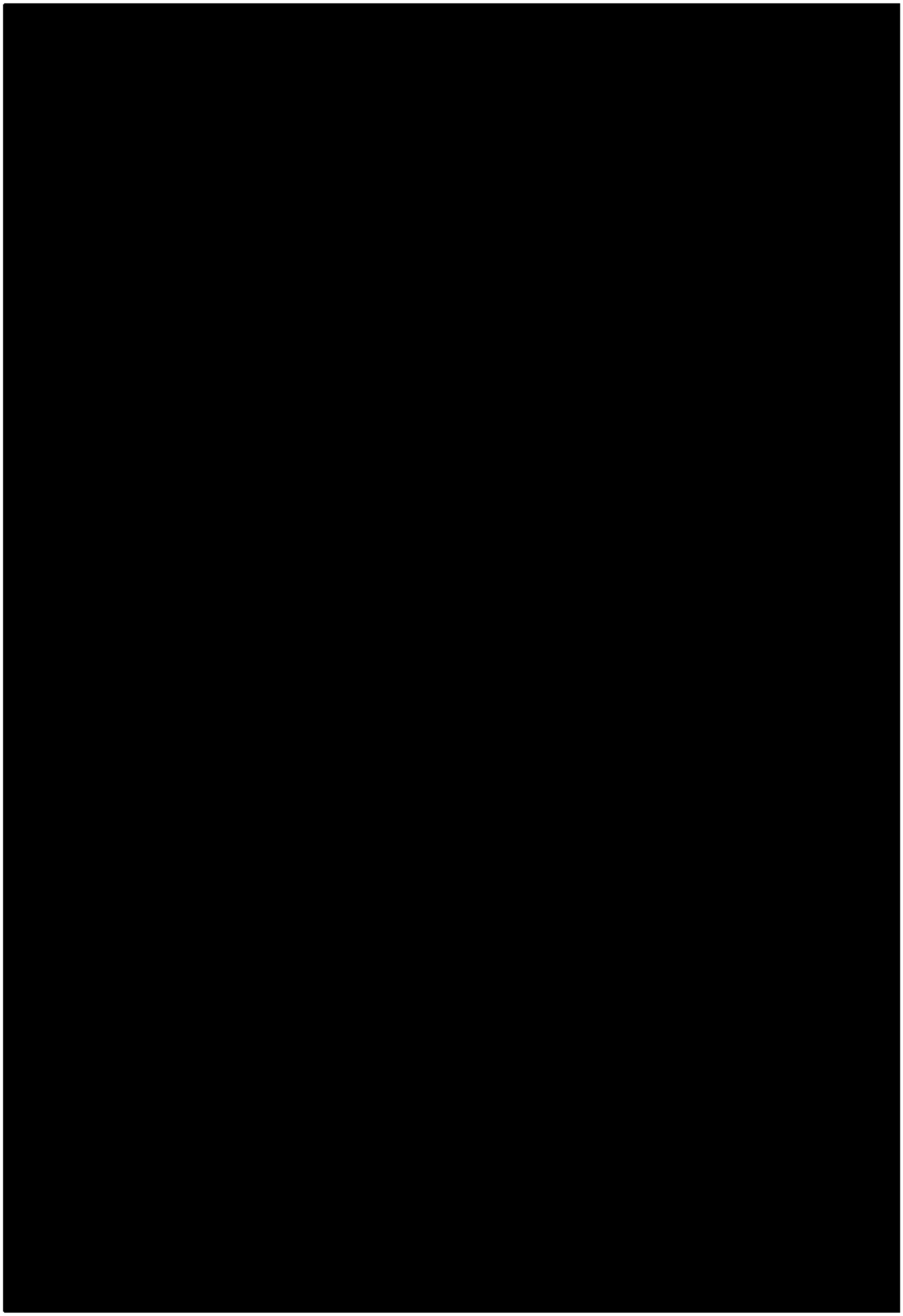

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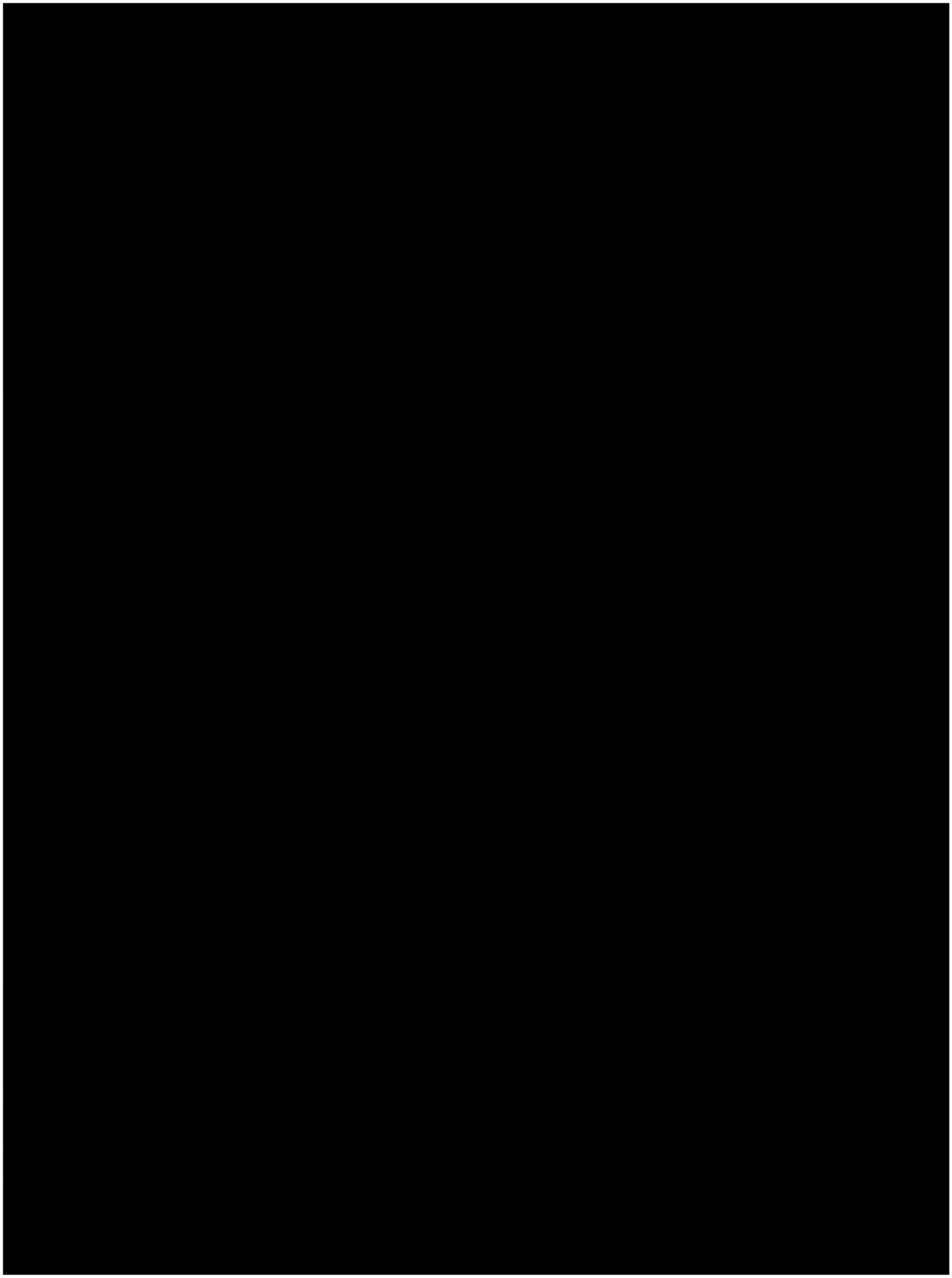

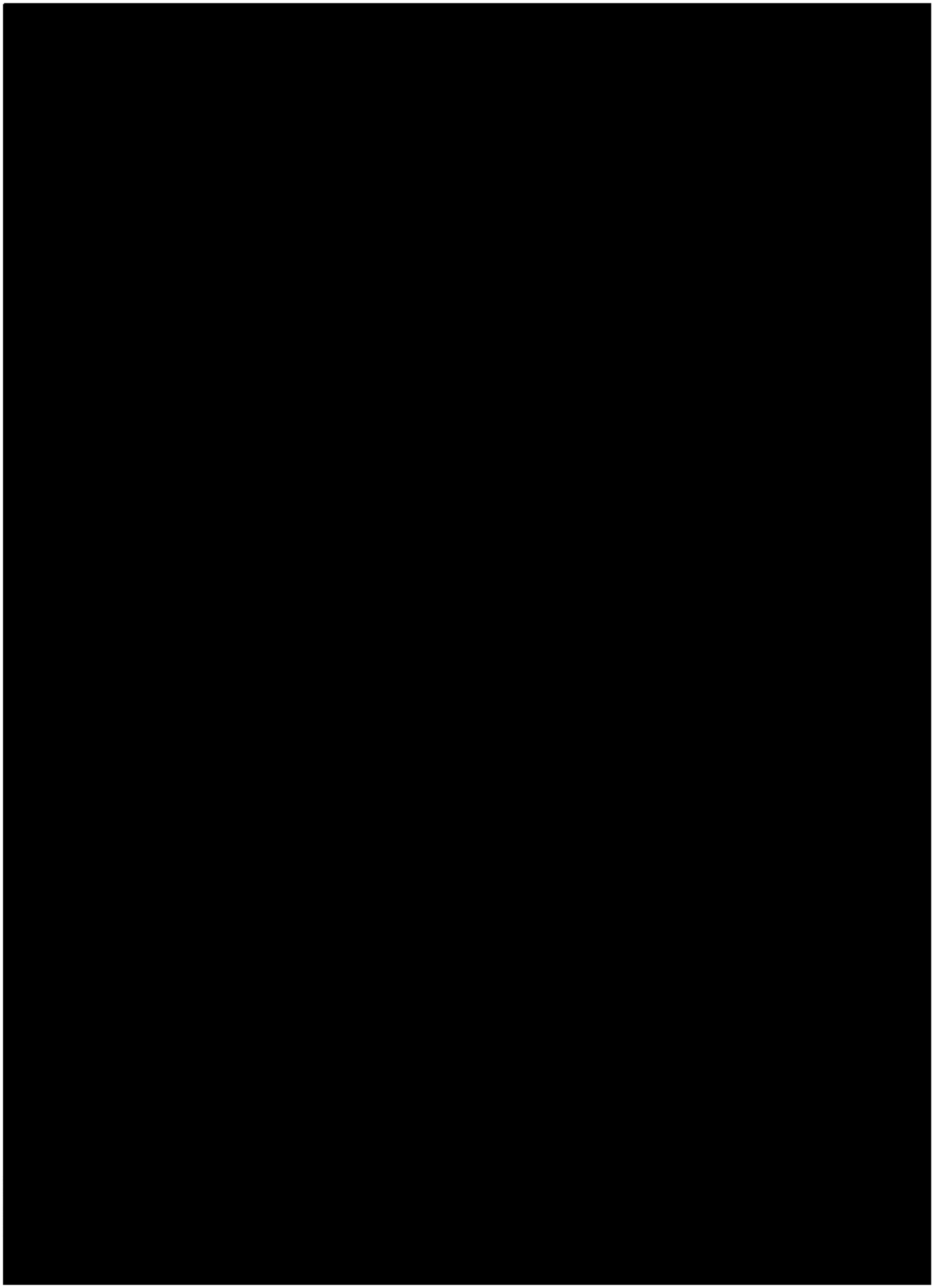

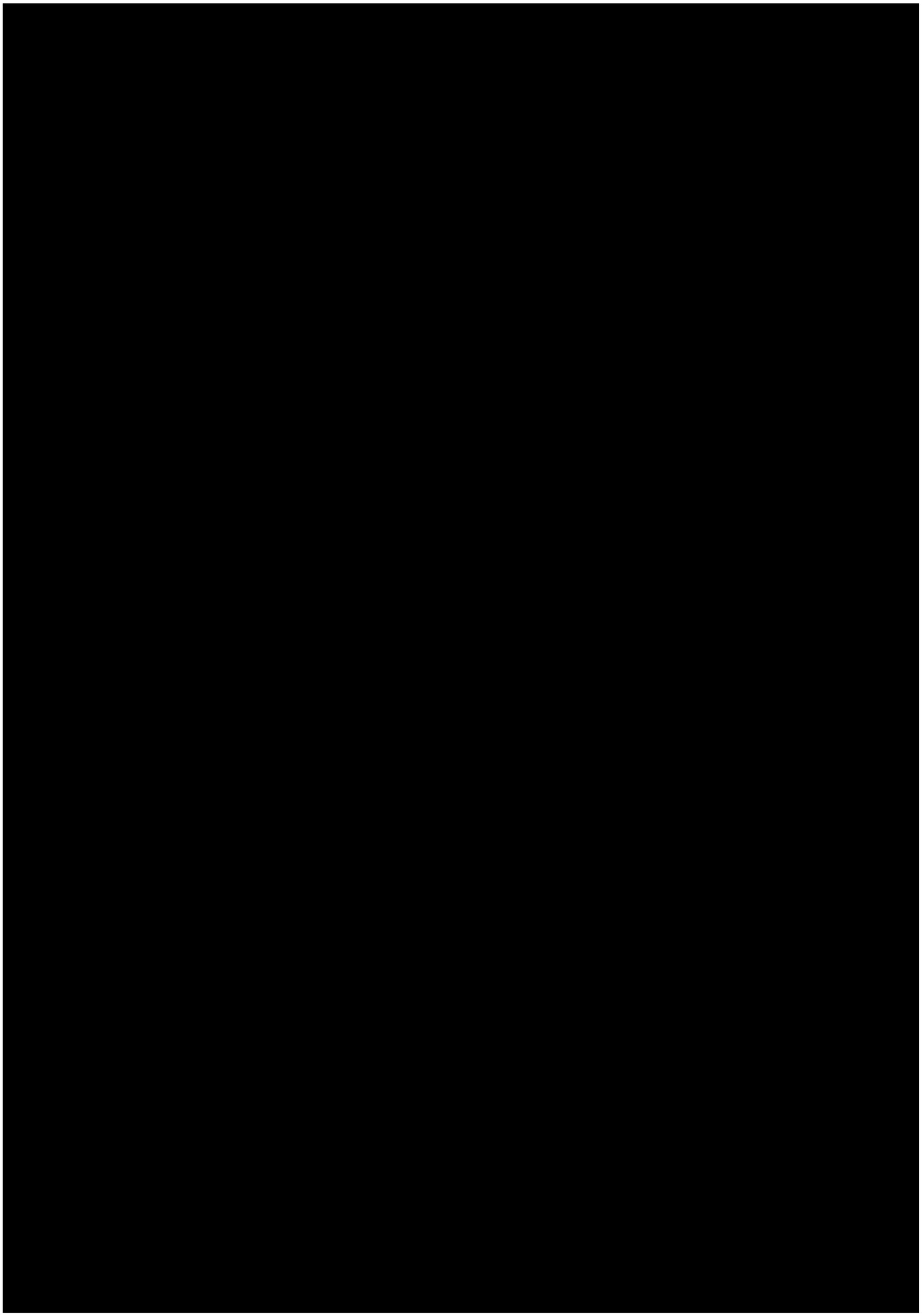

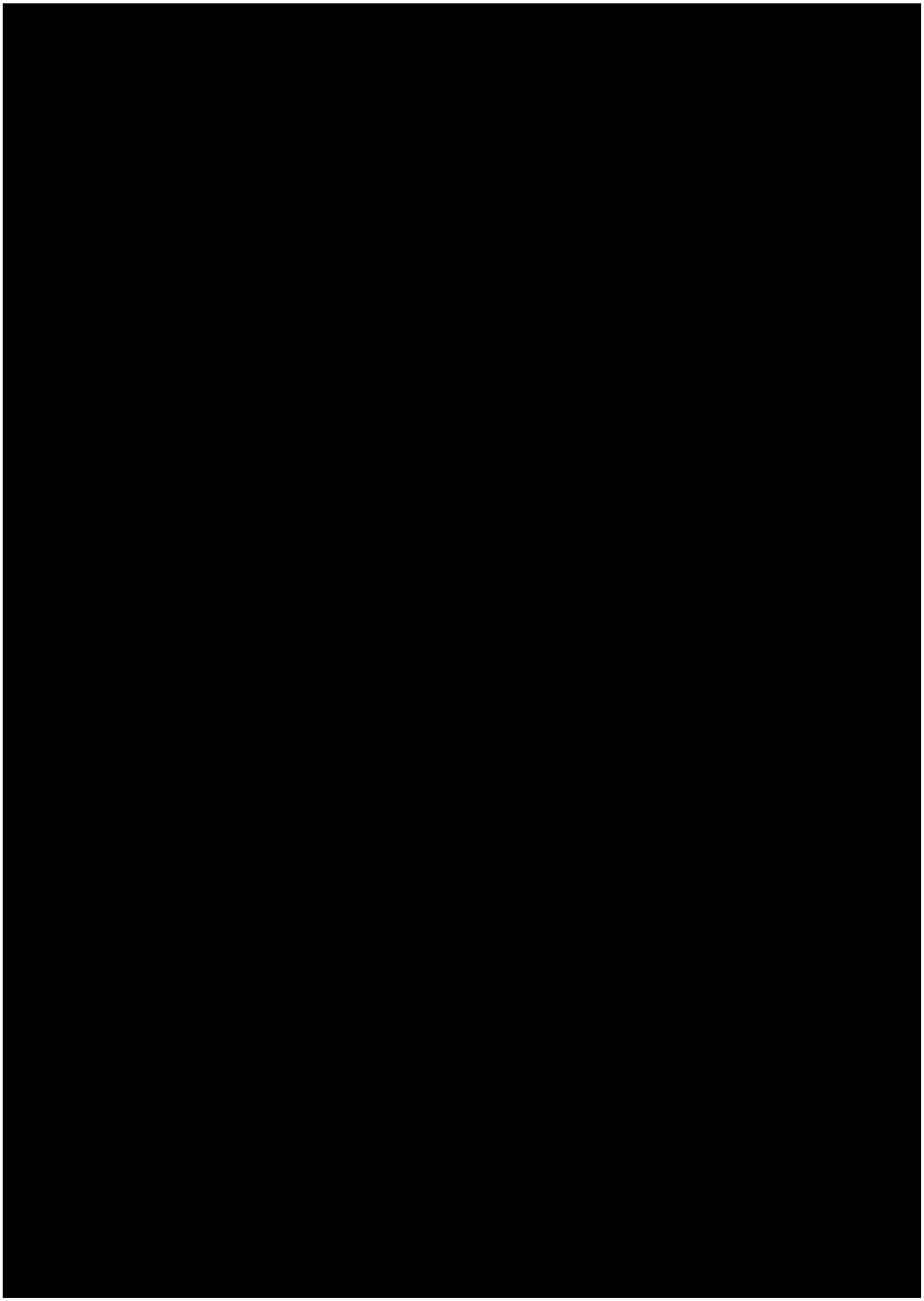

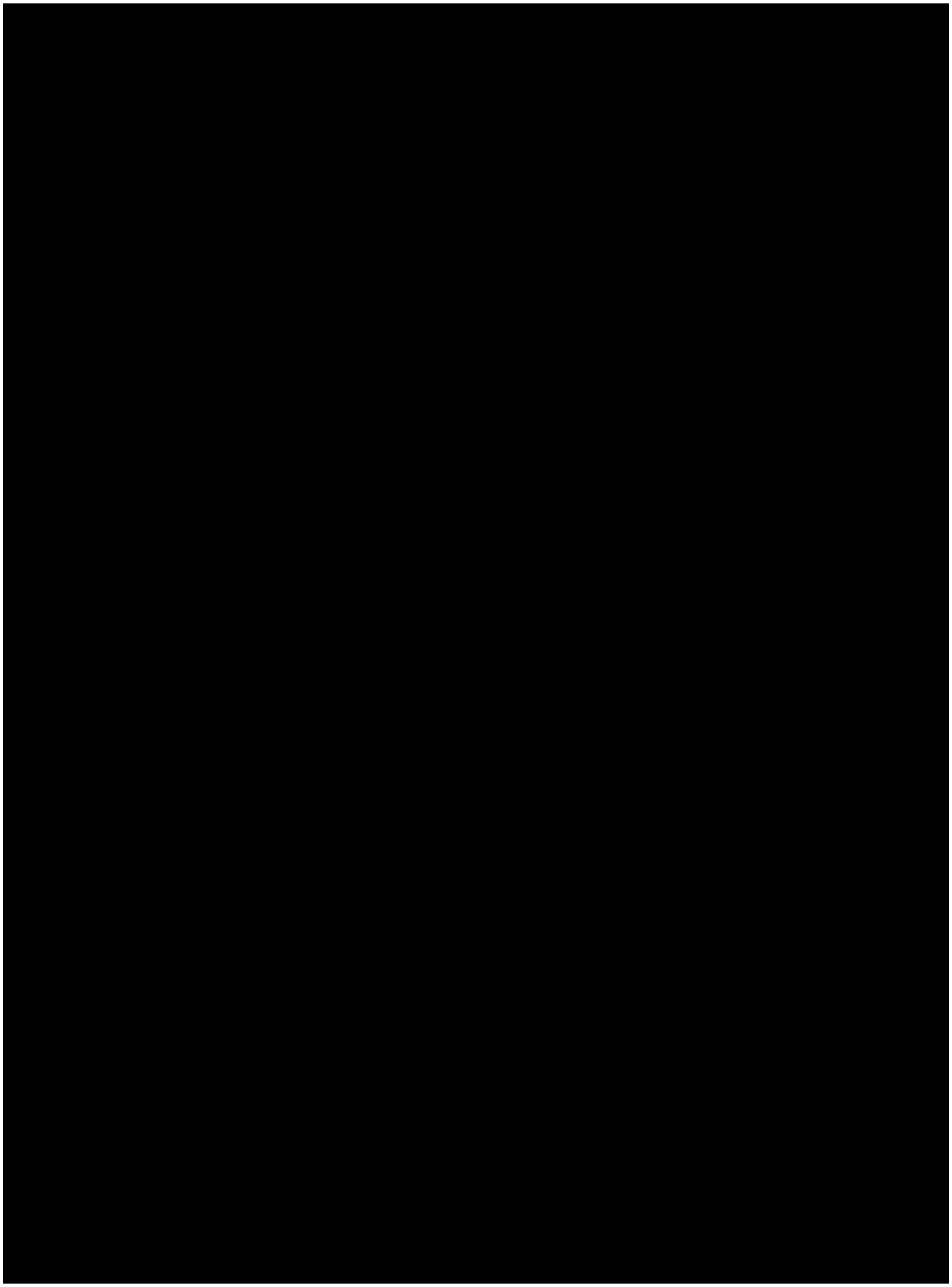

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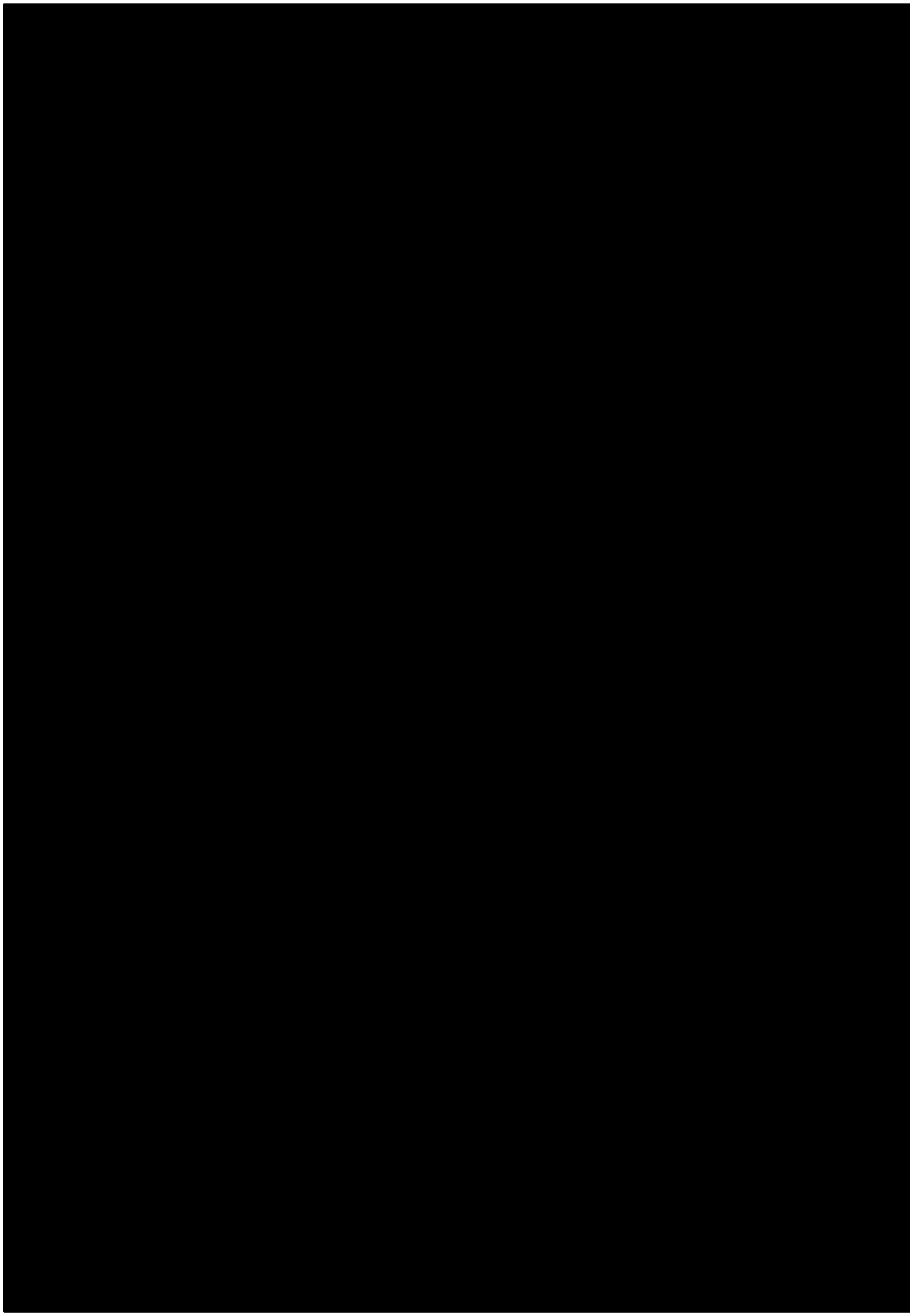

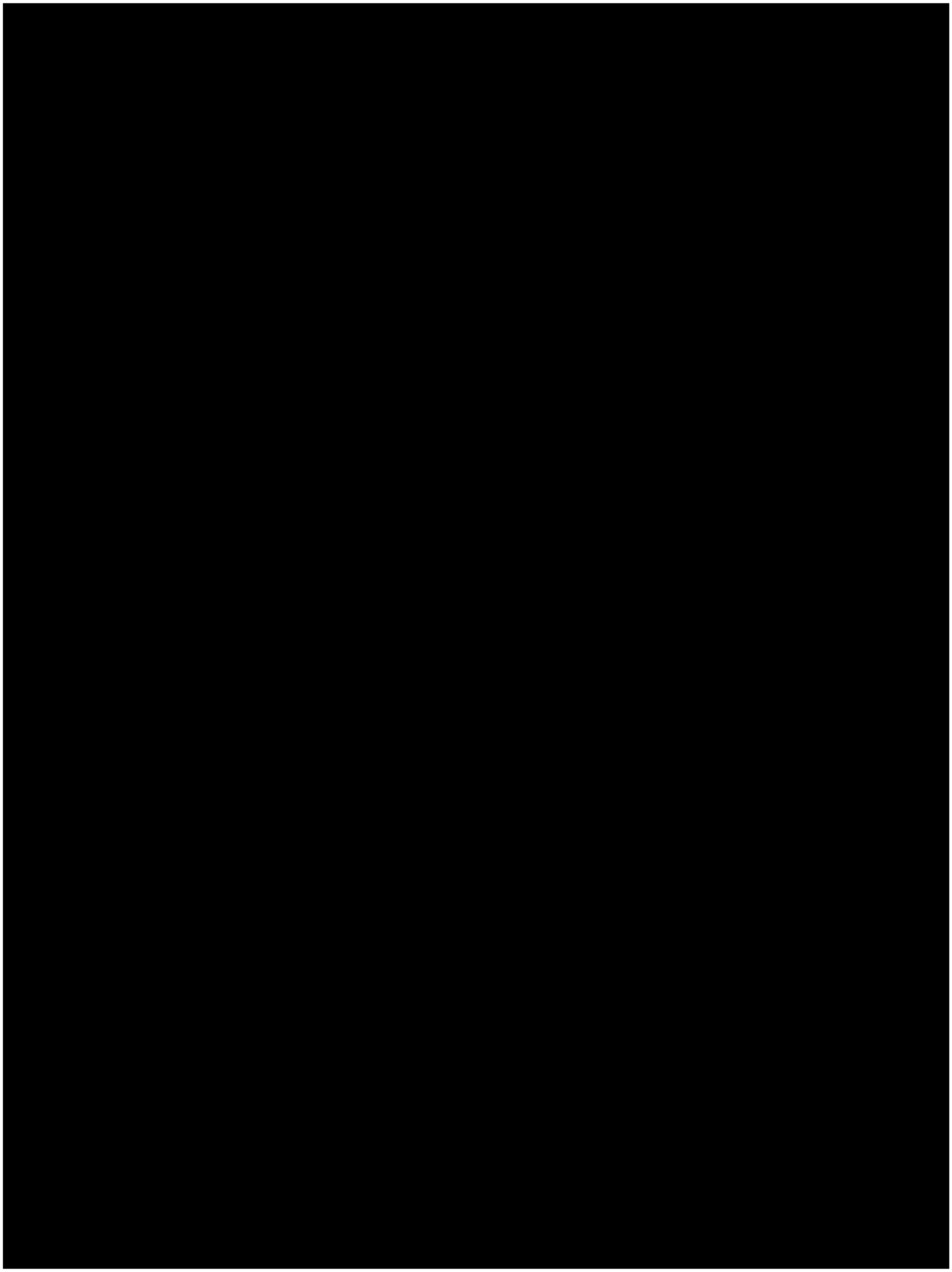

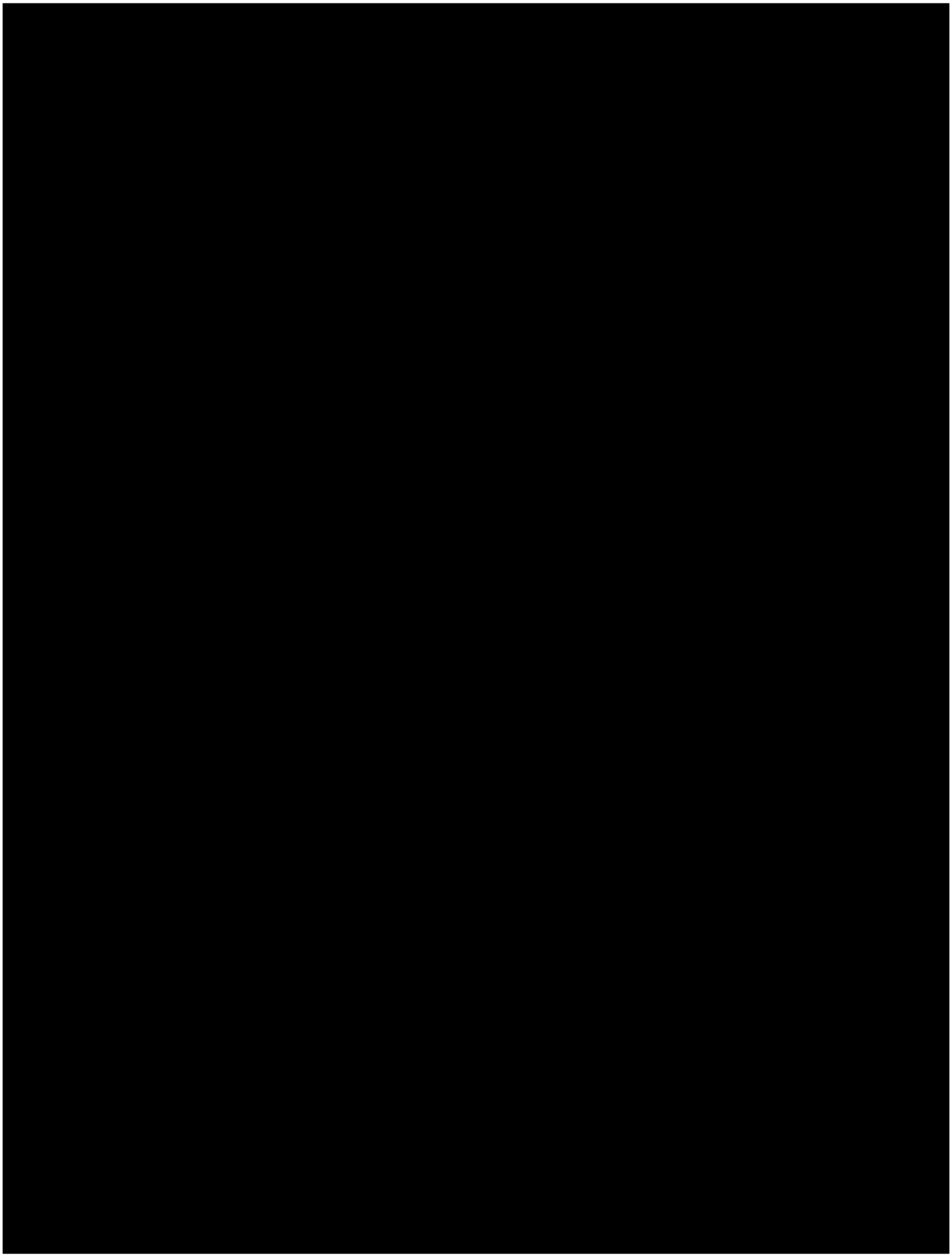

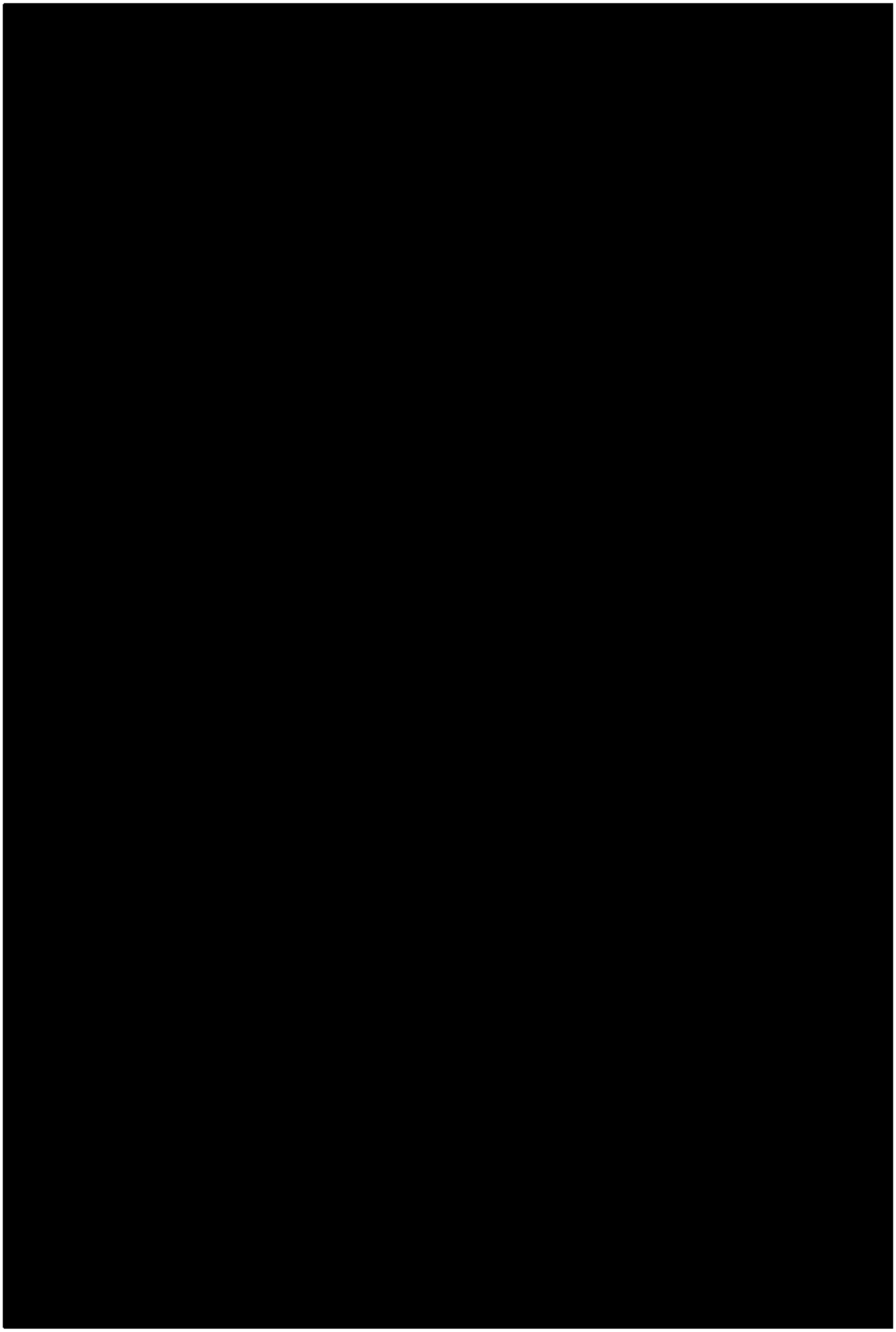

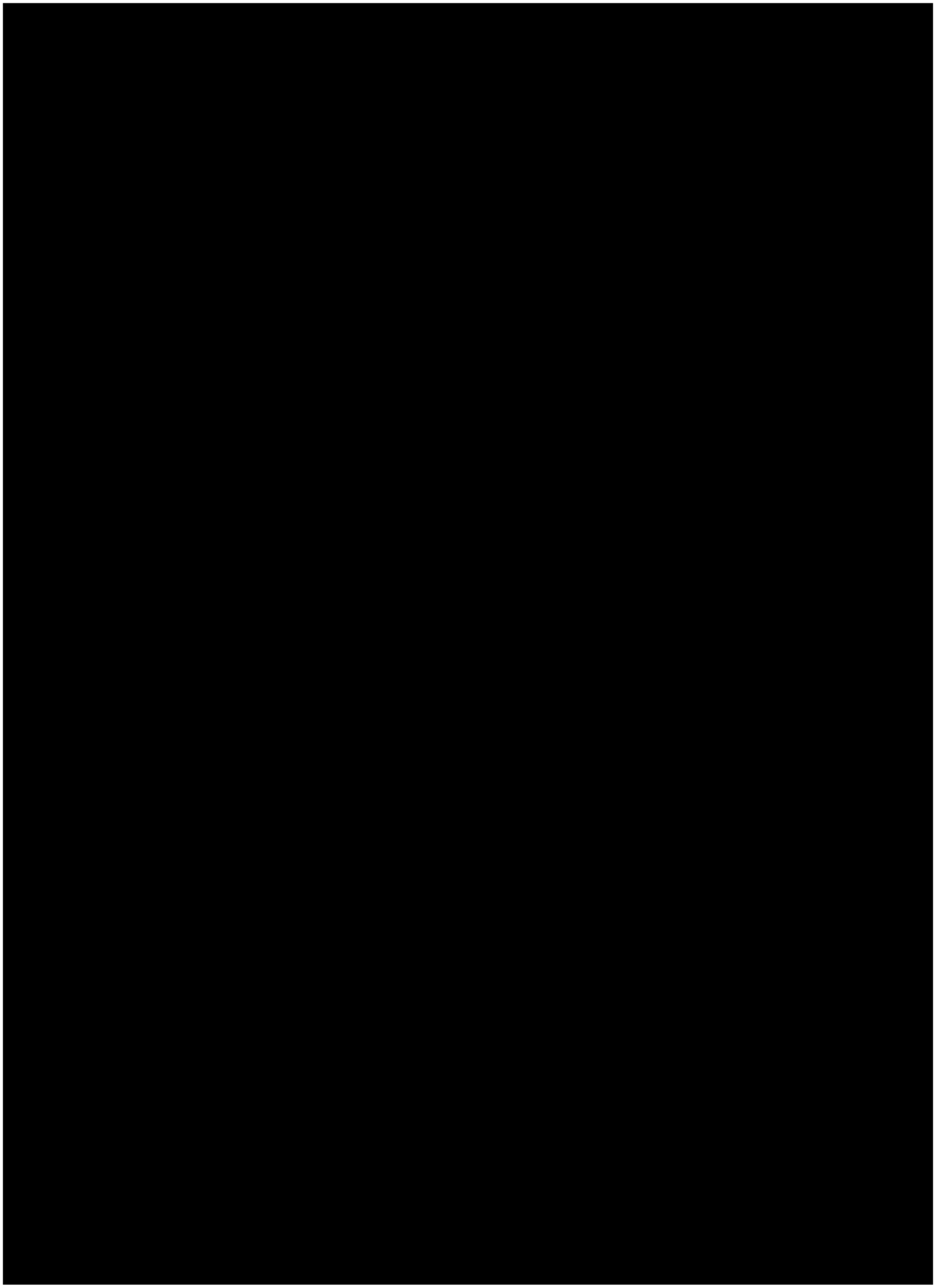

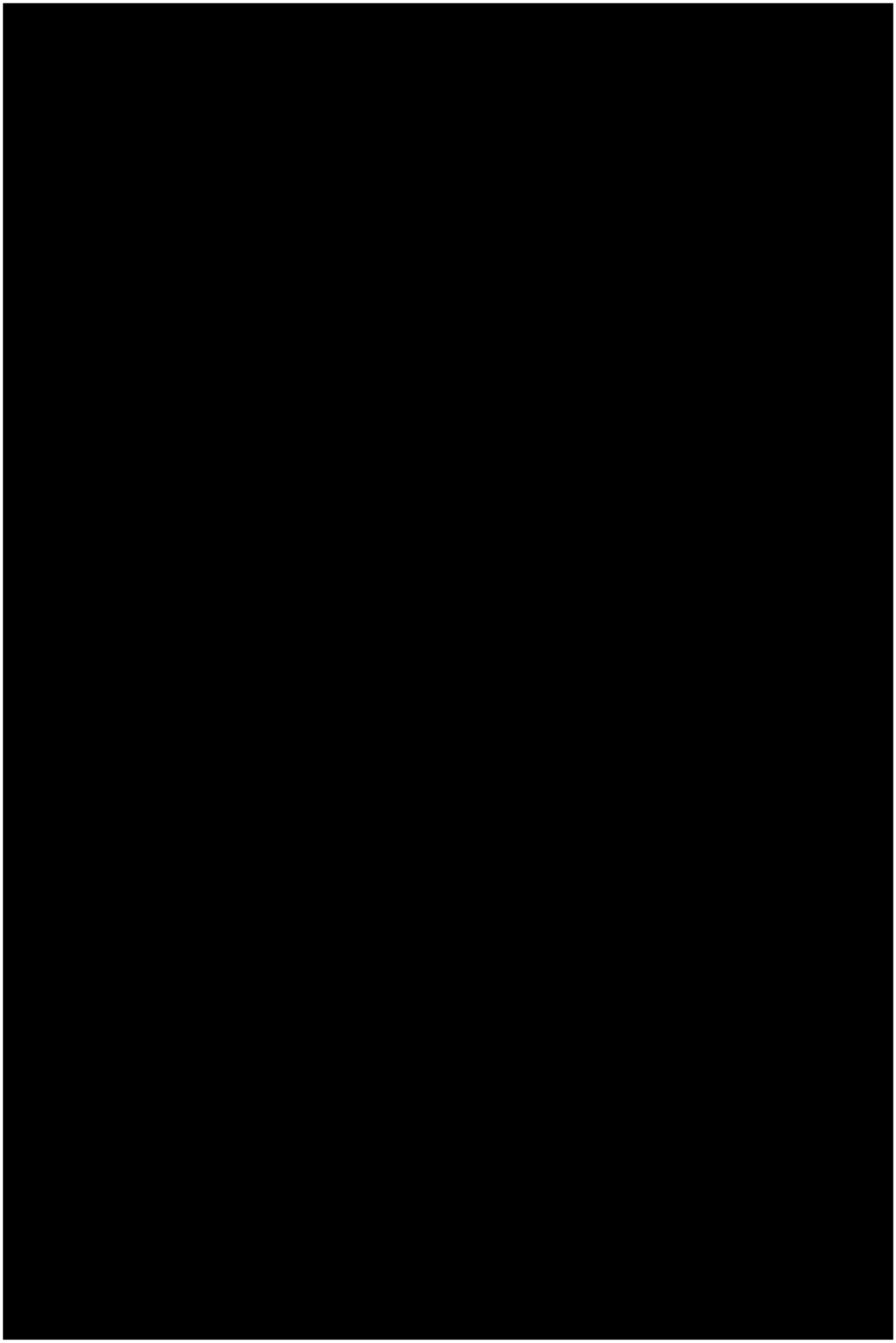

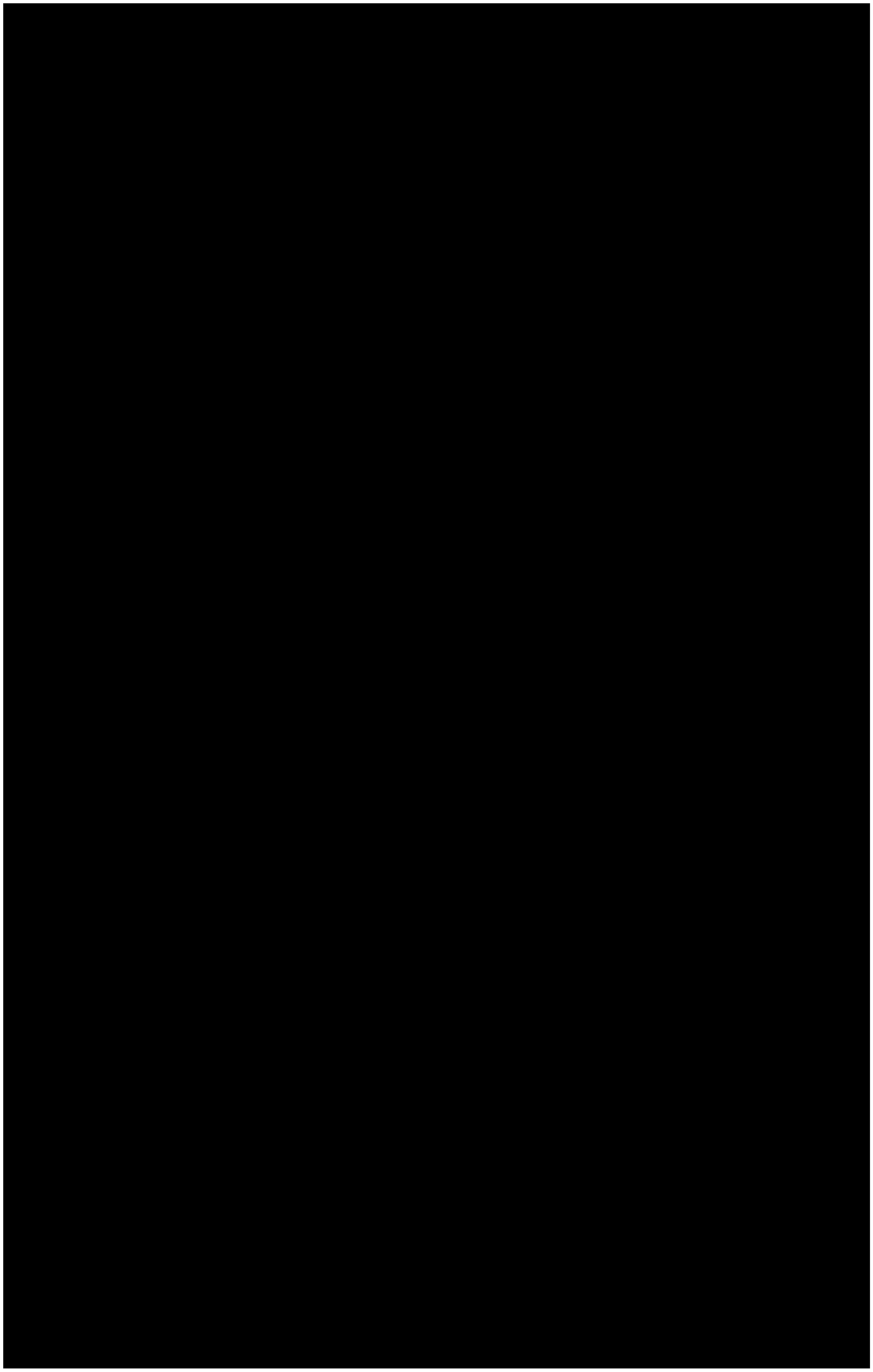

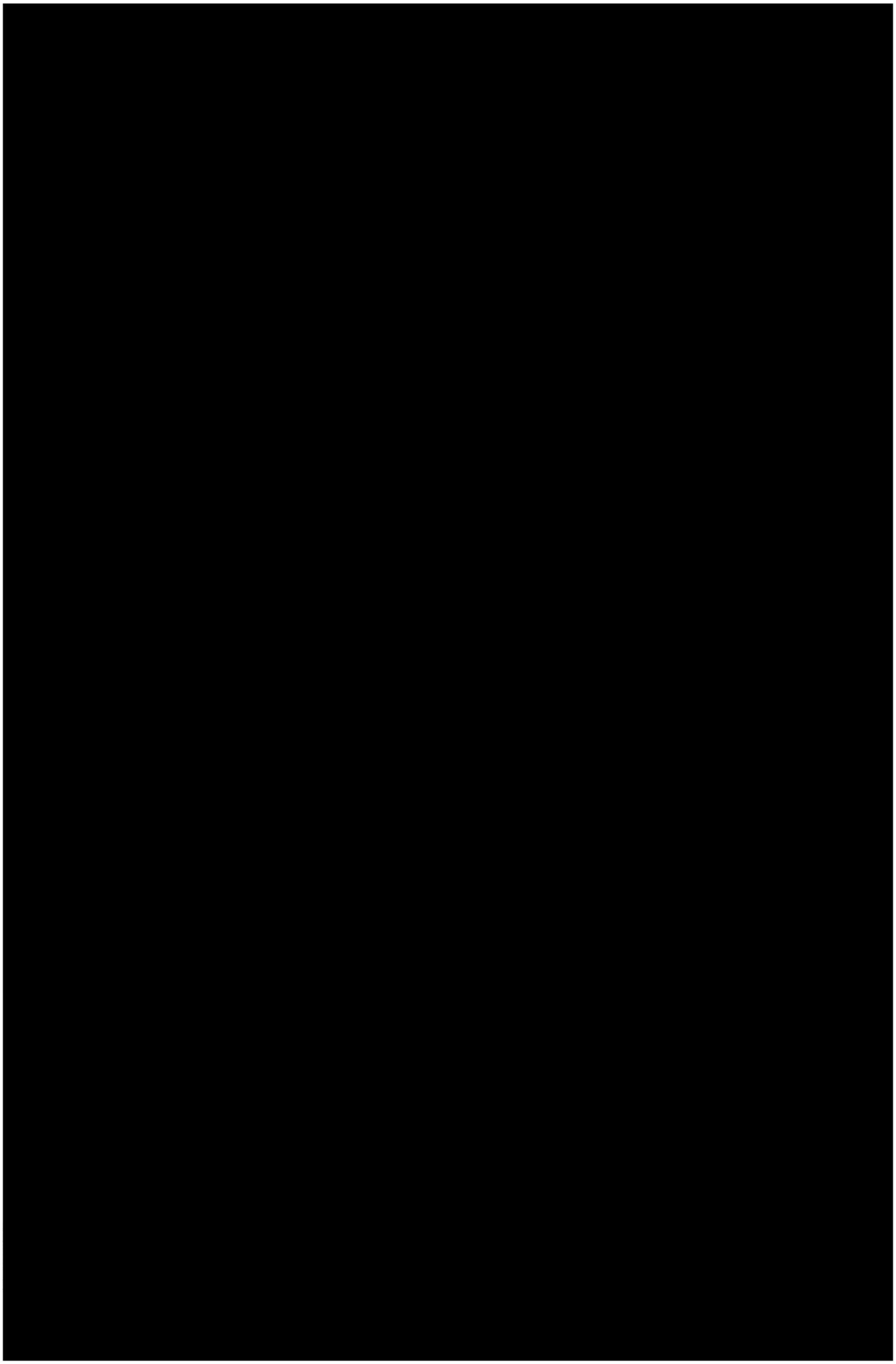

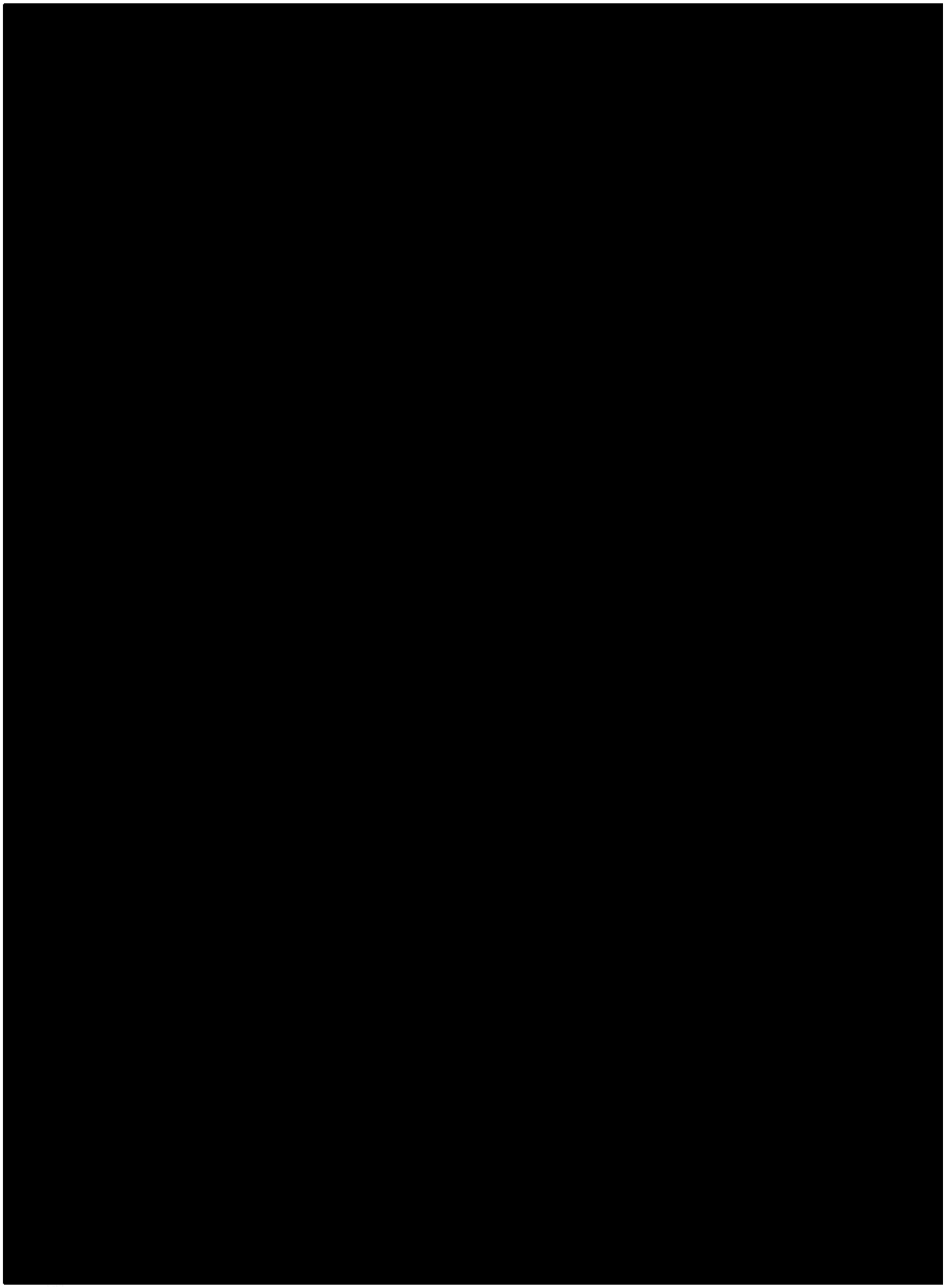

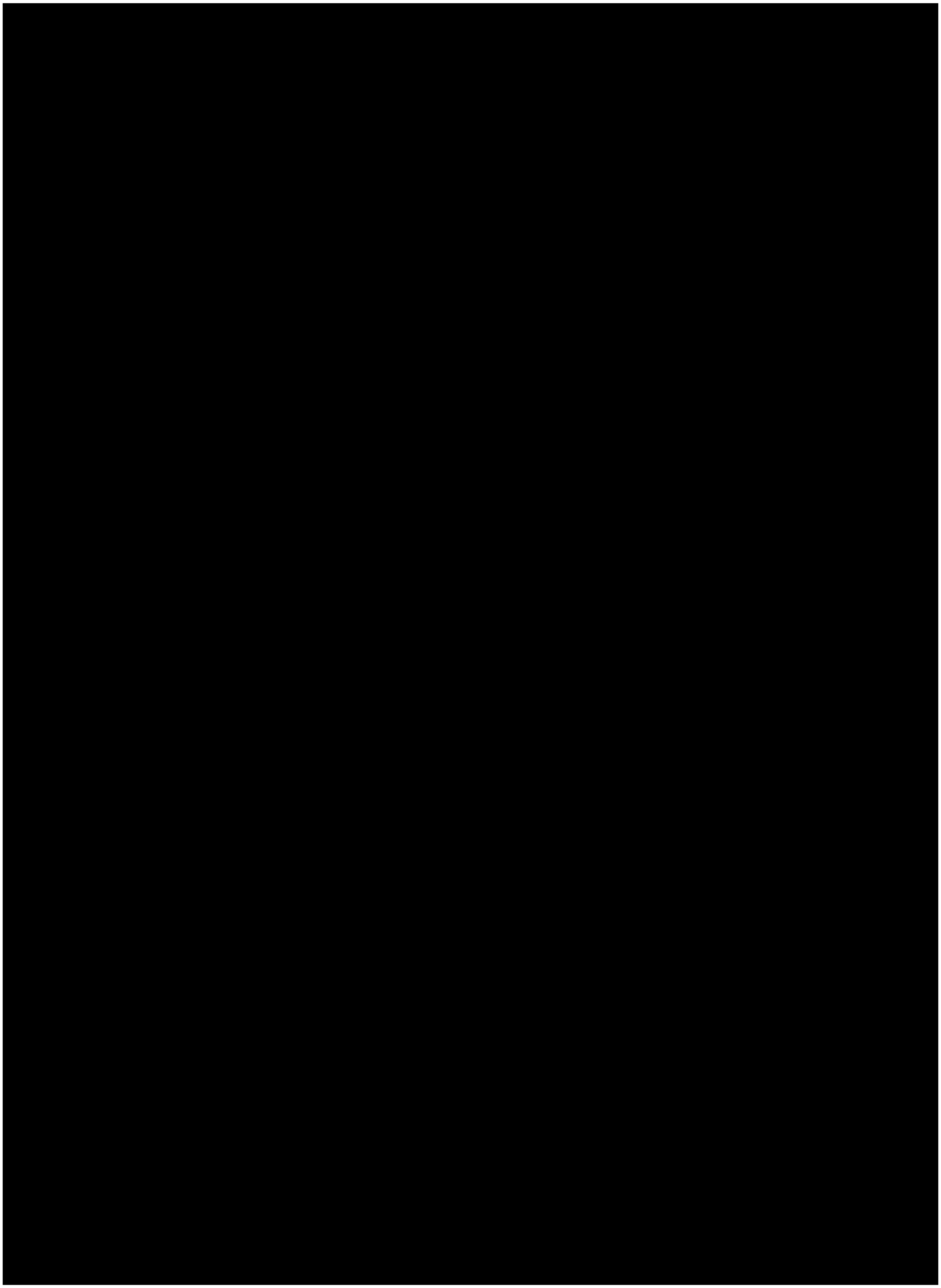

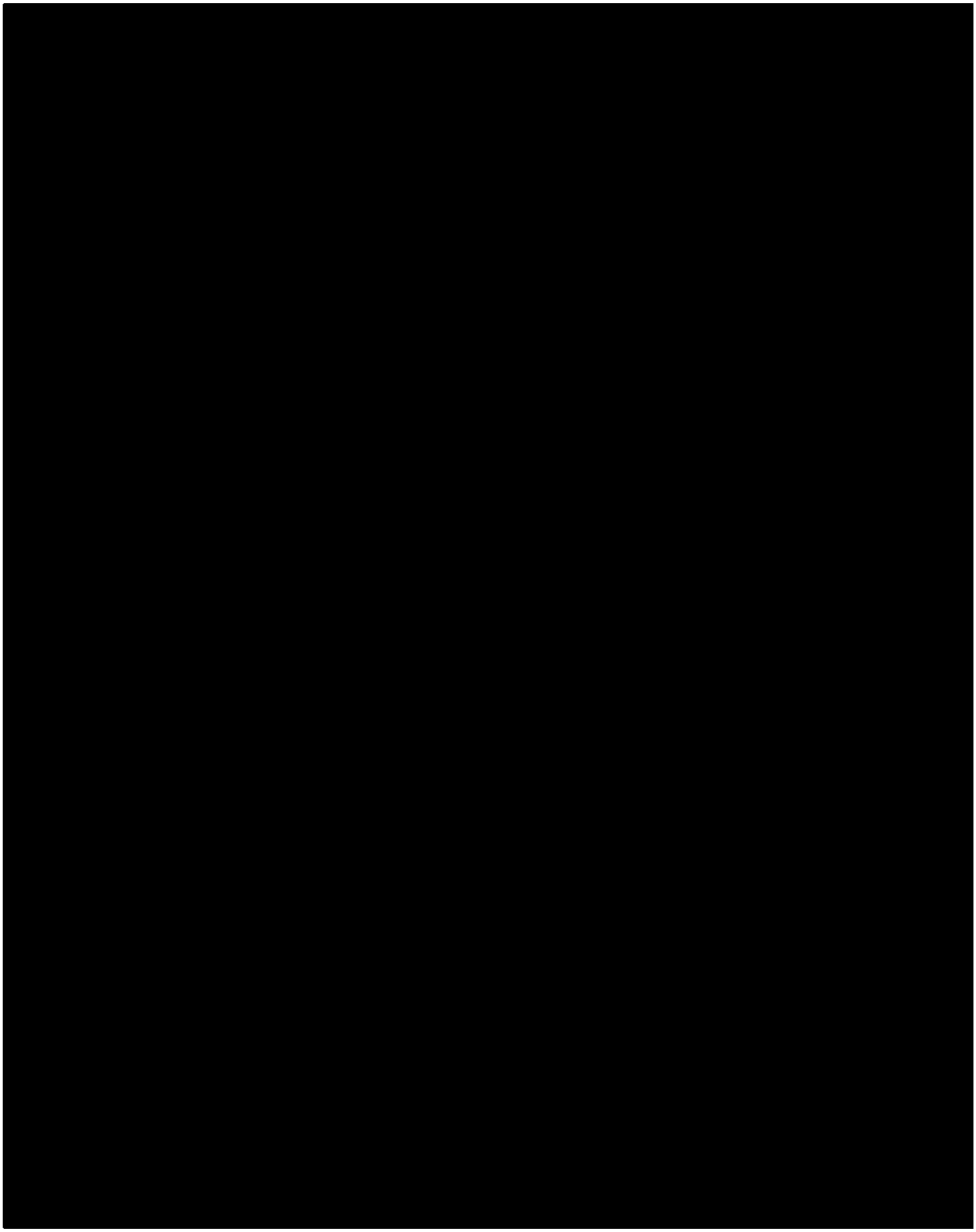

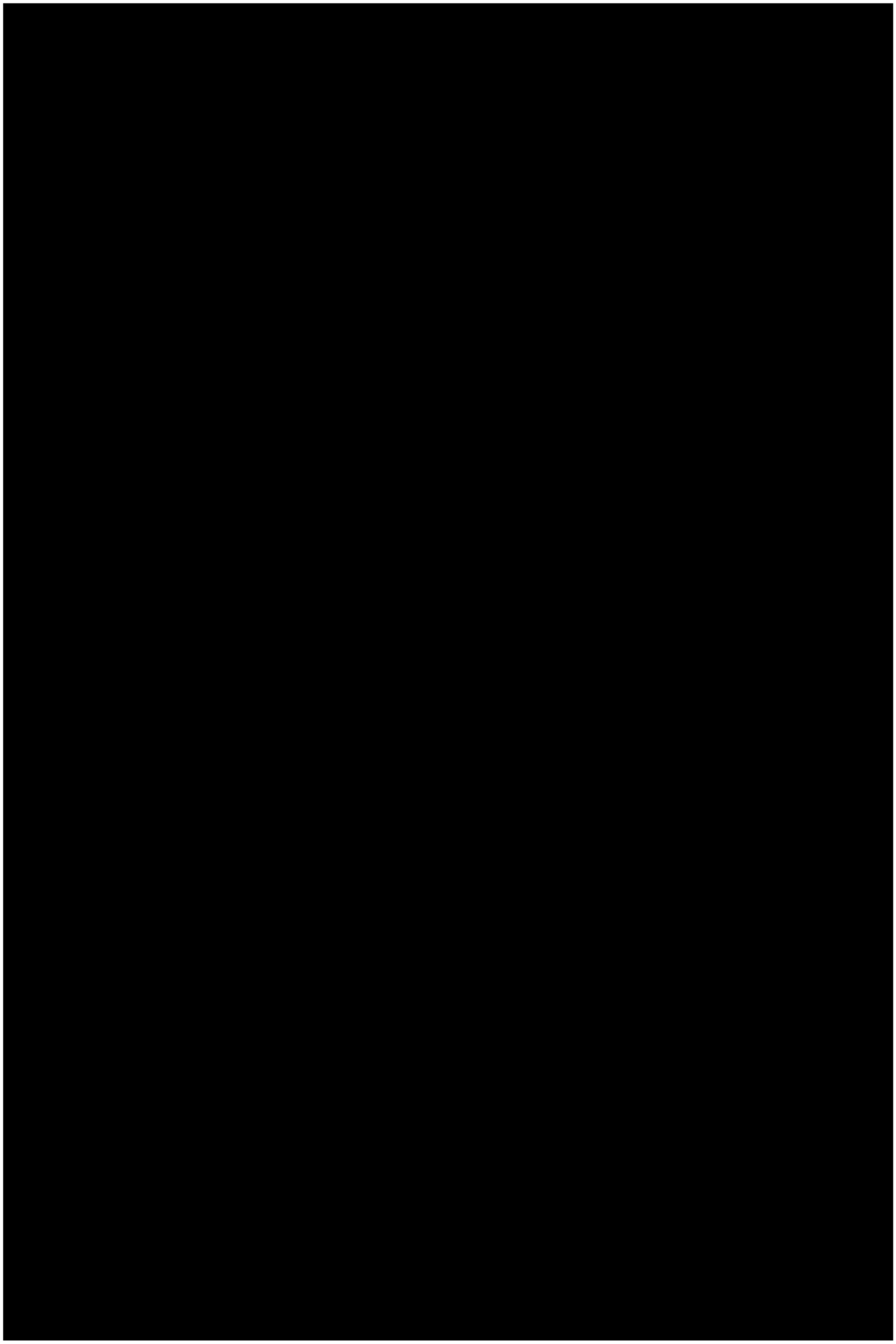

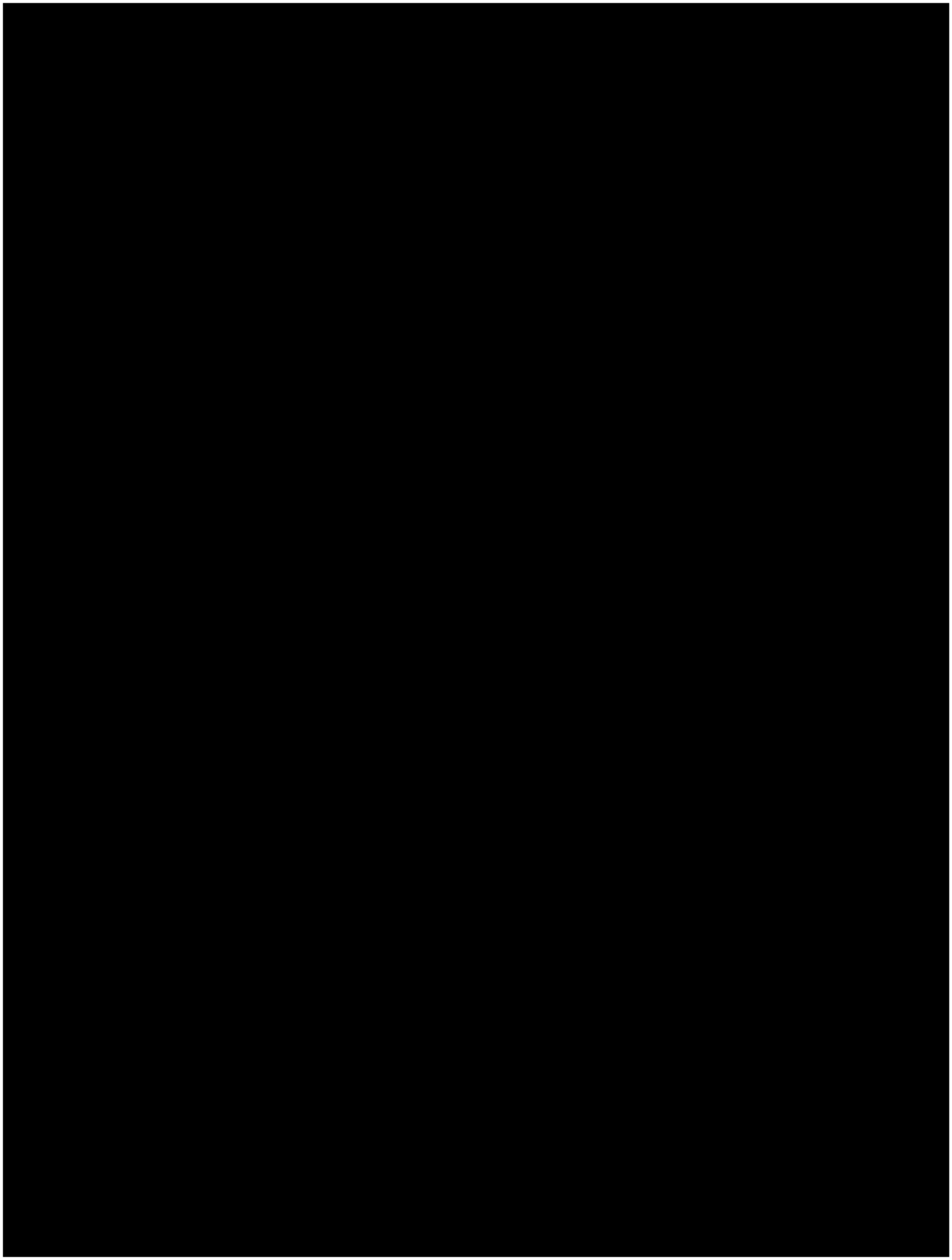

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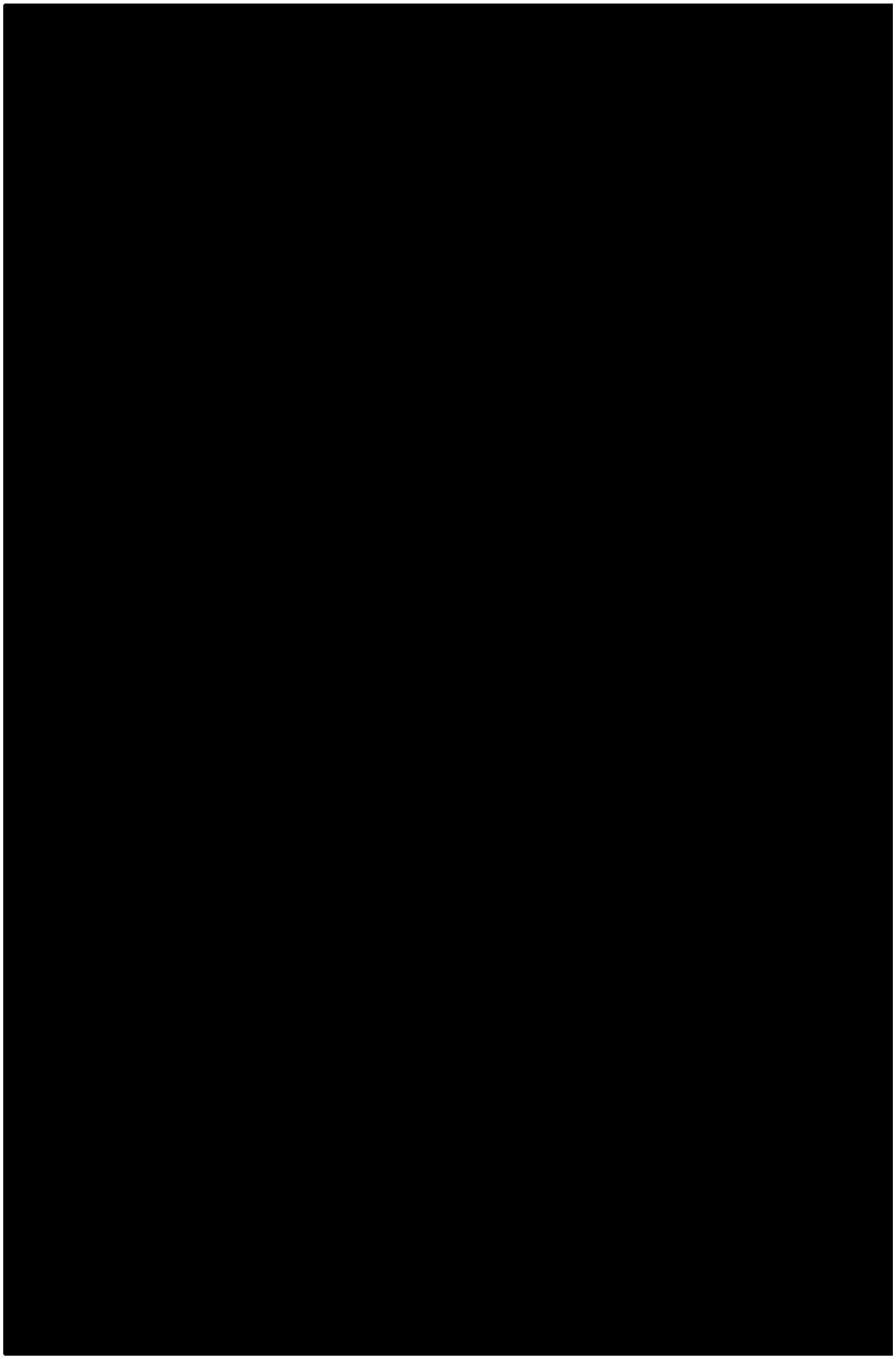

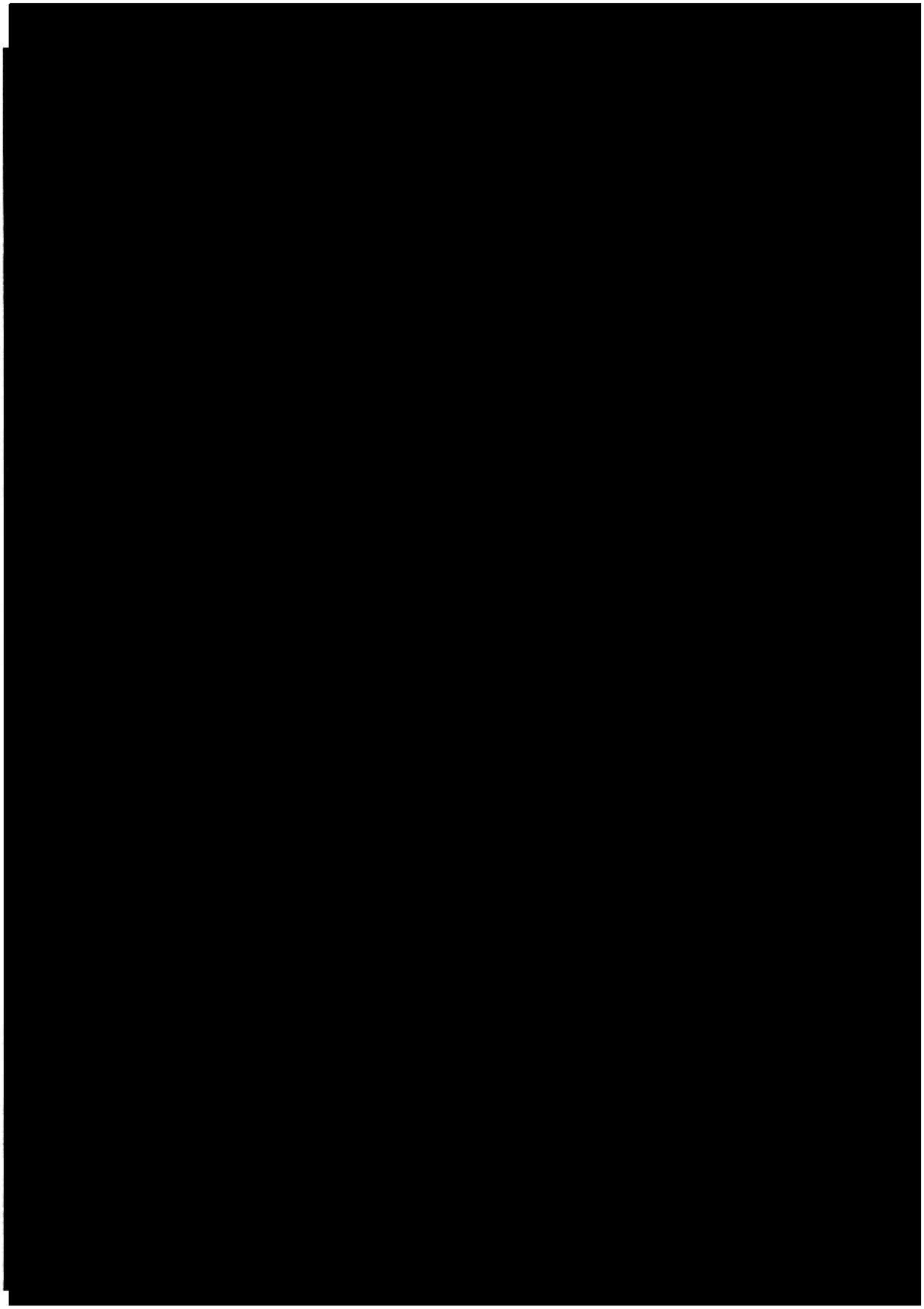

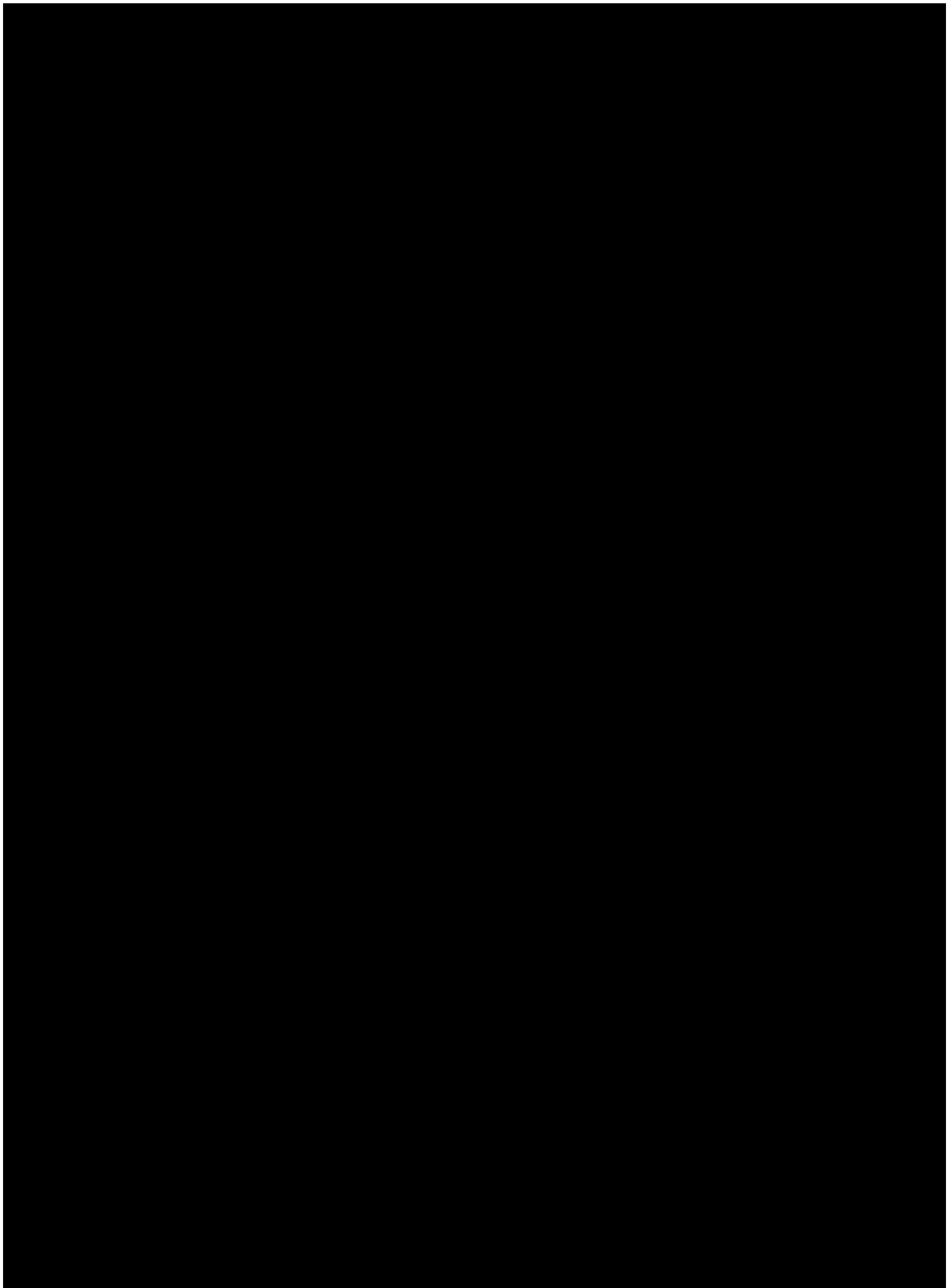

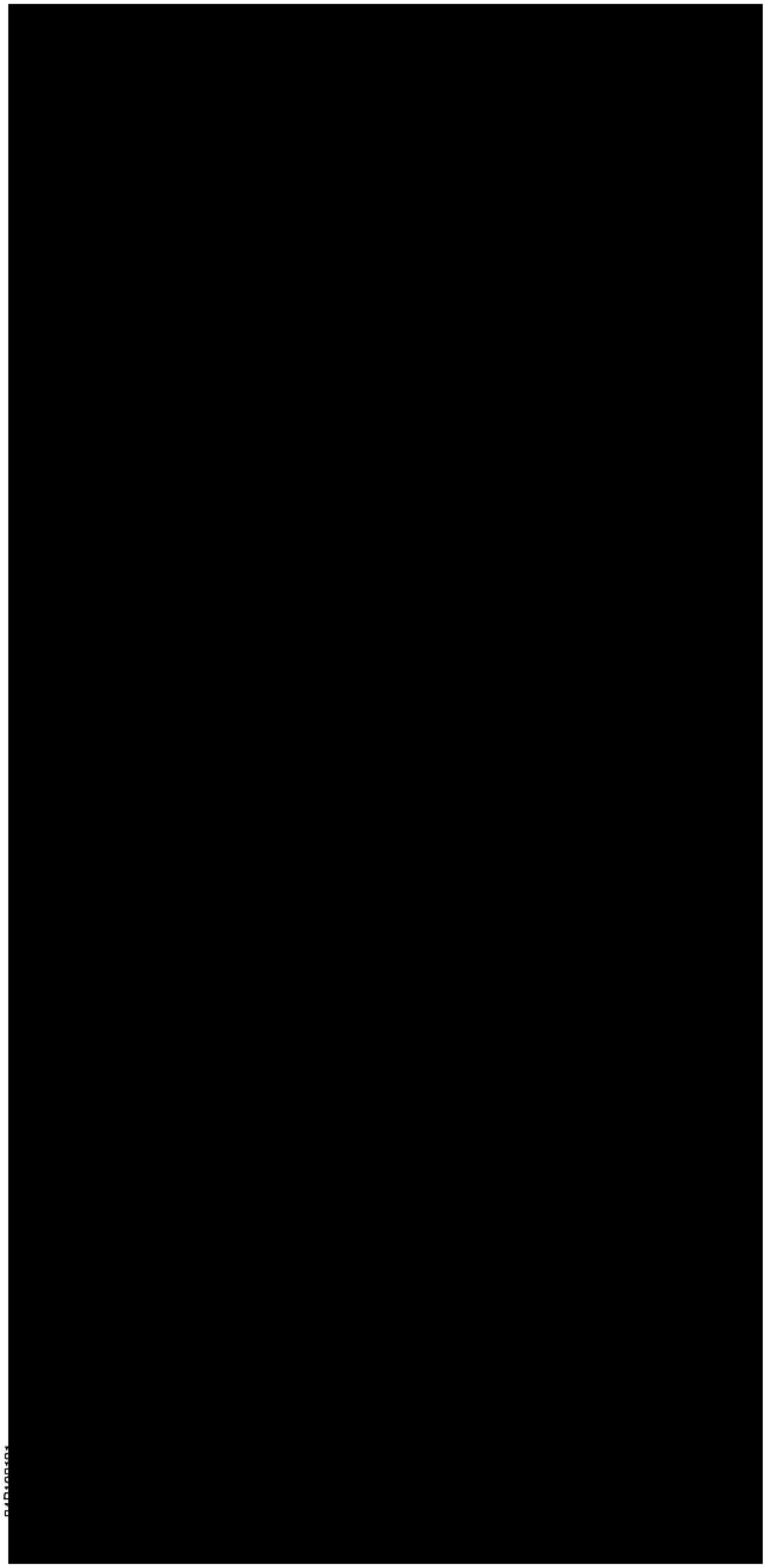

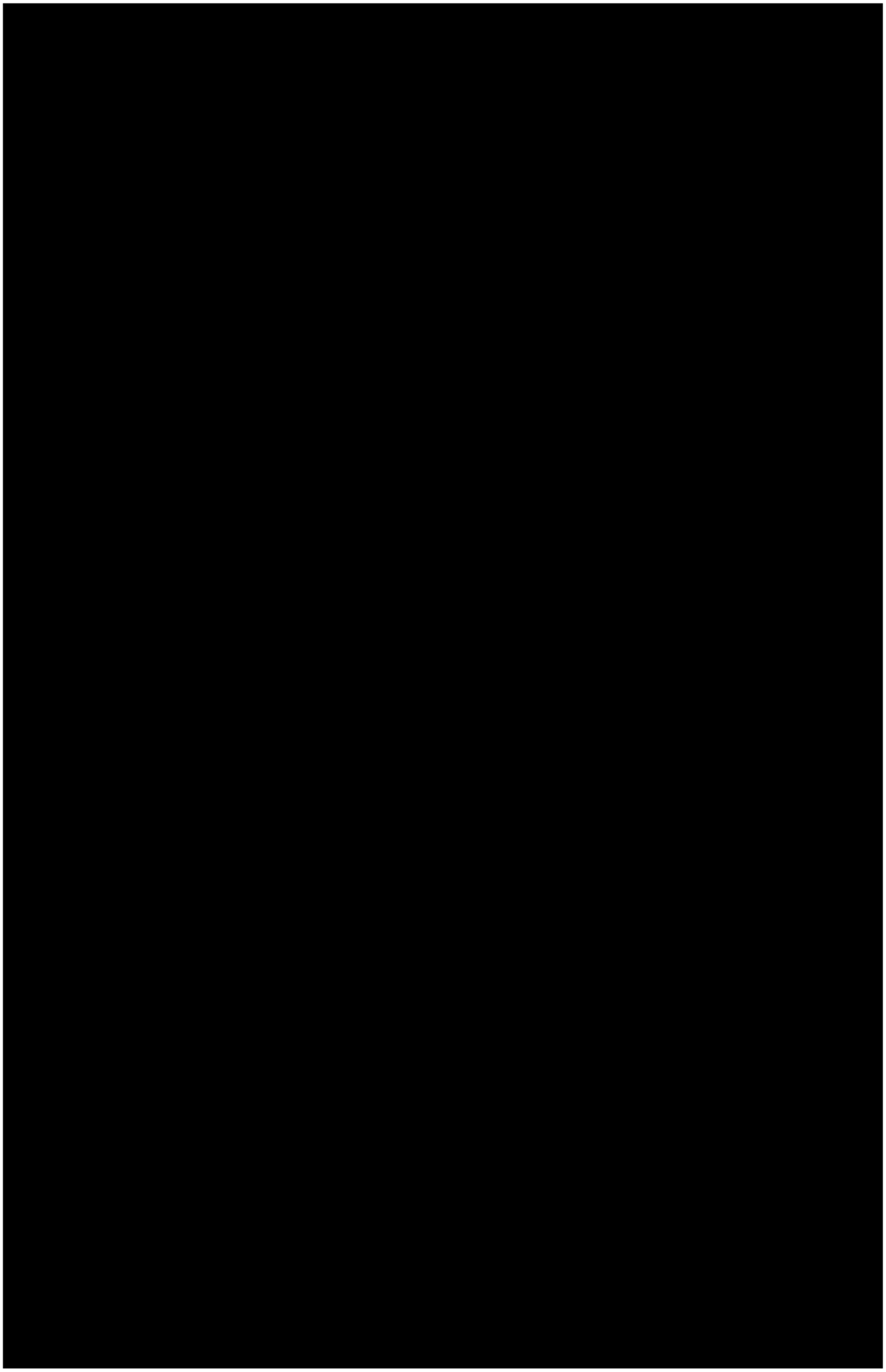

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84B108121
CONT.ON SH. 48 SH.NO. 47 M1 CONNECTOR SECT. 47A SECT. 47B M1 CONNECTOR REV. NO. F

M1				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
A	ET0257	CNA	16	26A
B	N11	CNA	33	26A
C	DBF+02	TB2	A	24A
D	87Y1	CNC	29	27A
E	87B1	CNC	26	26B
F	87W1	CNC	27	27A
G	85T1	CNC	24	26B
H	DBF+05	TB2	B	26B
J	DBF+06	TB2	B	26B
K	DBF+07	TB2	C	26B
L	45D1	CNA	29	26B
M	90Y2	CNA	30	26B
N	85H1	CNA	59	31A
O	87T1	CNA	12	31A
P	85A1	CNA	60	31A
Q	87Z1	CNA	25	31A
R	ET0803	CNC	82	27A
S	E265205	TB4	B	31A
T	E2653	CNA	102	31A
U	45C1	CNC	84	27C
V	87X1	CNC	28	27A
W	87V1	CNC	15	27A
X	61K1	CNC	89	27B
Y	61J1	CNC	90	27B
Z	61N1	CNC	91	27B

M1				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
a	ET0154	CNA	15	26A
b	ET0164	CNA	19	26A
c	ET015S4	CNA	DED	26A
d	ET0205	CNA	37	26A
e	ET0215	CNA	76	26A
f	ET020S5	CNA	DED	26A
g	ET0223	CNA	9	26A
h	ET0233	CNA	58	26A
j	ET022S3	CNA	DED	26A
k	LWP01	CNB	47	37B
m	ET01414	CNC	86	27A
n	84AS1	CNC	DED	27A
p	LWS01	CNB	27	37B
q	LWPSN01	CNB	33	37B
r	LWPSP01	CNB	30	37B
s	LWN01	CNB	48	37B
t	84A1	CNC	85	27A
u	45E104	TB4	C	24B
v	DRPT01	CNB	58	25B
w	DPTR01	CNB	57	25B
x	PTU1S01	CNB	59	25B
y	N2672	CND	36	39A
z	DPTX01	CNB	56	25B

84B108121
CONT.ON SH. 49 SH.NO. 48 M2 CONNECTOR SECT. 48A SECT. 48B M2 CONNECTOR REV. NO. F

M2				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
A	RDAT01	CNB	53	34A
B	PSTSB301	CNB	52	34A
C	3VDC101	CNC	41	17A
D	RSAT01	CNB	54	34A
E	3F0101	CNC	43	17A
F	3COM101	CNC	44	17A
G	SS3S01	CNC	45	17A
H	4VDC101	CNC	55	17A
J	3FB101	CNC	42	17A
K	———	RESERVED	———	17A
L	4F0101	CNC	57	17A
M	4COM101	CNC	58	17A
N	SS4S01	CNC	59	17A
O				
P				
Q	4FB101	CNC	56	17A
R	PRCT01	CNA	28	39B
S				
T	VLNE01	CNB	67	35A
U	VSNB01	CNB	66	35B
V				
W	85C101	M2	X	24A
X	85C101	M2	W	24A
Y				
Z				

M2				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
a				
b				
c				
d				
e				
f				
g				
h				
j				
k				
m				
n				
p	———	RESERVED	———	17A
q				
r				
s				
t				
u				
v	RSCRT01	CNA	13	29B
w	RSCRR01	CNA	27	29B
x	RSCRS01	CNA	14	29B
y				
z				

84B108121
CONT.ON SH. 50 SH.NO. 49 M3 CONNECTOR SECT. 49A SECT. 49B M3 CONNECTOR REV. NO. F

M3				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
A	N19103	TB1	B	24B
B	45E101	TB4	C	24B
C	1VDC101	CND	41	13A
D	————	RESERVED	————	13A
E	1F0101	CND	43	13A
F	1COM101	CND	44	13A
G	SS1S01	CND	45	13A
H	2VDC101	CND	55	13A
J	1FB101	CND	42	13A
K	EPG01	CNA	91	30B
L	2F0101	CND	57	13A
M	2COM101	CND	58	13A
N	SS2S01	CND	59	13A
O	VLBR01	CNB	39	35B
P	14VTC01	CNA	8	30B
Q	2BF101	CND	56	13A
R	LBRP01	CNA	23	31B
S	FCCP01	CNA	48	31B
T	LBRF01	CNA	17	39A
U	DBF+21	TB2	F	39B
V	FCCF01	CNA	10	30B
W	LBFB01	CNA	38	39B
X	LBOL01	CNA	65	39B
Y	DBF+22	TB2	F	32B
Z	N19127	TB1	G	32B

M3				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
a	CMINP01	CNB	23	34B
b	CMINM01	CNB	24	34B
c	CMINN01	CNB	25	34B
d	54S1	AUX	D1	33A
e	54T101	AUX	D2	33A
f	————	RESERVED	————	13A
g				
h				
j				
k	CMINS01	CNB	26	34B
m				
n				
p				
q				
r				
s				
t				
u				
v				
w				
x				
y				
z				

84B108121
CONT.ON SH. 51 SH.NO. 50 M4 CONNECTOR SECT. 50A SECT. 50B M4 CONNECTOR REV. NO. E

M4				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
1	3PAS	CNB	100	36A
2	3PASR	CNB	101	36A
3	1PASS	CNB	94	36A
4	1PAS	CNB	92	36A
5	3PASS	CNB	102	36A
6	4PASS	CNB	82	36A
7				
8	1PASR	CNB	93	36A
9	2PASR	CNB	97	36A
10	4PAS	CNB	80	36A
11	4PASR	CNB	81	36A
12				
13				
14	2PAS	CNB	96	36A
15	2PASS	CNB	98	36A
16	1I2A	CNC	2	18A
17	1I2AR	CNC	3	18A
18	2I2A	CNC	5	18A
19				
20				
21				
22				
23	1I2AS	CNC	4	18A
24	2I2AS	CNC	7	18A
25	2I2AR	CNC	6	18A

M4				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
26				
27				
28				
29				
30	1I1AS	CND	4	14A
31	2I1A	CND	5	14A
32	2I1AR	CND	6	14A
33				
34	1I1A	CND	2	14A
35	1I1AR	CND	3	14A
36	2I1AS	CND	7	14A
37				

84B108121
CONT.ON SH. 52 SH.NO. 51 MBCN CONNECTOR SECT. 51A SECT. 51B RGCN CONNECTOR REV. NO. F

* MBCN				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
A	CMINN03	CMIN	–	34B
B	EPG03	FCCFB	–	30B
C				
D	DBF+24	LBRR	C1	32B
E	45E103	LBCN	A	24B
F	N19131	MBTB1	A	24B
G	N19136	LBCN	D	32B
H	LBRP03	LBRR	CBL	32B
J	14VTC03	FCCFB	+	30B
K	DBF+26	MBTB1	C	39B
L	CMINS03	CMIN	DED	34B
M	CMINM03	CMIN	M	34B
N	VLBR03	VAM5	VL1	35B
P	LBRF03	LBRR	A1	39A
R	FCCF03	FCCFB	0	30B
S	LBFB03	LBCN	P	39B
T	FCCP03	FCC	+	32B
U	CMINP03	CMIN	+	34B
V	LBOL03	LBCN	S	39B

* LOCATED IN LBG

** RGCN				
PIN #	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
A	85C103	KNSW	TB1–B	24A
B	PRCT03	KNSW	TB1–A	24A
C				
D	RSCRT03	GFM	TBA–A	29B
E	RSCRR03	GFM	TBA–B	29B
F	RSCRS03	GFM	DED	29B
G				
H	VLNE03	VAM1	VL1	35A
J				
K	RDAT03	RDATB	A	34A
L	VSNB03	VAM1	VL2	35B
M				
N	RSAT03	RSATB	B	34A
P				
R				
S				
T				
U	PSTSB303	RSATB	A	34A
V				

** LOCATED IN RGG

84B108121
CONT.ON SH. 53 SH.NO. 52 CNA SECT. 52A SECT. 52B CNA REV. NO. E

* CNA				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
1				
2	N19118	TB1	E	39A
3				
4	N19111	TB1	D	26B
5	N19119	TB1	E	39A
6				
7	N19116	TB1	J	39A
8	14VTC01	M3	P	30B
9	ET0223	M1	g	26A
10	FCCF01	M3	V	30B
11				
12	87T1	M1	O	31A
13	RSCRT01	M2	v	29A
14	RSCRS01	M2	x	29A
15	ET0154	M1	a	26A
16	ET0257	M1	A	26A
17	LBRF01	M3	T	39A
18				
19	ET0164	M1	b	26A
20	N19110	TB1	C	26B
21				
22				
23	LBRP01	M3	R	31B
24				
25	87Z1	M1	Q	31A
26	FD2P	FDC2	CBL	31B
27	RSCRR01	M2	w	29A
28	PRCT01	M2	R	39B
29	45D1	M1	L	26B
30	90Y2	M1	M	26B
31	FANOLF02	FANTB	D	39A
32	N19102	TB1	B	39B
33	N11	M1	B	26A
34				
35				

* CNA				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
36				
37	ET0205	M1	d	26A
38	LBFB01	M3	W	39B
39				
40	45E105	TB4	C	39B
41	FD2F	FDC2	E1	39A
42	FD1F	FDC1	E1	39A
43				
44	N19115	TB1	J	39B
45	N19117	TB1	D	39A
46	E265203	TB4	B	31A
47	E265201	TB4	A	31A
48	FCCP01	M3	S	31B
49				
50				
51	CON12	CNB	103	29A
52				
53	N19120	TB1	E	39B
54				
55	14VTE	EDM	7	28B
56				
57	N19121	TB1	F	39B
58	ET0233	M1	h	26A
59	85H1	M1	N	31A
60	85A1	M1	P	31A
61				
62				
63				
64				
65	LBOL01	M3	X	39B
66				
67	N19122	TB1	F	39B
68	FIRST	EDM	17	28B
69	C	EDM	8	28A
70	D	EDM	25	28A

* CNA				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
71	DM	EDM	12	28A
72	DL	EDM	2	28A
73	DBF+15	TB2	E	31B
74				
75				
76	ET0215	M1	e	26A
77				
78	LAST	EDM	22	28B
79	B	EDM	5	28A
80	E	EDM	13	28A
81	H	EDM	14	28A
82	BUTPS2	EDM	11	28A
83	COM	EDM	6	28A
84				
85	DBF+12	TB2	D	31B
86				
87	E265202	TB4	A	31A
88				
89	DBF+13	TB2	E	31B
90				
91	EPG01	M3	K	30B
92	RESET	EDM	21	28B
93	A	EDM	4	28A
94	F	EDM	1	28A
95	G	EDM	10	28A
96	BUTPS1	EDM	3	28A
97				
98				
99				
100				
101	E265204	TB4	B	31A
102	E2653	M1	T	31A
103				
104				

* LOCATED IN ELECTRONICS PANEL

84B108121
CONT.ON SH. 54 SH.NO. 53 CNB SECT. 53A SECT. 53B CNB REV. NO. E

* CNB				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
1				
2				
3	PSTSB201	AMBTB	B	34A
4	GDAT01	GDATB	A	34A
5	AMBT01	AMBTB	A	34A
6				
7	PSTSB101	HCATB	A	34A
8	HCAS01	HCATB	B	34A
9	CCUF06	TB2	L	34B
10				
11				
12	CCUF05	TB2	M	23B
13	CCUF04	TB2	M	23B
14	CCUF03	TB2	M	23B
15	CCUF02	TB2	L	23B
16				
17				
18				
19				
20				
21				
22				
23	CMINP01	M3	a	34B
24	CMINM01	M3	b	34B
25	CMINN01	M3	c	34B
26	CMINS01	M3	k	34B
27	LWS01	M1	p	37B
28				
29				
30	LWPSP01	M1	r	37B
31				
32				
33	LWPSN01	M1	q	37B
34	CMUTP	CMUT	+	34B
35	CMUTM	CMUT	M	34B

* CNB				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
36	CMUTN	CMUT	-	34B
37	CMUTS	CMUT	DED	34B
38				
39	VLBR01	M3	O	35B
40				
41				
42				
43				
44				
45				
46				
47	LWP01	M1	k	37B
48	LWN01	M1	s	37B
49				
50	VLFR01	VAM4	VL1	35A
51	HVGR01	VAM4	VL2	35A
52	PSTSB301	M2	B	34A
53	RDAT01	M2	A	34A
54	RSAT01	M2	D	34A
55				
56	DPTX01	M1	z	25A
57	DPTR01	M1	w	25A
58	DRPT01	M1	v	25A
59	PTU1S01	M1	x	25A
60	N19125	TB1	G	34B
61	DPTUX	PTUR	2	25B
62	DPTUR	PTUR	3	25B
63	DRPTU	PTUR	7	25B
64	PTURS	PTUR	DED	25B
65				
66	VSNB01	M2	U	35A
67	VLNE01	M2	T	35A
68				
69				
70				

* CNB				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
71	N19104	TB1	H	23B
72	N19105	TB1	H	23B
73	N19106	TB1	H	23B
74	N19107	TB1	J	23B
75				
76				
77				
78				
79				
80	4PAS	M4	10	36A
81	4PASR	M4	11	36A
82	4PASS	M4	6	36A
83				
84				
85				
86				
87				
88				
89				
90				
91				
92	1PAS	M4	4	36A
93	1PASR	M4	8	36A
94	1PASS	M4	3	36A
95				
96	2PAS	M4	14	36A
97	2PASR	M4	9	36A
98	2PASS	M4	15	36A
99				
100	3PAS	M4	1	36A
101	3PASR	M4	2	36A
102	3PASS	M4	5	36A
103	CON12	CNA	51	29A
104				

* LOCATED IN ELECTRONICS PANEL

84B108121
CONT.ON SH. 55 SH.NO. 54 CNC SECT. 54A SECT. 54B CNC REV. NO. E

* CNC				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
1				
2	1I2A	M4	16	18A
3	1I2AR	M4	17	18A
4	1I2AS	M4	23	18A
5	2I2A	M4	18	18A
6	2I2AR	M4	25	18A
7	2I2AS	M4	24	18A
8				
9				
10				
11				
12				
13				
14	N19108	TB1	C	26B
15	87V1	M1	W	27A
16	CM2AS	CM2A	DED	16A
17	CM2AP	CM2A	+	16A
18	CM2AM	CM2A	M	16A
19	CM2AN	CM2A	–	16A
20	CM2BS	CM2B	DED	16B
21	CM2BP	CM2B	+	16B
22	CM2BM	CM2B	M	16B
23	CM2BN	CM2B	–	16B
24	85T1	M1	G	26B
25	N19109	TB1	C	26B
26	87B1	M1	E	26B
27	87W1	M1	F	27A
28	87X1	M1	V	27A
29	87Y1	M1	D	27A
30	DBF+08	TB2	C	27A
31	LV2C01	VAM2	VL3	16A
32	LVDC2P01	VAM2	VL4	16A
33	LVDC2N01	VAM2	VL5	16A
34	LV2A01	VAM2	VL1	16A
35	LV2B01	VAM2	VL2	16A

* CNC				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
36	FD1P	FDC1	CBL	27B
37				
38				
39				
40				
41	3VDC101	M2	C	17A
42	3FB101	M2	J	17A
43	3F0101	M2	E	17A
44	3COM101	M2	F	17A
45	SS3S01	M2	G	17A
46	I2TXD	INV2	2	15A
47	I2RXD	INV2	3	15A
48	I2GND	INV2	7	15A
49	INV2S	INV2	DED	15A
50				
51	DBF+10	TB2	D	27B
52				
53	GD2P	GDPS2	3	27B
54				
55	4VDC101	M2	H	17A
56	4FB101	M2	Q	17A
57	4F0101	M2	L	17A
58	4COM101	M2	M	17A
59	SS4S01	M2	N	17A
60	DBF+11	TB2	D	27B
61				
62				
63				
64				
65	CON34	CND	64	29A
66				
67				
68				
69				
70				

* CNC				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
71				
72				
73				
74				
75				
76				
77				
78	GD1P	GDPS1	3	27B
79	DBF+09	TB2	C	27B
80	FANP	FANC	CBL	27B
81				
82	ET0803	M1	R	27A
83	DBF+03	TB2	A	27C
84	45C1	M1	U	27C
85	84A1	M1	t	27A
86	ET01414	M1	m	27A
87				
88				
89	61K1	M1	X	27B
90	61J1	M1	Y	27B
91	61N1	M1	Z	27B
92				
93				
94				
95				
96				
97				
98				
99				
100				
101				
102				
103				
104				

* LOCATED IN ELECTRONICS PANEL

84B108121
CONT.ON SH. 56 SH.NO. 55 CND SECT. 55A SECT. 55B CND REV. NO. E

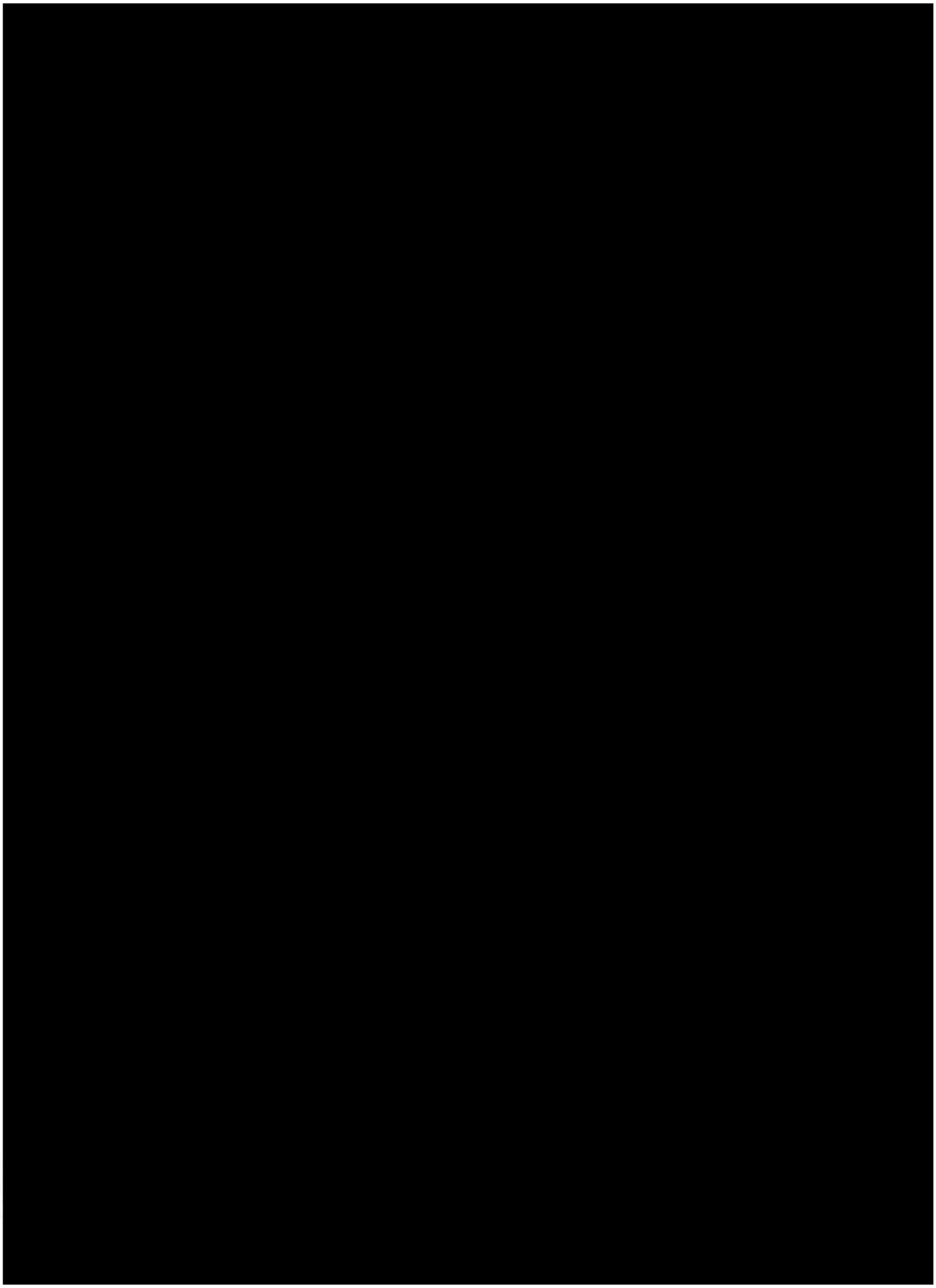
* CND				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
1	N19139	AUX	CBR	39A
2	1I1A	M4	34	14A
3	1I1AR	M4	35	14A
4	1I1AS	M4	30	14A
5	2I1A	M4	31	14A
6	2I1AR	M4	32	14A
7	2I1AS	M4	36	14A
8				
9				
10				
11				
12				
13				
14				
15				
16	CM1AS	CM1A	DED	12A
17	CM1AP	CM1A	+	12A
18	CM1AM	CM1A	M	12A
19	CM1AN	CM1A	-	12A
20	CM1BS	CM1B	DED	12B
21	CM1BP	CM1B	+	12B
22	CM1BM	CM1B	M	12B
23	CM1BN	CM1B	-	12B
24	AUXF	AUX	B3	39A
25				
26	DBF+44	TB2	E	27C
27	AUXP	AUX	CBL	27C
28				
29				
30				
31	LV1C01	VAM3	VL3	12A
32	LVDC1P01	VAM3	VL4	12A
33	LVDC1N01	VAM3	VL5	12A
34	LV1A01	VAM3	VL1	12A
35	LV1B01	VAM3	VL2	12A

* CND				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
36	N2672	M1	y	39B
37				
38				
39				
40				
41	1VDC101	M3	C	13A
42	1FB101	M3	J	13A
43	1FO101	M3	E	13A
44	1COM101	M3	F	13A
45	SS1S01	M3	G	13A
46	I1TXD	INV1	2	11A
47	I1RXD	INV1	3	11A
48	I1GND	INV1	7	11A
49	INV1S	INV1	DED	11A
50				
51				
52				
53				
54				
55	2VDC101	M3	H	13A
56	2FB101	M3	Q	13A
57	2F0101	M3	L	13A
58	2COM101	M3	M	13A
59	SS2S01	M3	N	13A
60				
61				
62				
63				
64	CON34	CNC	65	29A
65				
66				
67				
68				
69				
70				

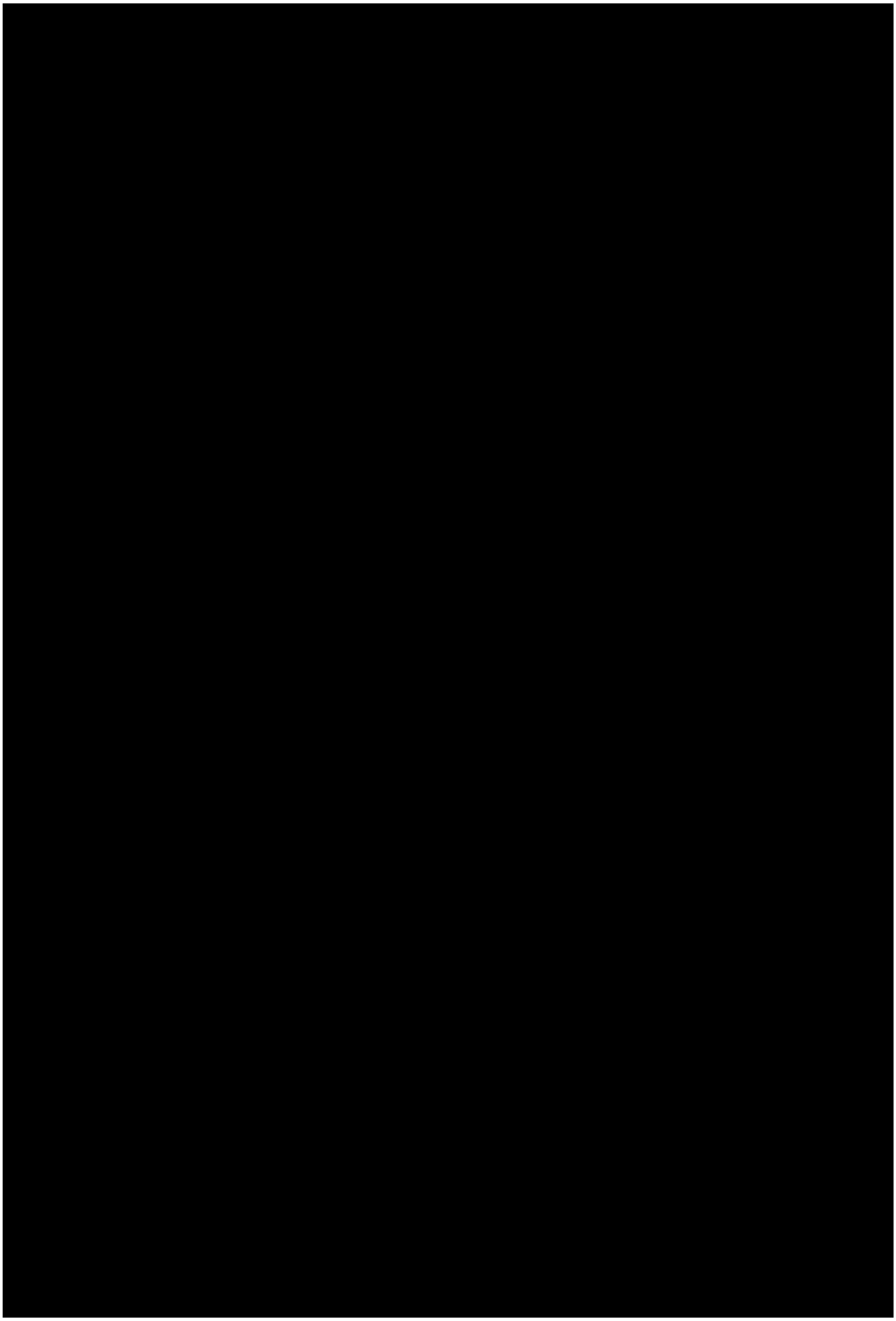
* CND				
PIN	WIRE NAME	DEVICE	TERM. POINT	SCH. SHEET
71				
72				
73				
74				
75				
76				
77				
78				
79				
80				
81				
82				
83				
84				
85				
86				
87				
88				
89				
90				
91				
92				
93				
94				
95				
96				
97				
98				
99				
100				
101				
102				
103				
104				

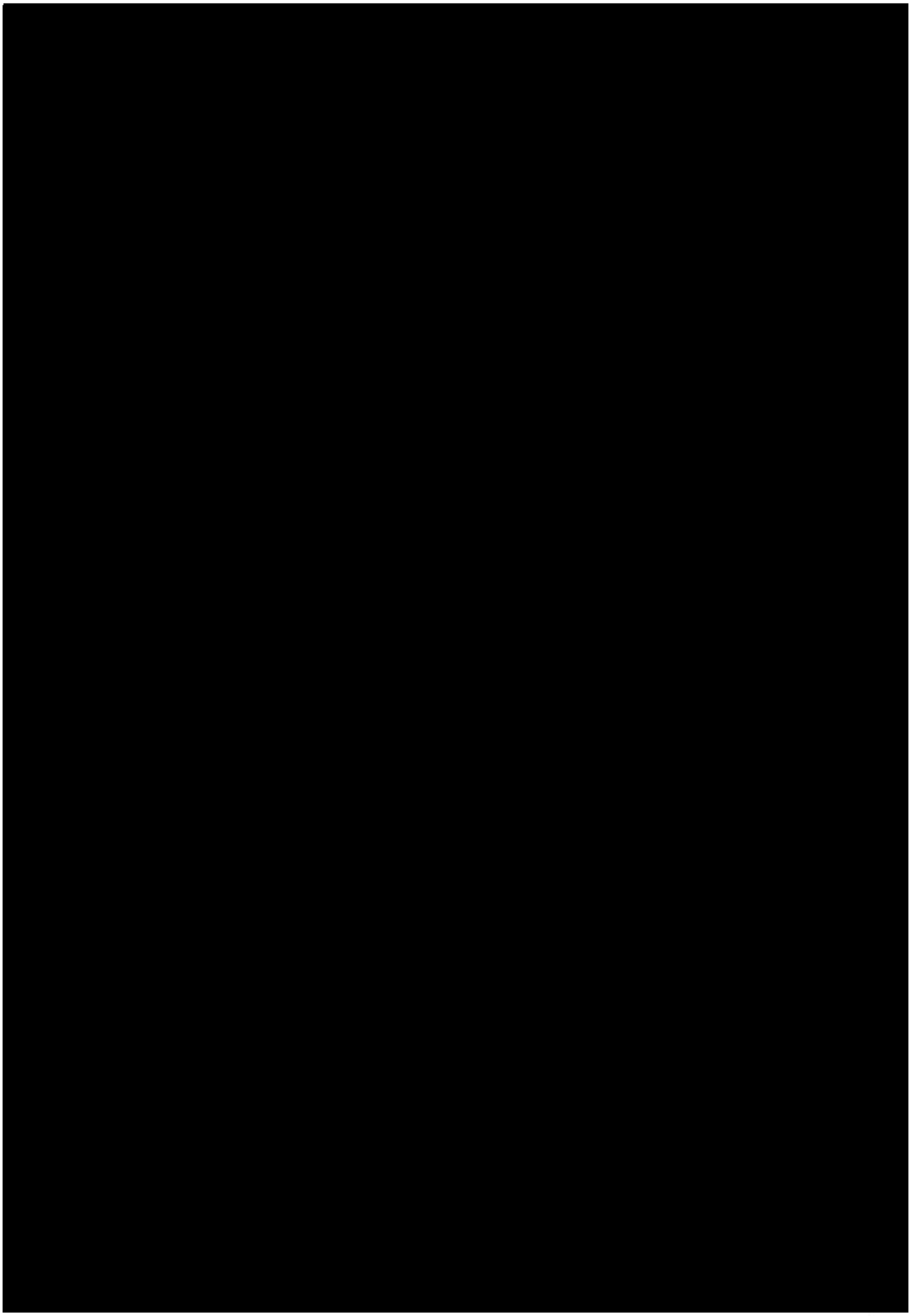
* LOCATED IN ELECTRONICS PANEL

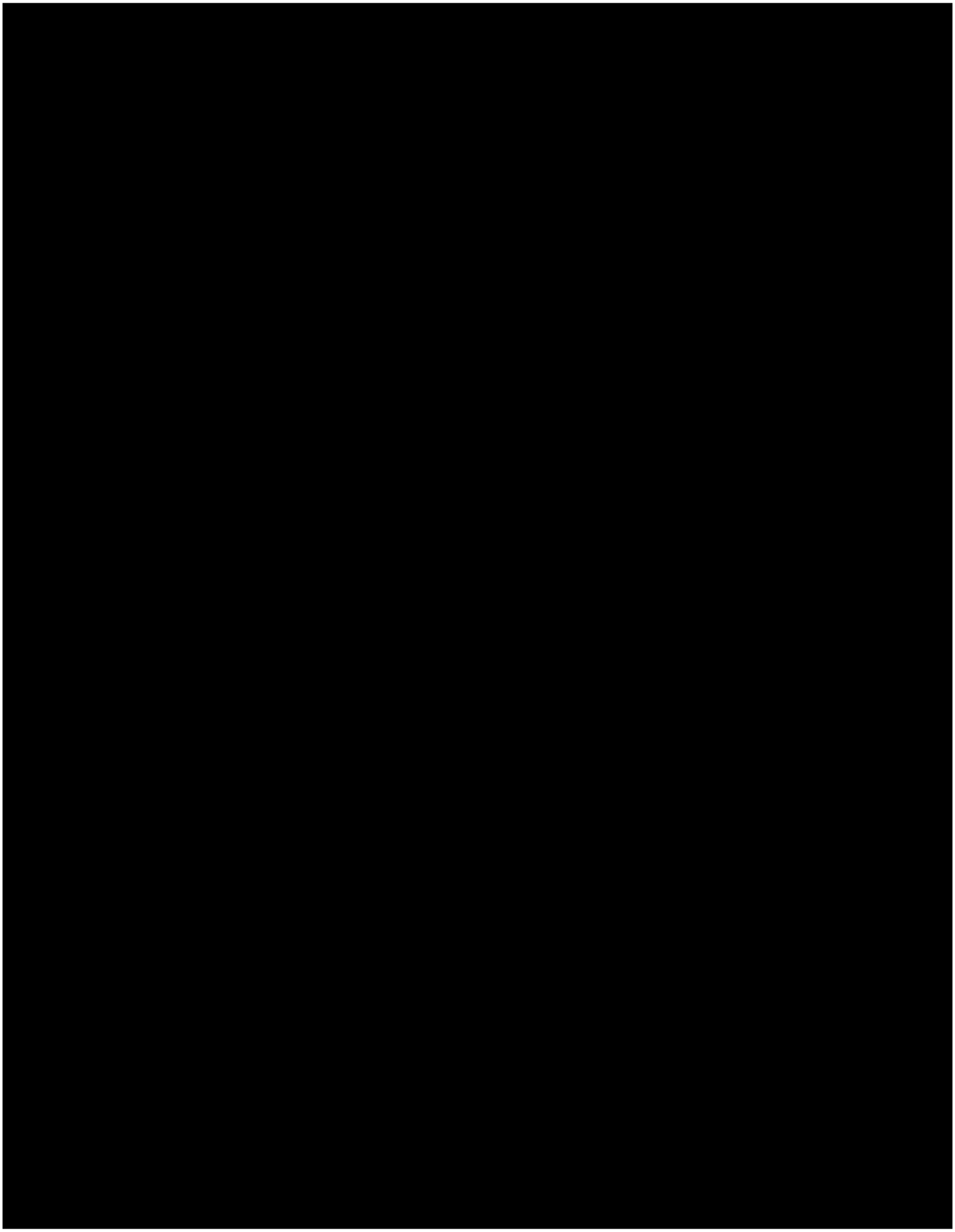
[redacted]

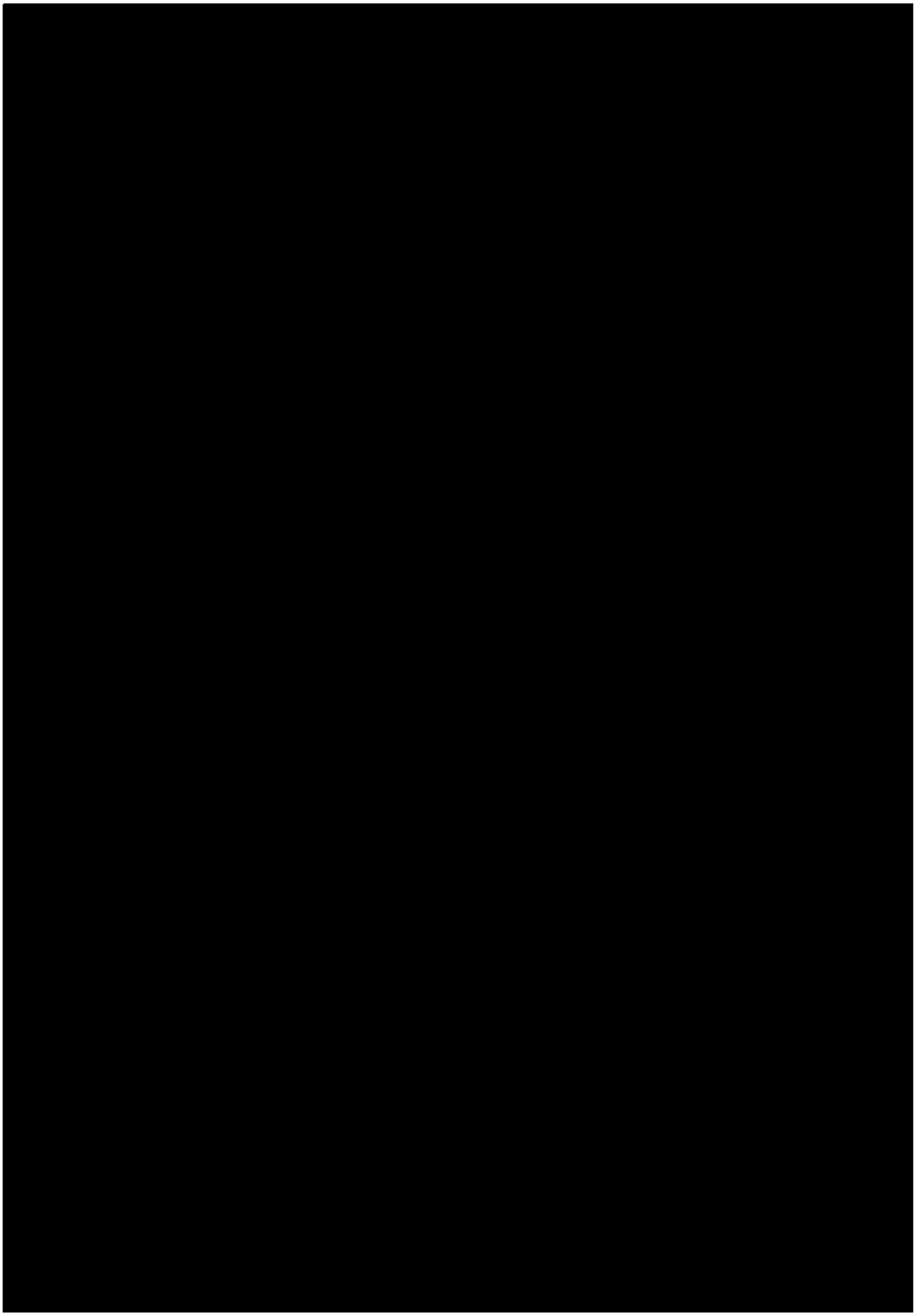


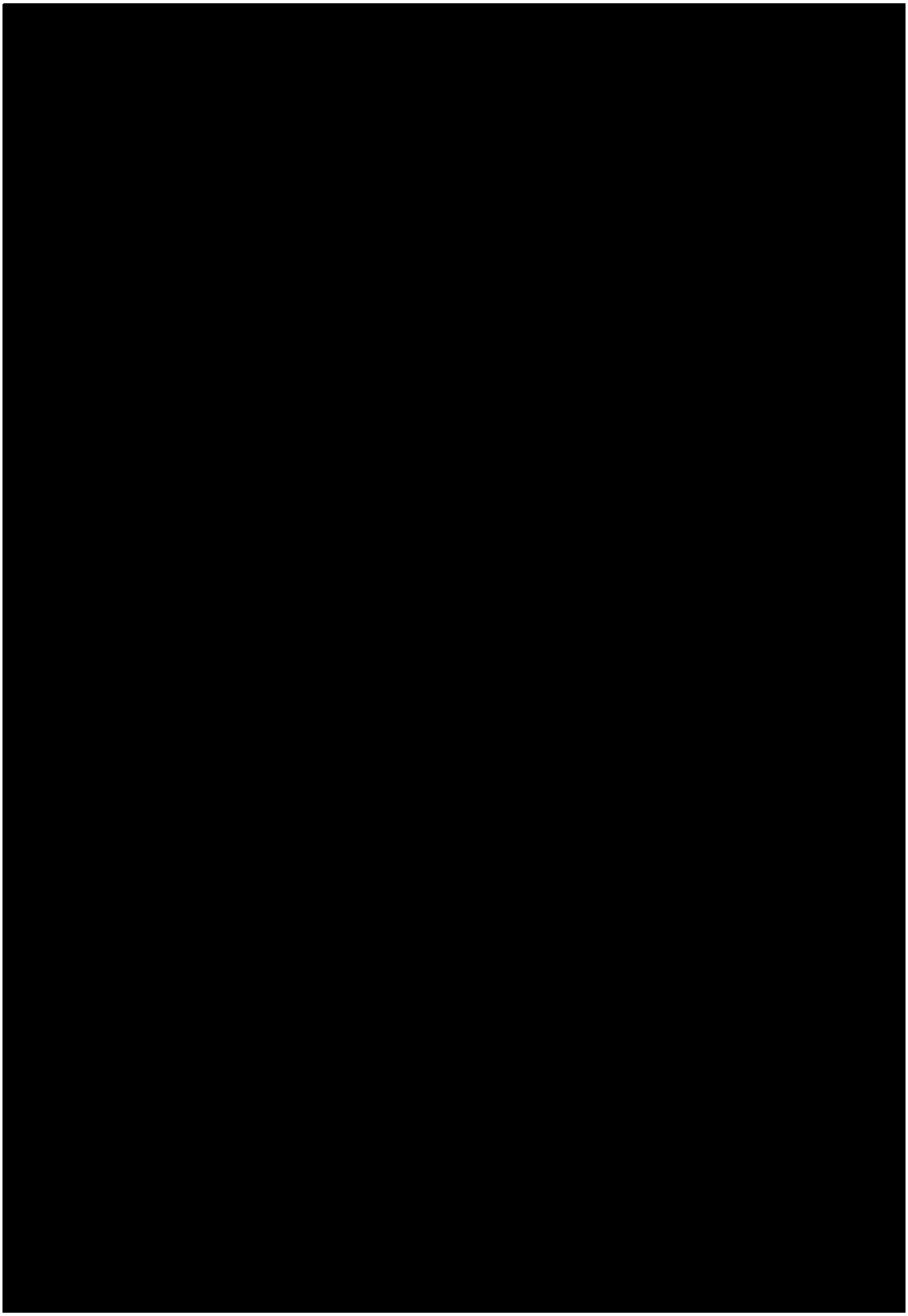
84B108121



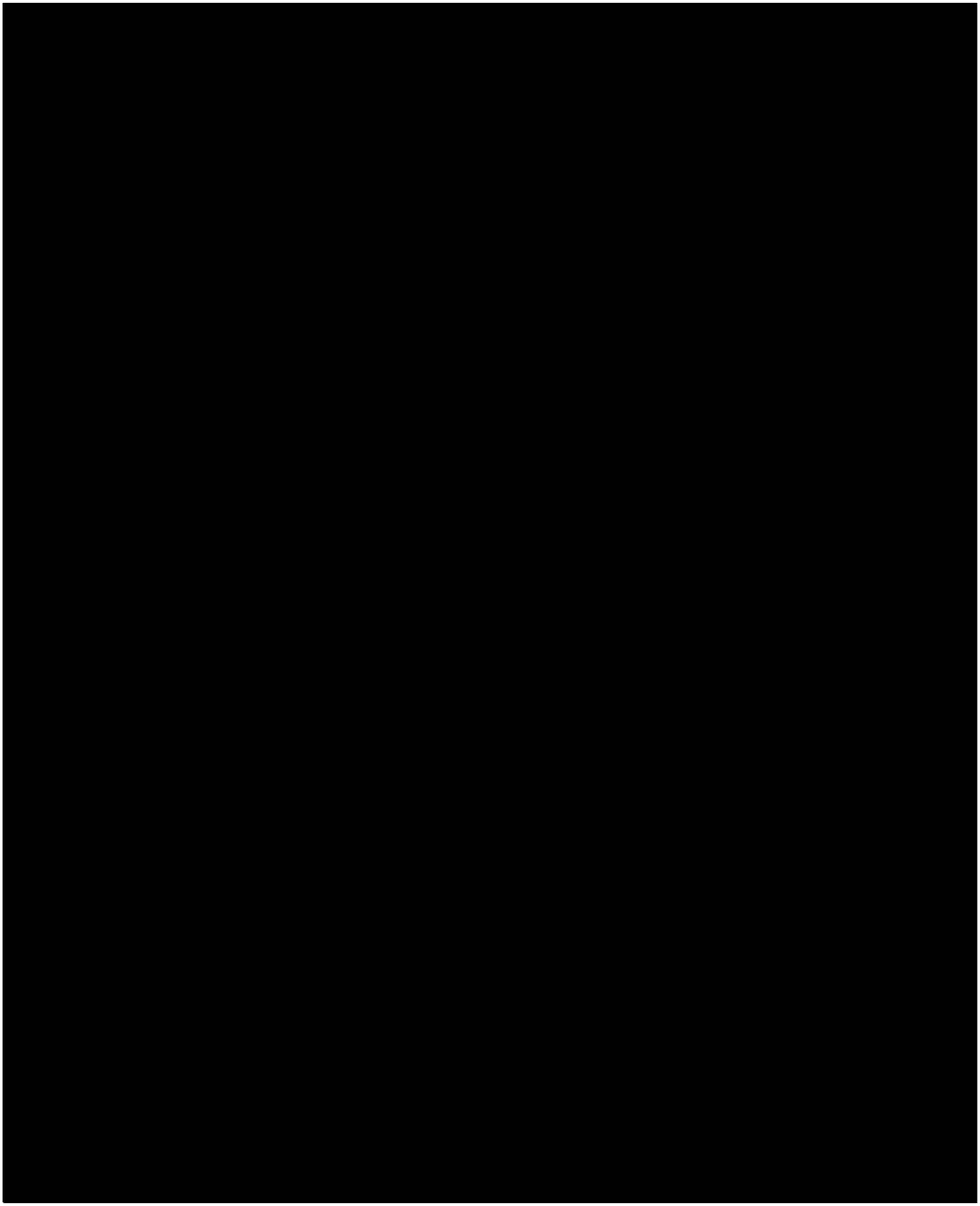








[redacted]



[redacted]

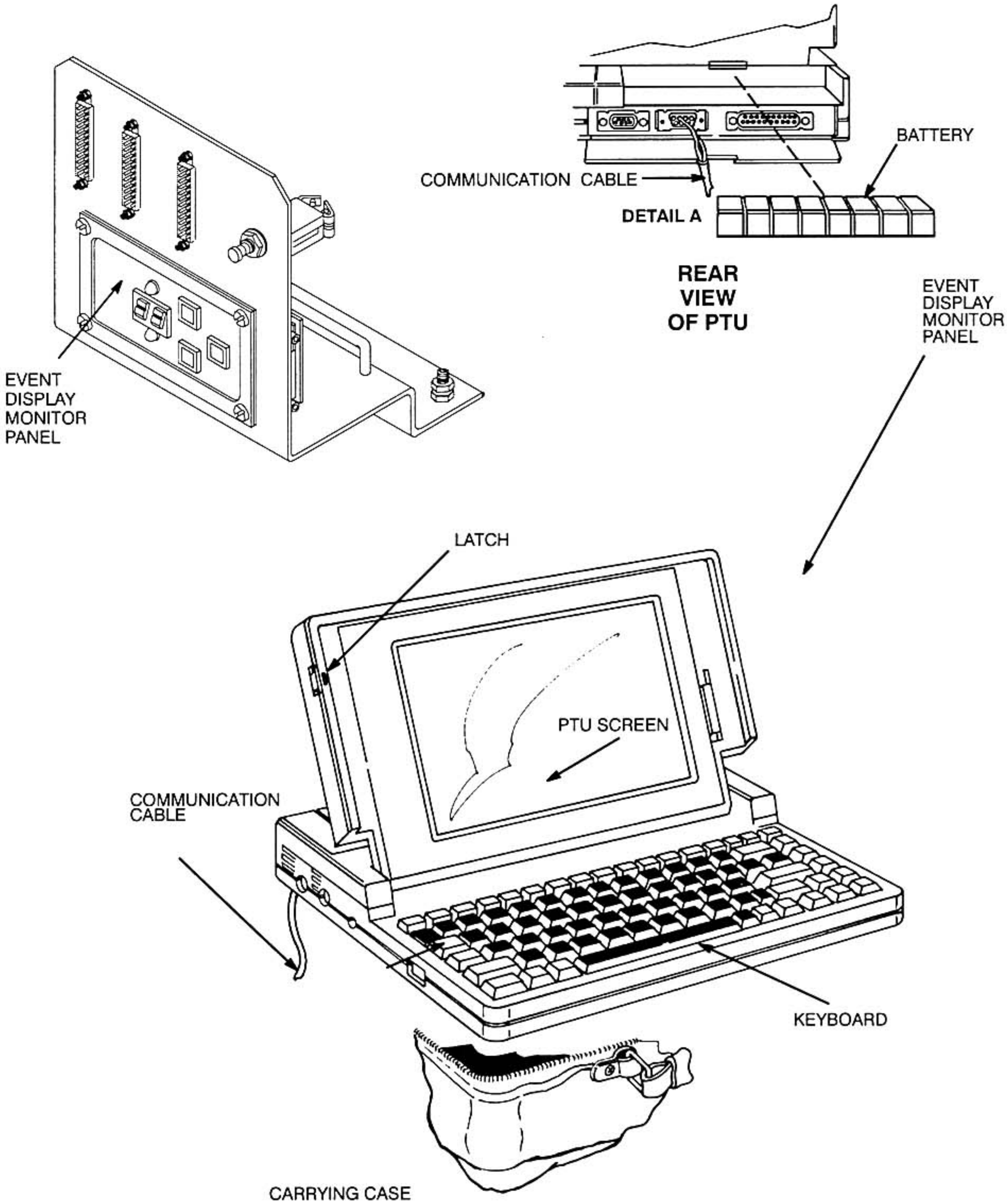


Figure 7–49 PTU Details

7–2.1.3 Event Display Panel

Pressing the Up key on the Event Display Panel (Figure 7–50), located in the Main Inverter group, displays the event that is previous to the one currently on the two digit display. If the current event being displayed is the first event in the queue, pressing the Up key will have no affect on the display. Pressing the Down key displays the event that is next in the queue to the event that is currently on the display. If the event being displayed is the last event, pressing the Down key will have no affect on the display.

To reset an event, the Reset key must be pressed twice within ten seconds. The first press of the Reset key initiates the special reset LED display. If the key is pressed again within ten second the active event on the two digit display is reset. If the Reset key is not pressed, or the Previous or Next key is pressed, the display will go back into the normal display mode without resetting the event being displayed.

Pressing the Up and Down buttons simultaneously will initiate Manual Lamp Test mode display. To return to the normal display mode, the Reset mode button is pressed one time only.

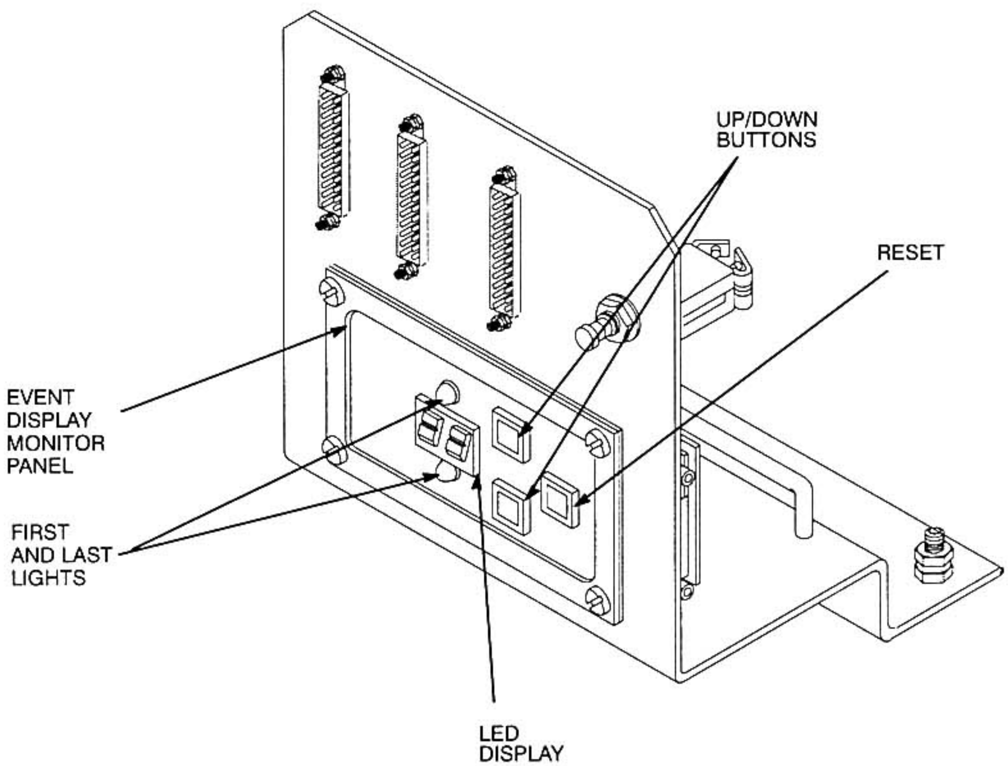


Figure 7–50 Event Display Panel

7–2.1.4 PTU Access Levels

The operating level of the PTU is determined by a password, which is entered at PTU start–up time. The operational level privileges are as follows:

Level 1 This level allows basic maintenance operations. The user can look at a real–time display, operate test functions, look at event data, set wheel diameters, set clock and car number, and isolate faults.

Level 2 This level provides the same privileges as Level 1.

Level 3 This level provides the same privileges as Level 2 with the addition of being allowed to manually test components.

> **NOTE:** No system parameters that affect system performance may be changed.

A list containing each password is provided separate from this publication. Personnel should only be given the password necessary to perform their assigned functions with the PTU, otherwise, accidental corruption of data or system parameters could cause damage to the system.

7–2.2 COMMON FUNCTIONS AND SCREEN DISPLAYS

7–2.2.1 Common Functions

Most PTU screens operate as a menu system. The arrow keys on the keyboard are used to highlight a selection on the screen and then the return key is pressed to enable the highlighted selection.

The ESC key acts as a "go back" or "cancel" key. Pressing the ESC key while using a menu or another screen will cause the previous screen to be displayed. Pressing the ESC key while entering data will cancel any new entry from taking affect.

The F1 key is the help key. Pressing this key will display a descriptive help screen about the screen that is currently in use.

The F2 key is the file key. Pressing this key will allow data to be saved or retrieved. For example, if event data is to be saved, press F2 while viewing the Event Data screen and select Record. The system will prompt for a name of a file to save the data to. After entering the file name, the PTU will save the event data in that file. At some point in the future, the data can be retrieved by pressing F2, selecting Playback, and then entering the file name that the event data is saved under.

When viewing the screens, an "=" beside any contactor indicates that the contactor is picked up, for contactors in the Digital Input row, or is being commanded to pick up, for contactors in the Digital Output row. The absence of an "=" beside any contactor indicates that the device is dropped out or is being commanded to drop out.

7–2.2.2 Common Screen Displays and Data Fields

Common screen displays and data fields are used primarily in those screens associated with Analog I/O, Event Data, and Manual Test. The primary differences in each display is the title (header) and top line information. The top line information is described later in this text (under each application).

Common displays in this category include the LA Red PSC Events, LA Red Real Time, Analog I/O, and LA Red Manual Test Screens.

Data fields in each of these screens contain (similar) type items. The basic division of data fields are shown in Figure 7–51. The abbreviations (data entries) within each field are defined on the following pages.

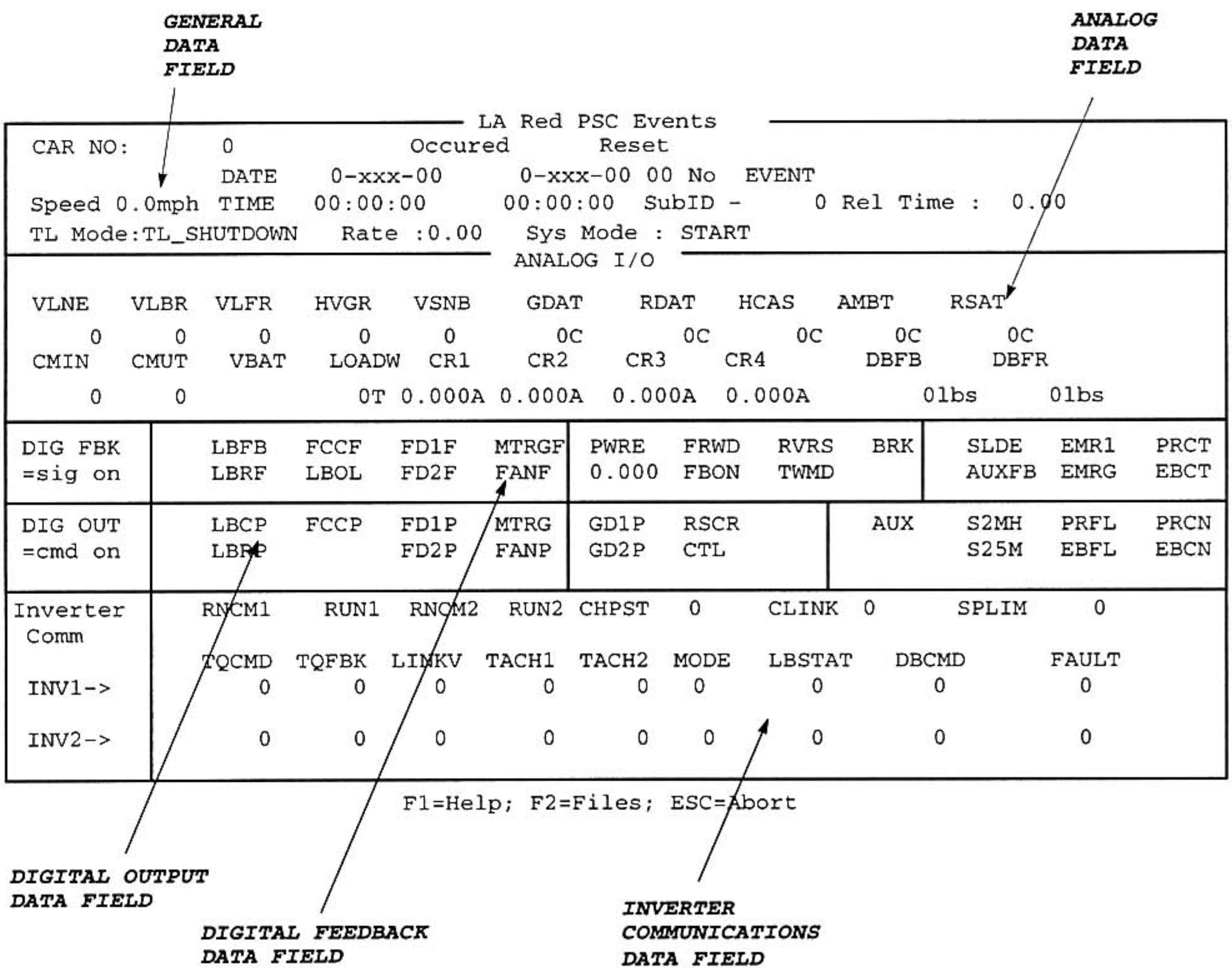


Figure 7–51 Common Screen Displays and Data Fields

7–2.2.2.1 General (Screen Header) Data Field

```
──────────────────── LA Red PSC Events ────────────────────
CAR NO:        0            Occured        Reset
               DATE     0-xxx-00       0-xxx-00 00 No   EVENT
Speed 0.0mph   TIME    00:00:00       00:00:00   SubID -      0 Rel Time :   0.00
TL Mode:TL_SHUTDOWN    Rate :0.00     Sys Mode : START
```

```
──────────────────── LA Red PSC Events ────────────────────



─────────────────────── ANALOG I/O ───────────────────────
VLNE    VLBR   VLFR    HVGR    VSNB     GDAT     RDAT    HCAS    AMBT     RSAT
   0       0      0       0       0       0C        0C      0C      0C       0C
CMIN    CMUT    VBAT   LOADW   CR1      CR2     CR3     CR4      DBFB      DBFR
   0       0                 0T 0.000A 0.000A  0.000A 0.000A      0lbs      0lbs
──────────────────────────────────────────────────────────
DIG FBK  |  LBFB   FCCF   FD1F   MTRGF| PWRE   FRWD   RVRS   BRK | SLDE   EMR1   PRCT
=sig on  |  LBRF   LBOL   FD2F   FANF | 0.000  FBON   TWMD       | AUXFB  EMRG   EBCT
──────────────────────────────────────────────────────────
DIG OUT  |  LBCP   FCCP   FD1P   MTRG | GD1P   RSCR       | AUX    S2MH   PRFL   PRCN
=cmd on  |  LBRP          FD2P   FANP | GD2P   CTL        |        S25M   EBFL   EBCN
──────────────────────────────────────────────────────────
Inverter |  RNCM1    RUN1   RNCM2   RUN2  CHPST    0    CLINK  0      SPLIM      0
 Comm    |
         |  TQCMD  TQFBK  LINKV  TACH1  TACH2  MODE   LBSTAT    DBCMD        FAULT
 INV1->  |     0      0      0      0      0     0       0         0            0
         |
 INV2->  |     0      0      0      0      0     0       0         0            0

                     F1=Help; F2=Files; ESC=Abort
```

Figure 7–52 General (Screen Header) Data Field

The General Data Field (see Figure 7–52) contains heads–up information, identifying the car number (CAR NO:), the inverter (ID=1), the most current event logged (EVENT) ,the time (TIME) and date (DATE) it occurred (Occurred), and the time it was reset (Reset). The General Data Field also identifies the speed in mph (Speed 0.0mph), the subordinate ID (Sub ID), and Real Time (Rel Time). The General Data field (for the common screen displays) varies somewhat, depending on which screen is selected. However the basic categories of data are similar in each one.

7–2.2.2.2 Analog I/O Data Field

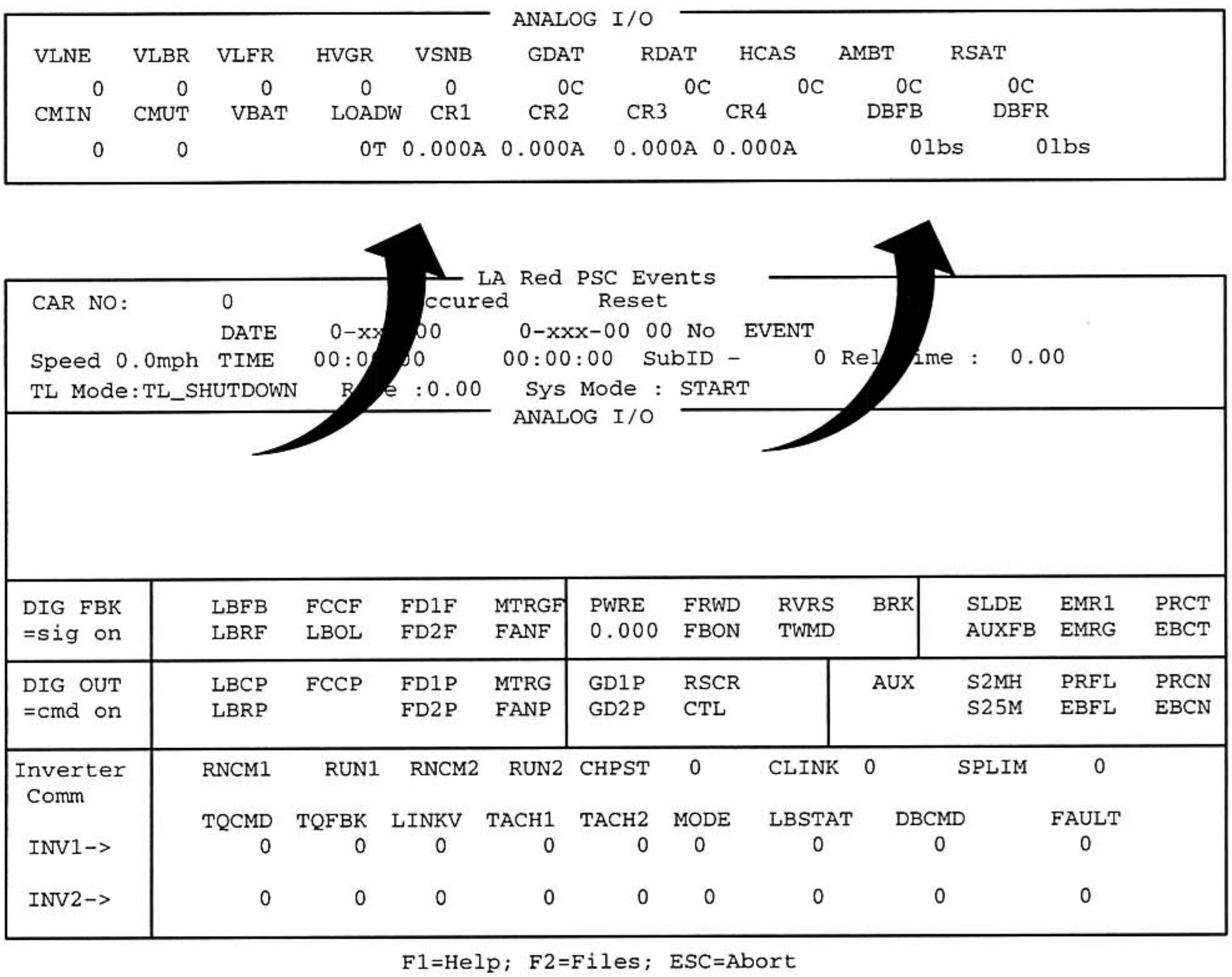


Figure 7–53 Analog I/O Data Field

This is the Analog I/O Data Field (See Figure 7–53) where:

a. VLNE: Is the monitored line voltage value, from line voltage sensor, measured in VDC.

b. CMIN: Is the monitored amperage value, from input current sensor.

c. VLBR: Is the monitored voltage value at line breaker, measured in VDC.

d. CMUT: Is the monitored amperage value at output current sensor (See Figure 7–54).

ANALOG I/O

VLNE	VLBR	VLFR	HVGR	VSNB	GDAT	RDAT	HCAS	AMBT	RSAT
0	0	0	0	0	0C	0C	0C	0C	0C
CMIN	CMUT	VBAT	LOADW	CR1	CR2	CR3	CR4	DBFB	DBFR
0	0		0T	0.000A	0.000A	0.000A	0.000A	0lbs	0lbs

Figure 7–54 Analog I/O Data Field (Cont.)

e. VBAT: Is the monitored +37VDC (nominal) battery voltage .

f. VLFR: Is the monitored voltage value at line filter reactor, measured in VDC.

g. HVGR: Is the monitored voltage at HV ground, from reference voltage sensor. measured in VDC.

h. LOADW: Is the monitored load weight, measured in tons, within an operating range of AWO–20% to AW3+30%

i. VSNB: Is the monitored voltage at snubber resistor, measured in VDC.

j. GDAT: Is the monitored ambient temperature in GTO compartment, measured in Celsius.

k. RDAT: Is monitored temperature in the Rail Gap group, measured in Celcious

l. HCAS: Is the monitored temperature of outside cooling (heatsink) air, measured in Celsius

m. AMBT: Is the monitored ambient temperature around filter capacitor banks, measured in Celsius.

n. RSAT: Is the monitored temperature around the rail gap scr, measure in Celsius.

o. DBFB: Is the monitored dynamic brake feedback, measured in pounds.

p. DBFR: Is the output of the dynamic brake feedback reader, measured in pounds

q. CR1: Is a monitored (undesirable) ripple frequency measured in amps (RMS).

r. CR2: Is a monitored (undesirable) ripple frequency measured in amps (RMS).

s. CR3: Is a monitored (undesirable) ripple frequency measured in amps (RMS).

t. CR4: Is a monitored (undesirable) ripple frequency measured in amps (RMS).

7–2.2.2.3 Digital I/O Data Field

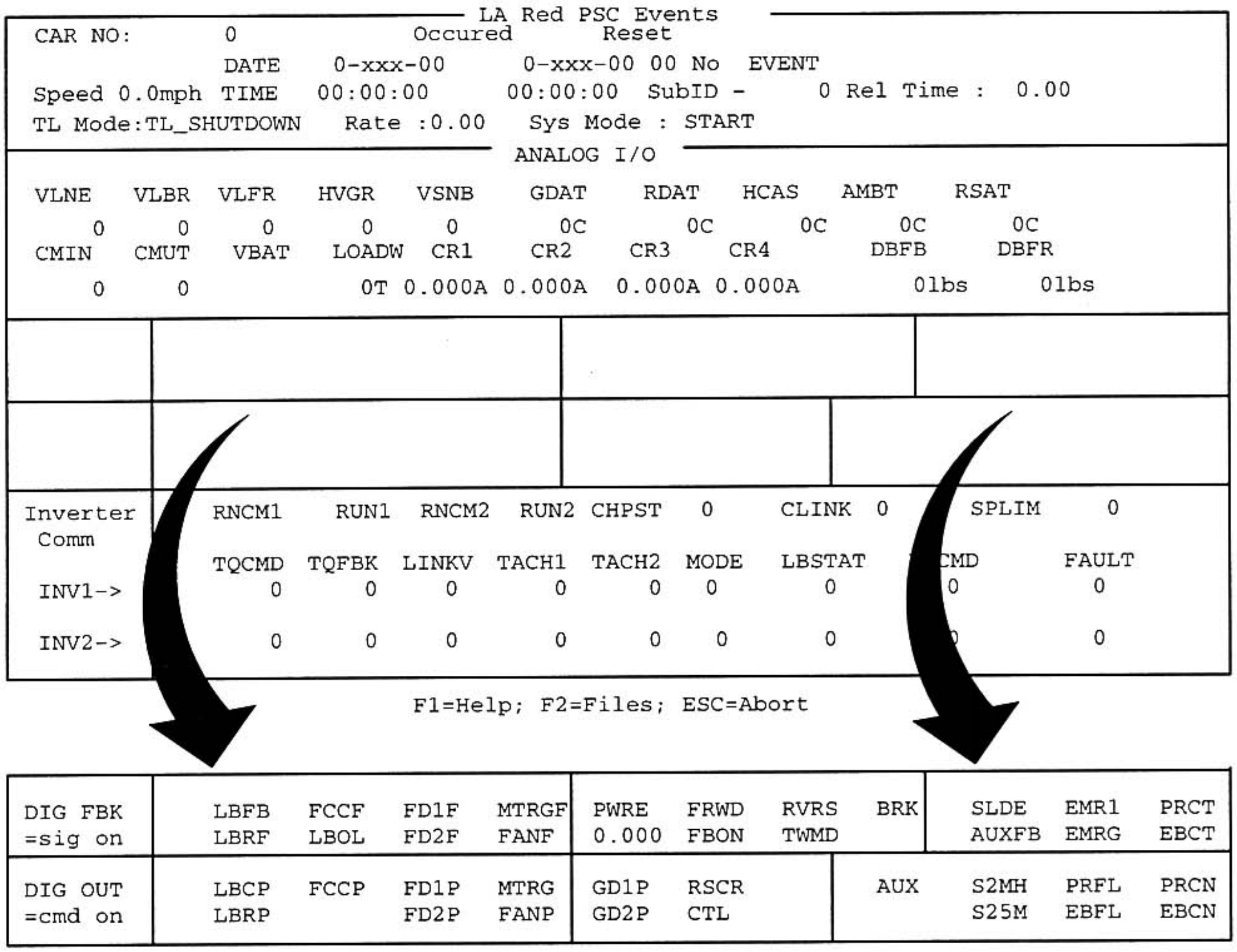


Figure 7–55 Digital I/O Data Field

This is the Digital I/O Data Field (See Figure 7–55) where:

a. LBFB: Is the line breaker position feedback signal.

b. FCCF: Is the filter charging contactor feedback signal.

c. FD1F: Is filter discharge relay feedback signal (Inverter 1).

d. MTRGF: Is the “Propulsion is in Motoring Mode”. feedback signal.

e. PWRE: Is the P–wire control signal (activated/deactivated).

f. FRWD: Is power in the forward direction signal (activated/deactivated).

DIG FBK =sig on	LBFB LBRF	FCCF LBOL	FD1F FD2F	MTRGF FANF	PWRE 0.000	FRWD FBON	RVRS TWMD	BRK	SLDE AUXFB	EMR1 EMRG	PRCT EBCT
DIG OUT =cmd on	LBCP LBRP	FCCP	FD1P FD2P	MTRG FANP	GD1P GD2P	RSCR CTL		AUX	S2MH S25M	PRFL EBFL	PRCN EBCN

Figure 7–56 Digital I/O Data Field (Cont)

g. RVRS: Is power in the reverse direction trainline signal (activated/deactivated).

h. BRK: Is power brake trainline signal (activated/deactivated).

i. SLDE: Is the wheelslide signal (activated/deactivated).

j. EMR1: Is the emergency relay signal, inverter 1 (activated/deactivated)

k. PRCT: Is propulsion cutout signal (activated/deactivated).

l. LBRF: Is line breaker reset relay state feedback signal.

m. LBOL: Is line breaker overload state signal (activated/deactivated).

n. FD2F: Is filter discharge relay feedback signal, inverter 2.

o. FANF: Is propulsion blower fan contactor feedback signal.

p. FBON: Is trainline friction brake on, feedback signal.

q. TWMD: Is tow mode signal (activated/deactivated).

r. AUXFB: Is the Auxiliary Trainline Relay used to disable Low Voltage Power Supply feed back signal.

s. EMRG: Is emergency signal (activated/deactivated).

t. EBCT: Is electric brake cutout signal (activated/deactivated).

u. LBCP: Is line breaker coil power command signal.

v. FCCP: Is filter charging contactor coil command signal.

w. FD1P: Is filter discharge command signal, inverter 1.

x. MTRG: Is “Propulsion in Motoring Mode” command signal.

y. GDP1: Is gate drive power supply command signal, Inverter 1.

z. RSCR: Regen SCR status signal (activated/deactivated).

aa. AUX: Is the Auxiliary Trainline Relay used to disable Low Voltage Power Supply

DIG FBK =sig on	LBFB LBRF	FCCF LBOL	FD1F FD2F	MTRGF FANF	PWRE 0.000	FRWD FBON	RVRS TWMD	BRK	SLDE AUXFB	EMR1 EMRG	PRCT EBCT
DIG OUT =cmd on	LBCP LBRP	FCCP	FD1P FD2P	MTRG FANP	GD1P GD2P	RSCR CTL		AUX	S2MH S25M	PRFL EBFL	PRCN EBCN

Figure 7–57 Digital I/O Data Field (Cont.)

ab. S2MH: Is speed over 2 mph signal (activated/deactivated) .

ac. PRFL: Is propulsion failure signal (activated/deactivated).

ad. PRCN: Is propulsion cutout indication signal (activated/deactivated).

ae. LBRP: Is line breaker reset power command signal.

af. FD2P: Is filter discharge command signal, inverter 2.

ag. FANP: Is propulsion fan command signal.

ah. GDP2: Is gate drive power supply, inverter 2, command.

ai. CTL: Is chopper control bit to each inverter, based on polarity, controlling the chopper.

aj. S25M: Is speed above 25 mph signal (activated/deactivated).

ak. EBFL: Is electric brake failure signal (activated/deactivated).

al. EBCN: Is electric brake output indication signal (activated/deactivated).

7–2.2.2.4 Inverter Communications Data Field

```
                              LA Red PSC Events
CAR NO:        0            Occured        Reset
               DATE     0-xxx-00      0-xxx-00 00 No  EVENT
Speed 0.0mph   TIME    00:00:00      00:00:00  SubID -     0 Rel Time :  0.00
TL Mode:TL_SHUTDOWN    Rate :0.00     Sys Mode : START
                                      ANALOG I/O
VLNE   VLBR  VLFR   HVGR   VSNB    GDAT    RDAT   HCAS   AMBT    RSAT
   0      0     0      0      0      0C      0C     0C     0C      0C
CMIN   CMUT   VBAT  LOADW  CR1     CR2     CR3    CR4    DBFB    DBFR
   0   | 0             0T  0.000A  0.000A  0.000A 0.000A  0lbs    0lbs

DIG FBK  | LBFB  FCCF  FD1F  MTRGF | PWRE   FRWD  RVRS  BRK | SLDE   EMR1  PRCT
=sig on  | LBRF  LBOL  FD2F  FANF  | 0.000  FBON  TWMD       | AUXFB  EMRG  EBCT

DIG OUT  | LBCP  FCCP  FD1P  MTRG  | GD1P   RSCR      | AUX   S2MH   PRFL  PRCN
=cmd on  | LBRP        FD2P  FANP  | GD2P   CTL       |       S25M   EBFL  EBCN

                      F1=Help; F2=Files; ESC=Abort

Inverter | RNCM1   RUN1  RNCM2  RUN2  CHPST   0    CLINK  0    SPLIM     0
 Comm    |
         | TQCMD  TQFBK  LINKV  TACH1  TACH2  MODE  LBSTAT  DBCMD   FAULT
 INV1->  |     0      0      0      0      0     0      0      0       0
         |
 INV2->  |     0      0      0      0      0     0      0      0       0
```

Figure 7–58 Inverter Communications Data Field

This is the Inverter Communications Data Field (See Figure 7–58) where:

a. RNCM1/RNCM2: Are run commands for inverters (1) & (2).

b. RUN1/RUN2: Are run feedback signals from Inverters (1) & (2).

c. CLINK: Is Inverter Control Voltage Reference

d. CHPST: Is chopper blend set point

e. SPLM: Is speed limit measured in rpm.

f. TQCMD: Is torque command to Inverter 1/Inverter 2.

g. TQFDBK: Is torque feedback signals, Inverter 1/Inverter 2.

h. LINKV: Is link voltage status in Inverter1/Inverter 2.

i. TACH1/TACH2: Tachometer feedback speed signals from Traction Motors (Inv.1/Inv.2)

j. MODE: Is mode status (Inv. 1/Inv. 2) as determined by PWM square wave.

k. DBCMD: Is dynamic brake command (Inv.1/Inv.2).

l. FAULT: Is fault status of inverters (1) & (2).

7–2.3 START UP PROCEDURES

CAUTION: THE FOLLOWING STEP DIRECTS ENSURING THE PTU INTERNAL BATTERY IS CHARGED PRIOR TO USE. NEVER POWER THE PTU FROM A 110VAC OUTLET WHILE THE PTU IS CONNECTED TO THE PROPULSION GROUP.

To successfully communicate with the AC Propulsion group using the PTU, follow the instructions listed below:

a. Ensure that the PTU internal battery is charged prior to use. **DO NOT** power the PTU from a 110V outlet while the PTU is connected to the AC Propulsion group.

b. Insert the communication cable into the serial port found on the back of the PTU.

c. Connect the other end of the cable to the PTUR receptacle located in the Inverter Groups, or to the PTU receptacle in Cab.

d. Open the PTU by sliding the latches on both sides of the screen toward the front and swing the screen up.

e. Turn on PTU by turning the "power" button on and wait for the program Main menu to appear on the screen.

NOTE: If the computer is already on, the Main menu can be displayed at anytime by typing MENU followed by a return at the DOS prompt (i.e. C:\>).

f. Use the arrow keys to highlight the Propulsion PTU heading on the Main menu and press the return key.

g. Wait for the PTU program to prompt for a user name, then enter your name and press the return key.

h. The PTU program will prompt for a password to be entered. Enter your password and press the return key.

i. When PTU program loading is complete, the GE PTU MAIN SELECTOR MENU menu is displayed on the PTU.

7–2.4 OPERATION

PTU operation begins with the Main Selection Menu (Figure 7–59). Selection of the various options on this menu either call up specific screens, or additional menus. For example, selection of the EVENT DATA option, calls up the Event Data Menu, and selection of the WHEEL DIAMETER PARAMETER option calls up the Wheel Diameters screen. A general description of the options available under the Main Menu is contained in the following paragraphs. Detailed descriptions of each option begin with the Event Data Menu description.

NOTE: All of the following menu selections are available in Level 1 except Manual Test. The user must be in Level 3 to access the Manual Test selection.

```
                              GE PTU
GE PORTABLE TEST UNIT FOR AC TRANSIT LA-Red  1.40  12/3/96

                        MAIN SELECTION MENU

                           EVENT DATA

                           REALTIME DATA

                           WHEEL DIAMETER PARAMETERS

                           SET CLOCK & CAR NUMBER

                           MANUAL TEST   LEVEL 3 ONLY

                           ANALOG OUTPUTS

                           FAULT ISOLATION

                                                        EXIT
   ENTR=Sel.  F1=Help   F2=Files   ESC=Abort  →← ↑↓  = Navigate
```

Figure 7–59 GE PTU Main Selection Menu

The GE PTU MAIN SELECTION MENU lists the major categories of operation. The EVENT DATA option calls up the Event Data Menu, which provides various ways of viewing logged events over time, resetting specified or all events, zeroing event historical counters, erasing all stored event data, and monitoring/changing event restriction values.

One option in this menu calls up the Data Pack screens that provide equipment status prior to, and after, a fault is logged. This data pack option provides a basis for equipment analysis (e.g. what happened, or what value changed, just prior to the logged event).

The REALTIME option allows viewing of equipment status as it is occurring. This option provides unlimited use in fault analysis, and monitoring of system status during controlled changes (e.g. trainline command signals, braking applications, and so forth).

The WHEEL DIAMETER PARAMETERS option, is an adjustable parameter dedicated to monitoring and compensating for changing wheel diameters.

The SET CLOCK AND CAR NUMBER option sets the time base line for the car the PTU program is associated with. Among other applications, this provides a baseline for analytical functions over time.

The MANUAL TEST (available in Level 3 only) option allows the user to turn ON/OFF contactors, relays, power supplies, etc. to use as part of troubleshooting, or to check out selected functions after repair, and so forth.

The ANALOG OUTPUTS option allows the user to monitor analog voltages, and to select various analog signals for output to a Chart Recorder for analysis.

The FAULT ISOLATION option, provides on–screen troubleshooting procedures. Procedures will be user selected by the Event Number in question.

7–2.4.1 Event Data Menu

```
[eventml]          EVENT DATA MENU

            GET ALL EVENT DATA

            GET EVENT SUMMARY

            GET DATA PACKS

            RESET SPECIFIED EVENT
            RESET ALL ACTIVE EVENTS

            ERASE ALL STORED EVENT DATA

            ZERO EVENT HISTORICAL COUNTERS

            EVENT PARAMETERS

            EXIT

ENTR=Sel.  F1=Help   F2=Files   ESC=Abort  →← ↑↓ = Navigate
```

Figure 7–60 Event Data Menu

The first three options on the EVENT DATA MENU Screen (Figure 7–60) are keyed to analyzing events that have occurred since the last time the queue was checked. An event as used in this document refers to a malfunction or abnormality that is serious enough to initiate a fault indication display on the event display panel, to be annunciated in the PTU, and to be logged in the PSC memory as something significant enough to log for analysis.

Events are classified into two major categories; Restrictive and Non–Restrictive. A complete list of Restrictive and Non–Restrictive Events is provided in NO TAG located in section 7–2.5. Each event is assigned a number. This number is referred to as an event code.

Each time an event occurs, a "snapshot" of the equipment status (at the time the event occurred) is taken. This "snapshot" gets stored in the PTU in a number of different screens accessible from the EVENT DATA MENU. Going from top to bottom, the LA Red PSC Events Screen (Figure 7–61) is selected by the GET ALL EVENT DATA option on the EVENT DATA MENU. This snapshot not only shows equipment status at the time the event occurred, but the time it was reset. The LA Red PSC Events Screen is described on the following page.

The Menu Options offered in the EVENT DATA MENU are unrestricted at any level of access.

7–2.4.1.1 All Event Data

```
                                LA Red PSC Events
CAR NO:        0              Occured         Reset
               DATE    0-xxx-00        0-xxx-00 00 No   EVENT
Speed 0.0mph   TIME   00:00:00       00:00:00  SubID -      0 Rel Time :   0.00
TL Mode:TL_SHUTDOWN    Rate :0.00     Sys Mode : START
                                   ANALOG I/O
VLNE    VLBR   VLFR    HVGR    VSNB     GDAT     RDAT    HCAS    AMBT     RSAT
   0       0      0       0       0        0C        0C       0C      0C       0C
CMIN    CMUT    VBAT    LOADW   CR1      CR2     CR3     CR4        DBFB      DBFR
   0       0              0T 0.000A 0.000A  0.000A 0.000A        0lbs      0lbs

DIG FBK      LBFB   FCCF   FD1F   MTRGF  PWRE   FRWD   RVRS   BRK    SLDE   EMR1   PRCT
=sig on      LBRF   LBOL   FD2F   FANF   0.000  FBON   TWMD          AUXFB  EMRG   EBCT

DIG OUT      LBCP   FCCP   FD1P   MTRG   GD1P   RSCR          AUX    S2MH   PRFL   PRCN
=cmd on      LBRP          FD2P   FANP   GD2P   CTL                  S25M   EBFL   EBCN

Inverter     RNCM1   RUN1  RNCM2  RUN2  CHPST   0     CLINK  0      SPLIM     0
 Comm
             TQCMD  TQFBK  LINKV  TACH1  TACH2  MODE   LBSTAT   DBCMD      FAULT
 INV1->          0      0     0      0      0   0         0        0          0

 INV2->          0      0     0      0      0   0         0        0          0

            F1=Help; F2=Files; ESC=Abort  (Sh)F3/F4=Prev/Next  [52/60]
```

Figure 7–61 All Event Data Screen

The LA Red PSC Events Screen(s) store new events as shown in the above format. Pressing the F4 Key brings the next (chronological) event. Pressing the F3 Key recalls the previous screen (Event#), Looking through these snapshots gives indications of what problems were occurring at the time the event was logged. When the Car comes in for service, the data should be downloaded, reviewed, and stored. After the Car has been serviced, all event data should be erased (described later in this text). In this manner the possibility of working on old problems is avoided. Stored data (downloaded) can also be used for comparisons or tracking a suspected (intermittent) recurring problem, and/or be used as a tool for analysis and/or troubleshooting.

7–2.4.1.2 Event Summary

Selection of GET EVENT SUMMARY from the EVENT DATA MENU, calls up the LA RED SNAPSHOT queue EVENT DATA SUMMARY Screen (Figure 7–62). This screen provides a “grocery list” of the new events recorded.

This screen provides a top level summary of events currently stored in the PSC. The listing (under the EVENT NAME) column is in chronological (Event Title) order. The description of each event is also listed. The numbers listed under the SUB column are to be used in conjunction with fault isolation described later in this text. The last columns provide the date and time each event occurred, and time of reset.

Selection of the right arrow key activates the inner window of the screen and enables the user to scroll up or down as required. Pressing the ESC Key returns the screen to its normal state.

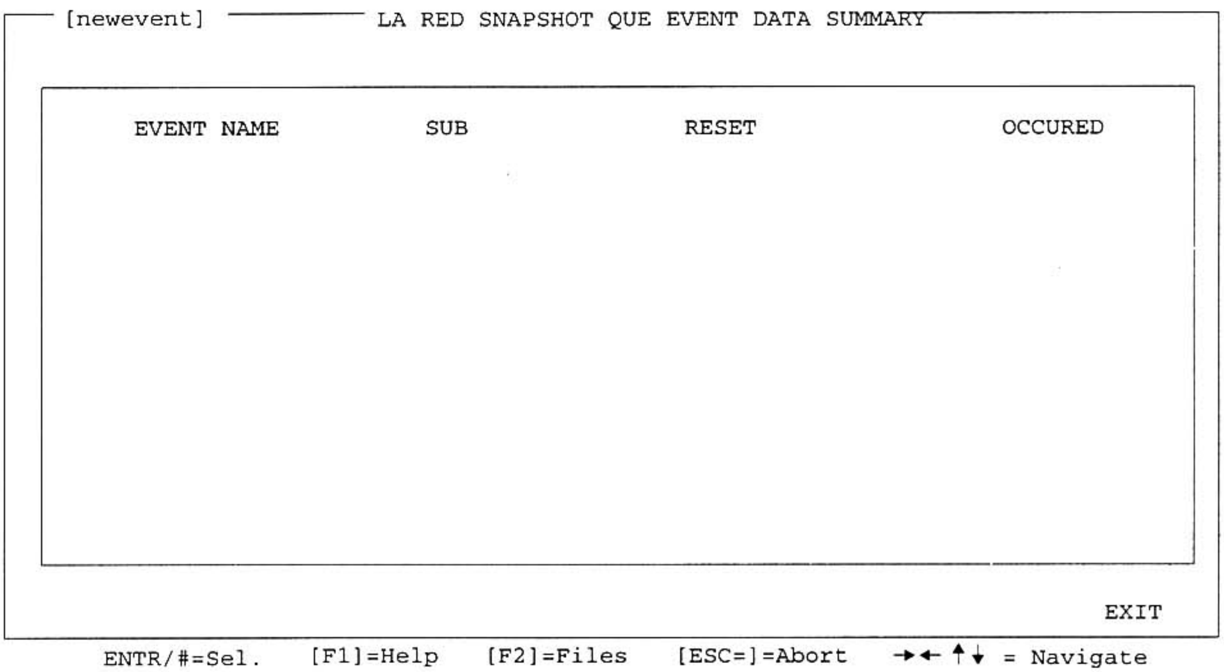


Figure 7–62 Event Summary Screen

7–2.4.1.3 Data Packs

Selection of GET DATA PACKS from the EVENT DATA MENU calls up the Data Pack Configuration Summary Screen (Figure 7–63).

```
[e_dptop]          Data Pack Configuration Summary

 PKG#        EVENT                         SUBID       TRIGGER      TIME

           ENTER NUMBER

     >:1

 [F1]=Help;  [DEL]=Edits; [ENTER]=Done

 GET DATA PACK FOR FILTER  1

ENTR/#=Sel.   [F1]=Help   [F2]=Files   [ESC=]=Abort   →← ↑↓ = Navigate
```

Figure 7–63 Data Pack Configuration

Directions for using this Screen are as follows:

GENERAL. Right arrow into the scrolling region (Changes to double line border). Arrow Keys navigate around within the window. From within the window, <Esc> moves to the Display Screen.

GET DATA PACK FOR FILTER. Enter the number of the requested filter. An Event Screen Display will be shown for the first record in the data pack. From the Event Screen, <Esc> returns to this screen

WINDOW COLUMNS.

PKG#: Data Pack #.
EVENT: The Event in the data pack.
SUB ID: The sub identifier under the event.
TRIGGER: Any Event or a specific Event.
TIME: Time the Event was logged

```
                    LA RED 5 SECOND DATAPACK EVENT SCREEN
CAR NO:        0             Occured        Reset
               DATE    0-xxx-00      0-xxx-00 00 No   EVENT
Speed 0.0mph   TIME    00:00:00      00:00:00  SubID -      0 Rel Time :  0.00
TL Mode:TL_SHUTDOWN    Rate :0.00    Sys Mode : START
                                     ANALOG I/O
VLNE    VLBR   VLFR    HVGR    VSNB     GDAT     RDAT    HCAS    AMBT     RSAT
    0      0      0       0       0       0C        0C      0C      0C       0C
CMIN    CMUT    VBAT   LOADW   CR1      CR2      CR3     CR4      DBFB     DBFR
    0      0                0T 0.000A 0.000A  0.000A 0.000A       0lbs     0lbs

DIG FBK  | LBFB   FCCF   FD1F   MTRGF | PWRE   FRWD   RVRS   BRK | SLDE   EMR1   PRCT
=sig on  | LBRF   LBOL   FD2F   FANF  | 0.000  FBON   TWMD        | AUXFB  EMRG   EBCT

DIG OUT  | LBCP   FCCP   FD1P   MTRG  | GD1P   RSCR        | AUX    S2MH   PRFL   PRCN
=cmd on  | LBRP          FD2P   FANP  | GD2P   CTL         |        S25M   EBFL   EBCN

Inverter | RNCM1   RUN1  RNCM2  RUN2 CHPST   0    CLINK  0      SPLIM     0
 Comm    |
         | TQCMD  TQFBK  LINKV  TACH1  TACH2  MODE   LBSTAT   DBCMD     FAULT
 INV1->  |     0      0      0      0      0   0        0        0         0

 INV2->  |     0      0      0      0      0    0       0        0         0

ENTR=Sel. F1=Help F2=Files ESC=Abort →←↑↓=Navigate(Sh)F3/F4=Prev/Next [61/100]
```

Figure 7–64 LA Red 5–Second Datapack Event Data Screen

Each five second Data Pack (Figure 7–64) is a collection of 100 snapshots that occur at 50Ms intervals. Screen (or frame) [61/100] shows the condition of the system at the time the Event is logged. Relative Time in upper right corner shows 0.00s. The time given 0.00 represents the relative time the event was logged, and is normally shown shown in Frame 61. By pressing the F3/F4 Key the user can scan through each frame up to [100/100], or back to {1/100}. Relative Time then shows a minus time if prior to the event, and a number (no minus) for the time after the event. By hitting Shift F3/F4, the user can scan up or down, ten frames at a time. Frame 100 contains system status at approximately two seconds after the Event occurred. The Event is normally logged at Frame [61/100] (as shown in the above screen). The entire time frame is five seconds, for 20 Frames per second. This allows the user to view 61 Frames before failure and 39 Frames after failure (approx.).

7–2.4.1.4 Reset Specified Event

The RESET SPECIFIED EVENT screen, (Figure 7–65) selected from the EVENT DATA MENU allows the user to reset a specific Event by typing in the Event Code –or – Event Name and selecting RESET THE EVENT. If the event selected was not logged by the system, a system error tutorial appears. To escape both the tutorial and reset screen, press ESC.

```
[ev_reset] ──────────── RESET SPECIFIED EVENT ────────────

   Select Event Number = 0    Name= 00 No EVENT

                               RESET THE EVENT

                               EXIT

ENTR/#=Sel.   [F1]=Help   [F2]=Files   [ESC=]=Abort   →← ↑↓ = Navigate
```

Figure 7–65 Reset Specified Event Screen

7–2.4.1.5 Reset All Active Events

RESET ALL ACTIVE EVENTS on the EVENT DATA MENU does not call up a screen. It is a command only. Selecting this option resets all Events that are currently logged on the Event Display Panel

7–2.4.1.6 Erase All Stored Event Data

The ERASE ALL STORED EVENT DATA option selected from the EVENT DATA MENU, is a command only. A "Please Verify Action" tutorial (Figure 7–66 and Figure 7–67) appears to ensure the user wants to erase all stored data at this time. Selecting this option erases all snapshots and event summaries that are currently stored in the PSC battery backed up memory. After reviewing the snapshot data, it is suggested to erase this data, so that new data can be entered. Before erasing Event Data, save the data using the F2 Key (as described previously).

```
[verify] ──────────── PLEASE VERIFY ACTION ────────────

   !  !  ! ALL STORED EVENT DATA WILL BE ERASED !  !  !
        (ALSO A RESET ALL EVENTS WILL BE PERFORMED)

                        NO              YES

ENTR/#=Sel.   [F1]=Help   [F2]=Files   [ESC=]=Abort   →← ↑↓ = Navigate
```

Figure 7–66 Erase All Stored Event Data Screen

7–2.4.1.7 Zero Event Historical Counters

Use of this command (on the EVENT DATA MENU) is accompanied with a prompt stating that if continued, all stored historical data will be removed.

```
[verify]            PLEASE VERIFY ACTION

      ! ! ALL HISTORICAL COUNTERS WILL BE SET TO ZERO ! !

                    NO           YES

ENTR/#=Sel.  [F1]=Help  [F2]=Files  [ESC=]=Abort  →← ↑↓ = Navigate
```

Figure 7–67 Erase All Stored Event Data Screen

7–2.4.1.8 Event Parameters

Selection of the EVENT PARAMETERS option on the EVENT DATA MENU, calls up the EVENT PARAMETERS SCREEN (Figure 7–68). Selecting the (highlighted) EVENT option calls up the Event List in numerical order. Scan to select desired Event, and enter. The screen will show the default information, and current information. As shown, this includes Restrictions, Auto Reset Tries, Group, and Lockout Group. This Screen allows display/adjustment of the mode restrictions and reset parameters for each Event. Descriptions for each selection are as follows:

EVENT provides a selector list of all Events. RESTRICTIONS displays a selector list of modes not allowed if the Event occurs. AUTO RESET TRIES refers to the number of times the Event is allowed to be reset before a lockout condition is set. A lockout condition is set when the current retry count exceeds AUTO RESET TRIES. AUTO RESET TIME is the time between AUTO RESET TRIES. GROUP matches the Event to a subsystem. LOCKOUT GROUP associates a lock out condition to a GROUP to condition LOCKOUT GROUP

In the Display Fields, the MAINTENANCE COUNT displays counts since the last maintenance count reset. The HISTORICAL COUNT displays count since the Car was put into service. The SET ALL=>DEFAULT sets all parameters for the Event to default.

```
[p_evnt]            EVENT PARAMETERS SCREEN
EVENT : 01 Line Breaker Overload
```

	DEFAULT	CURRENT
RESTRICTIONS	00 No Restrictions	00 No Restrictions
AUTO RESET TRIES	3	0
AUTO RESET TIME	0.0	0.0
GROUP	NO GROUP	NO GROUP
LOCKOUT GROUP	NO GROUP	NO GROUP

```
MAINTENANCE COUNT:  0
HISTORICAL COUNT:   0                    (SET ALL=>DEFAULT)

ENTR=Sel.  F1=Help  F2=Files  ESC=Abort ↑↓ = Navigate
```

Figure 7–68 Event Parameters Screen

7–2.4.2 Realtime Data

Selecting the REALTIME DATA option on the MAIN SELECTION MENU, calls up the REAL TIME DATA Screen (Figure 7–69).

```
                                   LA RED REAL TIME
CAR NO:        0            Occured        Reset
               DATE     0-xxx-00       0-xxx-00 00 No  EVENT
Speed 0.0mph  TIME    00:00:00       00:00:00  SubID -      0 Rel Time :  0.00
TL Mode:TL_SHUTDOWN   Rate :0.00    Sys Mode : START
                                    ANALOG I/O
VLNE    VLBR   VLFR    HVGR    VSNB     GDAT     RDAT    HCAS    AMBT     RSAT
   0       0      0       0       0       0C        0C      0C      0C        0C
CMIN    CMUT    VBAT    LOADW   CR1      CR2      CR3     CR4       DBFB      DBFR
   0       0              0T 0.000A 0.000A  0.000A 0.000A         0lbs      0lbs

DIG FBK        LBFB   FCCF   FD1F   MTRGF | PWRE   FRWD   RVRS   BRK  | SLDE   EMR1   PRCT
=sig on        LBRF   LBOL   FD2F   FANF  | 0.000  FBON   TWMD        | AUXFB  EMRG   EBCT

DIG OUT        LBCP   FCCP   FD1P   MTRG  | GD1P   RSCR         | AUX   S2MH   PRFL   PRCN
=cmd on        LBRP          FD2P   FANP  | GD2P   CTL          |       S25M   EBFL   EBCN

Inverter      RNCM1     RUN1   RNCM2    RUN2 CHPST    0      CLINK  0       SPLIM      0
 Comm
              TQCMD  TQFBK  LINKV  TACH1  TACH2  MODE   LBSTAT    DBCMD        FAULT
 INV1->           0      0      0      0      0     0        0        0            0

 INV2->           0      0      0      0      0     0        0        0            0

                          F1=Help; F2=Files; ESC=Abort
```

Figure 7–69 Realtime Data Screen

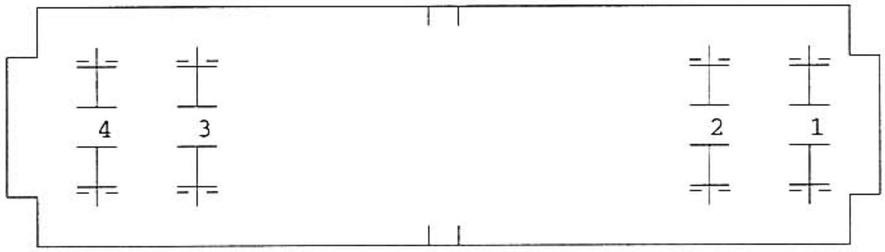
This Screen allows the user to monitor equipment status as it is occurring. Selecting SCAN stops the data update. Reselecting SCAN displays another update. Selecting REPEAT returns to Screen updates.

7–2.4.3 Wheel Diameter Parameters

Selecting the WHEEL DIAMETER PARAMETERS option on the MAIN SELECTION MENU, calls up the WHEEL DIAMETER PARAMETERS Screen (Figure 7–70). As shown, AXLES are numbered 1 to 4 from the A–End. The shaded background color and the = preceding the AXLE NUMBER shows the current axle. Move the cursor to the field to be changed. The CALIBRATION AXLE NUMBER allows entry of 1 through 4. Entries of 31.5 through 34.5 are valid for WHEEL DIAMETER. The <TAB> Key will clear a range error window. When

"CALIBRATED" is highlighted, this indicates the wheels have been calibrated A new wheel diameter has been entered and the calibration timer has not timed out.

```
[wdparam]        WHEEL DIAMETER PARAMETERS
```




```
B-END                CALIBRATED                A-END
              CALIBRATION AXLE NUMBER
              WHEEL DIAMETER            0.00 INCHES

ENTR/#=Sel.  [F1]=Help  [F2]=Files  [ESC=]=Abort  →← ↑↓ = Navigate
```

Figure 7–70 Wheel Diameter Parameters Screen

7–2.4.4 Clock and Car Number

Selecting the SET CLOCK & CAR NUMBER option on the MAIN SELECTION MENU, calls up the CAR NUMBER/REAL TIME CLOCK Screen (Figure 7–71). Arrow to applicable selection and enter Car Number, Date and Time. Time can also be automatically set by moving the cursor to the (SET CLOCK) position. Time is in military 24–hour time format (e.g. 9:PM=2100Hrs). This screen associates the PTU Program to the Car and time of installation, and establishes the time base for historical events.

```
[p_carnum]        CAR NUMBER / REAL TIME CLOCK

        CAR NUMBER: 0


        REAL TIME CLOCK

        DATE:                 0 XXX  0

        TIME:                00:00:00    (SET CLOCK)

ENTR/#=Sel.  [F1]=Help  [F2]=Files  [ESC=]=Abort  →← ↑↓ = Navigate
```

Figure 7–71 Set Clock and Car Number Screen

7–2.4.5 Manual Self Test

Selecting the MANUAL TEST option (Level 3 only) on the Main Menu Screen, calls up the LA RED MANUAL TEST Screen (Figure 7–72). This screen is used to operate in manual selftest.

```
                              LA RED MANUAL TEST
CAR NO:        0            Occurred     Reset                 PTU_EVENT
RESTR          0 ACTION     0 SPEED 0.0 mph

EVENT          0      TIME  0: 0: 0. 0                   DATE 0/ 0/ 0
                                   ANALOG I/O
VBAT         0
VLNE    VLBR     VLFR     HVGR     VSNB     GDAT     RDAT     HCAS     AMBT     RSAT
   0       0       0        0        0        0C       0C       0C       0C       0C
CMIN   CMUT           LOADW     CR1      CR2      CR3      CR4       DBFB     DBFR
   0      0              0T   0.000A   0.000A   0.000A   0.000A       0lbs     0lbs

DIG FBK       LBFB  FCCF  FD1F  MTRGR | PWRE  FRWD  RVRS  BRK | SLDE   EMR1  PRCT
=sig on       LBRF  LBOL  FD2F  FANF  | 0.000 FBON  TWMD      | AUXFB  EMRG  EBCT

DIG OUT       LBCP  FCCP  FD1P  MTRG  | GD1P  RSCR       | AUX   S2MH   PRFL  PRCN
=cmd on       LBRP        FD2P  FANP  | GD2P  CTL        |       S25M   EBFL  EBCN

          Activating MTRG will cause a test of MTRG1 as well as MTRG

                 RIPPLE TEST          0

              F1=Help F2=Files ESC=Abort →←↑↓=Navigate
```

Figure 7–72 LA Red Manual Test

<u>**CAUTION:**</u> WHEN IN MANUAL SELF TEST ENSURE NO HIGH VOLTAGE IS APPLIED. FAILURE TO COMPLY CAN RESULT IN EQUIPMENT DAMAGE.

<u>**NOTE:**</u> If contactor/relays etc. are picked up during test, and EXIT (ESC) has been performed, the system WILL log events. Reset and erase Events after test. Always ESC Screen before leaving area.

<u>**NOTE:**</u> The manual test option has a safeguard that voids operating in manual selftest if system detects any voltage over 50 Volts.

The Manual Selftest option provides the means to manually test contactors, relays, or command modes. Moving arrow keys will highlight selections along the digital outputs. Pressing ENTER will toggle the highlighted output form OFF to ON, or ON to OFF. Turning ON a relay or contactor does not necessarily mean closure of the devise. Some relays/contactors are normally open in the activated state. Although there are many uses associated with this option, an example would be testing the operation of a relay/contactor after removal/replacement has been performed. Other examples would include using this option as an aid to troubleshooting, or checking operation of selected items as part of a scheduled maintenance action.

7–2.4.6 Analog Output

Selecting the ANALOG OUTPUTS option on the MAIN SELECTION MENU, calls up the ANALOG OUTPUT Screen (Figure 7–73). Selecting SCAN Mode on this screen, stops data updates. Re–selecting SCAN displays another updated. Selecting REPEAT returns the screen to continuous update information. Each of the eight detail lines accepts the analog output number or an entry from the selector window in the NAME column. The corresponding values are displayed:

- PARAMETER VALUE is the raw value in engineering units.
- FULL SCALE is the value at which the output saturates.
- OFFSET allows adjustment to the DAC VALUE.
- DAC VALUE is the digital/analog conversion value. It is computed from PARAMETER VALUE plus OFFSET divided by FULL SCALE value. Value is limited to between –10 and +10 volts.
- RECALL & SAVE numbers are for saving/recalling previous configurations.

```
[p_anout]            ANALOG OUTPUT SCREEN                                8
                                                    SCAN      =REPEAT

        PARAMETER     DAC           PARAMETER           FULL      OFFSET
          VALUE      VALUE    #        NAME             SCALE

CH1;      0.000      0.00     0                          0.0       0.0
CH2;      0.000      0.00     0                          0.0       0.0
CH3:      0.000      0.00     0                          0.0       0.0
CH4:      0.000      0.00     0                          0.0       0.0
CH5:      0.000      0.00     0                          0.0       0.0
CH6:      0.000      0.00     0                          0.0       0.0
CH7:      0.000      0.00     0                          0.0       0.0
CH8:      0.000      0.00     0                          0.0       0.0

                   BATTERY BACKED SCREEN SETUPS

     RECALL SCREEN # 1 2 3 4 5           SAVE SCREEN    # 1 2 3 4 5

     ENTR=Sel.  F1=Help  F2=Files  ESC=Abort   →← ↑↓ = Navigate
```

Figure 7–73 Analog Output Screen

7–2.4.7 Fault Isolation

Fault Isolation procedures have been developed by GE Engineering. Selection of this option from the main menu calls a screen that requires typing in the Event Number (the problem is associated with) for detailed troubleshooting information.

Each fault isolation event screen provides the following information: (Refer to Figure 7–75 for a typical fault isolation event screen.)

```
[fi_entry]          GE FAULT ISOLATION

 Type the Event Code Number You Wish to Isolate:      1
                                                 ======

ENTR/#=Sel.  [F1]=Help  [F2]=Files  [ESC=]=Abort  →← ↑↓ = Navigate
```

Figure 7–74 Fault Isolation Screen

a. Description

A general description of the event and what caused it are in this section.

b. Restrictions

The system causes one of the following restrictions to occur when an event is logged: 1) None; 2) Propulsion Disabled; 3) Electric Brake Disabled; 4) Inverter 1 Disabled; 5) Inverter 2 Disabled; and, 6) LVPS Disabled.

c. Related Equipment Data

Information about other equipment that may have caused or contributed to the event is here.

d. Device Data

Specific information about the device that most likely caused the event is here.

e. Supporting Documentation

The GE propulsion system schematic (GE dwg 84B108121) is included in this manual. See Page 7–66. The schematic is provided as a reference only and is not guaranteed to be the latest revsion. The maintainer should consult the actual drawing.

f. Troublshooting Procedures

These detailed procedures provide the maintainer with an on–line resource for determining events

```
==========================================================================
EVENT 01 — LINE BREAKER OVERLOAD                         REV 01/10/96
==========================================================================
DESCRIPTION:
Event 01 is displayed when the Line Breaker trips due to an overcurrent
condition. The event is logged when the Line Breaker overload
digital feedback (LBOL) provides a battery level input to the system
controller.
RESTRICTIONS: All modes except Power–Up
RELATED EQUIPMENT DATA:
DEVICE              DATA
------              ----
Line Breaker (LB)      800 Amp 750 Volt DC Holec Line Breaker located
(41A296327AFP2)          in the Line Breaker Group (17KG510A1).
                Trip: 2400 Amp
                Operating Coil: 37VDC, 22VDC Min, 45VDC Max
                     2.68A Inrush, 0.7A Hold
                Reset Coil: 37VDC, 22VDC Min, 45VDC Max
                     24A Inrush (coil interlocked with
                     reset latch to remove the reset
                     coil after resetting the overload)

SUPPORTING DOCUMENTS:
84B108121 GE LA RED System Schematic (Sections 1B,24B,32B,39B)
GEK104312 GE LA RED Maintenance Manual
TROUBLESHOOTING PROCEDURE:
1. Check the data packs to see if an overcurrent condition existed
   at the time of the event.
    IF an overcurrent condition did NOT exist:
      AND this was the first occurrence of this event:
        Reset and restart the system.

      AND the event is recurring:
        Adjust or replace the Line Breaker.
    IF an overcurrent condition existed:
      Review data pack. See if a valid reason existed for the
      overcurrent. (For example: Hitting end of a rail gap while
      the filter voltage was low.) If a valid reason existed, reset
      and restart the system.

      If there was no apparent reason for the overcurrent:
      Check for inverter events and resolve them.

      If it is necessary to physically investigate the Line Breaker
      and its associated wiring, then :
   ***************************************************************
   *             WARNING:             *
   * REMOVE AND LOCK OUT HIGH VOLTAGE FROM CAR AND ENSURE THAT *
   *   FILTER CAPACITORS ARE DISCHARGED BEFORE PROCEEDING!   *
   ***************************************************************
      With High Voltage removed from the car (following approved
      safety procedures), open the cover on the 17KG510 Line Breaker
      group to gain access to the Line Breaker.
        Check for faulty power wiring below the Line Breaker.

        Restore all connections disturbed during troubleshooting and
        close all covers. Reset and restart the system.
```

Figure 7–75 Fault Isolation Screen Example

7–2.5 EVENT CODES

For complete up–to–date descriptions of event codes and sub id's, use the fault isolation screens.

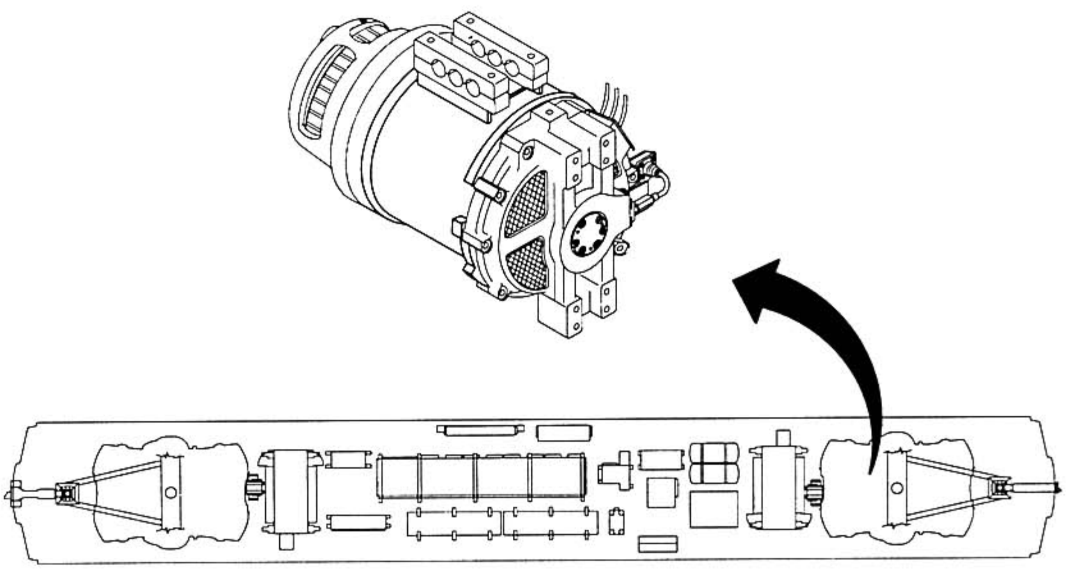
7–3 TRACTION MOTOR – 5GEB17A1

7–3.1 DESCRIPTION AND OPERATION

This frameless design Traction Motor – 5GEB17A1 (Figure 7–76) is a self ventilated alternating current (AC) device which converts electrical energy into mechanical energy to propel a transit car. The rugged motor construction includes a Drive End (D.E.) and Connection End (C.E.) frame which bolt directly to the stator. The insulation and ventilation system provide for long life and trouble–free operation. Because this is an AC motor, there are no brushes, brushholders, commutator or related components requiring maintenance. Thus, there are no inspection covers.

The stator winding is comprised of coils inserted in slots and locked in place. Connections are then made, and the end turns are braced before the entire stator is vacuum pressure impregnated.

The rotor construction permits operation of two motors from one inverter while tolerating moderate differences in wheel diameter between axles. The rotor is supported by bearings which can be lubricated.



(Typical Undercar Arrangement)

Figure 7–76 Traction Motor – 5GEB17A1

> **WARNING:** HIGH VOLTAGE IS PRESENT ON THE TRACTION MOTOR. REMOVE ALL POWER AND DISCHARGE MAIN INVERTER CAPACITORS PRIOR TO SERVICING UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

WARNING: ALWAYS CHOCK WHEELS BEFORE WORKING TRACTION MOTOR. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

7–3.2 FAULT ISOLATION

NOTE: In order to perform many of the inspections and corrective actions described in this table, Traction Motor must be removed and at least partially disassembled. Refer to Workshop Manual as necessary.

7–3.2.1 Noisy Operation of Traction Motor

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
1. Motor bearings.	1. Lack of lubrication or rough bearing.	1. Lubricate bearings or replace motor.
2. Fan.	2. Damage to fan.	2. Replace motor.

Table 7–5 Traction Motor Noisy Operation

7–3.2.2 Overheating of Traction Motor

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
1. Coil insulation failure.	1. Charred coil, smell of burnt insulation (excessively hot motor).	1. Replace motor.
2. Dirt/oil clogging air inlet screen.	2. Dirt/oil accumulation on inlet screen.	2. Remove dirt/oil from inlet screen.

Table 7–6 Traction Motor Overheating

7–3.2.3 No Motor Output

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
1. Coil insulation failure.	1. Charred or otherwise damaged insulation.	1. Replace motor.
2. Rotor Assembly.	2. Defective Rotor.	2. Replace motor.
3. Connection(s).	3. Loose connection(s).	3. Tighten cable terminations or remove motor and replace cables.

Table 7–7 Traction Motor No Output

7–3.2.4 Excessive Heat Between Motor Lead and Car Wiring

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
Connection(s).	1. Charred or burnt cable insulation, termination sleeves. 2. Loose connection(s).	1. Tighten terminals. 2. Replace terminals as required.

Table 7–8 Traction Motor Lead Excessive Heat

7–3.2.5 Traction Motor Turns Freely

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
Coupling.	Coupling hub slipping on gear unit pinion and/ or motor shaft.	Replace coupling. Replace motor or gear unit as required.

Table 7–9 Traction Motor Turns Freely

7–3.3 MAINTENANCE PRACTICES

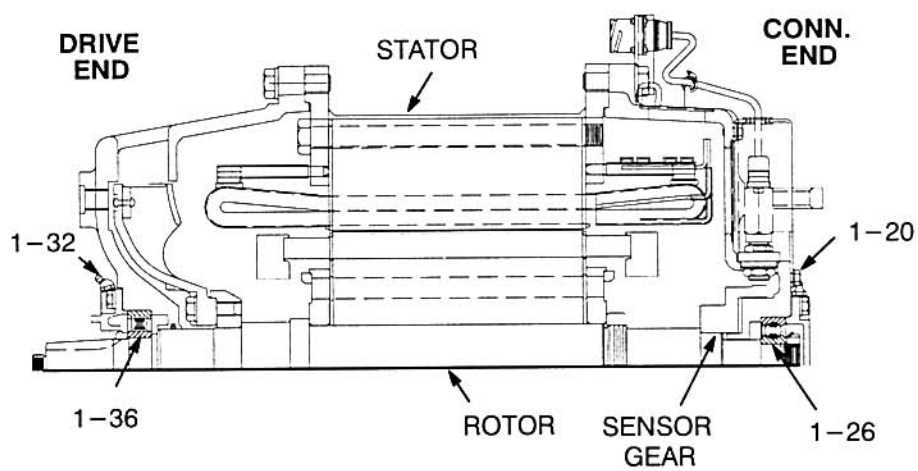
Refer to section 7–3.4.

7–3.4 SERVICING

7–3.4.1 120K Mile Interval (2 Years)

a. Lubricate C.E. bearing (1–26, Figure 7–77) thru fitting (1–26) with one ounce of grease GE Spec. D6A2C5 (Alvania No. 2 or equivalent) from a grease gun.

b. Lubricate D.E. bearing (1–36) thru fitting (1–32) with one ounce of grease (D6A2C5).



1–20. Lubricant Fitting
1–26. Ball Bearing
1–32. Lubricant Fitting
1–36. Roller Bearing

Figure 7–77 Service Traction Motor

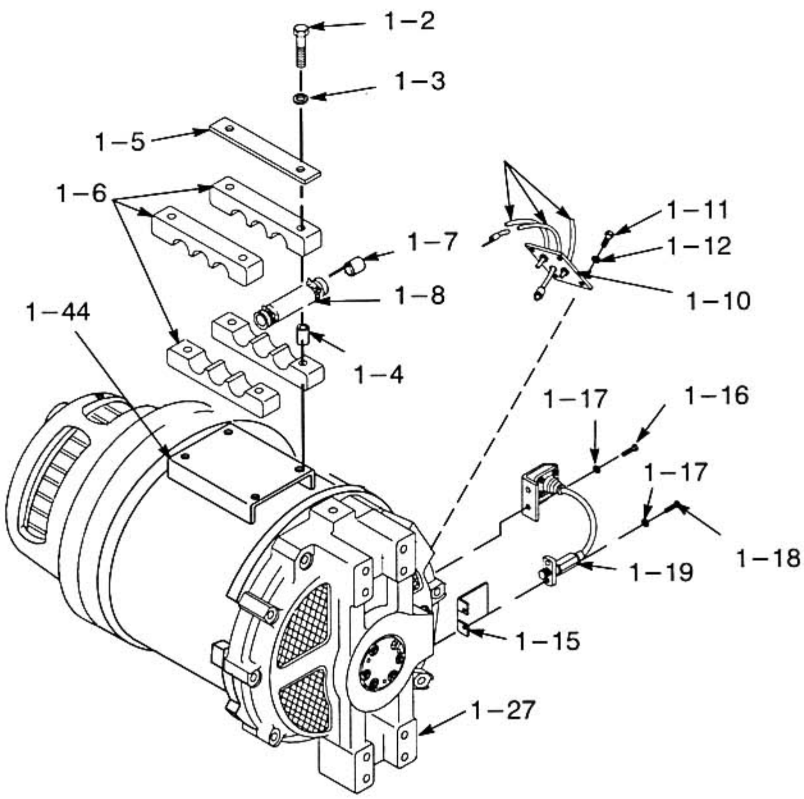
7–3.5 REMOVAL/INSTALLATION

a. Remove/install cover (1–10, Figure 7–78) to framehead (1–27) and secure with hardware (1–11, 1–12). Torque to 22–24 ft. lb.

b. Remove/install cable cleats (1–6), sleeves (1–8), spacers (1–4, 1–7), and plates (1–5) to stator (1–44). Secure with hardware (1–2, 1–3). Torque to 22–24 ft. lb.

c. Remove/install speed sensor assembly (1–19) with support (1–15). Secure with hardware (1–17, 1–18). Torque to 12–14 ft. lb. The sensor air gap is preset.

d. Remove/installl sensor cable with hardware (1–16, 1–17) and torque to 12–14 ft. lb.



		1–8.	Sleeve	1–16.	Hex Head Bolt
1–2.	Hex Head Bolt	1–7.	Spacer	1–17.	Washer
1–3.	Flat Washer	1–10.	Cover	1–18.	Hex Head Bolt
1–4.	Spacer	1–11.	Hex Head Bolt	1–19.	Speed Sensor
1–5.	Top Plate	1–12.	Flat Washer	1–27.	Framehead
1–6.	Cable Cleat	1–15.	Support	1–44,	Stator

Figure 7–78 Remove/Install Cables and Speed Sensor

7–3.6 ADJUSTMENT/TEST

Not applicable.

7–3.7 INSPECTION/CHECK

10K Mile Interval

a. Inspect motor (Figure 7–79) for physical damage such as cracks, or signs of overheating. Report defects to supervision.

b. Inspect cables (1–14). Report cracked, cut or frayed insulation to supervision.

c. Inspect bushings (1–13). Report cracks to supervision.

d. Inspect fan (1–41). Report cracks, bent or missing blades to supervision.

e. Visually inspect speed sensor assembly (1–19) for damage to speed sensor cable or cover. Report damage to Supervision.

f. Inspect for loose or missing hardware. Tighten or replace as necessary.

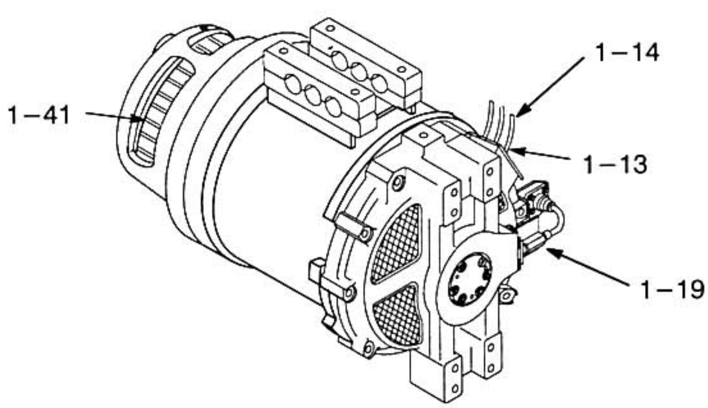
g. Inspect motor mounting bushings and mounting bolts for cracks, distortion or looseness. Replace damaged or missing components and hardware. Report defects to supervision.

7–3.8 CLEANING/PAINTING

a. Use a sash brush and clean wiping cloth to remove any loose debris from the traction motor.

b. Using a vacuum nozzle, brush, or clean wiping rag, remove dirt and debris from fan and air inlet screen.

c. Use a steam cleaner to remove any stubborn build up on the traction motor exterior surfaces.



1–13. Cable Bushing
1–14. Cable
1–19. Speed Sensor
1–41. Fan

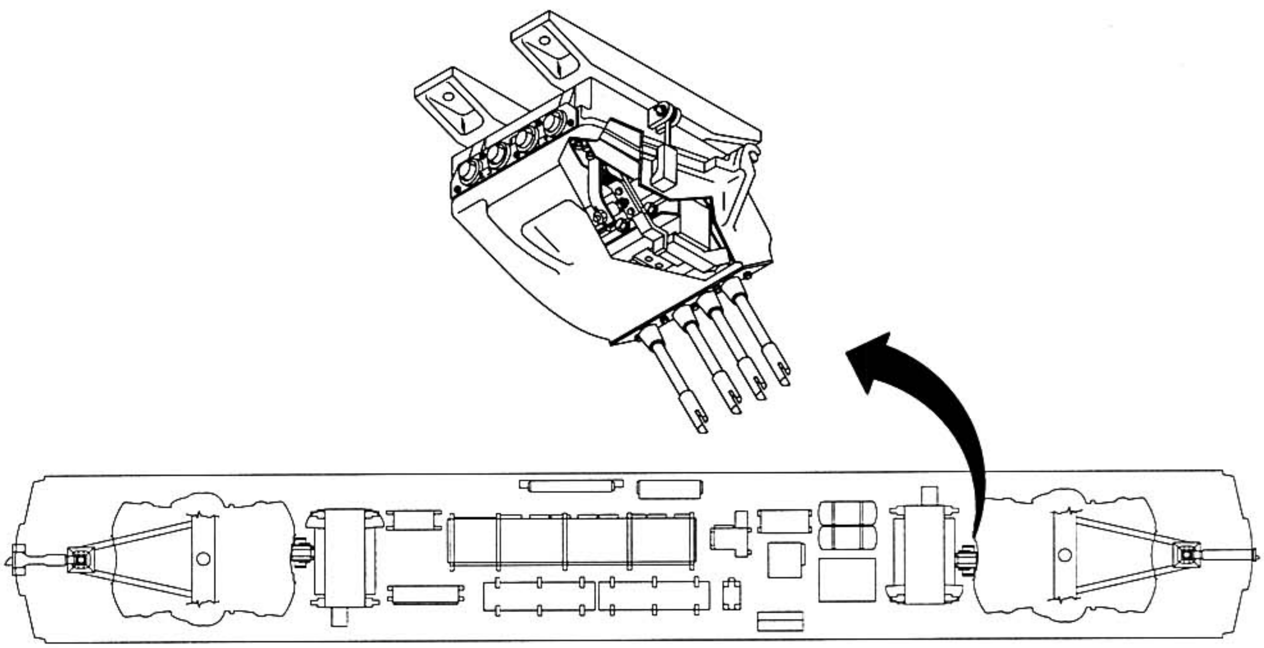
Figure 7–79 Inspect/Check Traction Motor

7–4 COUPLER SOCKET/PLUG – 17MS30D2/17MP30D2

7–4.1 DESCRIPTION AND OPERATION

The Coupler Plug and Coupler Socket are commonly referred to as the truck disconnect device. There is a coupler plug and socket for each traction motor.

The coupler socket and plug work together as a unit to couple the traction motor leads to the car leads at the truck. The two coupler halves must be fastened together to complete the traction motor electrical circuit.



(Typical Undercar Arrangement)

Figure 7–80 Coupler Plug/Socket 17MP30D2/17MS30D2

WARNING:	HIGH VOLTAGE IS PRESENT ON THE COUPLER SOCKET/PLUG ASSEMBLY. REMOVE ALL POWER AND DISCHARGE MAIN INVERTER CAPACITORS PRIOR TO SERVICING UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

WARNING:	ALWAYS CHOCK WHEELS BEFORE WORKING ON COUPLER PLUG/SOCKET. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

CAUTION: PROPER CABLE ROUTING AND BUNDLING ARE CRITICAL TO VEHICLE ELECTRO–MAGNETIC CAPABILITY. ENSURE THAT ALL CABLES ARE ROUTED AND BUNDLED PER THE ORIGINAL ARRANGEMENT.

7–4.2 FAULT ISOLATION

NOTE: In order to perform the inspections and corrective actions described in this table, the device must be opened. Refer to Workshop Manual as necessary.

Motor Interruptions:

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
1. Burnt Contacts	1. Loose Cover	2. Repair cover Clamp and Contacts
2. Burnt Contacts	2. Low Contact Pressure	3. Replace Springs and Readjust Overtravel

Table 7–10 Coupler Plug/Socket Motor Interruptions

7–4.3 MAINTENANCE PRACTICES

Not applicable.

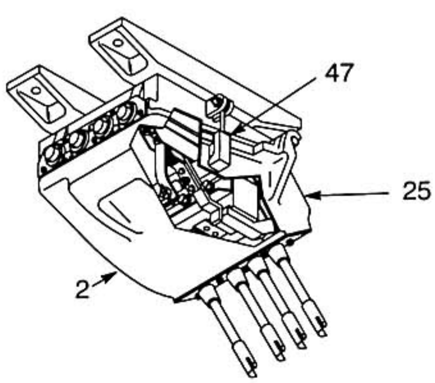
7–4.4 SERVICING

Not applicable.

7–4.5 REMOVAL/INSTALLATION

a. Swing out clamps (47, Figure 7–81) to unsecure/secure coupler plug to socket.

b. Remove/install coupler plug frame (2) hinge pivots to coupler socket frame (25) hinge pins.



2. Plug Frame
25. Frame
47. Clamp

Figure 7–81 Remove/Install Coupler Plug/Socket

7–4.6 ADJUSTMENT/TEST

Not applicable.

7–4.7 INSPECTION/CHECK

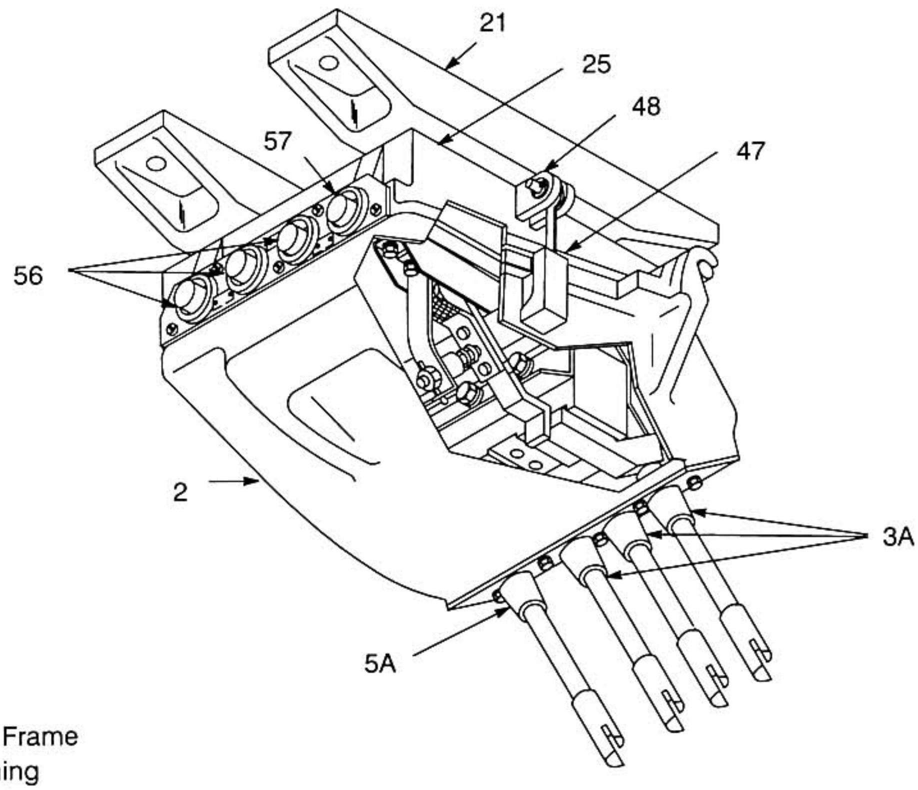
7–4.7.1 External Inspection

a. Inspect plug frame (2, Figure 7–82). Report any physical damage to Supervision.

b. Inspect bushings (3A, 5A, 56, 57). Replace if missing or damaged.

c. Inspect frame (25) and supports (21) . Report any physical damage to Supervision.

d. Inspect clamps (47) and hinge pins (48). If damaged, replace.



2. Plug Frame
3A. Bushing
5A. Bushing
21. Support
25. Frame
47. Clamp
48. Hinge Pin
56. Bushing
57. Bushing

Figure 7–82 Inspect Coupler Exterior

7–4.7.2 Internal Inspection

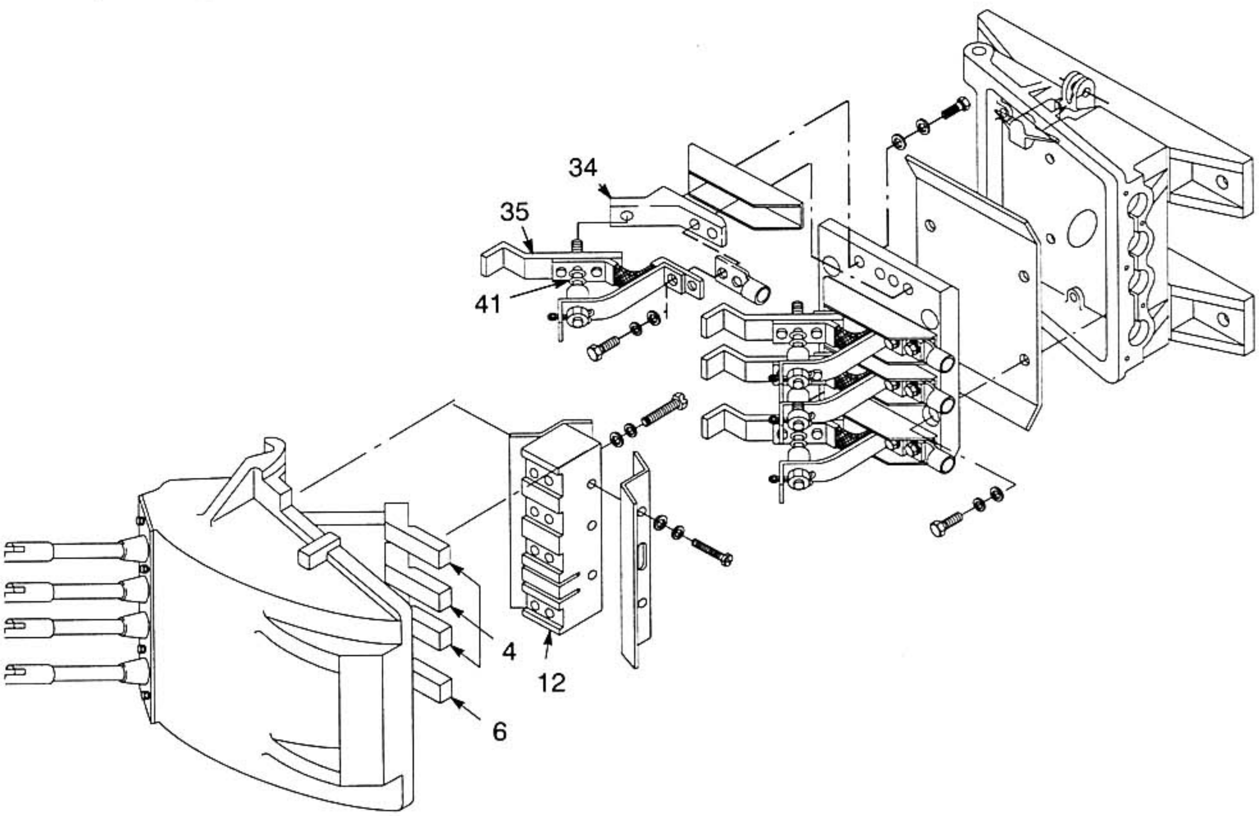
a. Inspect stationary contact fingers (4, 6, Figure 7–83). If severely burned or pitted, replace.

b. Inspect contact block (12). Report looseness or cracks to Supervision.

c. Inspect cables. Report loose connections or fraying to Supervision.

d. Inspect contact fingers (35). If severely burned or pitted, loose or damaged springs (41) are found, replace.

e. Inspect finger bases (34). Report looseness or cracks to Supervision.



4.	Contact Finger	34.	Finger Base
6.	Contact Finger	35.	Contact Finger
12.	Contact Block	41	Spring

Figure 7–83 Inspect Coupler Interior

7–4.8 CLEANING/PAINTING

a. Using a sash brush and clean wiping rag remove any loose debris from the coupler socket components.

b. A steam cleaner may be used to remove any stubborn build up from the exterior surfaces.

7–5 COUPLING – 7GAC9E1

7–5.1 DESCRIPTION AND OPERATION

The 7GAC9E1 Coupling (Figure 7–84) is a grease lubricated gear coupling device designed as the mechanical drive between the traction motor and gear unit for transit applications. The coupling accommodates misalignment which occurs between the motor and gear shafts during normal operation.

The coupling weighs approximately 32 lb. and consists basically of two gear toothed hubs which are connected together by a floating internally geared sleeve.

The two halves of the outer coupling housing are joined together by six bolts, supported on the traction motor half of the coupling, and form an enclosure for the coupling lubricant. A rubber seal between the gear unit side hub and housing guards against lubricant leakage and the entry of dirt or other foreign material into the lubricant enclosure. An o–ring seals the two halves of the outer coupling housing at the flange joint to prevent lubricant leakage.

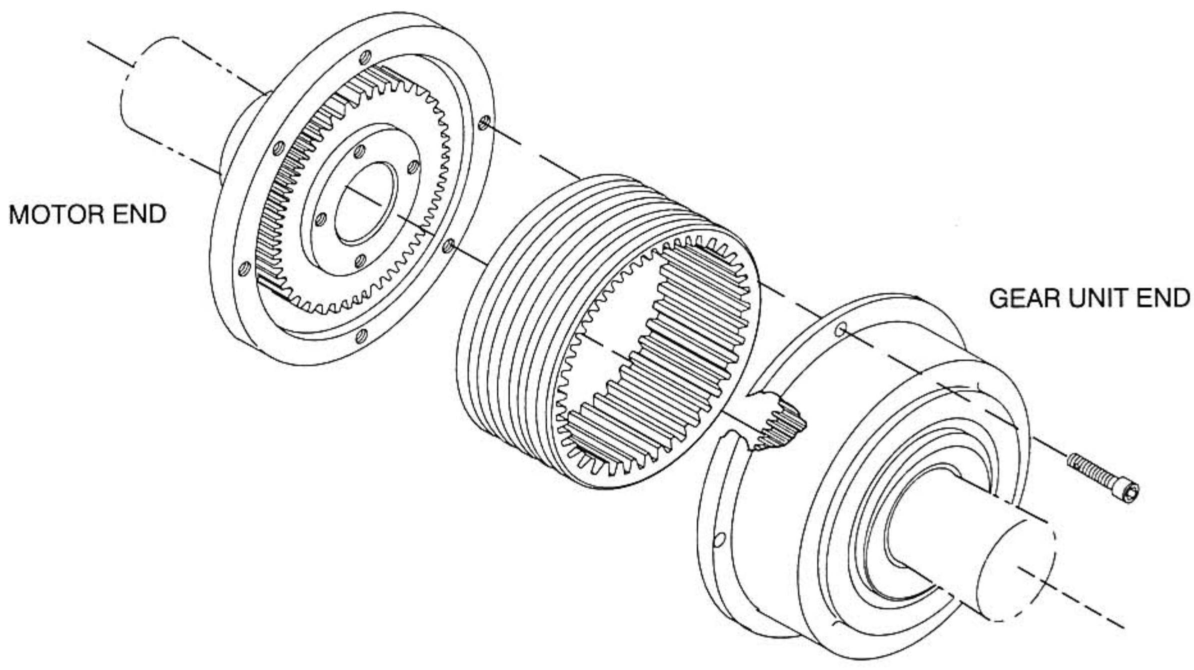


Figure 7–84 Coupling – 7GAC9E1

WARNING:	HIGH VOLTAGE IS PRESENT ON THE TRACTION MOTOR. REMOVE ALL POWER AND DISCHARGE MAIN INVERTER CAPACITORS PRIOR TO SERVICING UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

WARNING: ALWAYS CHOCK WHEELS BEFORE WORKING COUPLING. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

NOTE: In order to perform inspections and corrective actions of internal components, the coupling must be partially disassembled. Refer to Workshop Manual as necessary.

7–5.2 FAULT ISOLATION

7–5.2.1 Excessive Lubricant Loss from Coupling

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
1. Loose lubricant fittings.	1. Loose, leaky or missing lubricant fittings.	1. Clean empty holes and install new fittings. Remove grease throw–off from unit.
2. Faulty O–Ring seals.	2. Lubricant throw–off.	2. Replace O-Ring and hubs with worn teeth
3. Loose flange bolts.	3. Lubricant throw–off and loose or missing flange bolts.	3. Torque bolts.
4. Overfilling.	4. Leakage between end ring and motor hub.	4. Remove grease throw–off.

Table 7–11 Coupling Excessive Lubricant Loss

7–5.2.2 Noisy Operation of Coupling

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
1. Teeth	1. Worn coupling teeth	1. Replace as required
2. Dry Coupling	2. Lack of Lubricant	2. Add Lubricant
3. Hardware	3. Loose Bolts	3. Torque Bolts

Table 7–12 Coupling Noisy Operation

7–5.2.3 Traction Motor Turns Freely

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
Loose coupling hubs	Hubs slipping on shaft	Replace coupling

Table 7–13 Coupling Traction Motor Turns Freely

7–5.3 MAINTENANCE PRACTICES

Not applicable.

7–5.4 SERVICING

30K Mile Interval

Using a grease gun, apply approximately 0.75 oz. of GE Spec. D50E17 (Alvania No. 2EP or equivalent) grease into grease fitting (4, Figure 7–85) of the motor end coupling.

7–5.5 REMOVAL/INSTALLATION

Not applicable.

7–5.6 ADJUSTMENT/TEST

Not applicable.

7–5.7 INSPECTION/CHECK

a. Inspect for loose or damaged hardware (10, Figure 7–85). Torque to 24 ft.–lbs. or replace as necessary.

b. Inspect for loose, damaged or missing grease fittings (4). Torque to 120 in.–lbs.

c. Inspect coupling for evidence of leaking lubricant, a defective seal or O-ring. If leakage is visible, report to Supervision.

d. If any discoloration from overheating is visible, report to Supervision.

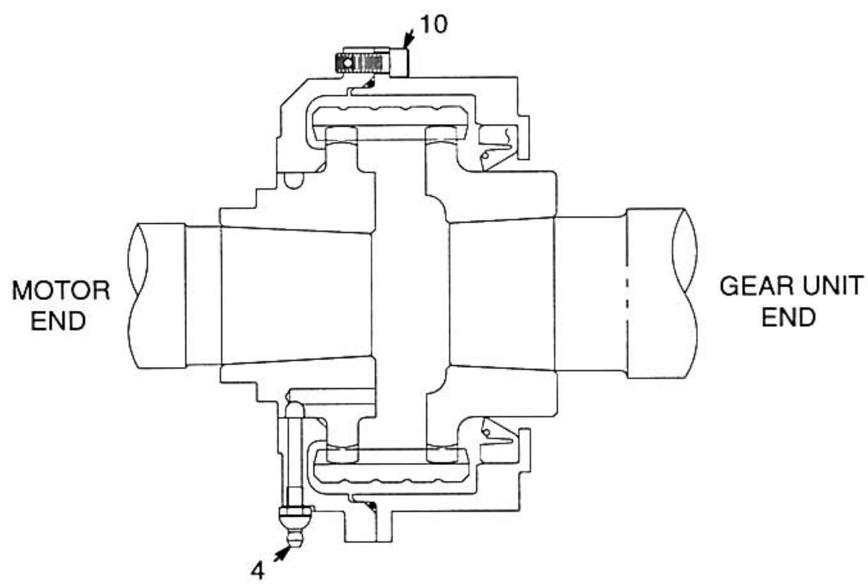


Figure 7–85 Service/Inspect Coupling

7–5.8 CLEANING/PAINTING

a. Using a sash brush and clean wiping rag remove any loose debris from the exterior of the coupling assembly.

b. A steam cleaner may be used to remove any stubborn buildup.

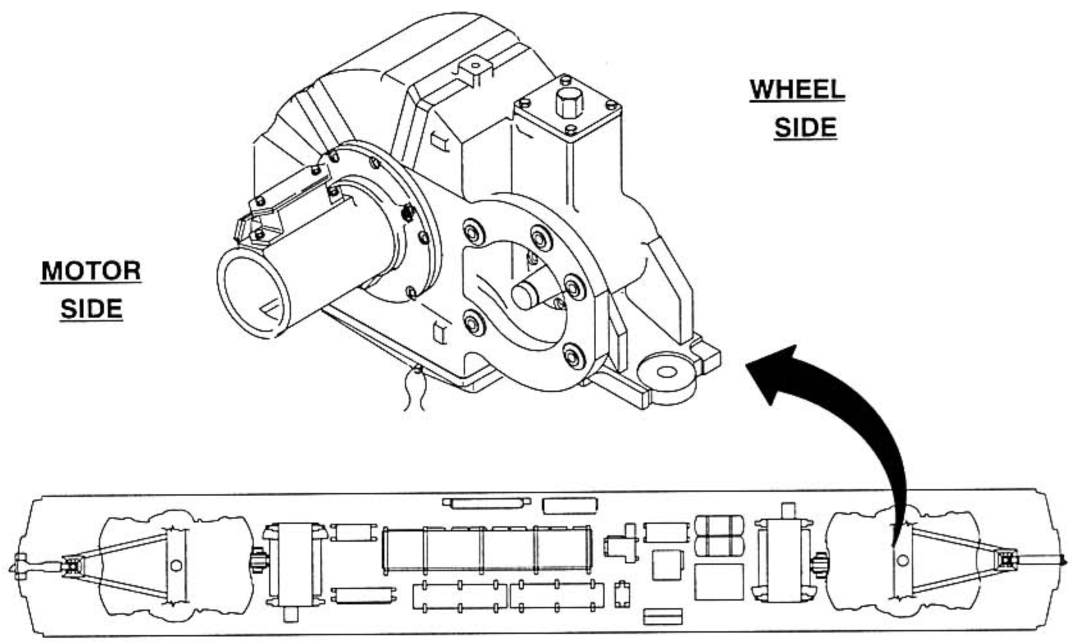
7–6 GEAR UNIT – 7GA81A1

7–6.1 DESCRIPTION AND OPERATION

The 7GA81A1 is a single-reduction, parallel-drive gear unit (Figure 7–86) which transfers motive power from a traction motor to a car axle.

The transfer is done by means of two gears and shafts. A pinion gear shaft is coupled to the traction motor through a flexible coupling. The traction motor drives the high–speed pinion which drives a quill gear and the axle.

The gear box provides a reduction of 6.368 to 1 from traction motor shaft to axle speed.



(Typical Undercar Arrangement)

Figure 7–86 Gear Unit – 7GA81A1

WARNING:	**HIGH VOLTAGE IS PRESENT ON THE TRACTION MOTOR. REMOVE ALL POWER AND DISCHARGE MAIN INVERTER CAPACITORS PRIOR TO SERVICING UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

WARNING:	**ALWAYS CHOCK WHEELS BEFORE WORKING GEAR UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

7–6.2 FAULT ISOLATION

NOTE: In order to perform some of the inspections and corrective actions described in this table, the gear unit may require cover removal. Refer to the Workshop Manual as required.

7–6.2.1 Gear Unit Leaking Oil at Quill Shaft

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
Oil charge.	Excessive oil charge.	Maintain proper oil level.

Table 7–14 Gear Unit Leaking Oil at Qull Shaft

7–6.2.2 Gear Unit Leaking Oil at High Speed Pinion

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
Oil charge.	Excessive oil charge.	Maintain proper oil level.

Table 7–15 Gear Unit Leaking Oil at High Speed Pinion

7–6.3 MAINTENANCE PRACTICES

Refer to section 7–6.4.

7–6.4 SERVICING

NOTE: Change oil after a new or overhauled gear unit has been in operation for two months or 10,000 miles and then every 60,000 miles or annually whichever comes first.

7–6.4.1 10K Mile Interval

a. Check oil level visiible sight gage (11, Figure 7–87) circle indicator. To check, remove plastic sight gage cover. Recover sight gage after checking.

b. Maintain the cold, settled oil level between the top and bottom of the gage circle. If oil level is below bottom of circle, oil must be added.

c. If in doubt about oil level, or if oil must be added, clean gear box in area of inspection cover. Remove cover, check oil or add oil to bottom of fill limit hole. Reinstall cover and gasket.

7–6.4.2 60K Mile Interval

a. Drain gear case oil by removing oil drain plug (4, Figure 7–87) from gear unit. If metal particles are found in waste oil, report to Supervision.

b. Apply Permatex No. 14 and re–install oil drain plug. Use lockwire (6) to secure.

c. Remove inspection cover and gasket (9, 10).

d. Add oil through oil fill opening until level reaches bottom of fill limit hole.

e. Install inspection cover and gasket (9, 10) using hardware (8, 9). Torque bolts to 56 – 60 ft. lbs.

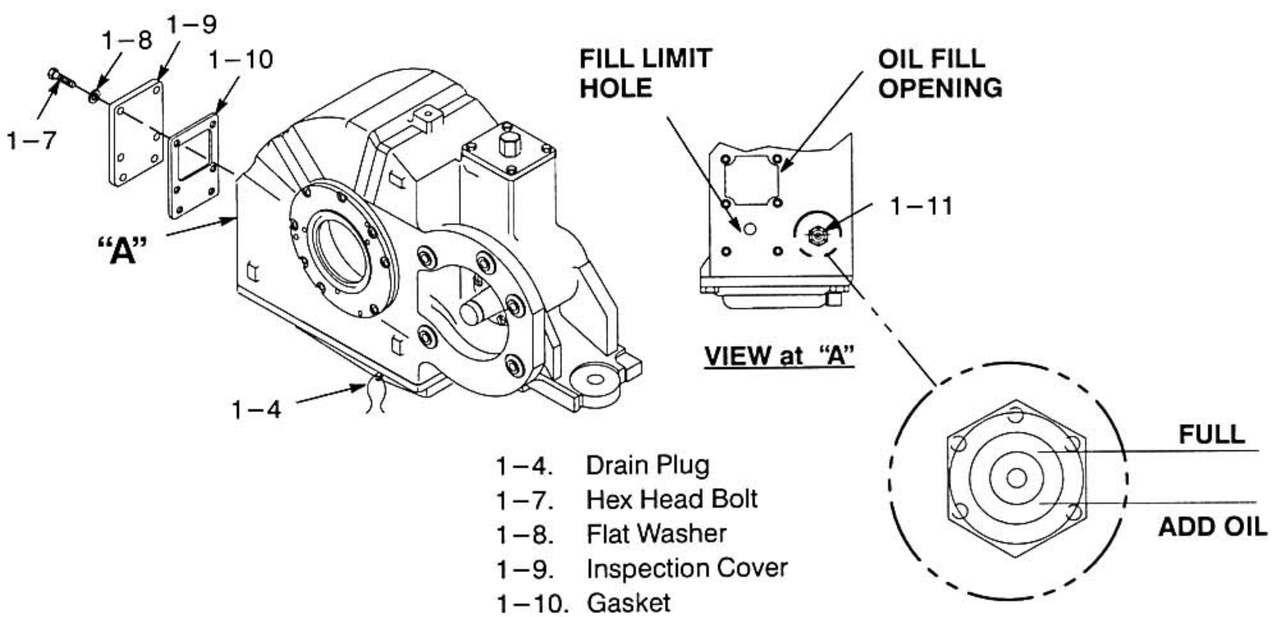
NOTE: Approximately 7.0 quarts of oil are required to fill gear unit. Recommended oil: SAE 85W–140 (Mil–L–Spec 2105D + GL5 additives. Acceptable oil: SAE 80W–90 (Mil–L–Spec 2105D + GL5 additives.

7–6.5 REMOVAL/INSTALLATION

Not applicable.

7–6.6 ADJUSTMENT/TEST

Not applicable.



1–4. Drain Plug
1–7. Hex Head Bolt
1–8. Flat Washer
1–9. Inspection Cover
1–10. Gasket
1–11. Oil Sight Gage

Figure 7–87 Service Gear Unit Oil

7–6.7 INSPECTION/CHECK

7–6.7.1 10K Mile Interval

a. Inspect gear unit (Reference Figure 7–88) for bulges (internal damage), dents (external damage), and cracks. Report any physical damage to Supervision.

b. Inspect for overheating. If observed, report to Supervision.

c. Clean breather (55) with a wiping rag and inspect for any blockage or physical damage. Replace as required.

d. Inspect unit for leaking bearing housing seals. If leaking occurs, wipe area clean and report to Supervision.

e. Inspect bearing housing bolts. If loose, torque to 56–60 ft–lbs.

f. Inspect cover (9) and gasket (10), if gasket is leaking, replace. Check for missing hardware (7,8). If found, replace and torque to 56–60 ft–lbs.

> **NOTE:** If oil drain plug or oil level sight gage is removed, oil will run out of unit. Place a suitable receptacle under unit to catch any oil drainage.

g. Inspect oil drain plug (4). If loose or leaking, clean and apply Permatex No. 14 to threads and tighten. If lockwire (6) is broken or disturbed, replace.

h. Inspect oil level sight gage (11). Replace if cracked or damaged. Apply Permatex No. 14 to threads and re-install. Tighten until one point of the oil level sight gage is at a 12 o'clock orientation. Install plastic sight gage cover and cover gage glass.

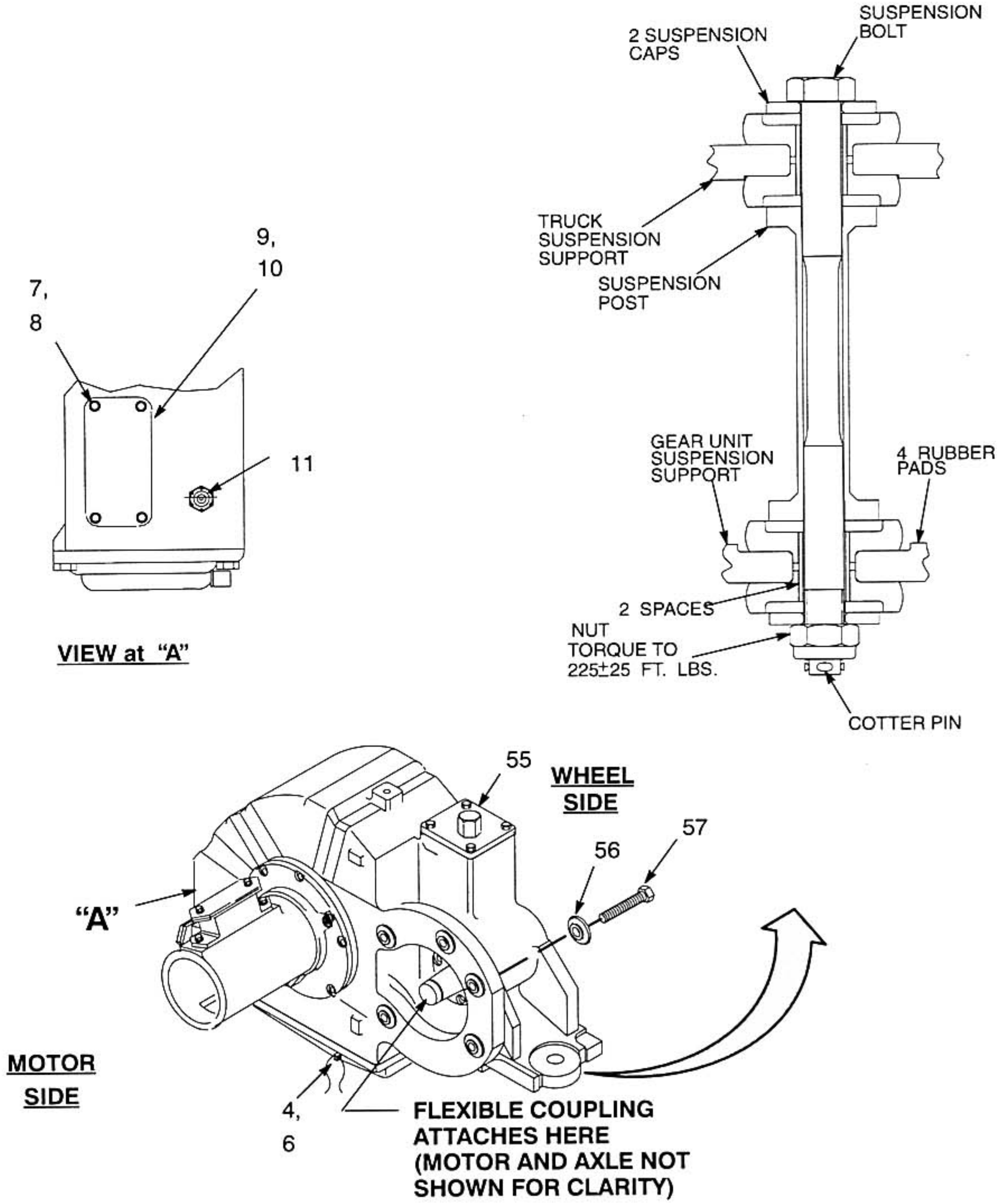
i. Examine the high speed shaft bearings by pushing upward on flexible coupling. Check for movement of pinion shaft assembly. If unusual or excessive play is detected, report to supervision.

j. If gear unit has been operated with oil below recommended level, remove inspection cover and inspect gears.

k. Inspect gears for chipped, pitted, cracked, scuffed or broken teeth, uneven tooth wear, nicks or burrs. Report the need for corrective maintenance to Supervision.

l. Inspect rubber bushing mounts (12), washers (56) and bolts (57). Torque bolts to 285–315 ft. lbs.

m. Inspect gear unit suspension. Check for loose nut/bolt, missing cotter pin below nut, looseness or free play of suspension assembly, cracked or distorted rubber pads, bent suspension assembly, or other physical damage. Check for loose or missing or bent safety support at wheel side of suspension link attachment nose. Report damage, looseness, missing parts or other unusual conditions to Supervision. Torque suspension hardware to 200–250 ft. lbs.



1–3.	Oil Pan	1–10.	Gasket
1–4.	Drain Plug	1–11.	Oil Sight Gage
1–6.	Wire	1–12.	Bushing
1–7.	Hex Head Bolt	1–55.	Breather
1–8.	Flat Washer	1–56.	Washer
1–9.	Inspection Cover	1–57.	Bolt

Figure 7–88 Inspect Gear Unit Exterior

7–6.7.2 30K Mile Interval

Same as 10K interval plus:

a. At all brush box locations,remove and inspect cover (3, Figure 7–89) and gasket (4). If damaged, replace.

b. Inspect spring (10A). Replace if damaged or burned.

c. Inspect carbon brush with pigtail (18), a slight pull on the pigtail will test its bond to the brush and verify that the brush is free in the body (8). Inspect brush for cracks, chips and length. Loosen and remove accumulated brush wear dust from the body using a stiff brush and vacuum. Replace brushes shorter than 1.38 inches.

d. Inspect brush pigtail shunts for frayed, broken, and/or burned wires. Replace brush as required.

e. Install brush and brush springs at the same time.

(1) The end of the new brush is precontoured to obtain a partial fit to the ground brush ring. Orient and install the brushes so that the contour mates with the ground brush ring curvature.

(2) Verify brush slides freely in the holder.

(3) Install the brush lead terminals under the two screws (7) inside the brush housing and tighten the screws securely. Arrange the brush leads so that they cannot restrict brush movement in the holder as the brush wears in service.

(4) Install the large end of the brush spring over the spring guide on the underside of the brush holder cover.

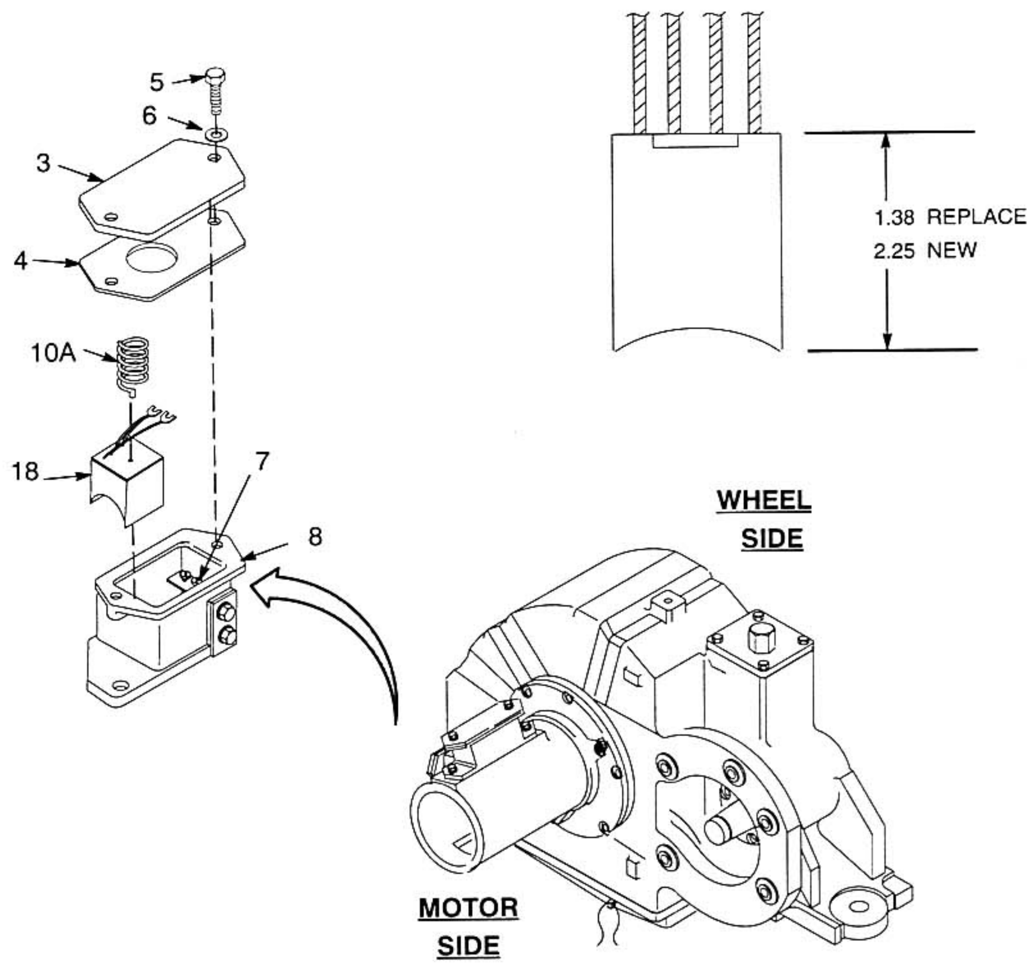
(5) Insert the tang projection at the small end of the spring in the center hole of the brush.

f. Compress the cover, gasket and spring into position on the brush holder body and install the cover bolts and lockwashers. Torque bolts (5) to 22–24 ft–lbs.

7–6.8 CLEANING/PAINTING

a. Using a sash brush and clean wiping rag remove any loose debris from exterior of the gear unit.

b. A steam cleaner may be used to remove any stubborn buildup.



4–3. Cover
4–4. Gasket
4–5. Hex Head Bolt
4–6. Lockwasher
4–7. Hex Head Bolt
4–8. Housing
4–10A. Spring
4–18. Carbon Brush with Pigtail

Figure 7–89 Inspect Gear Unit Ground Brush

7–7 MAIN INVERTER GROUP – 17KG497A1

7–7.1 DESCRIPTION AND OPERATION

The 17KG497A1 Main Inverter Group is of modular configuration measuring 179" long, 40" deep, 24" high and weighing approximately 3000 pounds. It contains Line Replaceable Units (LRUs) which result in minimum number of unique sub–assemblies and maintenance time for removal/replacement, and component location during troubleshooting. Figure 7–90 shows the location of the Main Inverter Group in the Vehicle.

The Main Inverter Group houses the power semiconductors and the control devices for the propulsion inverters and braking choppers. The group contains modules for each of the two inverters that consist of the power semiconductors (plus and minus modules, and the braking chopper), the filter capacitor banks, the microprocessor control panel, the low voltage power supply and various sensing devices.

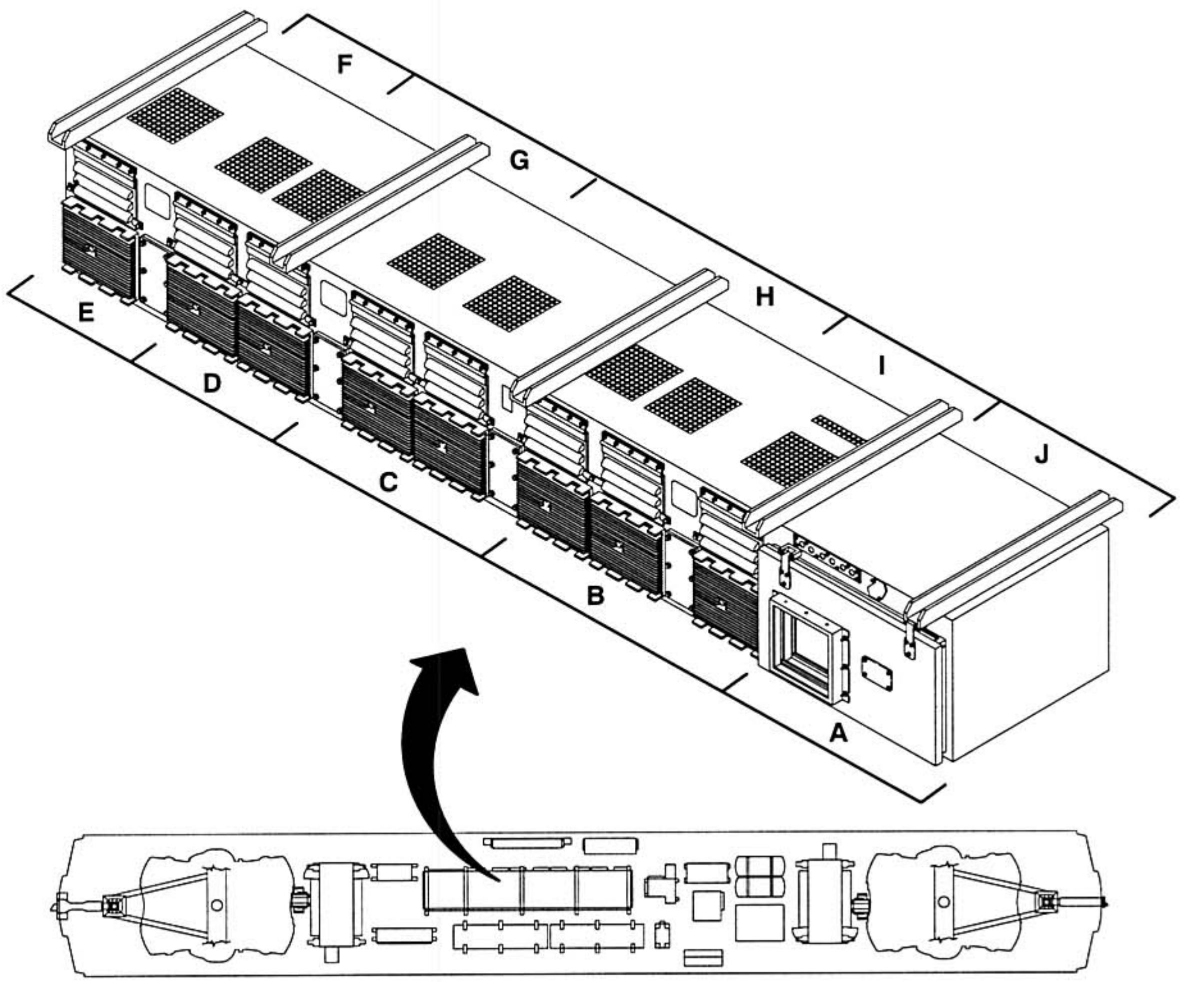


Figure 7–90 Main Inverter Group – 17KG497A1

WARNING: HIGH VOLTAGE IS PRESENT ON THE MAIN INVERTER GROUP. THIS VOLTAGE CAN BE FATAL IF CONTACTED. REMOVE ALL POWER AND ASSURE ALL CAPACITORS ARE DISCHARGED BEFORE WORKING ON GROUP. FAILURE TO COMPLY WITH ALL RAILROAD SAFETY REGULATIONS CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

7–7.2 FAULT ISOLATION

Refer to Faut Isolation Using the PTU, section 7–2.4.7.

7–7.2.1 Event Display Panel

a. Locate the Event Display Panel (Figure 7–91).

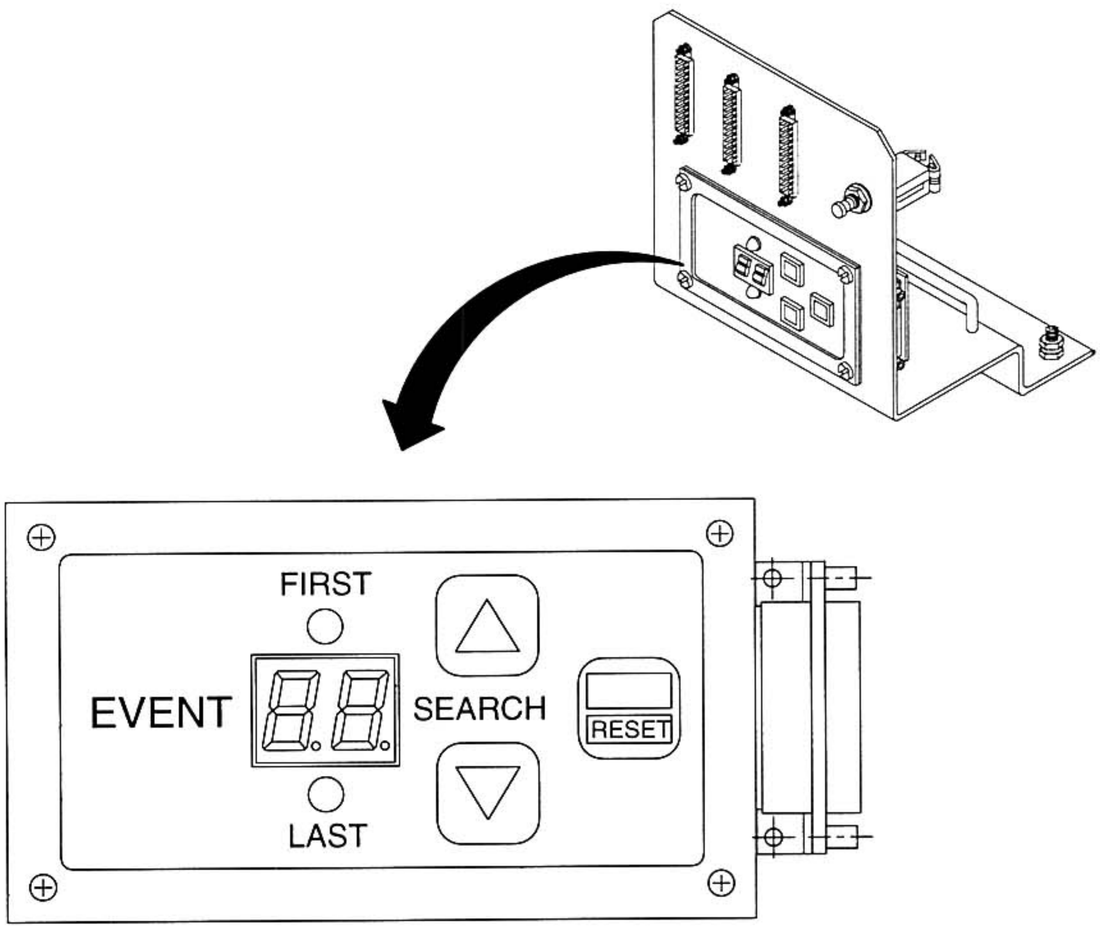


Figure 7–91 Event Display Panel

b. If the first and last lights are blinking and the event display is not illuminated, no events have been recorded.

c. If the last light is lit and the event display is illuminated, at least one event has occurred. The first and last lights will blink when the mid–range event codes are displayed.

d. Scan through the event display codes by pushing "UP" or "DOWN" arrow.

e. Record the codes on a log for future reference.

f. After performing maintenance for a code, erase codes by pushing the "RESET" button twice (within 10 seconds) at each event reading.

> **NOTE:** Any erased codes can be retrieved later using the PTU.

7–7.2.2 Portable Test Unit

Refer to the Portable Test Unit section 7–2 for its complete use.

7–7.3 MAINTENANCE PRACTICES

Refer to section 7–7.7.

7–7.4 SERVICING

Refer to section 7–7.7.

7–7.5 REMOVAL/INSTALLATION

7–7.5.1 Remove/install panel – 17FM311M1, battery line filter (BLF).

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–17, Figure 7–92) which secures panel (1–92) to the case weldment (1–2). Torque hardware to 30–35 in. lbs.

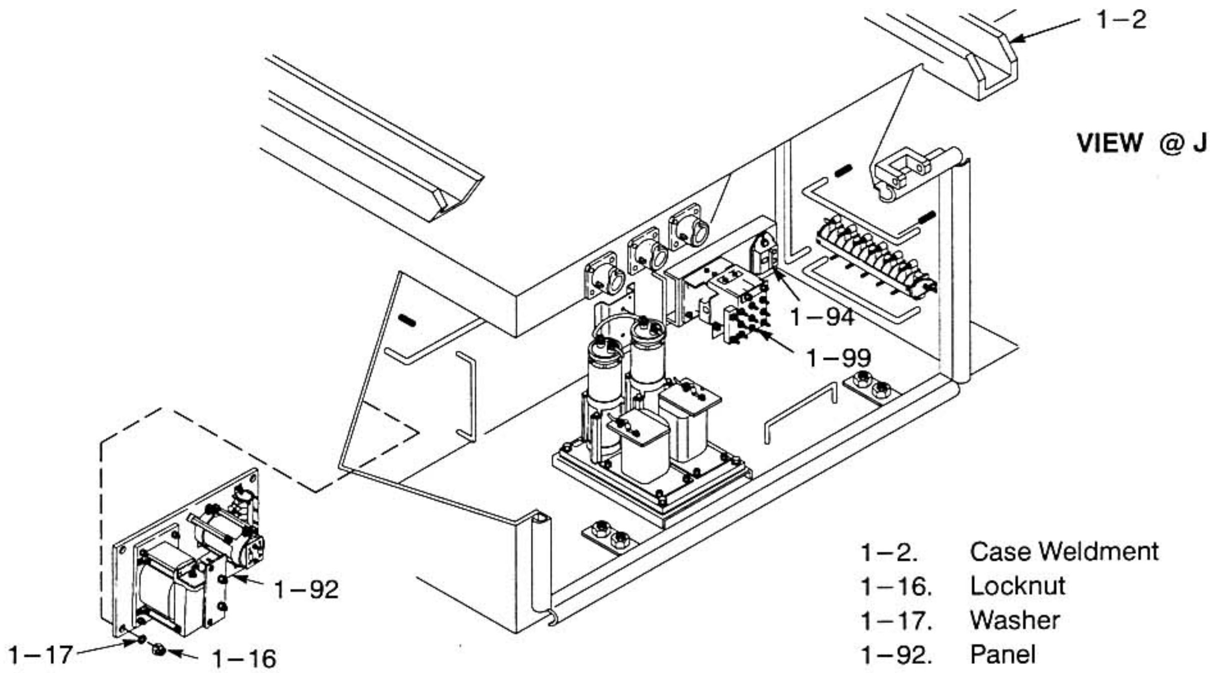


Figure 7–92 Remove/Install Battery Line Filter Panel

7–7.5.2 Remove/install Voltage Attenuation Module 17FM559A1.

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–135, Figure 7–93) which secures module (1–91) to the case weldment (1–2). Torque hardware to 74–83 in. lbs.

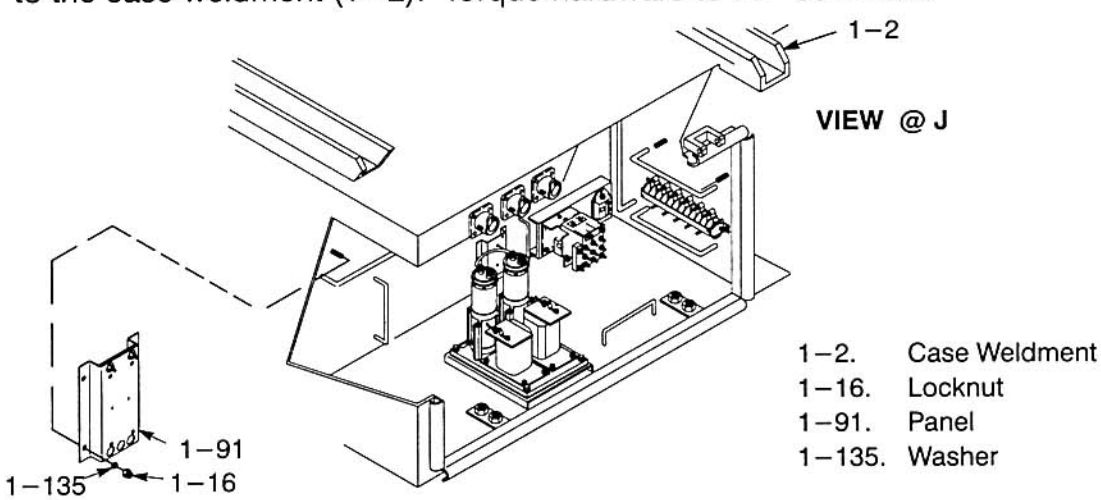
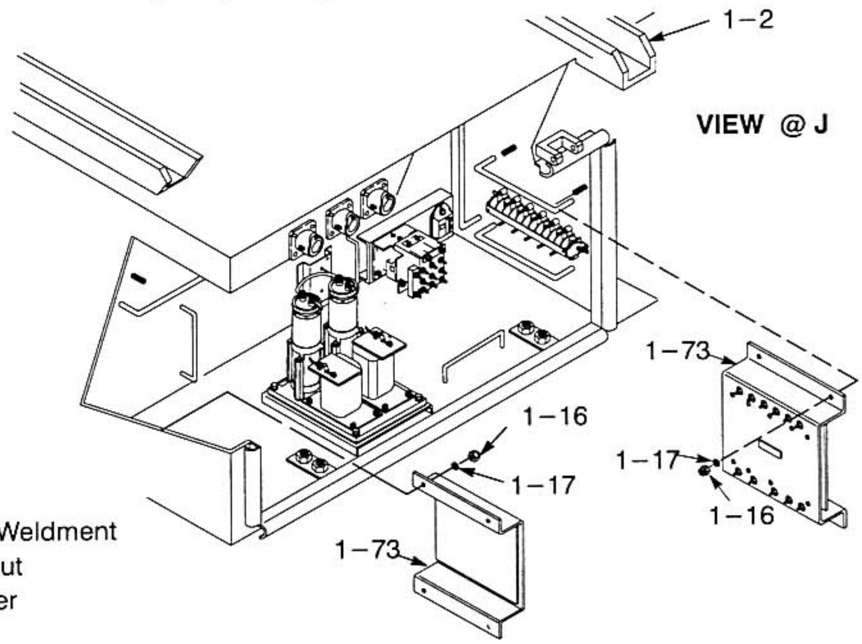


Figure 7–93 Remove/Install Voltage Attenuation Module 17FM559A1

7–7.5.3 Remove/install Voltage Attenuation Module 17FM560A1.

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–17, Figure 7–94) which secures module (1–73) to the case weldment (1–2). Torque hardware to 74–83 in. lbs.



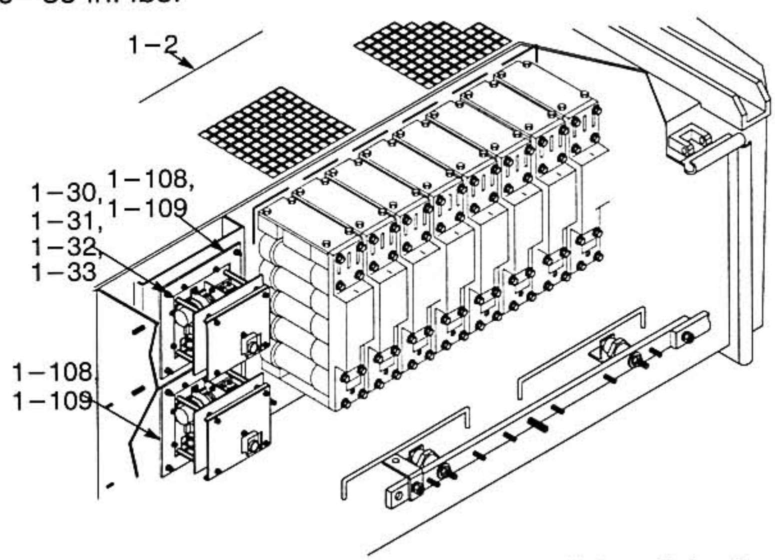
1–2. Case Weldment
1–16. Locknut
1–17. Washer
1–73. VAM

Figure 7–94 Remove/Install Voltage Attenuation Module 17FM560A1

7–7.5.4 Remove/install panel 17FM589A3, Gate Drive Power Supply (GDPS1–2).

a. Tag and remove/install wires.

b. Remove/install hardware (1–30, 1–31,1– 1–32, 1–33, Figure 7–95) which secures panel (1–108) with gasket (1–109) to the case weldment (1–2). Torque hardware to 30–35 in. lbs.



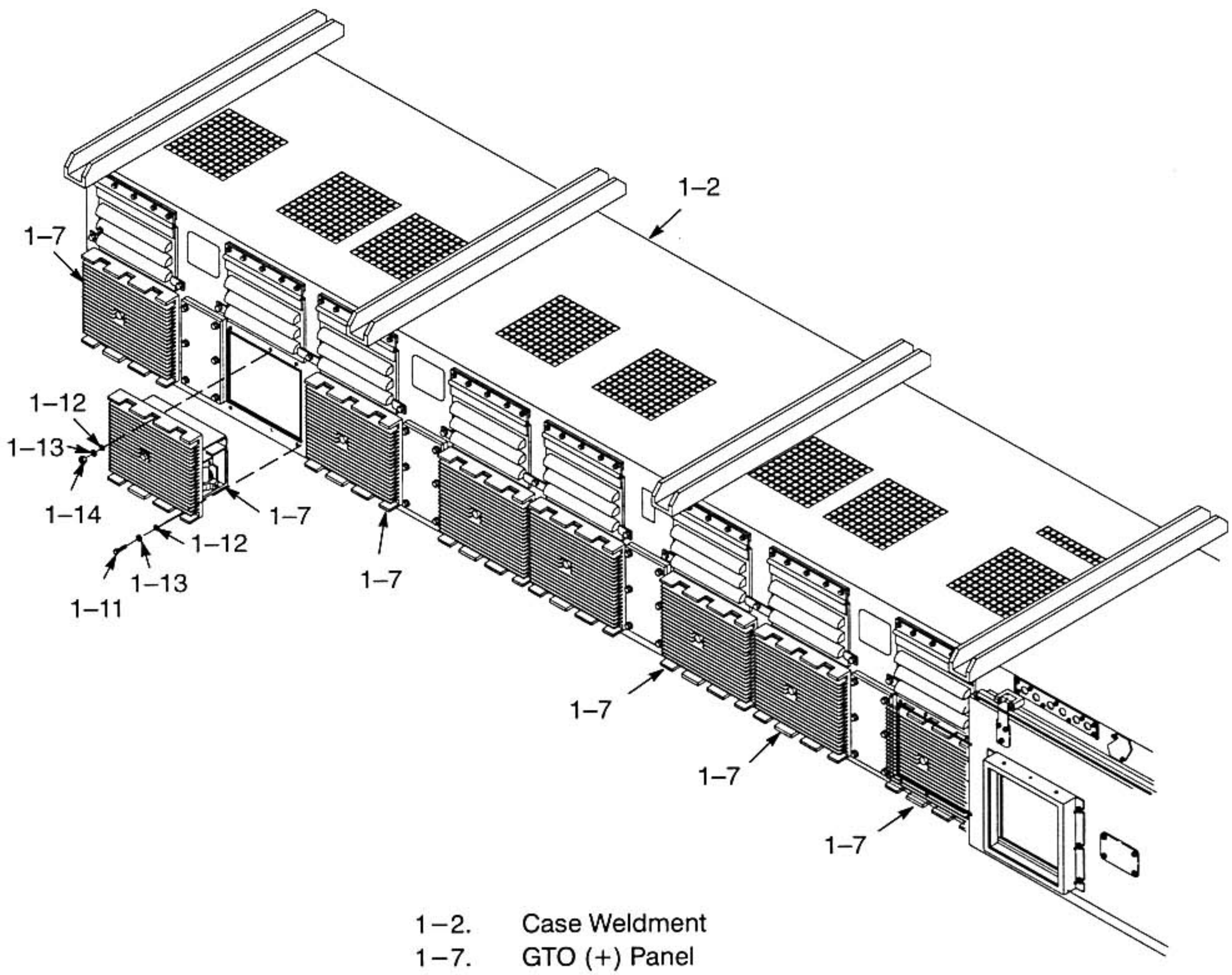
1–2. Case Weldment
1–30. Locknut
1–31. Washer
1–32. Lockwasher
1–33. Bolt
1–108. GDPS Panel

Figure 7–95 Remove/Install Gate Drive Power Supply

7–7.5.5 Remove/install panel 17FM590B1, GTO (+) Phase Module (+).

a. Tag and remove/install wires.

b. Remove/install hardware (1–11, 1–12, 1–13, 1–14, Figure 7–96) which secures panel (1–7) to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



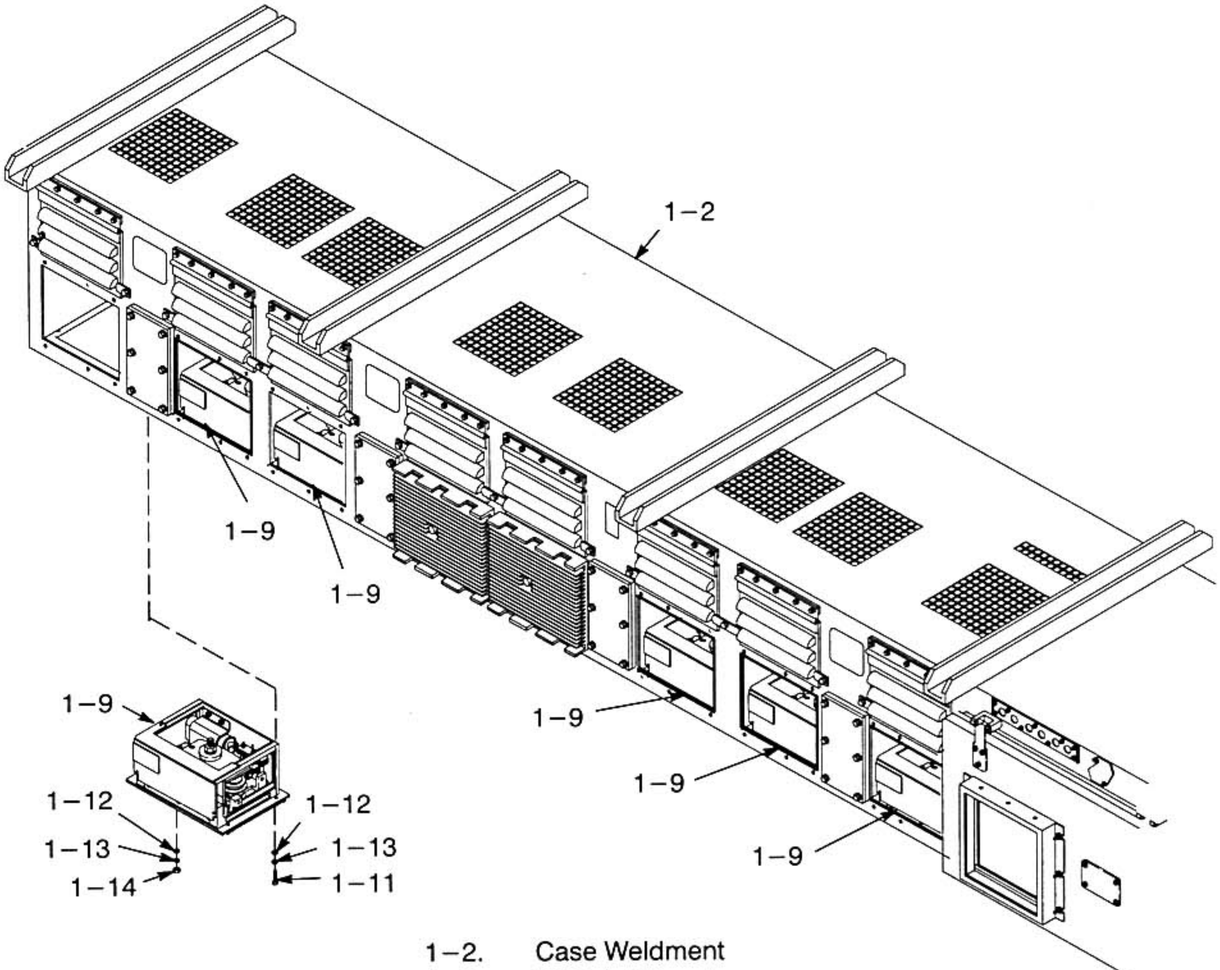
1–2. Case Weldment
1–7. GTO (+) Panel
1–11. Bolt
1–12. Washer
1–13. Lockwasher
1–14. Brass Nut

Figure 7–96 Remove/Install GTO (+) Phase Module

7–7.5.6 Remove/install panel 17FM591B1, GTO (–) Phase Module (PM–).

a. Tag and remove/install wires.

b. Remove/install hardware (1–11, 1–12, 1–13, 1–14, Figure 7–97) which secures panel (1–9) to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



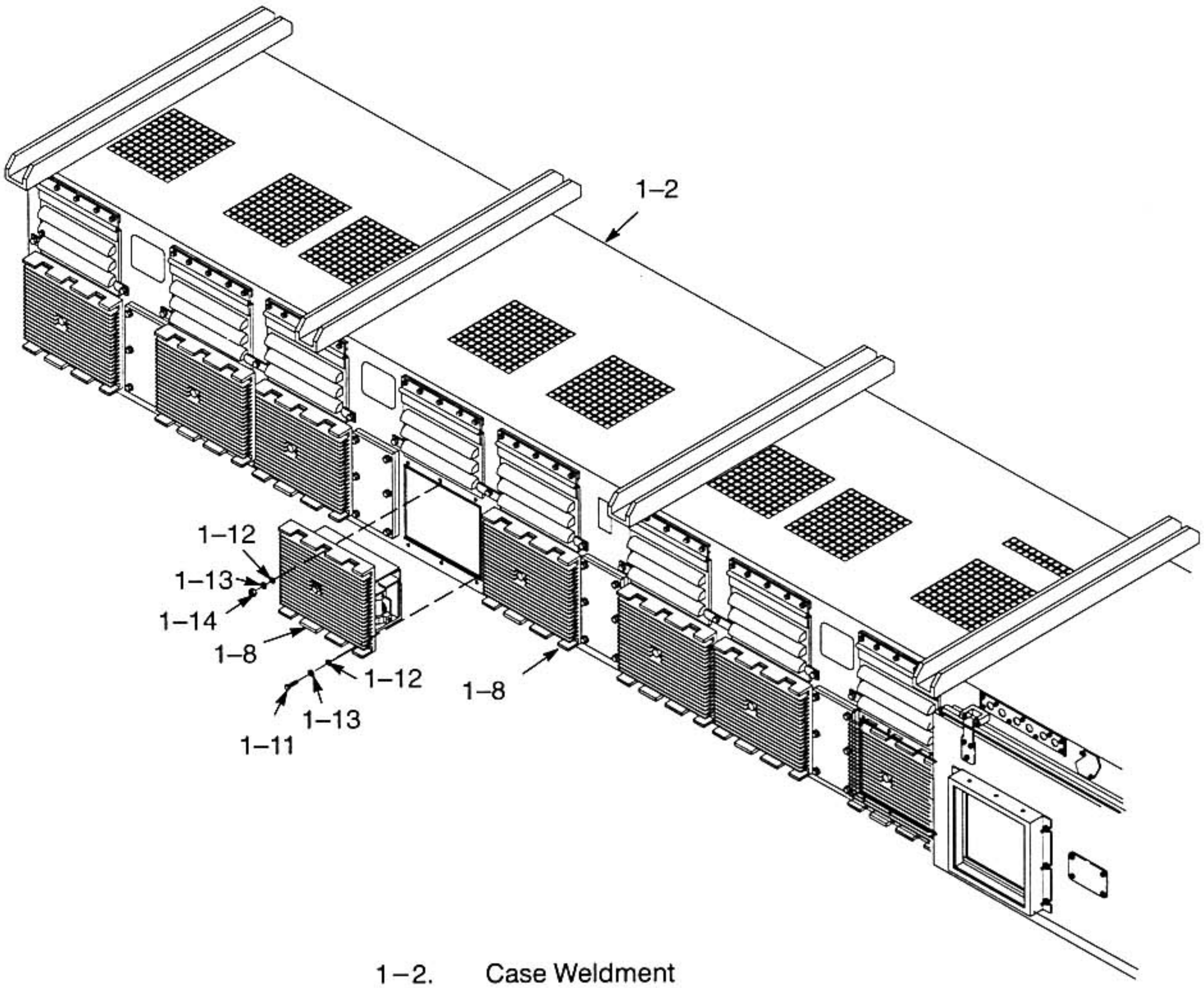
1–2. Case Weldment
1–7. GTO (–) Panel
1–9. Panel
1–11. Bolt
1–12. Washer
1–13. Lockwasher

Figure 7–97 Remove/Install GTO (–) Phase Module

7–7.5.7 Remove/install panel 17FM592A1, Motoring Diode Module (MD).

a. Tag and remove/install wires.

b. Remove/install hardware (1–11, 1–12, 1–13, 1–14, Figure 7–98) which secures panel (1–8) to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



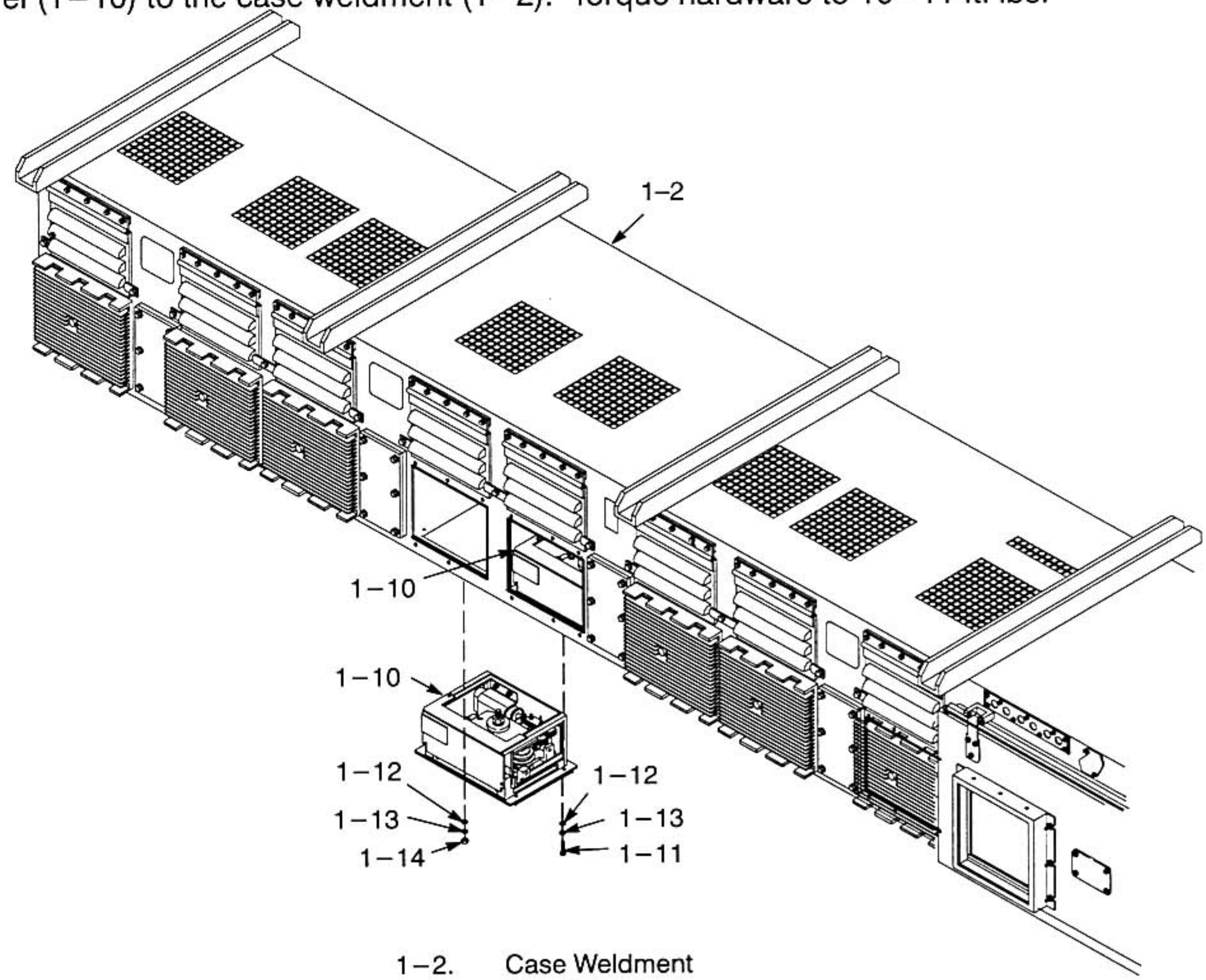
1–2. Case Weldment
1–8. MD Panel
1–11. Bolt
1–12. Washer
1–13. Lockwasher
1–14. Brass Nut

Figure 7–98 Remove/Install Motoring Diode Module

7–7.5.8 Remove/install panel 17FM668A1, Chopper Module (CM).

a. Tag and remove/install wires.

b. Remove/install hardware (1–11, 1–12, 1–13, 1–14, Figure 7–99) which secures panel (1–10) to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



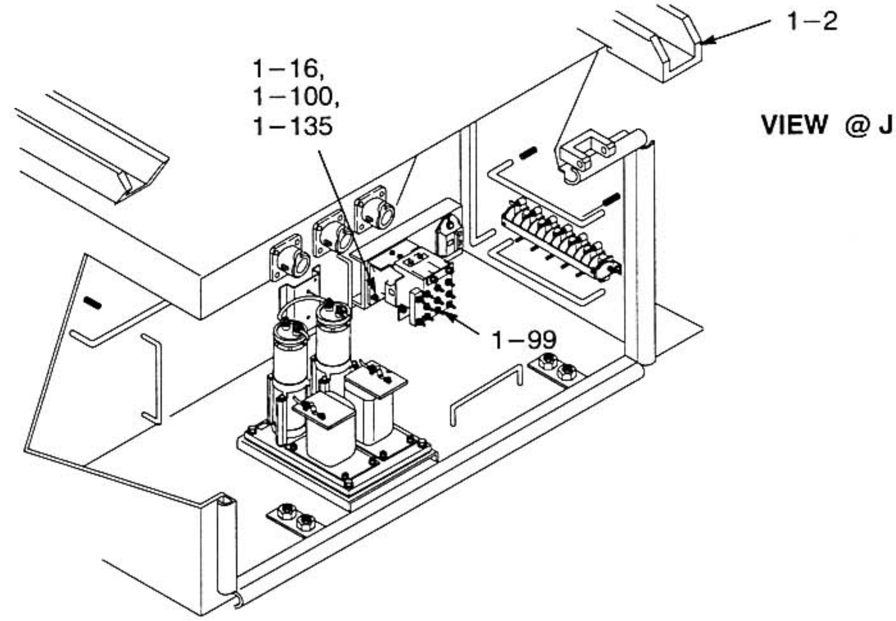
1–2. Case Weldment
1–10. CM Panel
1–11. Bolt
1–12. Washer
1–13. Lockwasher
1–14. Brass Nut

Figure 7–99 Remove/Install Chopper Module

7–7.5.9 Remove/Install Relay 17LV66AV1.

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–100, 1–135, Figure 7–100) which secures relay (1–99) to the case weldment (1–2). Torque hardware to 30–35 in. lbs.



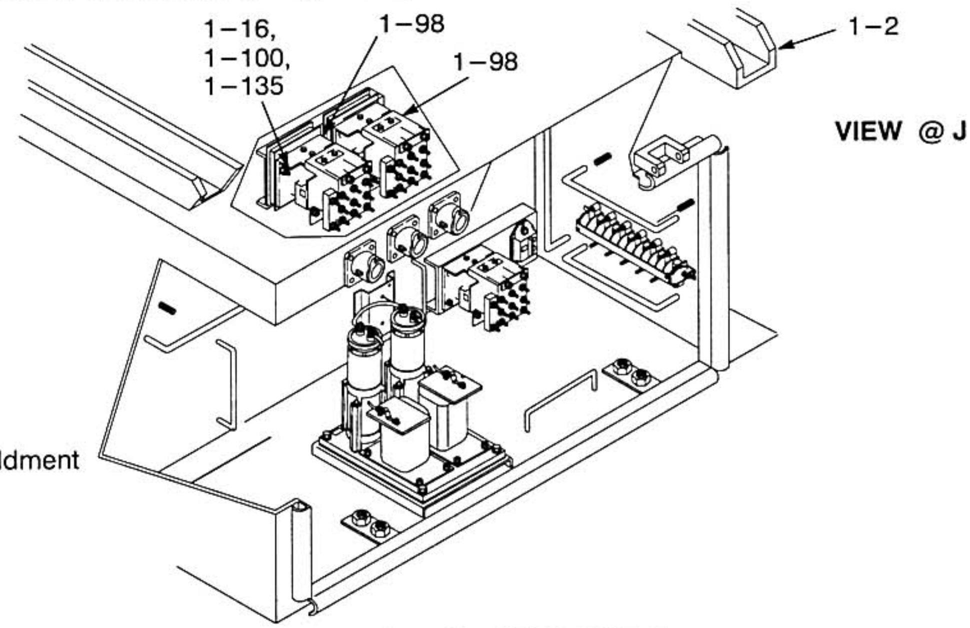
1–2. Case Weldment
1–16. Locknut
1–99. Relay
1–100. Bolt
1–135. Washer

Figure 7–100 Remove/Install 17LV66AV1 Relay

c. Remove/install Relay 17LV66EB1, Inverter Discharge Relay (FDC1, 2).

(1) Tag and remove/install wires.

(2) Remove/install hardware (1–16, 1–100, 1–135, Figure 7–101) which secures relay (1–98) to the case weldment (1–2). Torque hardware to 30–35 in. lbs.



1–2. Case Weldment
1–16. Locknut
1–98. Relay
1–100. Bolt
1–135. Washer

Figure 7–101 Remove/Install 17LV66EB1 Relay

7–7.6 ADJUSTMENT/TEST

a. Connect a system simulator and attach a PTU.

b. Power up the simulator and do diagnostic testing using the PTU.

c. Monitor the event display panel and refer to section 7–2.5 for Event Determination.

d. Inverter self tests

(1) Low voltage, chopper, and high voltage self tests shall be applied upon application of power after Shutdown mode. The entire test sequence shall be re–run (after auto–reset) if any section of the tests fail.

(2) If the inverter requests a self test after detection of a running event, the system controller will run that test as well as the chopper self test.

(3) To minimize test duration, both choppers shall be tested simultaneously. If that test should fail, they shall be tested sequentially for fault isolation purposes.

7–7.7 INSPECTION/CHECK

7–7.7.1 Inspect Group Exterior

a. Inspect case weldment and covers for bends, cracks, or obvious physical damage. If found repair or replace as required.

b. Inspect for loose or missing warning placards. Replace as required.

c. Inspect gaskets and O–rings for moisture leakage. If found replace as required.

7–7.7.2 Inspect Group Interior

a. Inspect group components for cracks, breaks, burns, or any other obvious physical damage. If foun, report to supervision.

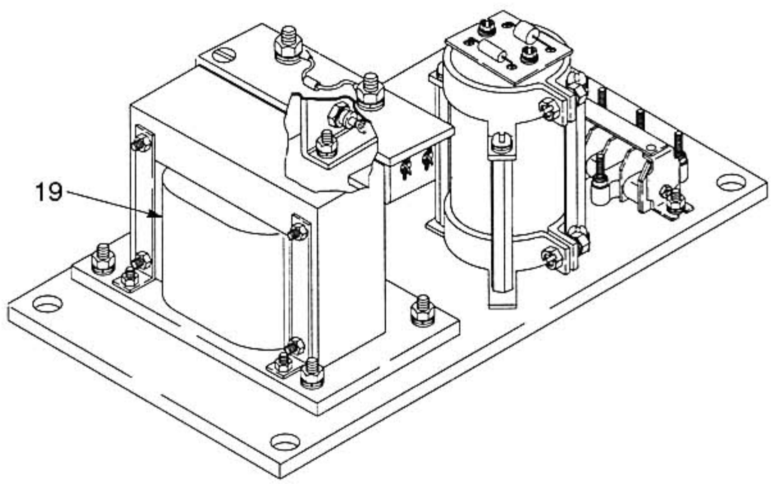
b. Inspect wires for breaks, frays, or loose terminals. If found repair or replace as required.

7–7.7.2.1 Inspect panel – 17FM311M1, Battery Line Filter (BLF).

a. Inspect reactor (19, Figure 7–102) for swollen coil, severe discoloration, signs of overheating or any obvious physical damage. If found replace reactor.

b. Inspect all other parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage. If found replace as required.

c. Inspect soldered leads. If loose or broken repair or replace as required.



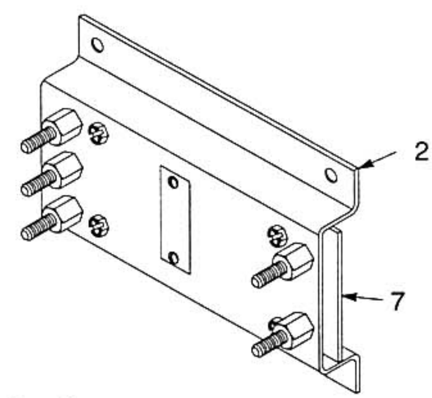
19. Reactor

Figure 7–102 Inspect Panel (BLF)

7–7.7.2.2 Inspect Voltage Attenuation Module 17FM559A1.

a. Inspect base (2, Figure 7–103) for signs of obvious damage, such as cracks or chips. Replace if damaged.

b. Inspect module (7) for burns, cracks, breaks, or obvious physical damage. If found replace module.



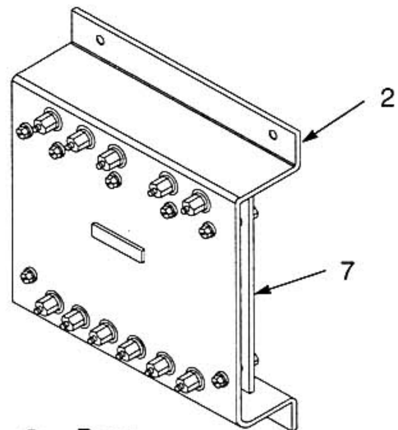
2. Base
7. Module

Figure 7–103 Inspect Voltage Attenuation Module 17FM559A1

7–7.7.2.3 Inspect Voltage Attenuation Module 17FM560A1.

a. Inspect base (2, Figure 7–104) for signs of obvious damage, such as cracks or chips. Replace if damaged.

b. Inspect module (7) for burns, cracks, breaks, or obvious physical damage. If found replace module.



2. Base
7. Module

Figure 7–104 Inspect Voltage Attenuation Module 17FM560A1

7–7.7.2.4 Inspect panel 17FM589A3, Gate Drive Power Supply (GDPS1–2).

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage (reference Figure 7–105). If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

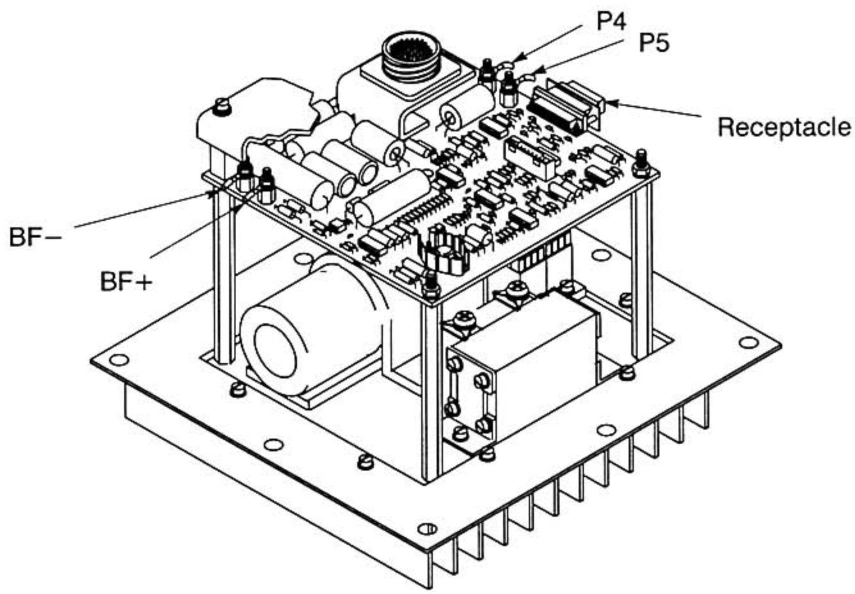


Figure 7–105 Inspect Gate Drive Power Supply

7–7.7.2.5 Inspect Panel 17FM590B1, GTO (+) Phase Module (+).

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage (reference Figure 7–106). If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

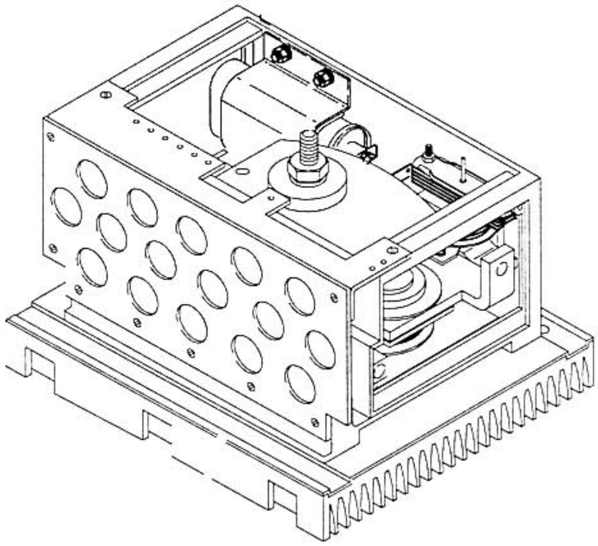


Figure 7–106 Inspect GTO (+) Phase Module

7–7.7.2.6 Inspect Panel 17FM591B1, GTO (–) Phase Module (PM–).

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage (reference Figure 7–107). If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

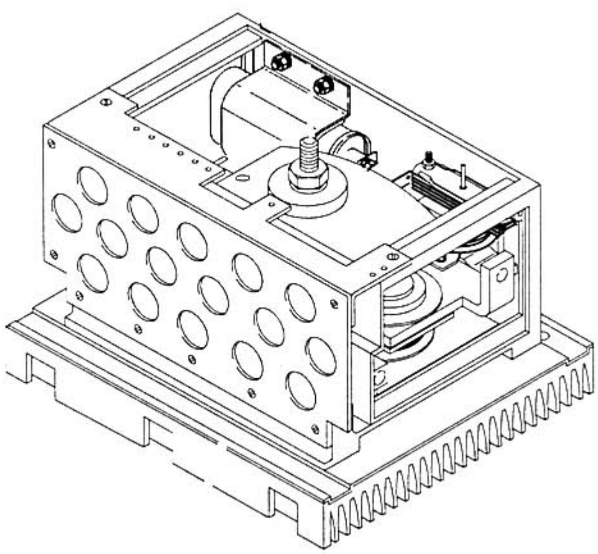


Figure 7–107 Inspect GTO (–) Phase Module

7–7.7.2.7 Inspect Panel 17FM592A1, Motoring Diode Module (MD).

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage (reference Figure 7–108. If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

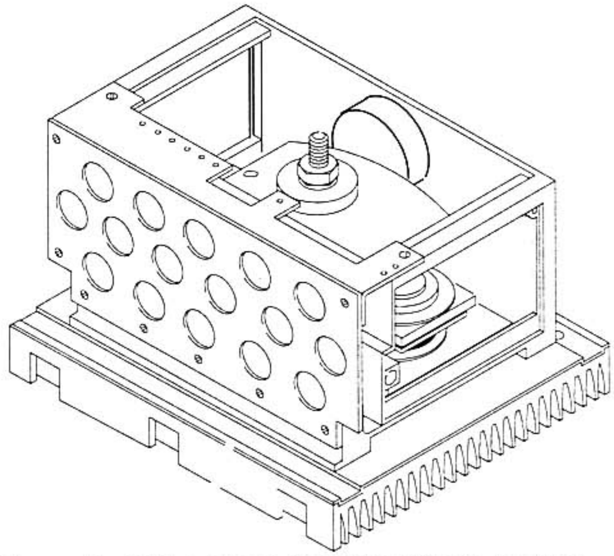


Figure 7–108 Inspect Motoring Diode Module

7–7.7.2.8 Inspect panel 17FM668A1, Chopper Module (CM).

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage (reference Figure 7–109). If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

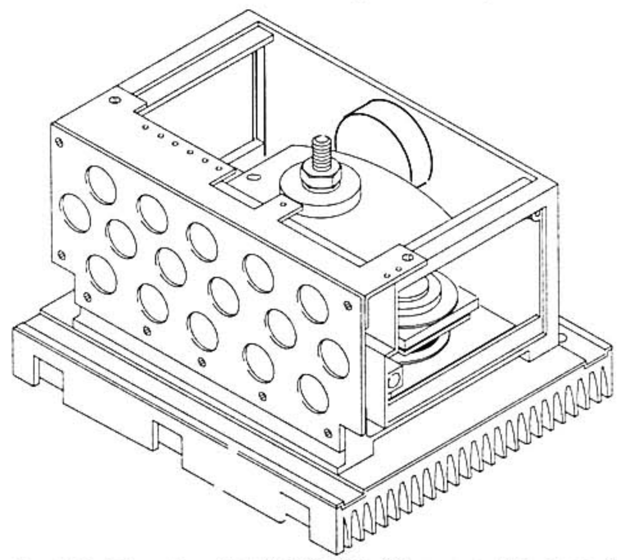


Figure 7–109 Panel – 17FM668A1, Chopper Module (CM)

7–7.7.2.9 Inspect Relay 17LV66AV1.

a. Inspect relay (reference Figure 7–110) for obvious physical damage such as broken or missing parts. If found, replace relay.

b. Inspect relay fingers and contacts. If burned or silver plating is worn thru, replace relay. If spherical finger or contact wear flat exceeds 7/32 in., replace relay.

c. Inspect finger shunts. If frayed broken, or discolored, replace relay.

d. Inspect operating coil. If scorched, cracked, or swollen, replace relay.

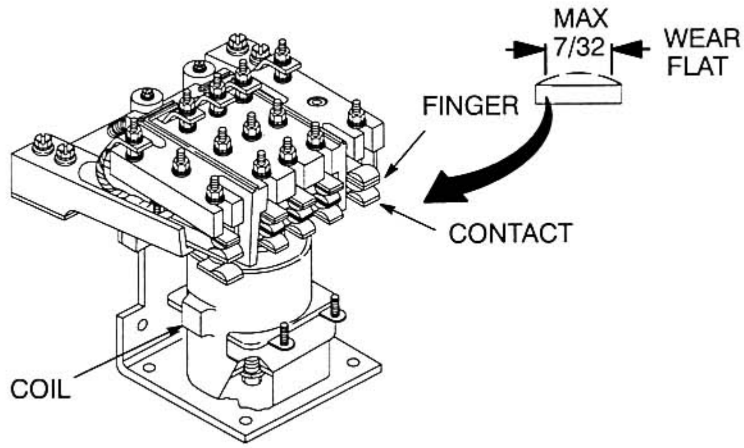


Figure 7–110 Inspect Relay – 17LV66AV1

7–7.7.2.10 Inspect Relay 17LV66EB1, Inverter Discharge Relay (FDC1, 2).

a. Inspect relay (reference Figure 7–111) for obvious physical damage such as broken or missing parts. If found, replace relay.

b. Inspect relay fingers and contacts. If burned or silver plating is worn thru, replace relay. If spherical finger or contact wear flat exceeds 7/32 in., replace relay.

c. Inspect finger shunts. If frayed broken, or discolored, replace relay.

d. Inspect operating coil. If scorched, cracked, or swollen, replace relay.

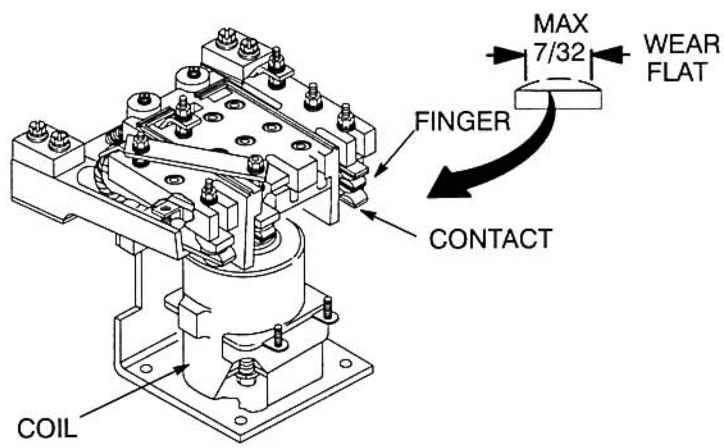


Figure 7–111 Inspect Relay – 17LV66EB1

7–7.8 CLEANING/PAINTING

a. Using a sash brush and/or clean wiping rag remove any loose debris from the exterior surfaces of the group case weldment.

b. An approved cleaner and wiping rag may be used to remove any stubborn build up.

CAUTION: WHEN DIRT IS ALLOWED TO ACCUMULATE, IT.CAN ABSORB ENOUGH MOISTURE TO FORM A CONDUCTIVE PATH ACROSS IT'S SURFACE AND SHORT OUT ELECTRONIC DEVICES.

c. Using a sash brush and/or clean wiping rag remove loose debris from the internal components of the group.

d. A vacuum may be used to remove stubborn buildup.

7–7.9 PANEL – 17FM311M1, BATTERY LINE FILTER (BLF)

7–7.9.1 DESCRIPTION AND OPERATION

The purpose of the Battery Line Filter is to provide protection against the transients in the battery supply. It also serves as a filter ripple which is present in systems where the battery is not normally "on line." This panel is located in the Main Inverter Group, has an overall size of approximately 10 in. x 6.5 in. x 5.5 in., and weighs about 11.5 lb.

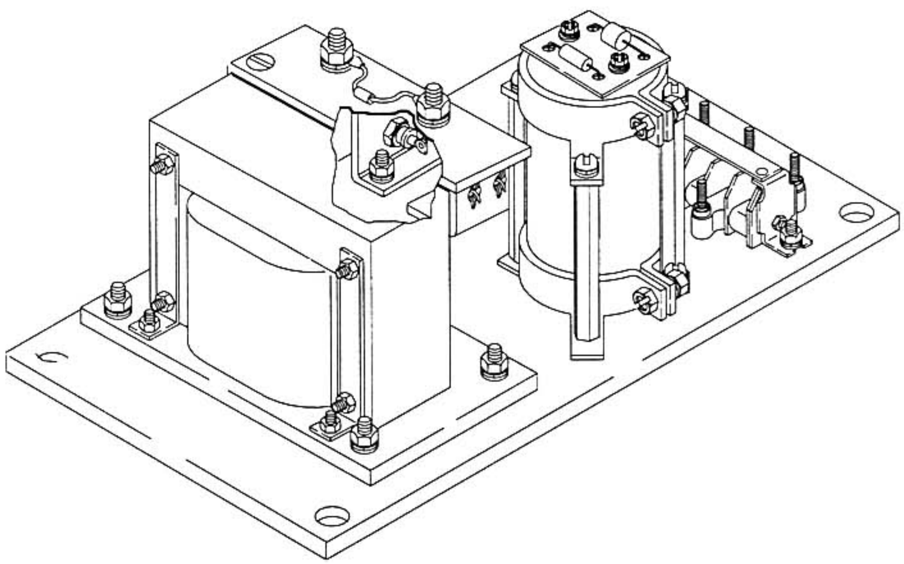


Figure 7–112 Panel – 17FM311M1, Battery Line Filter (BLF)

7–7.9.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.9.3 MAINTENANCE PRACTICES

Not applicable.

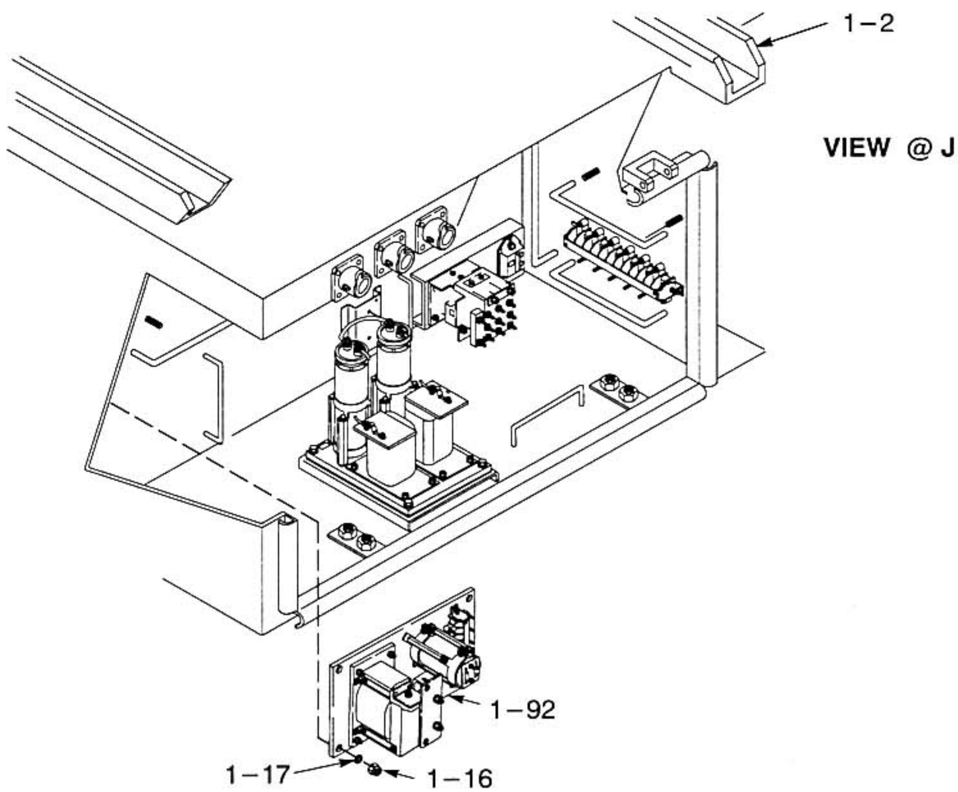
7–7.9.4 SERVICING

Not applicable.

7–7.9.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–17, Figure 7–113) which secures panel (1–92) to the case weldment (1–2). Torque hardware to 30–35 in. lbs.



1–2. Case Weldment
1–16. Locknut
1–17. Washer
1–92. Panel

Figure 7–113 Remove/Install Battery Line Filter Panel

7–7.9.6 ADJUSTMENT/TEST

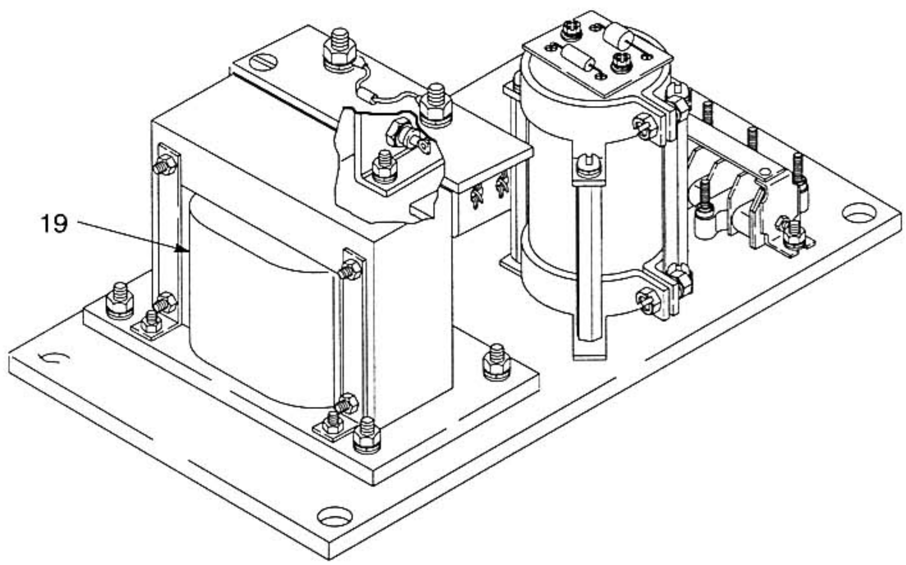
Refer to section 7–7.6.

7–7.9.7 INSPECTION/CHECK

a. Inspect reactor (19, Figure 7–114) for swollen coil, severe discoloration, signs of overheating or any obvious physical damage. If found replace reactor.

b. Inspect all other parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage. If found replace as required.

c. Inspect soldered leads. If loose or broken repair or replace as required.



19. Reactor

Figure 7–114 Inspect Panel (BLF)

7–7.9.8 CLEANING/PAINTING

Remove any loose debris from panel using a sash brush and/or clean wiping rag.

7–7.10 VOLTAGE ATTENUATION MODULE 17FM559A1

7–7.10.1 DESCRIPTION AND OPERATION

The Voltage Attenuation Module 17FM559A1 (Figure 7–115) is a 2MΩ resistor divider type panel with two measuring channels that measures voltage. VAM1 is located in the Rail Gap Group (17KG515A1) and provides measurements of the third rail voltage and the snubber bleed diode voltage. VAM4 is located in the Main Inverter Group (17KG497A1) and provides measurements of the line filter voltage and the ground return voltage reference. VAM5 is located in the Line Breaker Group (17KG510A1) and provides measurements of the line breaker input voltage.

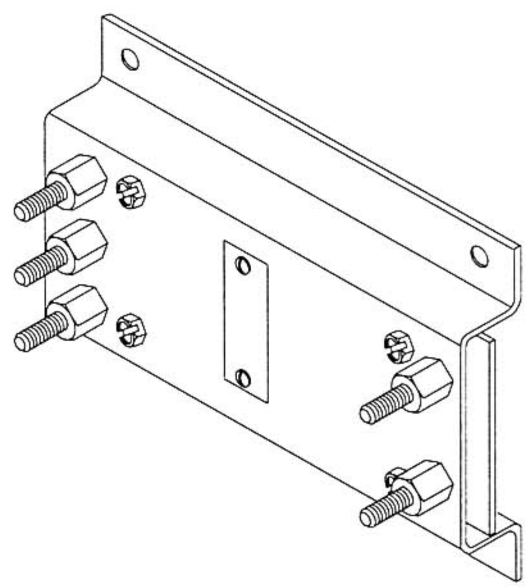


Figure 7–115 Voltage Attenuation Module (17FM559A1)

7–7.10.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.10.3 MAINTENANCE PRACTICES

Not applicable.

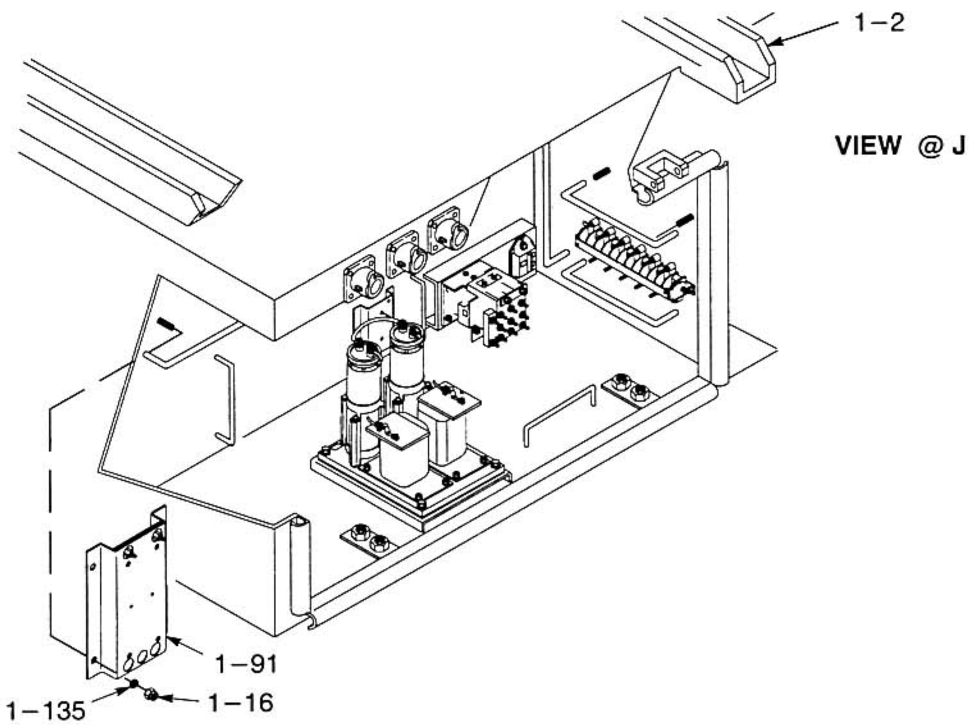
7–7.10.4 SERVICING

Not applicable.

7–7.10.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–135, Figure 7–116) which secures module (1–91) to the case weldment (1–2). Torque hardware to 74–83 in. lbs.



1–2. Case Weldment
1–16. Locknut
1–91. Panel
1–135. Washer

Figure 7–116 Remove/Install Voltage Attenuation Module (17FM559A1)

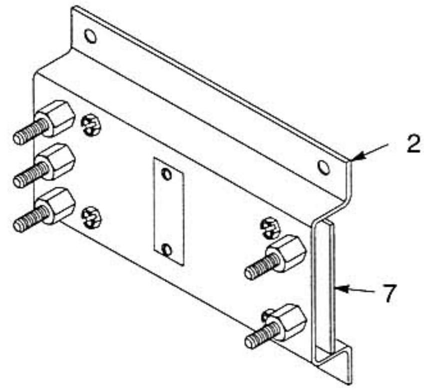
7–7.10.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.10.7 INSPECTION/CHECK

a. Inspect base (2, Figure 7–117) for signs of obvious damage, such as cracks or chips. Replace if damaged.

b. Inspect module (7) for burns, cracks, breaks, or obvious physical damage. If found replace module.



2. Base
7. Module

Figure 7–117 Inspect Voltage Attenuation Module (17FM559A1)

7–7.10.8 CLEANING/PAINTING

Remove any loose debris from module using a sash brush and/or clean wiping rag.

7–7.11 VOLTAGE ATTENUATION MODULE 17FM560A1

7–7.11.1 DESCRIPTION AND OPERATION

The 17FM560A1 Voltage Attenuation Module (FIGURE 7–118) is a 2MΩ resistor divider type panel with five measuring channels that measures voltage. VAM2 is located in the Main Inverter Group (17KG497A1) and provides measurements of the inverter #1 DC bus voltage and motor phase voltages. VAM3 is also located in the Main Inverter Group and provides measurements of the inverter #2 DC bus voltage and motor phase voltages. .

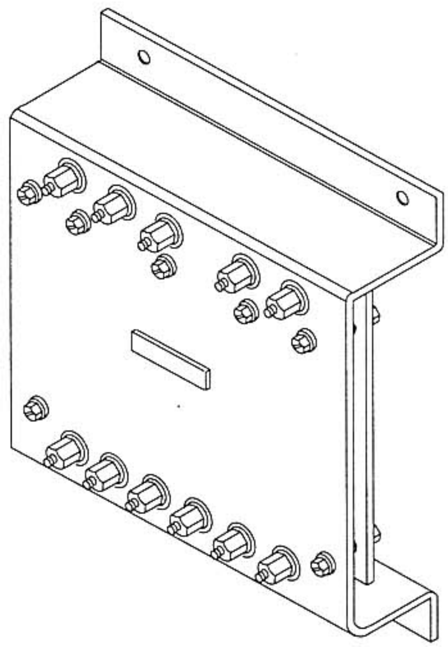


Figure 7–118 Voltage Attenuation Module (17FM560A1)

7–7.11.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.11.3 MAINTENANCE PRACTICES

Not applicable.

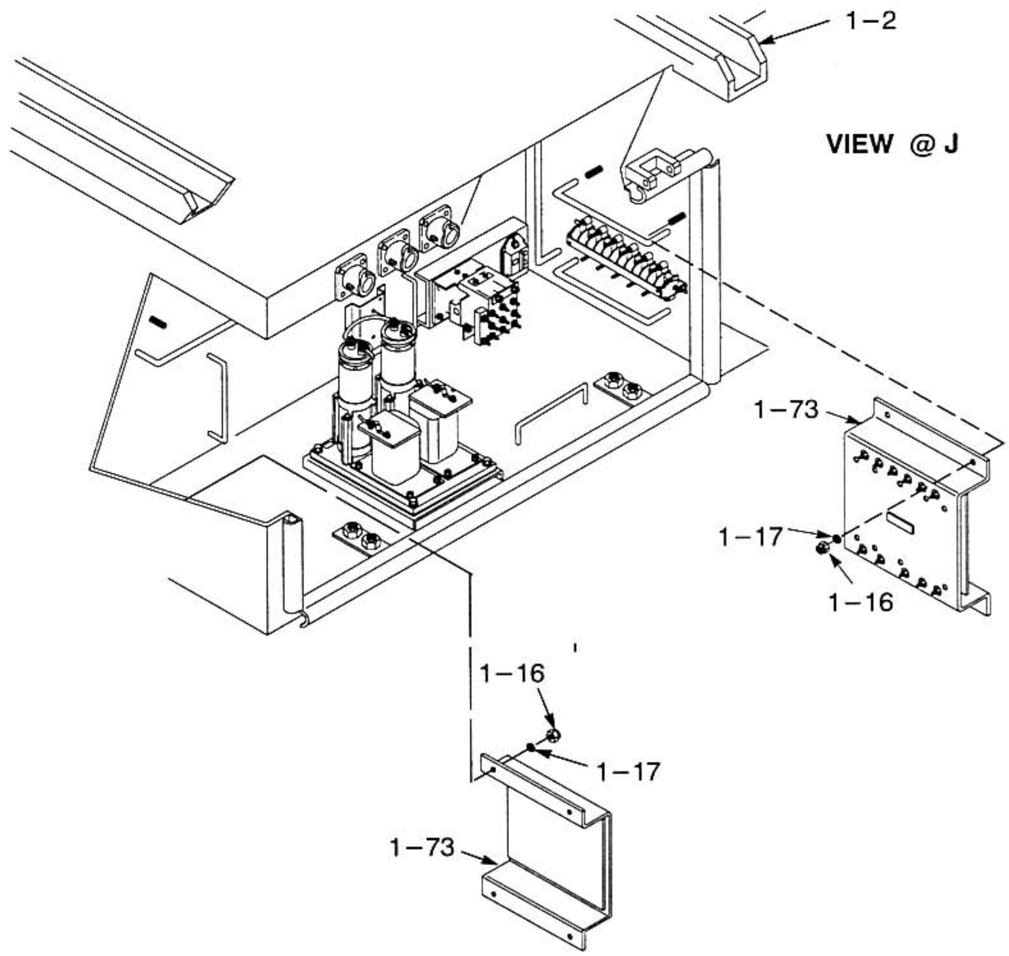
7–7.11.4 SERVICING

Not applicable.

7–7.11.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–17, Figure 7–119) which secures module (1–73) to the case weldment (1–2). Torque hardware to 74–83 in. lbs.



1–2. Case Weldment
1–16. Locknut
1–17. Washer
1–73. VAM

Figure 7–119 Remove/Install Voltage Attenuation Module (17FM560A1)

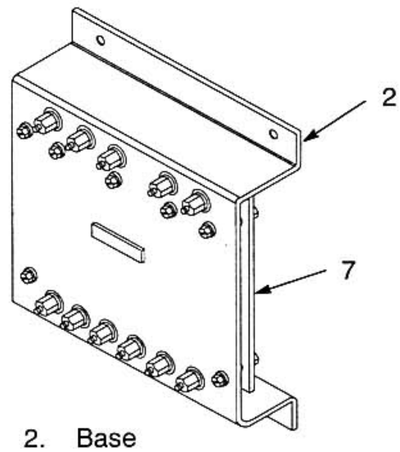
7–7.11.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.11.7 INSPECTION/CHECK

a. Inspect base (2, Figure 7–117) for signs of obvious damage, such as cracks or chips. Replace if damaged.

b. Inspect module (7) for burns, cracks, breaks, or obvious physical damage. If found replace module.



2. Base
7. Module

Figure 7–120 Inspect Voltage Attenuation Module (17FM560A1)

7–7.11.8 CLEANING/PAINTING

Remove any loose debris from module using a sash brush and/or clean wiping rag.

7–7.12 PANEL – 17FM589A3, GATE DRIVE POWER SUPPLY (GDPS1, 2)

7–7.12.1 DESCRIPTION AND OPERATION

The Gate Drive Power Supply (GDPS1, 2) (Figure 7–121) provides energy to operate up to eight gate drivers for the gate turn–off thyristors (GTO) phase panels. Eight separate (transformer coupled) outputs provide this energy to the gate drive portion of the 3000 Amp GTO's. The gate drive portion of the GTO phase panels consists of printed wiring boards, 17FM588. The GDPS provides operating voltage to the gate drivers, and the CPU (main propulsion computer) provides the signals to switch the GTO on and off. The GDPS operates with a nominal battery voltage input of 37.5 VDC. This voltage can vary between 23 to 46 VDC before undervoltage/overvoltage protection devices shut down the unit. The output is a 200 ± VAC square wave at 25 ± 2.5 kHz. The power rating is 300 Watts continuous and 800 Watts for ten second (max.) transients.

The GDPS is mounted on a finned heat sink for air cooling. It is mounted in the inverter group and is 10–1/2" square by 8–1/2" high. The unit is light weight and easily carried by a technician.

Major components of the GDPS1, 2 consist of a PWB, an input filter reactor, capacitor, and two types of N–MOFSET power modules.

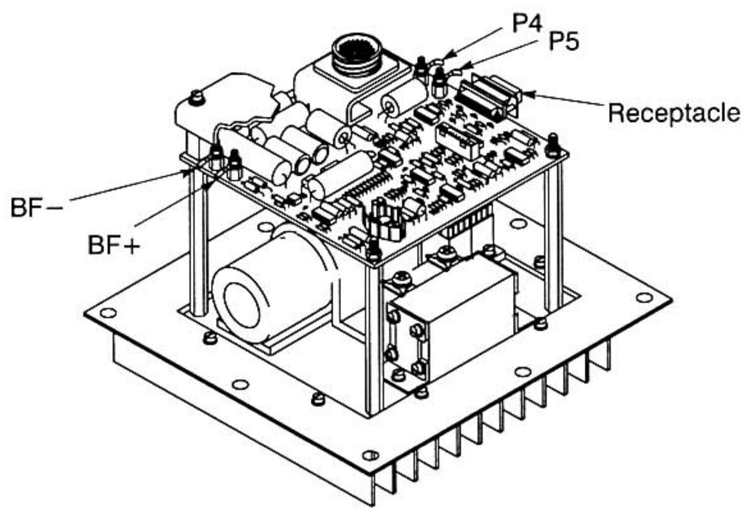


Figure 7–121 Panel – 17FM589A3, Gate Drive Power Supply (GDPS1, 2)

CAUTION: THIS DEVICE HAS ELECTROSTATIC DISCHARGE SENSITIVE COMPONENTS. USE **ESD** PROCEDURES WHEN HANDLING. FAILURE TO COMPLY CAN RESULT IN SERIOUS EQUIPMENT DAMAGE.

7–7.12.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.12.3 MAINTENANCE PRACTICES

Not applicable.

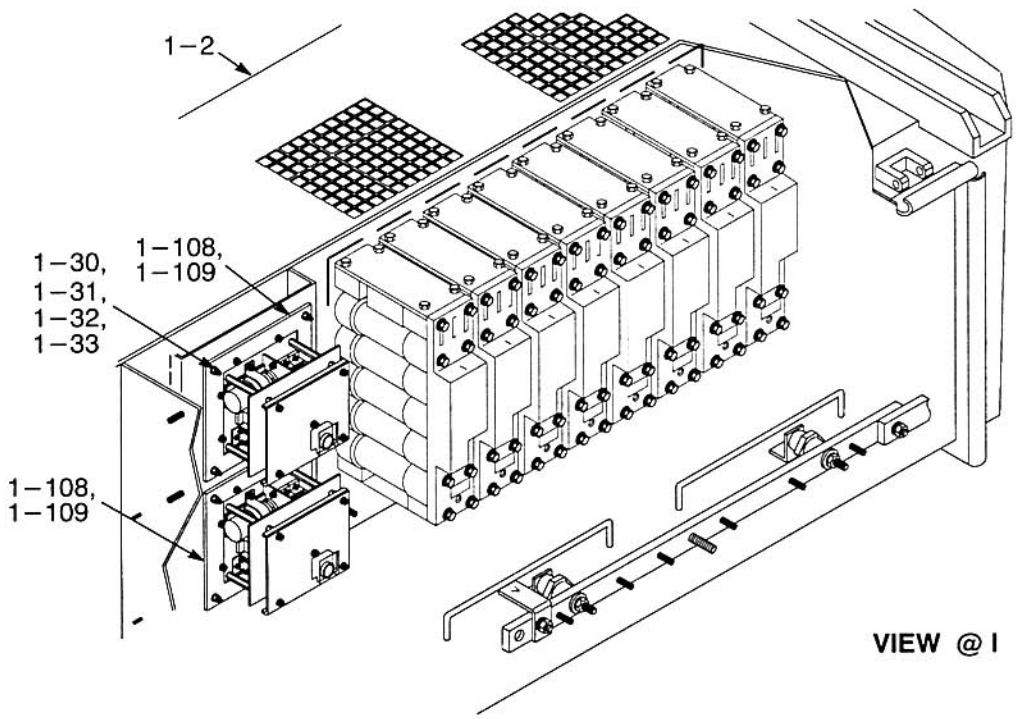
7–7.12.4 SERVICING

Not applicable.

7–7.12.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–30, 1–31,1– 1–32, 1–33, Figure 7–122) which secures panel (1–108) with gasket (1–109) to the case weldment (1–2). Torque hardware to 30–35 in. lbs.



1–2. Case Weldment
1–30. Locknut
1–31. Washer
1–32. Lockwasher
1–33. Bolt
1–108. GDPS Panel
1–109. Gasket

Figure 7–122 Remove/Install Gate Drive Power Supply

7–7.12.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.12.7 INSPECTION/CHECK

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage. If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

7–7.12.8 CLEANING/PAINTING

a. Remove any loose debris from panel using a sash brush and/or clean wiping rag.

> **WARNING:** FOLLOW ALL LOCAL SHOP SAFETY PROCEDURES WHEN USING COMPRESSED AIR. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY.

b. Using compressed air, clean heat sink fins of lodged debris.

7–7.13 PANEL – 17FM590B1, GTO (+) PHASE MODULE (PM+)

7–7.13.1 DESCRIPTION AND OPERATION

The 17FM590B1 Panel is the positive half (switch) of an inverter phase leg and is housed in the Main Inverter Group. It consists of a thyristor, diode, snubber diode, capacitor, thermister, and thyristor gate drive panel (17FM588B1).

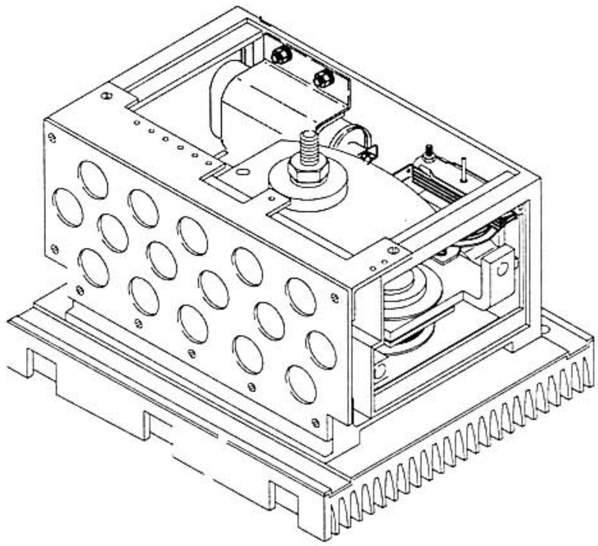


Figure 7–123 Panel – 17FM590B1, GTO (+) Phase Module (PM+)

CAUTION: THIS DEVICE HAS ELECTROSTATIC DISCHARGE SENSITIVE COMPONENTS. USE 'ESD' PROCEDURES WHEN HANDLING. FAILURE TO COMPLY CAN RESULT IN SERIOUS EQUIPMENT DAMAGE.

7–7.13.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.13.3 MAINTENANCE PRACTICES

Not applicable.

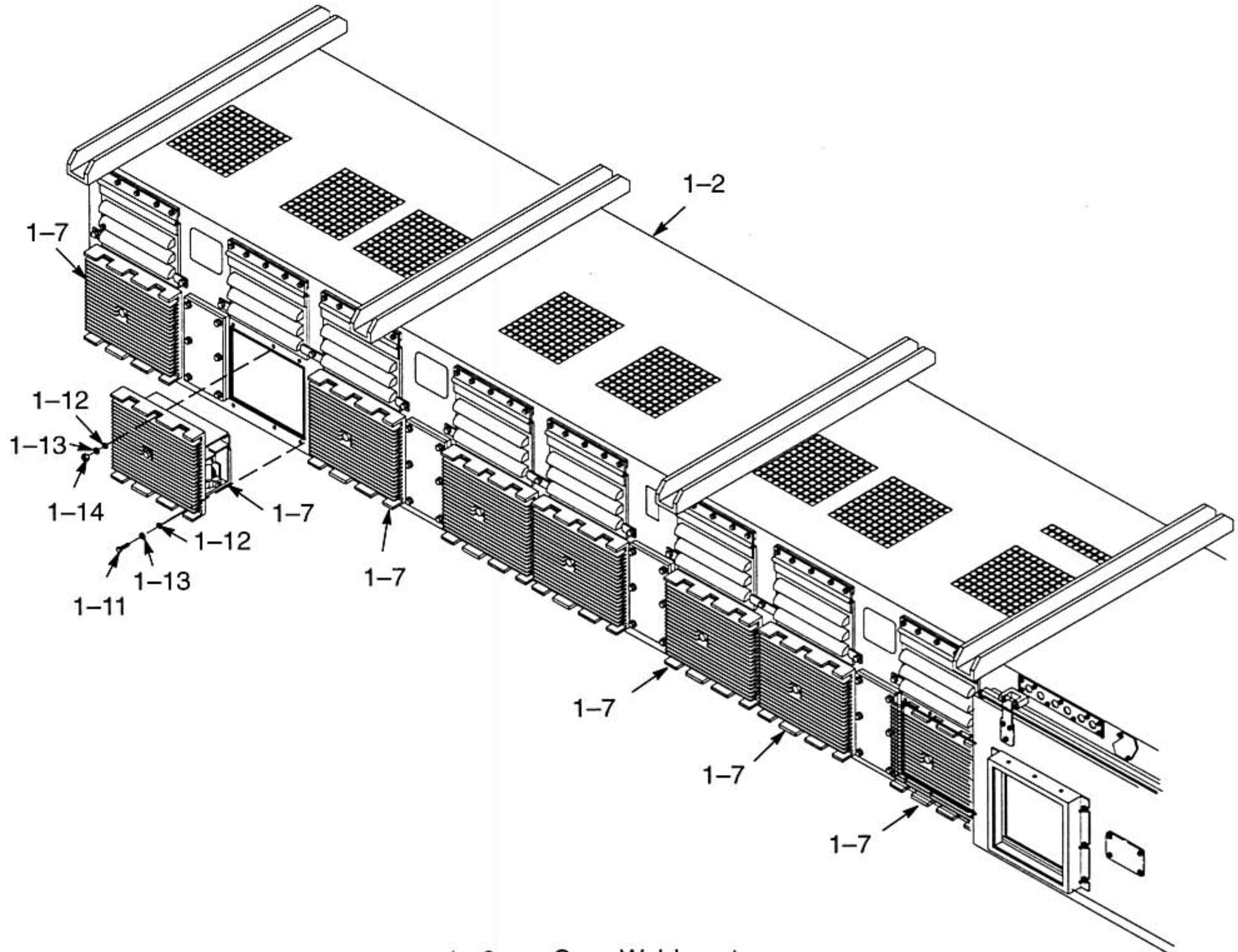
7–7.13.4 SERVICING

Not applicable.

7–7.13.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–11, 1–12, 1–13, 1–14, Figure 7–124) which secures panel (1–7) to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



1–2. Case Weldment
1–7. GTO (+) Panel
1–11. Bolt
1–12. Washer
1–13. Lockwasher
1–14. Brass Nut

Figure 7–124 Remove/Install GTO (+) Phase Module

7–7.13.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.13.7 INSPECTION/CHECK

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage. If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

7–7.13.8 CLEANING/PAINTING

a. Remove any loose debris from panel using a sash brush and/or clean wiping rag.

> **WARNING:** **FOLLOW ALL LOCAL SHOP SAFETY PROCEDURES WHEN USING COMPRESSED AIR. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY.**

b. Using compressed air, clean heat sink fins of lodged debris.

7–7.14 PANEL – 17FM591B1, GTO (–) PHASE MODULE (PM–)

7–7.14.1 DESCRIPTION AND OPERATION

The 17FM591B1 Panel is the negative half (switch) of an inverter phase leg and is housed in the Main Inverter Group. It consists of a thyristor, diode, snubber diode, capacitor, thermister, and thyristor gate drive panel (17FM588B1).

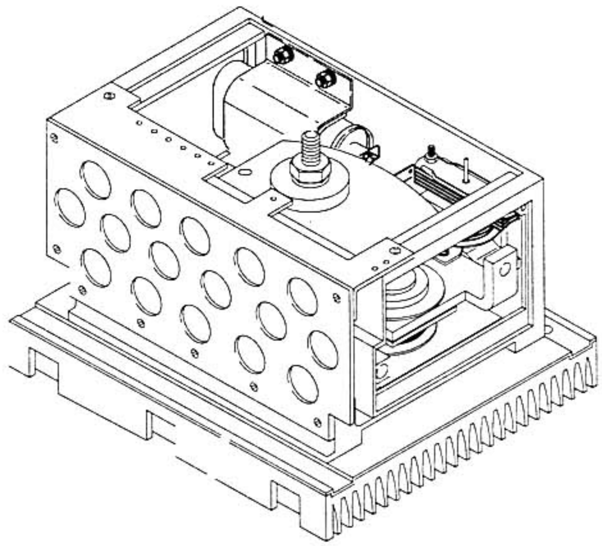


Figure 7–125 Panel – 17FM591B1, GTO (–) Phase Module (PM–)

CAUTION: THIS DEVICE HAS ELECTROSTATIC DISCHARGE SENSITIVE COMPONENTS. USE 'ESD' PROCEDURES WHEN HANDLING. FAILURE TO COMPLY CAN RESULT IN SERIOUS EQUIPMENT DAMAGE.

7–7.14.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.14.3 MAINTENANCE PRACTICES

Not applicable.

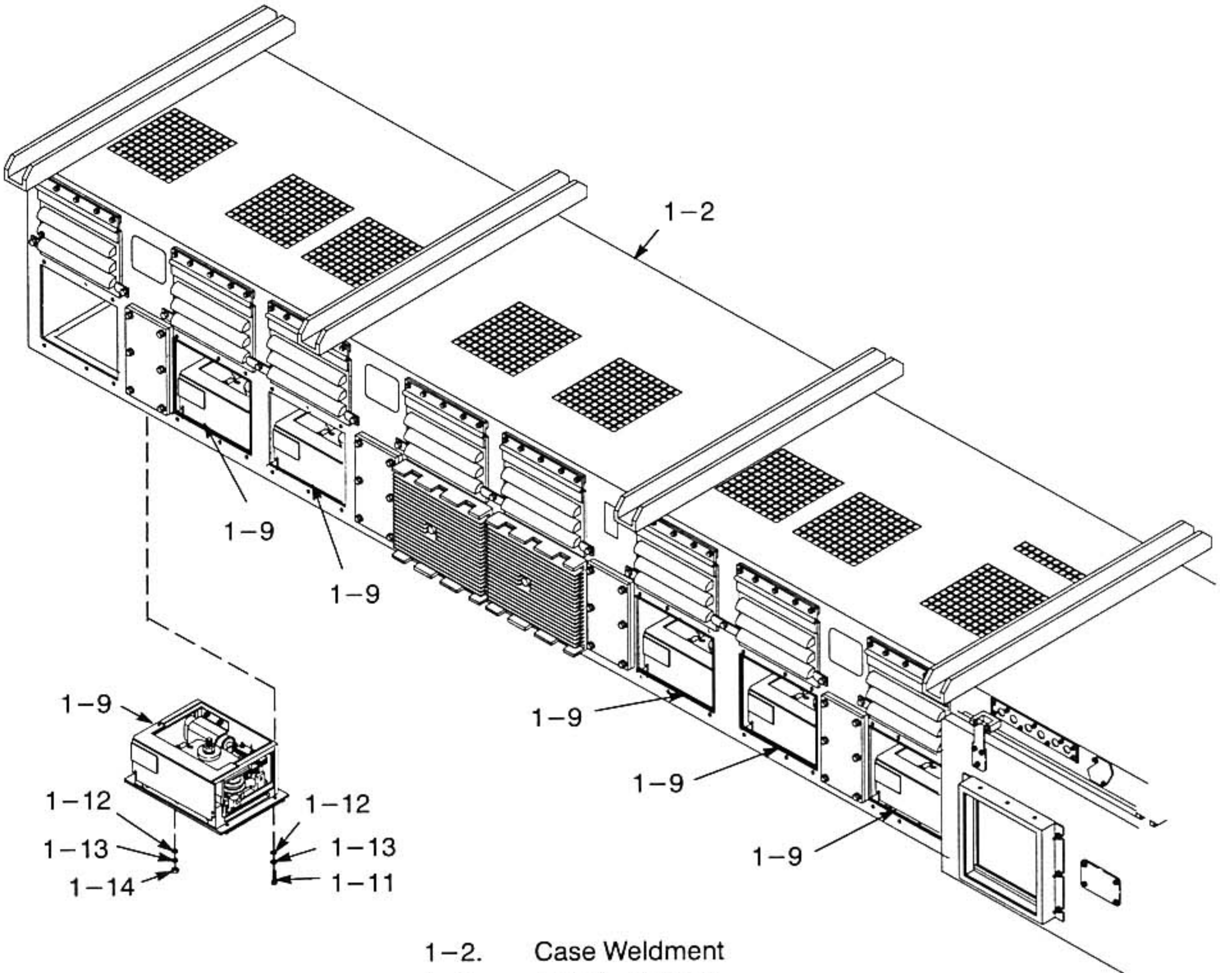
7–7.14.4 SERVICING

Not applicable.

7–7.14.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–11, 1–12, 1–13, 1–14, Figure 7–126) which secures panel (1–9) to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



1–2. Case Weldment
1–9. GTO (–) Panel
1–11. Bolt
1–12. Washer
1–13. Lockwasher

Figure 7–126 Remove/Install GTO (–) Phase Module

7–7.14.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.14.7 INSPECTION/CHECK

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage. If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

7–7.14.8 CLEANING/PAINTING

a. Remove any loose debris from panel using a sash brush and/or clean wiping rag.

> **WARNING:** **FOLLOW ALL LOCAL SHOP SAFETY PROCEDURES WHEN USING COMPRESSED AIR. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY.**

b. Using compressed air, clean heat sink fins of lodged debris.

7–7.15 PANEL – 17FM592A1, MOTORING DIODE MODULE (MD)

7–7.15.1 DESCRIPTION AND OPERATION

The 17FM592A1 Motoring Diode Panel is an integral part of and is housed in the Main Inverter Group. It consists of current diodes, a snubber, capacitor, resistor, heat sink, and associated mounting and electrical hardware.

The Motoring Diode is functionally located between the Chopper Module, Phase Panels, and DC Return. It interfaces the positive and negative phase panels. During Regenerative Braking, it blocks the path for direct current flow to ground, and forces the path thru the current limiting resistors. During Dynamic Braking, the snubber and captive/resistive network retard spiking.

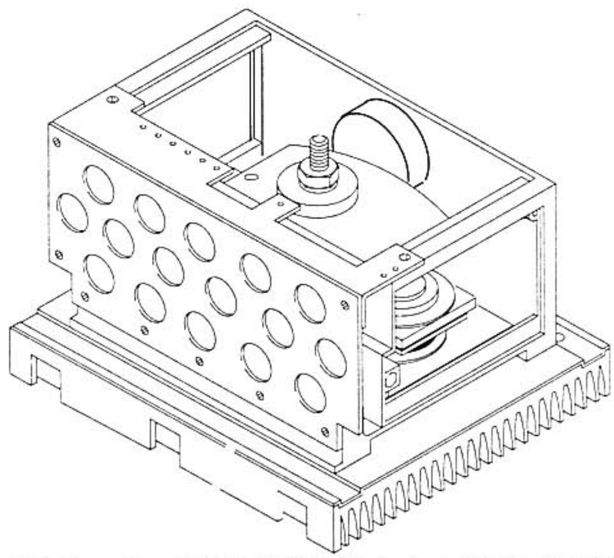


Figure 7–127 Panel – 17FM592A1, Motoring Diode Module (MD)

CAUTION: THIS DEVICE HAS ELECTROSTATIC DISCHARGE SENSITIVE COMPONENTS. USE 'ESD' PROCEDURES WHEN HANDLING. FAILURE TO COMPLY CAN RESULT IN SERIOUS EQUIPMENT DAMAGE.

7–7.15.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.15.3 MAINTENANCE PRACTICES

Not applicable.

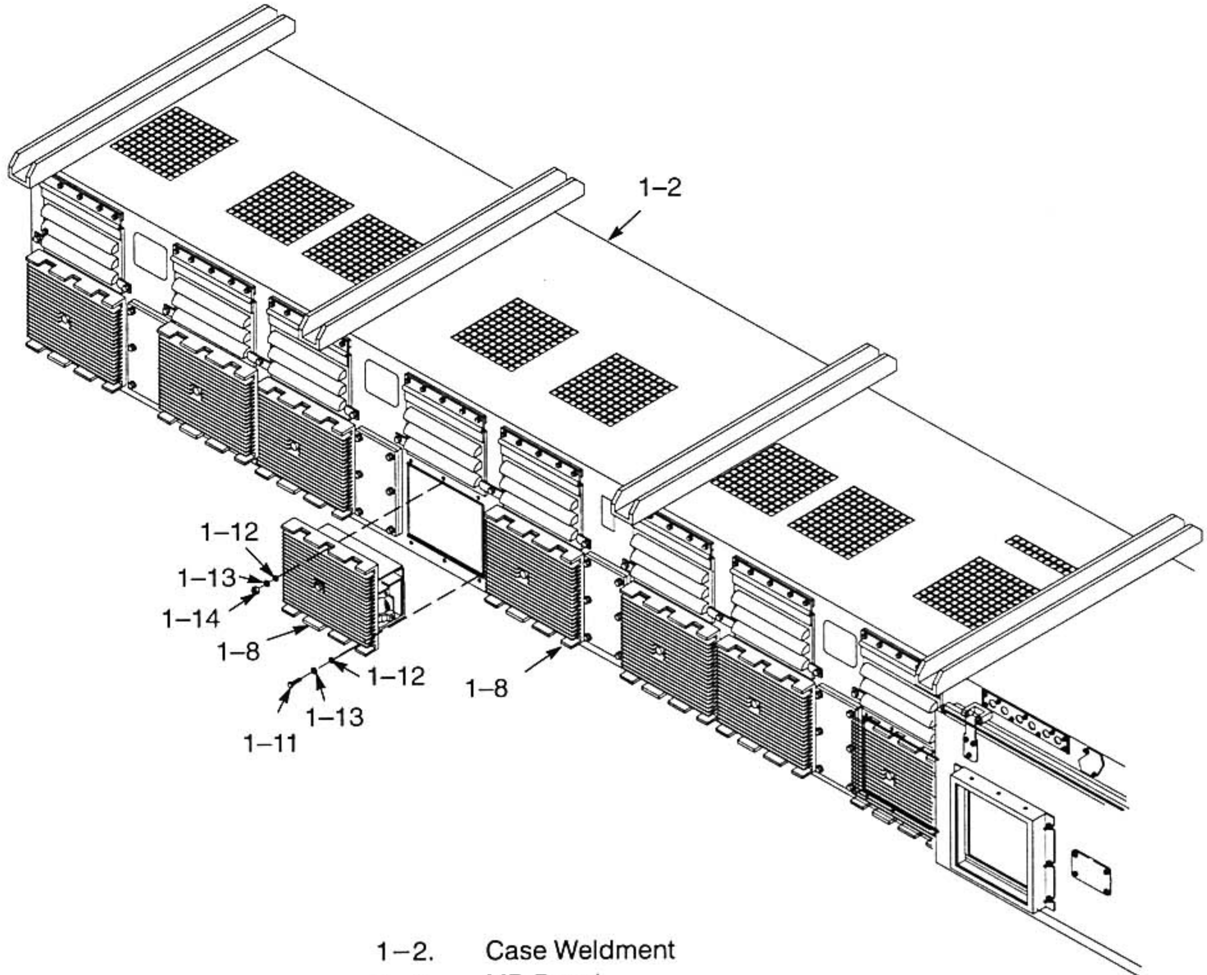
7–7.15.4 SERVICING

Not applicable.

7–7.15.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–11, 1–12, 1–13, 1–14, Figure 7–128) which secures panel (1–8) to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



1–2. Case Weldment
1–8. MD Panel
1–11. Bolt
1–12. Washer
1–13. Lockwasher
1–14. Brass Nut

Figure 7–128 Remove/Install Motoring Diode Module

7–7.15.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.15.7 INSPECTION/CHECK

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage. If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

7–7.15.8 CLEANING/PAINTING

a. Remove any loose debris from panel using a sash brush and/or clean wiping rag.

> **WARNING:** FOLLOW ALL LOCAL SHOP SAFETY PROCEDURES WHEN USING COMPRESSED AIR. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY.

b. Using compressed air, clean heat sink fins of lodged debris.

7–7.16 PANEL – 17FM668A1, CHOPPER MODULE (CM)

7–7.16.1 DESCRIPTION AND OPERATION

The 17FM668A1 Panel is the braking chopper GTO module. This device provides switching across the inverter filters to dissipate energy through the dynamic braking resistor group for dynamic braking and to regulate link voltage. This module is housed in the Main Inverter Group. It consists of a thyristor, diode, snubber diode, capacitor, thermister, and thyristor gate drive panel (17FM588B2).

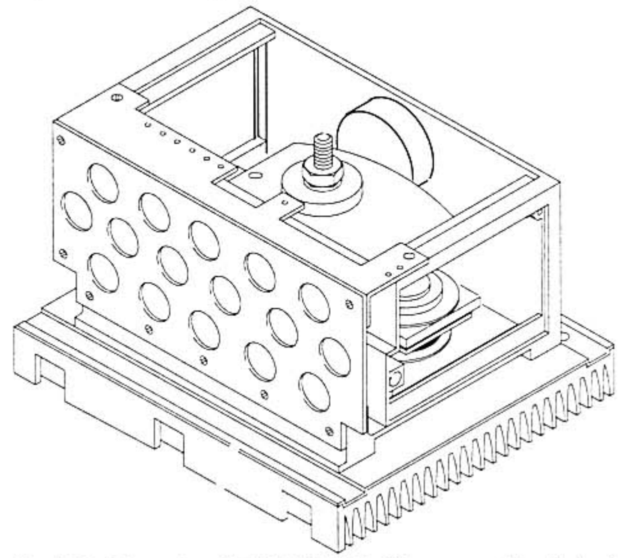


Figure 7–129 Panel – 17FM668A1, Chopper Module (CM)

CAUTION: THIS DEVICE HAS ELECTROSTATIC DISCHARGE SENSITIVE COMPONENTS. USE 'ESD' PROCEDURES WHEN HANDLING. FAILURE TO COMPLY CAN RESULT IN SERIOUS EQUIPMENT DAMAGE.

7–7.16.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.16.3 MAINTENANCE PRACTICES

Not applicable.

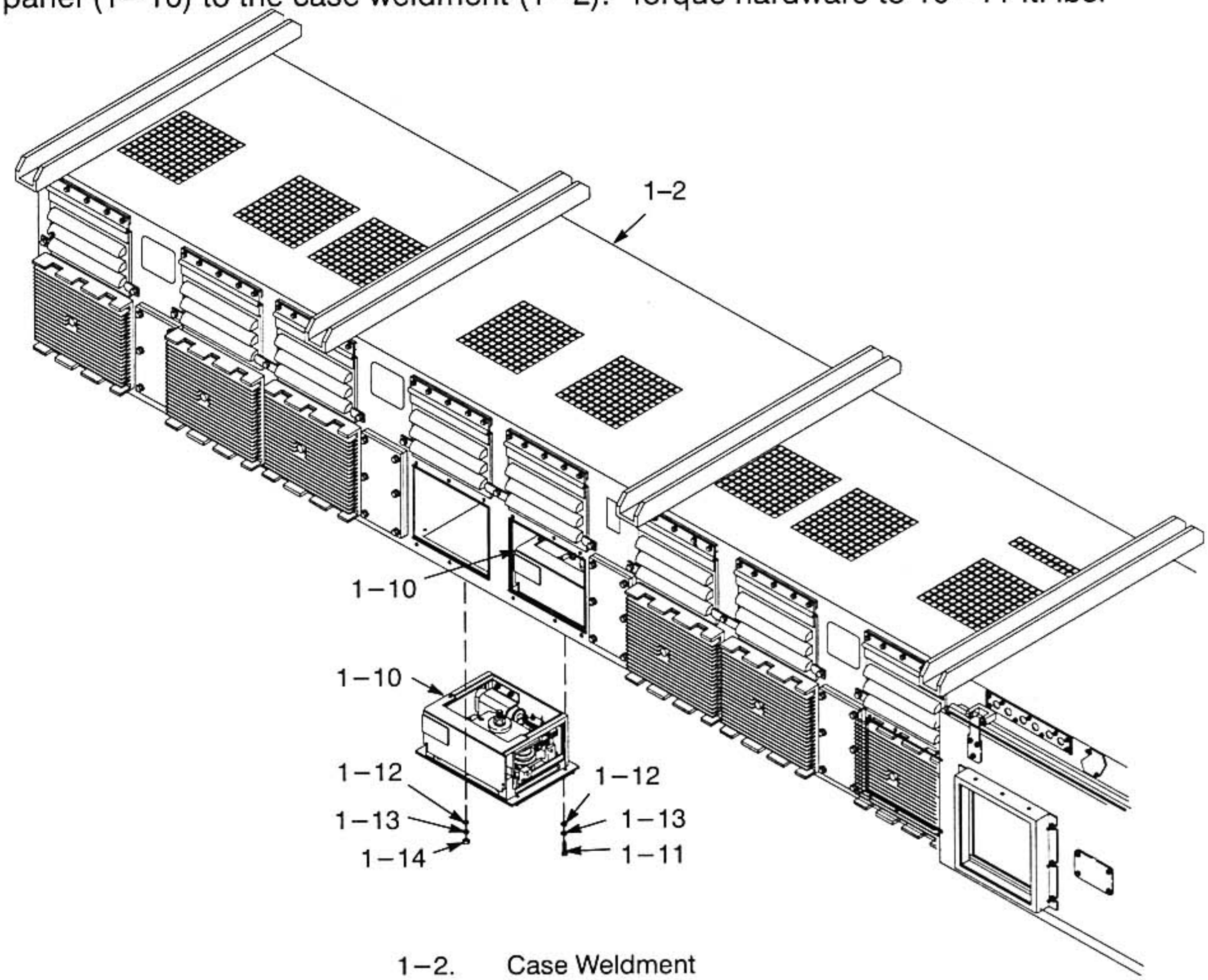
7–7.16.4 SERVICING

Not applicable.

7-7.16.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–11, 1–12, 1–13, 1–14, Figure 7–130) which secures panel (1–10) to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



1–2. Case Weldment
1–10. CM Panel
1–11. Bolt
1–12. Washer
1–13. Lockwasher
1–14. Brass Nut

Figure 7–130 Remove/Install Chopper Module

7–7.16.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.16.7 INSPECTION/CHECK

a. Inspect all parts for cracks, bends, breaks, arcing, pitting, burns or any obvious physical damage. If found replace as required.

b. Inspect soldered leads. If loose or broken repair or replace as required.

7–7.16.8 CLEANING/PAINTING

a. Remove any loose debris from panel using a sash brush and/or clean wiping rag.

> **WARNING:** FOLLOW ALL LOCAL SHOP SAFETY PROCEDURES WHEN USING COMPRESSED AIR. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY.

b. Using compressed air, clean heat sink fins of lodged debris.

7–7.17 RELAY – 17LV66AV1

7–7.17.1 DESCRIPTION AND OPERATION

The 17LV66AV1 Relay (Figure 7–131) is an electro–magnetic switching device, remotely controlled for opening and closing control circuits. It consists of a coil, armature, core, magnet frame and electrical contacts. There are four double throw contacts and one normally open (N.O.) contact on this relay. The relay is approximately 4–1/4 inches wide x 4–3/4 inches high x 5–3/4 inches deep and weighs approximately 5 pounds.

The relay contacts change state when the coil is energized or de–energized. The normally closed (N.C.) contacts are closed when the coil is de–energized and opened when the coil is energized. The N.O. contacts are open when the coil is de–energized and closed when the coil is energized.

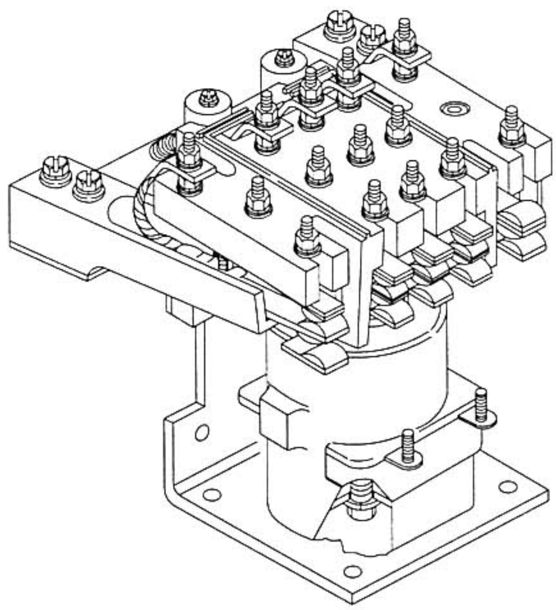


Figure 7–131 Relay – 17LV66AV1

7–7.17.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.17.3 MAINTENANCE PRACTICES

Not applicable.

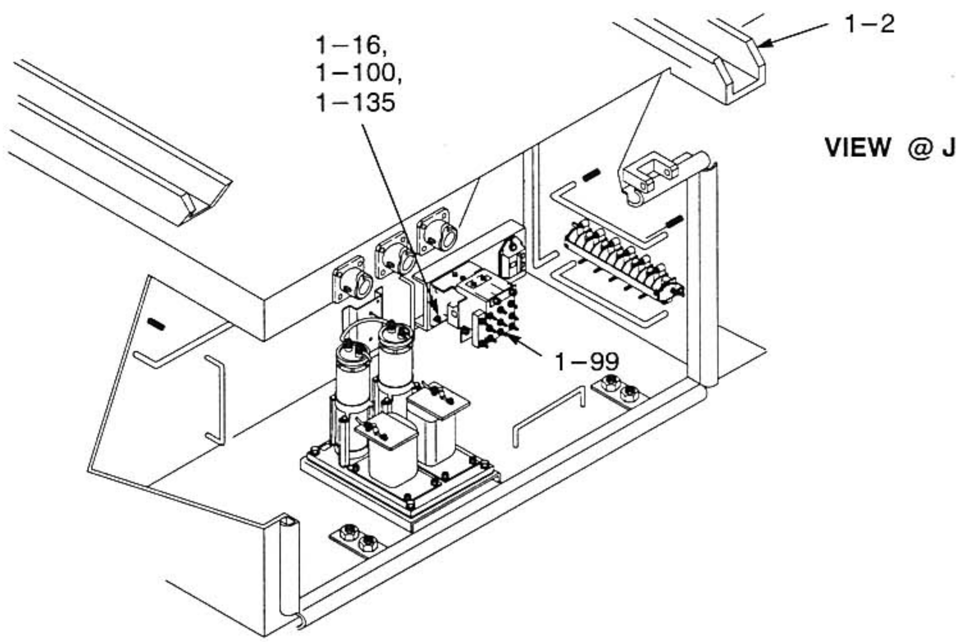
7–7.17.4 SERVICING

Not applicable.

7–7.17.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–100, 1–135, Figure 7–132) which secures relay (1–99) to the case weldment (1–2). Torque hardware to 30–35 in. lbs.



1–2. Case Weldment
1–16. Locknut
1–99. Relay
1–100. Bolt
1–135. Washer

Figure 7–132 Remove/Install Relay – 17LV66AV1

7–7.17.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.17.7 INSPECTION/CHECK

a. Inspect relay (reference Figure 7–133) for obvious physical damage such as broken or missing parts. If found, replace relay.

b. Inspect relay fingers and contacts. If burned or silver plating is worn thru, replace relay. If spherical finger or contact wear flat exceeds 7/32 in., replace relay.

c. Inspect finger shunts. If frayed broken, or discolored, replace relay.

d. Inspect operating coil. If scorched, cracked, or swollen, replace relay.

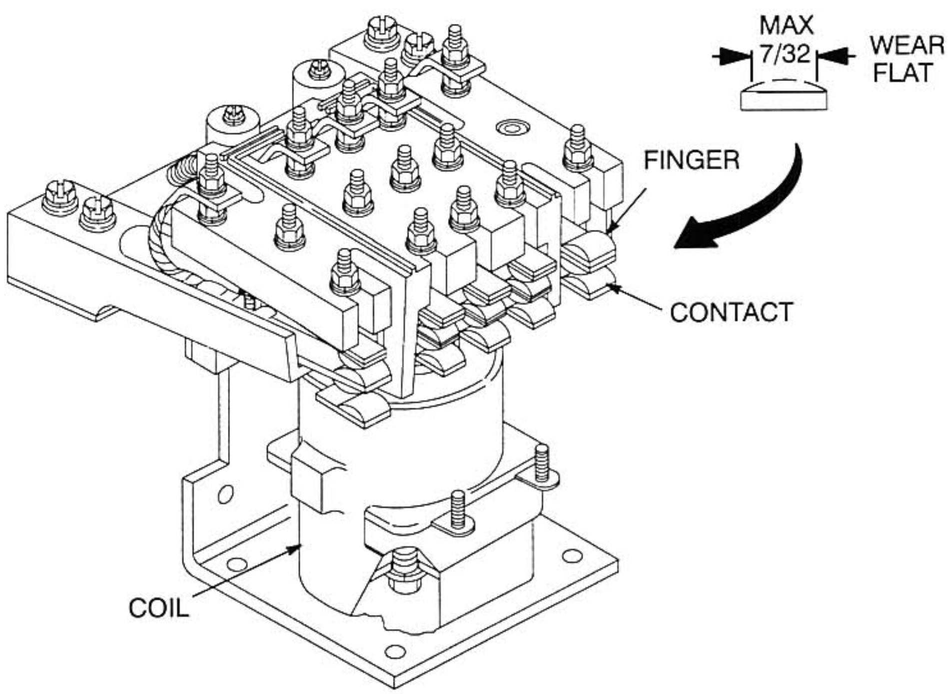


Figure 7–133 Inspect Relay – 17LV66AV1

7–7.17.8 CLEANING/PAINTING

Remove any loose debris from relay using a sash brush and/or clean wiping rag.

7–7.18 RELAY – 17LV66EB1, INVERTER DISCHARGE RELAY (FDC1, 2)

7–7.18.1 DESCRIPTION AND OPERATION

The 17LV66EB1 Relay (Figure 7–134) is an electro–magnetic switching device, remotely controlled for opening and closing control circuits. It consists of a coil, armature, core, magnet frame and electrical contacts. There is one double throw contact and two normally closed (N.C.) contacts on this relay. The relay is approximately 4–1/4 inches wide x 4–3/4 inches high x 5–3/4 inches deep and weighs approximately 5 pounds.

The relay contacts change state when the coil is energized or de–energized. The normally closed (N.C.) contacts are closed when the coil is de–energized and opened when the coil is energized. The N.O. contact is open when the coil is de–energized and closed when the coil is energized.

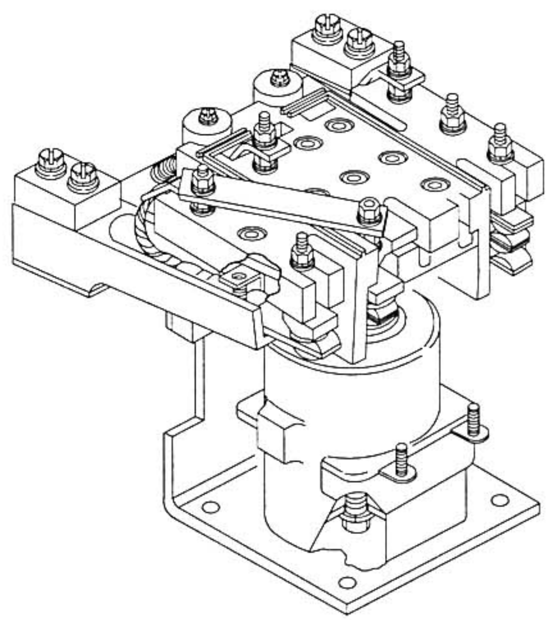


Figure 7–134 Relay – 17LV66EB1, Inverter Discharge Relay (FDC1, 2)

7–7.18.2 FAULT ISOLATION

Refer to section 7–7.2.

7–7.18.3 MAINTENANCE PRACTICES

Not applicable.

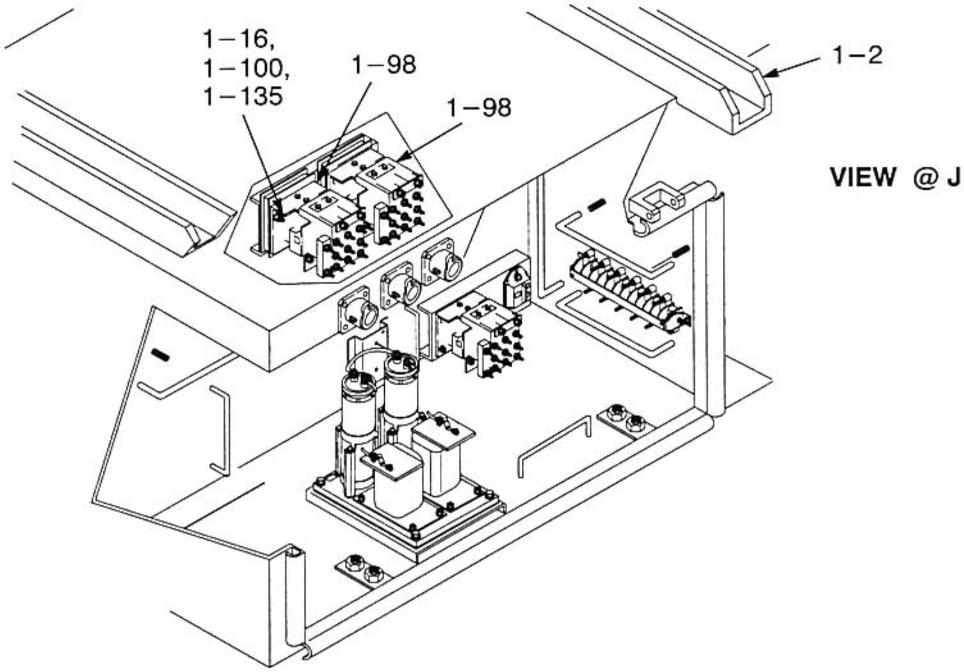
7–7.18.4 SERVICING

Not applicable.

7–7.18.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–16, 1–100, 1–135, Figure 7–135) which secures relay (1–98) to the case weldment (1–2). Torque hardware to 30–35 in. lbs.



1–2. Case Weldment
1–16. Locknut
1–98. Relay
1–100. Bolt
1–135. Washer

Figure 7–135 Remove/Install Relay – 17LV66EB1

7–7.18.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–7.18.7 INSPECTION/CHECK

a. Inspect relay (reference Figure 7–136) for obvious physical damage such as broken or missing parts. If found, replace relay.

b. Inspect relay fingers and contacts. If burned or silver plating is worn thru, replace relay. If spherical finger or contact wear flat exceeds 7/32 in., replace relay.

c. Inspect finger shunts. If frayed broken, or discolored, replace relay.

d. Inspect operating coil. If scorched, cracked, or swollen, replace relay.

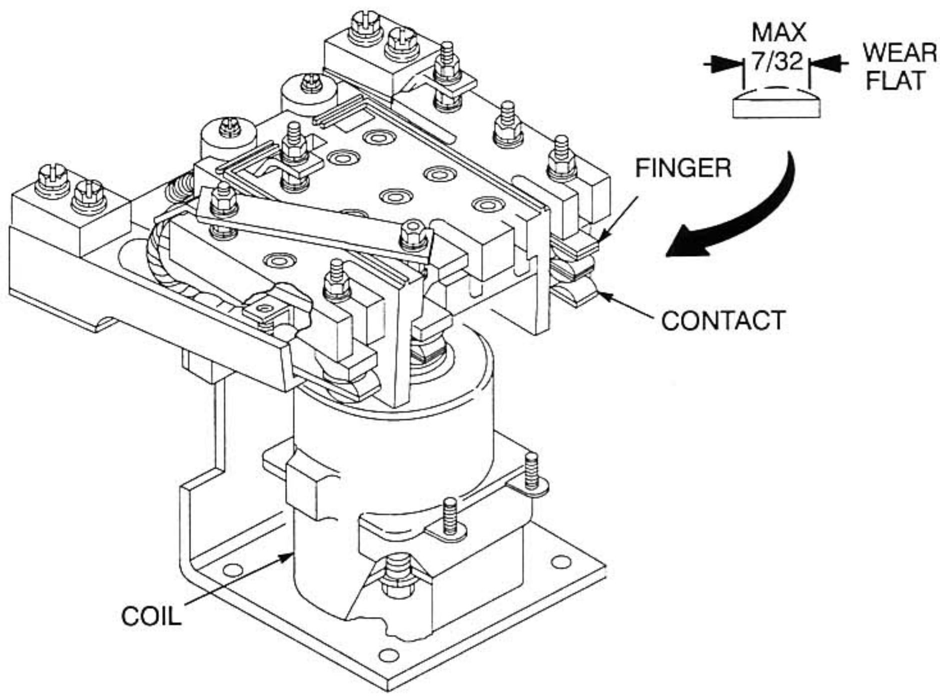


Figure 7–136 Inspect Relay – 17LV66EB1

7–7.18.8 CLEANING/PAINTING

Remove any loose debris from relay using a sash brush and/or clean wiping rag.

7–8 LINE BREAKER GROUP – 17KG510B1

7–8.1 DESCRIPTION AND OPERATION

The 17KG510B1 Line Breaker Group contains all of the electro–mechanical devices necessary for power switching, filter charging, and mode changeover. These items are housed in a case weldment designed to eliminate environmental effects. The Line Breaker Group is approximately 24 inches wide, 33 inches deep, 25 inches high, and weighs approximately 285 lbs. Figure 7–137 shows the location of the Line Breaker Group on the vehicle.

The Line Breaker Group houses the filter charging contactor, line breaker, line breaker overload reset relay, and voltage attenuation module.

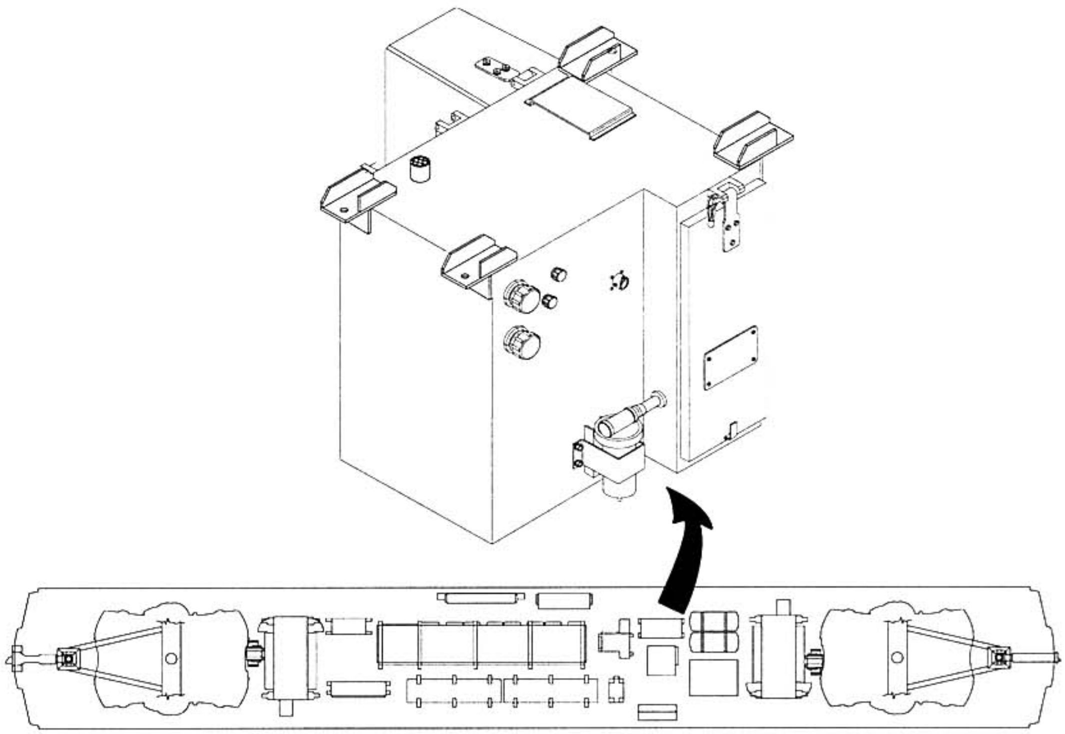


Figure 7–137 Line Breaker Group – 17KG510B1

> **WARNING:** **HIGH VOLTAGE IS PRESENT ON THE LINE BREAKER GROUP. THIS VOLTAGE CAN BE FATAL IF CONTACTED. REMOVE ALL POWER AND ASSURE ALL CAPACITORS ARE DISCHARGED BEFORE WORKING ON GROUP. FAILURE TO COMPLY WITH ALL RAILROAD SAFETY REGULATIONS CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH.**

7–8.2 FAULT ISOLATION

Refer to section 7–7.2.

7–8.3 MAINTENANCE PRACTICES

Not applicable.

7–8.4 SERVICING

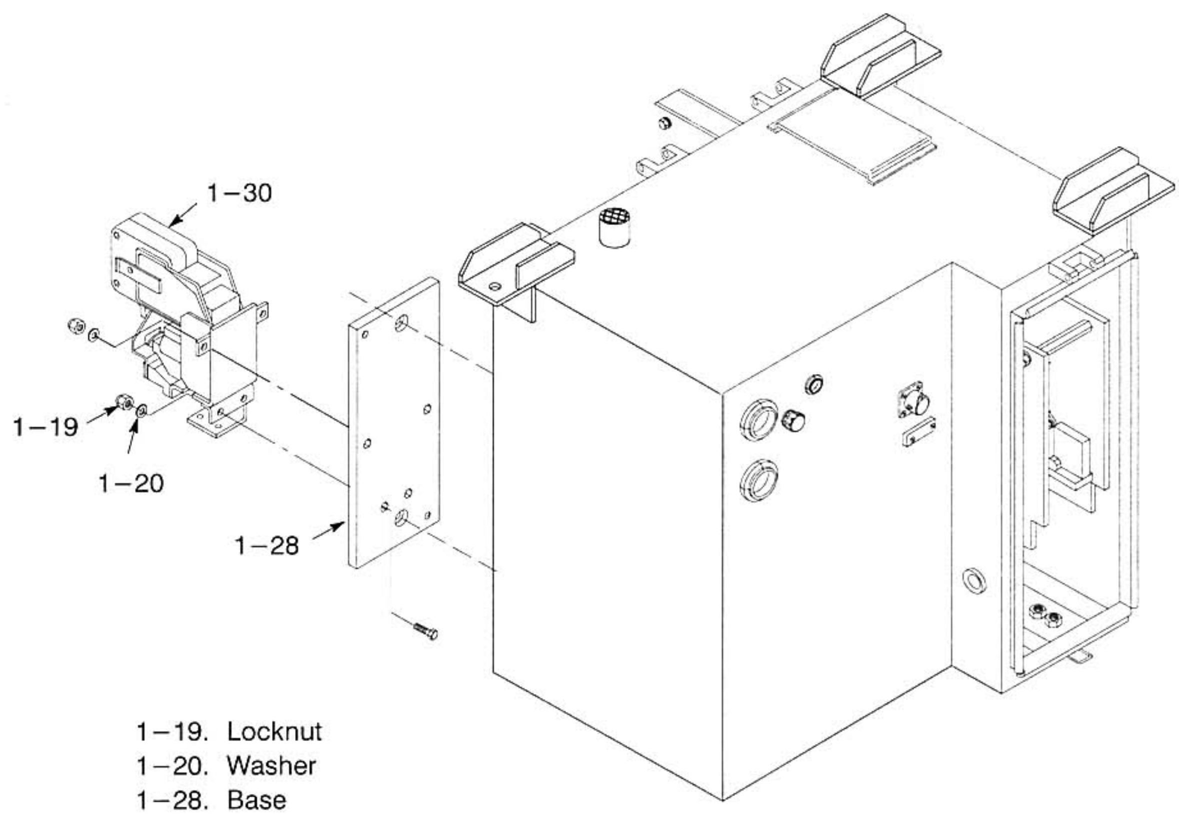
Not applicable.

7–8.5 REMOVAL/INSTALLATION

7–8.5.1 Remove/install Filter Charging Contactor (FCC), 41A296327ANP3.

a. Tag and remove/install wires.

b. Remove/install hardware (1–19, 1–20, Figure 7–138) which secures contactor (1–30) to the base (1–28). Torque hardware to 30–35 in. lbs.



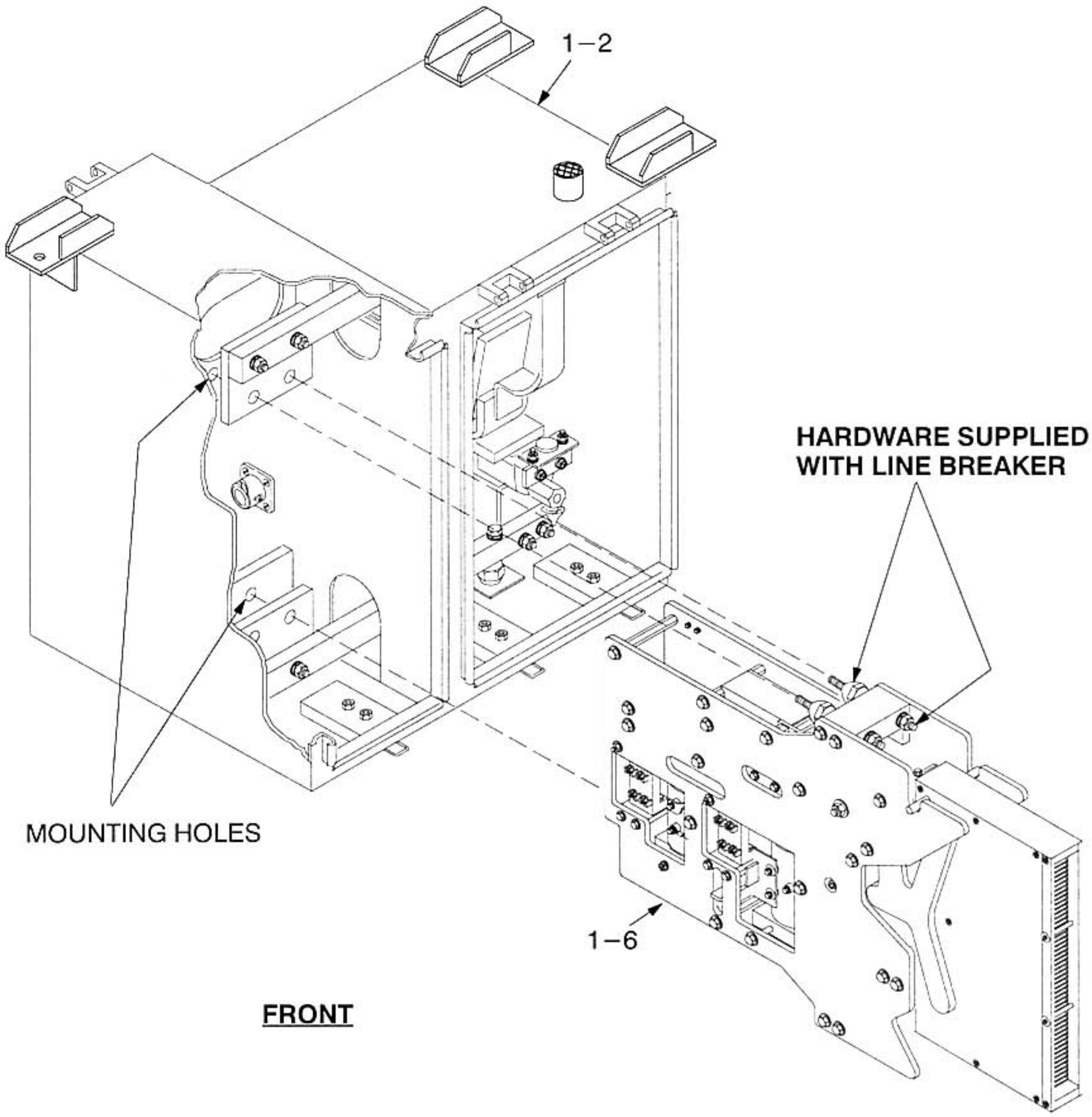
1–19. Locknut
1–20. Washer
1–28. Base
1–30. Contactor

Figure 7–138 Remove/Install Contactor (FCC)

7−8.5.2 Remove/install Line Breaker (LB), 41A296327AFP6.

a. Tag and remove/install wires.

b. Remove/install the hardware, supplied with the Line Breaker (1−6, Figure 7−139) which secures it to the case weldment (1−2). Torque hardware to 10−11 ft. lbs.



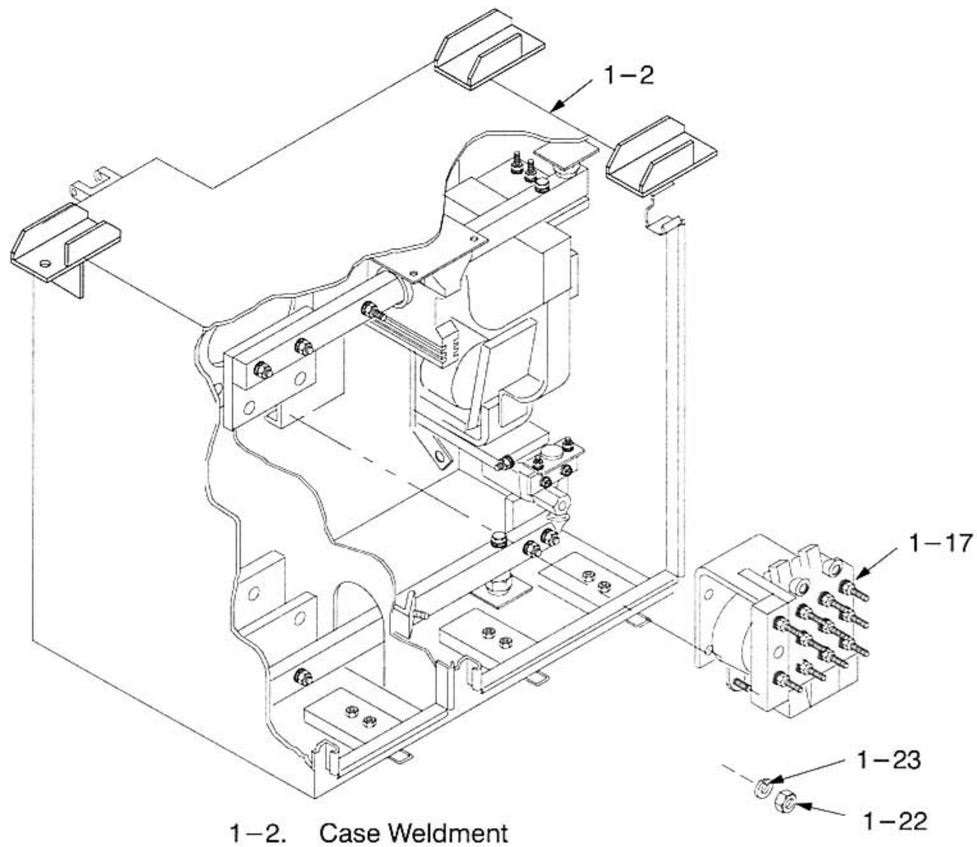
1−2. Case Weldment
1−6. Line Breaker

Figure 7−139 Remove/Install Line Breaker

7–8.5.3 Remove/install LIne Breaker Overload Reset Relay (LBRR), 17LV66CY53

a. Tag and remove/install wires.

b. Remove/install hardware (1–22, 1–23, Figure 7–140) which secures relay (1–17) to case weldment (1–2). Torque hardware to 74–83 in. lbs.



1–2. Case Weldment
1–17. Relay
1–22. Locknut
1–23. Washer

Figure 7–140 Remove/Install Relay (LBRR), 17LV66CY53

7–8.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–8.7 INSPECTION/CHECK

7–8.7.1 Inspect Group Exterior

a. Inspect case weldment and covers for bends, cracks, or obvious physical damage. If found repair or replace as required.

b. Inspect for loose or missing warning placards. Replace as required.

c. Inspect gaskets and O–rings for moisture leakage. If found replace as required.

7–8.7.2 Inspect Group Interior

a. Inspect group components for cracks, breaks, burns, or any other obvious physical damage, including the flexible air exhaust tube in the linebreaker arc chute cover. If found, report to supervision.

b. Inspect wires for breaks, frays, or loose terminals. If found repair or replace as required.

7–8.7.2.1 Inspect Filter Charging Contactor (FCC), 41A296327ANP3.

a. Visually inspect the contactor for obvious physical damage such as burned, broken or missing parts. If found, replace contactor.

b. Inspect for loose or missing hardware. If found tighten or replace as required.

c. Loosen the captive screw, then use a screw driver to release the latch and slide the arc chute (26, Figure 7–141) in a horizontal direction to remove.

d. Inspect the arc chute for evidence of wearing thru the ceramic or plastic walls as well as ceramic melting. If found replace arc chute.

e. When the contactor inspection is complete, reinstall the arc chute by sliding it over the arc runner (19) and between the pole pieces. Ensure the latch is engaged and torque the captive screw to 14–16 in. lbs.

f. Inspect the flexible shunt (31) for wear, frays or burn marks. If found replace contactor.

g. Inspect the operating coil (3) for swelling, cracks or burns. If found replace the contactor.

h. Inspect the arc runner (19) and blowout coil (2) for pitting or burns. If found replace contactor.

i. Inspect the contacts (15, 38), for wear thru the mating surface to the copper support. If found replace the contactor.

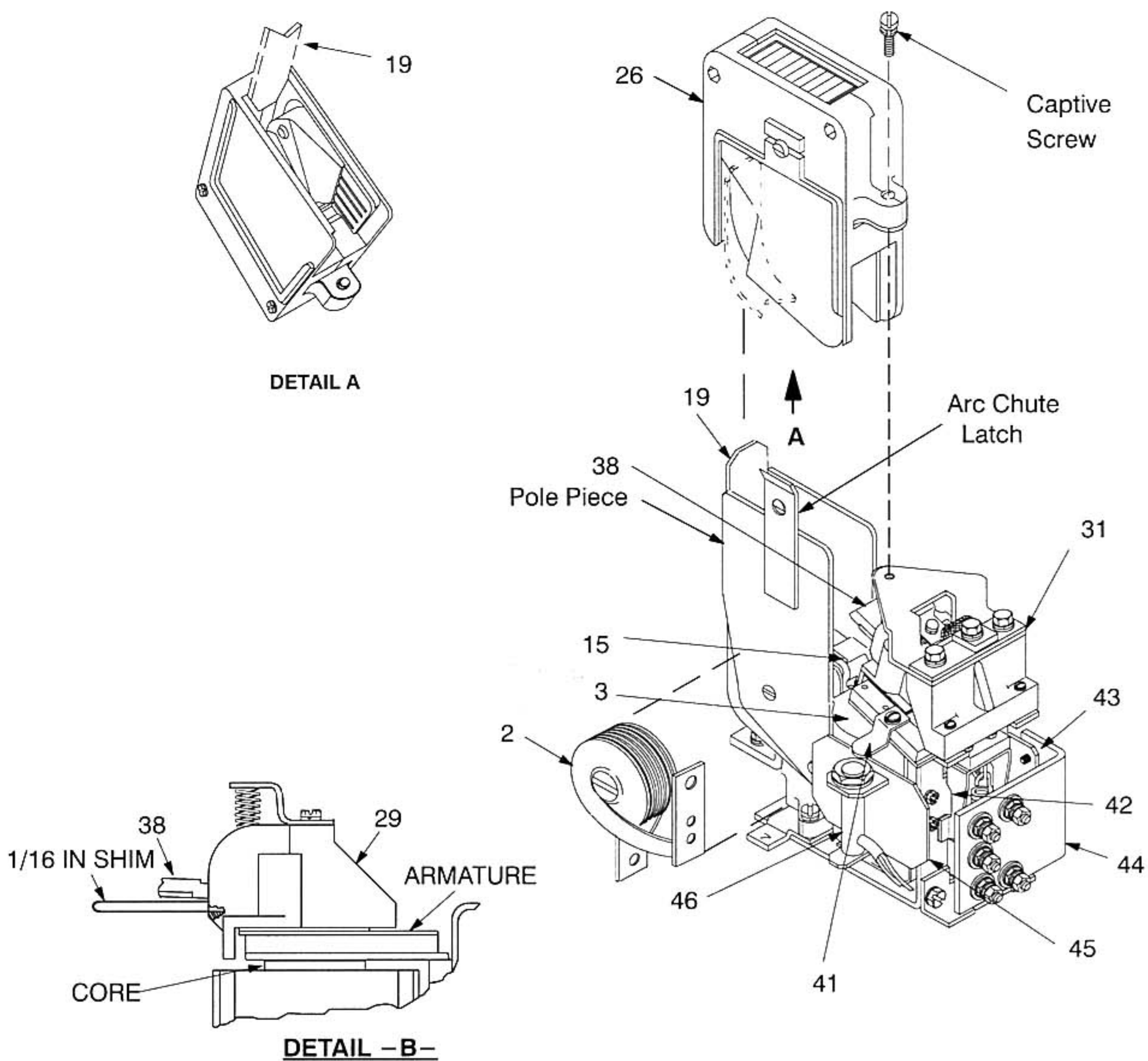
j. Inspect for minimum required contact wipe. Manually actuate the contactor to bring the armature into contact with the coil core. Insert a 1/16 in shim between the movable contact (38) and the tip support (29) as shown in DETAIL 'B'. If the shim wont fit replace contactor.

k. Inspect proximity sensor (46) for any damaged, loose, or missing hardware. Tighten or replace as required.

l. Inspect sensor (46) for any visual damage. Inspect sensor wires for breaks, frays or burns. If damaged replace sensor.

m. Inspect brackets and insulation (42, 43, 44, 45) for cracks, breaks or any other physical damage. If found replace.

n. Inspect pawl (41) for cracks bends or breaks. If found replace.



2 Blowout Coil	29 Support, Tip	43. Insulation
3 Operating Coil	31 Shunt	44. Insulation
15 Contact Tip Stationary	38 Contact Tip Assembly	45 Bracket, Sensor
19 Arc Horn, Stationary Tip	41 Pawl	46. Sensor
26 Arc Shute Assembly	42 Bracket, Sensor	

Figure 7 – 141 Inspect Contactor (FCC)

7–8.7.2.2 Inspect Line Breaker (LB), 41A296327AFP6.

a. Visually inspect the Line Breaker for obvious physical damage such as broken or missing parts. If found replace line breaker.

b. Inspect for loose or missing hardware. Tighten or replace as required.

c. Inspect operating coil (9, Figure 7–142) and reset coil (11) for cracks, burns or any other physical damage. If found replace coil.

d. Undo the latches and lift the arc chute (2) free of the line breaker. Inspect the arc chute for cracks or burns deeper than half the thickness of the sides. If found replace arc chute.

e. Rotate blue pole pieces upward.

NOTE: Pearls are pieces of molten copper which ar deposited at various locations along the tips and the arc runners. Splatter is very similar except it is flatter.

f. Inspect the movable contact (6) notch through which the lower arc runner (4) travels for pearl and splatter. Use a smal file or slotted head screwdriver to gently pry off any pearl or splatter which may bridge the gap between the contact tip (6) and the arc runner(4). Do not attempt to clean the mating srufaces of the contact tips (5,6) as this might cause there to be a poor contact surface during subsequent operations.

g. Repeat procedure (f) for the arc runners (3.4).

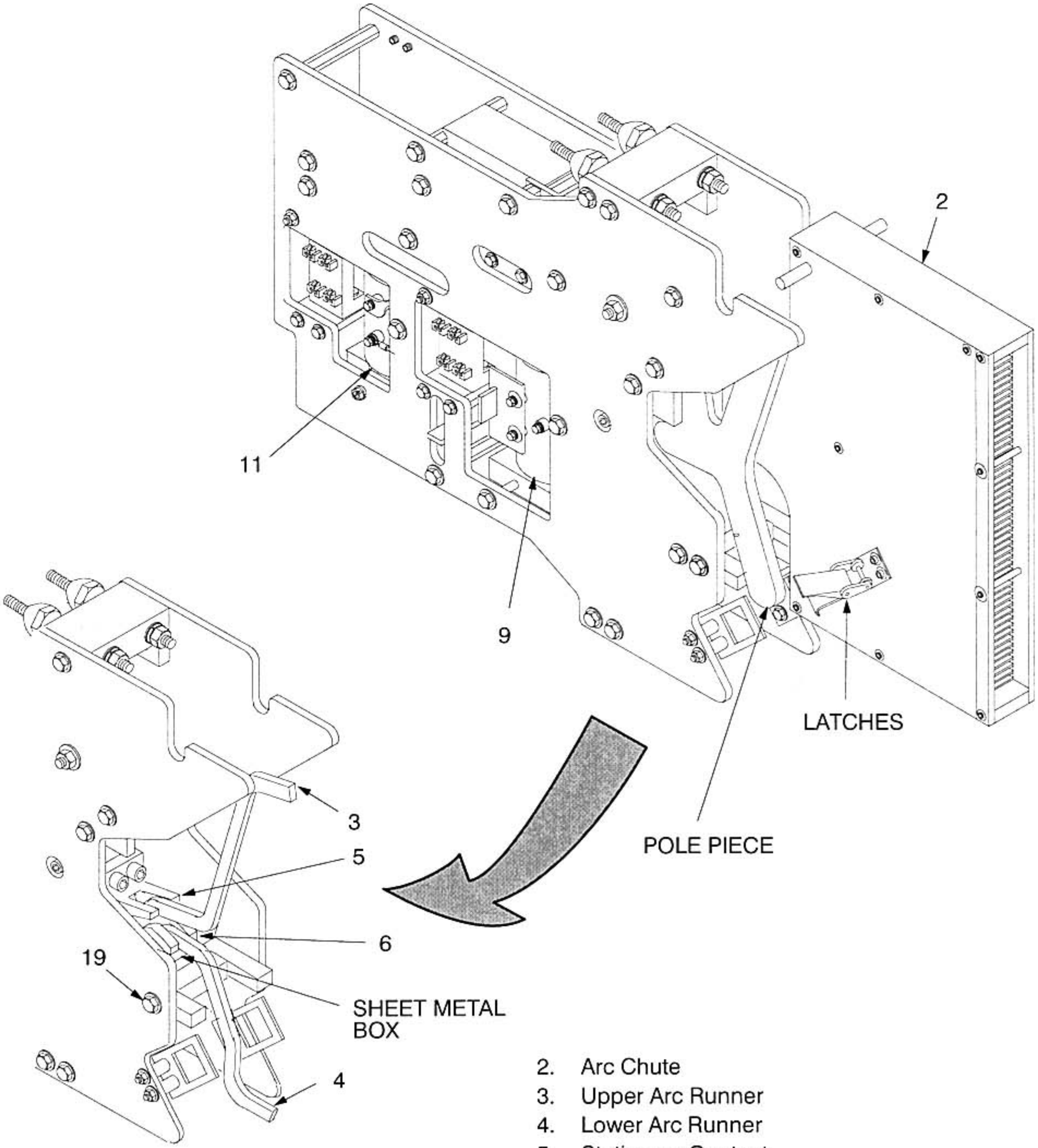
h. After removing all pearls and splatter, lightly file the vertical surface of the moveable contact (6) tip notch to square the edges.

i. Inspect arc runners (3, 4) for burns more than 1/96 inch deep. If found notify supervisor.

j. Place the linebreaker in the dropped out position. The arc runner (4) must be centered in the moveable contact tip (6) notch. There should be a 0.060 in. minimum gap on all sides of the moveable contact tip 96) notch to the lower arc runner. Move the tip assembly up to the "tips touch" position and down to "full drop–out". A 0.060 in. minimum gap must be maintained throughout the cycle. To adjust, loosen the screws (19) on glastic piece which holds the lower end of the arc runner(4) to the linebreaker and rotate to proper position. Tighten securely and verify adjustment.

k. Place the linebreaker in the closed and fully wiped position. Measure the distance between the top surface of the moveable contact tip (6) and the outside lower edge of the sheet metal box which houses this tip. The minimum distance for this gap should be 0.080 in. Replace both tips (5, 6) if the gap exceeds 0.080 in.

l. Inspect contact tips (5, 6). If contact tips are badly burnt or worn to less than 5/32 inch thick replace contact tips.



2. Arc Chute
3. Upper Arc Runner
4. Lower Arc Runner
5. Stationary Contact
6. Movable Contact
9. Operating Coil
11. Reset Coil
19. Adjustment Screws

Figure 7–142 Inspect/Check Line Breaker

7–8.7.2.3 Inspect LIne Breaker Overload Reset Relay (LBRR), 17LV66CY53

a. Inspect relay (reference Figure 7–143) for obvious physical damage such as broken or missing parts. If found, replace relay.

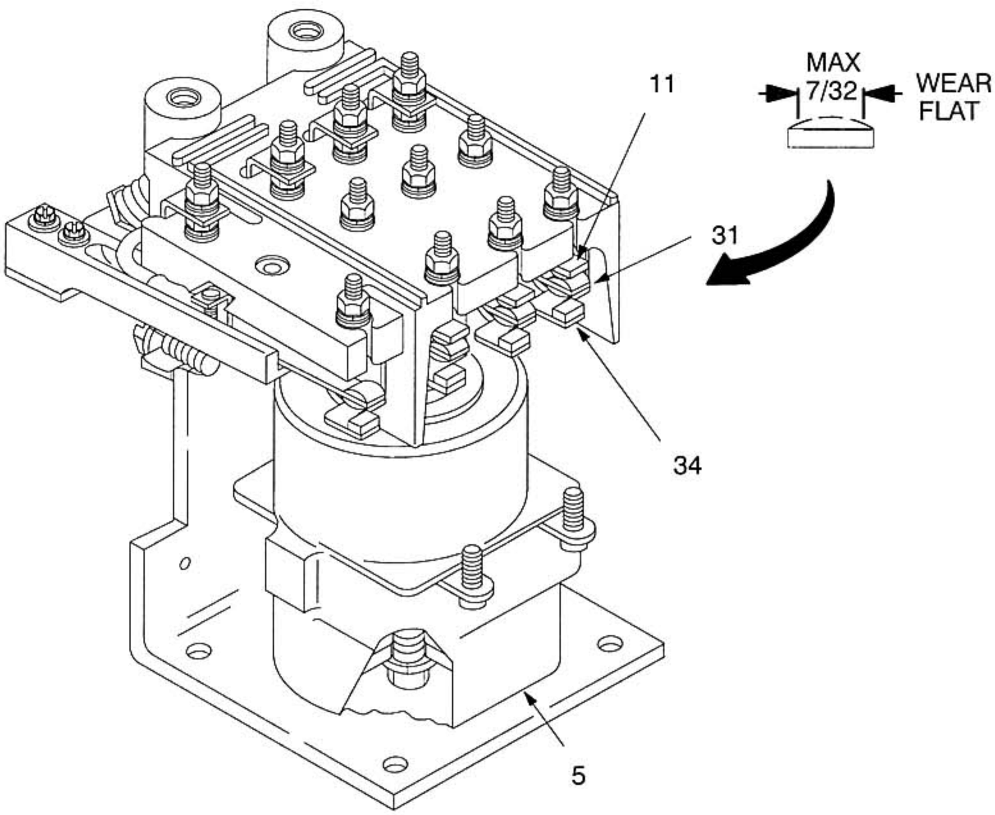
b. If coil or circuit terminal hardware is loose, tighten as necessary.

c. If coil (5) is swollen or burnt, replace relay.

d. Inspect contacts (11, 31, 34). If worn or burnt replace both stationary and movable contacts as a set.

e. Inspect relay fingers and contacts. If burned or silver plating is worn thru, replace both stationary and movable contacts as a set. If spherical finger or contact wear flat exceeds 7/32 in., replace both stationary and movable contacts as a set.

f. If shunts on moveable contacts are frayed, discolored, or broken, replace relay.



5. Operating Coil
11. Offset Contact
31. Finger Assembly
34. N.O. Contact

Figure 7–143 Inspect Relay (LBRR), 17LV66CY53

7–8.8 CLEANING/PAINTING

a. Using a sash brush and/or clean wiping rag remove any loose debris from the exterior surfaces of the group case weldment.

b. A steam cleaner may be used to remove any stubborn buildup from the exterior surfaces of the case weldment..

c. Using a sash brush and/or clean wiping rag remove loose debris from the internal components of the group.

d. A shop vacuum may be used to remove stubborn buildup. It is recommended that filtered, clean and dry air be blown through the linebreaker arc chute from the side of the latches to remove loose dust and debris.

7–8.9 FILTER CHARGING CONTACTOR (FCC), 41A296327ANP3

7–8.9.1 DESCRIPTION AND OPERATION

The Filter Charging Contactor (Figure 7–144) is an electro–mechanical, heavy duty, DC device. It is rated at 1000V, and can continuously withstand 150 Amps rms. It is remotely controlled by the propulsion control processor unit (system controller). The FCC allows charging of the filter capacitors before direct application of the third rail voltage.

Major components of the FCC Contactor include a 32 VDC (control voltage) coil, armature assembly, stationary and moveable power contacts, arc chute, arc horn, and blowout coil. A proximity sensor and terminal board are also attached to the unit. The proximity sensor notifies the system controller of the contactors (open or closed) status. This contactor is a self–contained unit. It is approximately 4.5 in. wide, 13 in. high, and about 10 in. deep. It weighs approximately 15 lb.

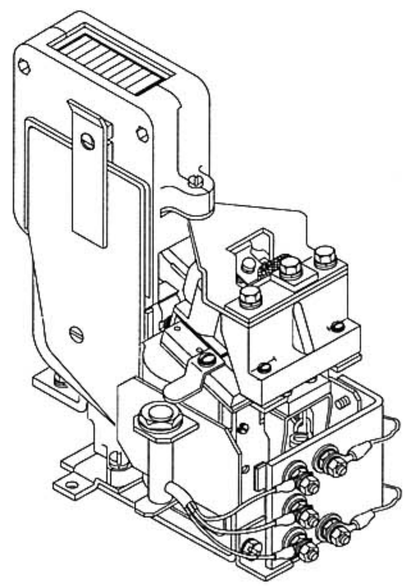
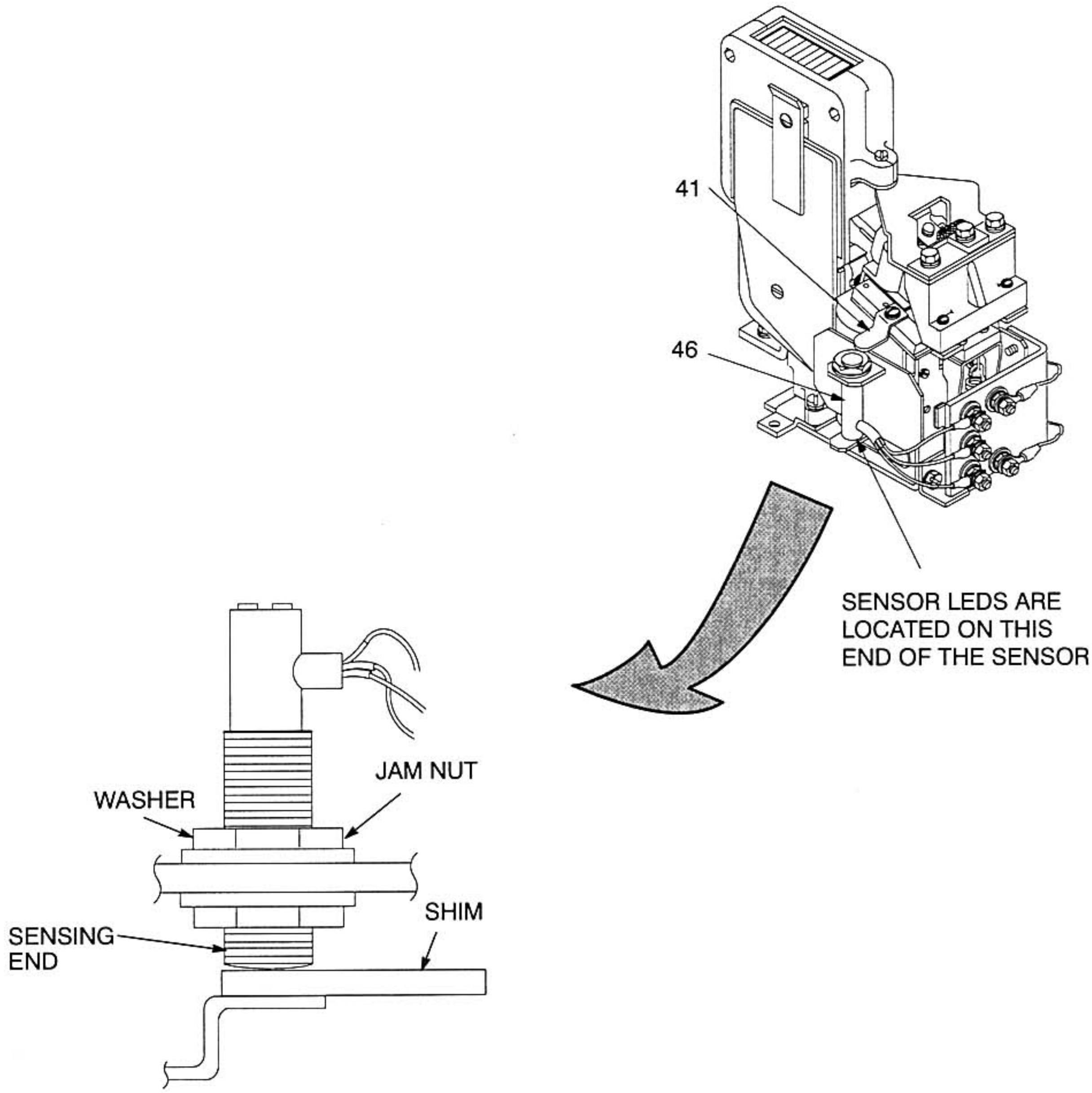


Figure 7–144 FCC Contactor, 41A296327ANP3

WARNING: REMOVAL OF CONTACTOR MAY REQUIRE THE REMOVAL OF PROTECTIVE PANELS OR COVERS WHICH COULD EXPOSE HIGH AND LOW VOLTAGE TERMINALS AND/OR CONTACTS. ALL POWER MUST BE DISCONNECTED PRIOR TO CONTACTOR REMOVAL. FAILURE TO COMPLY WITH RAILROAD SAFETY REGULATIONS CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH.



1–41 Pawl
1–46. Sensor

Figure 7–146 Adjustment/Test Filter Charging Contactor

7–8.9.7 INSPECTION/CHECK

a. Visually inspect the contactor for obvious physical damage such as burned, broken or missing parts. If found, replace contactor.

b. Inspect for loose or missing hardware. If found tighten or replace as required.

c. Loosen the captive screw, then use a screw driver to release the latch and slide the arc chute (26, Figure 7–147) in a horizontal direction to remove.

d. Inspect the arc chute for evidence of wearing thru the ceramic or plastic walls as well as ceramic melting. If found replace arc chute.

e. When the contactor inspection is complete, reinstall the arc chute by sliding it over the arc runner (19) and between the pole pieces. Ensure the latch is engaged and torque the captive screw to 14–16 in. lbs.

f. Inspect the flexible shunt (31) for wear, frays or burn marks. If found replace contactor.

g. Inspect the operating coil (3) for swelling, cracks or burns. If found replace the contactor.

h. Inspect the arc runner (19) and blowout coil (2) for pitting or burns. If found replace contactor.

i. Inspect the contacts (15, 38), for wear thru the mating surface to the copper support. If found replace the contactor.

j. Inspect for minimum required contact wipe. Manually actuate the contactor to bring the armature into contact with the coil core. Insert a 1/16 in shim between the movable contact (38) and the tip support (29) as shown in DETAIL 'B'. If the shim wont fit replace contactor.

k. Inspect proximity sensor (46) for any damaged, loose, or missing hardware. Tighten or replace as required.

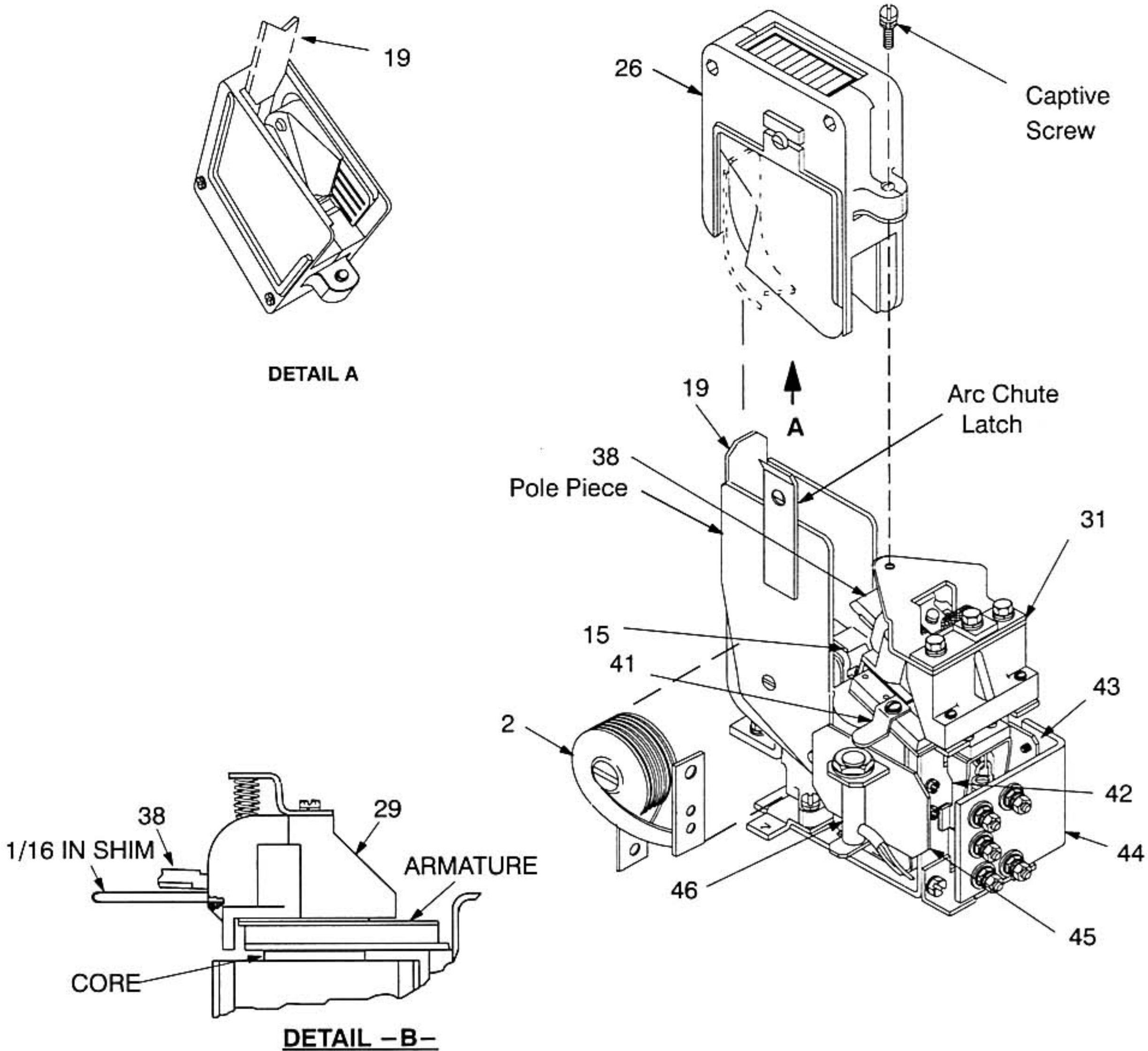
l. Inspect sensor (46) for any visual damage. Inspect sensor wires for breaks, frays or burns. If damaged replace sensor.

m. Inspect brackets and insulation (42, 43, 44, 45) for cracks, breaks or any other physical damage. If found replace.

n. Inspect pawl (41) for cracks bends or breaks. If found replace.

7–8.9.8 CLEANING/PAINTING

Remove any loose debris from contactor components using a sash brush and/or clean wiping rag.



2 Blowout Coil	19 Arc Horn, Stationary Tip	41 Pawl
3 Operating Coil	26 Arc Shute Assembly	42 Bracket, Sensor
8 Armature Assembly	29 Support, Tip	43. Insulation
9 Tension Spring	31 Shunt	44. Insulation
14 Screw/W W asher	38 Contact Tip Assembly	45 Bracket, Sensor
15 Contact Tip Stationary	40 Washer, Lock	46. Sensor

Figure 7–147 Inspect Contactor (FCC)

7–8.10 LINE BREAKER – 41A296327AFP6

7–8.10.1 DESCRIPTION AND OPERATION

The 41A296327AFP6 Line Breaker is an electro–mechanical device which supplies power to the traction motor. It also provides overload protection of the traction motor power circuit.

It consists of a set of main power contacts, operating coil, reset coil, arc runners, arc chute, auxiliary contacts, and pneumatic ventilator. It is approximately 6 inches wide, 18 inches high, and 24 inches deep and weighs approximately 97 lbs.

The movable main contact closes to the fixed main contact when the operating coil is energized and opens when the operating coil is deenergized. The main contacts supply power to the traction motor when closed. Should an over–current occur these contacts are opened by a lever which is electro–mechanically operated and blocked. The operation of this lever also removes power from the operating coil. The reset coil must be energized to unblock this lever and allow normal operation of the unit. The arc generated by opening the main contacts is carried thru the arc runners to the arc chute, as well as pneumatically directed by the pneumatic ventilator. The auxiliary switches are used to monitor and transmit line breaker operation to the control circuit.

7–8.10.2 FAULT ISOLATION

Refer to section 7–7.2.

7–8.10.3 MAINTENANCE PRACTICES

Refer to section 7–8.10.4.

7–8.10.4 SERVICING

a. Undo the latches and lift the arc chute (2, Figure 7–148) free of the line breaker (1).

b. Clean arc chute (2) with a clean, dry cloth, and blow filtered, clean and dry air through the arc chute from the side of the latches to remove dust and debris.

c. Inspect the arc chute (2) for cracks or burns deeper than half the thickness of the sides. If found, replace arc chute.

d. Rotate blue pole pieces upward.

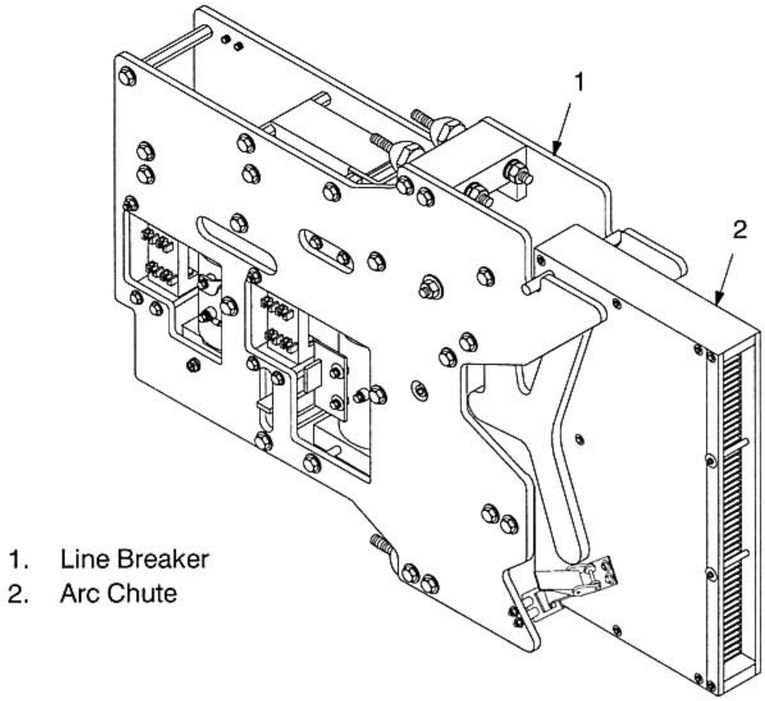


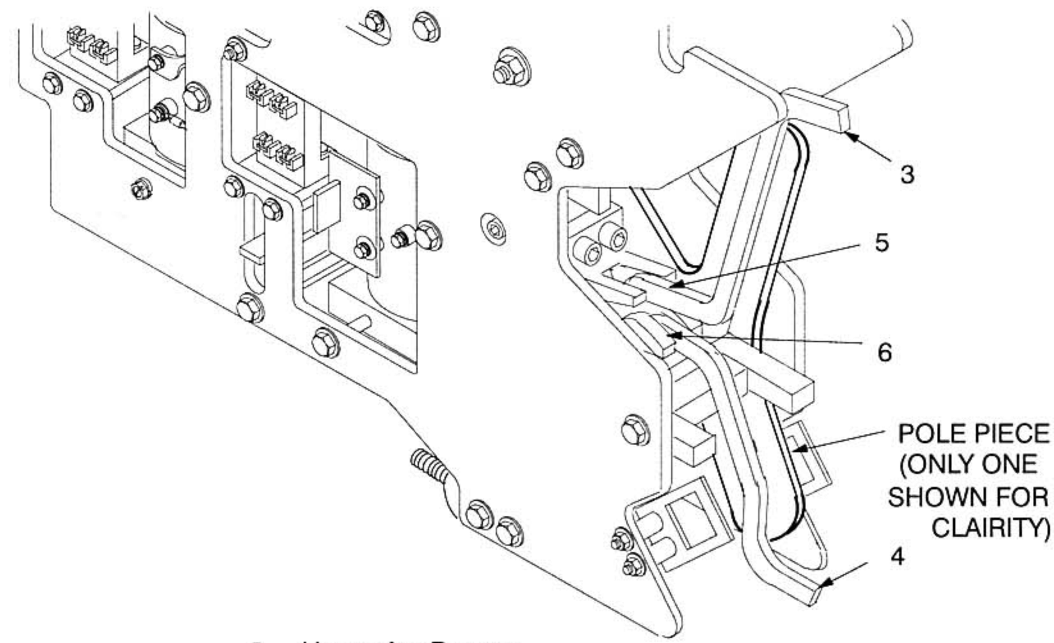
Figure 7–148 Line Breaker – 41A296327AFP6

e. Inspect the moveable contact (6, Figure 7–149) notch through which the lower arc runner (4) travels for pearls and splatter.

f. Use a small file or slotted head screwdriver to gently pry off any pearl or splatter which may bridge the gap between the contact tip (6) and arc runner (4). Do not attempt to clean the mating surfaces of the contact tips (5, 6) as this might cause there to be a poor contact surface during subsequent operations.

g. Repeat procedure (b) for the other arc runners (3, 4).

h. After removing all pearls and splatter, lightly file the vertical surface of the moveable contact (6) tip notch to square the edges.



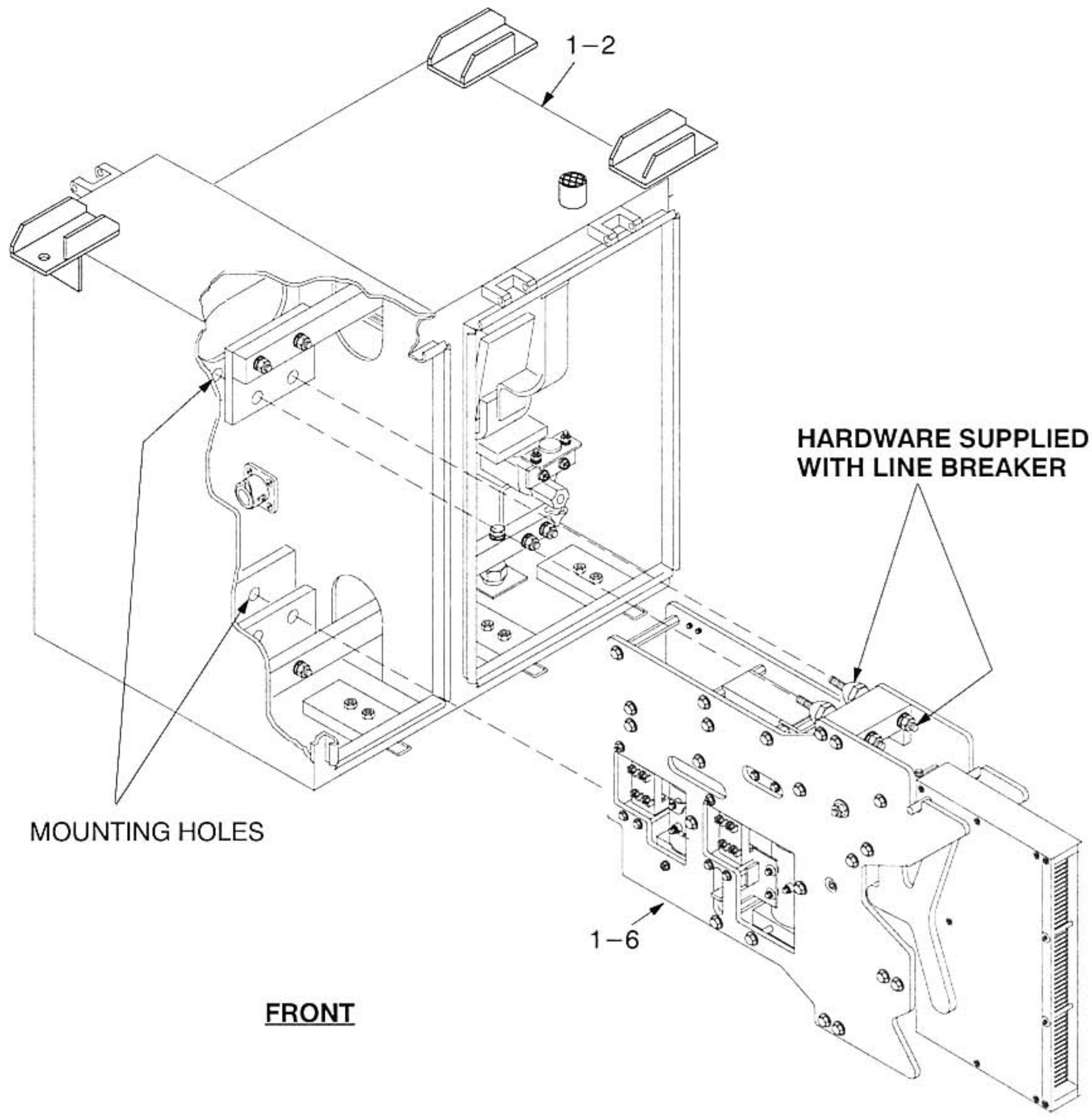
3. Upper Arc Runner
4. Lower Arc Runner
5. Stationary Contact
6. Movable Contact

Figure 7–149 Service, Adjust/Test Line Breaker

7–8.10.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install the hardware, supplied with the Line Breaker (1–6, Figure 7–150) which secures it to the case weldment (1–2). Torque hardware to 10–11 ft. lbs.



1–2. Case Weldment
1–6. Line Breaker

Figure 7–150 Remove/Install Line Breaker

7–8.10.6 ADJUSTMENT/TEST

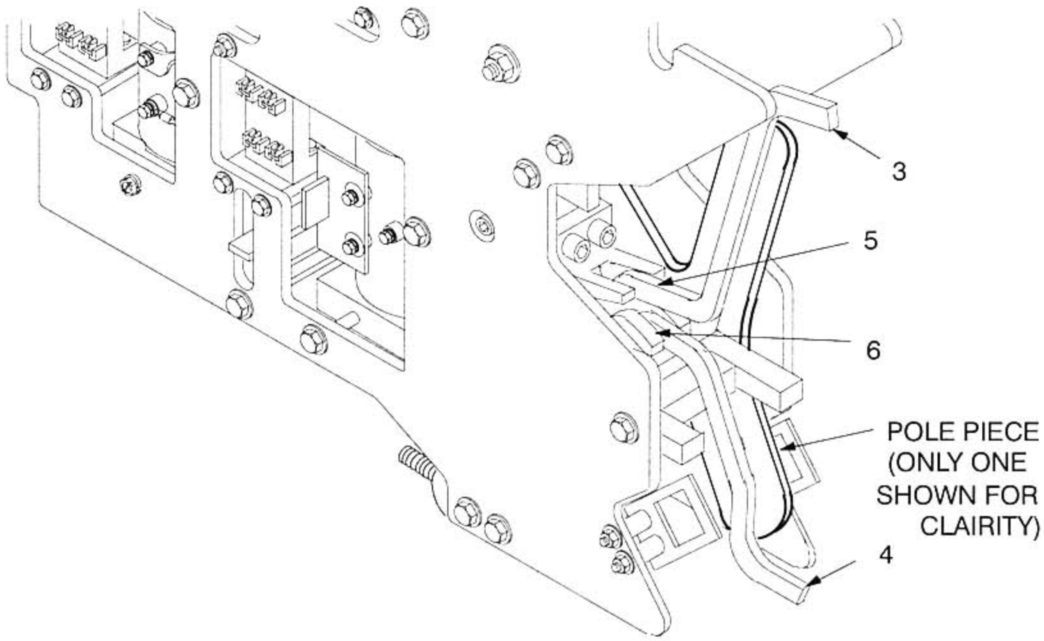
NOTE: The moveable tip should never touch or rub against the lower arc runner.

a. Place the line breaker (1, Figure 7–151) in the dropped–out position.

b. The arc runner (4) must be centered in the moveable contact tip (6) notch. There should be a 0.060 in. minimum gap on all sides of the moveable contact tip (6) notch to the lower arc runner (4).

c. Move the tip assembly up to the "tips touch" position and down to "full drop–out." A 0.060 in. minimum gap must be maintained throughout the cycle.

d. To adjust, loosen the screws (19) on plastic piece which holds the lower end of the arc runner (4) to line breaker (1) and rotate to proper position. Tighten securely and verify adjustment



3. Upper Arc Runner
4. Lower Arc Runner
5. Stationary Contact
6. Movable Contact

Figure 7–151 Adjust/Test Line Breaker

7–8.10.7 INSPECTION/CHECK

a. Visually inspect the Line Breaker for obvious physical damage such as broken or missing parts. If found replace line breaker.

b. Inspect for loose or missing hardware. Tighten or replace as required.

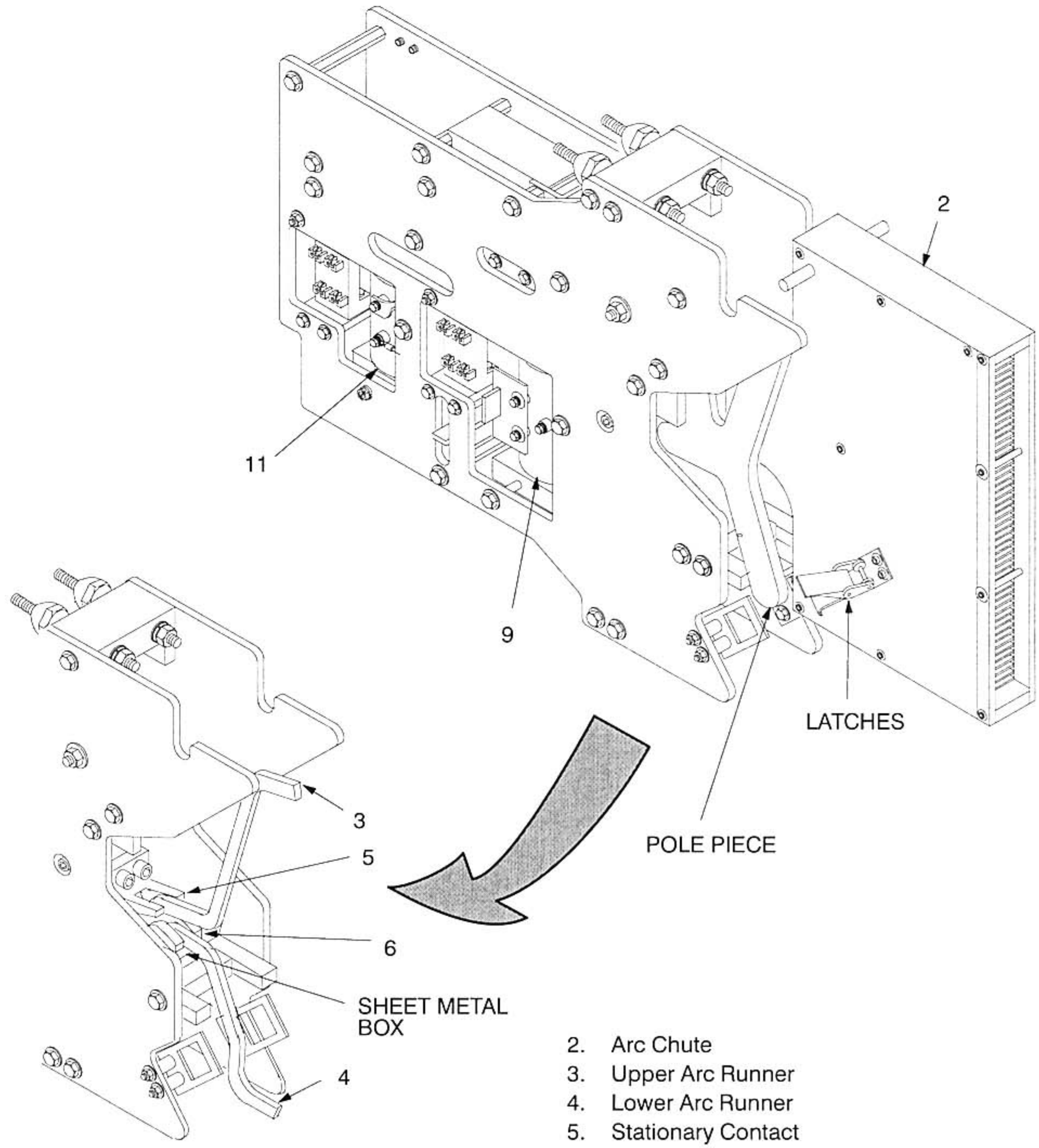
c. Inspect operating coil (9, Figure 7–152) and reset coil (11) for cracks, burns or any other physical damage. If found replace coil.

d. Undo the latches and lift the arc chute (2) free of the line breaker. Inspect the arc chute for cracks or burns deeper than half the thickness of the sides. If found replace arc chute.

e. Inspect arc runners (3, 4) for burns more than 1/96 inch deep. If found notify supervisor.

f. Place the line breaker in the closed and fully wiped position. Measure the distance between the top surface of the moveable contact tip (6) and the outside lower edge of the sheet metal box which houses this tip. The minimum distance for this gap should be 0.080 in. Replace both tips (5, 6) if the gap exceeds 0.080 in.

g. Inspect contact tips (5, 6). If contact tips are badly burnt or worn to less than 5/32 inch thick replace contact tips.



2. Arc Chute
3. Upper Arc Runner
4. Lower Arc Runner
5. Stationary Contact
6. Movable Contact
9. Operating Coil
11. Reset Coil

Figure 7–152 Inspect/Check Line Breaker

h. Visually inspect tube (20, Figure 7–153) in line breaker arc chute cover for obvious physical damage such as broken or missing parts. If found replace tube. Inspect for loose or missing tube mounting hardware. Tighten or replace as required.

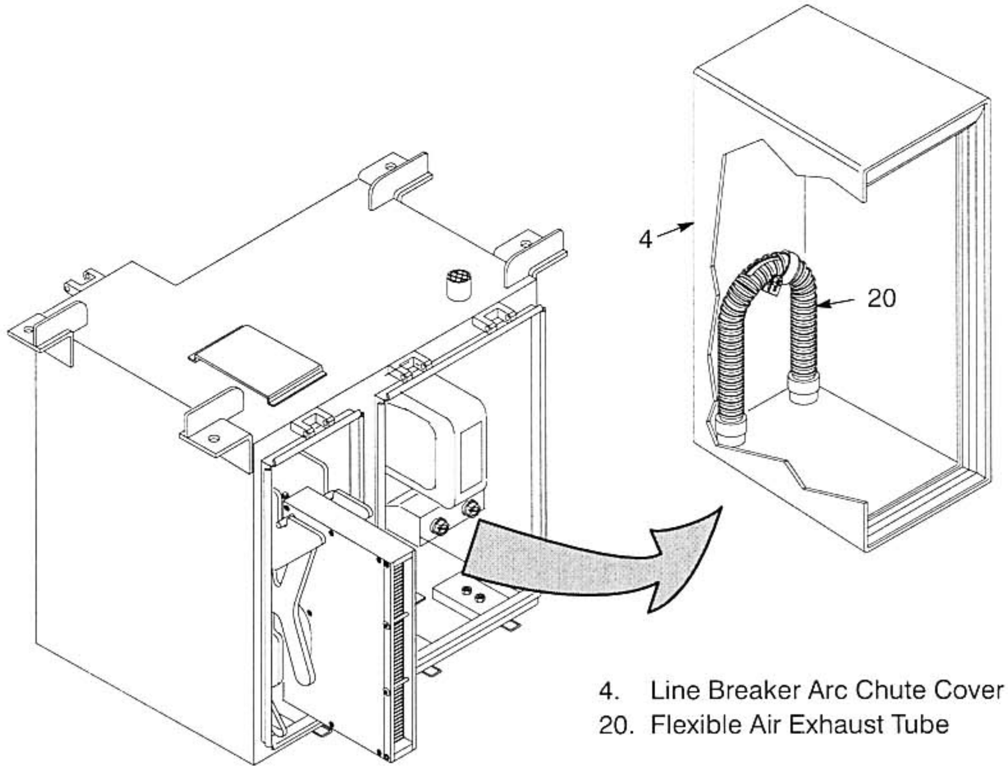


Figure 7–152A Inspect/Check Line Breaker Arc Chute Cover

7–8.10.8 CLEANING/PAINTING

Remove any loose debris from Line Breaker components using a sash brush and/or clean wiping rag. Use a shop vacuum to blow filtered, clean and dry air through the arc chute from the side of the latches to remove loose dust and debris.

7–8.10.9 LINE BREAKER CHECKOUT PROCEDURE

WARNING: CONTROL AND POWER VOLTAGE WILL BE RESTORED TO THE LINE BREAKER GROUP DURING THIS TEST. HIGH VOLTAGE WILL BE PRESENT WITHIN LINE BREAKER GROUP. THIS VOLTAGE CAN BE FATAL IF CONTACTED. FAILURE TO COMPLY WITH ALL RAILROAD SAFETY REGULATIONS CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

a. With the line breaker and all covers reinstalled in the line breaker group, restore power to the car.

b. Perform self–test on the car by first charging the air system, placing the Master Controller handle in the "Auto Store" position, connecting the PTU to the propulsion system control, and commanding the propulsion system to enter the "Self Test" mode via the PTU.

c. After the air compressor has stopped running (i.e. air system pressure at 155 PSI +/– 10 PSI), pick–up and drop–out the LIne Breaker 4 times to verify proper line breaker operation and to verify puffer operation.

d. Place an 8 gallon plastic bag over the exhaust tube opening at the bottom right side of the arc chute cover. Use the palm of your left hand to seal the exhaust air from the left exhaust opening.

e. After the air compressor has stopped running, energize, then deenergize the line breaker. AT 155 PSI +/– 10 PSI, the bag should fill.

NOTE: A small leak caused by improper sealing of the line breaker side of the box will result in the plastic bag not filling during this checkout procedure.

f. If the bag does not fill, repeat steps (d) and (e). If after repeating the steps there is no change in the ability to fill the bag, either the sealing of the line breaker side of the box is improper or the seal of the bag to exhaust opening is improper or the seal made by the palm of you hand is improper. Inspect and correct, and repeat steps (d) and (e).

7–8.11 LINE BREAKER OVERLOAD RESET RELAY (LBRR), 17LV66CY53

7–8.11.1 DESCRIPTION AND OPERATION

The 17LV66CY53 Relay (Figure 7–153) is an electro–magnetic switching device, remotely controlled for opening and closing control circuits. It consists of a coil, armature, core, magnet frame and electrical contacts. There are three double throw contacts and one normally open (N.O.) contact on this relay. The relay is approximately 4–1/4 inches wide x 4–3/4 inches high x 5–3/4 inches deep and weighs approximately 5 pounds.

The relay contacts change state when the coil is energized or de–energized. The normally closed (N.C.) contacts are closed when the coil is de–energized and opened when the coil is energized. The N.O. contacts are open when the coil is de–energized and closed when the coil is energized.

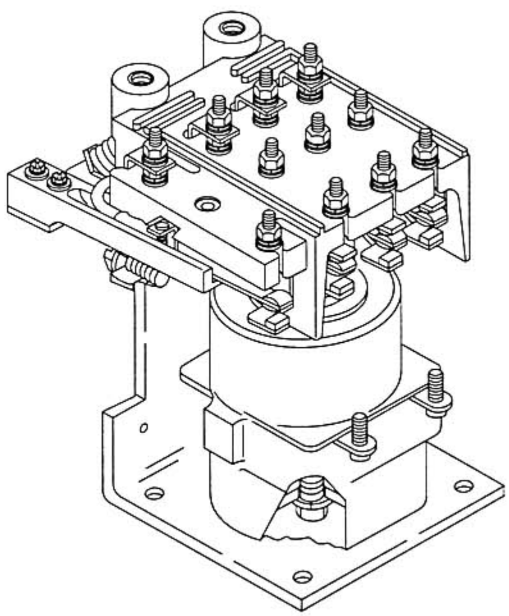


Figure 7–153 Line Breaker Overload Reset Relay (LBRR), 17LV66CY53

7–8.11.2 FAULT ISOLATION

Refer to section 7–7.2.

7–8.11.3 MAINTENANCE PRACTICES

Not applicable.

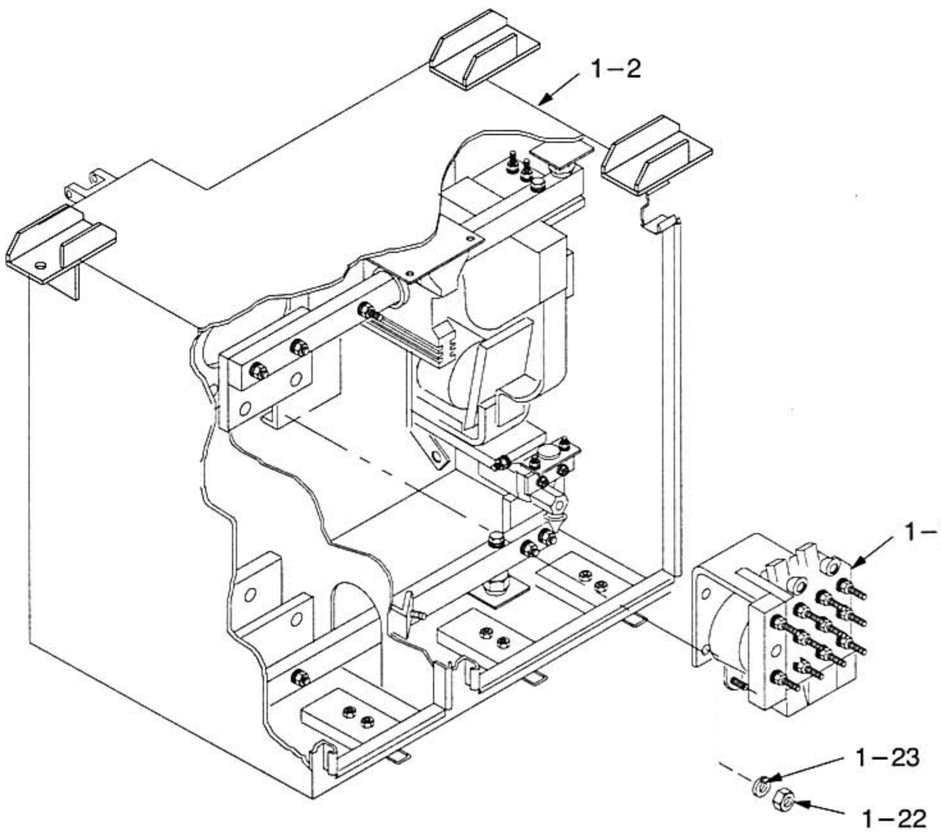
7–8.11.4 SERVICING

Not applicable.

7–8.11.5 REMOVAL/INSTALLATION

a. Tag and remove/install wires.

b. Remove/install hardware (1–22, 1–23, Figure 7–154) which secures relay (1–17) to case weldment (1–2). Torque hardware to 74–83 in. lbs.



1–2. Case Weldment
1–17. Relay
1–22. Locknut
1–23. Washer

Figure 7–154 Remove/Install Relay (LBRR), 17LV66CY53

7–8.11.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–8.11.7 INSPECTION/CHECK

a. Inspect relay (reference Figure 7–155) for obvious physical damage such as broken or missing parts. If found, replace relay.

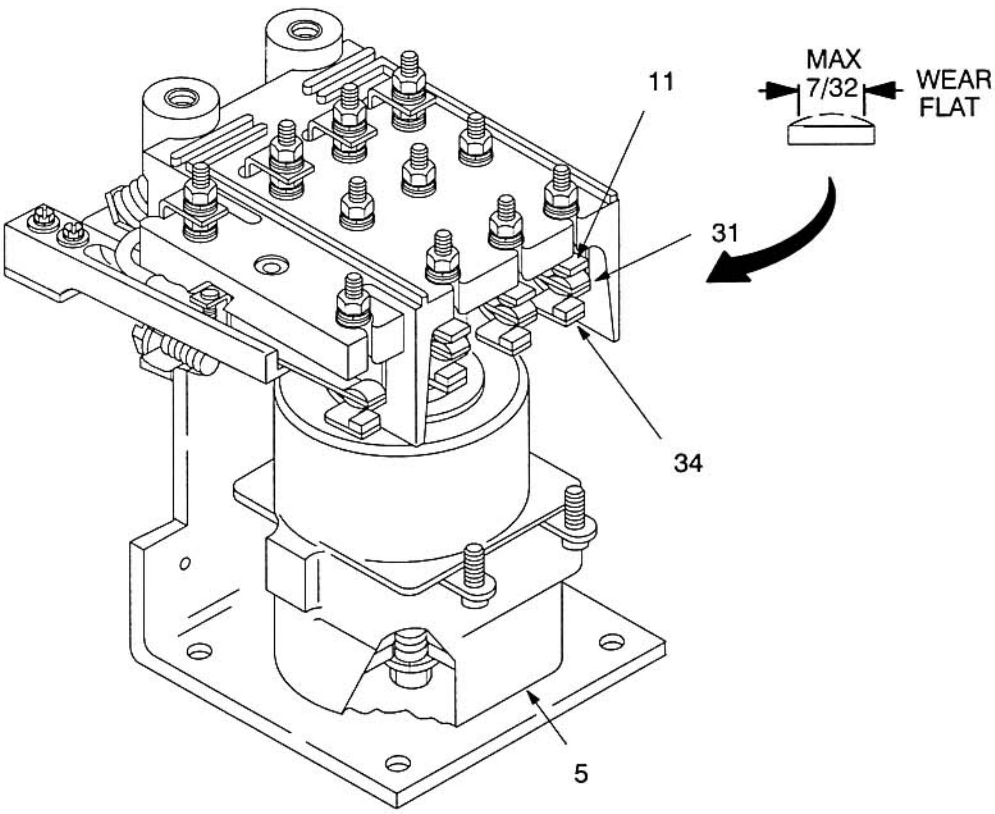
b. If coil or circuit terminal hardware is loose, tighten as necessary.

c. If coil (5) is swollen or burnt, replace relay.

d. Inspect contacts (11, 31, 34). If worn or burnt replace both stationary and movable contacts as a set.

e. Inspect relay fingers and contacts. If burned or silver plating is worn thru, replace both stationary and movable contacts as a set. If spherical finger or contact wear flat exceeds 7/32 in., replace both stationary and movable contacts as a set.

f. If shunts on moveable contacts are frayed, discolored, or broken, replace relay.



5. Operating Coil
11. Offset Contact
31. Finger Assembly
34. N.O. Contact

Figure 7–155 Inspect Relay (LBRR), 17LV66CY53

7–8.11.8 CLEANING/PAINTING

Remove any loose debris from relay using a sash brush and/or clean wiping rag.

7–9 RAIL GAP GROUP – 17KG515A1

7–9.1 DESCRIPTION AND OPERATION

The 17KG515A1 Rail Gap Group is of modular configuration measuring 47 in. long, 14 in. deep, 17 in. high and weighing approximately 300 lb. It contains Line Replaceable Units (LRUs) which result in minimum number of unique sub–assemblies and maintenance time for removal/replacement, and component location during troubleshooting. Figure 7–156 shows the location of the Rail Gap Group in the Vehicle.

The Rail Gap Group houses the knife switch, SCR panel, diode panel, GFM panel, and resistor assemblies.

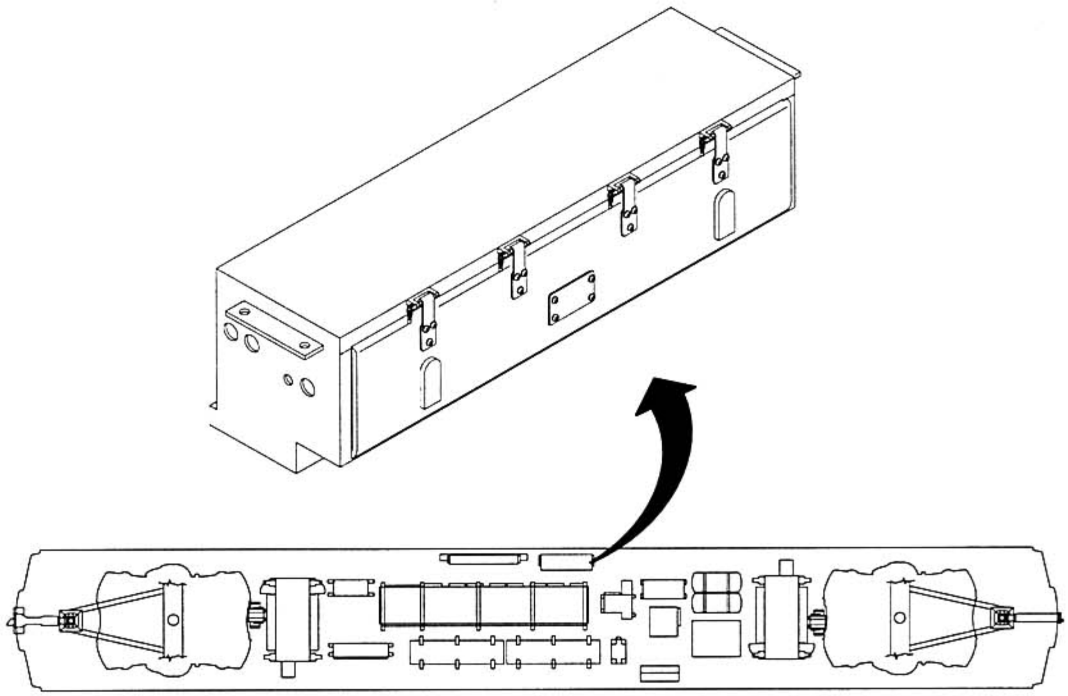


Figure 7–156 Rail Gap Group – 17KG515A1

<u>WARNING:</u>	HIGH VOLTAGE IS PRESENT ON THE RAIL GAP GROUP. THIS VOLTAGE CAN BE FATAL IF CONTACTED. REMOVE ALL POWER AND ASSURE ALL CAPACITORS ARE DISCHARGED BEFORE WORKING ON GROUP. FAILURE TO COMPLY WITH ALL RAILROAD SAFETY REGULATIONS CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

7–9.2 FAULT ISOLATION

Refer to section 7–7.2.

7–9.3 MAINTENANCE PRACTICES

Not applicable.

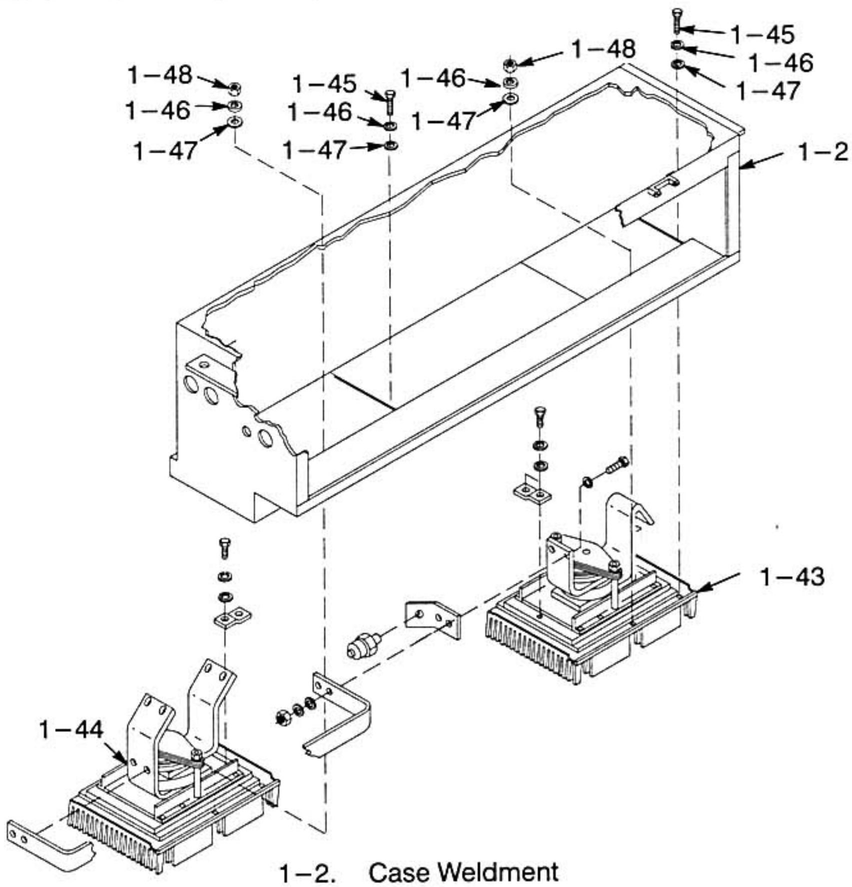
7–9.4 SERVICING

Not applicable.

7–9.5 REMOVAL/INSTALLATION

a. Remove/install Diode Panel (1–44, Figure 7–157) to case weldment (1–2) using hardware (1–45, 1–46, 1–47, 1–48). Torque hardware to 34–38 ft. lbs.

b. Remove/install SCR Panel (1–43, Figure 7–157) to case weldment (1–2) using hardware (1–45, 1–46, 1–47, 1–48). Torque hardware to 34–38 ft. lbs.



1–2. Case Weldment
1–43. SCR Panel
1–44. Diode Panel
1–45. Bolt
1–46. Lockwasher
1–47. Washer
1–48. Hex Nut

Figure 7–157 Remove/Installl Diode and SCR Panels

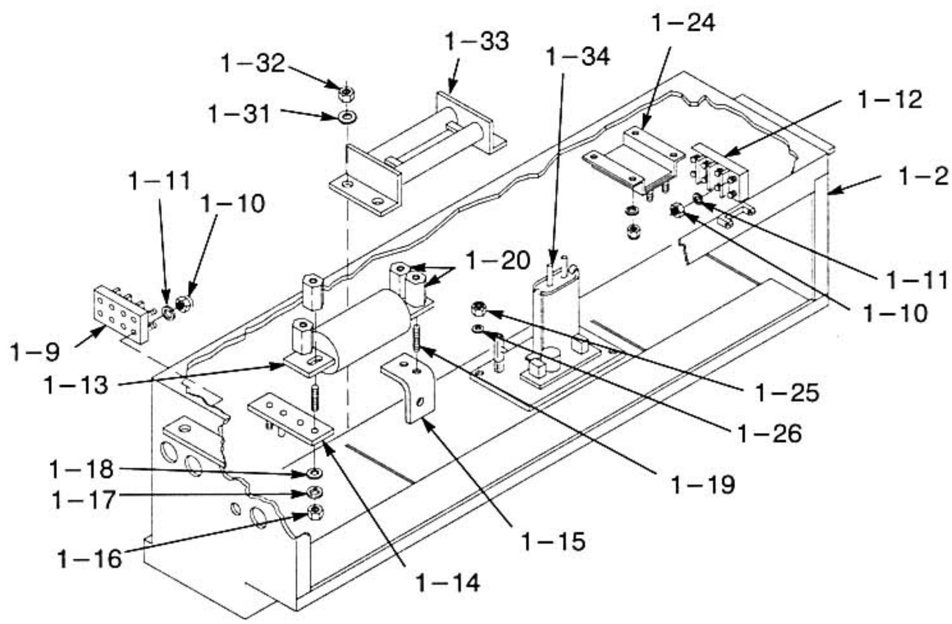
c. Remove/install Resistor Panel (1–33, Figure 7–158) to case weldment (1–2) using hardware (1–31, 1–32). Torque hardware to 35–39 in. lbs.

d. Remove/install Panel (1–34, Figure 7–158) to case weldment (1–2) using hardware (1–25, 1–26). Torque hardware to 30–35 in. lbs.

e. Remove/install Fuse with insulators and bus bars (1–13, 1–14, 1–15, 1–20, Figure 7–158) to case weldment (1–2) using hardware (1–16, 1–17, 1–18, 1–19). Torque hardware to 10–11 ft. lbs.

f. Remove/install VAM Panel (1–24, Figure 7–158) to case weldment (1–2) using hardware (1–25, 1–26). Torque hardware to 74–83 in. lbs.

g. Remove/install Terminal Boards (1–9, 1–12, Figure 7–158) to case weldment (1–2) using hardware (1–10, 1–11). Torque hardware to 10–12 in. lbs.

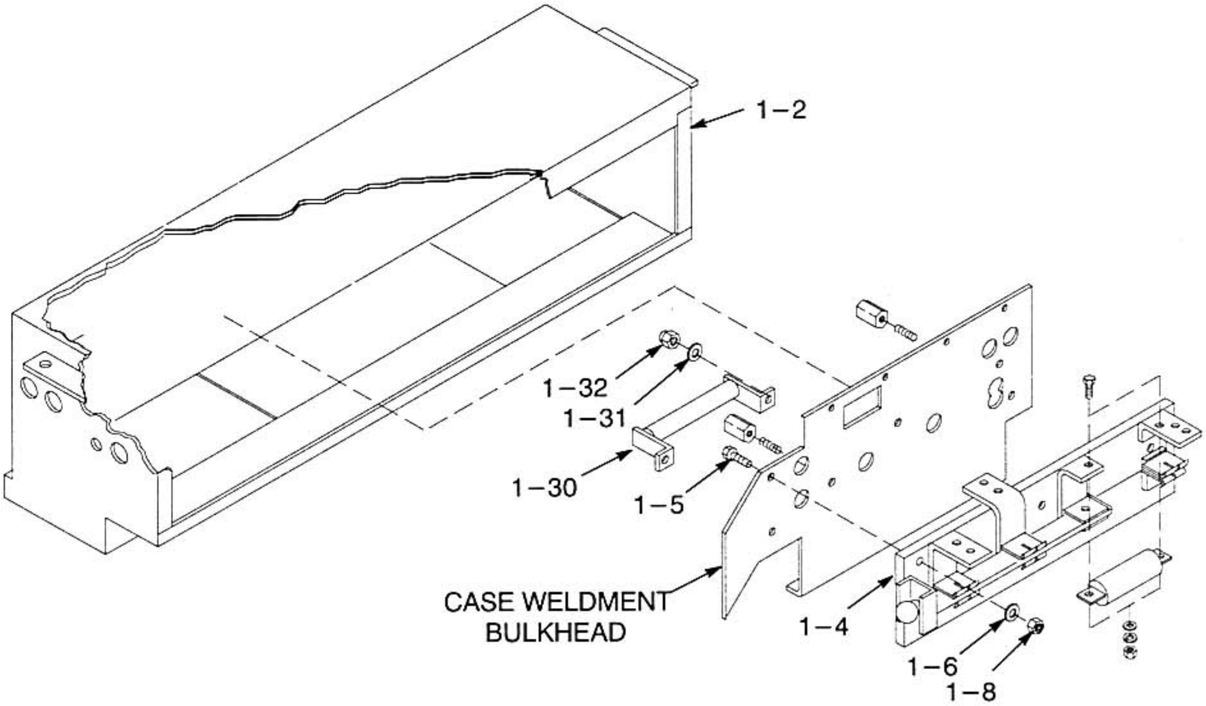


1–2. Case Weldment	1–18. Washer
1–9. Terminal Board	1–19. Stud
1–10. Locknut	1–20. Insulator
1–11. Washer	1–24. VAM Panel
1–12. Terminal Board	1–25. Locknut
1–13. 1000A Fuse (MPF)	1–26. Washer
1–14. Bus Bar	1–31. Washer
1–15. Bus Bar	1–32. Locknut
1–16. Hex Nut	1–33. Resistor Panel
1–17. Lockwasher	1–34. Panel

Figure 7–158 Remove/Install Fuse, Panels, and Terminal Boards

h. Remove/install Knife Switch (1–4, Figure 7–159) to case weldment (1–2) using hardware (1–5, 1–6, 1–8). Torque hardware to 8–10 ft. lbs.

i. Remove/install Resistor Panel (1–30, Figure 7–159) to case weldment (1–2) using hardware (1–31, 1–32). Torque hardware to 35–39 in. lbs.



1–2.	Case Weldment	1–27.	Fuse 250A (AF)
1–4.	Knife Switch	1–30.	Resistor Panel
1–5.	Bolt	1–31.	Washer
1–6.	Washer	1–32.	Locknut
1–8.	Locknut		

Figure 7–159 Remove/Install Knife Switch and Resistor Panel

7–9.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–9.7 INSPECTION/CHECK

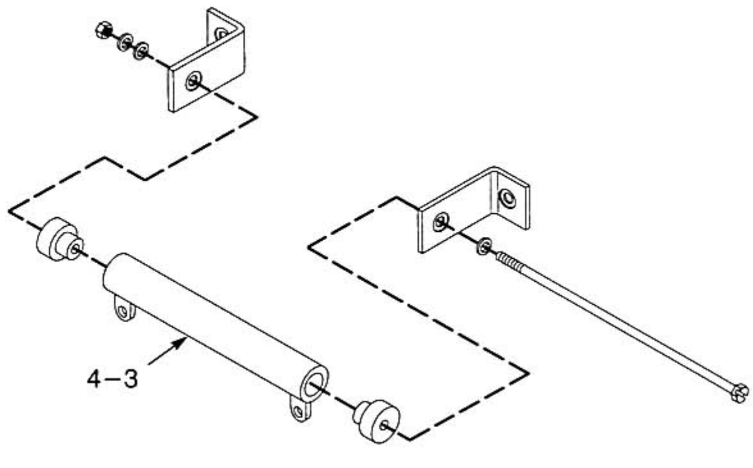
7–9.7.1 Inspect Rail Gap Group components

Inspect all parts for cracks, breaks, or obvious physical damage. If found, replace as required.

7–9.7.2 Inspect Resistor Panel 41C668977G1

a. Inspect all components for cracks, burn marks, or obvious physical damage. If found, replace defective component.

b. Use an ohmmeter to check resistor (4–3, Figure 7–160) resistance. If resistance is not 8000 ± 5% ohms, replace resistor.



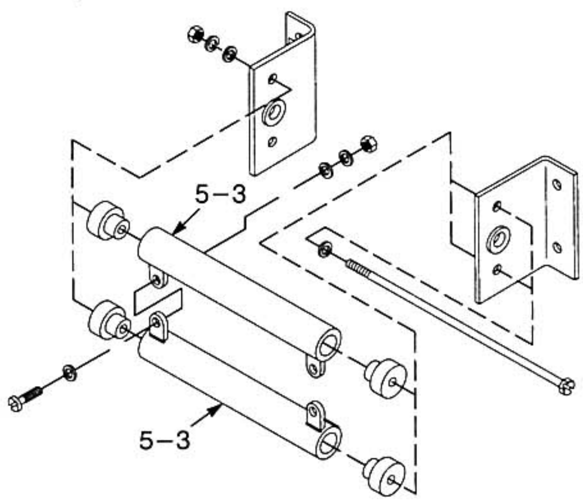
4–3. Resistor

Figure 7–160 Inspect/Check Resistor Panel

7–9.7.3 Inspect Resistor Panel 41C668644G1

a. Inspect all components for cracks, burn marks, or obvious physical damage. If found, replace defective component.

b. Use an ohmmeter to check resistors (5–3, Figure 7–161) resistances. If resistance is not 10000±5% ohms, replace resistor.



5–3. Resistor

Figure 7–161 Inspect/Check Resistor Panel

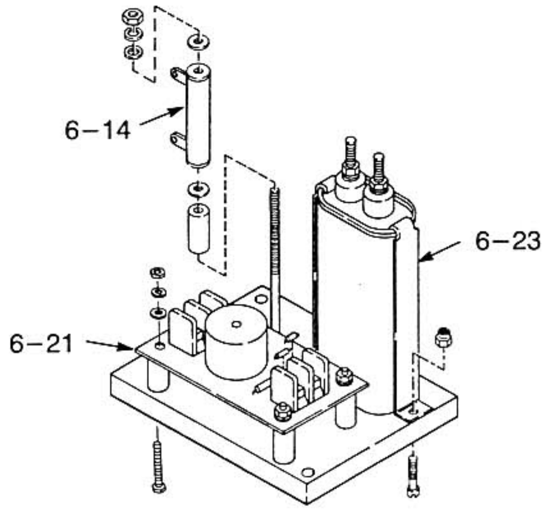
7–9.7.4 Inspect Panel 17FM573B1

a. Inspect all components for cracks, burn marks, or obvious physical damage. If found, replace defective component.

b. Remove and replace module (6–21, Figure 7–162). Torque mounting hardware to 14–16 in. lb.

c. Use an ohmmeter to check resistor (6–14) resistance. If resistance is not 5±5% ohms, replace resistor.

d. Use a capacitor checker to verify capacitor (6–23) has a capacitance of 4MFD. If capacitance is incorrect, replace capacitor.



6–14. Resistor
6–21. Module
6–23. Capacitor

Figure 7–162 Inspect/Check Panel

7–9.8 CLEANING/PAINTING

> **WARNING:** THE FOLLOWING STEP REQUIRES USE OF A STEAM CLEANER. FOLLOW ALL SHOP SAFETY PROCEDURES FOR OPERATION OF THIS EQUIPMENT. FAILURE TO DO SO CAN RESULT IN PERSONAL INJURY.

a. Use a steam cleaner to remove grease and residue from case weldment and covers. Recommended working pressure is 120 psi at 160–180°F.

b. Use a sash brush and/or clean wiping rag to remove dirt and residue from rail gap group components.

7–9.9 KNIFE SWITCH (KNSW), 41A327724P1

7–9.9.1 DESCRIPTION AND OPERATION

The 41A327724P1 Knife Switch is a manually operated switch for the connection and disconnection of either third rail power or shop power to the propulsion and auxiliary circuits. The switch consists of a four position, three pole, switch; a single pole, single throw interlock switch; a double pole, single throw interlock switch; and a shop test power plug. The switch also has a mechanical stop to prevent accidental engagement of the run position and to hold the shop power receptacle in place when in the shop test position.

The four switch positions are as follows:

Position 1 "RUN" – Supplies third rail power to the auxiliary and propulsion circuits.
Position 2 "RAIL TEST" – Supplies third rail power to the auxiliary circuit only.
Position 3 "OFF" – Disconnects power from all circuits.
Position 4 "SHOP TEST" – Supplies shop power to the auxiliary circuit, when connected to the shop power receptacle.

The single pole, single throw interlock switch is used to sense the shop power position of the switch. The double pole, single throw switch is used to sense the run position of the switch.

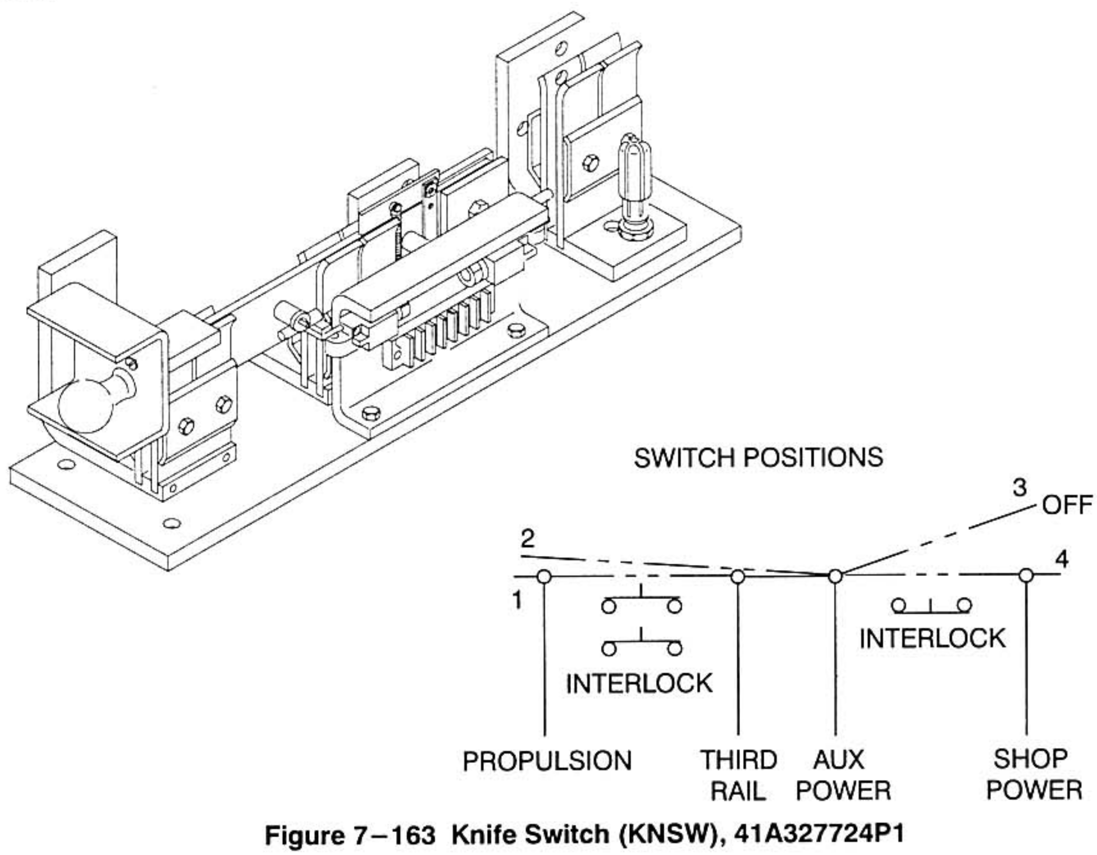


Figure 7–163 Knife Switch (KNSW), 41A327724P1

7–9.9.2 FAULT ISOLATION

Refer to section 7–7.2.

7–9.9.3 MAINTENANCE PRACTICES

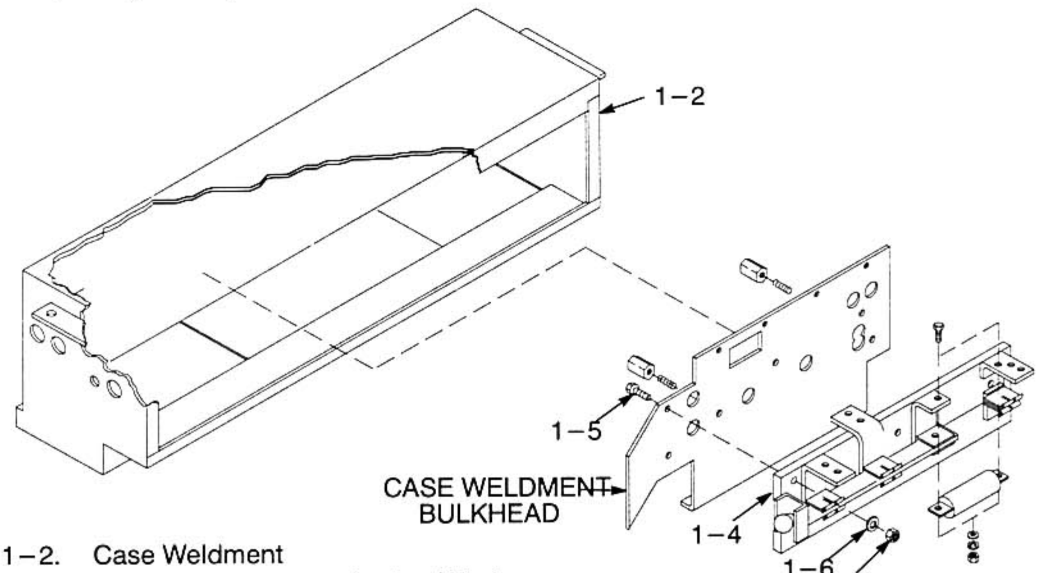
Not applicable.

7–9.9.4 SERVICING

Not applicable.

7–9.9.5 REMOVAL/INSTALLATION

Remove/install Knife Switch (1–4, Figure 7–159) to case weldment (1–2) using hardware (1–5, 1–6, 1–8). Torque hardware to 8–10 ft. lbs.



1–2. Case Weldment
1–4. Knife Switch
1–5. Bolt
1–6. Washer
1–8. Locknut

Figure 7–164 Remove/Install Knife Switch and Resistor Panel

7–9.9.6 ADJUSTMENT/TEST

7–9.9.6.1 Adjust Tension Hardware

a. Position the blade assembly (1–3, Figure 7–165) to fully engage the leaves of the propulsion power clip (1–20) and the third rail power clip (1–25).

b. Attempt to insert a 0.0015 in. feeler gage between the knife blade and the leaves in the contact areas.

c. The gage should be rejected in a minimum of 75% of each contact area.

d. If the rejection rate is less than 75%, tighten the tension hardware (1–23, 1–24) until the spacing between the tension springs (1–21) and the leaves is 0.125 in. with the knife blade engaged. Repeat feeler gage rejection procedure.

e. Repeat the rejection test between the leaves of the hinge block (1–26) and the knife blade. Tighten the tension hardware as required.

f. Position the blade assembly to fully engage the leaves of the SPS power clip (1–30) and repeat the rejection test and tighten the tension hardware as required.

g. Operate the knife switch blade to fully engage and disengage each power clip several times. Repeat the rejection test and tighten the hardware as required.

1– 3. Knife Blade Assembly
1–20. Power Clip
1–21. Spring
1–23. Hex Head Bolt
1–24. Locknut
1–25. Power Clip
1–26. Hinge Block
1–30. Power Clip

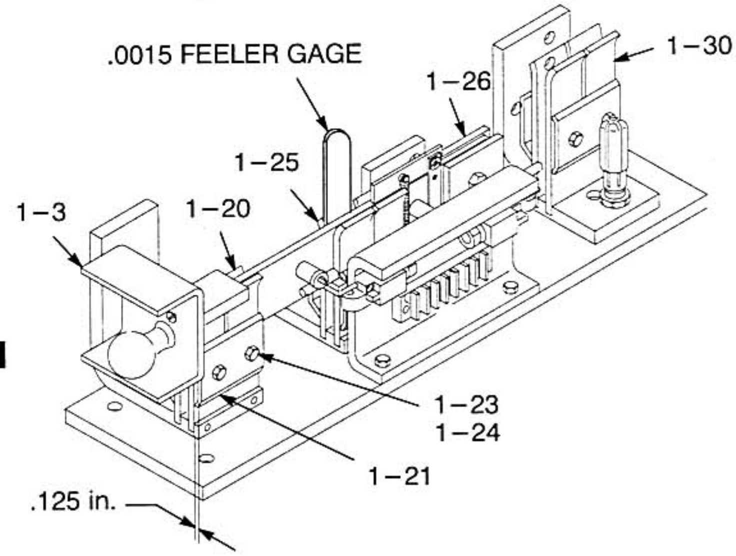
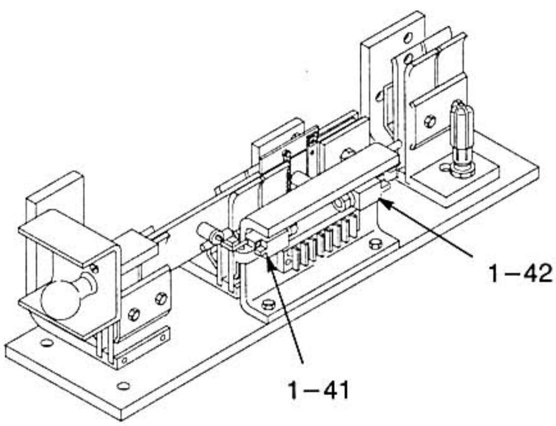


Figure 7–165 Adjust Tension Hardware

7–9.9.6.2 Adjust Interlock Switches

a. With the knife switch in the listed positions, use a continuity checker to verify interlock switch (1–41, 1–42, Figure 7–166) contacts open and close as indicated.

b. If switch closure is incorrect loosen trip arm screws, rotate trip arms on serrated shafts as required, tighten screws and report test.



1–41. Interlock Switch
1–42. Interlock Switch

INTERLOCK SWITCH LOGIC

KNIFE SWITCH POSITION	SWITCH 1–41 KS12	SWITCH 1–41 KS13	SWITCH 1–42 KS11
(1) RUN	C	C	C
(2) RAIL TEST	O	O	C
(3) OFF	O	O	C
(4) SHOP TEST	O	O	O

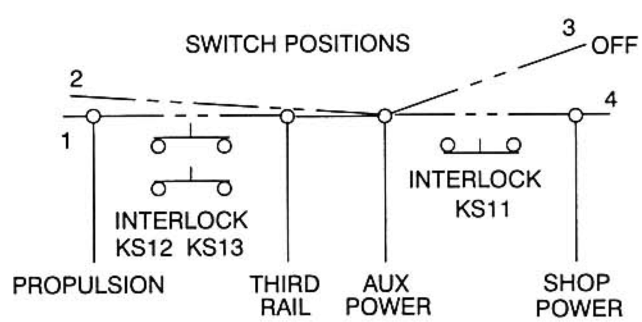


Figure 7–166 Adjust Interlock Switches

7–9.9.7 INSPECTION/CHECK

a. Inspect all parts for any obvious physical damage.

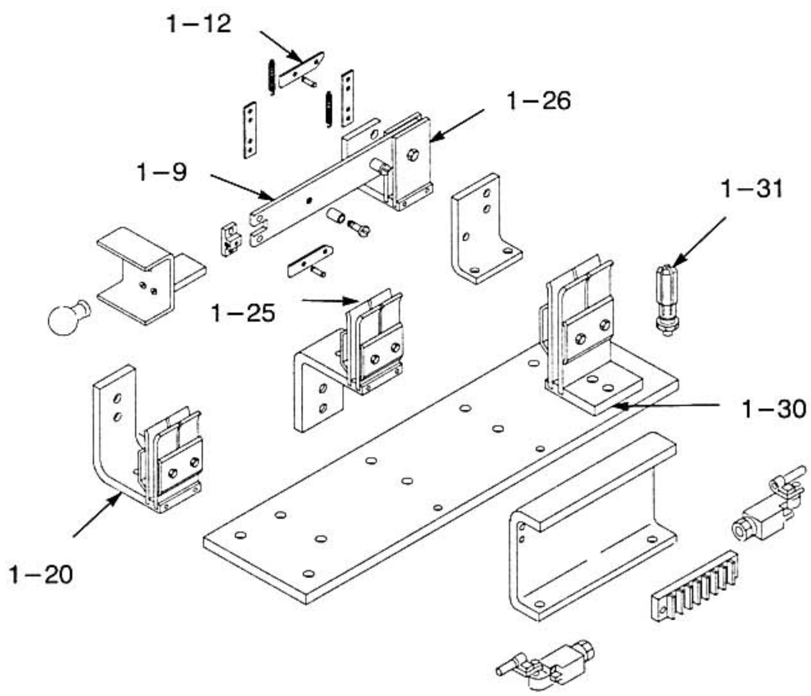
b. Inspect the contact surfaces of the power clip assemblies (1–20, 1–25, 1–30, Figure 7–167), hinge block (1–26), blade (1–9), and fly blades (1–12) for pits or burn marks. If found replace defective component.

7–9.9.8 CLEANING/PAINTING

a. Remove any loose debris from parts using a sash brush and/or clean wiping rag.

b. Any heavy build up of grease or oil may be removed by steam cleaning.

c. Use crocus cloth to remove any corrosion from the contact surfaces of the power clip assemblies (1–20, 1–25, 1–30, Figure 7–167), hinge block (1–26), knife blade (1–9), fly blades (1–12), and test plug (1–31).



1–9. Blade	1–26. Hinge Block
1–12. Fly Blade	1–30. Power Clip
1–20. Power Clip	1–31. Test Plug
1–25. Power Clip	

Figure 7–167 Inspection and Cleaning of Knife Switch Components

7–9.10 PANEL SCR – 84D704294G1

7–9.10.1 DESCRIPTION AND OPERATION

The 84D704294G1 SCR Panel allows the flow of regeneration current when voltage conditions are correct and gate is fired. It also halts the flow of current when "dead" third rail is encountered while regenerating. This device is convection cooled.

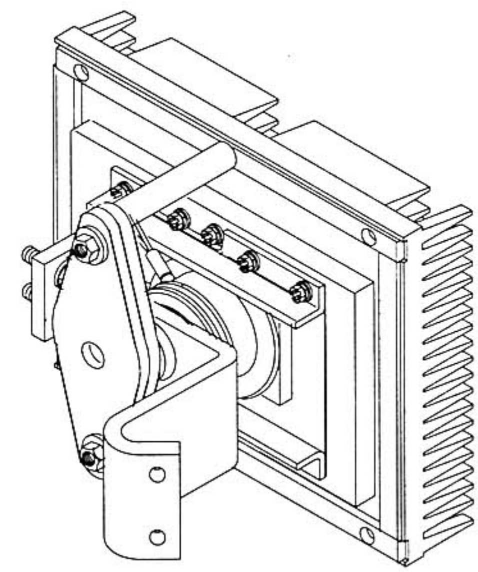


Figure 7–168 Panel SCR – 84D704294G1

7–9.10.2 FAULT ISOLATION

Refer to section 7–7.2.

7–9.10.3 MAINTENANCE PRACTICES

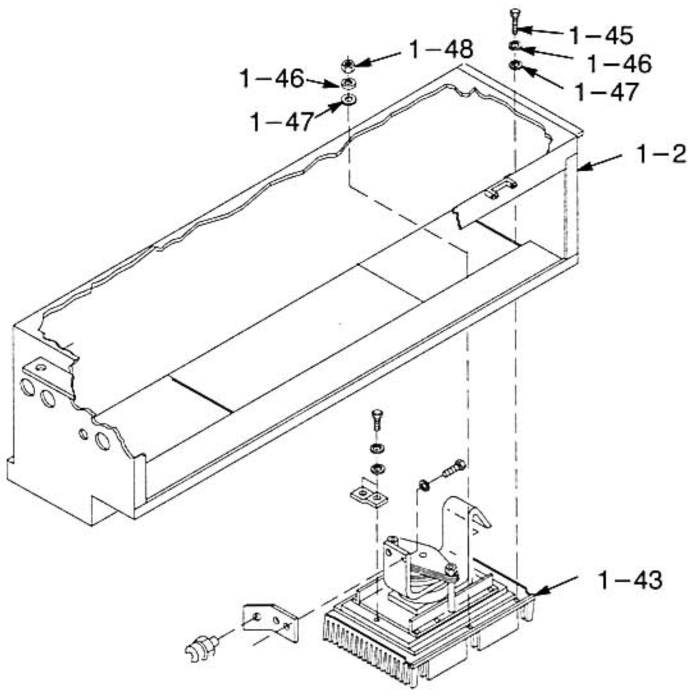
Not applicable.

7–9.10.4 SERVICING

Not applicable.

7–9.10.5 REMOVAL/INSTALLATION

a. Remove/install SCR Panel (1–43, Figure 7–169) to case weldment (1–2) using hardware (1–45, 1–46, 1–47, 1–48). Torque hardware to 34–38 ft. lbs.



1–2. Case Weldment
1–43. SCR Panel
1–45. Bolt
1–46. Lockwasher
1–47. Washer
1–48. Hex Nut

Figure 7–169 Remove/Installl SCR Panel

7–9.10.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–9.10.7 INSPECTION/CHECK

Inspect all parts for bends, cracks, breaks, pits, or obvious physical damage. If found, replace as required.

7–9.10.8 CLEANING/PAINTING

Using a sash brush and a clean wiping rag remove any loose debris from the SCR Panel.

7–9.11 PANEL DIODE – 84D704327G1

7–9.11.1 DESCRIPTION AND OPERATION

The 84D704327G1 Diode Panel provides protection against high dv/dt and di/dt for DL and SCRL. This device is convection cooled.

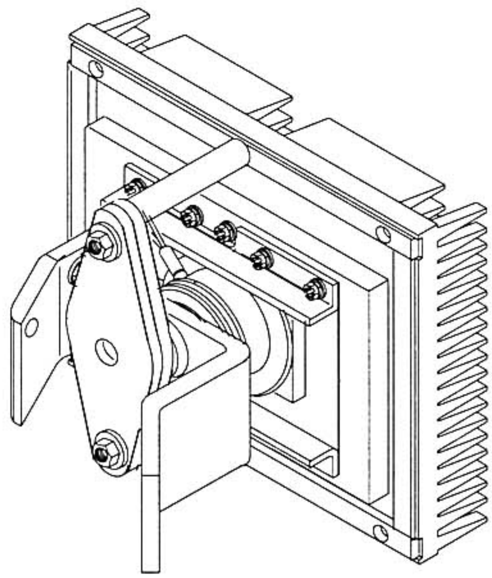


Figure 7–170 Panel Diode – 84D704327G1

7–9.11.2 FAULT ISOLATION

Refer to section 7–7.2.

7–9.11.3 MAINTENANCE PRACTICES

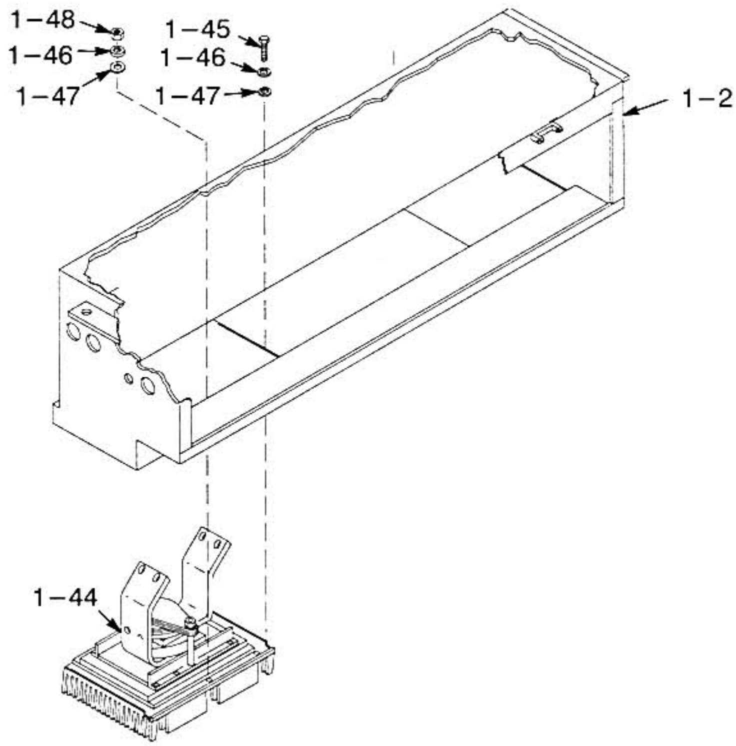
Not applicable.

7–9.11.4 SERVICING

Not applicable.

7–9.11.5 REMOVAL/INSTALLATION

Remove/install Diode Panel (1–44, Figure 7–171) to case weldment (1–2) using hardware (1–45, 1–46, 1–47, 1–48). Torque hardware to 34–38 ft. lbs.



1–2. Case Weldment
1–44. Diode Panel
1–45. Bolt
1–46. Lockwasher
1–47. Washer
1–48. Hex Nut

Figure 7–171 Remove/Installl Diode Panel

7–9.11.6 ADJUSTMENT/TEST

Refer to section 7–7.6.

7–9.11.7 INSPECTION/CHECK

Inspect all parts for bends, cracks, breaks, pits, or obvious physical damage. If found, replace as required.

7–9.11.8 CLEANING/PAINTING

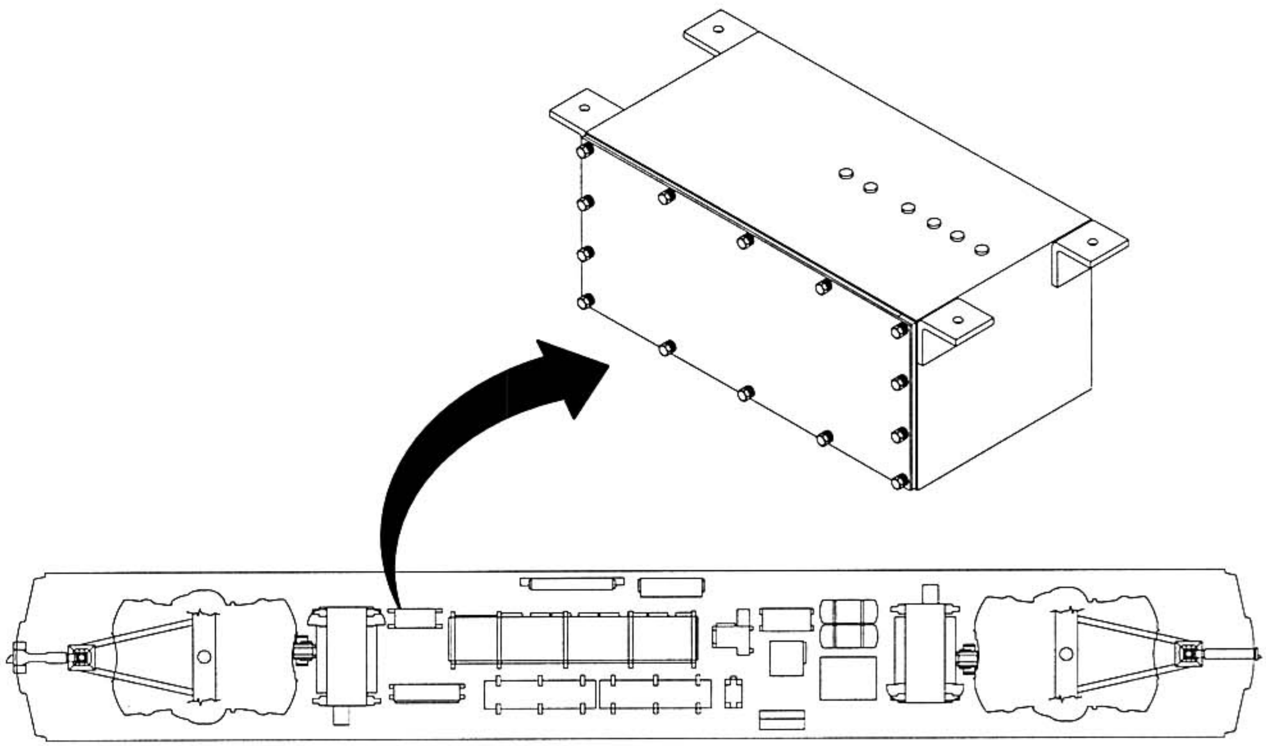
Using a sash brush and a clean wiping rag remove any loose debris from the Diode Panel.

7–10 CONTACTOR GROUP – 17KG511A1

7–10.1 DESCRIPTION AND OPERATION

The Contactor Group 17KG511A1 (Figure 7–172) is located on the "A" car only. The contactor group houses a low voltage contactor for load shed on the "A" car and its corresponding fuse. This group also contains circuit breakers for the gate drive power supplies for the "A" car propulsion system. There is no high voltage cabling present. The contactor group only serves as a part of the low voltage power distribution system.

Fabricated from sheet steel with a steel cover, the group is electrostatically powder coated white inside and out with a gray satin lacquer top coat on the outside surfaces. The overall dimensions are 33 in. long x 12 in. high x 14.5 in. deep. Less external cables, the group weight is approximately 60 lb.



(A–Car Undercar Arrangement)

Figure 7–172 Contactor Group – 17KG511A1

> **WARNING:** **LOW VOLTAGE IS PRESENT ON THE CONTACTOR GROUP. REMOVE ALL POWER PRIOR TO REMOVING UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

7–10.2 FAULT ISOLATION

Not applicable.

7–10.3 MAINTENANCE PRACTICES

Not applicable.

7–10.4 SERVICING

Not applicable.

7–10.5 REMOVAL/INSTALLATION

a. Remove/install circuit breakers (1–7, Figure 7–173) to weldment (1–2) using hardware (1–10, 1–9, 1–8). Tighten screws to 9–10 in. lbs.

b. Remove/install terminal board (1–3) using hardware (1–4, 1–5, 1–6). Torque to 26–29 in. lbs.

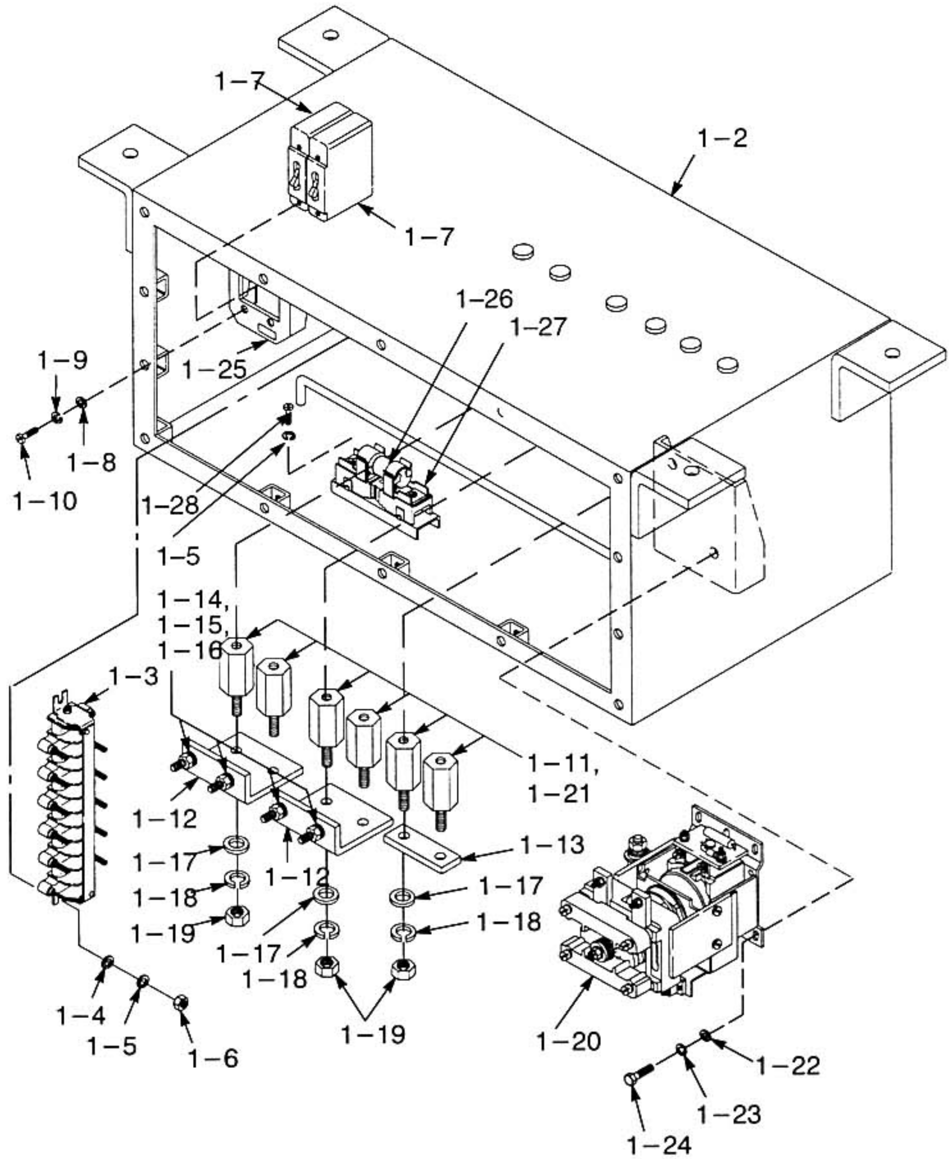
c. Replace defective insulators (1–11), if any. Use LOCTITE 271 on threaded insulator insert. Install insulators and torque to 17–19 ft. lbs.

d. Remove/install bus bars (1–12, 1–13) to insulators (1–11) with hardware (1–17, 1–18, 1–19). Torque hardware to 17–19 ft. lbs.

e. Remove/install contactor (1–20) with hardware (1–22, 1–23, 1–24). Torque hardware to 53–63 in. lbs.

f. Remove/install fuse (1–26).

g. Remove/install fuseholder (1–27) with hardware (1–28, 1–5). Torque to 26–29 in. lbs.



1–2	Weldment	1–11	Insulator	1–20	Contactor (KNE)
1–3	Terminal Board	1–12	Bus Bar	1–21	Sealant
1–4	Washer	1–13	Bus Bar	1–22	Washer
1–5	Lockwasher	1–14	Washer	1–23	Lockwasher
1–6	Nut	1–15	Lockwasher	1–24	Bolt
1–7	Circuit Breaker	1–16	Nut	1–25	Labels
1–8	Washer	1–17	Washer	1–26	Fuse, 80 Amp
1–9	Lockwasher	1–18	Lockwasher	1–27	Fuseholder
1–10	Nut	1–19	Nut	1–28	Screw

Figure 7–173 Contactor Group Removal/Installation

7–10.6 ADJUSTMENT/TEST

a. Close circuit breakers GDPSCB1 & 2. Verify control voltage to main inverters.

b. Start converter group (17KG512A1) and verify contactor (KNE) closes (picks up).

7–10.7 INSPECTION/CHECK

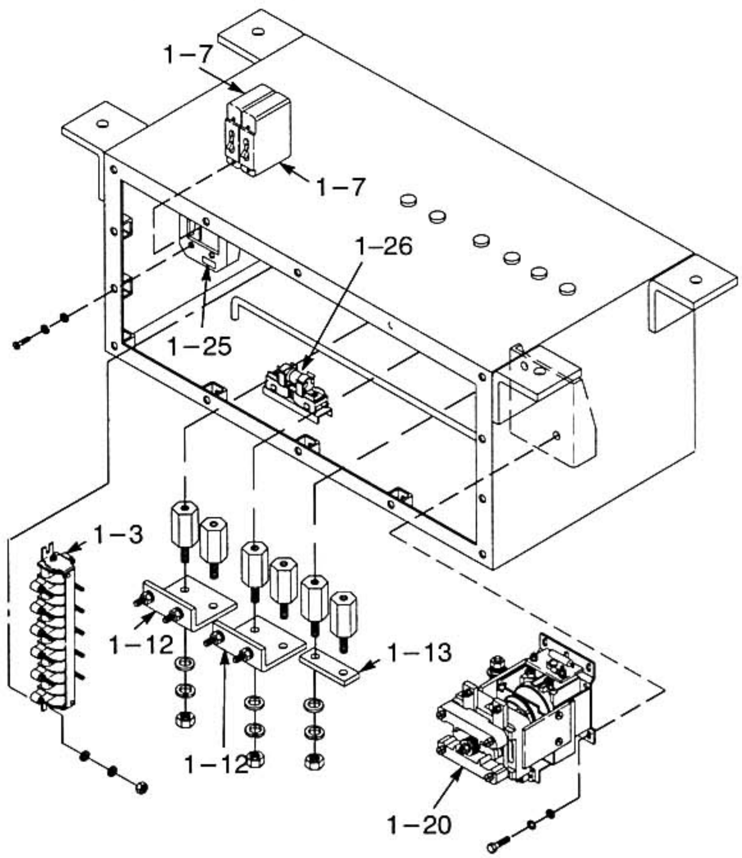
a. Inspect all parts for cracks, breaks or obvious physical damage. If found, replace defective parts.

b. Inspect fuse (1–26). If blown, replace fuse.

c. Inspect all wires and terminals for any obvious physical damage. If found, replace defective wires.

d. Inspect insulators (1–11, Figure 7–174) for cracks or damage. If found, replace defective insulators.

e. Inspect labels (1–25). Replace missing or damaged labels.



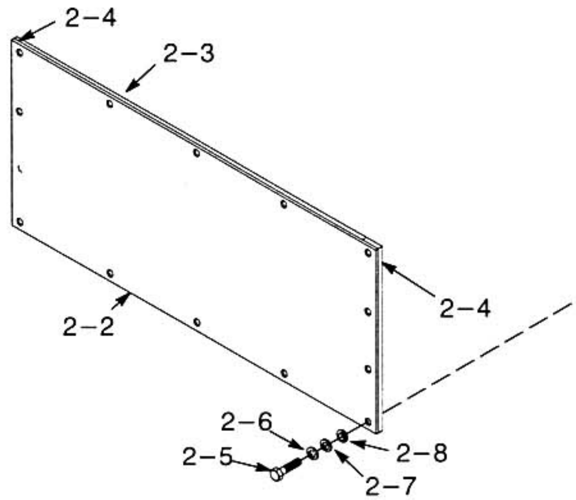
1–3. Terminal Board
1–7 Circuit Breaker
1–12 Bus Bar
1–13 Bus Bar
1–20 Contactor (KNE)
1–25 Labels
1–26 Fuse, 80 Amp

Figure 7–174 Inspect Contactor Group

f. Inspect cover (2–2, Figure 7–175) and cover hardware. Replace cover and cover hardware (2–5, 2–6, 2–7, 2–8) if damaged or missing.

g. Inspect cover gaskets (2–3, 2–4). Using a scraper, remove damaged cover gaskets and discard.

h. Use fine sandpaper to remove any residual glue from the area gaskets were removed. Use caution not to remove the finish in the areas which will not be covered by the new gaskets.



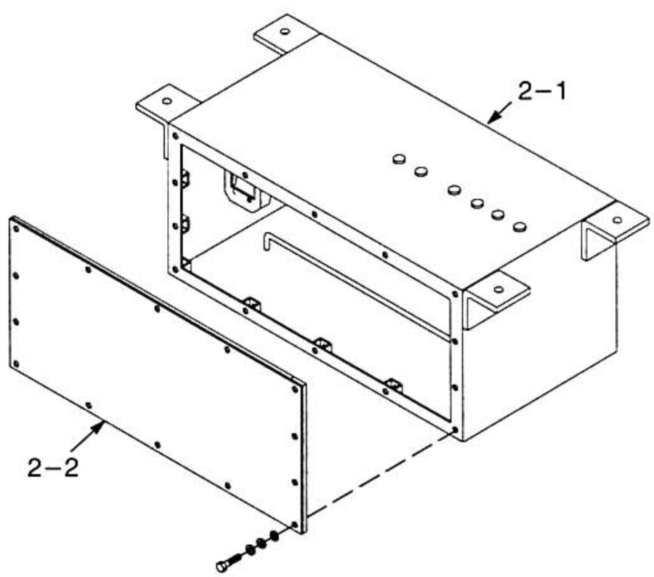
2–2 Cover
2–3 Gasket
2–4 Gasket
2–5 Bolt
2–6 Lockwasher
2–7 Washer
2–8 Seal Washer

Figure 7–175 Inspect Cover

7–10.8 CLEANING/PAINTING

a. Remove any loose debris from parts using a sash brush and/or clean wiping rag (Figure 7–176).

b. Use a steam cleaner to remove any heavy buildup on the case weldment (2–1) and cover (2–2).



2–1 Weldment
2–2 Cover

Figure 7–176 Clean Contactor Group

7–10.9 CONTACTOR (KNE) – 41B569857G2

7–10.9.1 DESCRIPTION AND OPERATION

The 41B569857G2 Contactor (KNE) is an electro magnetic switching device, remotely controlled for the opening and closing of control circuits. Located in the Contactor Group (17KG511A1) on the "A" car, it is a low voltage contactor for load shed.

The contactor contacts change state when the coil is energized and de–energized. The normally closed (N.C.) contacts are closed when the coil is de–energized and opened when the coil is energized. The normally open (N.O.) contacts are open when the coil is de–energized and closed when the coil is energized. The contactor also has an integral interlock which is used to transmit relay position through the standard control logic circuit.

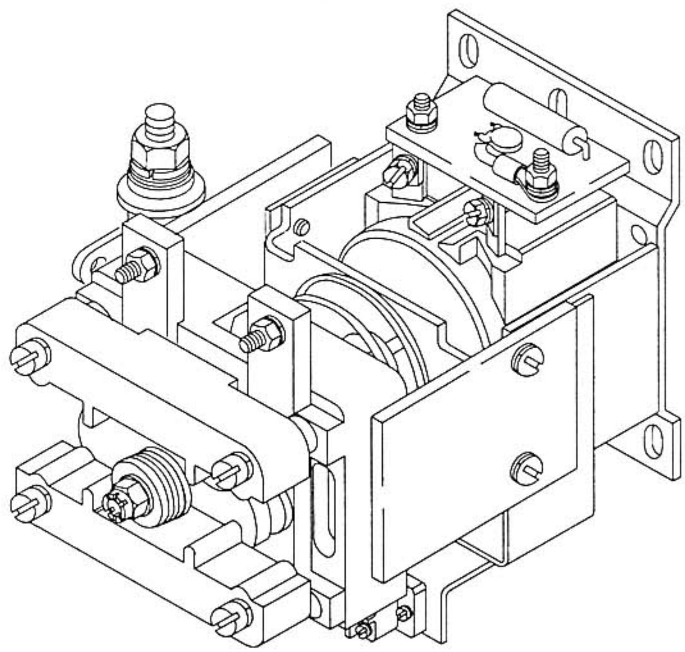


Figure 7–177 Contactor – 41B569857G2

7–10.9.2 FAULT ISOLATION

Not applicable.

7–10.9.3 MAINTENANCE PRACTICES

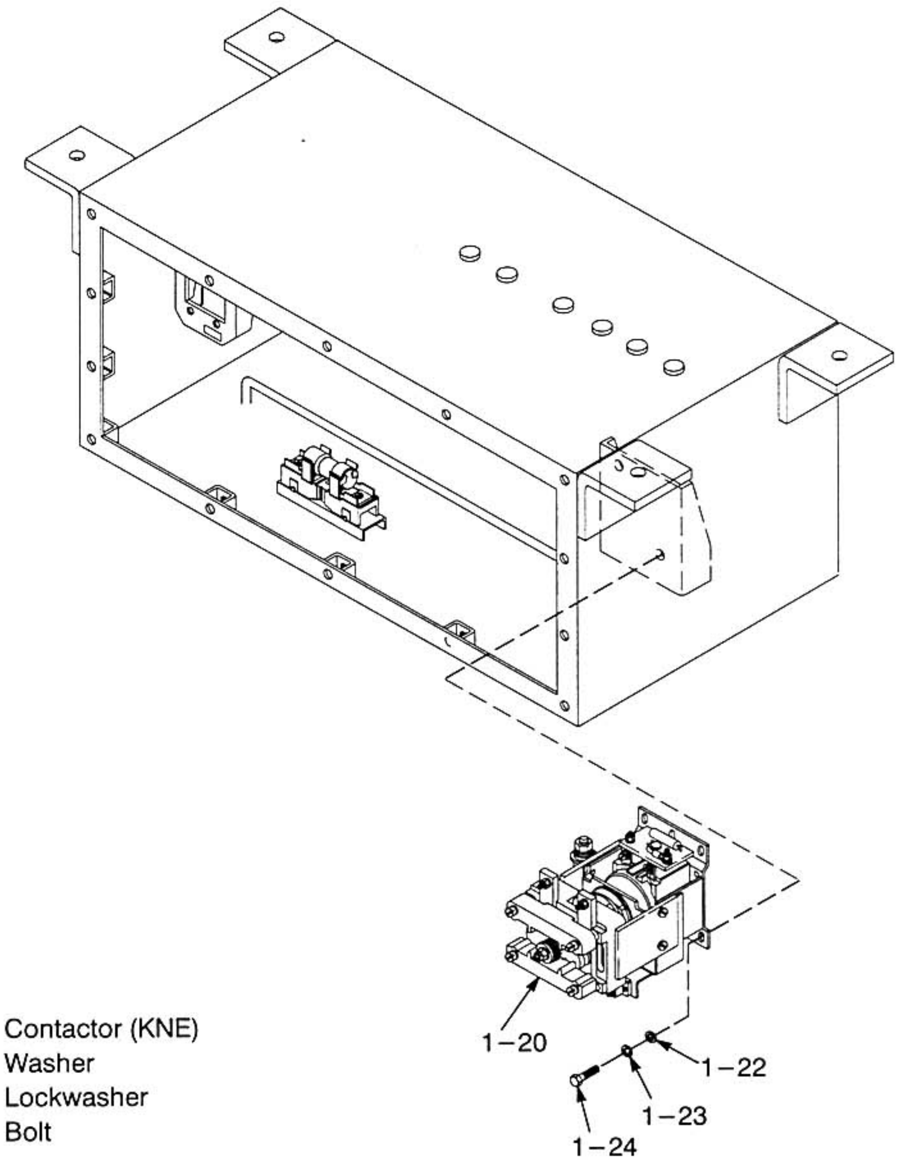
Not applicable.

7–10.9.4 SERVICING

Not applicable.

7–10.9.5 REMOVAL/INSTALLATION

Remove/install contactor (1–20, Figure 7–178) with hardware (1–22, 1–23, 1–24). Torque hardware to 53–63 in. lbs.



1–20 Contactor (KNE)
1–22 Washer
1–23 Lockwasher
1–24 Bolt

Figure 7–178 Contactor (KNE) Removal/Installation

7–10.9.6 ADJUSTMENT/TEST

a. Close circuit breakers GDPSCB1 & 2. Verify control voltage to main inverters.

b. Start converter group (17KG512A1) and verify contactor (KNE) closes (picks up).

7–10.9.7 INSPECTION/CHECK

a. Inspect all parts for any obvious physical damage.

b. Inspect the frame and base (2–19, 2–20, Figure 7–179) for cracks or breaks. If found replace frame or base.

c. Inspect tip guides (2–17, 2–18) for wear. If found replace guide.

d. Inspect armature (2–10) for bends, burrs or wear. If found replace armature.

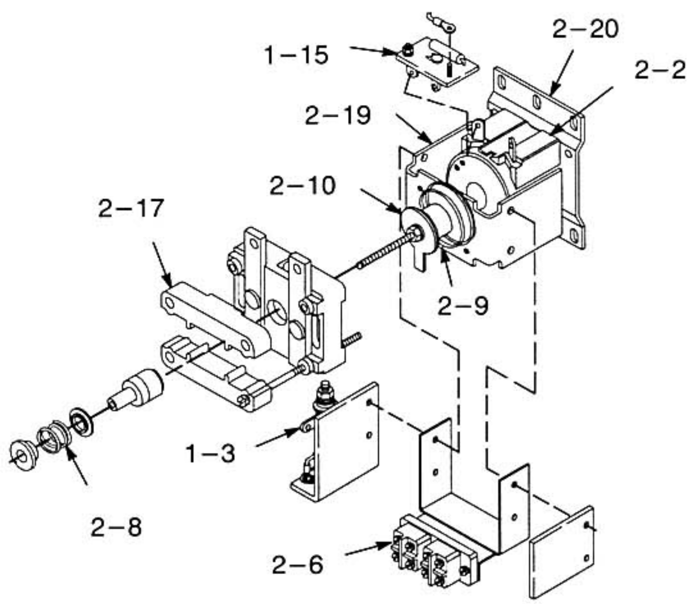
e. Inspect springs (2–8, 2–9) for bends, breaks or other obvious damage. If found, replace spring.

f. Inspect coil (2–2) for cracks, breaks or burn marks. If found replace coil.

g. Inspect interlock (2–6) for cracks or breaks. If found replace interlock.

h. Inspect resistor (1–3) for cracks, breaks or burn marks. If found replace resistor.

i. Inspect module (1–15) for cracks, breaks or burn marks. If found replace module.



1– 3.	Resistor	2– 8.	Spring	2–19.	Coil Frame
1–15.	Module	2– 9.	Return Spring	2–20.	Support
2– 2.	Coil	2–10.	Armature		
2– 6.	Interlock	2–17.	Tip Guide		

Figure 7–179 Inspect Relay Parts

7–10.9.8 CLEANING/PAINTING

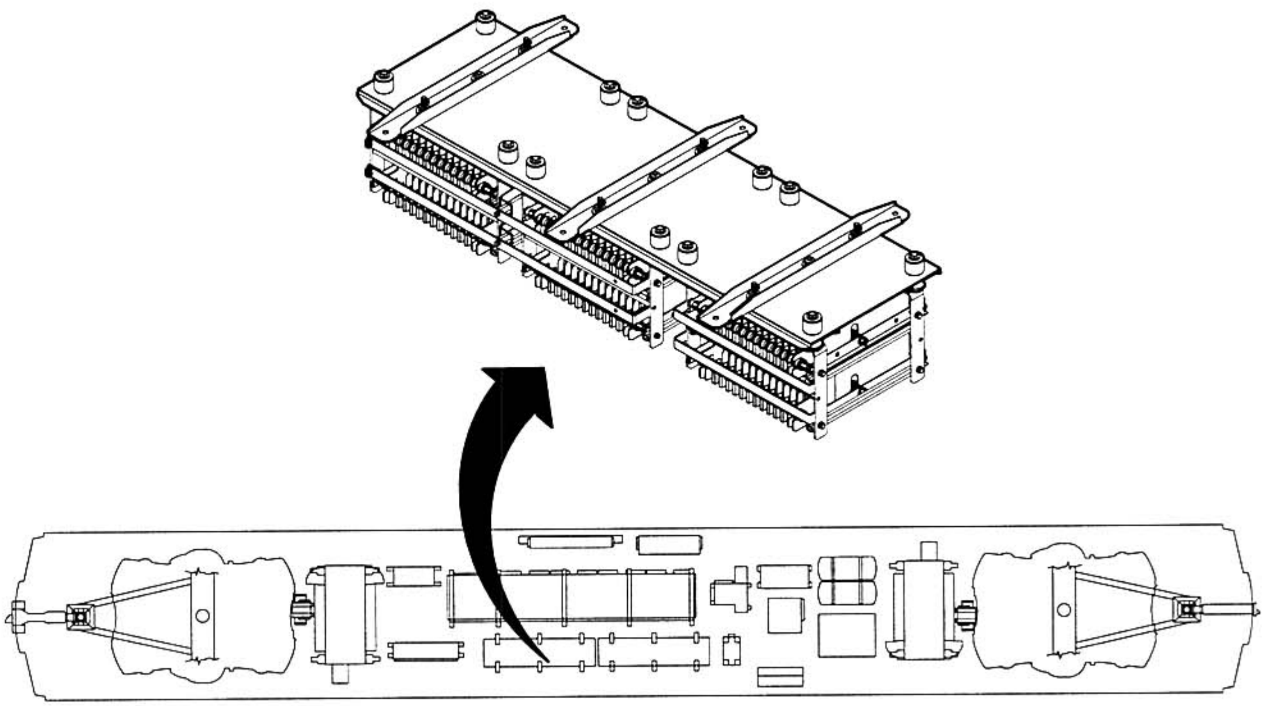
Remove any loose debris from relay using a sash brush and/or clean wiping rag.

7–11 BRAKING RESISTOR– 17EM128K1

7–11.1 DESCRIPTION AND OPERATION

The Braking Resistor – 17EM128K1 (Figure 7–180) is a device that allows for proper dissipation of energy though a rheostatic braking mode when the third rail is not receptive to regenerative power. The braking resistor also dissipates partial regenerative braking energy when the third rail power system is receptive to regenerative power.

The resistor carrier is constructed of stainless steel and the ribbon material is Alcres or Ohmaly. It is mounted under the car. This grid package consists of two resistance sections, one for the chopper (dynamic brake resistor) and one for the inverter (series resistor). Weighing approximately 450 lb., this resistor assembly is about 20.5 in. wide, 81.0 in. long, and 17.0 in. high.



(Typical Undercar Arrangement)

Figure 7–180 Braking Resistor 17EM128D1

WARNING: HIGH VOLTAGE IS PRESENT ON THE DYNAMIC BRAKING RESISTOR ASSEMBLY. REMOVE ALL POWER PRIOR TO REMOVING UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

7–11.2 FAULT ISOLATION

Refer to section 7–7.2.

7–11.3 MAINTENANCE PRACTICES

Not applicable.

7–11.4 SERVICING

Not applicable.

7–11.5 REMOVAL/INSTALLATION

a. Remove/install grid tray assemblies (14, 16, Figure 7–181) to carrier assemblies (15, 17) respectively, with hardware (29, 30, 33). Torque to 17–19 ft. lbs.

b. Remove/install zigzag jumper (22), jumper terminal (18), and standoff bracket (21) to grid tray assembly (14) with hardware (29, 30, 31). Torque to 17–19 ft. lbs.

c. Remove/installl insulator (32) to standoff bracket (21) using hardware (25, 26, 27). Torque to 9–11 ft. lbs. Then remove/install horizontal jumper (19) to insulator (32) with hardware (25, 26, 27). Torque to 9–11 ft. lbs.

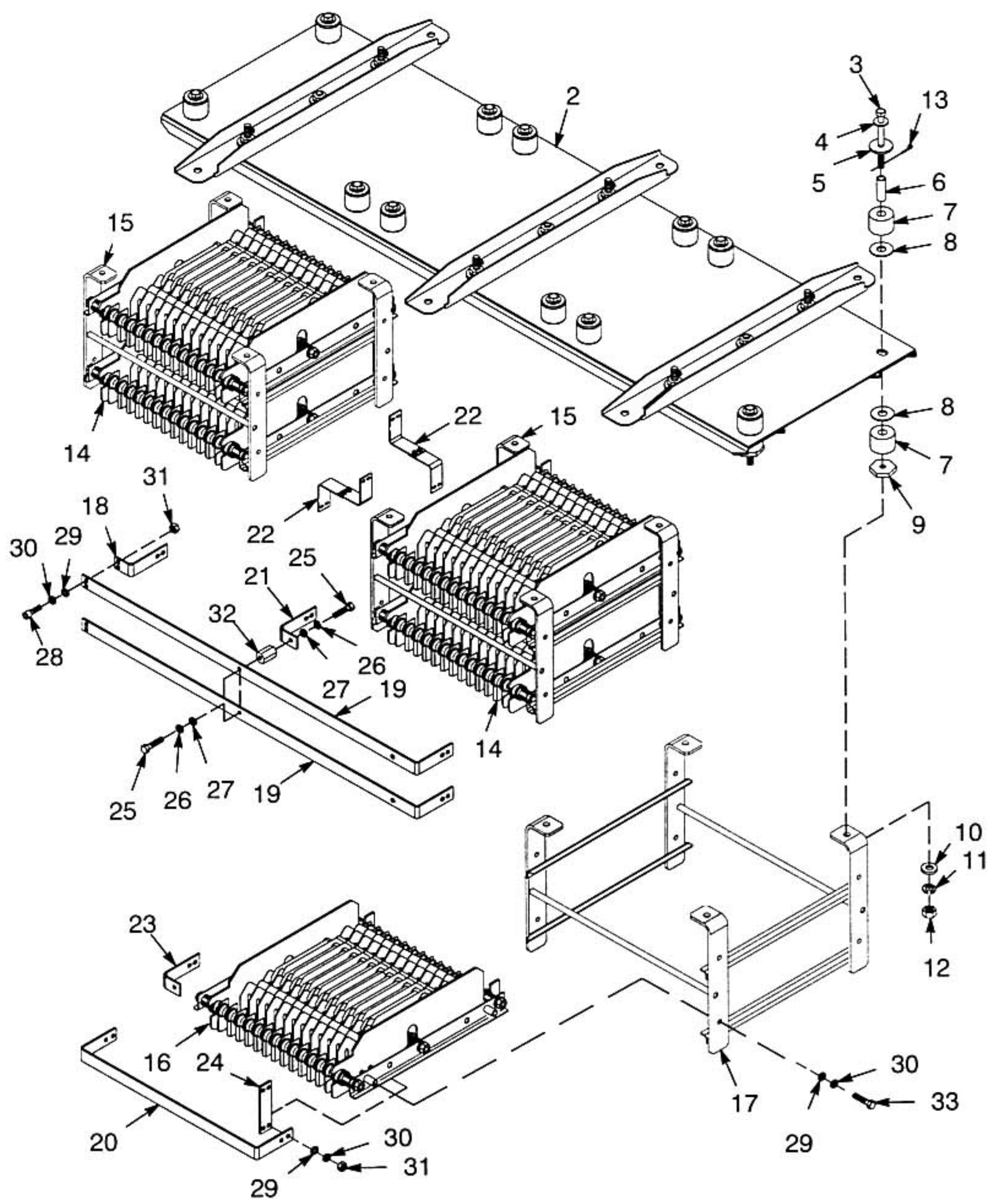
d. Remove/install horizontal jumper (19) to grid assembly tray (14) with hardware (29, 30, 31) and to jumper terminal (18) with hardware (28, 29, 30, 31). Torque to 17–19 ft. lbs.

e. Remove/install terminal set (23), vertical jumper (24), and horizontal jumper (20) to grid tray assembly (16) using hardware (29, 30, 31). Torque to 17–19 ft. lbs.

f. Disassemble/assemble bolt (3), lockwasher (4), and washer (5) through tube (6), insulator (7), washer (8), and top of heat shield (2). Disassemble/assemble washer (8), insulator (7), and nut (9) from the bottom of the heat shield to the bolt (3). Torque to 42–47 ft. lbs.

g. Remove/install carrier assemblies (15, 17) to heat shield (2) with hardware (10, 11, 12). Torque to 42–47 ft. lbs.

h. Remove/install cotter pin (13) to bolt (3). Wrap cotter pin closely around bolt.



2. Heat Shield	10. Washer	18. Jumper Terminal	26. Lockwasher
3. Bolt	11. Lockwasher	19. Jumper, Horiz	27. Washer
4. Lockwasher	12. Nut	20. Jumper, Horiz	28. Screw
5. Washer	13. Cotter Pin	21. Standoff Bracket	29. Washer
6. Tube	14. Grid Tray Assy	22. Jumper, Zig–zag	30. Lockwasher
7. Insulator	15. Carrier Assy	23. Terminal Set	31. Nut
8. Washer	16. Grid Tray Assy	24. Jumper, Vert	32. Insulator
9. Nut	17. Carrier Assy	25. Bolt	33. Bolt

Figure 7–181 Remove/Install Braking Resistor

7–11.6 ADJUSTMENT/TEST

a. Using an ohmmeter, measure the resistance between the resistor terminals HG and DC– (Figure 7–182). The series resistance should fall between 0.410 and 0.453 ohm at room temperature. The dynamic brake resistance between HG and RDB should read 1.007 and 1.113 ohm.

b. Measure the resistance between each of the terminals RDB, HG, DC– and the frame. If the circuit is not open, repair and start test over.

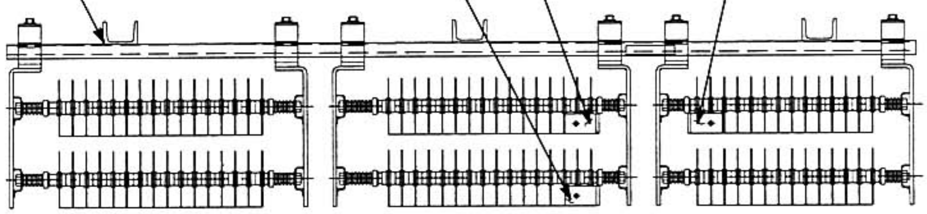


Figure 7–182 Adjustment Test

WARNING:	**VOLTAGES OF 5,000 VDC WILL BE PRESENT IN THIS PROCEDURE. OBSERVE ALL SAFETY PRECAUTIONS. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

c. Using a megohmeter, measure a minimum insulation resistance of 100 megohm between each electrical connection (RDB, HG, DC–, Figure 7–182) and the grid frame at a test voltage of 5,000 VDC.

WARNING:	**VOLTAGES OF 3,500 VAC WILL BE PRESENT IN THIS PROCEDURE. OBSERVE ALL SAFETY PRECAUTIONS. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

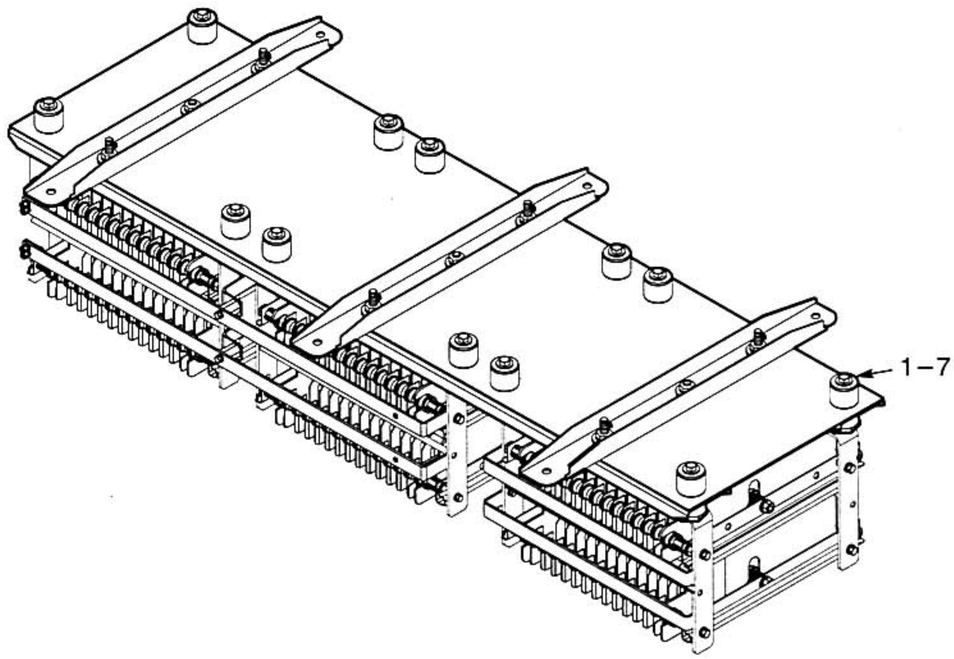
d. Using a 60 Hz tester, Hipot braking resistor assembly (Figure 7–182) at 3,500 VAC for one minute. Leakage current not to exeed 1.0 ma.

7–11.7 INSPECTION/CHECK

a. Inspect insulators (1–7, Figure 7–183) for cracks or breakage. If damaged replace.

b. Inspect resistor ribbons for signs of burning. If damaged replace.

c. Inspect all other parts for cracks or signs of physical damage. If damaged replace.



1–7. Insulator

Figure 7–183 Inspection/Check Braking Resistor

7–11.8 CLEANING/PAINTING

a. Using a sash brush, remove any loose debris from the resistor assembly (Figure 7–183).

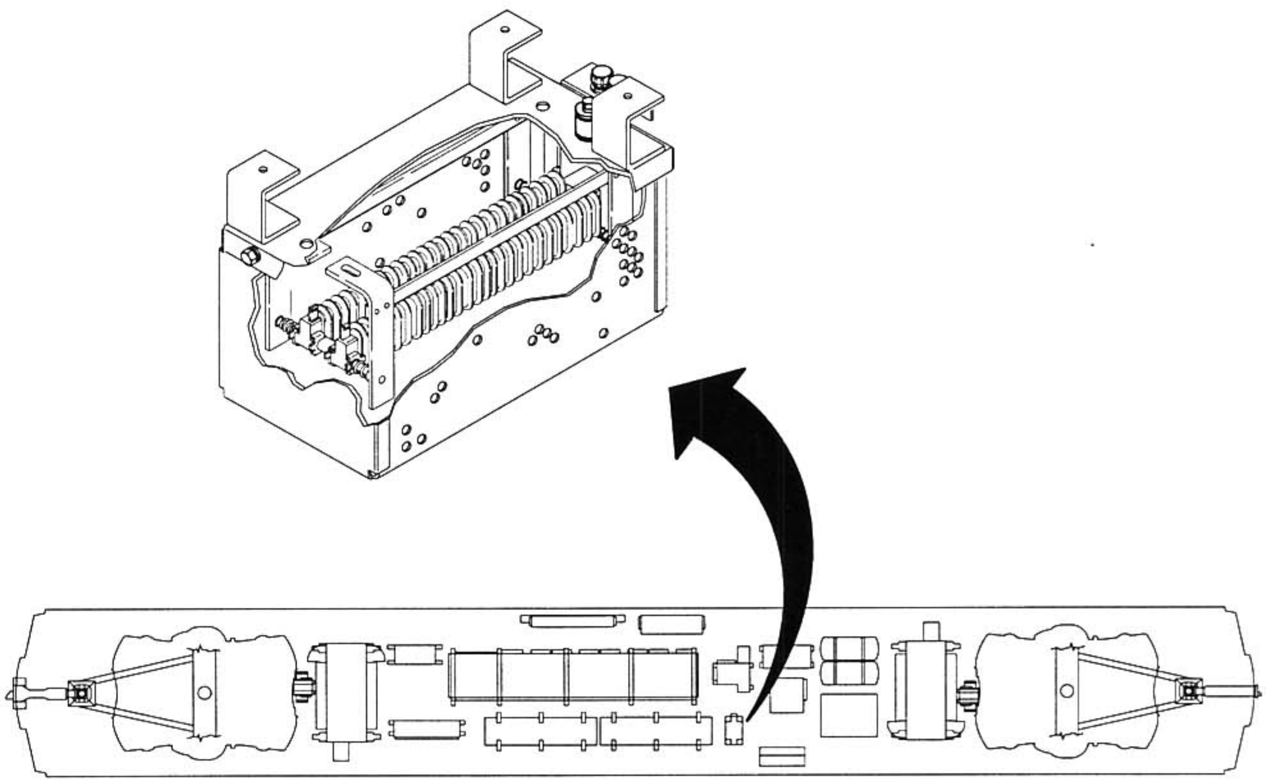
b. A vacuum may be used to remove any remaining build up from the resistor ribbons.

7–12 FILTER CHARGING RESISTOR – 17EM121AC1

7–12.1 DESCRIPTION AND OPERATION

The Filter Charging Resistor (Figure 7–184) consists of resistive elements bussed together to give the required resistance. The elements supply a path of 1.04 ohms resistance and are mounted on an insulated base. The resistor package measures 12 in. wide, 20.5 in. long, and 14 in. high. It weighs about 65 lb. and mounts under the vehicle.

The primary function of the filter charging resistor is to limit the inrush of current to less than 800 amperes at a 780 volt difference between the third rail voltage and the voltage on the propulsion filter capacitor banks.



(Typical Undercar Arrangement)

Figure 7–184 Filter Charging Resistor – 17EM121AC1

<u>WARNING:</u>	**HIGH VOLTAGE IS PRESENT ON THE COUPLER SOCKET/PLUG ASSEMBLY. REMOVE ALL POWER PRIOR TO REMOVING UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

7-12.2 FAULT ISOLATION

Refer to section 7-7.2.

7-12.3 MAINTENANCE PRACTICES

Not applicable.

7-12.4 SERVICING

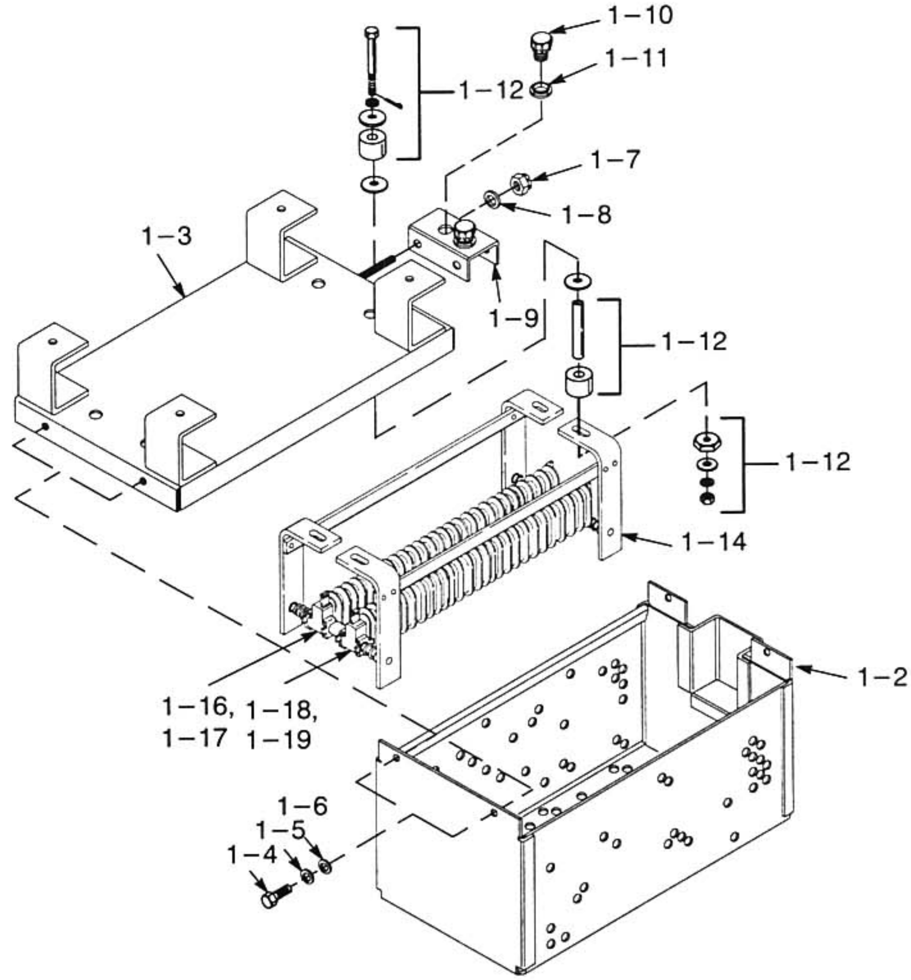
Not applicable.

7-12.5 REMOVAL/INSTALLATION

a. Remove/install insulator hardware (1-12, Figure 7-185) to fasten resistor assembly (1-14) to frame (1-3). Torque to 40 ft. lbs. Install cotter pin (2-7).

b. Remove/install cable cleat (1-9) to frame (1-3) using hardware (1-7, 1-8). Install connector and o-ring retainer (1-10, 1-11) on cable cleat. Hand tighten.

c. ,Remove/install screen assembly (1-2) to frame using hardware (1-4, 1-5, 1-6). Torque to 17 ft. lbs.



1-2	Screen Assembly
1-3	Frame
1-4	Bolt
1-5	Lockwasher
1-6	Washer
1-7	Nut
1-8	Washer
1-9	Cable Cleat
1-10	Connector
1-11	O-ring Retainer
1-12	Insulator
1-14	Frame
1-16	Resistor Asm
1-17	Insulator
1-18	Resistor Asm
1-19	Insulator

Figure 7-185 Reassemble Filter Charging Resistor

7–12.6 ADJUSTMENT/TEST

a. Using an ohmmeter, measure the resistance between the resistor terminals FCC1 and FCC2 (1–16, 1–18, Figure 7–186). It should fall between 0.936 and 1.144 ohms at room temperature.

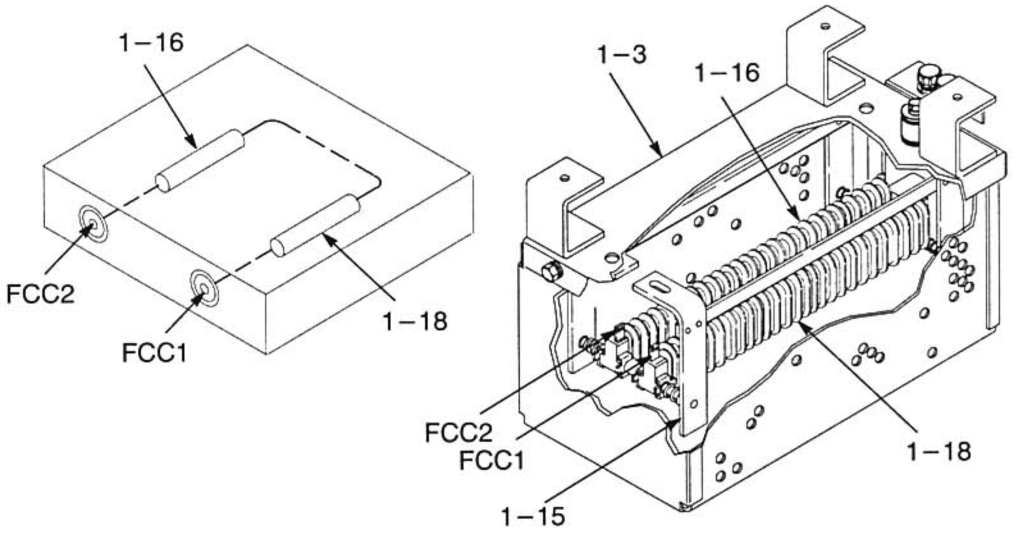
b. Now, measure the resistance between each resistor terminal FCC1 and FCC2 and the resistor frame assembly (1–15). If the circuit is not open, there exists a short to ground. Check insulation and elements for proper air gap and creepage. Repair and start test over.

c. Measure the resistance between the resistor frame assembly (1–15) and the frame (1–3). If the circuit is not open, repair and start test over.

WARNING: VOLTAGES OF 2500 VAC AND 3500 VAC WILL BE PRESENT IN THIS PROCEDURE. OBSERVE ALL SAFETY PRECAUTIONS. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

d. Dielectric test: 3500 VAC for 1 minute between FCC1 or FCC2 (1–16, 1–18) and the resistor frame assembly (1–15).

e. Dielectric test: 2500 VAC for 1 minute between the resistor frame assembly (1–15) and frame (1–3).



1–3	Frame
1–15	Frame
1–16	Resistor Asm
1–18	Resistor Asm

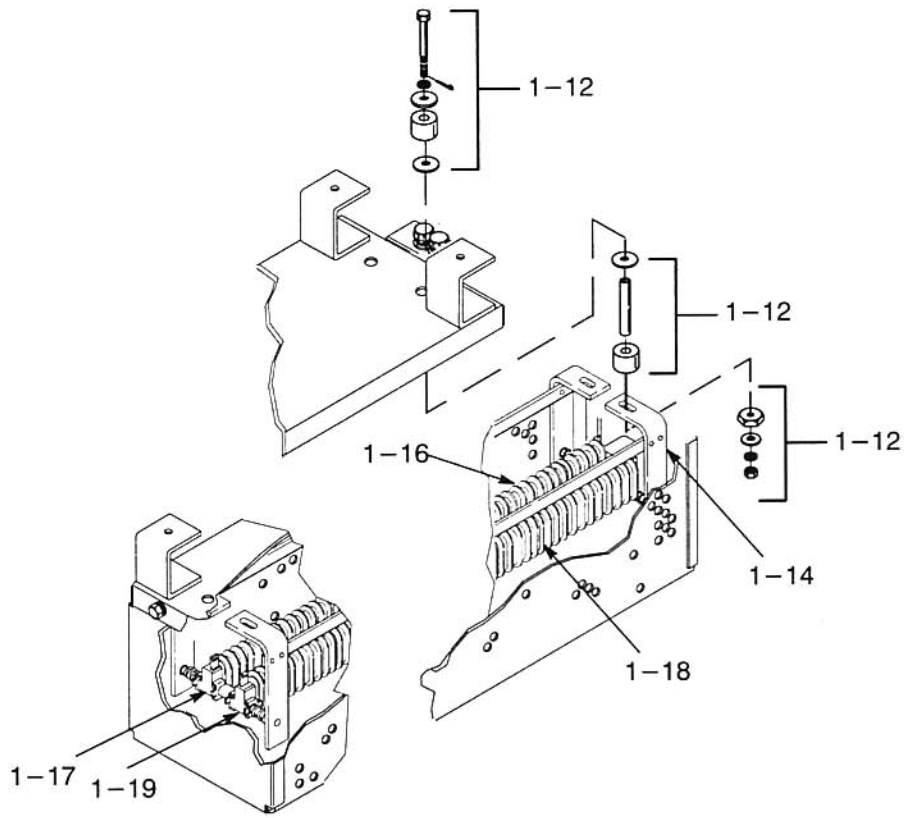
Figure 7–186 Test Filter Charging Resistor

7–12.7 INSPECTION/CHECK

a. Inspect insulators (1–12, 1–17, 1–9, Figure 7–187) for cracks or breakage. If damaged replace.

b. Inspect resistor elements (1–16, 1–18) for signs of burning. If damaged replace.

c. Inspect all other parts for cracks or signs of physical damage. If damaged replace.



1–12	Insulator	1–17	Insulator
1–14	Resistor Assembly	1–18.	Resistor Element
1–16.	Resistor Element	1–19	Insulator

Figure 7–187 Inspection/Check Charging Resistor

7–12.8 CLEANING/PAINTING

a. Remove any loose debris from resistor assembly (1–14, Figure 7–187).

b. Steam clean all resistor parts.

c. Scrape off any buildup on metal parts.

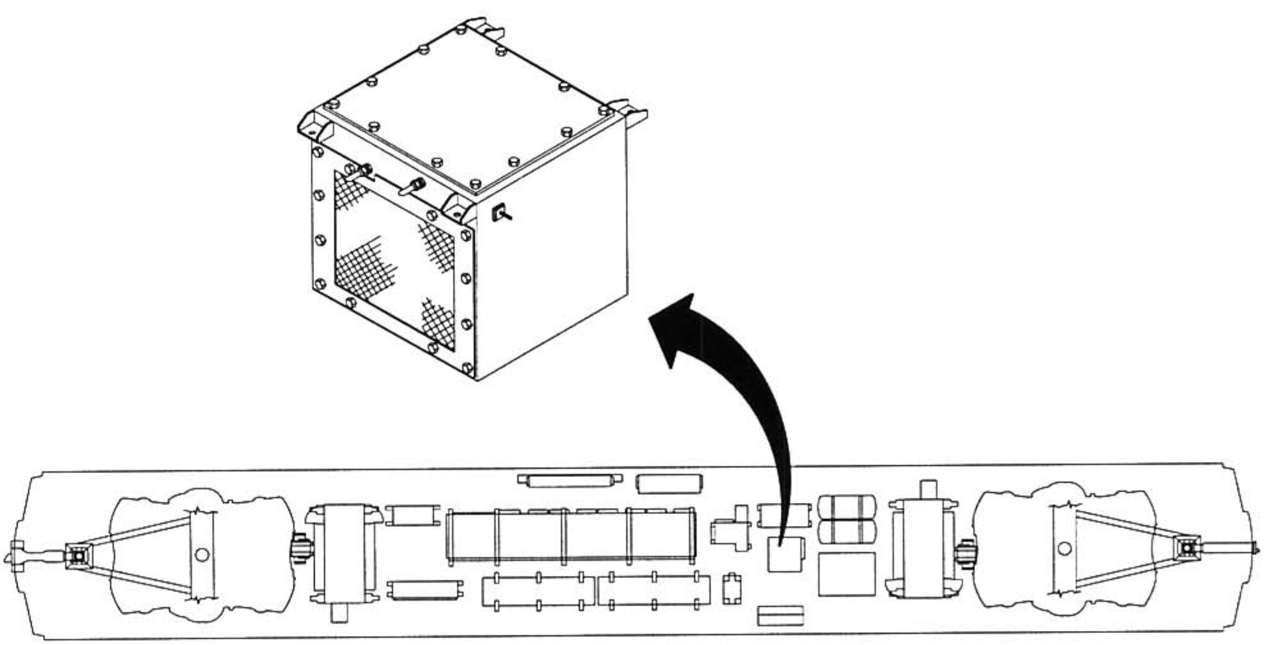
d. Wipe off insulators (1–12, 1–17, 1–19) with an approved cleaner.

7–13 LINE FILTER REACTOR 41A281970P1

7–13.1 DESCRIPTION AND OPERATION

The Line Filter Reactor (Figure 7–188) is mounted under the car along the longitudinal axis. It is convection cooled by normal outside air flow. The LFR is about 24 in. high, 25 in. long, and 25 in. wide and weighs about 500 lb. This device is grounded through a ground pad.

The Line Filter Reactor (LFR) is an insulated, air core reactor. It has a minimum inductance of 1.5 mh within a zero to 1500 amp (DC) range. The LFR is designed to handle 737 amp nominal current flow, with a peak current rating of 1500 amps. It is an isolation device between the DC input line and the propulsion drive system. It performs two functions. The LFR suppresses surges and ripple in the DC input line. It is also a part of an LC (series L, shunt C) filter used to filter spikes in the propulsion charging circuits, and isolates propulsion circuit fluctuation from the input line voltage.



(Typical Undercar Arrangement)

Figure 7–188 Line Filter Reactor 41A281970P1

> **WARNING:** HIGH VOLTAGE IS PRESENT ON THE LINE FILTER REACTOR. REMOVE ALL POWER PRIOR TO REMOVING UNIT. FAILURE TO DO SO CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

7–13.2 FAULT ISOLATION

Vehicle Is Running Erratic Or Not At All:

POSSIBLE CAUSE	INSPECT FOR	CORRECTIVE ACTION
1. Damaged core, windings, terminals, or other reactor parts.	1. Visible damage.	1. Replace reactor.
2. Reactor out of tolerance.	2. Test.	2. Perform DC resistance and HI POT tests. If any value is out of tolerance, replace the reactor.
3. Power source.	3. Incorrect power source.	3. Check power source and correct as necessary.

Table 7–16 Line Filter Reactor Troubleshooting

7–13.3 MAINTENANCE PRACTICES

Not applicable.

7–13.4 SERVICING

Not applicable.

7–13.5 REMOVAL/INSTALLATION

Not applicable.

7–13.6 ADJUSTMENT/TEST

WARNING: FOLLOW ALL TRANSIT AUTHORITY OPERATIONAL AND SAFETY PROCEDURES WHEN PERFORMING ELECTRICAL TESTS. FAILURE TO DO SO CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH.

7–13.6.1 Insulation Resistance Test

Test the line filter reactor (Figure 7–189) to ground using a 500 V megohmeter The minimum insulation resistance is 500 megohm.

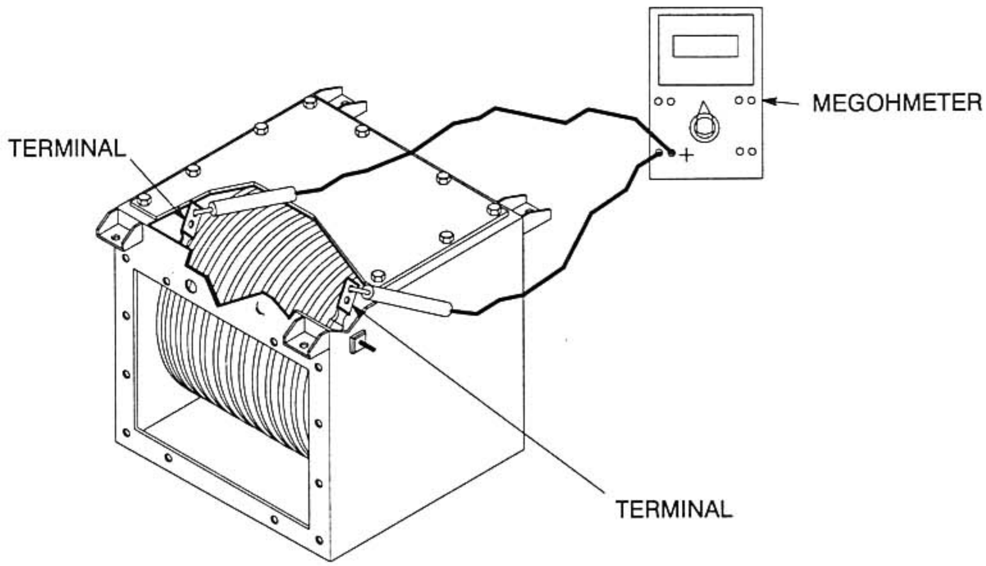


Figure 7–189 Insulation Resistance Test

7–13.6.2 Inductance Test

Using an inductance bridge, measure 1.5 mh minimum.

7–13.6.3 Dielectric Test

a. Connect a high voltage jumper between terminals (Figure 7–190).

b. Using a 60 Hz tester, Hipot at 2,700 volts for one minute maximum. Leakage current not to exceed 500 microamperes.

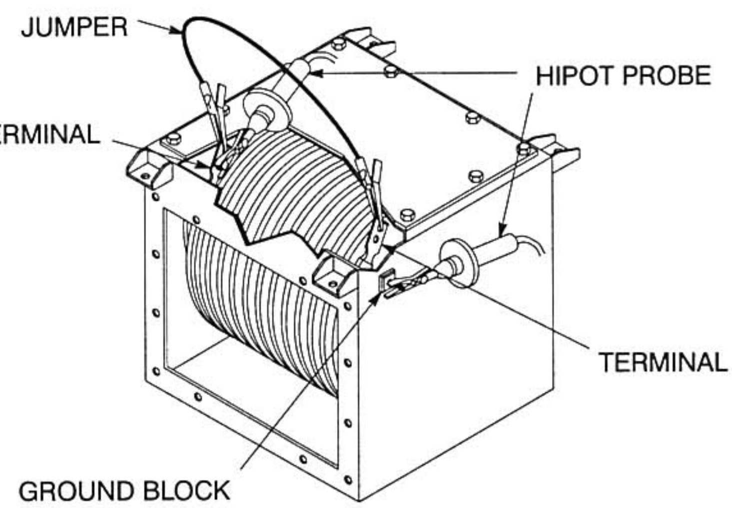


Figure 7–190 Hipot Test

7–13.7 INSPECTION/CHECK

a. Visually inspect Line Filter Reactor (Figure 7–191) for signs of physical damage. Report damage to supervision.

b. Ensure input/output terminal connections are tight and secure. Tighten per car builder's instructions.

c. Check line filter reactor for signs of overheating, as observed by severe discoloration or swollen coils. If found, replace reactor.

d. Ensure mounting bolts are tight and secure. Tighten as required.

e. Inspect reactor for signs of corrosion. If corrosion can be treated, use standard shop practices for treating corrosion, and clean as required. If corrosion is severe, report to supervision.

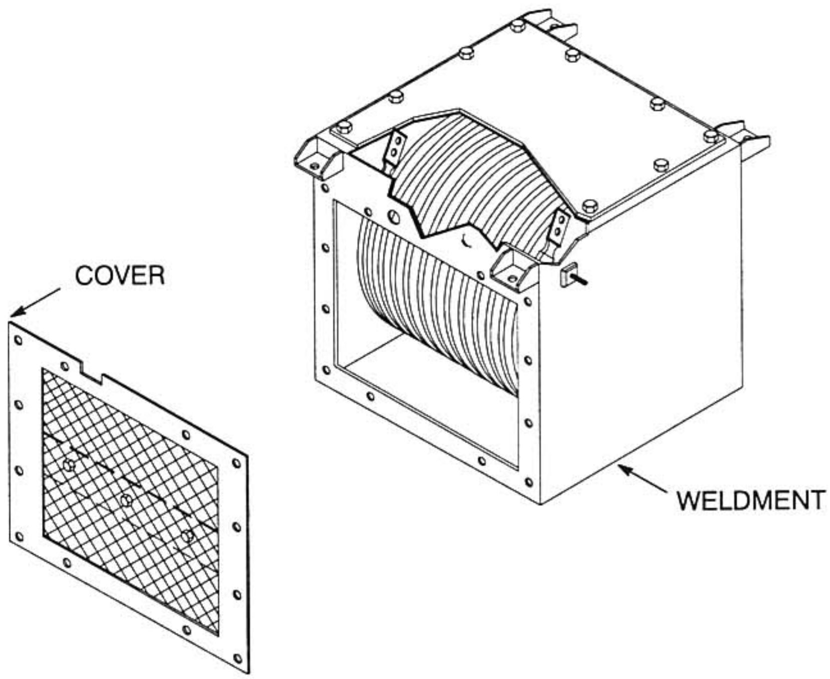


Figure 7–191 Inspection/Check Line Filter Reactor 41A281970P1

7–13.8 CLEANING/PAINTING

a. Blow out dirt and debris from reactor (Figure 7–192) coils and ducts using compressed air.

b. Using a sash brush, remove loose dirt and debris from reactor weldment.

c. Using dry lint–free rag and an approved cleaner, clean in and around terminals.

<u>NOTE:</u> Repair consists mainly of repairing the coating on the coils, supports, and brackets.

7–13.8.1 Repair Coating on Coils

NOTE: If corrosion is below surface area of coils, discard reactor. If corrosion is on surface area only, perform the following procedures.

a. Clean area to be repaired.

b. Apply a resin coating (GE 41A239176P478) to coil surface area and allow to dry.

7–13.8.2 Repair Coating on Supports and Brackets

a. Using a mild abrasive, clean area(s) to be repaired.

b. Apply corrosion–resistant black paint (GE 41A244104BAP1) over repaired area(s), and allow to dry.

7–13.8.3 Repair Coating on Terminals

CAUTION: DO NOT FILE INPUT/OUTPUT TERMINALS. INPUT/OUTPUT TERMINALS ARE TIN OR SILVER COATED. FILING OR USE OF HEAVY ABRASIVE WILL REMOVE COATING.

a. Using an approved cleaner, clean input/output terminals.

b. Do not apply grease to terminals as this can contaminate electrical contact areas when installed on vehicle.

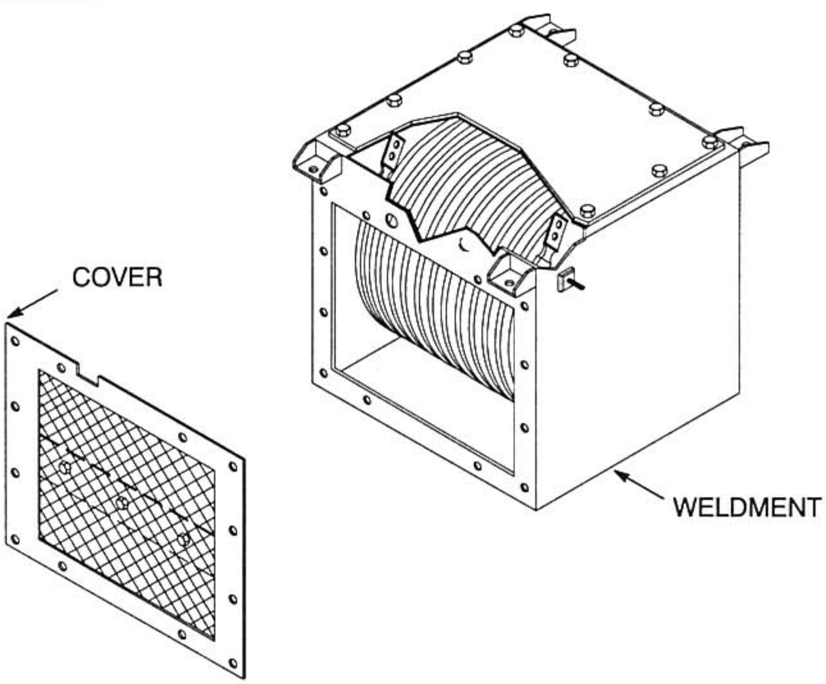


Figure 7–192 Cleaning/Painting Line Filter Reactor 41A281970P1

SECTION 10

LOW VOLTAGE POWER DISTRIBUTION AND BATTERY

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SECTION 10

LOW VOLTAGE POWER DISTRIBUTION AND BATTERY

10-1 GENERAL INFORMATION

The system takes the 750 Vdc (which can fluctuate between 450 Vdc and 900 Vdc) from the third rail and converts it into a regulated 37.5 Vdc at 16.6 KVA used to charge the Battery and supply the associated loads of a married - pair.

The 37.5 Vdc is applied, through the Contactor Group, to the L.V. Circuit Breaker Panels (“A” and “B” car), the KA and ER Trainline Junction Boxes (“A” and “B” car), the Gate Drivers of the Main Inverter and the LVPS fault lights.

The system includes the following main components which will be discussed in the next paragraphs:

- Input Section
- LVPS Circuit Breaker
- LVPS/Battery Charger
- Battery Circuit Breaker
- Battery
- Contactor Group (CG)
- Dead Battery Start (DBS)

10-2 OPERATION DESCRIPTION

The functional block diagram of the system is shown in Figure 10-1.

The 750 Vdc is collected from the third rail by the Current Collector, located on the truck, and is sent, through the Rail Gap Group (Knife Switch and Main Fuse), to the LVPS/Battery Charger, which converts the 750 Vdc into the 37.5 Vdc which is distributed to the loads. The Input Section is comprised of an Input Filter, the LVPS/Battery Charger Circuit Breaker, the Dead Battery Start (DBS), overvoltage protection circuits and the crow-bar. The Input Filter protects the LVPS/Battery Charger from being affected by surges in the line supply.

The LVPS/Battery Charger Circuit Breaker protects the LVPS/Battery Charger from being damaged by voltage too high for the system. If the voltage circuits detects a voltage > 1600 Vdc +/- 50 Vdc the crow-bar is triggered, which trips the internal fuse of the LVPS/Battery Charger.

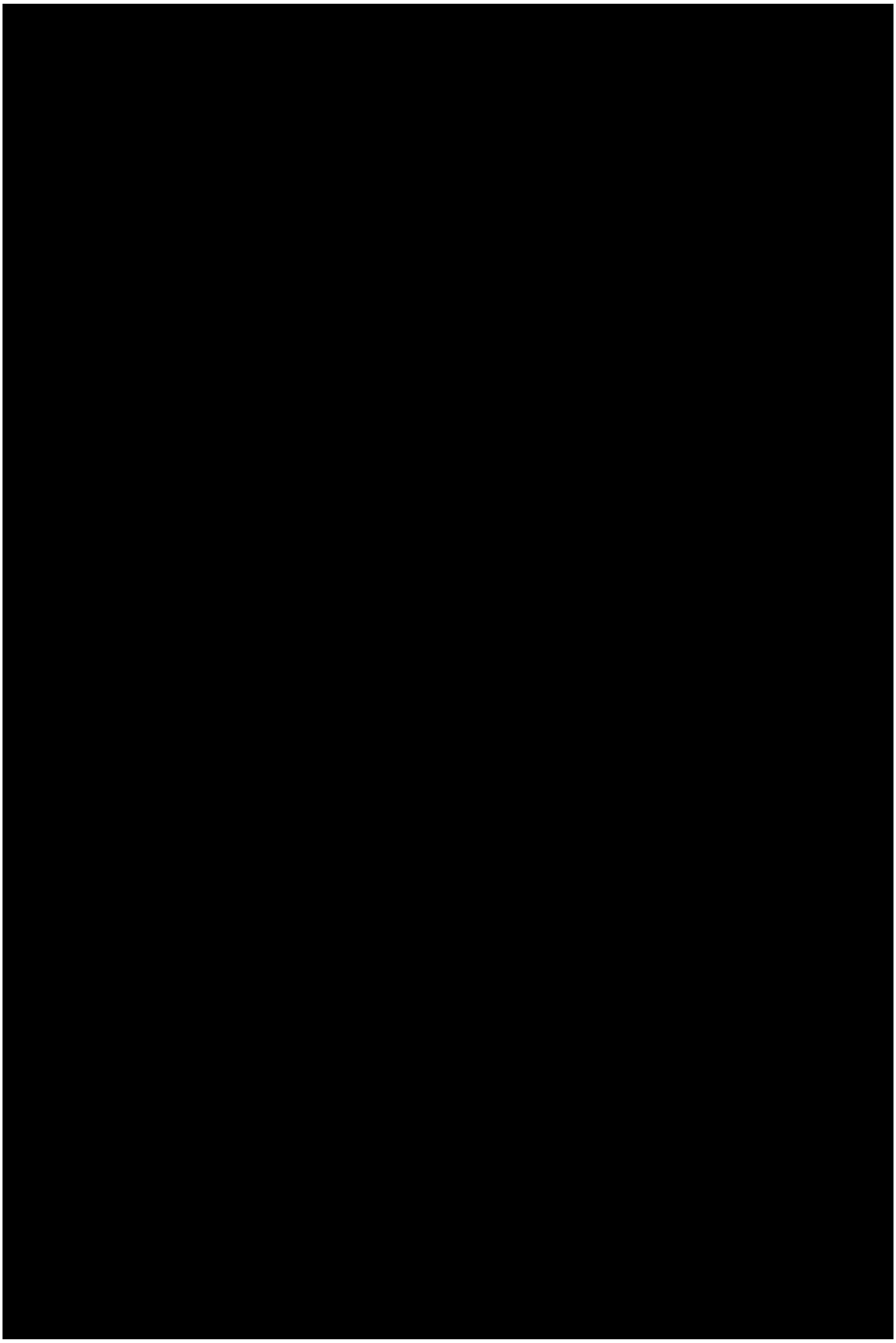


Figure 10-1. Low Voltage Power Distribution Block Diagram

10-3 COMPONENTS DESCRIPTION

10-3.1 LVPS/Battery Charger

The equipment provides the low voltage power for a pair of cars for battery charging and car low voltage circuits. The converter has a constant voltage output at a nominal value of 37.5 Vdc for any non-fault load demanded by a pair of cars, at any position in a train, for all input voltages specified. This output voltage is not reduced below regulated voltage as long as load current is less than the rated one.

The converter (see Figure 10-2) is made up of two choppers, each has two output transformers in parallel with two secondaries in each transformer, i.e. four secondaries per chopper. Each secondary has its own rectifier. The outputs are connected to the filter capacitor via inductors. Inductors and capacitors comprise the output filter. The actual value of the output voltage is also fed into the regulator. The regulator keeps the output voltage constant at 37.5 V under normal current conditions. The regulator controls the converter output by providing high amplitude gate firing pulses with proper timing.

In addition the LVPS/Battery Charger houses:

- The Dead Battery Start to start a dead battery (see Paragraph 10-3.4).

- The KBAT contactor (300 A) which disconnects the battery from the load when the battery voltage is below 25 Vdc and the converter is off. The contactor will pick up when the converter is restored. The contactor is always ON when the converter is in operation.

- The KNE contactor, which sheds non-essential loads 30s after the converter is shut down.

The following items are located on the enclosure:

- A group of connectors, for the input and output connections of the DC/DC converter.

- A yellow LED, to indicate the input capacitor charge. It is lit when V > 50 (for safety).

- A red LED to indicate LVPS faults.

The LVPS/Battery Charger is located on the “B” car, under the Carbody (see Figure 10-3).

More detailed information about LVPS composition and operation is contained in the Workshop Manual, Section 8.

Figure 10-2. LVPS/Battery Charger Block Diagram

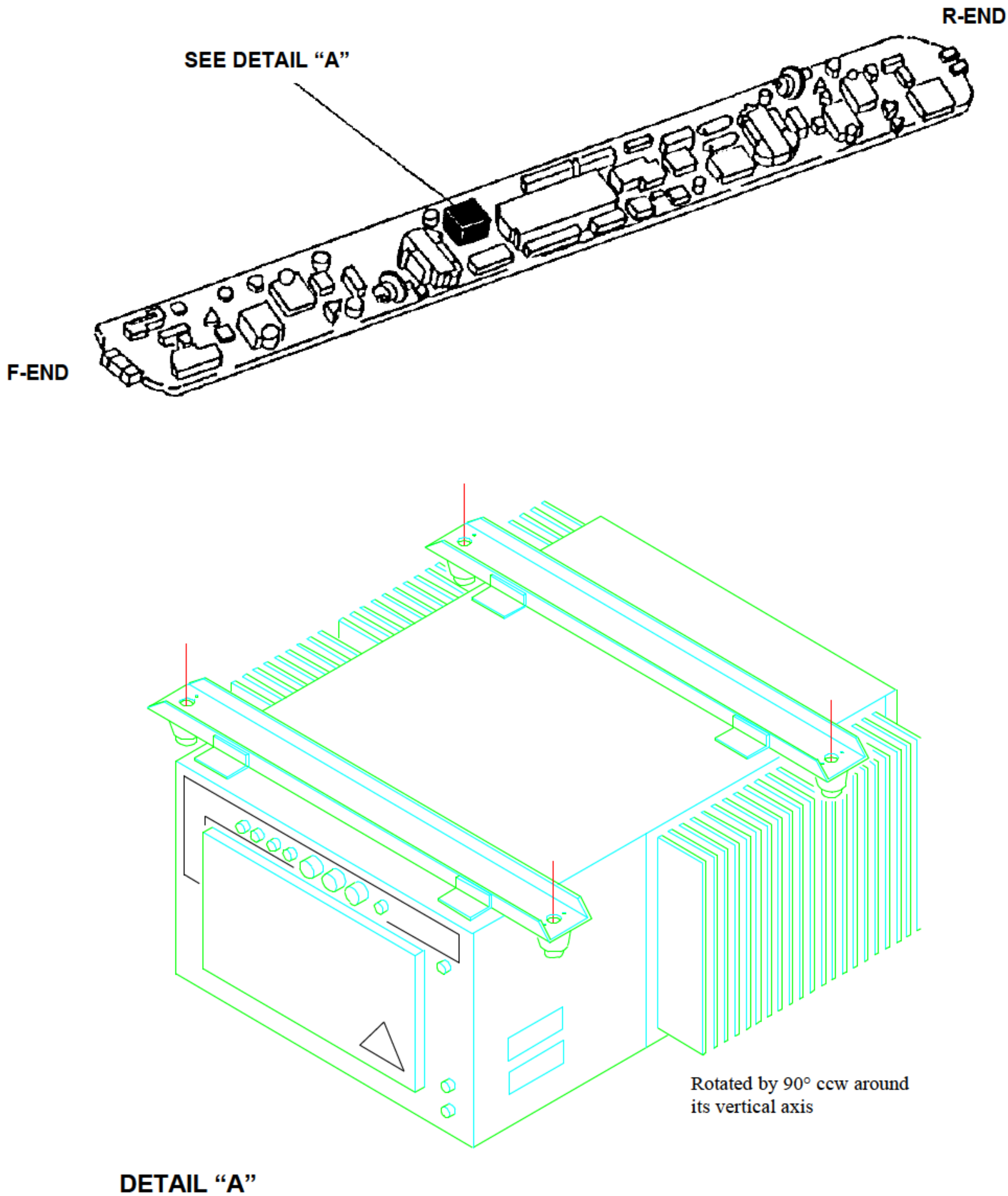


Figure 10-3. LVPS/Battery Charger Installation ("B" Car Only)

10-3.2 Battery

10-3.2.1 Battery and Battery Box

The battery box (see Figure 10-4) is located on car “B” under the carbody. Inside the box there is a thermostat which signals battery overheating to the battery circuit breaker panel.

The battery (see Figure 10-5) is a nominal 32V, 250 ampere/hour nickel-cadmium. Every battery includes 25 cells assembled in 5 plastic cradles, each containing 5 cells. The cells are connected in series by solid connectors (See Figure 10 - 9).

The battery is charged by the converter; therefore its normal operating voltage is 37.5V, 1.50V per cell.

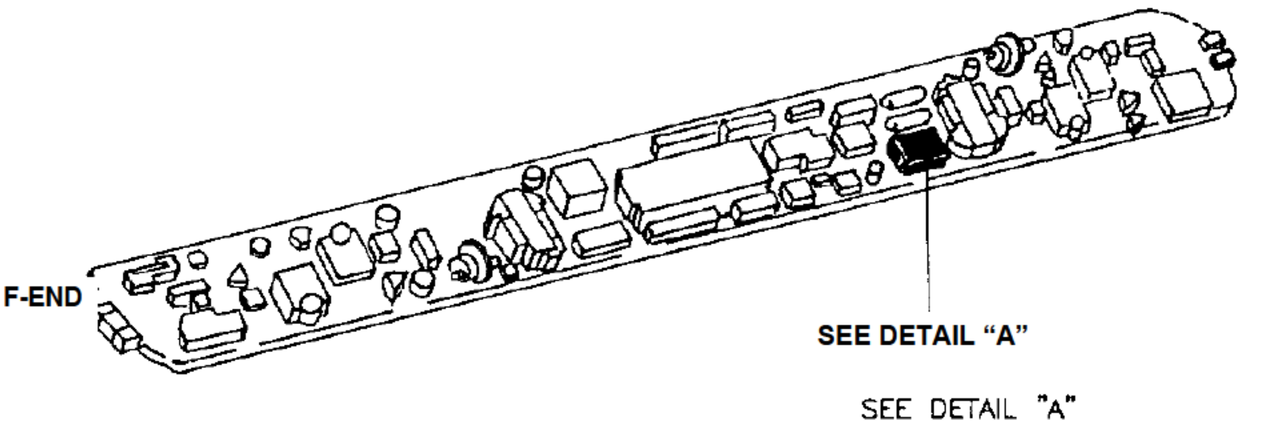
10-3.2.2 Schedule of Data

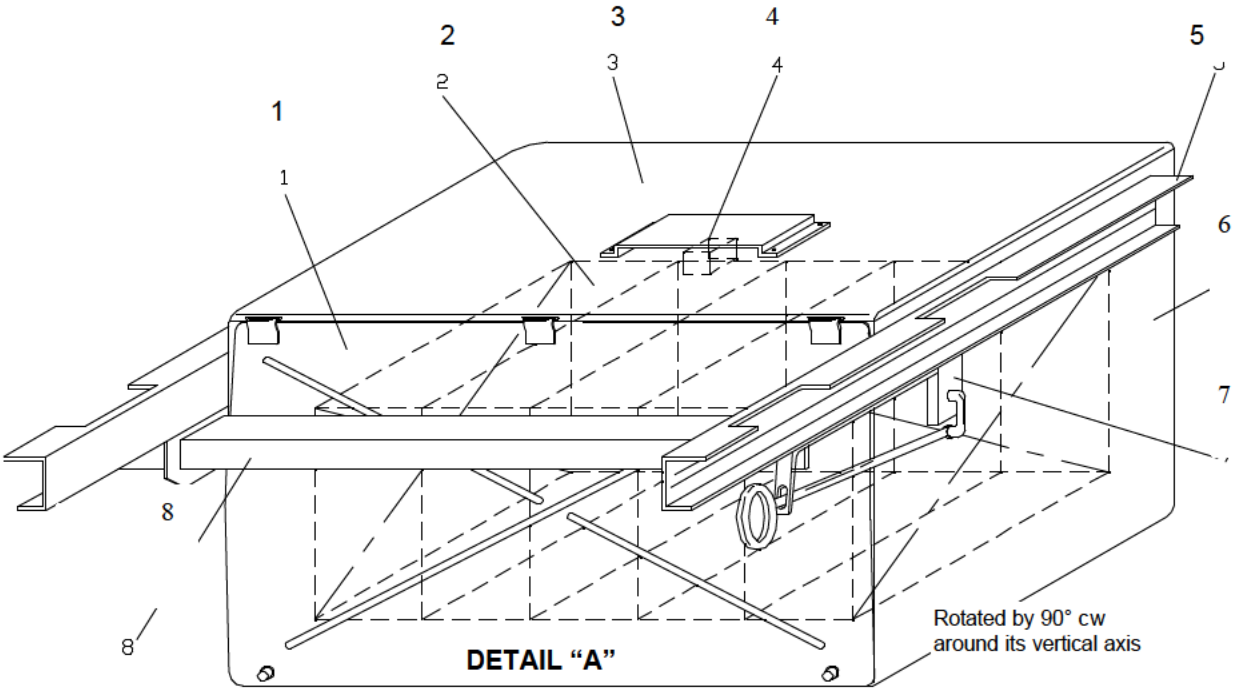
MAKER OF BATTERY	ALCAD
CLASS OF BATTERY	Nickel Cadmium Alkaline
MAKER'S TYPE NUMBER	MP240
NUMBER OF CELLS	25 (5 x 5 cell trays)
CHARGING DETAILS	In Service
	Float charged from the vehicle charger
	Supplementary Charging
	By constant current of 48 amperes for 8 hours, at 1.4 to 1.72 volts per cell
LEVEL OF ELECTROLYTE (above top of plates)	87 mm maximum, 5 mm minimum
ELECTROLYTE QUANTITY	95 litres per battery of 25 cells
ELECTROLYTE TYPE	ALCAD Type “R”

10-3.3 Battery Circuit Breaker Panel (See Figure 10-6)

This panel, located near the battery box, is used to remove or apply the 37.5V battery power from/to the associated equipment. The panel controls the battery undervoltage condition and the battery box overtemperature condition. It includes a 125A fuse.

In both cases the circuit breaker will trip and remove battery voltage from the associated equipment.



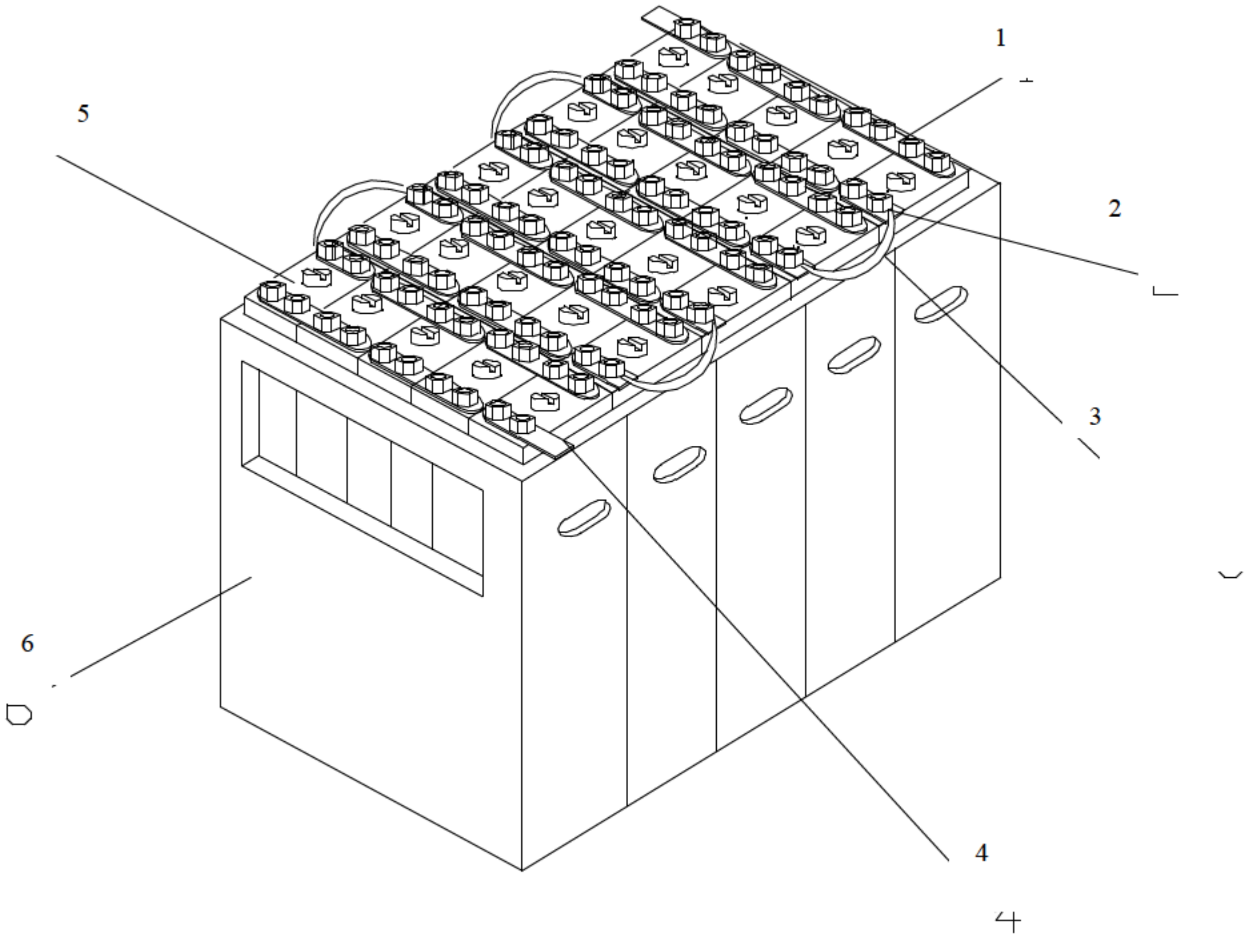


DETAIL "A"

LEGEND

1. ACCESS DOOR
2. BATTERY PACK
3. COVER
4. THERMOSTAT
5. SUPPORT
6. CONTAINER
7. OUTSIDE LOCK
8. SAFETY BAR

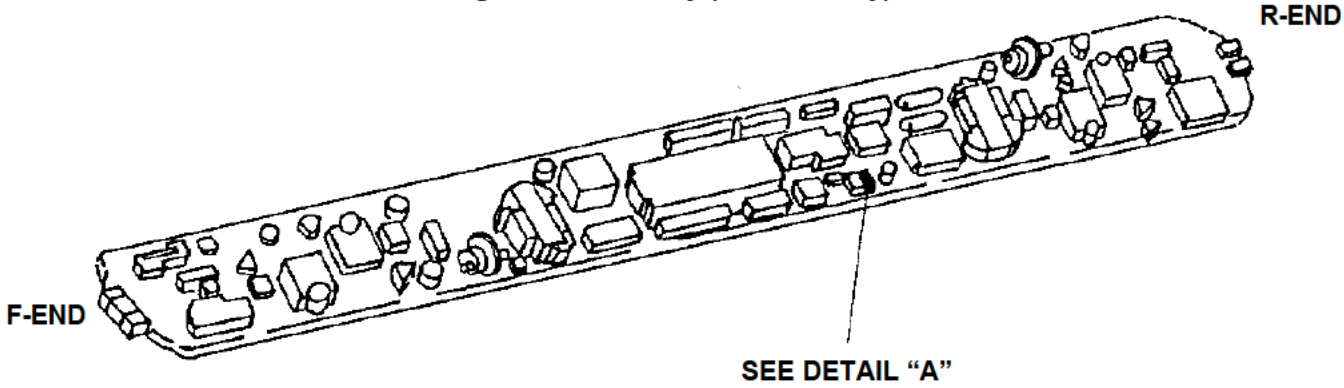
Figure 10-4. Battery Box Installation ("B" Car Only)

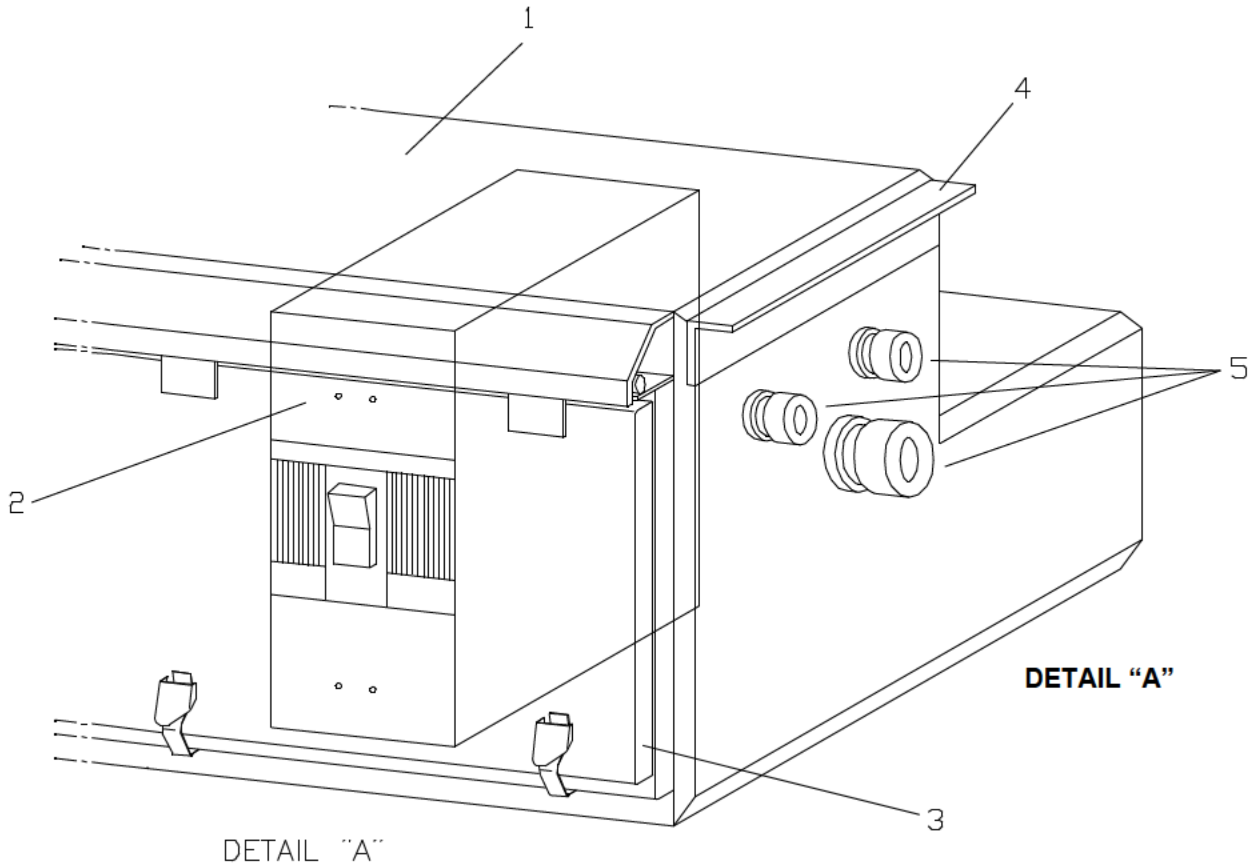


LEGEND

1.	CONNECTOR	4.	END LUG
2.	COLLECTING BAR	5.	CELL M250P
3.	CABLE CONNECTOR	6.	PLASTIC BATTERY BOX

Figure 10-5. Battery ("B" Car Only)





LEGEND

1.	BOX ASSEMBLY	4.	SUPPORT
2.	CIRCUIT BREAKER	5.	CABLE BUSHING
3.	ACCESS DOOR		

Figure 10-6. Battery Circuit Breaker Panel Installation ("B" Car Only)

10-3.4 Dead Battery Start

The Dead Battery Start (DBS) is a board located in the LVPS enclosure and provides the substitute battery voltage when the battery is dead. It is a DC/DC converter that operates directly from the input lines and converts the input voltage into battery equivalent voltage for the electronic circuits of the converter.

The Dead Battery Start requires a manual start switch to connect the input lines to the relative board. Once the converter is operating, the battery will be quickly charged and the dead battery start voltage will not be required any more. The manual start switch can be opened. The manual start switch is located under "B" Car (see Fig. 10-7).

10-3.5 Contactor Group

The Contactor Group is located on the Car "A" of each married pair (see Figure 10-8). It houses a low voltage contactor (KNE) (parallel controlled with the KNE contactor located in the LVPS enclosure) for load shed on "A" Car and its corresponding fuse and low voltage distribution tie points. This group also contains circuit breakers for the gate driver power supplies for the "A" Car propulsion system. There is no high voltage cabling present. The contactor group only serves as a part of the low voltage power distribution system.

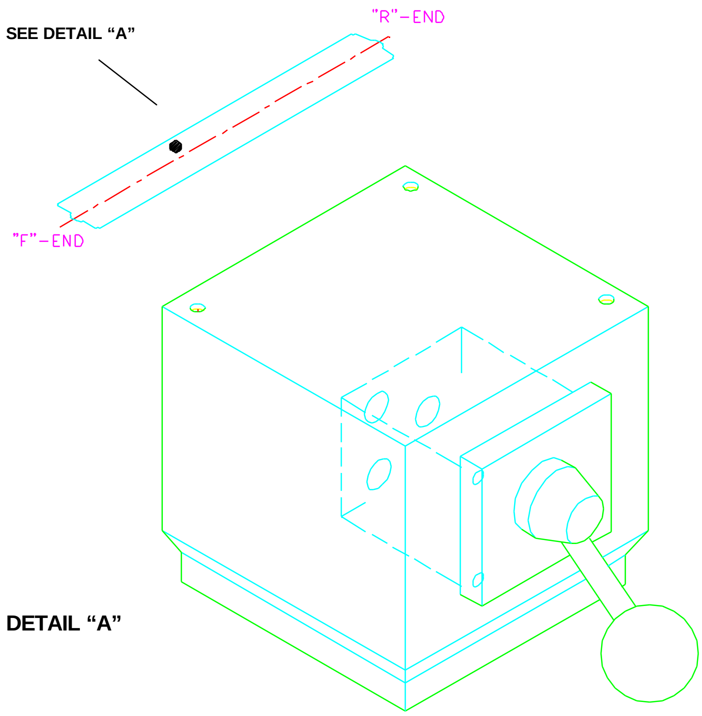


Figure 10-7. Dead Battery Start - Manual Switch ("B" Car Only)

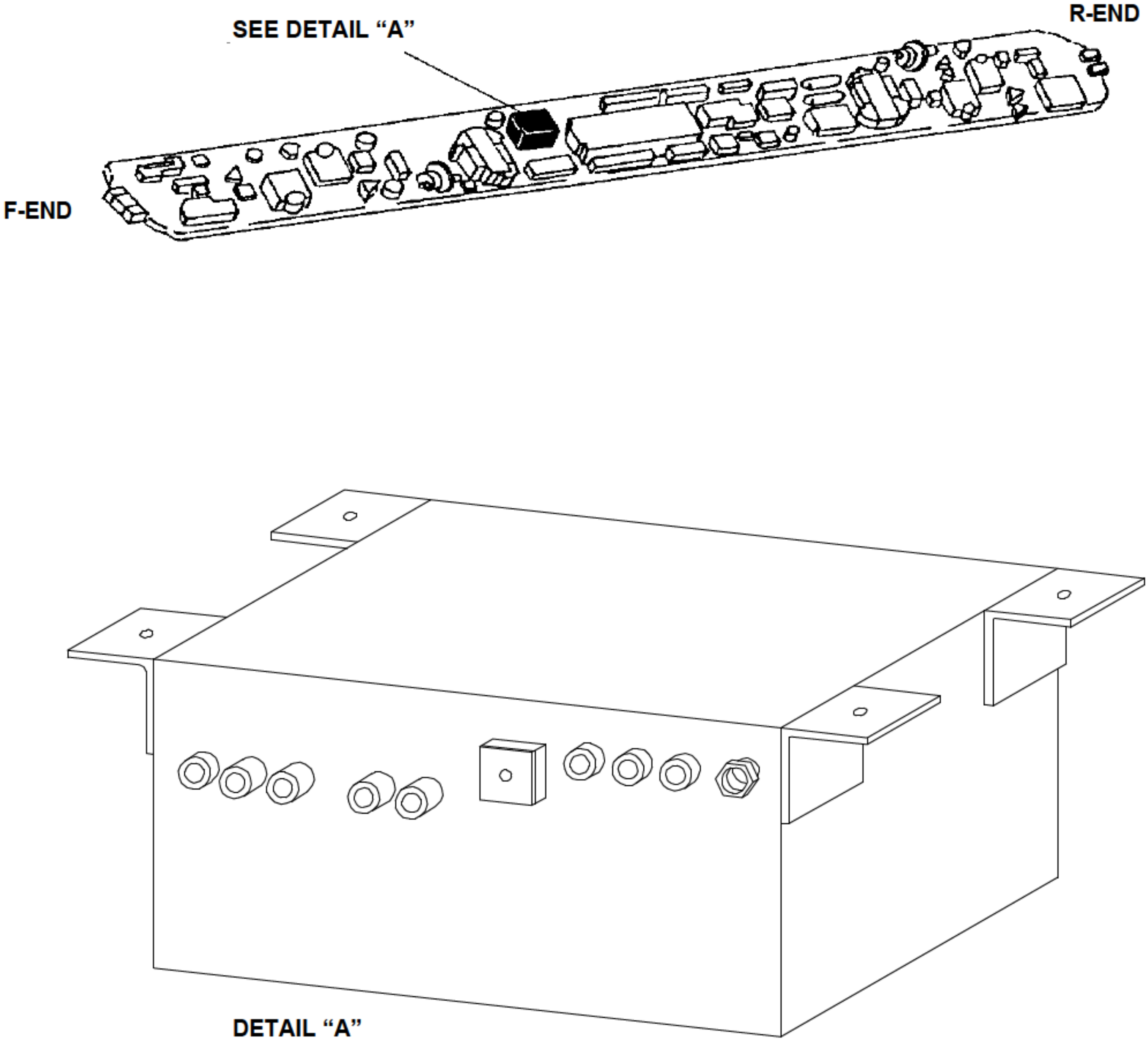


Figure 10-8. Contactor Group Installation ("A" Car Only)

10-4 PREVENTIVE MAINTENANCE

10-4.1 LVPS/Battery Charger

The following preventive maintenance operations are required:

a. Annual:

(1) Keeping the heat sinks clean and effective.

The heat sinks are located on the exterior of the converter.

Tools and expendable materials required are:

(a) Bristle brush.

(b) Water and an air hose.

Visually inspect the converter’s heat sinks for debris or encrustation. Assemble a water or air hose (or both) and a bristle brush. Do not use wire brushes!

Clean the heat sink fins with water, bristle brush and the air hose.

(2) Confirming the proper operation of the failure display and data logger.

For this procedure, see the Workshop Manual, Sect. 8.

b. Five years:

(1) Replacing the lithium battery on the failure monitoring board.

For this procedure, see the Workshop Manual, Sect. 8.

10-4.2 Battery

10-4.2.1 Safety Precautions

The use of alkaline batteries is not hazardous provided that strict precautions are taken. The following precautions are recommended.

DO:

* Keep batteries upright.
* Wear goggles when removing vent caps.
* Use tools with insulated handles.

* Wear protective clothing when handling electrolyte.

DO NOT:

* Smoke or permit open flames near the battery.
* Spill electrolyte on skin or clothing.
* Allow metal objects to rest on battery or fall across terminals.
* Wear nylon coats or overalls as they can create static electricity.

> **WARNING:** **THE BATTERY ELECTROLYTE IS CORROSIVE AND TOXIC.**
>
> **IN THE EVENT OF AN ACCIDENT:**
>
> **WASH SKIN BURNS WITH COPIOUS AMOUNTS OF CLEAN WATER THEN COVER IMMEDIATELY WITH DRY GAUZE.**
>
> **FOR THE EYES, WASH OUT WITH COPIOUS AMOUNTS OF CLEAN WATER FOLLOWED BY A WASH OF SALINE SOLUTION (TWO LEVEL TEASPOONS OF SALT DISSOLVED IN ONE PINT OF PURIFIED WATER). THIS SOLUTION SHOULD BE READILY AVAILABLE WHEREVER ELECTROLYTE IS HANDLED.**
>
> **IN ALL CASES OBTAIN IMMEDIATE MEDICAL ATTENTION.**

10-4.2.2 Charging in Service

The battery is float charged from the vehicle's low voltage power supply/battery charger circuit, the output voltage of which can be regulated within close limits. The nominal charging voltage of the battery is 37.5 volts, from which adjustments are made up or down.

This is the voltage at the battery terminals and any check and necessary adjustments are to be made with the battery in a high state of charge.

The aim is, and the charge systems will allow, for the battery to be maintained in a high state of charge - ready for an emergency and a low steady charge current of approximately 0.5 amperes will be indicated by an ammeter connected into the battery circuit.

After a discharge, emergency or otherwise, the battery will be automatically recharged. On restoration of the supply the battery will accept a high charge current, the value of which will fall as the battery is recharged, and until the final steady current of 0.5 ampere is flowing into the recharged battery.

NOTE: If circumstances arise where the battery needs recharging from an external power supply, and there is any doubt as to the amount required, always be generous and give a full normal charge. Normal charge for the battery from discharged is 48 amperes for 8 hours, with the charge voltage adjustable between 1.4 and 1.72 volts per cell.

10-4.2.3 Maintenance in Service

The batteries require only minimum routine maintenance, as described below.

Regular checking of the charging current in normal service is not necessary. The important check is that the correct charging voltage is being maintained at the terminals of the battery. The charge current is then self-regulating in accordance with the state of charge of the battery. With the battery deeply discharged the current is high; with the battery in a high state of charge the current is low.

NOTE: The gradual lowering of the electrolyte level is the very best indication that the battery is being kept in high state of charge, and that conditions are normal.

It follows that the rate of fall is directly proportional to the running time of the vehicle. Any marked difference in this rate of water consumption should be investigated at once.

A greater rate of consumption suggests the existence of a high charging voltage.

A lower or negligible rate of consumption means either a below-normal charging voltage, or that some fault has occurred on the discharge side which prevents the battery from becoming fully charged.

The investigation should always begin with a check on the condition of the charging equipment and regulators.

Check tightness of all connectors and clean off any accumulation of dirt.

10-4.2.4 Topping Off Battery

Topping-Off Water: for best results use only pure DISTILLED water, and be sure that it is free from acid contamination. Do not use any other water unless it has been tested for purity beforehand. This is known as APPROVED WATER, samples of which have been laboratory analyzed and confirmed as suitable for use with the batteries.

The following specifications refers to APPROVED water:

(a) Total solids not exceeding 2 parts in 100.00.

(b) Calcium Oxide)
Magnesium) each impurity not to exceed 1
Iron Oxide) part in 100.00
Chloride expressed as Chlorine)

(c) Lead to be absent.

(d) Water to be clear and free from suspended matter and oil.

Store topping-off water in clean glass or polyethylene containers only. Do not use containers which may have held sulphuric acid, since even slightly acidic water can be detrimental to battery cells, and do not use metal containers, which may corrode.

Topping-Off Procedure: Top-off with DISTILLED or APPROVED water to a maximum height of 87 mm over the plates.

Do not fill above the correct level, as this may cause loss of solution, necessitating frequent renewal and damage to the battery through external dampness and leakage currents. Always top-off before charging so that subsequent gassing mixes the solution.

It is recommended that the ALCAD© Celltopperª be used for topping-off. This consists of a filling pistol, a pressure tank to contain the topping-off water, an audible alarm and distance bushing appropriate to the cell being serviced.

The filling pistol is connected by a rubber tube to the pressure tank.

Topping-off procedure consists of inserting the tip of the pistol into each cell in turn, as far as it will go; opening the hand operated valve so that the water flows into the cell until, when the solution has reached the tip of the pistol, the electrical circuit is completed. The circuit consists of a small battery, electronic switch and an audible alarm. When the alarm sounds the operator releases the valve to stop the flow of water.

Each cell has then been topped-off steadily and accurately to the correct level of 87 mm over the plates.

NOTE: The Automatic Topping-Off Apparatus is for use with water only. It must not be used for electrolyte.

10-4.2.5 Cleanliness

Keep cells, trays and the inside of the battery compartment clean and dry.

Mop up any water or electrolyte which may be spilled immediately. Dirt and dampness cause leakage currents, which may damage metal parts of the cells by electrolytic corrosion.

After drying and cleaning, the terminals of the cells and connectors should be smeared liberally with petroleum jelly.

10-4.2.6 Electrolyte Specific Gravity

The normal specific gravity of the electrolyte in new cells is approximately 1.190, with the solution standing at the correct level of 87 mm over the plates.

The specific gravity does not vary with the state of charge of the battery, but falls gradually in the course of time.

Check the specific gravity every 12 months and when it has fallen to approximately 1.145, the electrolyte solution should be renewed completely.

Provided that reasonable care has been taken to use only DISTILLED or APPROVED water for topping-off, it is unlikely that electrolyte renewal will be needed in less than 5 years.

10-4.3 Battery Circuit Breaker Panel

Not applicable.

10-4.4 Dead Battery Start Manual Switch

Not applicable.

10-4.5 Contactor Group

Not applicable.

10-5 TROUBLESHOOTING AND REPAIR

10-5.1 Power Loss

Each married pair feeds 37.5 volts power from its converter or battery to the trainlines. A loss of 37.5 volts within a complete train indicates a failure of all converters within the train. When converters fail, batteries will supply power until the Undervoltage Relay(s) trips the Battery Circuit Breaker to protect batteries from excessive drain.

Complete loss of 37.5 volts power is readily observable because taillights and headlights will be extinguished and no annunciator panel will be energized.

10-5.2 LVPS/Battery Charger

In case of a converter failure:

a. Isolate the suspected pair electrically by cutting out KAS1 and KAS2 at the F-End T/L Junction Boxes on both cars.

b. Check H.V. Circuit Breaker Panel (KP) for tripped breaker. If a breaker is tripped, look for loose or shorted high voltage connections. These conditions can be corrected; other causes of tripped breaker require shop testing.

If the above procedures do not reveal the cause of malfunction, tests must be performed as described in Section 7 of this Repair and Maintenance Manual or Section 8 of the Workshop Manual.

10-5.3 Battery

10-5.3.1 Repairs

10-5.3.1.1 Electrolyte Renewal

CAUTION: CELLS SHOULD NOT BE EMPTIED OF ELECTROLYTE WITHOUT PRIOR ADVICE OF MAINTENANCE SUPERVISOR. IN THE EVENT OF ACCIDENTAL SPILLAGE, CELLS SHOULD BE REFILLED WITH ELECTROLYTE ONLY, AS SOON AS POSSIBLE. CELLS SHOULD NOT BE FILLED WITH WATER OF

(Cont'd) ANY KIND - THIS WILL CAUSE INTERNAL CORROSION AND DAMAGE.

CAUTION: IN THE ABSENCE OF ELECTROLYTE, PLUG EACH CELL VENT WITH A SOLID RUBBER OR WOODEN STOPPER SO AS TO EXCLUDE AIR; REMOVE THE PLUG ONLY WHEN READY TO REFILL WITH ELECTROLYTE.

Each battery of 25 cells requires 95 liters of electrolyte. Use only ALCAD renewal electrolyte type R. It will be supplied in non-returnable steel drums together with mixing instructions.

Have the electrolyte ready, together with a polyethylene plastic funnel that fits the cell vents, and proceed as follows: (see also paragraph 10-4.2, Safety Precautions).

Discharge the battery's 25 cells across a fixed resistance of approximately 0.6 ohms, with an ammeter in series to indicate the discharge current. The nominal discharge voltage is 1.2 volt per cell and the end voltage is 1.0 volt per cell.

The discharge data are shown in Table 10-1:

Table 10-1. Discharge Data (at 20°C ± 5°C)

AMPERES ON DISCHARGE	1 SEC	60 SEC	5 MIN	10 MIN	15 MIN	30 MIN	60 MIN	90 MIN	2 HRS	3 HRS	5 HRS	8 HRS
TO 1.00 VOLT PER CELL	741	590	483	445	419	330	211	152	119	82	50.8	32.3
TO 1.05 VOLT PER CELL	643	492	414	381	353	295	201	147	117	80.4	50.3	31.9
TO 1.10 VOLT PER CELL	546	413	326	290	274	241	180	140	110	77.9	49.3	31.6
TO 1.14 VOLT PER CELL	462	350	268	237	224	193	150	119	98.9	73.8	47.8	30.6

Disconnect the trays and cells from each other and work with one cell at a time. Open the cell vent caps and tip the cell so that the electrolyte is emptied away into a steel drum, and allow to drain for a few minutes.

DO NOT WASH OUT THE CELLS WITH WATER.

Return the cell to the upright position, and using the funnel, immediately refill with fresh electrolyte until the plates are covered to a depth of 87 mm. After all cells have been so treated, they are to be reconnected in series and the battery given a charge of 48 amperes for 15 hours before being returned to service.

> **NOTE:** To conform with hazardous waste disposal requirements, all spent electrolyte MUST BE stored in a suitable steel drum until ready for disposal. All empty drums in which new electrolyte has been removed MUST NOT BE thrown away with standard factory waste. Federal and State regulations must be followed when disposing of spent electrolyte and empty drums.

10-5.3.1.2 Battery Overhaul

When the vehicle is withdrawn for service for major overhaul (typically after 5-10 years) the opportunity should be taken to give a more extensive service to the battery. The following procedure is recommended.

(a) Remove battery from vehicle.

(b) Steam clean cells and cradles and replace any damaged components.

(c) Recommission the battery following procedure outlined in Section 10-5.3.

10-5.4 Contactor Group

Not applicable. For inspection, removal, installation see Section 7 of this Manual.

10-5.5 Dead Battery Start Manual Switch

Not applicable.

10-5.6 Battery Circuit Breaker

Not applicable.

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SECTION 11

LIGHTING CIRCUIT AND DESTINATION SIGNS

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LIGHTING CIRCUIT AND DESTINATION SIGNS

11-1.1 Installation Arrangement

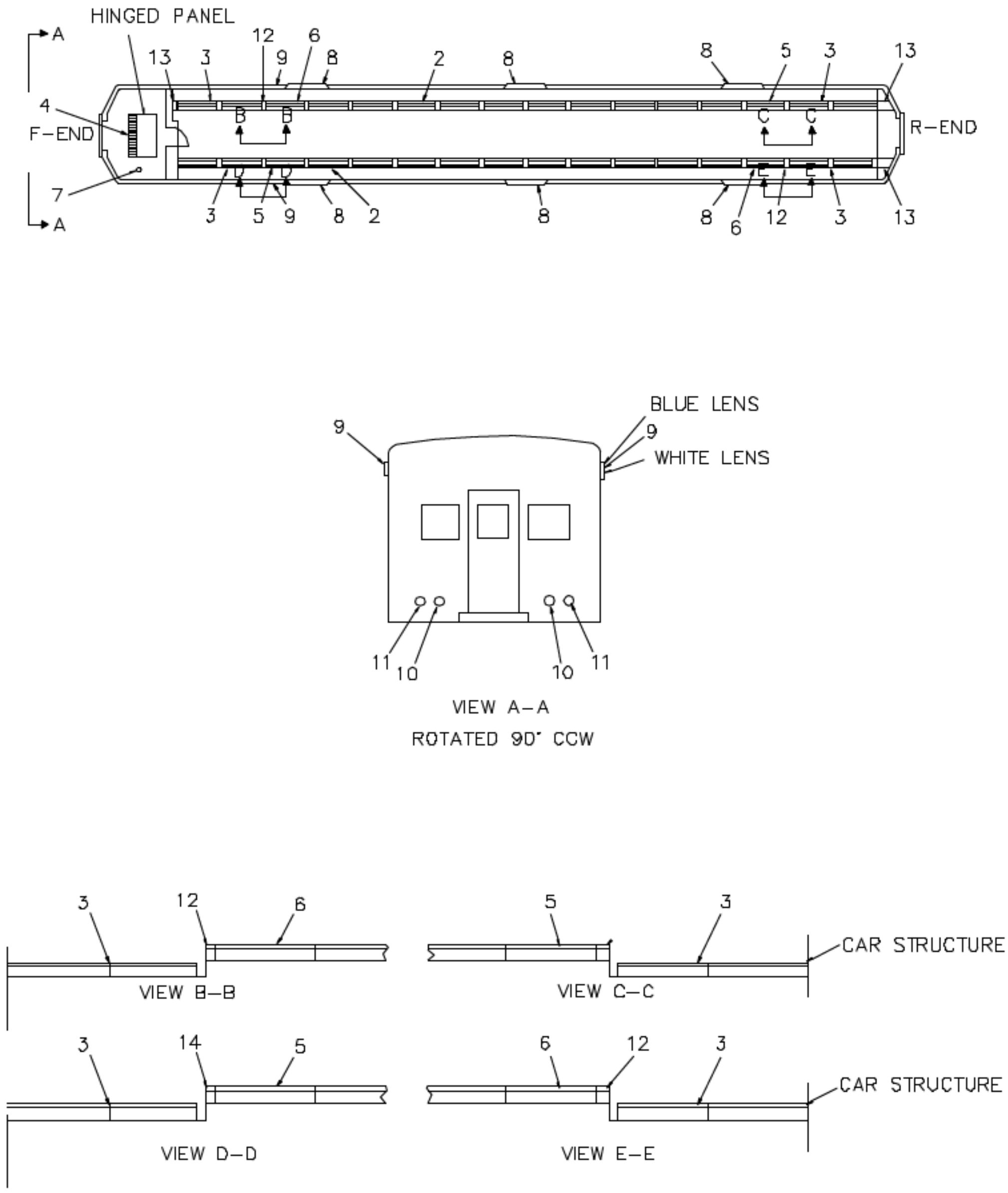

Figure 11-1. Installation Arrangement

FIG/ REF	QPV	PART NUMBER LUMINATOR #	TA #	DESCRIPTION
11-1-	REF	ICD105548		PLAN LAYOUT - LIGHTING/AIR DIFFUSER
2	20	105547001		. LIGHT/AIR DIFFUSER FIXTURE, (53.03" L) HIGH CEILING
3	4	105547003		. LIGHT/AIR DIFFUSER FIXTURE, (81.32" L) HIGH CEILING
4	1	105547005		. LIGHT/AIR DIFFUSER FIXTURE, (43.38" L) HIGH CEILING
5	2	105547007		. LIGHT/AIR DIFFUSER FIXTURE, (52.66" L) HIGH CEILING (see views C-C and D-D)
6	2	105547009		. LIGHT/AIR DIFFUSER FIXTURE, (53.03" L) HIGH CEILING (see views B-B and E-E)
7	1	105108001		. INCANDESCENT CEILING LIGHT FIXTURE, CAB AREA
8	6	105552001		. DOOR INDICATOR LIGHT FIXTURE, (RED LENS) EXTERIOR
9	2	105553001		. MODE AND TROUBLE INDICATOR LIGHT FIXTURE, (BLUE AND WHITE LENS) EXTERIOR
10	2	103236001		. HEADLIGHT FIXTURE ASSEMBLY
11	2	106515001		. TAILLIGHT FIXTURE ASSEMBLY
12	2	106588001		. FILLER ASSEMBLY (TERMINAL ASSEMBLY)
13	3	106588003		. FILLER ASSEMBLY
-14	1	106578002		. INSTALLATION KIT

(-) item not illustrated

Table 11-1. Lighting Particulars Quick Reference (See Figure 11-1)

REF	LIGHT ASSEMBLY IDENTIFICATION LUMINATOR #	DESCRIPTION	LAMPS (BY OTHERS) INCANDESCENT #	QPA	FLUORESCENT #	QPA	INVERTER BALLAST LUMINATOR #	QPA
2	105547001	High ceiling fluorescent light/air diffuser fixture.			F40T12	1	106590003	1
3	105547003	Low ceiling fluorescent light/air diffuser fixture.			F30T12	2	106590003	2
4	105547005	Cab fluorescent light/air diffuser fixture.			F30T12	1	106590003	1
5	105547007	High ceiling fluorescent light/air diffuser fixture.			F40T12	1	106590003	1
6	105547009	High ceiling fluorescent light/air diffuser fixture.			F40T12	1	106590003	1
7	105108001	Cab incandescent ceiling light fixture.	2232	1				
8	105552001	Door indicator light fixture.	CM8-95	1				
9	105553001	Mode and trouble indicator light fixture.	CM8-95	2				
10	103236001	Headlight fixture assembly.	200/PAR	1				
11	106515001	Taillight fixture assembly	60PAR/2/R	1				

11-1.2 Fluorescent Lights

11-1.2.1 Fluorescent Lights Description

Figure 11-2 shows the fluorescent lights. Figure 11-3 shows the typical exploded view. Although the fluorescent lights all have the same basic purpose of illuminating the passenger entrance and seating areas, they are designed to distribute forced conditioned air by means of air vents and is directed down to the seating area.

Each light fixture contains a DC inverter ballast which receives a nominal 37.5 V DC from a vehicle power source. DC inverter ballasts operate under normal vehicle operating conditions, they also serve for emergency lighting purposes. The specific fluorescent light assemblies are explained below in further detail.

c. Light/Air Diffuser Light Fixtures, Cab Area (Figure 11-2)

The cab area fluorescent light fixture (105547005) is similar to the high ceiling light fixture except that it is smaller (43.38" L) and is mounted to a hinged ceiling panel that swings open. The light fixture contains one small inverter ballast installed at one end of the housing assembly and is accessible through a cover assembly that easily removed by loosening two captive screws.

The ballast is held in place with two springs (one on each side). An eight pin connector plugs into the ballast, four pins are connected to the lamp circuit, two pins are connected to vehicle power source, and the remaining two pins are blank.

11-1.2.3 Ballast Replacement, Typical (Figure 11-3)

a. Removal

(1) Turn off all power to the fluorescent lighting system(s).

(2) Loosen the two captive screws located on the bottom of the ballast cover assembly and lower the cover, letting it hang down with the attached lanyard.

(3) Unplug the ballast socket from the ballast assembly and move it clear of the ballast.

(4) Grasp the defective ballast securely and remove it by pulling the ballast down until it clears the two ballast springs. Refer the ballast to electronics bench service or return it to Luminator for repair or replacement.

11-1.2.6 Light Assembly Replacement, Typical (Figure 11-3)

a. Removal

(1) Turn off all power to the fluorescent lighting system(s).

(2) Open the door/lens assembly and remove the fluorescent lamp(s) as detailed in paragraph 11-1.2.2 Fluorescent Lamp Replacement.

(3) Remove door/lens assembly as directed in paragraph 11-1.2.5 Door/Lens Replacement, Typical.

(4) Remove ballast cover assembly, disconnect ballast socket from ballast, and remove ballast assembly as detailed in paragraph 11-1.2.3 Ballast Replacement, Typical.

(5) Note and remove the vehicle wire leads from the ballast socket.

(6) Loosen three or four ceiling clamp screws and remove adjacent ceiling panels.

(7) While one person is holding light fixture in place, loosen and remove mounting screws securing fixture to vehicle structure.

(8) Gently lower the light fixture by letting it swing down on its rear hinge rail and at the same time removing the vehicle wire leads from the housing assembly grommet(s).

(9) Carefully remove light fixture and set it aside in a safe area.

11-1.3 Incandescent Lights

11-1.3.1 Incandescent Lights Description

Figure 11-5 shows the incandescent light fixtures.

The incandescent lights serve different purposes and receive 37.5 V DC from various power sources and/or switches according to their respective applications. The different incandescent light assemblies used in this arrangement are described below in further detail.

a. Incandescent Ceiling Light (Figure 11-5)

The Incandescent Ceiling Light Fixture (105108001) is mounted in the ceiling which is located in the operator's cab area. The fixture is comprised a lens cap assembly, bezel, and a housing assembly.

The housing assembly accommodates a lamp, terminal block and a resistor. The fixture uses a #2232 incandescent lamp. The fixture operates on a 37.5 Vdc power source and reduces to 28 Vdc by utilizing a 14.7 ohm, 15 watt wire wound dropping resistor.

b. Door Indicator Light (Red) (Figure 11-5)

Door Indicator Light Fixture (105552001) measures 3.75" in diameter and contains one red lens, bezel, sun shield, grommet, back plate and a molded plastic housing. There are six (6) light fixtures, one mounted over each exterior door of the vehicle. The light fixture has an exterior surface mount cover/lens assembly which mounts over and secures to a recess mounted housing assembly.

The lens appears to be hemispherical as it extends outward from the cover assembly and is secured into it's cover assembly with a weather proof grommet. Each indicator light supports a CM8-95 incandescent lamp.

c. Mode And Trouble Indicator Light (Figure 11-5)

Mode and Trouble Indicator Light Fixture (105553001) is an oblong fixture which measures 3.75" X 7.44" and contains one upper blue lens, one lower white lens, bezel/lens, back plate, two grommets, and two molded plastic housings.

The housing assemblies are recess mounted, each supporting a CM8-95 incandescent lamp and one flat surface mounted bezel/lens assembly that mounts over and is secured to the housing assemblies with screws.

11-1.3.2 Incandescent Ceiling Light (1051080001)

Figure 11-6 shows the incandescent ceiling light exploded view.

11-1.3.4 Indicator Lights (0105552-001 & 105553001)

Figure 11-7 shows the indicator lights exploded views.

11-1.3.7 Taillight (106515001)

Figure 11-8 shows the taillight exploded view.

11-1.3.9 Headlight

Figure 11-9 shows the headlight exploded view.

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SECTION 15

INTEGRATED SYSTEM TROUBLESHOOTING

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LIST OF ILLUSTRATIONS

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SECTION 15

INTEGRATED SYSTEM TROUBLESHOOTING

15-1 INTRODUCTION

This chapter contains field maintenance procedures. For each type of problem, the possible causes are given in order of probability and the symptoms with their remedies are described.

To support troubleshooting and proper maintenance action, table 15-1 lists the relays mentioned in the procedures, with their relative locations, repeated for clarity throughout the procedures listed in table 15-3.

Table 15-1 Relay Locations

"A" Car

LOCATION	PANEL	RELAY
KA box	Q1	FBFR KEA KDA KAM1 KAM2R KAM2C TDR HWR
KA box	Q4	PBR SBFR KSR1 DAO PCR FBCR KSR2 CCR PCR1
Brake Control Box cabinet in the passenger cab area (see Fig. 15-1)	Q2	EMRO EFI EIR CER ZSR MTOR

(Cont'd)

Table 15-1 Relays Location (Continued)

"A" Car

LOCATION	PANEL	RELAY
Brake Control Box cabinet in the passenger area opposite the cab (see Fig. 15-1)	Q2	KAM3 BBR KCA DCBR RMO FRE ATOR EMO DMLL DMLR
	KQ	KSR3 RJR BADR FLR

"B" Car

LOCATION	PANEL	RELAY
KA box	Q1	FBFR KEA KDA KAM1 KAM2R KAM2C TDR HWR
KA box	Q4	KSR1 DAO PCR KSR2 TDC TDO DOR DOL DSR DSL DCO

(Cont'd)

Table 15-1 Relays Location (Continued)

"B" Car

LOCATION	PANEL	RELAY
Brake Control Box cabinet in the passenger cab area (see Fig. 15-1)	Q2	EMRO EFI EIR CER ZSR MTOR KAM3 KCA DCBR FRE EMO DMLL DMLR AOR PFR APFR FBOR FBCR
Cabinet in the operator's cab area, behind the operator's seat.	KQ	KSR3 RJR BADR FLR

Table 15-2 is intended as a guideline where the maintainer can find a list of commonly found problems (divided into main groups) that can arise in Metro Red Line operation. Many of these problems are present in more than one group and are highlighted with an asterisk (*).

Table 15-2 Guideline To Troubleshooting

System and or equipment involved in the failure		Troubleshooting Steps in Table 15-3
1.	Key Switch	1
2.	Energy/Power (LV, HV Generation	2, 4, 5, 6, 28, 29*, 30*, 77, 81*, 100*

	and Distribution)	

(Cont'd)

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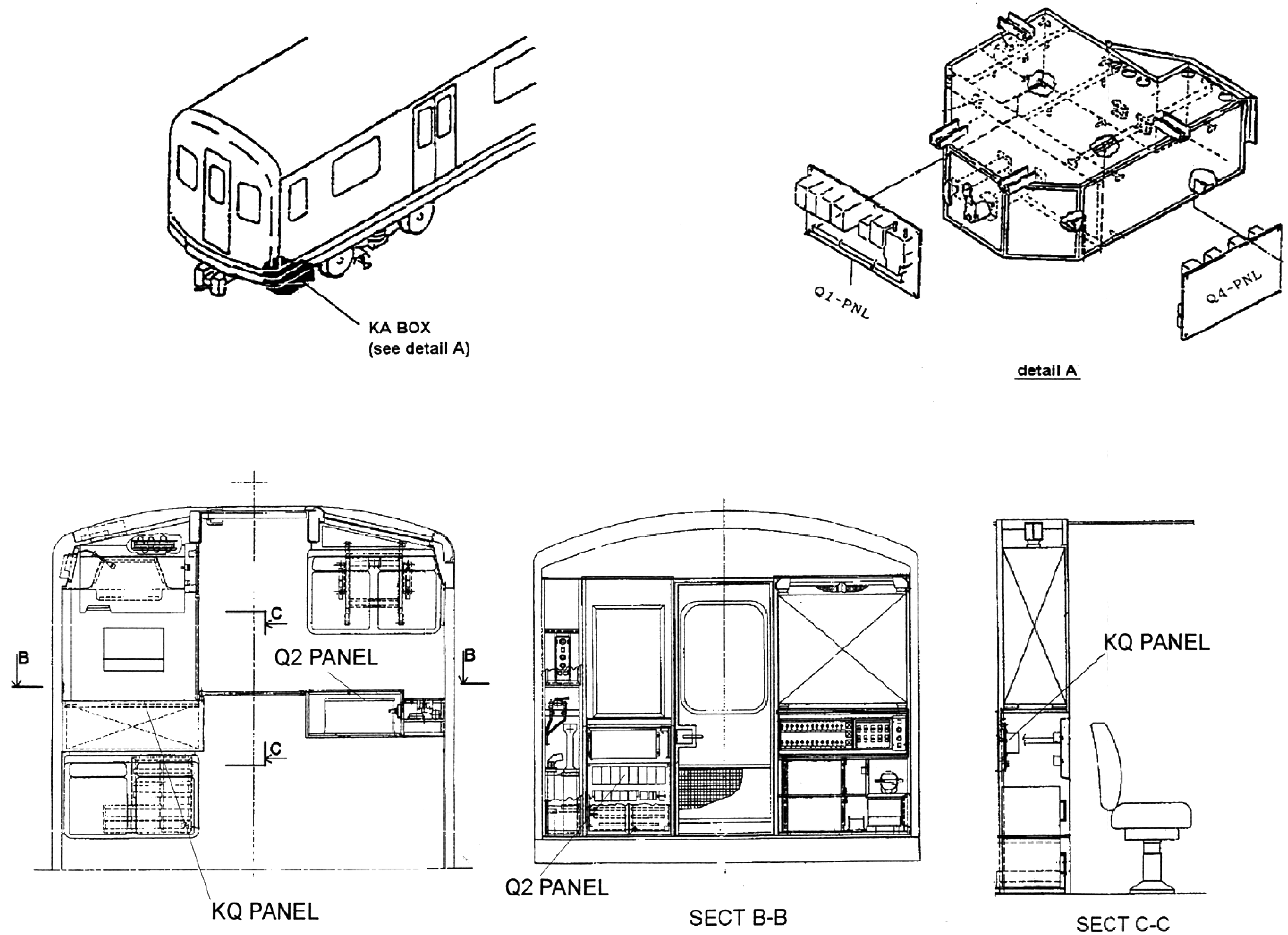

Figure 15-1. Relay Panel Locations

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Table 15-2 Guideline To Troubleshooting (Continued)

System and or equipment involved in the failure		Troubleshooting Steps in Table 15-3
3.	Auxiliary Systems	3, 7, 81*, 100*
4.	Doors	8 to 11 (closing problems), 18 to 22 (opening problems), 27, 63*, 88*, 105* (12 to 17)*, (23 to 26)*
5.	Lights	29* to 36
6.	Coupling	37 to 39
7.	Air Conditioning	40 to 43
8.	Destination Sign	44 to 46
9.	Communication System	47, 48
10.	ATP System (ATC System)	49, 50, 52*
11.	ATO (ATC System)	51, 55*, 62, 63*, 66*, 70*
12.	Signal/Indication (ATC System)	(12 to 17)*, (23 to 26)*, 53, 54, 56, 57*, 68*
13.	Brake (ATC System)	52*, 55*, 68*, 69, 73 to 76, 80*, (83 to 86)*, 95*, 96*, 97*, 99*
14.	MTO (ATC System)	57*, 58, 65*, 70*
15.	Sub - Mode (ATC System)	57*, 59, 60
16.	EMO (ATC System)	61, 71, 90*, 91*, 92*
17.	Propulsion System (ATC System)	64, 65*, 66*, 67, 68*, 79*, 82*, 94*
18.	Berthing Loop (ATC System)	72, 77*
19.	Luminous Indicators (ATC System)	78, (79 to 86)*, 87, 88*, 89, 93 to 100*, 101 to 104, 105*

15-2 TROUBLESHOOTING AND REPAIR PROCEDURE

Table 15-3 Troubleshooting

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
1) The key switch does not turn.	Broken mechanism.		Mechanism has to be replaced.
	Broken DM Solenoid release mechanism.		Solenoid has to be repaired.
	Other cab is already energized.	Other cab on indicator.	The other cab has to be de-energized.
2) The cab cannot be energized with the “key switch” in the on position.	Lack of 750 Vdc high voltage.	Auxiliary system off.	Energize the contact rail or feed the high voltage into exterior lug.
	Lack of 37.5 Vdc low voltage (battery discharged).	Auxiliary system off.	Operate the “Dead battery start” BU lever in car body B.
	AOR relay, on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (B car) does not operate.	Auxiliary system off.	Replace AOR relay.
	Battery bus circuit-breaker open.	Auxiliary system off.	Close the Aux. on/off CBS circuit-breaker.
	Short-circuit in BA box (battery).	Auxiliary system off.	Remove short-circuit. Close BBCB circuit-breaker in BB box.
	Excessive temperature in BA box (battery).	Auxiliary system off.	Check and replace faulty battery components.
	Faulty BT switch (in BA box).	Auxiliary system off.	Replace switch.

(Cont’d)

Table 15-3 Troubleshooting (Continued)

PROBLEM		POSSIBLE CAUSE	SYMPTOM	REMEDY
3)	Auxiliary systems off in car body A.	Short-circuit in connection between “ER” and “LVPS” in A car.	Missing positive con-tact on E1 terminal of “LVPS” of car A.	Verify that the ERCB circuit breaker in ER box (A car) is closed. Verify cabling and take out the short-circuit.
4)	No power supply to essential bus equipment.	LVPS does not function.	Auxiliary system off.	Close MCCB circuit-breaker in KP box.
5)	No power supply to married pair bus.	F2 fuse in BP box blown.	ATP does not function in both cars A and B. Car radio and TICU do not function.	Replace F2 fuse.
6)	No power supply to cab bus.	F1 fuse in BP box blown.	No indications on Lighting/Windshield HVAC Control Panel.	Replace F1 fuse.
7)	Turning the key switch off, the auxiliary system go off without delay.	Improper setting of delay time on DAO relay, on Q4 panel in KA box. (A and B car).		Adjust setting using relay knob.
8)	All doors do not close.	Door control CB18 open.	All exterior indicators on. “Door closed” indication on DE and DC panels does not come on.	Close the circuit breaker.
9)	All doors on right-hand side do not close.	“Door operator right” CB16 tripped.	All exterior indicators on right hand side are on. “Door closed” indication on DE panel off.	Close CB16 circuit breaker.
10)	All doors on left-hand side do not close.	“Door operator left” CB17 tripped.	All exterior indicators on left hand side are on.	Close CB17 circuit breaker.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM		POSSIBLE CAUSE	SYMPTOM	REMEDY
11)	One or more doors do not close.	Door operator panels CB tripped.	Indicator showing that door has re-mained open is on.	Close the CB.
		Emergency opening handle has been operated.	Indicator showing that door has re-mained open is on.	Re-set the handle in position.
		Obstruction in move-ment or between door leaves.	Indicator showing that door has re-mained open is on.	Remove obstruction.
12)	No "Doors closed" indica- tion on DE and DC panels, even if all ex-terior indi-cators are off.	CB18 in low voltage circuit breaker panel open (A and B car).	Door close lights on DE and DC panels off.	Close CB18 in A or B car.
		KCA relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area, fails to open.	Door close lights on DE and DC panel off.	Check KCA in A or B car.
		Problems in KAS1 rotary coupler switch.	Door close lights on DE and DC panels off.	Check KAS1 switch contacts status.
13)	No "Doors closed" indica-tion on DE panel when doors actually closed.	Indicator fault.	Indicator off.	Change indicator.
		Fault in DMRL relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car), of energized cab.	Indicator off.	Replace DMLR relay.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM		POSSIBLE CAUSE	SYMPTOM	REMEDY
14)	No "Door closed" indication on DC panel when doors actually closed.	Indicator fault.	Indicator off.	Change indicator.
		Fault in DMLL relay in KA box of energized cab.	Indicator off.	Replace DMLL relay.
15)	TICU does not receive doors closed signal from circuit.	Fault in DMLL and DMLR relays, on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (A and B car).	No retransmission of information.	Replace DMLL or DMLR.
16)	TICU does not receive "Door failed to close" signal when one door on right-hand side stays open.	Fault in DSR and DOR on panel Q4 in KA box (B car).	No retransmission of information.	Replace DSR or DOR.
		KATB4 23-24 diode blown.		Replace diode.
17)	TICU does not receive "Door failed to close" signal when one door on left-hand side stays open.	Fault in DSL or DOL. Relay on Q4 panel in KA box (B car).	No retransmission of information.	Replace DSL and DOL.
		KATB4 21-22 diode blown.		Replace diode.
18)	All doors do not open.	Train not berthed.		Operate berthing bypass.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM		POSSIBLE CAUSE	SYMPTOM	REMEDY
19)	All doors do not open even when berthing bypass is operated.	Door control CB18 open.		Close CB18.
		Low voltage circuit breaker panel CB25 open.		Close CB25.
		BMTB1 7-6 diode blown.		Replace diode.
		BMTB4 11-12 diode blown.		Replace diode.
		BMTB6 8-9-10 diodes blown.		Replace diodes.
		Fault in BBR relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A Car).		Replace the relay.
		Fault in KSR1 on Q4 panel in KA box. (A and B car).		Replace the relay.
20)	Doors on right-hand side do not open.	"Door operator right" CB16 tripped.		Close the CB16.
21)	Doors on left-hand side do not open.	"Door operator left" CB17 tripped.		Close the CB17.
22)	One or more doors do not open.	Door operator panel CB tripped.		Close the CB.
		Emergency doors		Re-position the

	opening handle has been operated.		handle.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
	Obstructed movement.		Remove obstruction.
23) TICU does not receive "Doors open" signal.	Faults in DMLL and DMLR on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (A and B Car).	No retransmission of information.	Replace DMLL or DMLR relay.
24) TICU does not receive "Door failed to open" signal when one door on right-hand side has stayed open.	Faults in DSR and DOR. on Q4 panel in KA box (B car).	No retransmission of information.	Replace DSR or DOR relay.
	KATB4 23-24 diodes blown.	No retransmission of information.	Replace the diodes.
25) TICU does not receive "Door failed to open" signal when one door on left-hand side has stayed open.	Faults in DSL and DOL relays on Q4 panel in KA box. (B car).	No retransmission of data information.	Replace DSL or DOL relays.
	KATB4 21-22 diodes blown.		Replace the diodes.
26) Door close by-pass control does function.	Failure of DCBR relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Deadman loop continues to remain open.	Replace the DCBR relay.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
27) Crew switch does not operate doors.	Lack of battery bus.	Door does not open or close.	Recharge battery. Activate Dead Battery Start (only with high voltage applied). Verify battery CB.
	Door control CB18 open.	Door does not open or close.	Close circuit breaker CB18.
	Door operator left CB17 open.	Door does not open or close.	Close circuit breaker CB17.
	Door operator right CB16 tripped.	Door does not open or close.	Close circuit breaker CB16.
28) Non-essential bus de-energized.	Battery level too low because LVPS/battery charger is not charging.	Only emergency lights come on.	Check LVPS/battery charger and battery.
29) "Interior lights 1" line de-energized.	"Interior lights 1" CB7 tripped.	Line "1" lights are off.	Close circuit breaker 7.
30) "Interior lights 2" line de-energized.	"Interior lights 2" CB6 tripped.	Line "2" lights are off.	Close circuit breaker 6.
31) Emergency lights off.	"Emergency lights" CB11 tripped.		Close circuit breaker 11.
32) Tail-lights both in front and end car are on.	Failure in KEA relay on Q1 panel in KA box (A and B car).		Replace KEA relay.
33) External headlights are off.	"External lights" CB15 tripped.		Close CB15.
	Fault in KDA relay, on Q1 panel in KA		Replace relay.

	box (A and B car) (active car).		

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
	No control lock-interlock T/L.		Verify KAS1 rotary switch.
	KA1TB2 1-6 and KA1TB1 17-18 diode blown.		Replace diodes.
34) External tail-lights are off.	"External lights" CB15 tripped.		Close CB15.
	Fault in KDA relay on Q1 panel in KA box (end car).		Replace KDA relay.
	No control lock-interlock T/L signal.		Verify KAS1 rotary switch (end car).
	KA1TB1 17-18 diode blown.		Replace diode.
35) Tail-lights in both front and end cars are on.	Fault in KEA relay on Q1 panel in KA box. (A and B car).		Replace KEA relay.
	KA1TB2 1-6 diode in front cab blown.		Replace diode.
36) Headlight by-pass does not function.	External lights CB15 tripped.	Headlights do not come on.	Close CB15.
37) No electrical coupling.	Coupler control CB20 tripped.	"Couple" magnet valve inactive.	Close CB20.
	MTO Generator CB24 tripped.	Vehicle does not move.	Close CB24.
38) No wash/couple mode operation.	Fault in "P" signal Generator.	Vehicle does not move. Master Control does not generate the required percentage of "P"	Replace Master Controller.

		signal (65%).	

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
39) No coupling.	Coupler control CB20 tripped.	"Isolate" and "Uncouple" magnet valve inactive.	Close CB20.
	MTO Generator CB24 tripped.	Vehicle does not move.	Close CB24.
	Fault in KSR3 relay on KQ panel, in the lower part of the cabinet located behind the operator seat (A car).	Vehicle does not move.	Replace KSR3 relay.
	Fault in RJR relay on KQ panel or incorrect setting.	Vehicle does not move or moves too short or too long a distance.	Replace RJR relay or adjust the delay to open timing using the relay knob.
40) Air-conditioning system does not start.	Miscellaneous control CB27 tripped.		Close CB27.
	KATB2 19-24 diode blown.	No signal on HVAC on/off trainline.	Replace diode.
41) Air-conditioning system does not function.	HVAC CB14 tripped.	HVAC failure indicator on.	Close CB14.
	Auxiliary CB1 and CB2 inside HP box tripped.	HVAC failure indicator on.	Close CB1 and CB2.
42) Front part of air-conditioning system does not function.	One of the following high voltage circuit breakers inside the KP box tripped: CMB1, CFMCB1, BFCB1, OHCB1.	HVAC failure indicator on.	Close tripped CB.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM		POSSIBLE CAUSE	SYMPTOM	REMEDY
43)	Rear part of air-conditioning system not operational.	One of the following high voltage circuit breakers inside the KP box tripped: CMB2, CFMCB2, BFCB2, OHCB2.	HVAC failure indicator on.	Identify and close the tripped CB.
44)	No destination sign gives indications.	Destination sign CB8 of car "B" of M-pair leader tripped.		Close CB8.
45)	Destination signs on one car do not give indications.	Destination sign CB8 on that car tripped.		Close CB8.
46)	Destination signs do not change indications or give wrong indications.	Radio/TICU CB28 on car "B" of Married Pair leader tripped.		Close CB.
		Faulty connection between RS232 TICU sign and Control Unit.		Check connection.
47)	Communication system does not function.	Comm. CB23 tripped.		Close circuit breaker.
		Fault in KSR1 relay in the lead car KA box, Q4 panel.		Replace relay.
48)	Communication system functions only partly.	Comm. CB23 tripped on cars where system is not operational.		Close CB23.
		Cutout of trainlines which control inac-		Check continuity of trainlines.

	tive function.		

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM		POSSIBLE CAUSE	SYMPTOM	REMEDY
49)	ATP system does not function.	ATP CB2 tripped.	ATP off.	Close CB2.
		MTO Generator CB24 tripped.	ATP off.	Close CB24.
50)	ATP does not give "Restricted" signal when vehicle is in the yard.	Fault in RMO relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area. (A car).	Berthing function is not bypassed (BBR relay in KA box deenergized).	Replace RMO relay.
51)	Overspeed alarm function activates in ATO.	Fault in MTOR relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Overspeed buzzer sounds in ATO mode.	Replace MTOR relay.
52)	ATP always applying emergency brake instead of a service brake function.	Fault Master Controller.	Emergency light on console comes on whenever braking is necessary.	Replace Master Controller.
		Defective KSR3 relay on KQ panel, in the lower part of the cabinet located behind the operator's seat (A car).		Replace KSR3 relay.
53)	Zero-speed sigal does not turn off when vehicle is in motion.	Defective ZSR relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area, (A and B car).	Zero-speed indicator cannot be turned off.	Replace ZSR relay.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM		POSSIBLE CAUSE	SYMPTOM	REMEDY
54)	Open deadman loop prevents train movements.	Defective Master Controller.	Application of emergency brake.	Replace Master Controller.
		Defective ZSR relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Application of emergency brake.	Replace ZSR relay.
		Defective DMLL relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Application of emergency brake.	Replace DMLL relay.
		Defective DMLR relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Application of emergency brake.	Replace DMLR relay.
55)	Brake cannot be released in both ATO and MTO mode.	Cutout of US BRK+ and BRK- connections.	When the Master Controller is turned to coast position, brake stays on.	Verify connections.
56)	No speed limit indication is given.	Defective KSR2 relay on Q4 panel in KA box (A and B car).	LEDs on speedometer panel off.	Replace KSR relay.
		Defective speedometer panel.		Replace speedometer.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
57) Mode switch cannot be switched from off to MTO.	ATP CB2 and MTO Generator CB24 off.		Close CB2 and CB24.
	No zero-speed signal from ATP.		Activate zero-speed bypass switch.
58) Manual train operation does not function.	MTO Generator CB24 tripped.	Brake cannot be released in MTO.	Close CB24.
	Defective Master Controller.	Brake can be released but train does not move.	Replace Master Controller.
59) Wash/couple sub-mode does not function.	Defective Master Controller.	Train does not move when wash/couple pushbutton is pressed.	Replace Master Controller.
60) Reverse/jog sub-mode does not function.	Defective Master Controller.	Train does not move when rev/jog button is pressed.	Replace Master Controller.
61) Emergency mode operation (EMO) does not function.	MTO Generator CB24 tripped.	EMO indicator on console stays off.	Close CB24.
	One or more doors do not close.		Verify door closing.
	Defective DMLL or DMLR relay on Q2 in the Brake Control Box cabinet, in the passenger cab area (A and B car).		Replace defective DMLL or DMLR relay.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
	Defective EMO relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area.		Replace EMO relay.
	Faulty full service brake contact in Master Controller.		Replace Master Controller.
62) Automatic train operation does not function.	ATO CB1 tripped.	Train does not move in ATO mode.	Close CB1.
	Defective ZSR relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area, (A and B car).		Replace ZSR relay.
	Defective KSR3 relay on KQ panel, in the lower part of the cabinet located behind the operator's seat.		Replace KSR3 relay.
	Defective DMLL or DMLR relays on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area, (A and B car).		Replace defective relay.
63) Doors do not open in ATO.	Fault ATO equipment.	No berthing verification.	Consult ATO Workshop Manual.
64) Propulsion system is not operational.	Propulsion control CB on BD panel tripped.	Propulsion failure indicator on KL Trainline Indicator panel on.	Close CB.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
	Propulsion FAN CB on BD panel tripped.	Propulsion failure indicator on KL and Trainline Indicator panel on.	Close CB.
	Knife switch cutout fuse blown.	Propulsion failure indicator on KL and Trainline Indicator panel on.	Change fuse.
	ACCB Air compressor CB tripped.	Propulsion failure on KL and Trainline Indicator panel or and blower failure indicators on KL panel on.	Close CB. Check magnet switch of Air compressor.
	HVAC front compressor CMB1 tripped.	Propulsion failure and blower failure indicators on	Close HVAC Front compressor CMB1
	HVAC rear compressor CMB2 tripped.	Motor thermal trips.	Close HVAC Rear compressor CMB2.
65) Propulsion equipment operates only in MTO mode.	Faulty equipment.		Check ATO equipment.
	Faulty ATOR relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (A car).		Replace ATOR relay on "A" car of lead Married Pair.
66) Propulsion equipment functions only in ATO mode.	Faulty MTOR relay on Q2 panel (A and B car).		Replace MTOR relay on active car.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
67) Propulsion does not receive forward and reverse signals.	Faulty KSR3 relay on KQ panel, in the lower part of the cabinet located behind the operator's seat.	Vheicle does not move.	Replace KSR3 relay.
68) Propulsion does not receive friction brake off signal.	Faulty FRE relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Vehicle does not move.	Replace FRE relay.
	Faulty 21-22 contact sect. 6 of KAS1 rotary switch.	Vehicle does not move.	Check KAS1 rotary switch.
69) No penalty brake application.	BADR relay on KQ panel, in the lower part of the cabinet located behind the operator's seat, is not correctly set.	Application of emergency braking instead of full service brake.	Replace BADR relay or set it properly (delay to open of 0.7 sec.).
70) Emergency loops cannot be reset in ATO and MTO modes.	ATP CB2 on BD panel tripped.	Indicator flashing. Emergency brake stays on.	Close CB2.
	ATO CB1 on BD panel tripped.	Indicator flashing. Emergency brake stays on.	Close CB1.
	Faulty emergency stop pushbuttons.	Indicator flashing. Emergency brake stays on.	Check pushbuttons.
	Faulty CER relay on Q2 panel, in the Brake Control Box cabinet, in the pas-	Indicator flashing. Emergency brake stays on.	Replace CER relay.

	senger cab area (A and B car).		

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
	Faulty EMRO relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Luminous emergency reset indicator does not come on when reset push-button pressed.	Replace EMRO relay.
	Faulty FRE relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (B car).	Emergency brake on flashing indicator remains lit.	Replace FRE relay.
	Defective contacts of KAS1 rotary switch.	Emergency brake on flashing indicator on Trainlines Indicator panel, remains lit.	Check rotary switch.
	Defective main pressure switch "FK".	Emergency brake on flashing indicator on Trainline Indicator panel remains lit.	Verify main pressure switch.
	Faulty trip switch "FK".	Emergency brake on flashing indicator on Trainline Indicator panel remains lit.	Verify trip switch.
	Faulty ZSR relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area.	Emergency brake on flashing indicator on Trainline Indicators panel remains lit.	Replace ZSR relay.
71) EMO emergency mode cannot be reset.	Miscellaneous CB on BD panel tripped.	Flashing "emergency brake on" indicator remains lit.	Close CB.
	Faulty Master Controller.	Flashing "emergency brake on" indi-	Replace Master Controller.

		cator remains lit.	

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
	Faulty EMO relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Flashing "emergency brake on" indicator remains lit.	Replace EMO relay.
	Faulty Mode switch.	Car will go into EMO.	Replace Mode switch.
72) Berthing loop is not operational.	Cutout of KQTB2 7-8 diode.	No train berthed indication on the right side Doors control panel when train is in station.	Replace diode.
	Faulty KSR3 relay on KQ panel, in the lower part of the cabinet located behind the operator's seat (A car).		Replace KSR3 relay.
	Faulty rotary switch contacts KAS1 12 (45-46) and 12 (47-48).	No train berthed indication when train is in station.	Check KAS1 contacts.
	Faulty ATO equipment berthing verification circuits.	No train berthed indication when train is in station.	Consult ATO Workshop Manual.
	P1 rack 2 pin X, c, x, y.		Replace affected pins. See ATO Workshop Manual.
73) Brake system does not function on some cars. (Brake remains applied).	"P" signal missing.	In MTO mode with the handle of the Master Controller in coast position brake remains applied.	Check "P" signal loop.
			Verify that all the H4

			and MN connectors are connected.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
	Faulty MTOR relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).	The relay is de-energized.	Replace MTOR relay.
	Faulty rotary switch KAS1.	"P" signal loop open.	Verify rotary switch KAS1 10 (39-40) contact.
	"P" signal trainline interrupted.	"P" signal loop open.	Check "P" signal trainline continuity.
	Faulty DMLL and DMLR relays on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).	Command missing to MTOR relay.	Replace relays DMLL and DMLR.
	Miscellaneous CB on BD panel open.	Command missing to MTOR relay.	Close CB.
	Faulty CER on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area.	Command missing to MTOR relay.	Replace CER.
	Faulty "FSB" contact of Master Controller.	Command missing to MTOR relay.	Replace Master Controller.
74) Brake system does not function.	"BRK" signal missing.	In MTO mode with the handle of the Master Controller in "coast position", brake remains applied.	Trainline BRK signal continuity test.
75) Brake system	Friction brake CB on	"Friction brake fail-	Close CB.

	does not function on some cars.	BD panel of non-functioning cars open.	ure” indicators on KL and Trainline Indicators panel light on.	

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM		POSSIBLE CAUSE	SYMPTOM	REMEDY
		Faulty H4 unit.	“Friction brake failure” indicators on KL and Trainline Indicators panel light on.	See Friction Brake Workshop Manual.
76)	Brake system does not function.	Friction brake on loop open.	“Friction brake on” indicators on KL and Trainline Indicators panel light on.	Check loop continuity.
77)	Power to berthing loop missing.	Faulty FBOR relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (B car).	No “train berthed” indication on DE panel when vehicle within platform.	Replace FBOR relay.
78)	All indicator lights are off.	CB26 “console aux/annunciator” open.		Close CB26.
79)	“Propulsion cutout” indicators on KL and Trainline Indicators panel do not function.	Faulty PCR relay on Q4 panel in KA box (A car).		Replace PCR relay.
		Faulty PCRI relay on Q4 panel in KA box (car A).		Replace PCRI relay.
80)	“Friction brake cutout” indicators on KL and Trainline Indicators panel do not function.	Faulty FBCR relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (B car).		Replace FBCR relay.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
81) "Auxiliary power failure" indicator on Trainline Indicators panel does not function.	Faulty KR board in the operator's cab area.		Replace KR board.
	Faulty KT board in the operator's cab area.		Replace KT board.
	Faulty APFR relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (B car).		Replace APFR relay.
82) "Propulsion failure" indicator on KL and Trainline Indicators panel do not function.	Faulty KR board in the operator's cab area.		Replace KR board.
	Faulty KT board in the operator's cab area.		Replace KT board.
	Faulty PFR relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (B car).		Replace PFR relay.
83) "Parking brake on" indicator on Trainline	Faulty KR board in the operator's cab area.		Replace KR board.

	Indicators panel does not function.			

(Cont'd)

Table 15-3 Troubleshooting (Continued)

	PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
		Faulty PBR relay on Q4 panel in KA box (A car).		Replace PBR relay.
84)	"Service brake failure" indicator on Trainline Indicators panel does not function (AC).	Faulty KB board in the operator's cab area.		Replace KR board.
		Faulty KT board in the operator's cab area.		Replace KT board.
		Faulty SBFR relay on Q4 panel in KA box (A car).		Replace SBFR relay.
85)	"Emergency brake on" indicator does not function on Trainline Indicators panel.	Faulty CER on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).		Replace CER relay.
		Faulty KR board in the operator's cab area.		Replace KR board.
86)	"Electric brake cutout" indicator does not function on Trainline Indicators panel.	Faulty KR board in the operator's cab area.		Replace KR board.
87)	"Compressor	Faulty CCR relay on		Replace CCR relay.

cutout” indicator does not function on Trainline Indicators panel.	Q4 panel in KA box (car A).		

(Cont’d)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
88) “Door cutout” indicator does not function on Trainline Indicators panel.	Faulty KR board.		Replace KR board.
	Faulty DCO relay in KA box (car B).		Replace DCO relay.
89) “Other cab on” indicator does not function on Trainline Indicators panel.	Faulty KR board in the operator’s cab area.		Replace KR board.
90) EMO light on Mode Control panel does not function.	Faulty KR board in the operator’s cab area.		Replace KR board.
91) EMO light on Mode Control panel does not function (ext. light).	Faulty EIR relay on Q2 panel, in the Brake Control Box cabinet in the passenger cab area (A and B car).		Replace EIR relay.
92) EMO light on Mode Control panel not flashing.	Faulty EFI relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (A and B car).		Replace EFI relay.
93) “Propulsion cutout” indicator on, Auxiliary Annunciator panel	Defective PCR relay in Q4 panel in KA box (A and B car).		Replace PCR relay.

“KL” not functioning..			

(Cont’d)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
94) “Propulsion failure” indicator on KL panel not functioning.	KT board in the operator’s cab area defective.		Replace KT board.
	PFR relay on Q2 panel, in the Brake Control Box cabinet, in the passenger cab area (B car), defective.		Replace PFR relay.
95) “Electric brake failure” indicator on KL panel not functioning	KT board in the operator’s cab area defective.		Replace KT board.
96) “Service brake failure” indicator on KL panel not functioning.	KT board in the operator’s cab area defective.		Replace KT board.
	SBFR relay on Q4 panel in KA box (A car) defective.		Replace SBFR relay.
	FBFR relay on Q1 panel in KA box (B car) defective.		Replace FBFR relay.
97) “Friction brake on” indicator on KL panel not functioning.	Pressure switches, FC1, FC2 on that car are defective.		Check pressure switches.
	Diode on pressure switch (NO2-SP) blown.		Replace diode.

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
98) "Compressor cutout" indicator on KL panel not functioning.	KT board in the operator's cab area defective.		Replace KT board.
99) "Friction brake cutout" indicator on KL panel not functioning.	"Friction brake cutout" switch on KM panel defective.		Check the switch.
100) "Auxiliary power failure" indicator on KL panel not functioning.	KT board in the operator's cab area defective.		Replace KT board.
101) "LVPS failure" indicator on KL panel not functioning.	KT board in the operator's cab area defective.		Replace KT board.
102) "HVAC failure" on KL panel not functioning.	Auxiliary contact of "HVAC" CB on BD panel defective.		Replace auxiliary contact or CB.
	Auxiliary contacts of CB1-CB2 inside the HP box defective.		Replace auxiliary contact or CB.
	Auxiliary contacts of the following high voltage CB's are defective: CMB1, CMB2, CFMCB1, CFMCB2, BFCB1, BFCB2, OHCB1, OHCB2.		Replace auxiliary contacts or CB.
103) "Blower failure"	KT board defective.		Replace KT board.

indicator on KL panel not functioning.			

(Cont'd)

Table 15-3 Troubleshooting (Continued)

PROBLEM	POSSIBLE CAUSE	SYMPTOM	REMEDY
	Auxiliary contacts of the following high voltage CB's are defective: CBMOR, CBMO, CBMOF.		Check auxiliary contacts.
104) "Zero speed" indicator on KL panel not functioning.	KT board defective.		Replace KT board.
	ZSR relay on Q2 panel in the Brake Control Box cabinet, in the passenger cab area (A and B car) defective.		Replace ZSR relay.
	Interface problem between ATP and vehicle wiring.		Repair affected wiring circuits.
105) "Door cutout" indicator on KL panel not functioning.	KT board defective.		Replace KT board.
	DCO relay in KA box defective (B car).		Replace DCO relay.

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SECTION 16

PERIODIC INSPECTIONS AND PREVENTIVE MAINTENANCE REQUIREMENTS

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BLOWDOWN PROCEDURE AND CHECKLIST

SECTION 16

PERIODIC INSPECTIONS AND PREVENTIVE MAINTENANCE REQUIREMENTS

NOTICE

THE MILEAGE PER YEAR THAT WAS THE BASIS FOR VEHICLE DESIGN IS 80,000MILES. CONSEQUENTLY, AVOID UNDERESTIMATING FREQUENCY OF MAINTENANCE IN THE EVENT YEARLY VEHICLE MILEAGE INCREASES.

16-2 LUBRICATION TABLE

Lubrication Table

ITEM	LUBRICANT	REFERENCE	
		Workshop Manual	**Repair & Maintenance Manual**
PROPULSION		Section 5	Section 7
Traction Motor	GE A11330204 P3, Alvania #.2	Para. 5-1.4.1 Para. 5-1.7.3 Para. 5-1.7.4 Para. 5-1.7.5 Para. 5-1.7.6	Para. 7-3.4.1
Coupler Socket/Plug	International Products Corp., P-80 Rubber Lubricant or equivalent.	Para. 5-2.7.1 Para. 5-2.7.2	
Coupling	DyKem Hi - Spot Blue N. 107 or equivalent.	Para. 5-3.7.1	
	GE41A330204P14, Mobilax EP #2.	Para. 5-3.7.3	
		Section 4	
	Multipak EP-2 (TEXACO).	Para. 4-8.1.7	
	GED50E17 (Alvania N. 2 EP).		Para. 7-5.4

(Cont'd)

Lubrication Table (Continued)

ITEM	LUBRICANT	REFERENCE	
		Workshop Manual	Repair & Maintenance Manual
		Section 5	Section 7
Gear Unit	Lord P-80	Para. 5-4.7.1	
	SAE 85W-140, MIL-2105D + +GL5 Additives, API Services GL-5.	Para. 5-4.7.3 Para. 5-4.7.4 Para. 5-4.7.15	Para. 7-6.4.2
	Permatex N. 14	Para. 5-4.7.14 Para. 5-4.8.1	Para. 7-6.4.2 Para. 7-6.7.1
Battery Line Filter	Silicone Grease DOW CORNING #3 or equivalent.	Para. 5-5.9.7.4	
Panel, GTO (+) Phase Module (+).	SF 1154 Oil	Para. 5-5.13.7.3	
Panel, GTO (-) Phase Module (-).	SF 1154 Oil	Para. 5-5.14.7.2 Para. 5-5.14.7.3	
Panel, Motoring Diode Module	SF 1154 Oil	Para 5-5.15.7.2	
TRUCKS AND VEHICLE SUSPENSION SYSTEM		Section 4	
Bearings and Axle - Boxes	Molybdenum Disulfide + Oil Mixture Rule 1K7 of AAR S-723.	Para. 4-8.1.3	
Wheels		Para. 4-8.1.5	

16-3.6 Low Voltage Power Supply Generation and Distribution

PREVENTIVE MAINTENANCE SCHEDULE

Contract:	Metro Red Line	No.:	Page: 1 of 9
System:	Passenger Vehicle		Date: March 1997
Subsystem:	Low Voltage Power Supply Generation and Distribution		Rev.:
Equipment:	DC/DC Converter (LVPS/Battery Charger)		Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
08	Heat sinks visual inspections	1 Year	BAS	0.25	1	0.25	Sect. 10
09	Heat sinks cleaning	1 Year	BAS	0.5	1	0.5	Sect. 10
10	Lap top computer failure display and data logger functional test	1 Year	ADV	1	1	1	Sect. 10
11	A79 failure monitoring board battery change	5 Years	ADV	0.5	1	0.5	Sect. 10

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

PREVENTIVE MAINTENANCE SCHEDULE

Contract: Metro Red Line No.:
System: Passenger Vehicle
Subsystem: Low Voltage Power Supply Generation and Distribution
Equipment: Contactor Group

Page: 2 of 9
Date: March 1997
Rev.:
Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
12	Contactor group inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-10
13	Contactor KNE inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-10

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

16-3.7 Propulsion and Control

PREVENTIVE MAINTENANCE SCHEDULE

Contract:	Metro Red Line	No.:	Page: 3 of 9
System:	Passenger Vehicle		Date: March 1997
Subsystem:	Propulsion and Control		Rev.:
Equipment:	Main Inverter Group		Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
01	External inspection	10 K miles	INT	0.5	1	0.5	Para. 7-7
02	Internal inspection	30 K miles	ADV	2	2	4	Para. 7-7
03	Battery line filter inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.9
04	Voltage attenuation modules inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.10
05	Gate driver power suppy inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.12
06	GTO (+) - phase module (+) inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.13
07	GTO (-) - phase module (-) inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.14
08	Monitoring diode module inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.18

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

PREVENTIVE MAINTENANCE SCHEDULE

Contract:	Metro Red Line	No.:	Page: 4 of 9
System:	Passenger Vehicle		Date: March 1997
Subsystem:	Propulsion and Control		Rev.:
Equipment:	Main Inverter Group		Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
9	Chopper module inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.16
10	Relay - 17LV66AV1 inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.17
11	Inverter disconnection relay inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-7.18

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

PREVENTIVE MAINTENANCE SCHEDULE

Contract:	Metro Red Line	No.:	Page: 5 of 9
System:	Passenger Vehicle		Date: March 1997
Subsystem:	Propulsion and Control		Rev.:
Equipment:	Traction Motor		Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
12	Traction motor inspection	10 K miles	ADV	0.5	1	0.5	Para. 7-3
13	Drive end and connection end bearings lubrication	120 K miles (2 Years)	ADV	1	1	1	Para. 7-3
14	Coupling lubrication	30 K miles	ADV	0.5	1	0.5	Para. 7-5
15	Coupling inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-5
16	Coupler socket/plug external inspection	10 K miles	INT	0.25	1	0.25	Para. 7-4

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

PREVENTIVE MAINTENANCE SCHEDULE

Contract: Metro Red Line No.:
System: Passenger Vehicle
Subsystem: Propulsion and Control
Equipment: Gear Unit

Page: 6 of 9
Date: March 1997
Rev.:
Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
17	Oil change	10 K miles	ADV	1	1	1	Para. 7-6
18	Oil level check	10 K miles	INT	0.25	1	0.25	Para. 7-6
19	Oil change	60 K miles	ADV	1	1	1	Para. 7-6
20	External inspection	10 K miles	INT	0.5	1	0.5	Para. 7-6
21	Inspection	30 K miles	ADV	2	2	4	Para. 7-6

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

16-3.11 High Voltage Power Distribution

PREVENTIVE MAINTENANCE SCHEDULE

Contract:	Metro Red Line	No.:	Page: 7 of 9
System:	Passenger Vehicle		Date: March 1997
Subsystem:	High Voltage Power Distribution		Rev.:
Equipment:	Rail Gap Group		Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
01	Inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-9
02	Knife switch inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-9.9
03	Panel SRC inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-9.10
04	Panel diode inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-9.11

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

PREVENTIVE MAINTENANCE SCHEDULE

Contract: Metro Red Line No.:
System: Passenger Vehicle
Subsystem: High Voltage Power Distribution
Equipment: Miscellaneous

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Date: March 1997
Rev.:
Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
05	Braking resistor inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-11
06	Filter charging resistor inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-12
07	Line filter reactor inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-13

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

Filter Charging Contactor

a. Inspection (Para. 7-8.9).

Line Breaker

a. Inspection (Para. 7-8.10).

Line Breaker Overload Reset Relay (LBRR)

a. Inspection (Para. 7-8.11).

B-8 60,000 MILES PREVENTIVE MAINTENANCE INSPECTIONS

B-8.1 Propulsion and Control

<u>Gear Unit</u>

a. Oil change (Para. 7-6).

B-9 120,000 MILES PREVENTIVE MAINTENANCE INSPECTIONS

B-9.1 Propulsion and Control

<u>Traction Motor</u>

a. Lubricate C.E. bearings (Para. 7-3).

b. Lubricate D.E. bearings (Para. 7-3).

PREVENTIVE MAINTENANCE SCHEDULE

Contract:	Metro Red Line	No.:	Page: 9 of 9
System:	Passenger Vehicle		Date: March 1997
Subsystem:	High Voltage Power Distribution		Rev.:
Equipment:	Line Breaker Group		Prepared by: BREDA C.F.

Step No	Recommended Action	Frequency Miles/Interval	Skill Level	Elapsed Time Hours	Crew Size	Labor Hours	Reference*
08	External inspection	10 K miles	INT	0.25	1	0.25	Para. 7-8
09	Internal inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-8
10	Filter charging contactor inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-8.9
11	Line breaker inspection	30 K miles	ADV	0.5	1	0.5	Para. 7-8.10
12	Line breaker overload reset relay inspection (LBRR)	30 K miles	ADV	0.5	1	0.5	Para. 7-8.11

* Unless otherwise specified, references are to Repair & Maintenance Manual sections.

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APPENDIX A

BLOWDOWN PROCEDURE AND CHECKLIST

CAUTION: ALWAYS TURN ON THE BLOWDOWN PITS EXHAUST AND FRESH AIR BLOWERS BEFORE PROCEEDING WITH THE BLOW-DOWN PROCEDURE. IN ADDITION, TO AVOID INJURY TO PERSONNEL, DUST MASKS AND FACE SHIELDS ARE TO BE WORN DURING BLOWDOWN.

NOTE: Air pressure is not to exceed 90 psi and oiler is to be turned off. Air nozzles with soft sleeves are to be used at all times to avoid damage to components. Always wait until airborn dust/debris settles before proceeding to a next step.

CAR NO. ____________ DATE__________________

(Initial each step as completed)

4. TM blowers and PCE blower filter boxes. DELETED

6. TM and PCE blower motors. DELETED

8. Ground brush assemblies.

a. Remove brush holder covers (3 per axle).	F-end truck	___________
	R-end truck	___________
b. Inspect brushes.	F-end truck	___________
	R-end truck	___________
c. Remove any brush debris build up.	F-end truck	___________
	R-end truck	___________
d. Replace covers, taking care to avoid overtorquing bolts.	F-end truck	___________
	R-end truck	___________

9. PCE and APSE. DELETED

12. TM and PCE blower filters. DELETED

APPENDIX B

PREVENTIVE MAINTENANCE FORMS

APPENDIX B

PREVENTIVE MAINTENANCE FORMS

B-1 10,000 MILES PREVENTIVE MAINTENANCE INSPECTIONS

B-1.6 High Voltage Power Distribution

Line Breaker Group

a. External inspection (Para. 7-8).

B-1.7 Propulsion and Control

Main Inverter Group

a. External inspection (Para. 7-7).

Traction Motor

a. Inspect traction motor (Para. 7-3).

b. Inspect coupler/socket plug exterior (Para. 7-4).

Gear Unit

a. Oil change (Para. 7-6.7.1).

b. Oil level check (Para. 7-6.4.1).

c. External inspection (Para. 7-6.4.2).

Traction Motor Blower

DELETED

Power Control Equipment (PCE)

DELETED

PCE Enclosures

DELETED

PCE Blower

DELETED

B-1.8 Auxiliary Power Supply Equipment (APSE)

APSE

DELETED

APSE Enclosure

DELETED

B-2 QUARTERLY PREVENTIVE MAINTENANCE INSPECTIONS

B-2.7 Propulsion and Control

Traction Motor Blower

DELETED

Power Control Equipment (PCE)

DELETED

PCE Enclosures

DELETED

PCE Enclosures

DELETED

Propulsion Electronic Control Equipment

DELETED

B-2.8 Auxiliary Power Supply Equipment

APSE Enclosure

DELETED

B-3 SEMIANNUAL PREVENTIVE MAINTENANCE INSPECTIONS

B-3.7 Propulsion and Control

Traction Motor Blower

DELETED

Power Control Equipment (PCE)

DELETED

PCE Enclosures

DELETED

PCE Blower

DELETED

Propulsion Electronic Control Equipment (PECE)

DELETED

B-3.8 Auxiliary Power Supply Equipment (APSE)

APSE Enclosure

DELETED

B-4 ANNUAL PREVENTIVE MAINTENANCE INSPECTIONS

B-4.7 Propulsion and Control

Traction Motor Blower

DELETED

Power Control Equipment (PCE)

DELETED

PCE Enclosures

DELETED

PCE Blower

DELETED

Propulsion Electronic Control Equipment (PECE)

DELETED

B-4.8 Auxiliary Power Supply Equipment (APSE)

APSE Enclosure

DELETED

B-4.14 Low Voltage Power Supply Generation and Distribution

DC/DC Converter (LVPS/Battery Charger)

Heat Sinks

a. Visual inspection (Sect. 10).

b. Cleaning (Sect. 10).

Failure Display and Data Logger

a. Lop Top Computer functional Test (Sect. 10).

B-5 BIANNUAL PREVENTIVE MAINTENANCE INSPECTIONS

B-5.7 Propulsion and Control (Sect. 7-3.4.1)

Traction Motors

a. Drive end and connection end bearing. Lubricate.

Traction Motor Blower

DELETED

Power Control Equipment (PCE)

DELETED

PCE Enclosure

DELETED

PCE Blower

DELETED

Propulsion Electronic Control Equipment (PECE)

DELETED

PCE Relay (A1)

DELETED

B-5.8 Auxiliary Power Supply Equipment (APSE)

DELETED

APSE Enclosure

DELETED

B-6 FIVE YEARS PREVENTIVE MAINTENANCE INSPECTIONS

B-6.7 Propulsion and Control

Traction Motor Blower

DELETED

Power Control Equipment (PCE)

DELETED

PCE Enclosures

DELETED

PCE Blower

DELETED

Propulsion Electronic Control Equipment (APSE)

DELETED

B-6.8 Auxiliary Power Supply Equipment (APSE)

APSE

DELETED

APSE Enclosure

DELETED

B-6.15 Low Voltage Power Generation and Distribution

DC/DC Converter (LVPS/Battery Charger)

Failure Monitoring Board

a. Battery Change (Sect. 10).

B-7 30,000 MILES PREVENTIVE MAINTENANCE INSPECTIONS

B-7.1 Low Voltage Power Generation and Distribution

Contactor Group

a. Inspection.

Contactor KNE

a. Inspection.

B-7.2 Propulsion and Control

Main Inverter Group

a. Inspect Main Inverter Group interior (Para. 7-7).

Battery Line Filter

a. Inspection (Para. 7-7.9).

Voltage Attenuation Modules

a. Inspection (Para. 7-7.10).

Gate Driver Power Supply

a. Inspection (Para. 7-7.12).

GTO (+) - Phase Module (+)

a. Inspection (Para. 7-7.13).

GTO (-) - Phase Module (-)

a. Inspection (Para. 7-7.14).

Monitoring Diode Module

a. Inspection (Para. 7-7.15).

Chopper Module

a. Inspection (Para. 7-7.16).

Relay - 17LV66AV1

a. Inspection (Para. 7-7.17).

Inverter Disconnection Relay

a. Inspection (Para. 7-7.18).

Traction Motor

Coupling

a. Lubrication (Para. 7-5).

b. Inspection (Para. 7-5).

Gear Unit

a. Inspection (Para. 7-6).

B-7.3 High Voltage Power Distribution

Rail Gap Group

a. Inspection (Para. 7-9).

Knife Switch

a. Inspection (Para. 7-9.9).

Panel SCR

a. Inspection (Para. 7-9.10).

Panel Diode

a. Inspection (Para. 7-9.11).

Miscellaneous

Braking Resistor

a. Inspection (Para. 7-11).

Filter Charging Resistor

a. Inspection (Para. 7-12).

Line Filter Reactor

a. Inspection (Para. 7-13).

Line Breaker Group

a. Internal inspection (Para. 7-8).

Filter Charging Contactor

a. Inspection (Para. 7-8.9).

Line Breaker

a. Inspection (Para. 7-8.10).

Line Breaker Overload Reset Relay (LBRR)

a. Inspection (Para. 7-8.11).

B-8 60,000 MILES PREVENTIVE MAINTENANCE INSPECTIONS

B-8.1 Propulsion and Control

Gear Unit

a. Oil change (Para. 7-6).

B-9 120,000 MILES PREVENTIVE MAINTENANCE INSPECTIONS

B-9.1 Propulsion and Control

Traction Motor

a. Lubricate C.E. bearings (Para. 7-3).

b. Lubricate D.E. bearings (Para. 7-3).