PRELIMINARY REPORT
CONTRACT DOT-FR-9027

CHOPPER PROPULSION SYSTEM FOR ELECTRIC LOCOMOTIVES

TRANSPORTATION SYSTEMS BUSINESS DIVISION
GENERAL ELECTRIC COMPANY
2901 E. LAKE RD.
ERIE, PA. 16531

DECEMBER 1979
PRELIMINARY REPORT

PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION
PASSENGER EQUIPMENT DIVISION
WASHINGTON, D.C. 20590

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, 2901 EAST LAKE ROAD, ERIE, PENNSYLVANIA 16501
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TRANSPORTATION
SYSTEMS
BUSINESS
DIVISION

December 17, 1979

Federal Railroad Administration
Passenger Equipment Division, RRD-21
400 7th Street, S.W.
Washington, D.C. 20590

Attention: Mr. M.C. Gannett

Dear Mr. Gannett:

Enclosed are the deliverables for the Phase I portion of the Chopper Propulsion System Project, Contract DOT-FR-9027. A brief preliminary report has also been submitted. You have been sent two separate copies. Mr. F. Jones and Mr. R. Watson have also been sent one complete copy.

Very truly yours,

H.B. Henderson
Program Manager
Building 14-4, Ext. 3496

bu
enc

Copy: Mr. Felton Jones
Federal Railroad Administration
Office of Procurement, RAD-30
400 7th Street S.W.
Washington, D.C. 20590

Mr. R. Watson
L.T. Klauder & Associates
Philadelphia National Bank Bldg.
Philadelphia, Pa. 19107

J. McDonnell, GE Philadelphia Office

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INTRODUCTION

This preliminary report summarizes the work done during Phase I of contract DOT-FR-9027. The background and objection of Phase I activity are clearly defined in the contract and are therefore not repeated here. This program covers the design and retrofit of a Conrail E44 electric locomotive with a chopper drive system. The chopper system was previously developed by the General Electric Company at its Erie facility and operated on a test bed locomotive at its Erie test track. A locomotive using this system will provide many railroad benefits. This program will serve to demonstrate these benefits and provide a means of testing and documenting all key parameters based on an electric locomotive operating in revenue service. This report also documents all locomotive arrangement drawings and preliminary performance curves that have been prepared during the Phase I portion of the contract.

RESULTS

Phase I drawings provide all layouts and arrangements that are required to partially strip a Conrail E44, fabricate new structural parts, and assemble the converted locomotive to a chopper equipped E60C configuration. Many drawings have also been completed for components that will be required for the single axle test (scheduled for the Phase II program) because of their manufacturing lead time. Typical examples are electronic panels and chopper components. A major design objective was to use as much of the existing E44 as possible. The converted E44 will reuse the nose cab, operator's cab, trucks, air compressor, and platform with changed equipment mounting supports and ventilation openings. Major tasks during the design were equipment ventilation, filter design, weight distribution, equipment accessibility, system integration and performance, control compartment design, platform modifications, and equipment cab design. The modified locomotive will use D.C. drive motors, one for the existing air compressor and one for the single equipment blower. The thyristor phase control system can provide rated output at reduced catenary voltage. All air is cleaned to improve equipment life using GE self-cleaning inertial air filters. Preliminary performance curves are included in the appendix. During operational tests of the converted locomotive on the Erie test track and on Conrail parameters will be measured and final curves provided. Also included is the preliminary locomotive specification. Other drawings are being sent with this report, but are not part of it due to their size. However the appendix does contain the preliminary locomotive list that contains these Phase I drawings. Locomotive top speed is limited by the existing truck design and not the drive system. However this top speed will continue to be satisfactory for the Conrail freight service.

The new roof arrangement requires insulation for 25 KV and uses a vacuum breaker. Therefore the locomotive height has been increased. During the program the M.U. arrangement was changed to have the chopper

locomotive only U.U. in a trail position. This insures safe operation for the remainder of the E44 fleet without any fleet modifications. Wheel-slip testing will be an important part of Phase II testing as the E60 has individual axle detection and correction with all six motor/chopper circuits in parallel. Improved dynamic braking is being provided with peak braking effort being held down to approximately 3 MPH. The preliminary schematic diagram (also being sent separately) will be completed as Phase II details are completed. Annunciator/diagnostic panels and lights are being provided to simplify maintenance of the locomotive. Service experience should indicate where changes in this function are required for a future design. Equipment cab improvements are expected to reduce water leaks.

APPENDIX A

LOCOMOTIVE SPECIFICATION

REV NO.	TITLE
41A304031	CHOPPER EQUIPPED E44/E60 FOR OPERATION ON CONRAIL
CONT ON SHEET 2 SH NO. 1	FIRST MADE FOR CONTRACT DOT-FR-9027

REVISIONS

LOCOMOTIVE SPECIFICATION

CHOPPER EQUIPPED E44/E60 FOR OPERATION ON CONRAIL

Contract DOT-FR-9027

PRINTS TO

MADE BY	APPROVALS	DIV OR DEPT.	41A304031
ISSUED	HBH.	LOCATION	CONT ON SHEET 2 SH NO. 1

REVISIONS

INDEX

PRINTS TO

REV NO.	TITLE
41A304031	CHOPPER EQUIPPED E44/E60 FOR OPERATION ON CONRAIL
CONT ON SHEET 4 SH NO. 3	FIRST MADE FOR CONTRACT DOT-FR-9027

REVISIONS

1. GENERAL

A current E44 locomotive will be equipped with a propulsion system of chopper design that is capable of operating from any one of three (3) power sources, namely: 11kV 25 Hz, 25kV 60 Hz, and 12.5kV 60 Hz.

In order to minimize the locomotive structural changes, the maximum equipment clearance diagram of the locomotive will be raised to accommodate insulators necessary for 25kV electrical clearances. The locomotive will no longer be capable of operating through the East and Hudson River Tunnels into New York.

TRANSFORMER

The forced air, forced oil-cooled transformer consists of a multiple winding primary with an internal no-load tap changing mechanism. An operating shaft projects through the tank for an air operated transfer operator.

The tank is of the sealed pressure type with pressure relief valve. The heat exchanger supplied uses cooling air from the platform air duct.

Three secondary windings are included, two (2) for propulsion power and one (1) for auxiliary power to the blower, compressor, etc.

A high voltage bushing projects through a watertight seal to the roof power connection. A mid-tap bushing is provided for connection to the midpoint of two (2) 18kV lightning arresters.

The transformer is designed with silicone oil coolant.

A double rotor induction motor-driven pump circulates oil. The pump has dual speed, with 1450 RPM on 25 Hz and 1750 RPM at 60 Hz.

ROOF ARRANGEMENT

Because of the operation on a system primarily fed from utility supply lines, and because of operation in parallel with locomotives presently equipped with vacuum circuit breakers, it is planned to remove the rear pantograph and substitute in its present location a vacuum breaker. The JR circuit breaker presently installed on the locomotive will be removed. The vacuum breaker is necessary to accommodate automatic negotiation of phase breaks and also to allow automatic changeover from one power source to another.

BLOWER DRIVE UNITS

Because of multiple power source requirements, a GY64 DC drive motor is to be used to drive the equipment blower. The equipment blower is a

PRINTS TO

horizontal shaft centrifugal blower arrangement located in the same general area as the present blower. Inertial filters will be used for cleaning equipment air as required. The blower operational modes will minimize energy requirements.

COMPRESSOR DRIVE

A GY64 motor will also be used to drive the air compressor. The present compressor drive motor is a single bearing motor, flange mounted to the compressor. It is planned to use the existing E44 compressor, but driven by the two (2) bearing DC drive motor with a coupling mounted on a separate common subbase. The shorter length of the DC motor makes this combination approximately the same length as the existing arrangement. A separate cooling air duct from the platform air duct/plenum provides cooling air to this motor.

CHOPPER PROPULSION SYSTEM

The chopper propulsion system consists of six (6) individual chopper/power modules which are mounted in the existing rectifier compartment. DC supply rectifiers will be located in the present tap switch area. These modules are individually ventilated from the locomotive platform air duct. Power cabling is required between the power contactors located next to the transformer and the rectifier modules. Immediately above the chopper modules are motor disconnect switches, DC bus filter capacitors, and power cable connections. The DC bus filter reactor and traction motor smoothing reactors are located under the platform.

MISCELLANEOUS CHANGES

Two (2) individual rectifier-control assemblies for the auxiliary equipment will be located in the control compartment.

The main control stands will be modified to accept the 8-notch 17KC108 AAR approved controller.

All control wiring, except for cab signal control, will be removed and rewired to accommodate the new control system.

The MU connectors will be retained, but the pin designations will be such as to allow MU operation with only an unmodified E44 leading.

Battery charging will be done with a static regulator.

Certain changes in the AC auxiliary system are necessary to allow multiple frequency operation.

Wheelslip control will utilize motor armature speed sensors mounted on each GE725AF traction motor.

No changes in the cab signal equipment are included.

No changes in the air brake system are included, except for that required to move the main air reservoir.

2. APPLICATION ENVIRONMENT

2.1 Power Source

2.1.1 Voltage and Frequency - (At Pantograph)

25 Hz ± .25 Hz

Normal Voltage	-	11kV
Max. 1/2 Sec.	-	14kV (Once per year)
Max. Sustained	-	13.5kV
Min. Sustained	-	9.5kV
One Hour	-	9kV
1/2 Hour	-	8.25
1/4 Hour Emergency	-	7.5kV

60 Hz ± .25 Hz

Normal Voltage	-	12.5kV
Max. 5 Minutes	-	14kV
Max. Sustained	-	13.75kV
Min. Sustained	-	9.50kV
Emergency	-	8.75kV

60 Hz ± .25 Hz

Normal Voltage	-	25kV
Max. 5 Minutes	-	28kV
Max. Sustained	-	27.5kV
Min. Sustained	-	19kV
Emergency	-	17.5kV

2.1.2 Line Transients

2.1.2.1 On-board equipment shall be provided for protection against lightning strokes and switching transients on the power line. (Via 9L11PGA018 Tranquel Lightning Arresters across the main power transformer primary.)

2.1.2.2 Minimum BIL = 150kV @ 25kV connection
= 95kV @ 11kV or 12-1/2kV connection

2.1.2.3 Peak magnetizing inrush current when vacuum breaker is closed shall not exceed:

Line Voltage	Allowable Peak Current
11kV, 25 Hz	3500
13.5kV, 25 Hz	3900
27.5kV, 60 Hz	Less than 2000

2.1.3 Substation/Impedance

j 1.25 ohms at 25kV and 60 Hz

j 0.5 ohms at 11kV and 25 Hz

2.1.4 Line Impedance

0.25 + j 0.65 to 0.25 + j 1.2/mile (60 Hz)

Z = .42/mile (25 Hz)

2.1.5 Phase Breaks

7 miles between phase breaks typical.

2.2 Environmental Conditions

2.2.1 Ambient Temperature

The design shall be based on the following temperature environment:

Variations of ambient temperature are taken from AIEE No. 1, December, 1962, Introduction to AIEE Standards, General Principles Upon Which Temperature Limits are Based in the Rating of Electrical Equipment which represents Weather Bureau data over a fifty-year period. Ambient temperature is for the worst case of Philadelphia or Pittsburgh, and is taken from Page 13A, Table 1 of indicated reference.

Annual Average (T_1)	12°C
Average Yearly Variation (T_2)	24°C
Average Daily Variation (T_3)	10°C
Absolute Maximum (T_4)	41°C
Absolute Minimum (T_5)	-29°C

Average hours the temperature exceeds a certain reference temperature taken from Page 13B, Table II.

Reference Temperature	30°C	35.5°C	41.1°C
Average Hours Per Year	263	10	0
Average Percent of Year	3	0.1	0

2.2.2 Atmospheric Conditions

Relative humidity up to 100% for 50% of time; ocean salt spray atmosphere, dry snow, corrosive vapors, fine particulate matter coal dust, sand, ingestion of leaves and cotton tree fuzz, etc. and frequent lightning storms.

2.2.3 Shock and Vibration

The equipment must be good for the following forces and vibration frequencies:

Coupling Shocks	2.5G
Horizontal (Transverse Shock)	1.5G
Vertical	1.5G
Max. Sustained Deceleration	1.5 MPH/Sec.
Max. Peak Acceleration/Deceleration	5.0 MPH/Sec.

2.2.4 Altitude

Sea level to 2200 feet.

2.2.5 Noise Limits

2.2.5.1 OSHA Section 1910.95 - Occupational Noise Exposure

"Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown below when measured on the "A" scale of a standard sound level meter at slow response."

Duration Per Day Hours	Sound Level dbA, Slow Response
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

2.2.5.2 FRA 49 CFR 210 - Railroad Noise Emission Standards

Conditions - Noise measured at 100 ft. from center of locomotive perpendicular to centerline of track	Locomotives mfd. after 12/31/79 dbA, Fast Response
Stationary - Full Load	87
Stationary - Idle	70
Moving, under any condition of grade, load, acceleration, or deceleration	90

3. LOCOMOTIVE PERFORMANCE RATINGS/PHYSICAL PARAMETERS

Speed Tractive Effort Curve	41H141337
Maximum Starting Tractive Effort	135,000 lbs.
Continuous Horsepower	5,130 RHP
Gear Ratio	83:20
Maximum Locomotive Speed	60 MPH
Speed Braking Effort Curve	41H105988
Power Factor	41H119318
Efficiency (Without Auxiliaries at Full Load)	41H115682
It. Product	41H119319
Starting Adhesion Limit	34.6%
Continuous Adhesion Limit	21%
Dynamic Braking	17.4%
MU Capability	Trail only
Performance Under Abnormal Conditions	Full performance at + 10% Nominal Voltage (25kV, 60 Hz)
	Full tractive effort at -24% Nominal Voltage (25kV, 60 Hz)
	15-minute emergency operation at -30% nominal voltage (25kV, 60 Hz)
Location of Apparatus	41D722707

PRINTS TO

Loco Weight — 390,000 ± 2% (with individual axle load tolerance of ± 1% of average axle load)

4. EQUIPMENT DESIGN REQUIREMENTS

4.1 Chopper Propulsion

4.1.1 Individual propulsion module per motor.

4.1.2 Chopper/motor control may be cutout on an individual basis (with remaining chopper/motor sets each continuing to operate at their full tractive effort).

4.1.3 Wheelslip Control

- Single axle detection & correction
- Correct on velocity differential & acceleration
- Built-in locomotive overspeed
- Automatic wheel diameter compensation for up to 2-1/2" wheel diameter differential
- Operating from motor armature speed sensors

4.1.4 No staging; notchless control (but with numerical notches on the master controller).

4.1.5 Motor/Truck Cutout

- Individual motor cutout
- Isolation of both sides of motor circuit
- Remaining choppers at full power per motor with motor cutout

4.2 Dynamic Braking

- Provisions shall be made for maintaining dynamic braking during individual motor cutouts up to maximum of two motors cutout.
- Extended range braking provided by chopper control from just over 3 MPH to the speed at max. braking effort.

4.3 MU Provisions

Capability is to be provided for MU operation with only an unmodified E44 leading. The corresponding notch of the leading E44 and the trailing E44/E60 are as follows:

Motoring	E44	1,2	3,4	5,6	7,8	9-12	13-16	17-20	21-29
	E44/E60	1	2	3	4	5	6	7	8
Dynamic Braking	E44	1,2	3,4	5,6	7-9	10,11	12,13	14,15	16,17
	E44/E60	1	2	3	4	5	6	7	8

4.4 Vacuum Breaker

4.4.1 Worst cast breaker operations/year is estimated with the following locomotive duty cycles.

7,000 Miles/Month, 12000 Breaks/Year

4.4.2 Design is based on a 30 year life with reasonable maintenance and replacement of wearing parts. For most of these operations, the breaker will operate as a line switch under no power conditions. Approximately 1 in 2,000 operations will be of the fault-trip nature.

4.5 Battery Charger

4.5.1 Equivalent of AMTRAK battery charger is to be used, providing 74V dc, 125 amps, charging into the existing E44 batteries.

4.5.2 A low battery voltage trip shall be provided to shut the locomotive down at 55 volts. An alarm at this condition shall be sounded.

4.5.3 The battery box will accommodate a DEKA #823 battery, which is 27-1/2 x 7-1/2 x 9-5/8, and weighs 160 pounds wet. (Made by East Penn Mfg.)

4.7 EMI

4.7.1 The chopper propulsion subsystem shall not have any detrimental effects on the 100 Hz carrier cab signal subsystem that exists on the E44 locomotive.

4.7.2 Electrical equipment powered or operating in control and auxiliary power circuits shall have transient voltage suppression applied.

4.7.3 Appropriate grounding, shielding, separation of signal, control and power wires, and electronic card practices shall be incorporated in the design to the extent possible to inhibit any electromagnetic interference in the locomotive electrical system.

4.8 Cooling Air

Primary filtering of all air is provided. Air intake located high on equipment cab. Cab pressurization to keep dirt out.

4.9 Telephone Interference Filter

A filter shall be supplied to reduce the It product of the catenary current. The calculated performance is shown in 41H119319.

4.10 Air System Compressor and Blower Drives/Electronics

Two separate DC motors, with phase control electronics, to be furnished for driving the existing air compressor and the centrifugal blower. Overspeed and overvoltage protection are provided.

4.11 Automatic Voltage/Frequency Changeover

Make provision only, for future installation of the controls and mechanism to achieve automatic "on the fly" changeover of the power system from 11kV catenary power to the 25kV catenary power and vice versa. The system shall also provide for automatic removal and reapplication of locomotive power when negotiating a phase break. The system shall receive and respond to signals from permanent magnet modules on the wayside. The design of the system shall provide redundancy to assure that power is interrupted prior to passing through the gap, and a monitor catenary voltage and transformer tap switch position to assure agreement prior to reapplication. A light and reset switch in the operator's cab will be provided to indicate and reset system fault on a trainline basis.

4.12 Maintainability

4.12.1 Locomotive Operator Indicating Panel

An Operator Indicating Panel shall be provided, which indicates when there are locomotive faults for which the operator can take action (propulsion faults, wheelslip/slides, overtemperature and grounds).

4.12.2 Diagnostic Panel/Status Lights/Test Points

Maintenance aids, such as logic card status lights and test points, shall be provided for troubleshooting the propulsion subsystem and the overall locomotive system. These maintenance aids shall be separated from the Operator Indicating Panel and will be located inside a small control compartment that is accessible from the operator cab.

4.12.3 In addition, the following maintenance features shall also be provided:

- Ready accessibility to expendable maintenance items (brushes, filters, fuses, contactor tips, etc.)
- Provisions for easy field realignments, where required, upon replacement of such items as blowers, couplings, motors, and compressor.
- Ready accessibility of all electronic panel wiring, electrical terminals, and all electrical test points for test and disassembly.
- Ready accessibility to all mechanical bolted connections for disassembly from the locomotive.

4.13 Hipot and Megger

4.13.1 Hipot

The equipment shall be designed to meet the dielectric strength of insulation and tests of ANSI C35/IEEE #11 standard for power circuits and ANSI C48/IEEE #16 standard for auxiliary and control circuits.

4.13.2 Megger

Individual circuits and complete control and auxiliary systems of all equipment shall have at least three (3) megohms insulation resistance to ground when measured by a megger, a resistance bridge, or by the voltmeter-ammeter system, all using 500 volt DC. Power systems shall be tested in a similar manner, using 1050 volts DC.

Exceptions are as follows:

1. The high voltage measuring modules must be disconnected during the megger measurement. (Their inherent design impedance is under three (3) megohms when all measuring modules are in place.)

2. Complete Control and Auxiliary Circuits - 3 megohm minimum. If locomotive fails to meet the 3 megohm minimum, individual circuits for cab heaters, running lights, fuel pump, radio and cab signal will be isolated and measured separately. The individual circuits will meet 5 megohms minimum. The remainder of the basic control circuit will meet 3 megohms.

3. If the locomotives fail to meet the 3 megohm limit, the test will be repeated later in the test cycle at a time chosen by GE. However, the hipot test will be made if the megger reading is above 1 megohm, and hipot wires will be removed and not replaced for the retest - nor will hipot testing be repeated.

5. RETROFIT WORK DESCRIPTION OF E44 CONVERSION TO CHOPPER PROPULSION

5.1 Remove the following equipment:

- Rear pantograph
- Cab roof over transformer
- Main transformer
- Ground switch
- Tap switches
- J.R. breaker
- Main equipment blower and drive motor
- Control wire troughs and wire (but not cab signals and train cont. wiring)
- Rectifier compartment cab/roof section
- Main propulsion rectifiers
- Blower start contactor and resistor
- Everything in Control Compartment
- KM45 Controller
- Motor cutout switch
- Compressor start contactor and resistors
- Air compressor, drive motor
- Wheelslip panel in cab control compartment

- Battery compartment
- Braking and accelerating resistors
- Auxiliary transformer
- Both master controllers (leave housing)
- Overload relays in cab control compartment
- Main smoothing reactor

5.2 Burn off blower support (radiator and piping enclosure).

5.3 Modify rectifier room to accept chopper control panels, line filter capacitors, and motor disconnect contactors.

5.4 Remove traction motors, gears, and wheels.

5.5 Steam clean the stripped down locomotive.

5.6 Modify transformer mounting pads.

5.7 Mount new base frames for the following equipment:

- Equipment blower/filter housing/blower drive motor.
- New smoothing reactor supports - chopper reactors under platform, auxiliary motor reactors near drive motors.
- Compressor drive motor.
- Duct work for equipment blower/motor and air filter subassembly.
- Pre-regulator and chopper modules.
- Eight notch master controllers (2).

5.8 Install new equipment to base frames of 5.7. In addition:

- Install the main transformer.
- Install 4 line disconnect switches alongside main transformer.
- Install line filter capacitors and motor disconnect contactors above chopper modules.

5.9 Do power cabling (above platform). Mount CT's near transformer.

5.10 Control Wiring

- Strip out all control wiring less that used for cab signal and train control.

5.11 New cab section for blower will be furnished. Roof hatches will be reused, if possible.

Run control air pipe line to roof for vacuum breaker.

Mount vacuum circuit breaker on main transformer.

5.12 Mount new traction motors, gears, and wheels.

5.13 Install lightning arresters on main transformer.

5.14 Put new equipment in control compartment.

5.15 Mount new auxiliary transformer in control compartment.

5.16 Mount air compressor and new drive motor on subbase and align.

5.17 Mount and align equipment blower and drive motor.

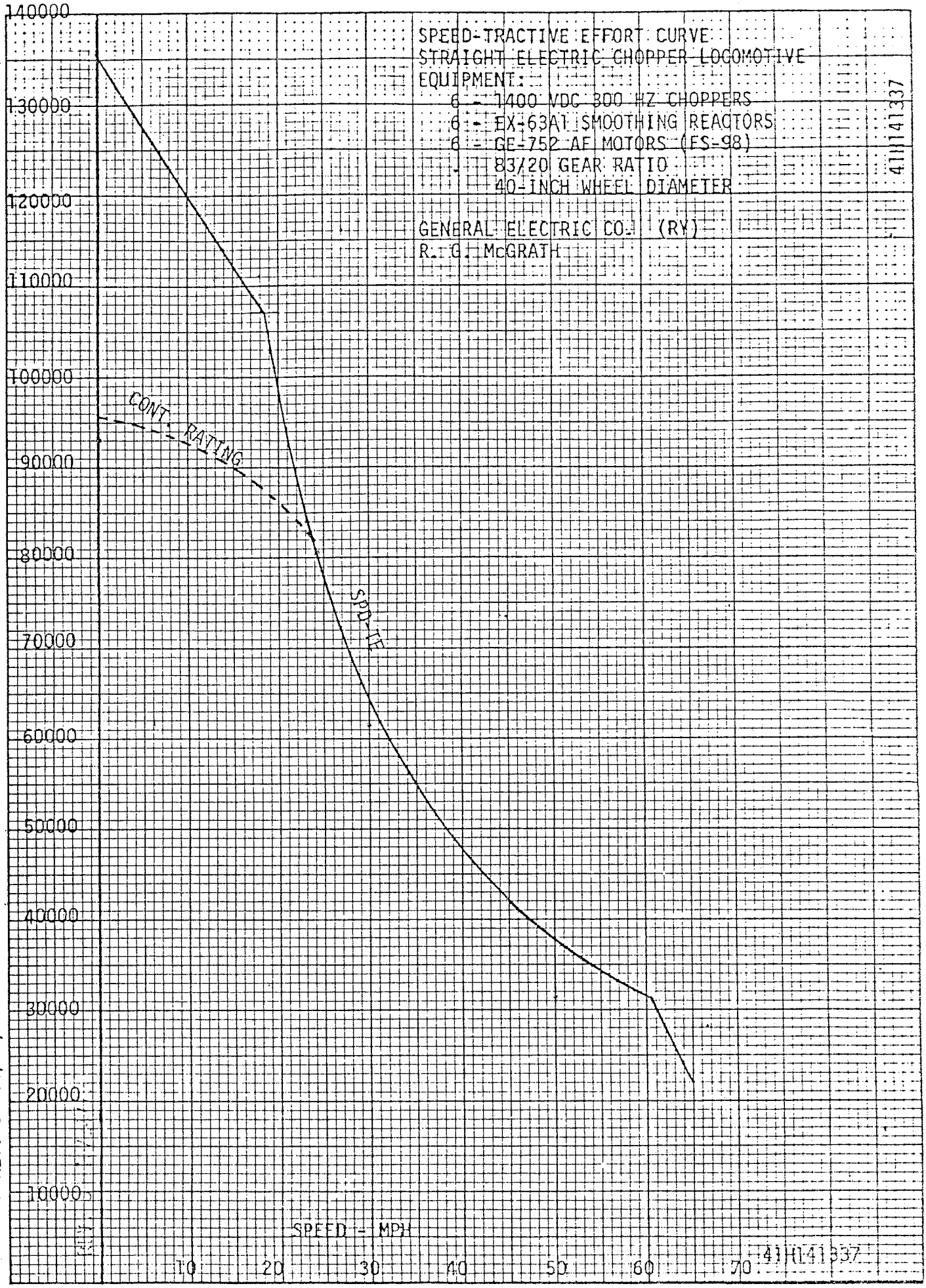
5.18 Miscellaneous changes to switches, indicating lights, breakers, etc. in operating cab, mount new overload relays.

5.19 Paint.

5.20 Test - wiring, cabling, control sequence, limited load test, motor rotation, etc. Track test at Erie.

APPENDIX B

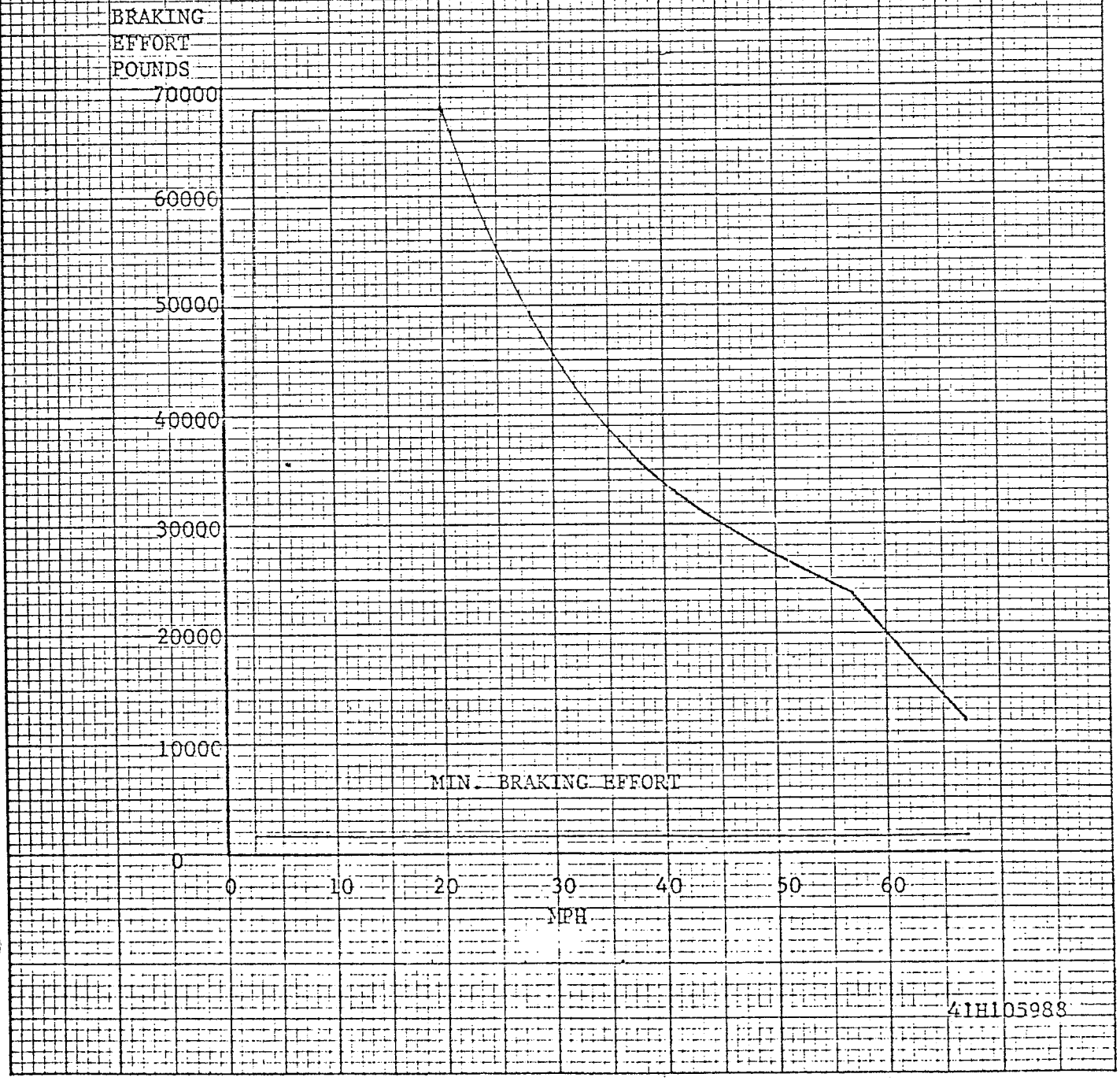
PERFORMANCE CURVES



REV. 0 10/24/79

E44/E60 CHOPPER LOCOMOTIVE
DOT-FR-9027
BRAKING EFFORT VS SPEED
(6) 5GE 752AF MOTORS
83/20 GR 40" W.D.
3-26-79 H.H.HENNELL

41H105988



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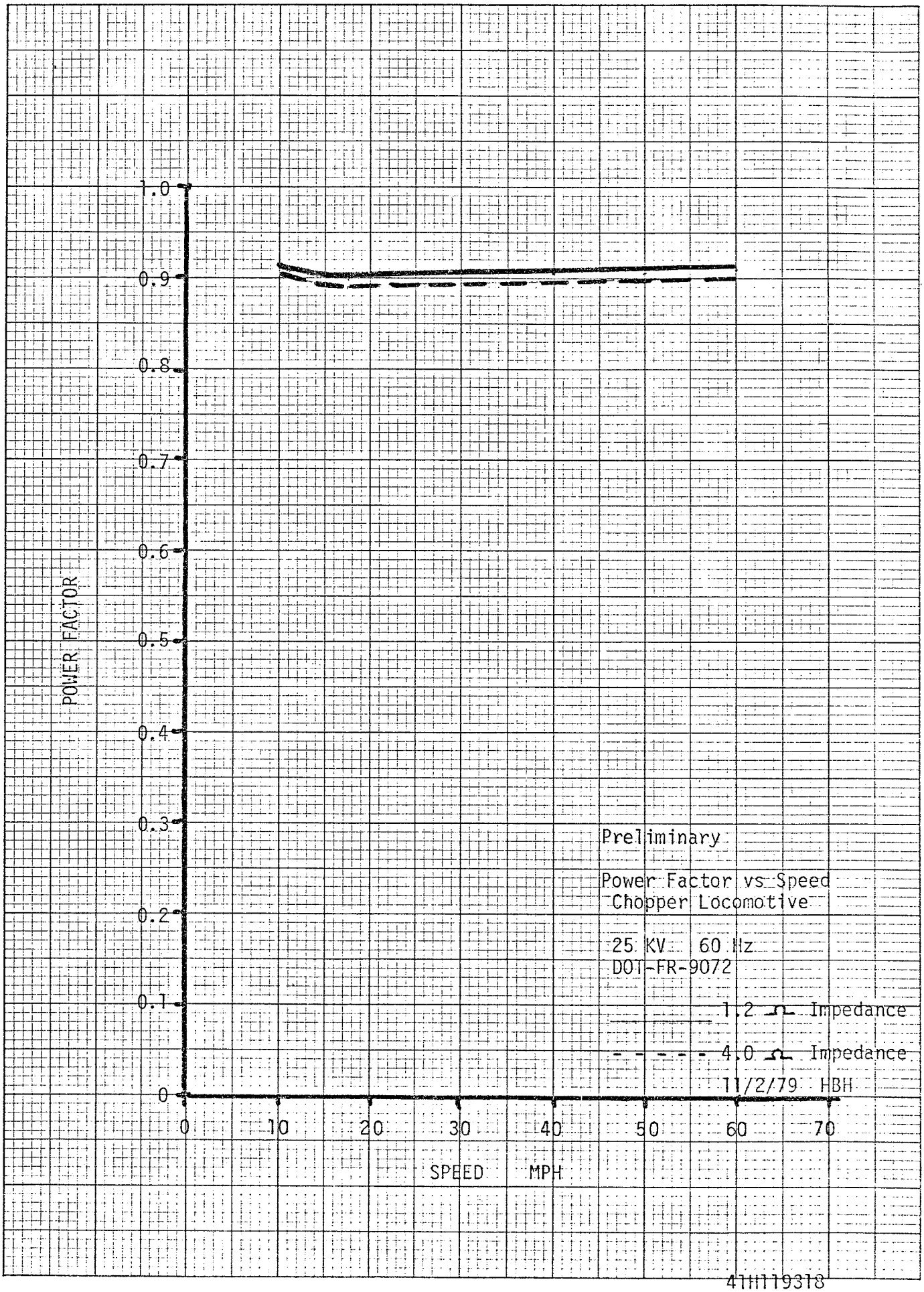

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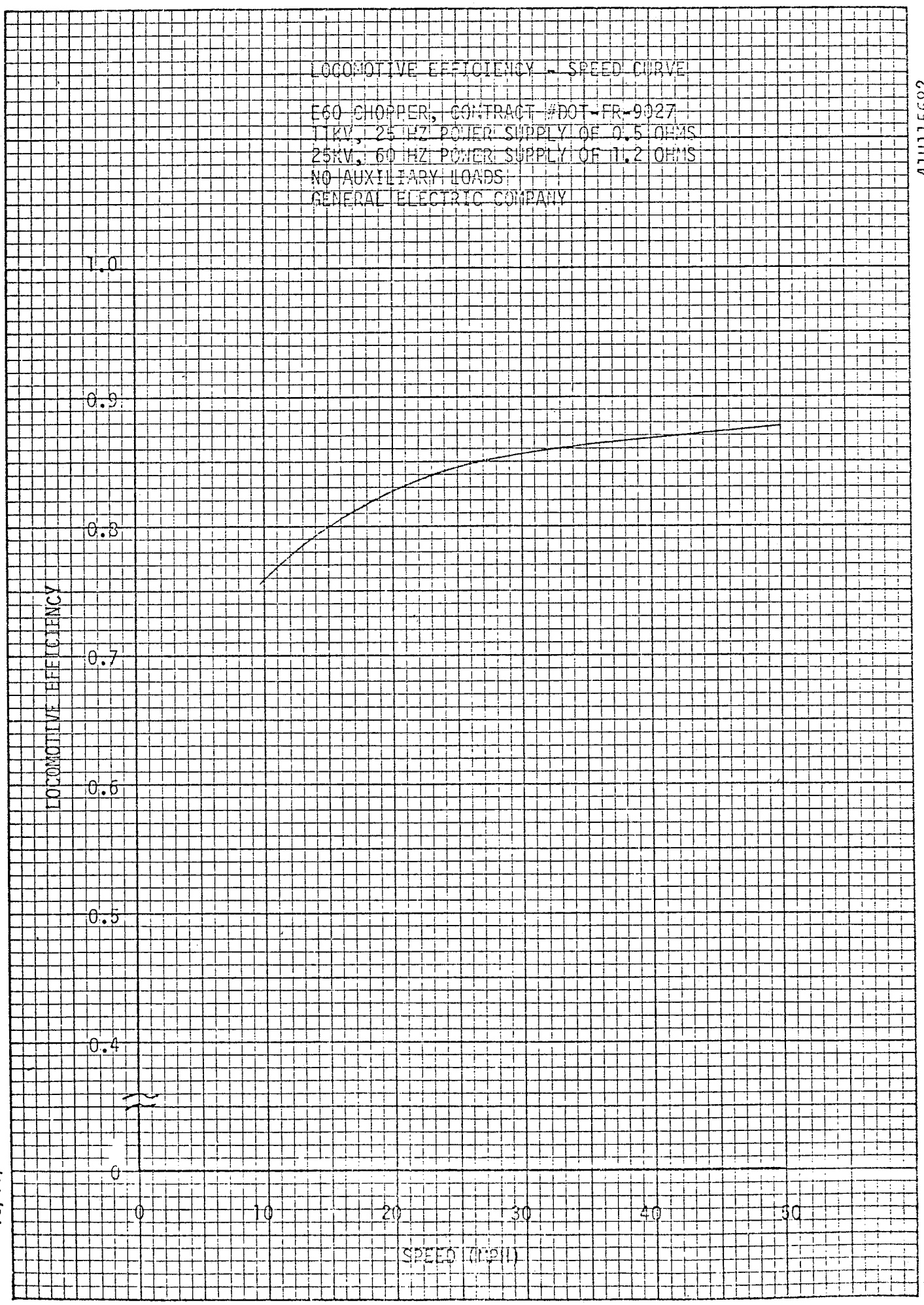
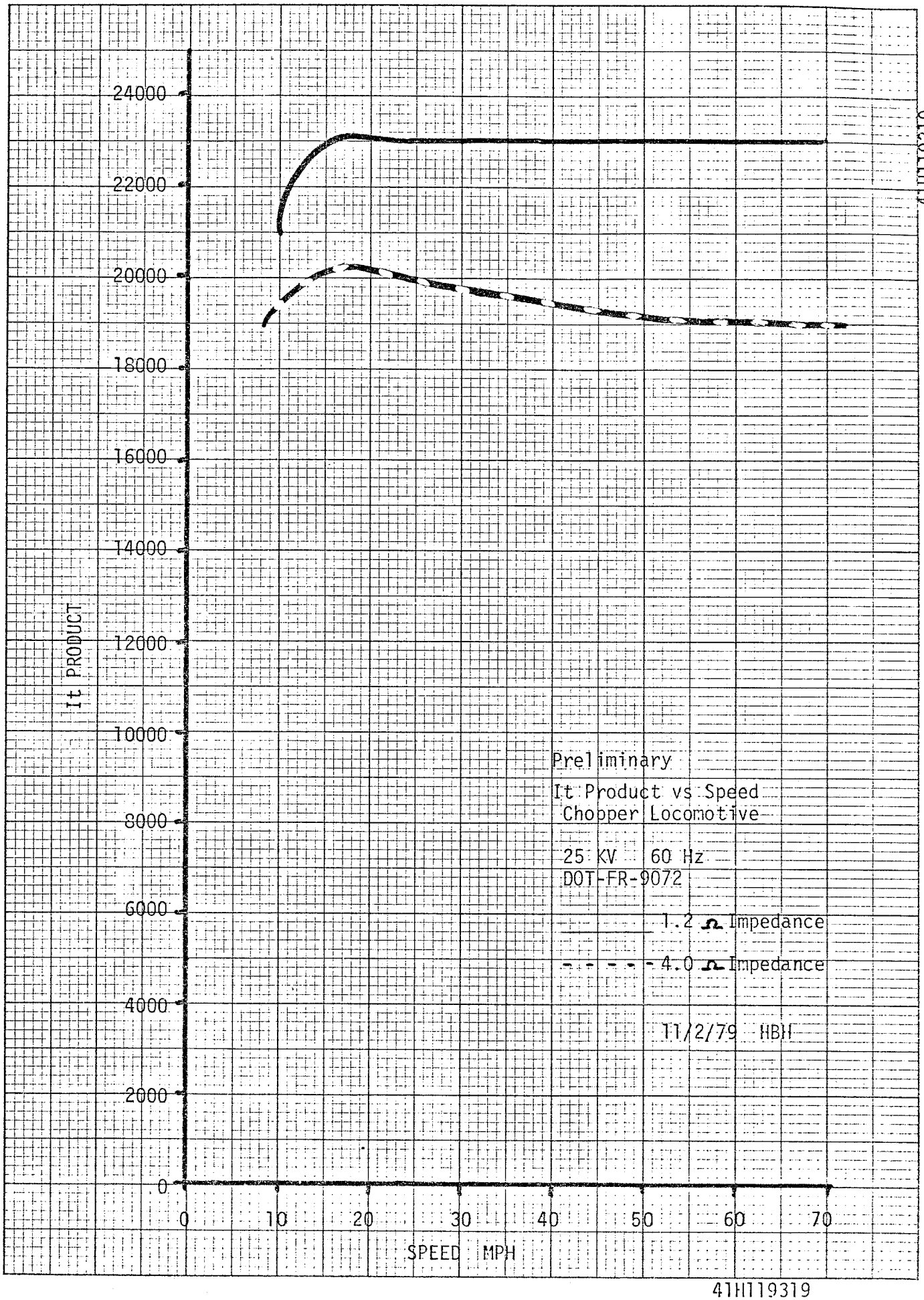


41H115682

10/16/79 RJH

41H115682



41HT19319

APPENDIX C

PRELIMINARY LOCOMOTIVE LIST

GENERAL ELECTRIC TSBD ERIE, PA.

1-11 PARTS LIST FOR 41X277264

CONT. ON SHEET 2 SH. NO. 1

DATE 10/24/72

FOR DRAFTING/KEYPUNCH USE ONLY

UNIT OF MEASURE CODES

P - PIECE	I - INCHES	J - POUNDS	K - KILOGRAM
X - FOR REF.	G - GALLONS	Z - OUNCES	L - LITERS
V - VARIOUS	Q - QUARTS	M - METERS	
F - FEET	N - PINTS	C - CENTIMETERS	

16-30 TITLE MODIF LIST

46-55 DESIGN SPEC.

"1" IN CC 80

31-45 FIRST MADE FOR E44/E60 CHOPPER

71-75 AN

76-77 REV.

12-14 ITEM NO.	16-30 IDENTIFICATION NUMBER	31-45 DESCRIPTION	GROUP NO. AND QUANTITY 46-50 G1	51-55 G2	56-60	61-65	66-70	71-75	76 UNIT MEAS.	77 ("2" IN 80)
1	41R960518	EQUIP REMOVAL	X							
2	41R991968	STRUCTURE REMVL	X							
3	41R960520	RELAY COMPT MOD	X							
4	41R960521	RELAY COMPT MOD	X							
5										
6										
7										
8										
9										
10	41X2772655G1	EARL		1						
11	41X2772655G2	EARL		1						
12	41X2772655G3	EARL		1						
13	41X2772655G4	EARL		1						
14	41D7227077	LOCATION OF APPR		X						
15		OUTLINE		X						
16	41B5410844	ELECT SCHEMATIC		X						
17	41R9709000	AIR PPG DIAGRAM		X						
18		WIRING DIAGRAM		X						
19		TEST INSTR		X						

MADE BY E Kuehn

ISSUED BY

APPROVALS

REVISION

DISTRIBUTION

TSBD-5066-1 (12-7

GENERAL ELECTRIC TSBD ERIE, PA.

1-11 PARTS LIST FOR 41X277264

CONT. ON SHEET 3 SH. NO. 2

DATE 10/26/79

FOR DRAFTING/KEYPUNCH USE ONLY

UNIT OF MEASURE CODES

P - PIECE I - INCHES J - POUNDS K - KILOGRAM
X - FOR REF. G - GALLONS Z - OUNCES L - LITERS
V - VARIOUS Q - QUARTS M - METERS
F - FEET N - PINTS C - CENTIMETERS

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12-14 ITEM NO.	16-30 IDENTIFICATION NUMBER	31-45 DESCRIPTION	GROUP NO. AND QUANTITY 46-50 G1	51-55 G2	56-60	61-65	66-70	71-75	76 UNIT MEAS.	77 ("2" IN 80)
20		WIRING MTLS		1						
21		PLAT PREP INST		X						
22	41C610289GAR	AXLE ARRGT		1						
23	41C610289GHR	AXLE ARRGT		1						
24	41B535861G11	TRACTION MOTOR		6						
25		TRUCK ASM		X						
26	41R991981G1	MAIN RESVR MOD		1						
27	41R991992G1	PANTO ARRGT MOD		1						
28	41R991955G1	CONT CONSOLE AR		1						
29	41R991989G1	RELAY COMPT AR		1						
30	41E911900	XFMR OUTLINE		X						
31	41D72402161	XFMR DETAILS		1						
32	41R991993G1	ROOF ARRGT		1						
33	41R996200G1	ARE REG APPRT		1						
34	41R991988G1	CHOPPER ARRGT		1						
35	41R991996G1	LINE FILTER AR		1						
36	41R991970G1	BLOWER EQUIP AR		1						
37	41R991991G1	BL MTR LEAD AR		1						
38	41R991965G1	FILTER BOX ASM		1						

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TSBD-5066-1 (12-7

GENERAL ELECTRIC TSBD ERIE, PA.

CONT. ON SHEET F SH. NO. 3

1-11 PARTS LIST FOR 41X277264

DATE 10/24/79

FOR DRAFTING/KEYPUNCH USE ONLY

UNIT OF MEASURE CODES
P - PIECE I - INCHES J - POUNDS K - KILOGRAM
X - FOR REF. G - GALLONS Z - OUNCES L - LITERS
V - VARIOUS Q - QUARTS M - METERS
F - FEET N - PINTS C - CENTIMETERS

16-30 TITLE MODIF LIST

46-55 DESIGN SPEC.

"1" IN CC 80

31-45 FIRST MADE FOR E44/E60 CHOPPER

71-75 AN

76-77 REV.

12-14 ITEM NO.	16-30 IDENTIFICATION NUMBER	31-45 DESCRIPTION	GROUP NO. AND QUANTITY 46-50 G1	51-55 G2	56-60	61-65	66-70	71-75	76 UNIT MEAS.	77 ("2" IN 80)
39	41R991983G1	REACTOR BLKH AR		1						
40	41R991982G1	BLOWER CAB ASM		1						
41	41R991987G1	AIR FLTR ASST		1						
42	41R991992G1	COMP/SM REAC AR		1						
43	41R991997G1	CONT COMP PT SD		1						
44	41R996203G1	CONT COMP LT SD		1						
45										
46	41R996202G1	TIF ARRGT		1						
47	41R991999G1	REACTOR ARRGT		1						
48	41R996201G1	BATTERY BX AR		1						
49	41R991998G1	CAB/WIREWAY AR		1						
50		PAINT INST		1						
51		BALLAST AR		1						
52										
53										
54										
55										
56										
57										

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APPENDIX D

DRAWINGS DELIVERED

41A278712
41A303264

41B541084
41B554037
41B564024

41C635005
41C635888
41C661981, 2, 3
41C662018
41C662028
41C662081
41C662174, 5, 6

41D722707
41D724021
41D756333
41D756358

41E911900

K 1006068-1096, 7, 8
-1108, 9
-1138

L 6735662

41R960518
41R960520, 1
41R970900
41R991955
41R991968, 9
41R991970
41R991981, 2, 3
41R991987, 8, 9
41R991991, 2, 3, 4
41R991996, 7, 8, 9
41R996200, 1, 2, 3

41X277264

APPENDIX E

PRELIMINARY TEST PLAN FOR SINGLE AXLE CHOPPER

E44 CHOPPER PROJECT

PRELIMINARY TEST PLAN

A. SCOPE

This test will include all electrical and thermal stresses to a single chopper section. This chopper section will be loaded into a motor load, capable of loading the chopper components to their full rating in either motor or brake operation.

The electronic controls required for the chopper section and preregulator section will be tested to the inferred system requirements of locomotive specification 41A303259.

The scope of this test is limited to a single chopper section of the production variety. A preregulator will be required to perform the testing, however, it will not be a production model.

Testing will be of the devices described by the following:

Chopper (Power)	17KG391
Schematic	41D756333
Outline	41C662018

Control

Power Supply Panel	17FL213
Chopper/Regulator	17FL215
Chopper/Braking	17FL216
Annunciator	17FL217

B. OBJECTIVE

To confirm that the production designs of power and control circuits of a single section chopper meet the design specifications 18073-NL*A*A2 and 18073-NL*B*A2 and the inferred system requirements of locomotive specification 41A303259.

C. FACILITY DESCRIPTION

The facility required for this testing is shown in simplified form on sketch JAL91379 and consists of the following:

1) A single phase AC source rated

volts RMS	1935 V RMS
Amps	1000 amps

2) A DC preregulator similar to or the same as the preregulator required for the E44 chopper locomotive. This preregulator must be capable of being controlled by E44 preregulator controls so that start up high and low line and dynamic braking can be accomplished.

2.A) Preregulator controls which are to be checked for performance.

3) Filter bank and dynamic brake resistors

Filter choke & cap bank - Use the present equipment in Bldg. 50.

Resistors and contactors -

(Contactors are available at Bldg. 50, dynamic brake resistors need to be defined then found).

4) Chopper - A single section chopper (production version) and all controls necessary to operate this chopper. To specifications ?

5) Test machine 6E 752 AF shafted to another 752 which will be the load machine.

The test machine will be a series field 752 motor. The load machine will be a separately excited 752 motor. The field will be held constant, its output will be fed to a 752 separately excited machine which is directly shafted to a synchronous machine driven by utility power. Controlling the field of this machine controls the output voltage and then the speed of the load machine. The field then can be controlled to load the test machine and chopper section as desired.

6) Air Requirements

(a) Single Chopper Section - 1500 CFM at 10" H_2O.
This will require special ducting although the blower presently in bldg. 50 can supply this air.

(b) Preregulator - The preregulator in 50 already has an air supply, however, it is combined with the air supply to the breadboard chopper. This chopper will be removed and the air supply modified to supply only the preregulator and filter.

C. FACILITY DESCRIPTION - Continued

6) Air Requirements - Continued

(c) Dynamic Brake Resistors - It is possible if sufficient resistors can be obtained that no forced air would be required. However, if air is necessary low pressure - high CFM air could be used.

Depending on the location and quantity of dynamic brake resistors it might be possible to duct exhaust air from preregulator or chopper through them.

(d) Machine Cooling - As exist will be satisfactory for chopper testing.

D. EQUIPMENT BEING EVALUATED

1. Single Section Chopper as shown on schematic 41D756333 and outline 41C662018

This chopper section will be loaded to full load motoring and braking.

(a) Thermal Stresses encountered by the semiconductors, commutation reactors and capacitors will be evaluated at those conditions considered to be worst case.

(b) Electrical Evaluation

Semiconductors	Watts dissipated Voltage stresses a) V_B b) $\frac{dv}{dt}$ c) di/dt d) Voltage overshoots
Commutation capacitors and Reactors	a) RMS currents b) di/dt c) peak currents d) voltage excursion & stresses
Snubbers	a) Proper Watt rating b) RMS I c) Peak currents d) Voltage balance d) Voltage sharing

D. EQUIPMENT BEING EVALUATED - Continued

1. (b) Electrical Evaluation - Continued

System Logic

a) Motoring
b) Braking
c) Startup
d) Shutdown

System logic in general will be checked out to a degree to confirm that the requirements of locomotive specification 41A303259 can be met with the control equipment. The testing will include all the contactor control necessary to satisfy proper braking and motoring in addition to chopper control logic.

System logic check includes the following control panels:

17FL215A1	Preregulator
17FL216A1	Chopper
17FL213A1	Power Supply
17FL217A1	Annunciator Panel

These panels will be connected into the system and to the extent possible on a single chopper, their logic checked out.

System logic would also include power system test in general; i.e. harmonic generation in line, telephone interference, switching transients, crowbar functioning, and etc.

E. TEST EQUIPMENT REQUIRED

This list of test equipment would represent a minimum requirement, in addition to facility.

1)	Oscilloscope	- Double amp capability - Extended horizontal sweep - Differential amplifier - Chopper type amplifier - Camera
2)	Multimeters Analog	- Two min. hand type. Similar to 260 Simpson or a Triplett.
3)	Digital Multimeters	-. (3) Similar to John Fluke 8010
4)	Recording Instrument	- Visicorder, six channel minimum - Isolation and attenuation amplifiers for use with above.

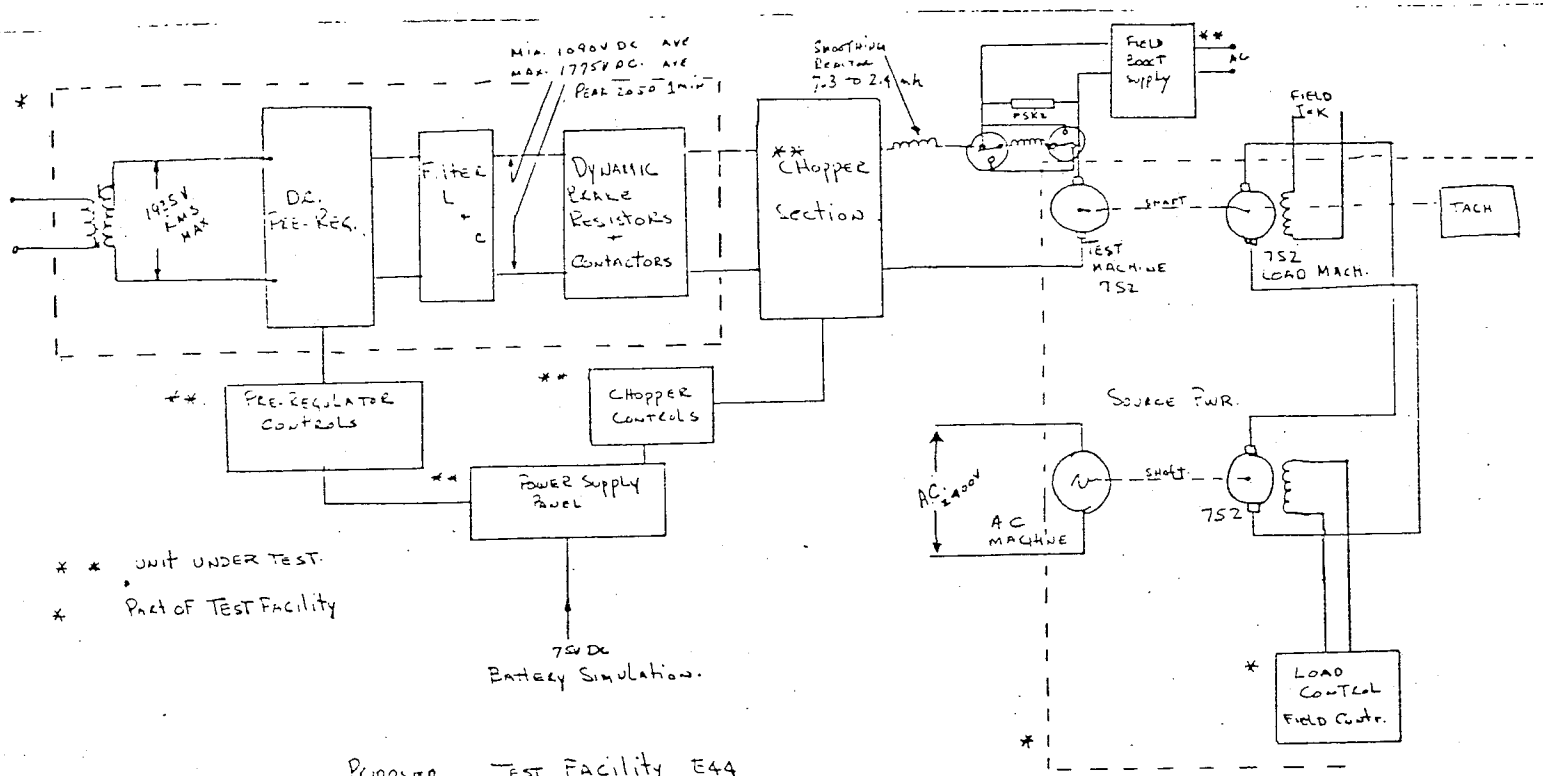
E. TEST EQUIPMENT REQUIRED - Continued

5)	Recording Instrument	- Brush type for recording performance characteristics - Four to six channels with isolation amplifiers
6)	Harmonic Measuring Meter	- Similar to Gen Rad Model 2512 Fast Forier Transform type scope or - Hewlett Pachard wave analyzer Either would probably be satisfactory
7)	Temperature Measuring Equipment	- Heat run information required will be quite extensive. Automatic data taking instrumentation will be required.
8)	Air Flow Measuring Equipment	- Need ability to measure pressure drop and Velocities.
9)	Control Power	- (2) 0±15 V control power - (1) 75 V battery simulation - (2) 0 to 25
10)	Isolation Transformers	- 115 to 115 for instrument isolation where necessary. (scopes, visicorder, etc. if required)
11)	Sound Level Meter	- As Required
12)	Electromagnetic	- To demonstrate that equipment meets the requirements of paragraph 4.7 of 41A303259.

J.A. Laukaitis
42-2, Ext. 2489

September 20, 1979

mrr



Proposed TEST FACILITY E44
SKJAL 91379

GENERAL ELECTRIC

41A278712

COVER SHEET

TITLE CIRCUIT BREAKER

CONT. ON SHEET 2 SH. NO. 1

FIRST MADE FOR 18073NL*M

SPECIFICATION REVISION STATUS

REVISIONS	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T	U	V	W	Y	Z
A. N. NO. / DATE																						
SHEET NO.							SHEET REVISION STATUS															
1																						
2																						
3																						
4																						
5																						
6																						
7																						

7011

* ADDED SHEET
** DELETED SHEET

(20)

PRINTS TO

MADE BY [illegible]

ISSUED [illegible]

CONTROL [illegible]

41A278712

CONT. ON SHEET 2 SH. NO. 1

REV NO.

CONT ON SHEET SH NO.

TITLE

PURCHASE SPECIFICATION FOR 25 KV VACUUM CIRCUIT BREAKER

FIRST MADE FOR GENERAL (DOT-FR9027 E44/E60 LOCO)

REVISIONS

1.0 SCOPE

The scope of this specification covers electrical, mechanical, environmental and general characteristics of a vacuum type circuit breaker to be used on General Electrical locomotives. The unit is to be mounted on the roof of the locomotive as a pantograph line breaker whose output will feed the main transformer primary high voltage bushing. The unit will close and open on command of either normal signals or fault signals at a low level DC control voltage.

1.1 VARIATIONS IN CONTROL POWER

1.1.1 The breaker will be controlled by 75 VDC (50 VDC min). In addition, compressed air is available from the locomotive's control equipment air tank. This air may be used to power the vacuum breaker if desired. The locomotive air supply will be set at either 70 $\pm$ 3 psi or 90 $\pm$ 3 psi. Once it is set it will be regulated at $\pm$ 1 psi from the set point.

1.1.2 Breaker must close upon application of control voltage and open when voltage is removed.

1.1.2.1 If dual speed opening breaker is offered, the fast opening (i.e. trip) mode shall be activated by removal of control voltage to a trip circuit which is separate from the normal slow open-close circuit described in Paragraph 1.1.3. No electrical energy storage devices (e.g. capacitors) shall be required in the control circuits.

1.2 DEFINITIONS

1.2.1 PARTIES

Purchaser - General Electric Company
Transportation Systems Business Div.
Erie, Pennsylvania

PRINTS TO

1.2 DEFINITIONS (continued)

1.2.1

Supplier - Vendor supplying material, services or equipment to this purchase specification

2.0 DESIGN CHARACTERISTICS/RATINGS

2.1 ELECTRICAL

2.1.1 All part number designations of this breaker should be capable of operating on all the following single phase systems with the following ratings:

KV			HZ	AMP CURRENT		ASYM. CLOSE/LATCH	MVA INTERRUPT
MIN	NOM	MAX		CONT	INTERRUPT		
7.5	11	14	25	600	8000	12000	
8.75	12.5	14	60	600	8000	12000	
17.5	25	27.5	60	450	7200	12000	180

2.1.2 Voltage Withstand Ratings

2.1.2.1 Power frequency withstand External voltage to ground as mounted on locomotive 75 KV required WET 60 second rating. Internal voltage across open interrupter bottles 130KV.

2.1.2.2 Impluse Withstand (BIL) 1.2 x 50 u sec wave

External voltage to ground mounted on locomotive 150 KV

Internal voltage across interrupter bottles 150 KV

2.1.2.3 Lightning arrestor will be provided external to breaker (by GE Co) in service.

1) for 11-12.2 KV , 9L11PGA018
2) for 25 KV , 2 of 9L11PGA018

2.1.3 Opening speed versus control voltage. The breaker shall open and clear fault current as a result of control voltage signals from the locomotive system.

2.1.3.1 Open time shall be from time breaker receives trip signal to time fault has been cleared. Fault shall consist of maximum rated current at maximum rated voltage at any offset rates from 1.0 to 1.4. Breaker shall respond at 50 or 75 V no slower than the following times which are given in milliseconds.

	FAULT CLEARANCE TIME	
	25HZ	60HZ
P1	45	33

2.1.4 Close latch and 100 ms current carry - 12,000A asym. peak.

2.1.5 The breaker shall include three single pole double throw switches mechanically actuated by the opening and closing of the breaker. Switch contacts shall be capable of switching 1.0A @ 75V inductive load for the overhaul life of the breaker.

2.2 MECHANICAL

2.2.1 Maximum closing time shall be 250 ms and maximum slow opening time (if any, in case of a dual speed breaker) shall be 250 ms at 50 and 75 volts.

2.2 MECHANICAL (continued)

2.2.2 The breaker shall operate in fast trip and slow opening modes (if any) and shall close with control voltage as low as 50 VDC.

2.2.3 The breaker will operate at each line phase break at 14 mile intervals, 84000mi./year are expected, 6000 operations per year. 30 year life with reasonable maintenance is expected. Normal phase break opening will be at 50 amp. 1 per 2000 openings will be of fault trip nature.

2.2.4 The breaker shall be capable of being remotely controlled from anywhere in the locomotive through application or removal of low voltage DC control signals. Special power supplies, external controls or other apparatus which are external to the vacuum breaker and which must be mounted separately within the locomotive, must be compact. All such apparatus as well as low voltage control wiring and those switches covered in Paragraph 2.1.5 shall be properly isolated from the high voltage portions of the breaker such that they are suitable for operation at or near ground potential.

2.2.5 The breaker shall be trip free. That is, the breaker shall be capable of instantaneously tripping open at any time the breaker is closed, or at any time during the closing stroke or the opening stroke.

2.2.6 Mounting - Outline drawing showing mounting dimensions and insulators shall be included by the supplier in response to this specification.

2.2.7 An outline of the breaker and any auxillary box shall be provided. In interim, outline 3078A0449 is being used for roof layout. Early update is required to minimize packaging impact.

2.2 MECHANICAL (continued)

2.2.8 Definition of the following is required:

Mounting requirements
Terminal interface requirements
Special Tools requirements
Standard Hardware requirements
Markers and standard terminal marking requirements
Nameplates and product marking

2.3 MAINTENANCE SCHEDULE

Maintenance shall be minimized. A recommended maintenance and tip wear inspection shall be included in response to this specification. One year minimum inspection period is desired.

2.4 ENVIRONMENTAL

The breaker is mounted on the locomotive roof unprotected from the environment. It will be subject to a typical railroad atmosphere which may contain as a minimum, iron dust, ozone, fine sand, carbon dust, salt air, alkaline dust, 100 MPH winds, freezing rain, ice, snow and sleet as well as RR car washing detergents under high pressure stream or spray (e.g., commerical caustic water soluble hot or cold cleaning solutions such as oakite).

2.4.1 Relative humidity may be from 0 to 100%

2.4.2 Ambient temperature may be from a minimum of -40°C to a maximum of 40°C plus direct solar radiation equivalent to a total of 74°C in the shade.

Av. hours ambient temperature exceeds ref. temp as below

Ref. Temp	30°C	35.5°C	41.1°C
Av. Hr/Yr	263	10	0
Av % of Yr	3	.1	0

2.4 ENVIRONMENTAL (continued)

2.4.3 ELEVATION
Elevation will vary from sea level to 2200 ft.

2.4.4 THERMAL CYCLING DUE TO OPERATION
0 - Max rating 20 times/day PLUS
0 to continuous rating 100 times/day

2.4.5 THERMAL SHOCK
Must be capable of withstanding 100 step changes starting at 0 current at -30°C then operating at full rated performance.

2.4.6 MECHANICAL SHOCK REQUIREMENTS

Shock	(Coupling Shocks (longitudinal)	2.5g
	(Horizontal & Vertical	1.5g
Vibration	(1 -40 Hz	3"/sec velocity
	(40-300Hz	1.5g Acc.

3.0 WARRANTY AND PRODUCT SERVICE

3.1 The supplier will comply with all requirements of Vendor Product Service Instruction 41A218021 and Warranty for Purchased Components 41A282026.

4.0 QUALITY ASSURANCE REQUIREMENTS

4.1 Quality assurance requirements shall include Test and inspection plan records and first article inspection, notice of changes and deviations for approval.

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3. Critical Frequencies

No critical frequencies of the oil cooler tubes shall be excited by air flow from 50% to 150% of the design air flow velocity. In addition, no resonant frequencies below 300 cps shall exist in the cooler tube design.

4. Tank Construction

A. Special precaustions shall be taken to minimize the danger of transformer leaks at the tank corners and terminal boards. Creepage distance between LV terminals should be as large as possible to minimize the problems of oil seepage. Minimum acceptable creepage distance is 5 inches.

5. Machine Screws

A. All machine screws shall be in accordance with requirements of the American Standards Association.

1. Hex head screws ASA Standards B18.6.

2. Slotted and recessed head screws ASA Standards B18.6.

B. All machine screws shall be rolled or cut to national form thread.

1. Thread for machine screws #12-28 and smaller shall be NC fine.

2. Thread for machine screws size 1/4" - 20 and above shall be NC Coarse.

6. Plain and Lock Washers shall be in accordance with ASA B27.1.

7. All hardware (nuts, screws, and plain washers) shall have a zinc (hot dip) coating or cadmium plate (.002" to .004") for outdoor use. F70 B4D zinc electroplate may also be used.

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8. Class of Fit

A. All nuts and tapped holes shall have Class 2B tolerances.

B. All capscrews, machine screws and bolts shall have Class 2A tolerances.

9. Lock Washers or Other Locking Devices

Shall be provided for bolts, screws, and nuts except where flat head screws are used in which case the heads will be center punched to prevent them from loosening.

10. Screw Threads

In wood or molded compounds are not permitted. Any device mounted on wood or molded compount shall be secured with a trhough bolt or machine screw. It is permissible to hex counter bore a nut on the back side of a panel to keep the nut from turning while the screw is being inserted.

11. Exterior of the transformer shall be primed and finish coated with gray paint. The bidder shall obtain approval of his paint system.

12. Accessibility

A. All accessories mounted on a transformer shall be easily removable.

B. All mounting screws shall be accessible.

C. Sufficient clearance around bolt heads shall be provided.

D. All nuts not accessible from the front shall be welded in place.

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V. ENGINEERING COORDINATION

The transformer equipment covered by this specification shall be a coordinated design between the vendor and the Locomotive Engineering Department, General Electric Company.

VI. TESTING

1. Engineering Tests

Engineering tests to be made on only one unit.

The transformer shall be designed to ASA Standards for "Distribution, Power, and Regulating Transformers and Reactors other than Current Limiting Reactors" Section 12-02 10/29/1958 for a transformer with a single phase line to ground voltage of 25 Kv. Basic impulse level of 150 Kv full wave voltage applies. Impulse test will be made on one transformer in accordance with the above named standards, using the method without normal frequency excitation both full and chopped wave.

The Engineering tests shall include the following:

A. With rated load on the transformer, (primary and three secondaries), liquid circulating pump in operation and rated cooling air through the radiator temperature rise shall not exceed that specified by the bidder.

B. Determine pressure-flow characteristic of radiator on one transformer with air inlet as it will be on the locomotive. (In the event that the identical cooler that was used on the E44 outline 579E257 is used this test is waived.)

C. Resistance of transformer windings and impedance volts and impedance loss for each winding shall be determined with transformer at room temperature.

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D. Make tests to determine whether or not high frequency surges will be transmitted through the transformer. This test is to determine the capacitive coupling between the primary and secondary windings in circuits. Peak voltage should be chosen so as to give reliable values of capacitance coupling consistant with the measuring device chosen.

A sharp front (rise time .2 microseconds) voltage at the high voltage bushing of at least 1000 microseconds duration should be applied and the voltage transient at each secondary tap to ground measured.

E. Secondary Impedance Tests

Primary to secondaries X_1 X_2 and X_3 X_4 individually and between secondaries X_1 X_2 - X_3 X_4 with H_1 H_2 open and X_1 X_2 and X_3 X_4 both short circuited.

2. Commercial Tests

A. Designed for dielectric tests in accordance with the American Standard Test Code for "Distribution, Power, and Regulating Transformers and Shunt Reactors" C57.23.00-1965.

Applied voltage (to other windings and ground)
HV winding - 15 Kv for one minute*
LV winding - 10 Kv for one minute*
Induced voltage - 50 Kv from high voltage terminal to ground, with high voltage windings in series, in accordance with test code referred to.

The induced voltage test shall be repeated with the high voltage windings connected in parallel, and with an induced voltage of 25 Kv primary.

* Duration specified by GE Co. Test Form 13483

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B. Winding resistance.

C. Turn ratio shall be determined for all taps and for the full secondary winding, including main and auxiliary windings.

D. Excitation loss determination shall be based on a sine wave voltage.

E. Exciting current at normal and maximum continuous voltage shall be corrected to a sine wave basis.

F. All tests subject to inspection by the customer.

G. Electrical isolation of the secondary windings shall be proven by testing per ASA code referred to, with each secondary tested at 10 Kv to ground with other windings grounded.

H. Verify direction of pump motor rotation to be correct for both supply frequencies.

I. Auxiliary equipment including current transformers, pump motor, and temperature switch must be megger tested at 500 volt megger. The insulation resistance of each device must be in excess of 10 megohms. The auxiliary equipment must also be hipotted at 1500V ac RMS, 60 Hz for 1 minute.

VII. INSPECTION

The transformer equipment covered by this specification shall be subject to inspection by representatives of Locomotive Operations, General Electric Company. Vendor shall warrant all material furnished on this specification in accordance with 41A282026.

VIII. VENDOR PRODUCT SERVICE

1. Instruction and Customer Education Material

At the time the locomotive is placed in service on the customers property, complete instruction books are to be in the hands of the ultimate customer. The vendor is to supply complete manuals in a format and bound in a manner agreed upon between the vendor and representatives of the Locomotive Operations and in quantities to meet the requirement of the ultimate customer as specified in this requisition.

Manuscript and reproducible illustrative art work to be supplied for the use of the Locomotive Operations in preparing running maintenance and customer education manuals. The content arrangement and production lead time for the material is to be individually negotiated with representatives of the Locomotive Operations in quantity to meet the requirements of the ultimate customer as specified in the requisition.

2. Renewal Parts Bulletins

Parts catalogs and bulletins are to be supplied so as to be in the hands of the ultimate customer when the locomotive is placed in service on his property. Catalogs and bulletins are to be furnished in a format and bound in a manner agreed upon between the vendor and representatives of the Locomotive Operations in quantity to meet the requirements of the ultimate customer as specified in the requisition.

IX. DRAWINGS

Vendor to furnish outline drawings, and photographs in quantities to be specified at time requisition is issued.

X. DRAWING LIST PER GENERAL ELECTRIC, PITTSFIELD AS FOLLOWS:

1. Connection Diagram
2. Elementary Diagram
3. Outline Drawing (Railroad)

XI. WARRANTY

The equipment covered by this specification will be under warranty by the transformer manufacturer, including material, labor and delivery charges to the Locomotive Operation or the final customer, by the following clauses:

1. The manufacturer of the transformer shall provide an unconditional two year warrantee.

2. All equipment shall be free from defects in title.

3. All equipment shall be 100% new and unused and in accord with this specification and shall be free from defects in material and workmanship.

GENERAL ELECTRIC

41A303264
CONT ON SHEET F SH NO. 20

REV NO.

TITLE
TRANSFORMER SPECIFICATION FOR MULTIPLE VOLTAGE/FREQUENCY LOCOMOTIVE WITH CHOPPER

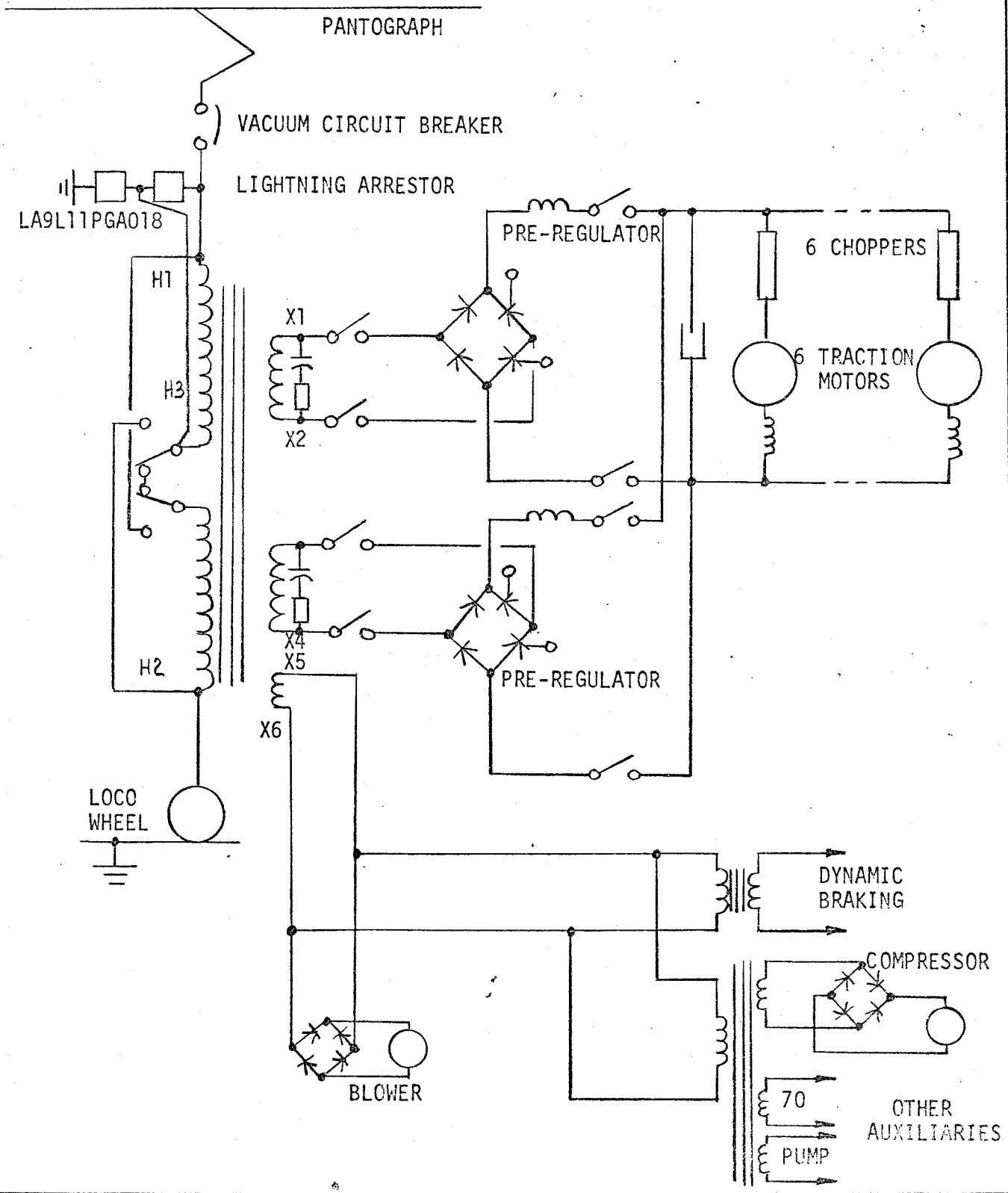
CONT ON SHEET SH NO.

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

1 5/30/79 R. J. Hopkins

SIMPLIFIED POWER CIRCUIT



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MADE BY RM Smith 2/20/79
ISSUED R. J. Hopkins 3/9/79

APPROVALS RJH

LO DIV OR DEPT.
ERIE LOCATION

41A303264
CONT ON SHEET F SH NO. 20
CODE IDENT NO.

FF-803 WF (5-78)
PRINTED IN U.S.A.

LO

REV NO.

CONT ON SHEET SH NO.

TITLE

TRANSFORMER DUTY CYCLE

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

DUTY CYCLE 1

WINDING	VOLTAGE	RMS CURRENT
Primary = H_1-H_2	11,000	432
and H_3-H_4 in parallel		
X_1-X_2 and X_3-X_4	1,600	1,373
X_5-X_6	880	455

PRINTS TO

REV NO.

CONT ON SHEET SH NO.

TITLE

TRANSFORMER DUTY CYCLE

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

DELTA TIME (MIN)	SPEED (MPH)	CURRENT AMPS PRIM	SECOND WDG.	AUX. WDG.	TRACT MOTOR	RAIL POWER (HP)	TOTAL TIME (MIN)
Ø.25	1.Ø	182.	5Ø1.	455.	24Ø7.	533.	Ø.25
Ø.25	4.Ø	228.	66Ø.	455.	1781.	154Ø.	Ø.5Ø
Ø.27	7.Ø	297.	897.	455.	1635.	2453.	Ø.77
Ø.28	1Ø.Ø	368.	114Ø.	455.	1538.	3275.	1.Ø5
Ø.29	13.Ø	423.	1328.	455.	1456.	4Ø07.	1.34
Ø.3Ø	16.Ø	476.	1511.	455.	1381.	4648.	1.64
Ø.32	19.Ø	517.	1651.	455.	1286.	5Ø92.	1.96
Ø.36	22.Ø	521.	1666.	455.	1157.	5228.	2.32
Ø.13	24.Ø	51Ø.	1628.	455.	1Ø69.	52Ø7.	2.45
3.Ø1	25.Ø	36.	Ø.	455.	Ø.	1.	5.46
6.24	25.Ø	255.	751.	455.	559.	2413.	11.7Ø
Ø.28	26.Ø	5Ø4.	16Ø8.	455.	999.	5212.	11.98
Ø.2Ø	29.Ø	492.	1566.	455.	9ØØ.	513Ø.	12.18
3.76	3Ø.Ø	36.	Ø.	455.	Ø.	1.	15.94
2.96	3Ø.Ø	489.	1555.	455.	867.	5Ø79.	18.9Ø
1.14	31.Ø	489.	1555.	455.	847.	5Ø99.	2Ø.Ø4
2.22	34.Ø	488.	1553.	455.	786.	51Ø2.	22.26
1.3Ø	36.Ø	487.	155Ø.	455.	75Ø.	5Ø98.	23.56
1.8Ø	33.Ø	488.	1552.	455.	8Ø6.	51Ø6.	25.36
Ø.95	31.Ø	488.	1554.	455.	847.	5Ø98.	26.31
Ø.66	33.Ø	488.	1552.	455.	8Ø6.	51Ø5.	26.97
Ø.74	3Ø.Ø	487.	155Ø.	455.	75Ø.	5Ø98.	27.71
Ø.5Ø	39.Ø	484.	1537.	455.	7Ø3.	5Ø85.	28.21
1.73	4Ø.Ø	36.	Ø.	455.	Ø.	1.	29.94
Ø.76	39.Ø	483.	1535.	455.	7Ø2.	5Ø78.	3Ø.7Ø
Ø.25	39.Ø	483.	1535.	455.	7Ø2.	5Ø78.	3Ø.95
1.25	4Ø.Ø	36.	Ø.	455.	Ø.	1.	32.2Ø
1.55	38.Ø	484.	1539.	455.	718.	5Ø89.	33.75
1.27	37.Ø	486.	1545.	455.	734.	5Ø97.	35.Ø2
3.33	38.Ø	342.	1Ø5Ø.	455.	537.	3472.	38.35
1.35	39.Ø	482.	1533.	455.	7Ø1.	5Ø7Ø.	39.7Ø
3.47	39.Ø	483.	1534.	455.	7Ø1.	5Ø74.	43.17
2.Ø9	37.Ø	485.	1544.	455.	734.	5Ø95.	45.26
1.18	35.Ø	489.	1555.	455.	766.	5Ø91.	46.44
Ø.65	36.Ø	487.	155Ø.	455.	75Ø.	5Ø99.	47.Ø9
Ø.45	38.Ø	484.	1539.	455.	717.	5Ø87.	47.54
1.67	4Ø.Ø	36.	Ø.	455.	Ø.	1.	49.21
2.56	39.Ø	482.	1533.	455.	7Ø1.	5Ø71.	51.77
Ø.75	39.Ø	373.	1156.	455.	566.	3825.	52.52
Ø.6Ø	4Ø.Ø	334.	1Ø23.	455.	5Ø8.	3381.	53.12
2.1Ø	39.Ø	482.	1533.	455.	7Ø1.	5Ø71.	55.22
2.25	39.Ø	264.	781.	455.	431.	2583.	57.47
1.Ø5	4Ø.Ø	36.	Ø.	455.	Ø.	1.	58.52
2.78	35.Ø	49Ø.	1558.	455.	768.	51Ø2.	61.3Ø
2.24	33.Ø	487.	1551.	455.	8Ø5.	51Ø1.	63.54

PRINTS TO

MADE BY RJ Hopkins 4/2/79

ISSUED

APPROVALS

LO DIV OR DEPT.

ERIE LOCATION

FF-803-WB (5-78)
PRINTED IN U.S.A.

LO

CODE IDENT NO

REV NO.

CONT ON SHEET SH NO.

TITLE

TRANSFORMER DUTY CYCLE

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

1.51	35.0	489.	1555.	455.	766.	5091.	65.05
1.07	34.0	489.	1555.	455.	787.	5110.	66.12
1.11	31.0	489.	1555.	455.	847.	5100.	67.23
0.20	29.0	36.	0.	455.	0.	1.	67.43
0.50	23.0	36.	0.	455.	0.	1.	67.93
0.60	20.0	203.	573.	455.	523.	1761.	68.53
6.30	20.0	466.	1477.	455.	1111.	4536.	74.83
2.40	20.0	203.	573.	455.	523.	1761.	77.23
6.90	20.0	466.	1477.	455.	1111.	4536.	84.13
4.50	20.0	466.	1477.	455.	1111.	4536.	88.63
0.30	20.0	203.	573.	455.	523.	1761.	88.93
0.83	21.0	532.	1704.	455.	1212.	5262.	89.76
15.87	22.0	518.	1657.	455.	1151.	5199.	105.63
11.19	22.0	518.	1657.	455.	1151.	5198.	116.82
1.22	24.0	511.	1633.	455.	1072.	5225.	118.04
15.39	24.0	510.	1628.	455.	1070.	5208.	133.43
4.17	33.0	490.	1559.	455.	809.	5130.	137.60
0.91	45.0	487.	1550.	455.	631.	5106.	138.51
1.05	48.0	486.	1545.	455.	597.	5060.	139.56
0.04	49.0	484.	1537.	455.	584.	5018.	139.60
1.12	50.0	36.	0.	455.	0.	1.	140.72
0.73	49.0	485.	1542.	455.	585.	5033.	141.45
4.52	40.0	485.	1543.	455.	690.	5099.	145.97
0.73	32.0	488.	1553.	455.	826.	5105.	146.70
0.	33.0	36.	0.	455.	0.	1.	146.70
1.06	33.0	487.	1550.	455.	805.	5100.	147.76
0.94	38.0	485.	1542.	455.	718.	5097.	148.70
0.47	43.0	488.	1552.	455.	654.	5110.	149.17
0.50	46.0	487.	1549.	455.	620.	5098.	149.67
0.41	48.0	485.	1541.	455.	596.	5049.	150.08
3.29	50.0	36.	0.	455.	0.	1.	153.37
1.20	49.0	484.	1537.	455.	584.	5018.	154.57
1.23	48.0	485.	1542.	455.	596.	5051.	155.80
0.51	48.0	485.	1542.	455.	596.	5050.	156.31
0.95	50.0	36.	0.	455.	0.	1.	157.26
1.33	40.0	36.	0.	455.	0.	1.	158.59
1.42	29.0	489.	1557.	455.	895.	5100.	160.01
0.61	29.0	468.	1485.	455.	860.	4862.	160.62
1.01	29.0	489.	1555.	455.	894.	5092.	161.63
1.05	28.0	494.	1575.	455.	930.	5155.	162.68
2.25	28.0	414.	1299.	455.	794.	4253.	164.93
16.92	26.0	503.	1604.	455.	997.	5199.	181.85
0.	22.0	36.	0.	455.	0.	1.	181.85
0.51	23.0	513.	1640.	455.	1109.	5204.	182.36
0.30	25.0	509.	1625.	455.	1034.	5218.	182.66
0.33	28.0	494.	1574.	455.	930.	5153.	182.99
0.35	31.0	489.	1555.	455.	847.	5100.	183.34
0.38	34.0	489.	1555.	455.	787.	5110.	183.72
0.40	37.0	486.	1545.	455.	734.	5098.	184.12

PRINTS TO

MADE BY RJ Hopkins 4/2/79

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APPROVALS

LO DIV OR DEPT.

ERIE LOCATION

FF-803-WB (5-78)
PRINTED IN U.S.A.

LO

CODE IDENT NO

GENERAL ELECTRIC

41A303522

CONT ON SHEET 5 SH NO. 4

REV NO.

TITLE

TRANSFORMER DUTY CYCLE

CONT ON SHEET SH NO.

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

0.11	39.0	483.	1535.	455.	702.	5076.	184.23
5.08	40.0	36.	0.	455.	0.	1.	189.31
1.50	40.0	36.	0.	455.	0.	1.	190.81
1.05	39.0	482.	1533.	455.	701.	5070.	191.86
1.20	39.0	482.	1534.	455.	701.	5072.	193.06
0.04	39.0	482.	1533.	455.	701.	5071.	193.10
0.56	40.0	36.	0.	455.	0.	1.	193.66
3.45	40.0	36.	0.	455.	0.	1.	197.11
1.20	40.0	36.	0.	455.	0.	1.	198.31
0.75	40.0	122.	296.	455.	254.	977.	199.06
0.45	40.0	122.	296.	455.	254.	977.	199.51
0.90	40.0	407.	1275.	455.	596.	4213.	200.41
3.45	40.0	36.	0.	455.	0.	1.	203.86
10.61	31.0	495.	1576.	455.	856.	5168.	214.47
2.67	26.0	502.	1600.	455.	995.	5186.	217.14
2.85	27.0	498.	1587.	455.	962.	5176.	219.99
2.84	24.0	510.	1629.	455.	1070.	5212.	222.83
6.45	23.0	513.	1639.	455.	1108.	5202.	229.28
0.30	24.0	512.	1634.	455.	1073.	5228.	229.58
0.32	27.0	500.	1594.	455.	966.	5201.	229.90
0.35	30.0	494.	1573.	455.	876.	5138.	230.25
0.37	33.0	488.	1552.	455.	806.	5105.	230.62
0.40	36.0	488.	1551.	455.	751.	5103.	231.02
0.34	38.0	484.	1539.	455.	718.	5089.	231.36
1.04	40.0	36.	0.	455.	0.	1.	232.40
2.55	40.0	220.	631.	455.	371.	2086.	234.95
2.47	36.0	487.	1551.	455.	750.	5101.	237.42
0.38	34.0	489.	1555.	455.	787.	5110.	237.80
0.40	37.0	486.	1545.	455.	734.	5098.	238.20
0.11	39.0	483.	1535.	455.	702.	5076.	238.31
5.18	40.0	36.	0.	455.	0.	1.	243.49
9.35	31.0	494.	1574.	455.	856.	5163.	252.84
1.82	26.0	503.	1605.	455.	998.	5203.	254.66
0.34	30.0	494.	1573.	455.	876.	5138.	255.00
0.20	32.0	488.	1553.	455.	826.	5105.	255.20
0.22	31.0	36.	0.	455.	0.	1.	255.42
8.40	30.0	36.	0.	455.	0.	1.	263.82
1.60	30.0	321.	978.	455.	601.	3194.	265.42
2.00	15.0	36.	0.	455.	0.	1.	267.42
1.00	1.0	36.	0.	455.	0.	1.	268.42
3.23	5.0	248.	728.	455.	1702.	1832.	271.65
0.54	11.0	374.	1161.	455.	1462.	3406.	272.19
0.49	12.0	397.	1241.	455.	1456.	3699.	272.68
5.00	16.0	479.	1523.	455.	1391.	4687.	277.68
1.56	22.0	523.	1672.	455.	1160.	5245.	279.24
4.77	29.0	493.	1571.	455.	902.	5144.	284.01
3.57	27.0	499.	1589.	455.	964.	5184.	287.58
3.39	19.0	516.	1650.	455.	1285.	5089.	290.97
3.68	22.0	518.	1656.	455.	1151.	5195.	294.65
2.00	31.0	491.	1562.	455.	850.	5122.	296.71

PRINTS TO

MADE BY RJ Hopkins 4/2/79

ISSUED

APPROVALS

LO DIV OR DEPT.

ERIE LOCATION

41A303522

CONT ON SHEET 5 SH NO. 4

FF-803-WB (5-78)
PRINTED IN U.S.A.

LO

CODE IDENT NO

REV NO.

CONT ON SHEET SH NO.

TITLE

TRANSFORMER DUTY CYCLE

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

Ø.63	37.Ø	486.	1544.	455.	734.	5Ø96.	297.34
Ø.15	39.Ø	483.	1536.	455.	7Ø2.	5Ø79.	297.49
3.19	39.Ø	483.	1535.	455.	7Ø2.	5Ø78.	3ØØ.68
2.9Ø	37.Ø	486.	1544.	455.	734.	5Ø96.	3Ø3.58
1.73	34.Ø	488.	1551.	455.	785.	5Ø95.	3Ø5.31
Ø.69	34.Ø	488.	1551.	455.	785.	5Ø96.	3Ø6.ØØ
Ø.33	35.Ø	489.	1555.	455.	767.	5Ø93.	3Ø6.33
1.74	37.Ø	485.	1544.	455.	734.	5Ø95.	3Ø8.Ø7
1.63	37.Ø	486.	1545.	455.	734.	5Ø97.	3Ø9.7Ø
Ø.52	34.Ø	487.	1551.	455.	785.	5Ø94.	31Ø.22
5.86	33.Ø	487.	1550.	455.	8Ø5.	51ØØ.	316.Ø8
1.22	34.Ø	488.	1552.	455.	785.	5Ø98.	317.3Ø
Ø.67	35.Ø	489.	1555.	455.	767.	5Ø93.	317.97
2.Ø3	41.Ø	486.	1547.	455.	677.	51Ø3.	32Ø.ØØ
Ø.26	46.Ø	487.	1548.	455.	619.	5Ø94.	32Ø.26
1.64	47.Ø	486.	1546.	455.	6Ø8.	5Ø78.	321.9Ø
Ø.37	48.Ø	486.	1546.	455.	597.	5Ø66.	322.27
Ø.51	46.Ø	486.	1546.	455.	619.	5Ø88.	322.78
2.68	4Ø.Ø	485.	1543.	455.	69Ø.	5Ø99.	325.46
3.57	33.Ø	488.	1552.	455.	8Ø6.	51Ø6.	329.Ø3
Ø.37	32.Ø	488.	1552.	455.	826.	51Ø4.	329.4Ø
1.46	32.Ø	488.	1553.	455.	826.	51Ø5.	33Ø.86
1.Ø7	33.Ø	487.	1551.	455.	8Ø5.	51Ø1.	331.93
3.67	41.Ø	486.	1544.	455.	676.	5Ø93.	335.6Ø
Ø.14	49.Ø	484.	1539.	455.	584.	5Ø23.	335.74
1.54	5Ø.Ø	36.	Ø.	455.	Ø.	1.	337.28
1.93	49.Ø	484.	1539.	455.	584.	5Ø23.	339.21
Ø.24	49.Ø	485.	1541.	455.	585.	5Ø3Ø.	339.45
Ø.73	49.Ø	485.	1542.	455.	585.	5Ø33.	34Ø.18
Ø.24	49.Ø	485.	1542.	455.	585.	5Ø35.	34Ø.42
1.58	49.Ø	485.	1544.	455.	586.	5Ø39.	342.ØØ
1.34	49.Ø	486.	1545.	455.	586.	5Ø44.	343.34
1.96	45.Ø	486.	1547.	455.	63Ø.	5Ø96.	345.3Ø
Ø.14	42.Ø	488.	1554.	455.	665.	51Ø7.	345.44
Ø.28	42.Ø	488.	1552.	455.	665.	51Ø2.	345.72
1.97	39.Ø	485.	1542.	455.	7Ø4.	5Ø99.	347.69
Ø.	37.Ø	36.	Ø.	455.	Ø.	1.	347.69
Ø.16	37.Ø	486.	1545.	455.	734.	5Ø97.	347.85
Ø.72	39.Ø	485.	1542.	455.	7Ø4.	51ØØ.	348.57
Ø.81	42.Ø	488.	1554.	455.	665.	51Ø7.	349.38
Ø.92	45.Ø	487.	1549.	455.	631.	51Ø4.	35Ø.3Ø
Ø.99	48.Ø	485.	1543.	455.	596.	5Ø55.	351.29
Ø.31	5Ø.Ø	36.	Ø.	455.	Ø.	1.	351.6Ø
2.67	3Ø.Ø	36.	Ø.	455.	Ø.	1.	354.27
Ø.6Ø	1Ø.Ø	36.	Ø.	455.	Ø.	1.	354.87
8.67	1Ø.Ø	167.	45Ø.	455.	698.	1292.	363.54
Ø.	Ø.	36.	Ø.	455.	Ø.	5.	363.54

PRINTS TO

MADE BY RJ Hopkins 4/2/79

ISSUED

APPROVALS

LO DIV OR DEPT.

ERIE LOCATION

FF-803-WB (5-78)
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LO

CODE IDENT NO

DUTY CYCLE 2

WINDING	VOLTAGE	RMS CURRENT
Primary = H_1-H2	25,000	189
and H_3-H_4 in series		
X_1-X_2 and X_3-X_4	1,818	1,201
X_5-X_6	1,000	400

REV NO.

TITLE

TRANSFORMER DUTY CYCLE

CONT ON SHEET SH NO.

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

DELTA TIME (MIN)	SPEED (MPH)	CURRENT (AMPS) PRIM	SECOND WDG.	AUX. WDG.	TRACT MOTOR	RAIL POWER (HP)	TOTAL TIME (MIN)
0.25	1.0	89.	501.	400.	2407.	533.	0.25
0.25	4.0	104.	605.	400.	1781.	1540.	0.50
0.27	7.0	131.	791.	400.	1635.	2453.	0.77
0.28	10.0	159.	985.	400.	1538.	3275.	1.05
0.29	13.0	182.	1144.	400.	1456.	4007.	1.34
0.30	16.0	205.	1299.	400.	1381.	4648.	1.64
0.32	19.0	224.	1427.	400.	1286.	5092.	1.96
0.36	22.0	228.	1459.	400.	1157.	5228.	2.32
0.13	24.0	224.	1430.	400.	1069.	5207.	2.45
3.01	25.0	16.	0.	400.	0.	1.	5.46
6.24	25.0	112.	662.	400.	559.	2413.	11.70
0.28	26.0	222.	1415.	400.	999.	5212.	11.98
0.20	29.0	216.	1375.	400.	900.	5130.	12.18
3.76	30.0	16.	0.	400.	0.	1.	15.94
2.96	30.0	214.	1364.	400.	867.	5079.	18.90
1.14	31.0	214.	1364.	400.	847.	5099.	20.04
2.22	34.0	214.	1362.	400.	786.	5102.	22.26
1.30	36.0	214.	1360.	400.	750.	5098.	23.56
1.80	33.0	214.	1362.	400.	806.	5106.	25.36
0.95	31.0	214.	1363.	400.	847.	5098.	26.31
0.66	33.0	214.	1361.	400.	806.	5105.	26.97
0.74	36.0	214.	1360.	400.	750.	5098.	27.71
0.50	39.0	212.	1349.	400.	703.	5085.	28.21
1.73	40.0	16.	0.	400.	0.	1.	29.94
0.76	39.0	212.	1347.	400.	702.	5078.	30.70
0.25	39.0	212.	1347.	400.	702.	5078.	30.95
1.25	40.0	16.	0.	400.	0.	1.	32.20
1.55	38.0	212.	1350.	400.	718.	5089.	33.75
1.27	37.0	213.	1355.	400.	734.	5097.	35.02
3.33	38.0	150.	921.	400.	537.	3472.	38.35
1.35	39.0	212.	1345.	400.	701.	5070.	39.70
3.47	39.0	212.	1346.	400.	701.	5074.	43.17
2.09	37.0	213.	1354.	400.	734.	5095.	45.26
1.18	35.0	214.	1364.	400.	766.	5091.	46.44
0.65	36.0	214.	1360.	400.	750.	5099.	47.09
0.45	38.0	212.	1350.	400.	717.	5087.	47.54
1.67	40.0	16.	0.	400.	0.	1.	49.21
2.56	39.0	212.	1345.	400.	701.	5071.	51.77
0.75	39.0	164.	1014.	400.	566.	3825.	52.52
0.60	40.0	147.	897.	400.	508.	3381.	53.12
2.10	39.0	212.	1345.	400.	701.	5071.	55.22
2.25	39.0	116.	685.	400.	431.	2583.	57.47
1.05	40.0	16.	0.	400.	0.	1.	58.52
2.78	35.0	215.	1367.	400.	768.	5102.	61.30
2.24	33.0	214.	1360.	400.	805.	5101.	63.54

PRINTS TO

MADE BY RG Hopkins 4/2/79

ISSUED

APPROVALS

LO DIV OR DEPT.

ERIE LOCATION

41A303522

CONT ON SHEET 8 SH NO. 7

TITLE

TRANSFORMER DUTY CYCLE

CONT ON SHEET SH NO.

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

1.51	35.0	214.	1364.	400.	766.	5091.	65.05
1.07	34.0	214.	1364.	400.	787.	5110.	66.12
1.11	31.0	214.	1364.	400.	847.	5100.	67.23
0.20	29.0	16.	0.	400.	0.	1.	67.43
0.50	23.0	16.	0.	400.	0.	1.	67.93
0.60	20.0	89.	499.	400.	523.	1761.	68.53
6.30	20.0	203.	1285.	400.	1111.	4536.	74.83
2.40	20.0	89.	499.	400.	523.	1761.	77.23
6.90	20.0	203.	1285.	400.	1111.	4536.	84.13
4.50	20.0	203.	1285.	400.	1111.	4536.	88.63
0.30	20.0	89.	499.	400.	523.	1761.	88.93
0.83	21.0	233.	1489.	400.	1212.	5262.	89.76
15.87	22.0	227.	1451.	400.	1151.	5199.	105.63
11.19	22.0	227.	1450.	400.	1151.	5198.	116.82
1.22	24.0	225.	1435.	400.	1072.	5225.	118.04
15.39	24.0	224.	1431.	400.	1070.	5208.	133.43
4.17	33.0	215.	1368.	400.	809.	5130.	137.60
0.91	45.0	210.	1333.	400.	631.	5106.	138.51
1.05	48.0	205.	1302.	400.	597.	5060.	139.56
0.04	49.0	203.	1287.	400.	584.	5018.	139.60
1.12	50.0	16.	0.	400.	0.	1.	140.72
0.73	49.0	204.	1290.	400.	585.	5033.	141.45
4.52	40.0	213.	1353.	400.	690.	5099.	145.97
0.73	32.0	214.	1362.	400.	826.	5105.	146.70
0.	33.0	16.	0.	400.	0.	1.	146.70
1.06	33.0	214.	1360.	400.	805.	5100.	147.76
0.94	38.0	213.	1352.	400.	718.	5097.	148.70
0.47	43.0	213.	1352.	400.	654.	5110.	149.17
0.50	46.0	208.	1323.	400.	620.	5098.	149.67
0.41	48.0	205.	1299.	400.	596.	5049.	150.08
3.29	50.0	16.	0.	400.	0.	1.	153.37
1.20	49.0	203.	1287.	400.	584.	5018.	154.57
1.23	48.0	205.	1299.	400.	596.	5051.	155.80
0.51	48.0	205.	1299.	400.	596.	5050.	156.31
0.95	50.0	16.	0.	400.	0.	1.	157.26
1.33	40.0	16.	0.	400.	0.	1.	158.59
1.42	29.0	215.	1367.	400.	895.	5100.	160.01
0.61	29.0	206.	1303.	400.	860.	4862.	160.62
1.01	29.0	215.	1365.	400.	894.	5092.	161.63
1.05	28.0	217.	1384.	400.	930.	5155.	162.68
2.25	28.0	182.	1141.	400.	794.	4253.	164.93
16.92	26.0	221.	1411.	400.	997.	5199.	181.85
0.	22.0	16.	0.	400.	0.	1.	181.85
0.51	23.0	225.	1438.	400.	1109.	5204.	182.36
0.30	25.0	224.	1431.	400.	1034.	5218.	182.66
0.33	28.0	217.	1383.	400.	930.	5153.	182.99
0.35	31.0	214.	1364.	400.	847.	5100.	183.34
0.38	34.0	214.	1364.	400.	787.	5110.	183.72
0.40	37.0	213.	1355.	400.	734.	5098.	184.12

PRINTS TO

TITLE

TRANSFORMER DUTY CYCLE

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

0.11	39.0	212.	1346.	400.	702.	5076.	184.23
5.08	40.0	16.	0.	400.	0.	1.	189.31
1.50	40.0	16.	0.	400.	0.	1.	190.81
1.05	39.0	212.	1345.	400.	701.	5070.	191.86
1.20	39.0	212.	1345.	400.	701.	5072.	193.06
0.04	39.0	212.	1345.	400.	701.	5071.	193.10
0.56	40.0	16.	0.	400.	0.	1.	193.66
3.45	40.0	16.	0.	400.	0.	1.	197.11
1.20	40.0	16.	0.	400.	0.	1.	198.31
0.75	40.0	54.	259.	400.	254.	977.	199.06
0.45	40.0	54.	259.	400.	254.	977.	199.51
0.90	40.0	179.	1118.	400.	596.	4213.	200.41
3.45	40.0	16.	0.	400.	0.	1.	203.86
10.61	31.0	217.	1382.	400.	856.	5168.	214.47
2.67	26.0	221.	1408.	400.	995.	5186.	217.14
2.85	27.0	219.	1395.	400.	962.	5176.	219.99
2.84	24.0	224.	1432.	400.	1070.	5212.	222.83
6.45	23.0	225.	1437.	400.	1108.	5202.	229.28
0.30	24.0	225.	1436.	400.	1073.	5228.	229.58
0.32	27.0	220.	1402.	400.	966.	5201.	229.90
0.35	30.0	217.	1380.	400.	876.	5138.	230.25
0.37	33.0	214.	1361.	400.	806.	5105.	230.62
0.40	36.0	214.	1361.	400.	751.	5103.	231.02
0.34	38.0	212.	1350.	400.	718.	5089.	231.36
1.04	40.0	16.	0.	400.	0.	1.	232.40
2.55	40.0	97.	554.	400.	371.	2086.	234.95
2.47	36.0	214.	1360.	400.	750.	5101.	237.42
0.38	34.0	214.	1364.	400.	787.	5110.	237.80
0.40	37.0	213.	1355.	400.	734.	5098.	238.20
0.11	39.0	212.	1346.	400.	702.	5076.	238.31
5.18	40.0	16.	0.	400.	0.	1.	243.49
9.35	31.0	217.	1381.	400.	856.	5163.	252.84
1.82	26.0	221.	1412.	400.	998.	5203.	254.66
0.34	30.0	217.	1380.	400.	876.	5138.	255.00
0.20	32.0	214.	1362.	400.	826.	5105.	255.20
0.22	31.0	16.	0.	400.	0.	1.	255.42
8.40	30.0	16.	0.	400.	0.	1.	263.82
1.60	30.0	141.	858.	400.	601.	3194.	265.42
2.00	15.0	16.	0.	400.	0.	1.	267.42
1.00	1.0	16.	0.	400.	0.	1.	268.42
3.23	5.0	112.	657.	400.	1702.	1832.	271.65
0.54	11.0	162.	1002.	400.	1462.	3406.	272.19
0.49	12.0	172.	1070.	400.	1456.	3699.	272.68
5.00	16.0	207.	1310.	400.	1391.	4687.	277.68
1.56	22.0	229.	1463.	400.	1160.	5245.	279.24
4.77	29.0	217.	1379.	400.	902.	5144.	284.01
3.57	27.0	219.	1397.	400.	964.	5184.	287.58
3.39	19.0	223.	1427.	400.	1285.	5089.	290.97
3.68	22.0	227.	1450.	400.	1151.	5195.	294.65
2.06	31.0	215.	1370.	400.	850.	5122.	296.71

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TRANSFORMER DUTY CYCLE

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

0.63	37.0	213.	1355.	400.	734.	5096.	297.34
0.15	39.0	212.	1347.	400.	702.	5079.	297.49
3.19	39.0	212.	1347.	400.	702.	5078.	300.68
2.90	37.0	213.	1355.	400.	734.	5096.	303.58
1.73	34.0	214.	1361.	400.	785.	5095.	305.31
0.69	34.0	214.	1361.	400.	785.	5096.	306.00
0.33	35.0	214.	1364.	400.	767.	5093.	306.33
1.74	37.0	213.	1354.	400.	734.	5095.	308.07
1.63	37.0	213.	1355.	400.	734.	5097.	309.70
0.52	34.0	214.	1360.	400.	785.	5094.	310.22
5.86	33.0	214.	1360.	400.	805.	5100.	316.08
1.22	34.0	214.	1361.	400.	785.	5098.	317.30
0.67	35.0	214.	1364.	400.	767.	5093.	317.97
2.03	41.0	213.	1357.	400.	677.	5103.	320.00
0.26	46.0	208.	1322.	400.	619.	5094.	320.26
1.64	47.0	207.	1311.	400.	608.	5078.	321.90
0.37	48.0	206.	1303.	400.	597.	5066.	322.27
0.51	46.0	208.	1320.	400.	619.	5088.	322.78
2.68	40.0	213.	1353.	400.	690.	5099.	325.46
3.57	33.0	214.	1362.	400.	806.	5106.	329.03
0.37	32.0	214.	1362.	400.	826.	5104.	329.40
1.46	32.0	214.	1362.	400.	826.	5105.	330.86
1.07	33.0	214.	1360.	400.	805.	5101.	331.93
3.67	41.0	213.	1355.	400.	676.	5093.	335.60
0.14	49.0	203.	1288.	400.	584.	5023.	335.74
1.54	50.0	16.	0.	400.	0.	1.	337.28
1.93	49.0	203.	1288.	400.	584.	5023.	339.21
0.24	49.0	204.	1290.	400.	585.	5030.	339.45
0.73	49.0	204.	1290.	400.	585.	5033.	340.18
0.24	49.0	204.	1291.	400.	585.	5035.	340.42
1.58	49.0	204.	1292.	400.	586.	5039.	342.00
1.34	49.0	204.	1293.	400.	586.	5044.	343.34
1.96	45.0	209.	1330.	400.	630.	5096.	345.30
0.14	42.0	214.	1363.	400.	665.	5107.	345.44
0.28	42.0	214.	1362.	400.	665.	5102.	345.72
1.97	39.0	213.	1352.	400.	704.	5099.	347.69
0.	37.0	16.	0.	400.	0.	1.	347.69
0.16	37.0	213.	1355.	400.	734.	5097.	347.85
0.72	39.0	213.	1353.	400.	704.	5100.	348.57
0.81	42.0	214.	1363.	400.	665.	5107.	349.38
0.92	45.0	210.	1332.	400.	631.	5104.	350.30
0.99	48.0	205.	1300.	400.	596.	5055.	351.29
0.31	50.0	16.	0.	400.	0.	1.	351.60
2.67	30.0	16.	0.	400.	0.	1.	354.27
0.60	10.0	16.	0.	400.	0.	1.	354.87
8.67	10.0	73.	389.	400.	698.	1292.	363.54
0.	0.	16.	0.	400.	0.	5.	363.54

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TRANSFORMER SPECIFICATION FOR MULTIPLE VOLTAGE/FREQUENCY LOCOMOTIVE WITH CHOPPER

FIRST MADE FOR CONTRACT # DOT-FR-9027 (CONRAIL E60)

REVISIONS

This specification covers transformer equipment for a locomotive wherein a nominal 11Kv 25Hz, 25Kv 60Hz, 12-1/2 Kv 60 Hz single phase power is converted to 1800 volts dc for driving six traction motors.

The transformer equipment is to include:

1 - Single phase, silicon coolant immersed, forced air cooled outdoor type locomotive transformer having a two winding primary with switching for a 2/1 voltage change, two propulsion power secondary windings plus one auxiliary winding.

1 - Pump: 240 volt 60 Hz
212 volt 25 Hz

1 - Pump motor capacitor(s)

1 - Indicating thermometer

1 - High voltage bushing C.T. (for relaying only)

Note: Secondary CT's will be applied by locomotive builder.

1 - Overtemperature trip

1 - AWR type relay - primary winding

1 - Pressure relief device plus indicator

1 - Spare thermostat tap block

1 - Sight glass oil level indicator

1 - Top oil sampling valve

1 - Drain valve with sampler

1 - Filter press valve

1 - Terminal board(s) for all customer connections

2 - Shutoff valves for transformer pump removal without draining transformer

1 - Pump motor rotation sight glass

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I. ELECTRICAL REQUIREMENTS

1. Power Supply

25 Hz ±.25 Hz

Nominal	11 Kv
Maximum 1/2 sec	14 Kv (once per year)
Maximum sustained	13.5 Kv
Minimum sustained	9.5 Kv
One hour	9.0 Kv
1/2 hour	8.25 Kv
1/4 hour	7.5 Kv

60 Hz ±.25 Hz

Nominal	12.5 Kv
Maximum continuous	13.75 Kv
Minimum sustained	9.5 Kv
Emergency minimum	8.75 Kv
Maximum - 5 minutes	14.0 Kv

60 Hz ±.25 Hz

Nominal	25 Kv
Maximum continuous	27.5 Kv
Minimum sustained	19 Kv
Emergency minimum	17.5 Kv
Full performance required to 90% line voltage	
Maximum - 5 minutes	28.0 Kv

Minimum BIL = 150 Kv @ 25 Kv connection
Minimum BIL = 95 Kv @ 11 Kv or 12-1/2 Kv connection

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ELECTRICAL REQUIREMENTS (CONTINUED)

2. Transformer

A. Primary Winding

1. RMS current based on rating at 100% line voltage (25 Kv) and 60 Hz,

I_p = 189 amps

2. RMS current based on rating at 100% line voltage (11 Kv) and 25 Hz,

I_p = 432 amps

3. This rating is based on a duty cycle from Enola, Pennsylvania to Waverly, New Jersey hauling a 8560 ton train. The duty cycle is documented on drawing 41A303522.

4. A 9L11PGA018 lightning arrestor (GE Tranquell) will be connected as shown for the 11 and 12-1/2 Kv connection. Two of these units in series will be connected for 25 Kv. Supplied by locomotive builder.

5. Magnetizing inrush current allowable when vacuum breaker is closed is as follows:

LINE VOLTAGE	ALLOWABLE PEAK CURRENT
11 Kv, 25 HZ	3500
13.5 Kv, 25 HZ	3900
27.5 Kv, 60 HZ	Less Than 2000

6. The transformer must have the ability to withstand repeated inrush currents from the following sources.

Impedance of J1.0 ohms at 11 Kv and 25 HZ.

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Impedance of J1.25 ohms at 25 Kv and 60 Hz.
Due to the introductions of phase breaks, on 60 Hz only, approximately 12,000 energizations per year can be expected.

B. Secondary Windings

1. Two secondary windings will be provided for the traction circuits and one for the auxiliary power.

2. Transformer secondary voltages and impedances are based on published performance @ 90% line voltage 60 Hz, and 100% line voltage 25 Hz. RMS current ratings are based on 100% line voltage in both cases.

PRIMARY VOLT/FREQ	WINDING		LEAKAGE IMPEDANCE PRIMARY-SECONDARY REFERRED TO SECONDARY	O.C. RMS VOLTAGE	RMS CURRENT
	X_1 X_2		0.12 OHMS	1818 V	1201a
	X_3 X_4		0.12 OHMS	1818 V	1201a
25KV, 60Hz	X_5 X_6		as required	1000 V	400a
	H_1 H_2 H_3 H_4 Series		----	25 Kv	189a
	X_1 X_2		0.05 OHMS	1600 V	1373a
	X_3 X_4		0.05 OHMS	1600 V	1373a
11Kv, 25Hz	H_1 H_2	Parallel	----	11Kv	432a
	H_3 H_4				

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3. Windings X_1, X_2, X_3, and X_4, should be matched within 5% reactance and be capable of being connected directly in parallel if desired. An interwound secondary winding is not requested to meet this specification.

4. For certain applications the X_1, X_2, X_3, and X_4 windings will be paralleled to give a single winding secondary. This will be done by the locomotive builders. Load sharing between the two windings must be within the limits established by the differences in impedance. External sharing reactors or resistance are not permitted.

5. Zero impedance faults can occur on the secondary windings. The transformer should be designed using the latest state of the art design practices so that such faults cause minimal/no degradation or damage.

   In calculating fault currents, a minimum system reactance given in 2A6, and a maximum 3-cycle (.050 Sec.) breaker opening line should be used. Over the life of the transformer two (2) such faults should be assumed. Assuming a locomotive breaker failure once in the life of the transformer a clearing time of .16 Sec should be considered.

C. Auxiliary Load (Loads below are typical but not limited to these)

1. X5 - X6 will supply a regulated power supply for one 200 horsepower blower drive motor.

2. X5 - X6 will also supply a dry type isolation transformer for a 53 hp compressor drive motor and regulated supply.

3. For this order, maximum inrush current for dc motor starting is regulated to 150% of running current.

4. The same auxiliary transformer will have a 240V winding for the transformer oil pump, battery charger, and miscellaneous control.

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D. High Voltage Bushing Current Transformer

1. One high voltage bushing current transformer is required as follows: (mounted inside tank) intended for protective relaying

   Ratio required: 240/200/160 to 1 (5 amp secondary)
   Total burden of CT - .140 ohms (P.F. 1.0)
   0.5% accuracy to 2000 amps (primary)
   10% accuracy required above 2000 amps up to maximum fault current possible due to bolted fault on secondary winding.

E. Low Voltage Current Transformers (supplied and mounted by Locomotive Operations)

1. Two CT's one each on windings X1 - X4 2000:5 ratio externally mounted. Each to operate an instantaneous trip relay coil ohms = .0026. (GE 752X20G8)

2. One CT on auxiliary winding X5 - X6 1500:5 ratio externally mounted (GE 752X20G7).

3. A ground block should be welded to the outside of the transformer tank near the low voltage bushing and a copper connection strap (removable) connected between the two, capable of handling full primary amperes.

F. High voltage switching of the primary winding is to be furnished to allow 12-1/2 Kv, 60 Hz, or 25 Kv, 60 Hz operation. No switching is to be done between 11 Kv, 25 Hz, and 12-1/2 Kv, 60 Hz. The transfer switch is to be located inside the transformer tank with a rotating operating shaft extending through. Transfer will be made only with transformer de-energized, with the external operating mechanism furnished by the locomotive builder. It is estimated that the switch will see not more than 2000 operations (or 1000 hi-lo cycles) per year. The tap changer should be identical to the one used on the AMTRAK E60C Locomotives. The external tap change operating mechanism will be furnished by Locomotive Operations and will be the same as that used on the AMTRAK E60CP Locomotives.

G. An auxiliary high voltage bushing shall be provided to bring out the center tap of the primary winding. This point will be connected to the mid-point of the two lightning arrestors so that external shorting of one arrestor on 11/12.5 Kv is not required.

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II. ELECTRICAL DESIGN

1. Reactance Design

A. Reactance specified is nominal figure and is subject to negotiation between builder and user. Once agreed upon in a final issue of this specification variations of not more than 3% between transformers is allowed.

B. It is desired that the coupling between secondary windings be as low as possible. Short circuit reactance primary to secondary should be equal for each winding alone. Ideally a separate parallel primary winding for each secondary would provide the optimum isolation, this winding arrangement however, should not be used if it incurs a significant cost penalty.

2. Winding Temperature Rise

A. Transformer primary winding will be excited 24 hours per day. The secondary may be in use at least 16 hours per day. It is estimated that there would be 500 trips/year.

B. The maximum admissible winding temperatures is 145°C. Required minimum transformer life is 30 years. Transformer builder will supply thermal time constant data for evaluation of instantaneous winding temperatures.

3. The primary winding is protected by a high voltage vacuum circuit breaker. It is also used as a line switch to deenergize the locomotive but at no main load. The 50 hp auxiliary load is present when the circuit breaker opens.

   Tripping to clear a fault is initiated by one of the transformer CT's operating a Type 12PJC14D3 instantaneous trip relay, in turn signalling the vacuum breaker to open. Normally three cycle 60 Hz interruption or better is expected.

4. Winding Capacitance

The bidder shall furnish Locomotive Operations with an interwinding capacitance model of the transformer. This is necessary to properly design the power electronics tied to the transformer secondaries.

III. MECHANICAL REQUIREMENTS

1. Cooling System

A. Transformer will be cooled by means of a recirculating cooling system using a liquid silicone to air heat exchanger.

B. Liquid coolant to be circulated by a pump driven by a capacitor start and run motor. The motor to be designed in accordance with American Standard for Rotating Electrical Machinery on Railway Locomotive and Rail Cars C35.1-1943 (IEEE #11-176 and 11-177). Hipot with 1500V to ground for 1 minute. The supply voltage for this pump will be

240 V 60 Hz @ 12-1/2 Kv, 25 Kv

or

212 V 25 Hz @ 11 Kv

Voltage variations for starting will correspond to those given for the primary input voltage.

Circuit breaker and switching between power supplies for the pump motor(s) to be provided by the locomotive builder.

The bidder shall furnish Locomotive Operations with estimated values of pump motor currents for both starting and running conditions for all combinations of power supply voltage and frequency including the lowest voltage conditon described on Sheet No. 9.

The pump must be capable of running but not starting @ 60 Hz with a minimum line voltage = 120 and at 25 Hz of 110 volts.

The pump motor(s) shall be capable of operation with degradation when the voltage supply contains approximately the following harmonics:

22%	3rd	
12%	5th	Others less than 1%
1%	75h	

Direction of rotation of the motor must be marked so that rotation can be checked with motor installed in place in transformer with electrical connections complete before cover is applied. A sight glass permitting observation of motor rotation shall be provided.

Pump inlet and exit is to be provided with shut off valves so the pump can be removed without draining the transformer. In addition, a vent at the highest point (pipe plug satisfactory) so the replacement unit can be filled without introducing air into the core. A method of sealing the valve handles in the open position must be provided. A drain plug should also be provided at the lowest point of the pump assembly to facilitate pump replacement. If this requirement causes the overall transformer to exceed that of 579E257 outline, agreement with the locomotive builder to waive this section should be reached.

C. The design shall be based on the following temperature environment:

Variations of ambient temperature are taken from AIEE No. 1 December, 1962, introduction to AIEE standards, General Principles Upon Which Temperature Limits are Based in the Rating of Electrical Equipment which represents weather bureau data over a fifty year period. Ambient temperature is for the worst case at either Pittsburgh or Philadelphia and is taken from Page 15, Table 1 of indicated reference.

Annual Average (T_1)	12°C
Average Yearly Variation (T_2)	24°C
Average Daily Variation (T_3)	10°C
Absolute Maximum (T_4)	41°C
Absolute Minimum (T_5)	-29°C

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Average hours the temperature exceeds a certain reference temperature taken from Page 16, Table II.

Reference Temperature	30°C	35.5°C	41.1°C
Average Hours Per Year	263	10	0
Average Percent of Year	3	0.1	0

D. Approximately 6000 CFM @ 5.6" of water @ .0744 #/ft^3 will be available for forced air cooling of the heat exchanger. Cooling air for heat exchanger will enter the bottom of the transformer from a longitudinal air duct underneath the locomotive floor. Cooling air will be 7°C warmer than ambient.

E. An indicating thermometer will be provided by the bidder to indicate coolant temperature in degrees centigrade.

F. An AWR type relay shall be provided by the bidder to indicate that the windings are approaching maximum temperature. It shall be similar to that supplied on the transformer for Taiwan per 41A241587. The relay shall have normally open contacts rating 1 amp at 75 volts dc.

G. Provision should be made for calibration of the transformer cooler so that air flow can be readily verified on the locomotive. It is suggested that a pressure tap be located on the cooler duct between the air inlet and heat exchanger. This can be accomplished by drilling a hole with a #64 drill through the cooler duct, polishing off all burrs on both sides and then brazing 1/4" pipe coupling centered on the hole. A manometer is connected to record static pressure at known flow.

H. Cooling air will be filtered by an inertial type filter but fine dust (10 micron and below) will still pass. A fouling factor of 10% (that is K = 90%) should be allowed before cleaning is required.

REVISIONS

1 5/30/79 R. J. Hopkins

2. Weight

Weight is not a consideration, and no premium for lightweight is allowed.

The total weight expected is approximately 36,000 lbs. Transformer builder must confirm.

3. Outline Dimensions

The transformer must fit within the overall outline dimensions as shown on 41D724021.

Exact locations of the high and low voltage bushings, etc., will be determined during Phase 1 design.

4. High Voltage Bushings

The high voltage bushing should be gray color. Bushing should be supplied with 4 brass locking nuts for buss connection.

5. Accessories

A. Pressure relief switch and indicating flag must be protected against accidental damage by people working on roof.

B. Temperature protective switch must be sealed in such a manner that condensation does not occur in the well.

C. Temperature gage and AWR relay should be mounted so they do not form a head bumping hazard.

2023

PRINTS TO

6. Preferred winding sequence on the low voltage taps will consist of a horizontal row near the top side facing LV face. Sequence can be negotiated but X_1 X_2 X_5 X_6 X_3 X_4 is preferred.

7. Control wiring to the primary CT, AWR relay, the overtemperature switch, and pressure relief switch, should terminate in a common junction box on terminal studs (not loose wires).

8. Low voltage studs should terminate in a flat horizontal surface suitable for bus bar bolting on 4" wide bar with two bolts 1/2" diameter spaced 2" apart 1" from edge of bar. Line of bolt holes should be perpendicular to face of transformer. Studs must be not closer than 4-1/2" with 1-1/2" stagger, or 6-5/8" with no stagger. The external portion of the low voltage studs shall be tin or zinc plated to inhibit corrosion.

   These terminations are identical as to dimensions (but not as to location on the transformer tank) to 3903E532 as supplied on Requisition 463-132670P.

IV. MECHANICAL DESIGN

1. Wreck Damage

Mounting must be secure so that the locomotive may be rolled on its side and then returned to vertical without damage to the transformer due to internal movement of the core and coils or excessive stress on the mounting feet. A 2G load while the locomotive comes to rest in the horizontal position should be allowed for.

2. Shock

A. The assembly must be designed for the following forces but no test is required:

Coupling shocks	2-1/2 G
Horizontal (transverse shock)	1.5G
Vertical Shock	1.5G
Pitch of locomotive	1-1/4° Max
Roll of locomotive	7° Max
Max sustained deceleration	1.5 mph/sec
Max peak acceleration/deceleration	5.0 mph/sec

B. 10,000 applications of the shocks specified in 2.A shall not result in damage to or malfunction of the equipment.

C. 1,000,000 applications at 0.5G peak and 0.010 second base in any direction shall not result in damage to or malfunction of the equipment.

D. 15 times in each of 3 orthogonal planes with 10G's at longest pulse available on test machine (0.150 sec. minimum) with no failure of any part.

2.5 Vibration (Design only, no test required)

A. No malfunction or damage shall result when the equipment is exposed to sinusoidal vibrations in any plane having peak values as described below:

1-30 Hz	3 In/Sec Velocity
30-300 Hz	1.5G Acceleration

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K/K1	BRK. GRID PROTECTION/RECT. CUTOUT	30	
K2/K3	MOTOR CUTOUT	31	
K4/K5	CONSOLE LIGHTS	32	
K6/K7	ALARMS	33	
K8/K9	ALARMS	34	
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REVISIONS	TITLE	MADE BY	APPROVAL		ERIE	
	SCHEMATIC DIAGRAM EGO CHOPPER	S. J. HOPKINS 10/27/79		GENERAL ELECTRIC	PLANT	41B541084
	FIRST MADE FOR CONTRACT # DOT-FR-9027	ISSUED				CONT. ON SH. SH. NO. 1

CONT. ON SH. SH. NO. DEVICE TABLE SECT. A2 | SECT. A3 DEVICE TABLE REV. NO.

SECT. A2 — DEVICE TABLE

SYMBOL	TYPE OR CATALOG NO.	SECTION	FUNCTION	LOC.
AGR	17LV69A3	E,G3	AUXILIARY GROUND RLY.	CC
AGRT	41A303761P1	E	AUXILIARY GRD. TRANSFORMER	CC
AGRCO	41A259608P1	E	AUX. GRD. RLY. CUT-OUT SW.	RC
AT	41A303586P1	E	AUXILIARY TRANSFORMER	CC
ATF	41B561230P1	E	AUX. TRANSF. FUSE	CC
BET	41A281835P1	E2,D3-8	BRAKING EXCITATION TRANSF.	CC
BEC	17CM57B9	H8	BRAKING EXCITATION CONTACTOR	CC
BEF		E3	BRAKING EXCITATION FUSE	CC
BEP1-6		D3-8	BRAKING EXCITATION PANEL	CC
BAS	497A423AAP4	F1	BATTERY SHUNT	NOSE
BAT	DEKA # 823	F1	BATTERY	P
BCR	41B560270P4	K	BRAKING CURRENT RLY	CC
BCRA	41B560270P4	K	AUX. BRK. CURRENT RLY	CC
BCRP	17FM352A3	F	BATT. CHRG. RECT. PANEL	CC
BCX	17EX61A1	F1	BATT. CHRG. SMOOTH. REACT.	CC
BD1	41C662086	D1	BLOCKING DIODE	CC
BFPS		K8	BLOCKED FILTER SWITCH	
BFRS	501A222P18	J	BLOWER RESET SW	RC
BCRA-DM	41B563171G10	K	BCRA DELAY MODULE	CC
BGBM		D1	BRK. GRID BLOW MOTOR	ROOF
BKS1,2	17GP29A1	H3,4	BRAKING SWITCH	CC
BM	5GY64A3	E1	BLOWER MOTOR	RECT
BMPU	41B556073P2	E1	BM MAGNETIC PICKUP	RECT
BMCR	17LS16D14	D1	BRAKING MOTOR CURR. RLY	CC
BMCR1-4	41A271681G2	E1	BLOWER MOTOR CALB. RES.	CC
BOSR	41B560270P4	J	BLOWER OVERSPD RLY	CC
BOVR	17LV66AD22	E1	BLOWER OVERVOLT RLY	CC
BOVRA	41B560270P4	J	AUX BLOW OVERVOLT RLY	CC
BRF	41A243135P1	E	BLOW. RECTIFIER FUSE	CC
BRG	17EM92D	D1	BRAKING RESISTOR GROUP	ROOF
BRR	17LV66AD22	E1	BLOWER RUN RELAY	CC
BRS	41B560270P4	J	BLOWER RESET RELAY	CC
BRSC	41B519095P1	E	BLOW RECT SNUB CAP	CC
BRSR1-3	41A242691P1	E	BLOW RECT SNUB RES	CC

SECT. A3 — DEVICE TABLE

SYMBOL	TYPE OR CATALOG NO.	SECTION	FUNCTION	LOC.
BRSW	501A222P18	K	BRAKING RESET SW	RC
BRSX	41A243787P2	E	BLOWER RECT. REACTOR	CC
BRX	17LV66J10	J	AUX BLOWER RUN RLY	CC
BS	M-9948492G1	F1	BATTERY SWITCH	NOSE
BSW	501A222P8	J	BLOWER START SWITCH	RC
BSX	17EX56A2	E1	BLOWER SMOOTH. REACTOR	ROOF
BTD	17LV66J10	J	BLOW TIME DELAY RLY	CC
BTD-DM	41B563171G10	J	BTD DELAY MODULE	CC
BWR	17LV66AD22	D1	BRAKING WARNING RELAY	CC
BWRR	488A353AH20	D1	BRAKING WARNING RES	CC
BCRA	41B560270P4	K	AUX BRK WARNING RLY	CC
BCRA-DM	41B563171G1	K	BCRA DELAY MODULE	CC
B123, B123A	17CP28K3	H7	BRAKING CONTACTOR	CC
B23, B3, B3A	17CP2BK3	H8	BRAKING CONTACTOR	CC
B15, B16, B25, B26, B35, B36, B45, B46, B55, B56, B65, B66	17CP2BL3 ↓	H6,H7 ↓	BRAKING CONTACTOR ↓	CC ↓
[illegible]	17KC100E1	H3,4	MASTER CONTROLLER HANDLES	OC
BRXA	41B560270P4	J	AUX BLOWER RUN RELAY	CC
CB	17FM449A1	D,D1	DC BUS CROW-BAR	CHC
CBR	PART OF CB	D1	CROW BAR RELAY	CHC
CDC	17CM53E7	J3	COMPRESSOR DISCON. CONT.	CC
CFRS	501A222P18	J2	COMPRESSOR RESET SW	RC
CGR	17LV69A3	E2,G3	COMPRESSOR GRD RELAY	CC
CGRCO	41A259608P1	E2	CGR CUT-OUT SWITCH	RC
CGR1,2		E2	COMPRESSOR GRD RES	CC
CGS	336B164P11	J2	COMPRESSOR PRESS. SW.	ACC
CHB1,2	495A893P1	G	CAB HEAT BREAKER	RC
CH1-6	17KG391A1	D2-8	CHOPPER GROUP	CHC
CLR	41B560270P4	J2	CURRENT LIMIT RELAY	CC

REVISIONS	TITLE: SCHEMATIC DIAGRAM E60 CHOPPER FIRST MADE FOR CONTRACT # DOT-FR-9027	MADE BY: R.J. HOPKINS 10/22/79 ISSUED	APPROVAL
GENERAL ELECTRIC	ERIE PLANT	41B541084	CONT. ON SH. SH. NO. 2

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CONT. ON SH.	SH. NO.	DEVICE TABLE	SECT. A4	SECT. A5	DEVICE TABLE	REV. NO.

SYMBOL	TYPE OR CATALOG NO.	SECTION	FUNCTION	LOC.
CM	5GY64	E3	COMPRESSOR MOTOR	ACC
CMCRI-4	17FR47C4	E3	CM CALIBRATING RES	CC
CMPU	41B556073P2	E3	CM MAGNETIC PICK-UP	ACC
CMS	41A256270P8	E3	COMP. MOTOR SHUNT	CC
CMRI-6		D3-8	CURRENT MEAS REACTOR	CC
CNB	41A203032P1	F1	CONTROL NEG. BKR.	RC
COR	41B560270P4	K3	CUTOUT RELAY	CC
COSR	41B560270P4	J2	COMP. OVERSPEED RLY	CC
COSI-6	41A215469P1	K2,3	MOTOR CUTOUT SWITCH	RC
COTD	17LV66J10	H4	CUTOUT TIME DELAY RLY	CC
COTD-DM	41B563171G2	H4	COTD DELAY MODULE	CC
COVR	17LV66AD22	E3	COMP OVERVOLTAGE RLY	CC
COVRA	41B560270P4	J2	AUX. COMP. OVERVOLT RLY	CC
CRF	41A240635P1	E2	COMP. RECTIFIER FUSE	CC
CRP	17FM403	E2,3	COMP. RECTIFIER PANEL	CC
CRR	17LV66AD22	E3	COMP. RUN RELAY	CC
CRSC		E2	COMP. RECT. SNUBBER CAP.	CC
CRSR		E2	COMP RECT. SNUBBER RES	CC
CRSX		E2	COMP. RECT SMOOT REACT	CC
CRX	17LV66J10	J2	AUX. COMP. RUN RELAY	CC
CSNGB	M99484G64G3	F1	CAB SIGNAL MG SET BKR	RC
CSR	41B560270P4	J2	COMP. START RELAY	CC
CSW	501A222P8	J3	COMP. START SWITCH	RC
CSI,2	41A210620	H,H4,G1	CONTROL SWITCH	OC
CSX	17EX56A2	E3	COMP. SMOOTHING REACT.	ACC
CTD	41B560270P4	J2	COMP TIME DELAY RLY	CC
CTD-DM	41B563171G19	J2	CTD DELAY MODULE	CC
CUV	FA4 (527418)	J2	COMP UNLOADER VALVE	
				RC
C1,2		C1	TIF FILTER CAP.	CC
C3-6		C1	TIF FILTER CAP	CC
C7,8	41A250094P13	G2,3	RELAY RESET CAPACITOR	CC

SYMBOL	TYPE OR CATALOG NO.	SECTION	FUNCTION	LOC.
DBCO	336B164P1	H3	DYN. BRK. C.O. PRESS. SW	
DBSR	17LV66J10	H4	DYN. BRK SETUP RLY	CC
DIR	41B560270P4	G2	DOOR INTERLOCK RLY	RC
DSI	41A303590P1	E1	BLOWER SCR STACK	CC
DS2	41A303590P2	E1	BLOWER DIODE STACK	CC
EGSI,2	497A911P1	G5	EMERGENCY GRD. SW	OC
FC1	41B518386P1	C1	SNUBBER CAPACITOR	MT
FCMI,2	17FM415	L1	FIRING MODULE	CC
FFI	41A243798P1	C1	SNUBBER FUSE	MT
FRIA,B	41C618101G1	C1	SNUBBER RESISTOR	MT
FR2S	17LV66J10	G2	25HZ RELAY	RC
FR6O	17LV66J10	G2	60HZ RELAY	RC
FSRI-6		D3-8	FIELD SHUNT RESISTOR	CC
FI-6		C1	TIF FUSE	CC

REVISIONS	TITLE	MADE BY	APPROVAL		ERIE	
	SCHEMATIC DIAGRAM E60 CHOPPER	R.L. HOPKINS 10/22/79		GENERAL ELECTRIC	PLANT	41B541084.
	FIRST MADE FOR CONTRACT H DOT-FR-7027	ISSUED				CONT. ON SH. SH. NO. 3

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CONT. ON SH. | SH. NO. | DEVICE TABLE | SECT. A6 | SECT. A7 | DEVICE TABLE | REV. NO.

SYMBOL	TYPE OR CATALOG NO.	SECTION	FUNCTION	LOC.
GPT1,2		L1,3	GATE PULSE TRANSF.	CC
GR	17LV69A2	D,G2	GROUND RELAY	CC
GRCO	41A259608P1	D,H	GRD. RELAY CUT-OUT SW	RC
GRR1,2	482A444AGP27	D	GRD. RELAY RESISTOR	CC
GFM	17FM405A1	E2	GATE FIRING MODULE	CC
HLB	M9948464G3	M3	HEADLIGHT BREAKER	RC
HLLS1	494A143ADP2	M3	HEADLIGHT SW1 (REAR)	OC
HLLS2	494A143ADP1	M3	HEADLIGHT SW2 (FRONT)	OC
HLRS1	494A143ADP1	M3	HEADLIGHT SW1 (FRONT)	OC
HLRS2	494A143ADP2	M3	HEADLIGHT SW2 (REAR)	OC
HLRP1,2		M3	HEADLIGHT RES PANEL	
HLSS	492A101AL	M3	HEADLIGHT SELECTOR SW	RC
HL1-4		M3	HEADLIGHT	
LA1,2	GE9L11PGA018	C	LIGHTNING ARRESTOR	ROOF
LFC1-30	41A302133P1	D	LINE FILTER CAPACITOR	CHC
LFF1-30	41A302134P1	D	LINE FILTER FUSE	CHC
LFX1,2	17EX64	C3	DC BUS FILTER REACTOR	P
LS1-4	ME433N10	H5	LINE SWITCH	CHC
LCAR	41B560270P4	K8	LOW COOLING AIR RELAY	CC
LCAS	501A222P18	K8	LOW COOLING AIR RESET SW	RC
L1,2		C1	TIF INDUCTOR	CC
L3,4		C1	TIF INDUCTOR	CC

SYMBOL	TYPE OR CATALOG NO.	SECTION	FUNCTION	LOC.
MCB	M-9948641G1	F1	MAIN CONTROL BKR	RC
MC01-6	17GP29B1	K2,3	MOTOR CUTOUT SWITCH	CHC
MR	17LV66J10	H	MOTOR RELAY	CC
MSX1-6	17EX63	D5-8	MOTOR SMOOTHING REACT.	P
MT	41A303264	C	MAIN TRANSFORMER	P
NBCR	17LE113A1	F1	NO BATT CHARGE RELAY	CC
NBR	17LV66J10	H1	NO BRAKING RELAY	CC
NVR1,2	41B560270P4	E1	NO VOLTAGE RELAY	CC
NVRM1,2	41A271060G1	E1	NVR RECTIFIER MODULE	CC
OFFR	17LV66J10	H5	OFF RELAY	CC
OLR	17LV66J10	K9	OVERLOAD RELAY	CC
OLRA	41B560270P4	G5	AUX OVERLOAD RELAY	RC
OLRP	41B560270P4	G5	PRIMARY OVERLOAD RLY	RC
OLRS	501A222P18	G5	OVERLOAD RESET SW	RC
OLR1,2	41B560270P4	G5	OVERLOAD RELAY 1&2	RC
OTD	41A264547P10	H3	OPERATE TIME DELAY RLY	CC
PAN		C	PANTOGRAPH	ROOF
PANR	41B560270P4	G3	PANTO RELAY	RC
PCS	336B164P1	H3	POWER CUTOUT PRESS SW	
PDR	41B560270P4	G1	PANTO DOWN RELAY	RC

REVISIONS | TITLE: SCHEMATIC DIAGRAM E60 CHOPPER | FIRST MADE FOR CONTRACT # DOT-FR-9027

MADE BY R.A. HOPKINS 10/22/74 | ISSUED | APPROVAL

GENERAL ELECTRIC | ERIE PLANT | 41B541084. | CONT. ON SH. | SH. NO. 4

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CONT. ON SH. | SH. NO. | DEVICE TABLE | SECT. A8

SYMBOL	TYPE OR CATALOG NO.	SECTION	FUNCTION	LOC.
PHR	41B560270P4	G1	PANTO HOLD RELAY	RC
PCR	17LV66J10	H3	POWER KNOCK-OUT RELAY	CC
PLB	41A278712	G2,4	VACUUM INTERRUPTER	ROOF
PD	TE49FF2	G1	PANTO DOWN MV	NOSE
POCR	41B561218P3	C	PRIM OVERCURRENT RELAY	RC
PR50	41B560270P4	K8	50% POWER RELAY	RC
PR75	41B560270P4	K9	75% POWER RELAY	RC
PRA,B	17KG392A1	C2/3	PRE-REGULATOR	RECT
PTR	41B560270P4	G4	PANTO TRIP RELAY	RC
PU	TE49FF2	G1	PANTO UP MAGNET VALVE	NOSE
PUTD	41B560270P4	G2	PANTO UP TIME DELAY RLY	RC
PUTD-DM	41B563171G7	G2	PUTD DELAY MODULE	RC
PUR	41B560270P4	G1	PANTO UP RELAY	RC
PSCS	41A240816P1	G2,4	POWER SOURCE CHANGEOVER SW.	RC
RH1&2,BH1&2,TH1&2	17KC108E1	H,H2	MASTER CONTROLLER HANDLES	OC
RCB	M9984646G3	F1	REGULATED CONTROL BKR	RC
RCD	17FM203D1	F1	REVERSE CURRENT DIODE	CC
RCR	41A264547P10	H	REVERSER CHECKING RLY	CC
RCR1,2	17LV66J10	K1	RECTIFIER CUTOUT RELAY	CC
RCS1,2	502A140P1	K1	RECTIFIER CUTOUT SWITCH	RC
REV1,2	17DP29A1	H	REVERSER	CC
RLB	M9984646G3	F1,M	RUNNING LIGHT BKR.	RC
ROTR	41B560270P4	K10	RECTIFIER OVERTEMP RLY	CC
ROTS	501A222P18	K10	RECTIFIER RESET SW	RC
RSR	41B560270P4	H4	RESET RELAY	CC
R1-8	17EA5A128	C1	TIF RESISTOR	CC
R9-10	17EA5A107	C1	TIF RESISTOR	CC
R11	41A274375G3	G3	CAPACITOR DISCHARGE RESISTOR	CC
SC1-8	41B518387P1	C1	SECONDARY SNUBBER CAP	MT
SCA1,2	41B518387P1	C1	AUX SEC. SNUBBER CAP	MT

SECT. A9 | DEVICE TABLE | REV. NO.

SYMBOL	TYPE OR CATALOG NO	SECTION	FUNCTION	LOC
SCTA	GE752X20G7(1500:5)	C	AUX CURRENT TRANSF	RECT
SCT1,2	GE752X20G8(2000:5)	C	SECONDARY CURRENT TRANSF	RECT
SCS1,2	501A222P3	G1	SAFETY CONTROL SW	OC
SCV	FH4(S27418)	G1	SAFETY CONTROL VALVE	NOSE
SOCRA	41B561218P3	C	AUX OVERCURRENT RLY	RC
SOCR1,2	41B561218P3	C	SECONDARY OVERCURR RLY	RC
ST	41A296060	C1	SYNC. TRANSF	MT
TCA	17MK33A1	C	TAP CHANGER	MT
THR	17LV66J10	H3	THROTTLE RELAY	CC
TMSS1-6	41C635157G3	D3-8	TRACTION MOT SPEED SEN.	P
TM1-6	GE752AF4	D3-8	TRACTION MOTOR	
TOTS	PART OF MT	K9	TRANSF OVERTEMP SW	MT
TPM	PART OF MT	E1	TRANSF PUMP MOTOR	MT
TPMCB	41A218842P7	E	TRANSF PUMP CIRC. BKR	RC
TS1-4	ME433N10	H1	TRANSFORMER SWITCH	RECT
TAR	17LV66J10	K9	TRANSF ALARM RELAY	RC
TOPS	PART OF MT	K9	TRANSF OVER PRESSURE SW	MT
TH1&2,BH1&2,RH1&2	17KC108E1	H2,3,4	MASTER CONTROLLER HANDLES	OC
UVT	17FM322A1	G3	UNDER VOLTAGE TRIP PNL	CC
WSR	17LV66J10	H8	WHEELSLIP RELAY	CC
WSTD	17LV66J10	H8	WHEELSLIP TIME DLY RLY	CC
WSTD-DM	41B563171G6	H8	WSTD DELAY MODULE	CC

REVISIONS | TITLE SCHEMATIC DIAGRAM E60 CHOPPER | FIRST MADE FOR CONTRACT # DOT-FR-9027

MADE BY K.J. HOPKINS 10/22/79 | ISSUED | APPROVAL | GENERAL ELECTRIC | ERIE PLANT | 41B541084 | CONT. ON SH. | SH. NO. 5

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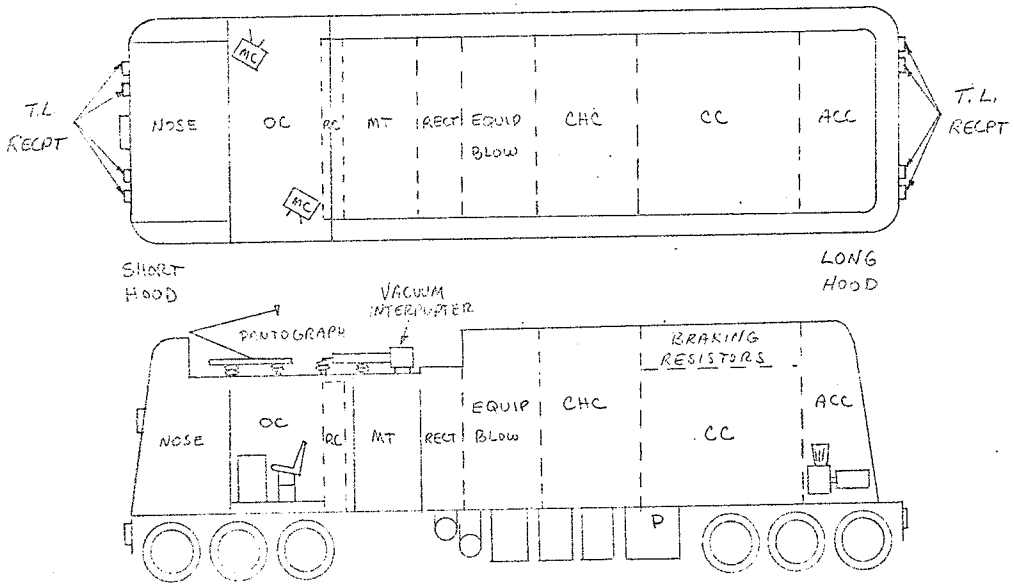
CONT. ON SH.	SH. NO.	LEGEND	SECT. A10	SECT. A11	LEGEND	REV. NO.



SYMBOL

ACC	AIR COMPRESSOR COMPARTMENT
CC	CONTROL COMPARTMENT
CHC	CHOPPER COMPARTMENT
MT	MAIN TRANSFORMER
NOSE	NO. 1 END
OC	OPERATORS COMPARTMENT
RC	RELAY COMPARTMENT
RECT	RECTIFIER COMPARTMENT
P	PLATFORM

REVISIONS	TITLE	MADE BY	APPROVAL		ERIE	4185410B4
	SCHEMATIC DIAGRAM E60 CHOPPER	J. F. HOPKINS 10/23/79		GENERAL ELECTRIC	PLANT	CONT. ON SH. SH. NO. 6
	FIRST MADE FOR CONTRACT # DOT-ER-9027	ISSUED				

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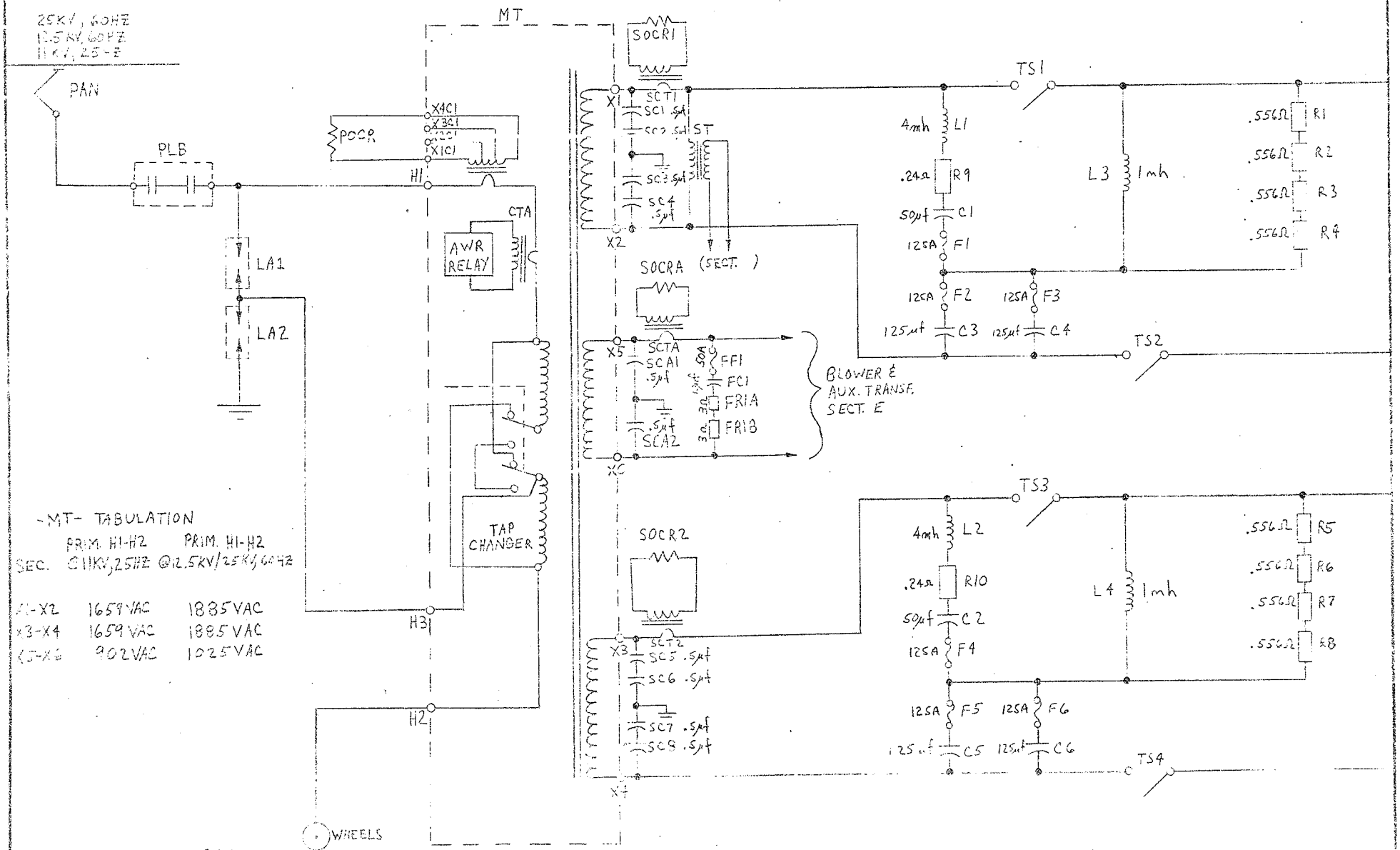
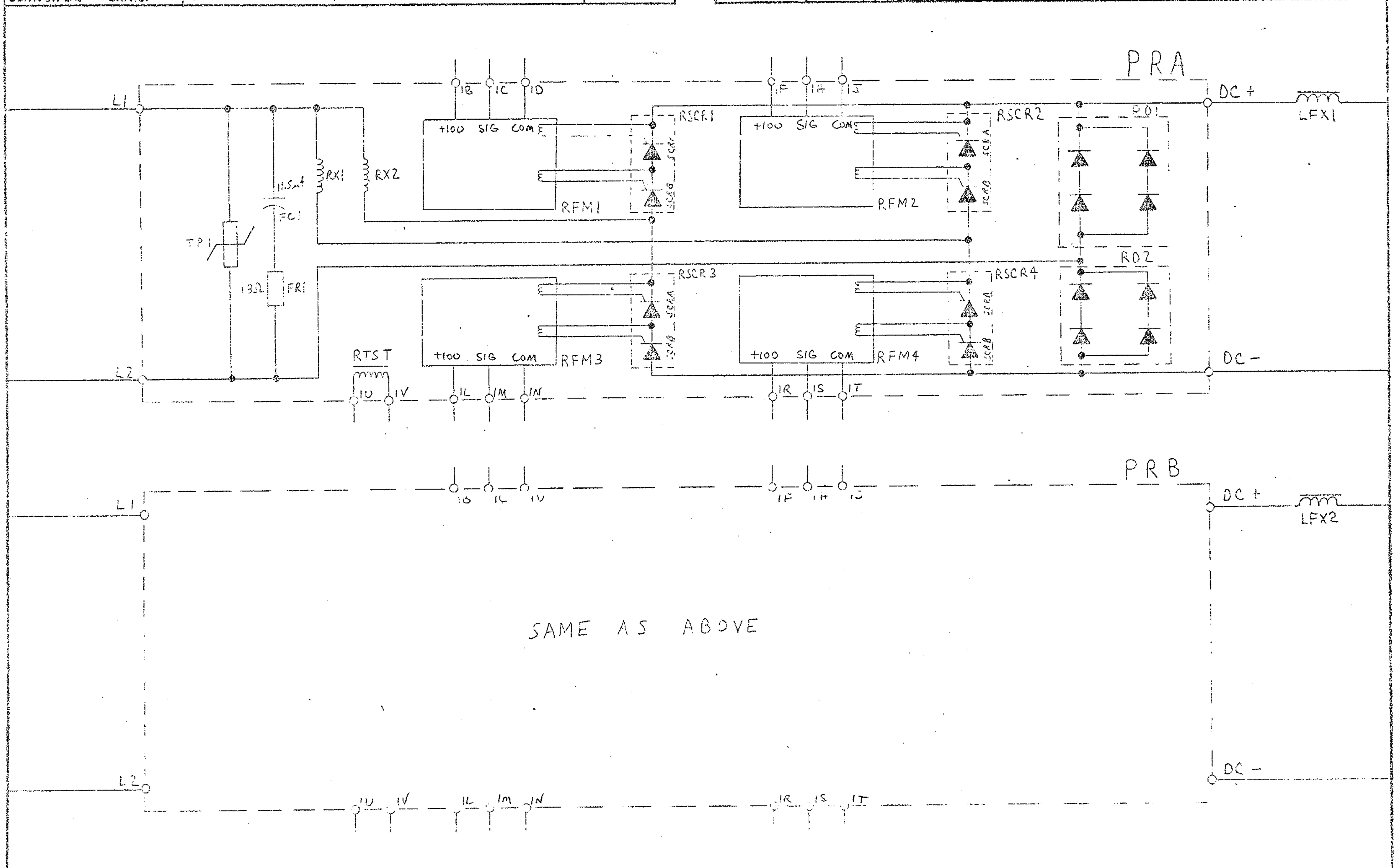


-MT- TABULATION

	PRIM. H1-H2	PRIM. H1-H2
SEC. C	11KV, 25HZ @12.5KV/25KV, 60HZ	
X1-X2	1659 VAC	1885 VAC
X3-X4	1659 VAC	1885 VAC
X5-X6	902 VAC	1025 VAC

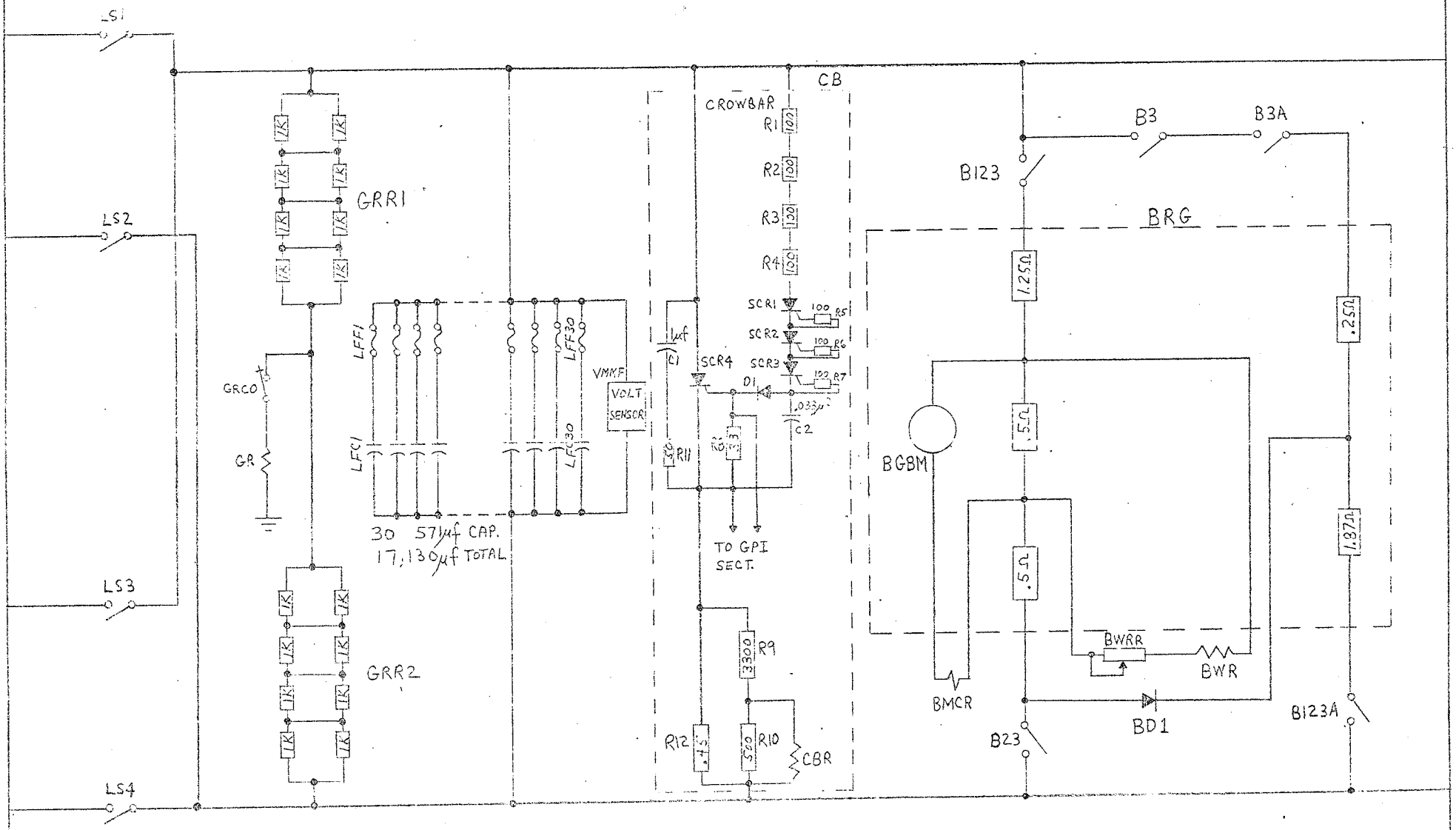
		TITLE SCHEMATIC DIAGRAM E60 CHOPPER FIRST MADE FOR CONTROL F ST DOT-TR-9027	MADE BY K.D. HOPKINS 10/22/79 ISSUED	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT	4185410B4 CONT. ON SH SH. NO. 10

CONT. ON SH.	SH. NO.	PREREGULATOR	SECT. C2	SECT. C3	PREREGULATOR	REV. NO.



TITLE	MADE BY	APPROVAL		ERIE	41B541084
SCHEMATIC DIAGRAM 360 CHOPPER	HOPKINS 10/21/73		GENERAL ELECTRIC CO.	PLANT	CONT. ON SH. SH. NO. 1
FIRST MADE FOR CONTRACT & DOT - FR - 9027	ISSUED				

C2 : C3

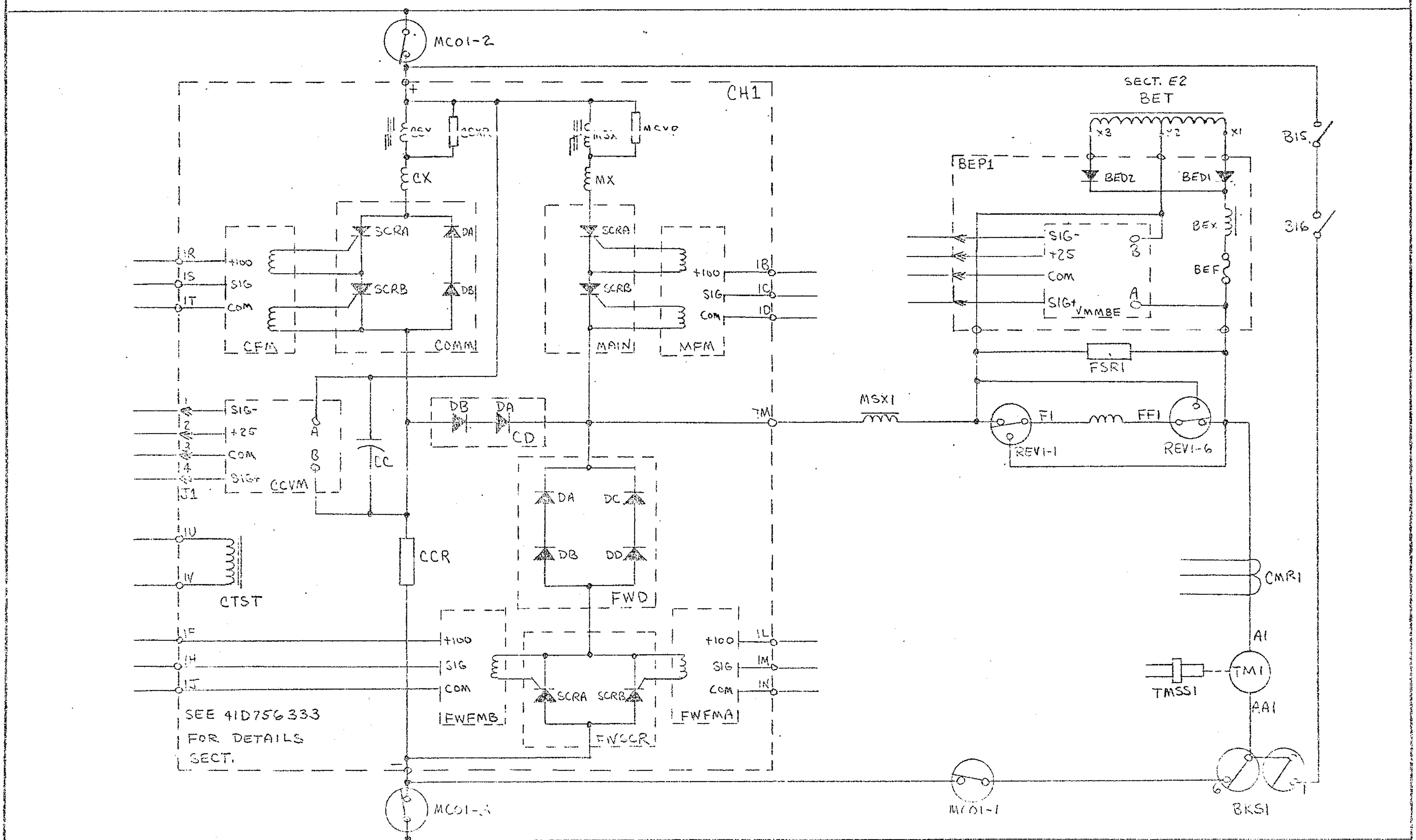


REVISIONS	TITLE: SCHEMATIC DIAGRAM EGC CHOPPER FIRST MADE FOR CONTRACT # DOT-FR-9027	MADE BY: [illegible] 7-9-79 ISSUED	APPROVAL	TRANS. SYSTEMS BUS. DIV. GENERAL ELECTRIC	ERIE PLANT	418541 084 CONT. ON SH. SH. NO. 19

D D1

TSBD-1544-A (4-73)

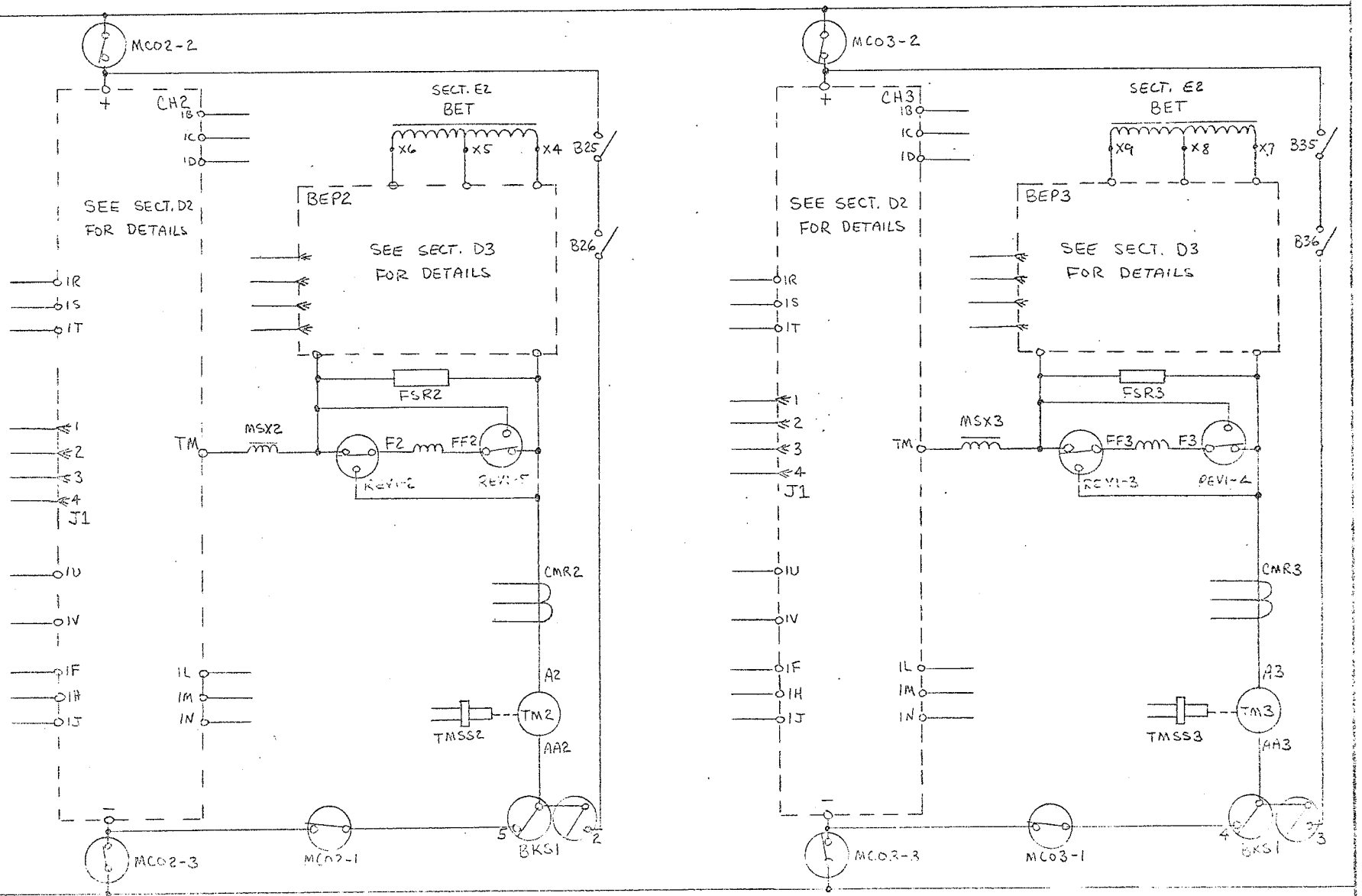
CONT. ON SH.	SH. NO.	PROPULSION CIRCUIT	SECT. D2	SECT. D3	PROPULSION CIRCUIT	REV. NO.



TITLE	MADE BY	APPROVAL		ERIE	
SCHEMATIC DIAGRAM EGO CHOPPER	5/25/79		GENERAL ELECTRIC CO.	PLANT	41B541084 CONT. ON SH. SH. NO. 13

D2 : D3

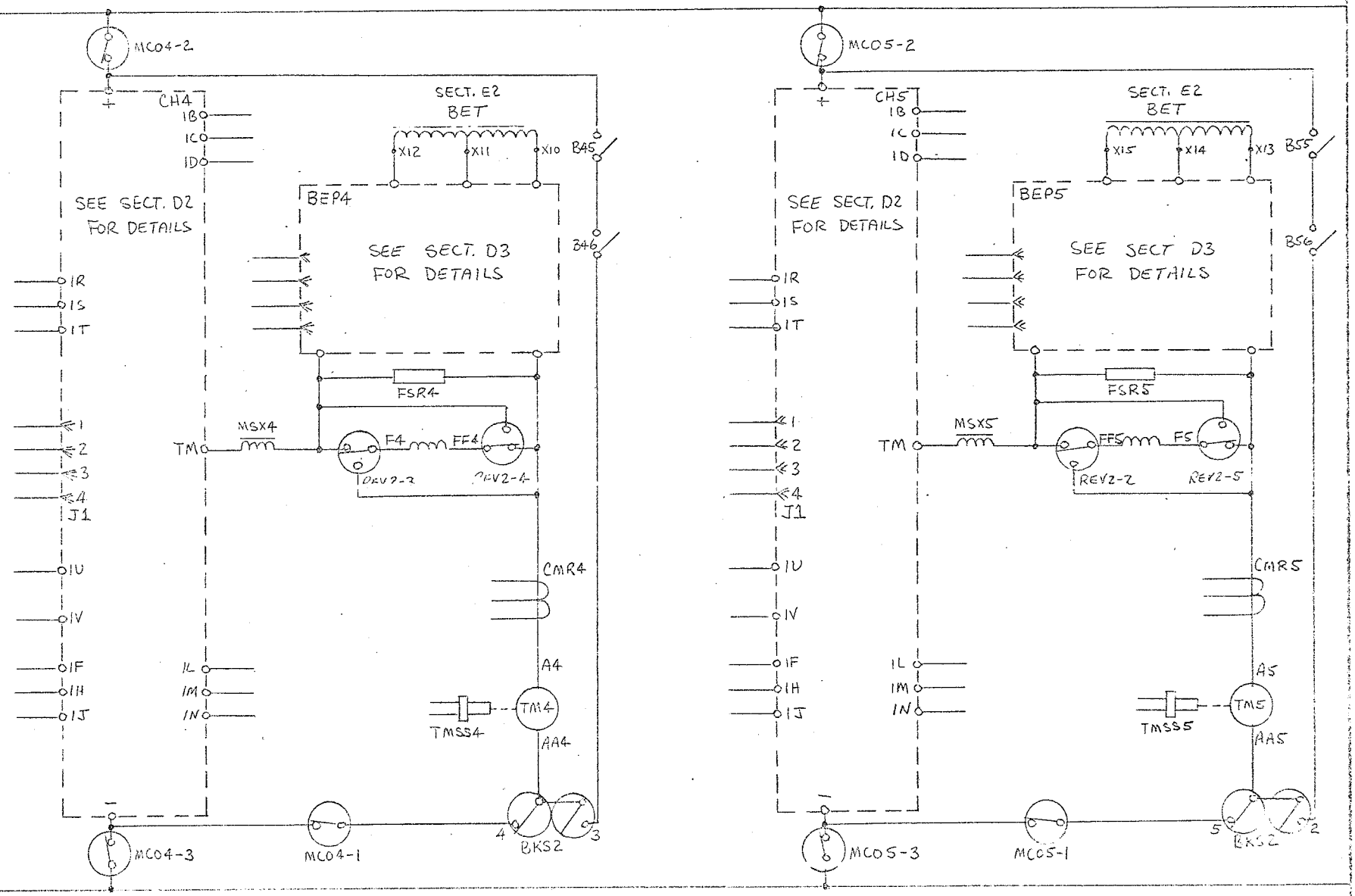
CONT. ON SH.	SH. NO.	PROPULSION CIRCUIT	SECT. D4	SECT. D5	PROPULSION CIRCUIT	REV. NO.



REVISIONS	TITLE: SCHEMATIC DIAGRAM EGO CHOPPER FIRST MADE FOR CONTRACT # DOT-FR-7027	MADE BY: P. L. Hopkins 9/25/74 ISSUED	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT	4185410 84 CONT. ON SH.	SH NO. 14

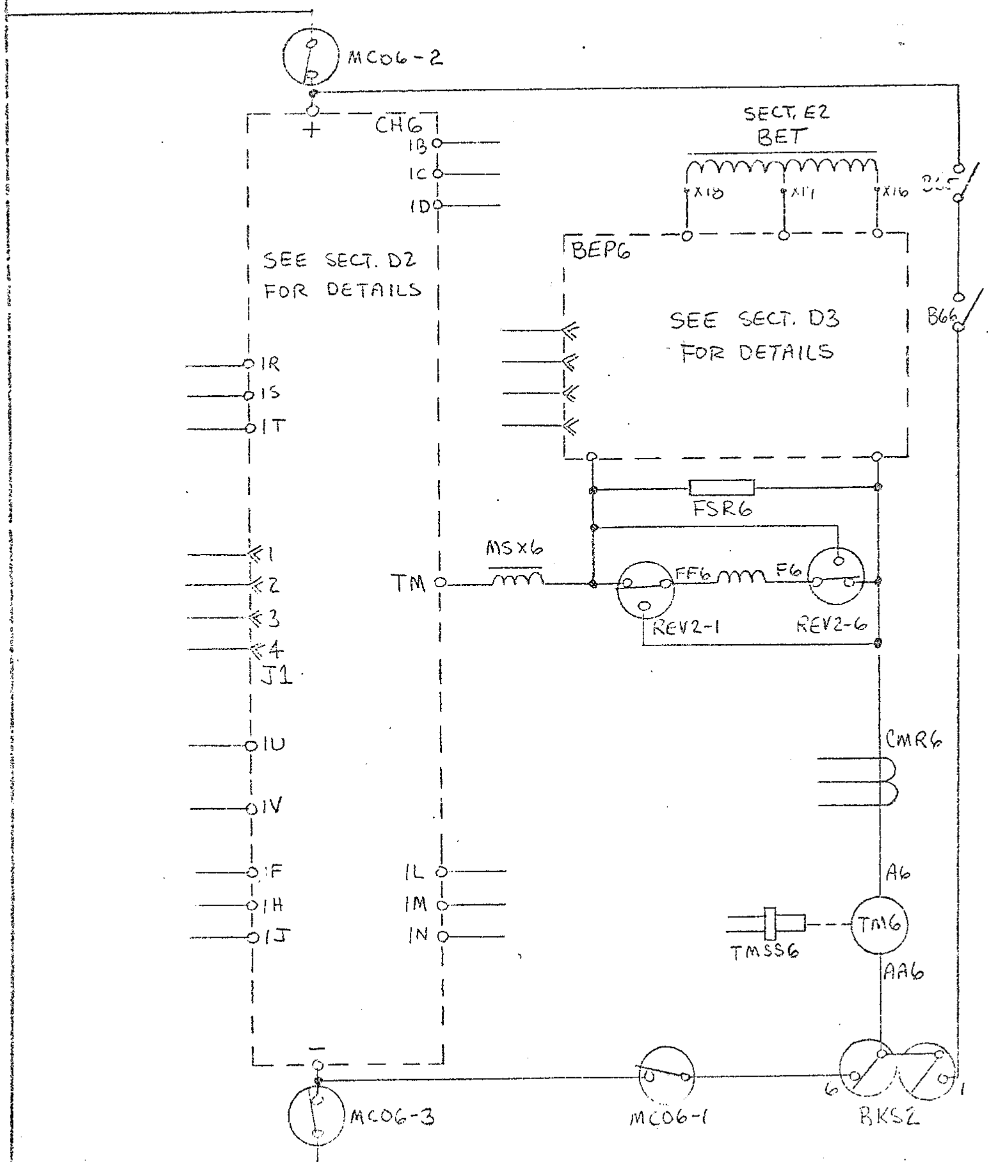
04 D5

CONT. ON SH.	SH. NO.	PROPULSION CIRCUIT	SECT. D6	SECT. D7	PROPULSION CIRCUIT	REV. NO.



REVISIONS	TITLE: SCHEMATIC DIAGRAM EGO CHOPPER FIRST MADE FOR CONTRACT # DOT-FR-7027	MADE BY: [illegible] HOPKINS 9/25/79 ISSUED	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT	41B541084 CONT. ON SH. SH. NO. 15

CONT. ON SH. SH. NO. PROPULSION CIRCUIT SECT. D8 SECT. D9 REV. NO.

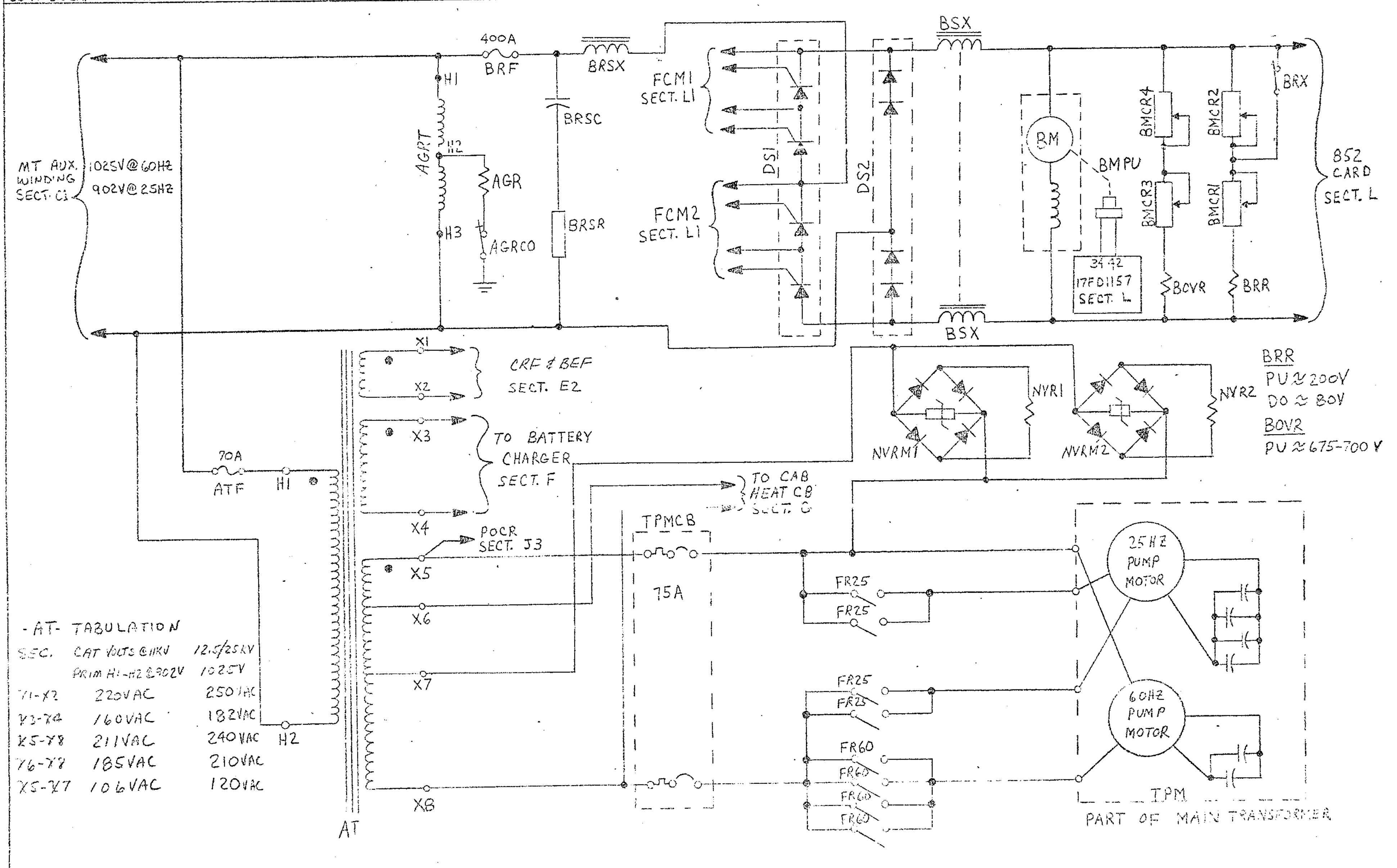


TITLE SCHEMATIC DIAGRAM EGO CHOPPER
FIRST MADE FOR CONTRACT # DOT-FR-9027

MADE BY Hopkins 9/25/77
ISSUED
APPROVAL
GENERAL ELECTRIC CO.
ERIE PLANT
41B541084
CONT ON SH. SH. NO. 10

D8 D9

AUXILIARY TRANSFORMER | SECT. E | SECT. E1 | BLOWER MOTOR / PUMP MOTOR | REV. NO.



- AT - TABULATION

SEC.	CAT VOLTS @11KV / PRIM H1-H2 @ 902V	12.5/25 KV / 1025V
X1-X2	220VAC	250VAC
X3-X4	160VAC	182VAC
X5-X8	211VAC	240VAC
X6-X8	185VAC	210VAC
X5-X7	106VAC	120VAC

REVISIONS

TITLE SCHEMATIC DIAGRAM E60 CHOPPER

FIRST MADE FOR CONTRACT # DOT-FR-9027

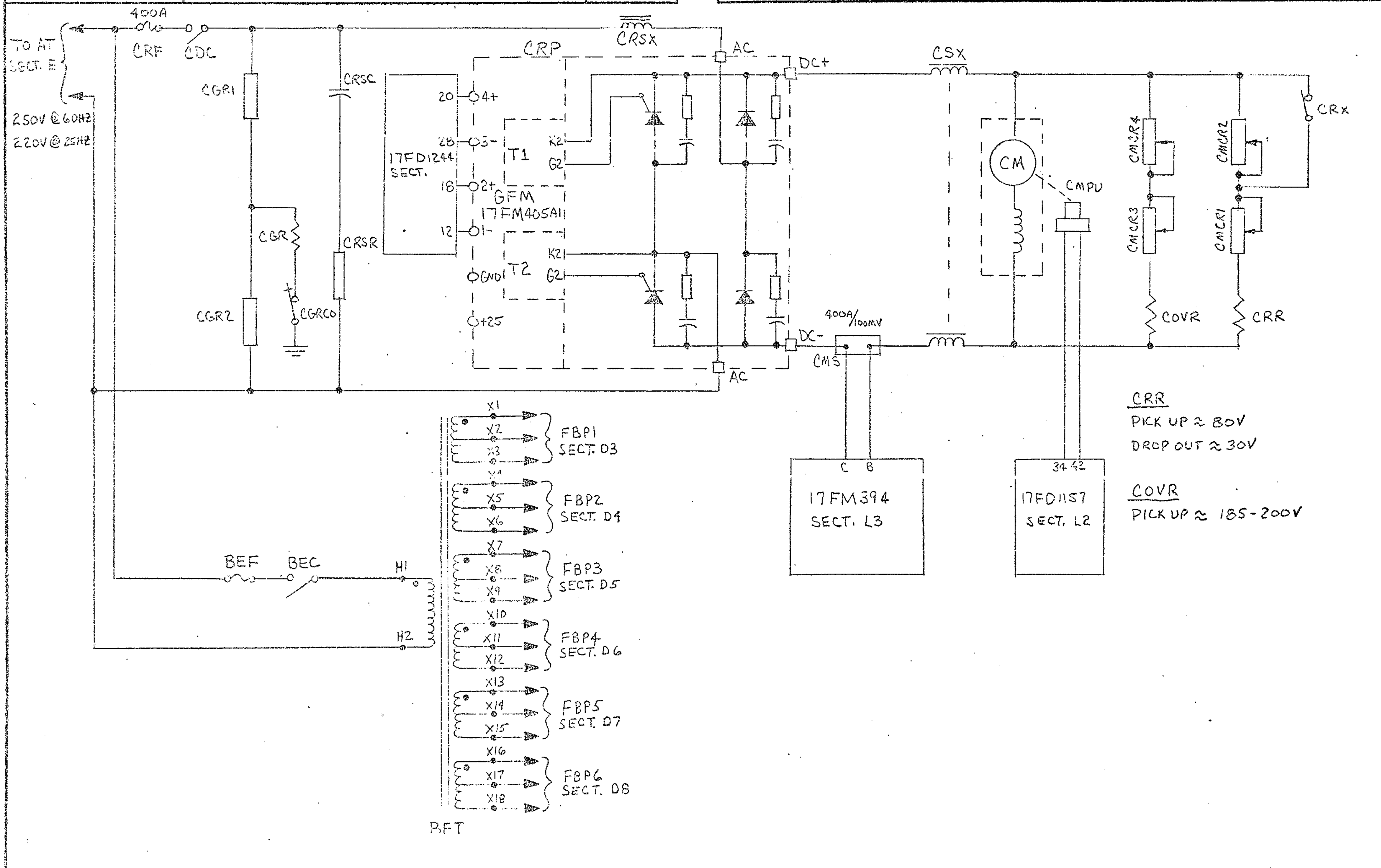
MADE BY J. S. HOPKINS 7-9-79 | ISSUED | APPROVAL | TRANS. SYSTEMS BUS. DIV. | GENERAL ELECTRIC | ERIE PLANT

41B541084 | CONT. ON SH. | SH. NO.

E E1

TSBD 1544-4 (3-73)

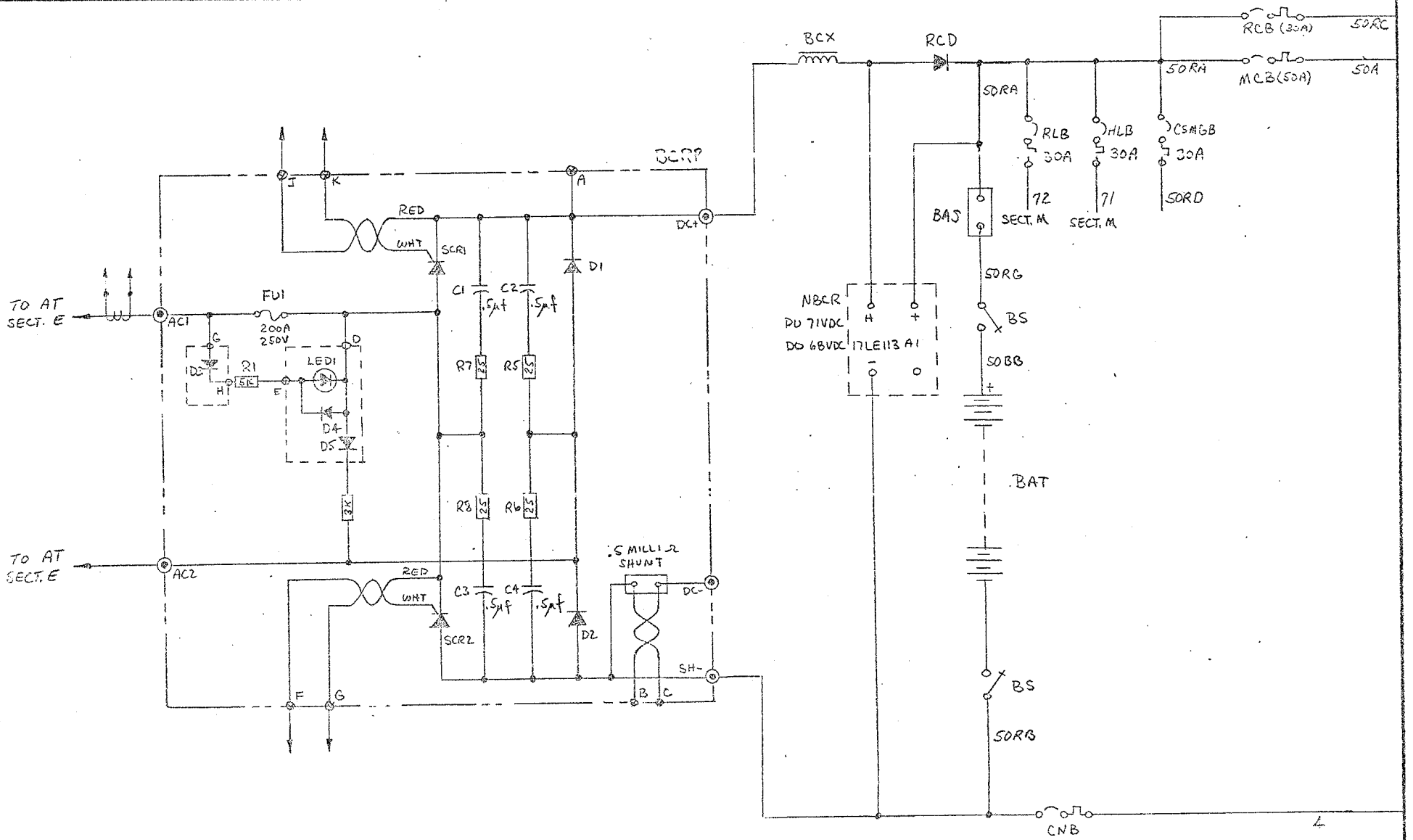
CONT. ON SH. | SH. NO. | BRAKING EXCITATION | SECT. E2 | SECT. E3 | COMPRESSOR | REV. NO.



REVISIONS	TITLE SCHEMATIC DIAGRAM E60 CHOPPER FIRST MADE FOR CONTRACT # DOT-FR-9027	MADE BY HOPKINS 7-10-79 ISSUED	APPROVAL
GENERAL ELECTRIC CO.	ERIE PLANT	41B541084 CONT. ON SH.	SH. NO. 13

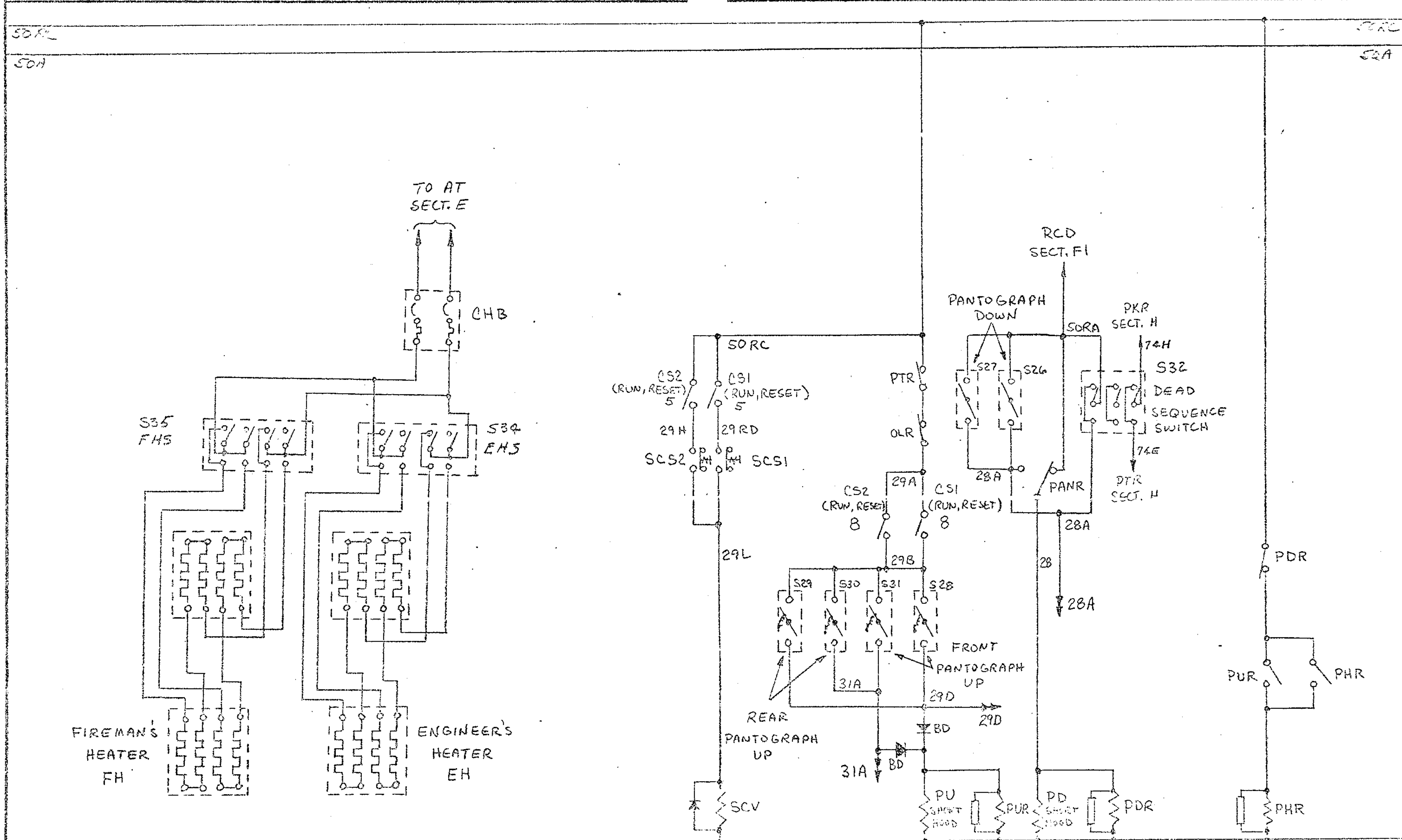
E2 E3

CONT. ON SH.	SH. NO.	BATTERY CHARGER	SECT. F	SECT. F1	BATTERY	REV. NO.



REVISIONS	TITLE: SCHEMATIC DIAGRAM E60 CHOPPER FIRST MADE FOR CONTRACT = DOT-FR-1027	MADE BY: HAWKINS 7-10-79 ISSUED	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT	41B541C84 CONT. ON SH.	SH. NO. 17

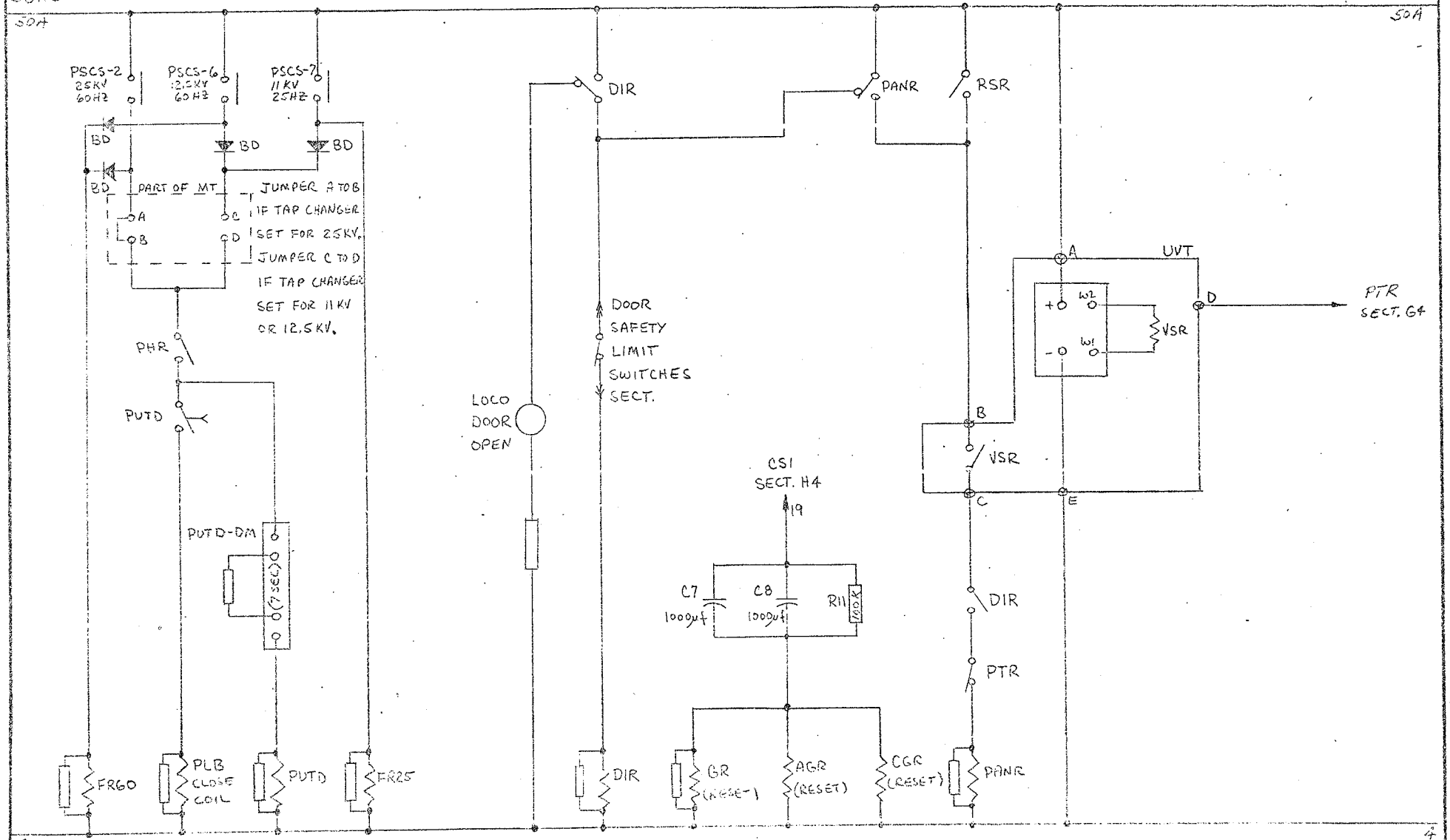
CONT. ON SH.	SH. NO.	CAB HEATERS	SECT. G	SECT. G1	PANTOGRAPH CONTROL	REV. NO.



TITLE SCHEMATIC DIAGRAM EGO. CHOPPER	MADE BY HOPKINS 7-6-79	APPROVAL	ERIE PLANT	41B541084
FIRST MADE FOR CONTRACT # [illegible]	ISSUED	GENERAL ELECTRIC CO.		CONT. ON SH. SH. NO. 20

G | G1

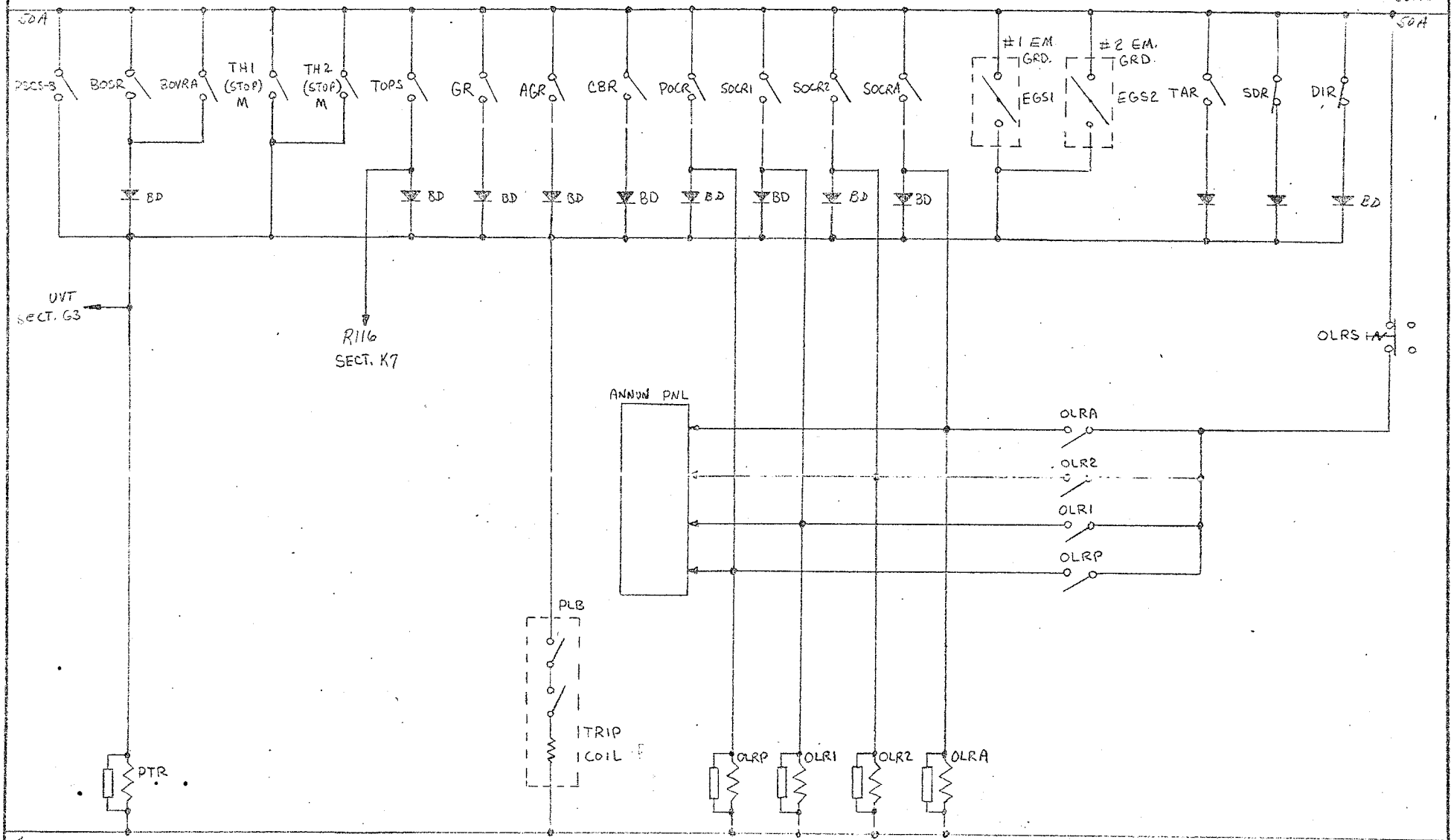
CONT. ON SH.	SH. NO.	PANTOGRAPH / LINEBREAKER CONTROL	SECT. G2	SECT. G3	PANTOGRAPH/LINE BREAKER CONTROL	REV. NO.



REVISIONS	TITLE: SCHEMATIC DIAGRAM EGG CHARGER FIRST MADE FOR CONTRACT 4 UNIT ER-7627	MADE BY	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT	41B341084 CONT. ON SH.	SH. NO. 21
		ISSUED					

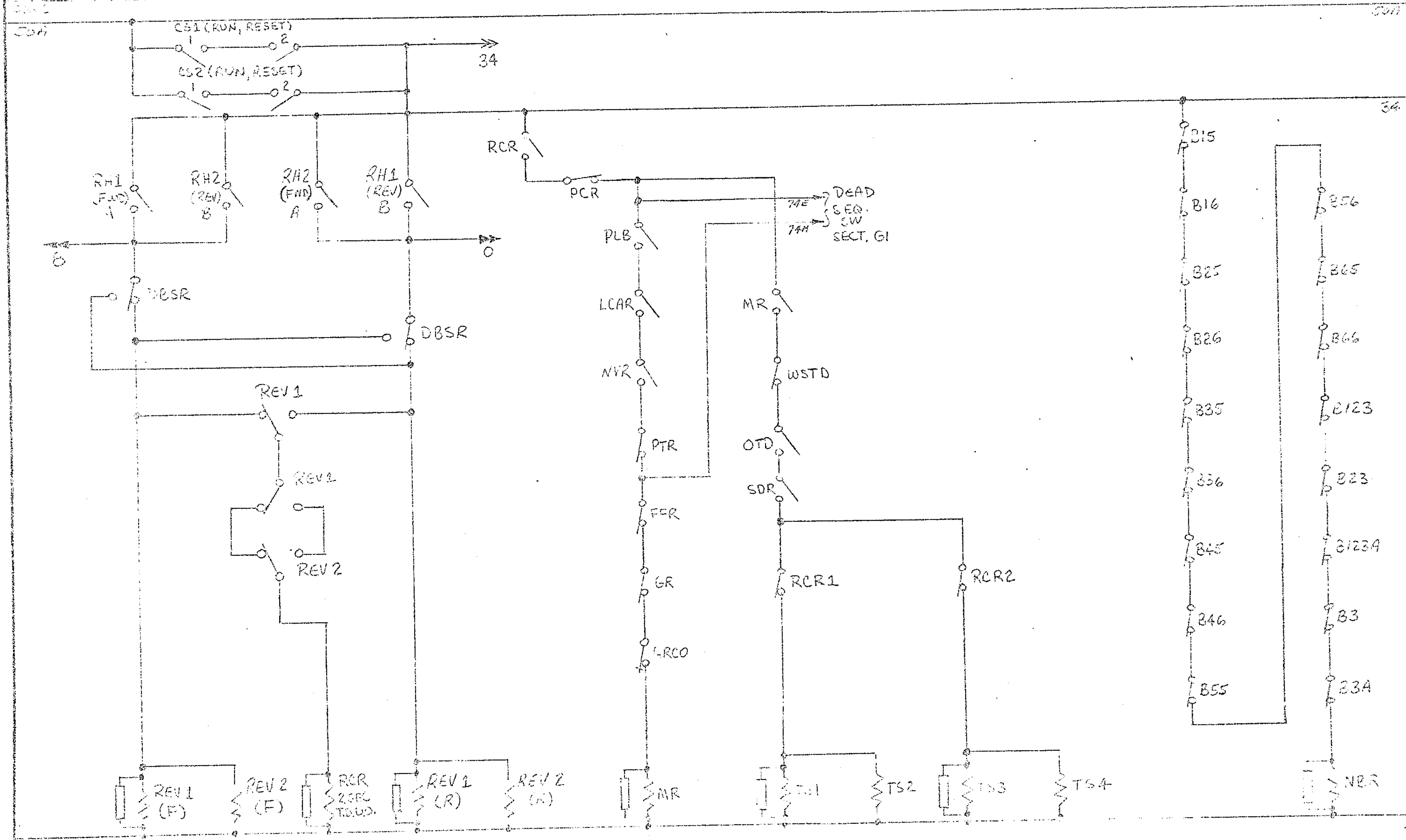
G2 | G3

CONT. ON SH.	SH. NO.	PANTOGRAPH/LINE BREAKER CONTROL	SECT. G4	SECT. G5	PANTOGRAPH/LINE BREAKER CONTROL	REV. NO.



REVISIONS	TITLE: SCHEMATIC DIAGRAM E60 CHIPPER FIRST MADE FOR CONTRACT # INT-ER-9027	MADE BY HOPKINS 7-6-79 ISSUED	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT	41B541024 CONT. ON SH. SH. NO. 23

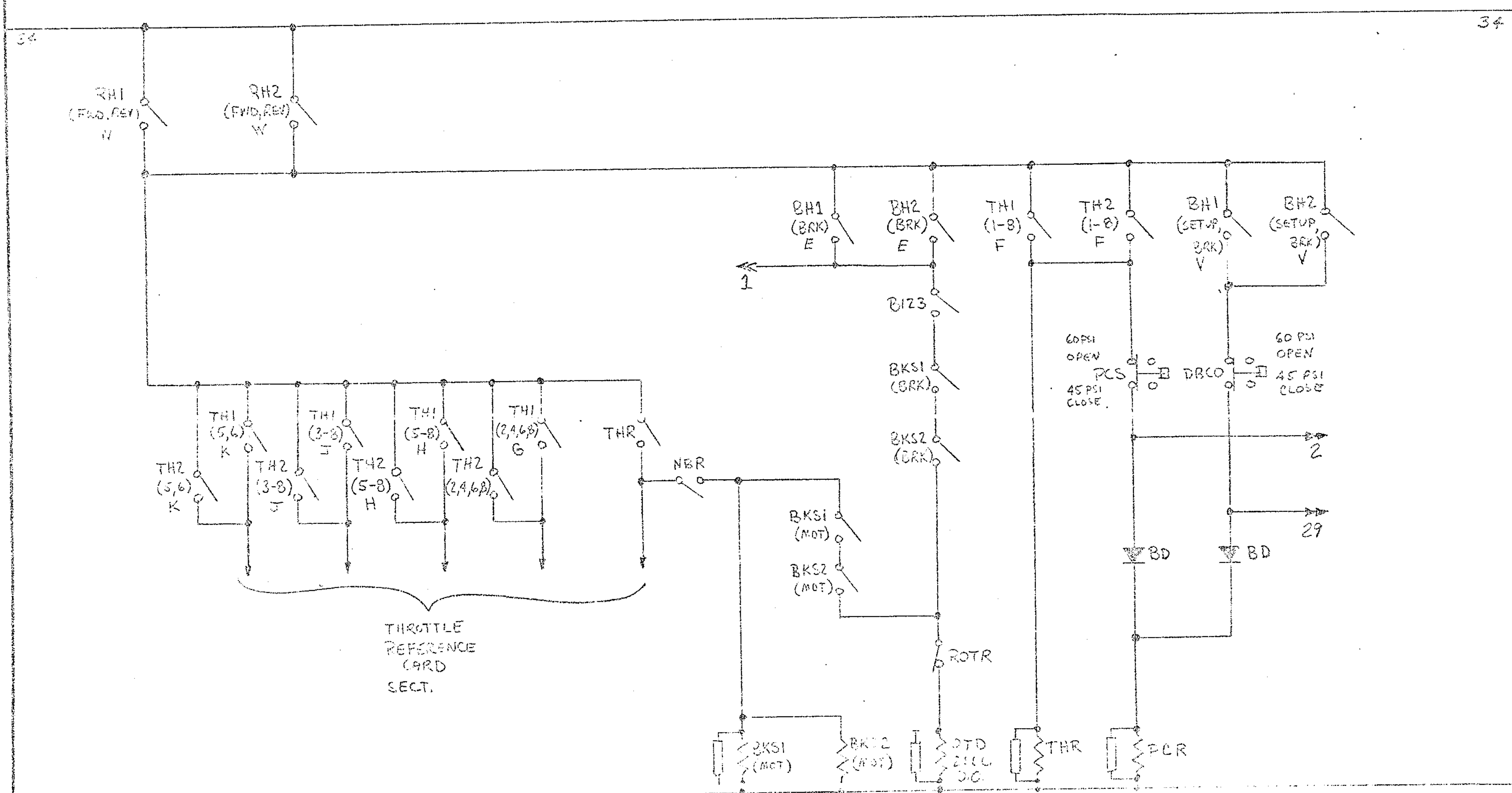
CONT. ON SH.	SH. NO.	PROPULSION CONTROL	SECT. H	SECT. H1	PROPULSION CONTROL	REV. NO.



TITLE SCHEMATIC DIAGRAM AND CHARTS	MADE BY	APPROVAL
FIRST MADE FOR CONTRACT	ISSUED	GENERAL ELECTRIC CO.
ERIE PLANT	CONT. ON SH.	SH. NO.

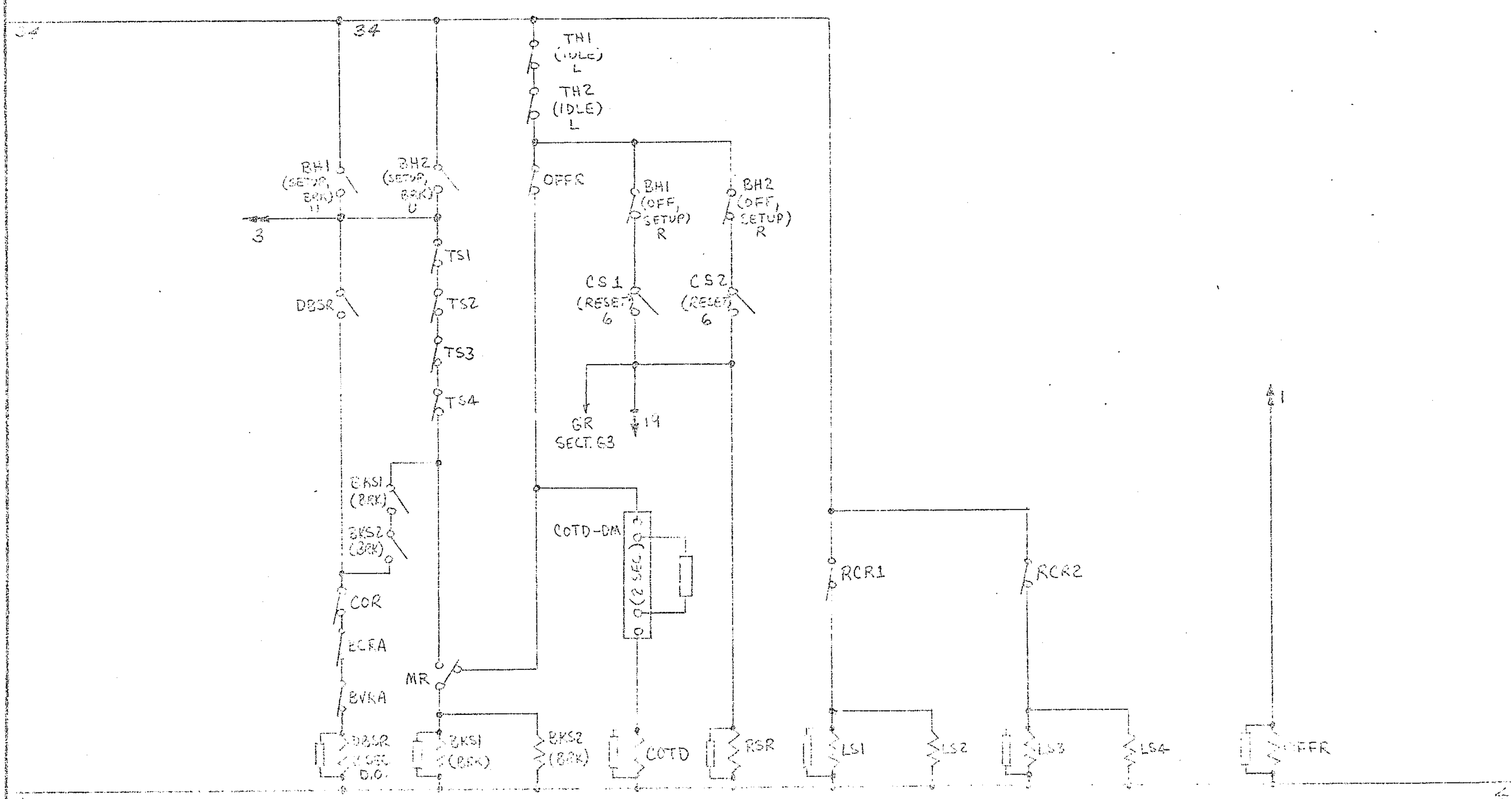
H H1

CONT. ON SH.	SH. NO.	PROPULSION CONTROL	SECT. H2	SECT. H3	PROPULSION CONTROL	REV. NO.



TITLE SCHEMATIC DIAGRAM	MADE BY	APPROVAL		ERIE PLANT	
FIRST MADE FOR	ISSUED		GENERAL ELECTRIC CO		CONT. ON SH. SH. NO. 34

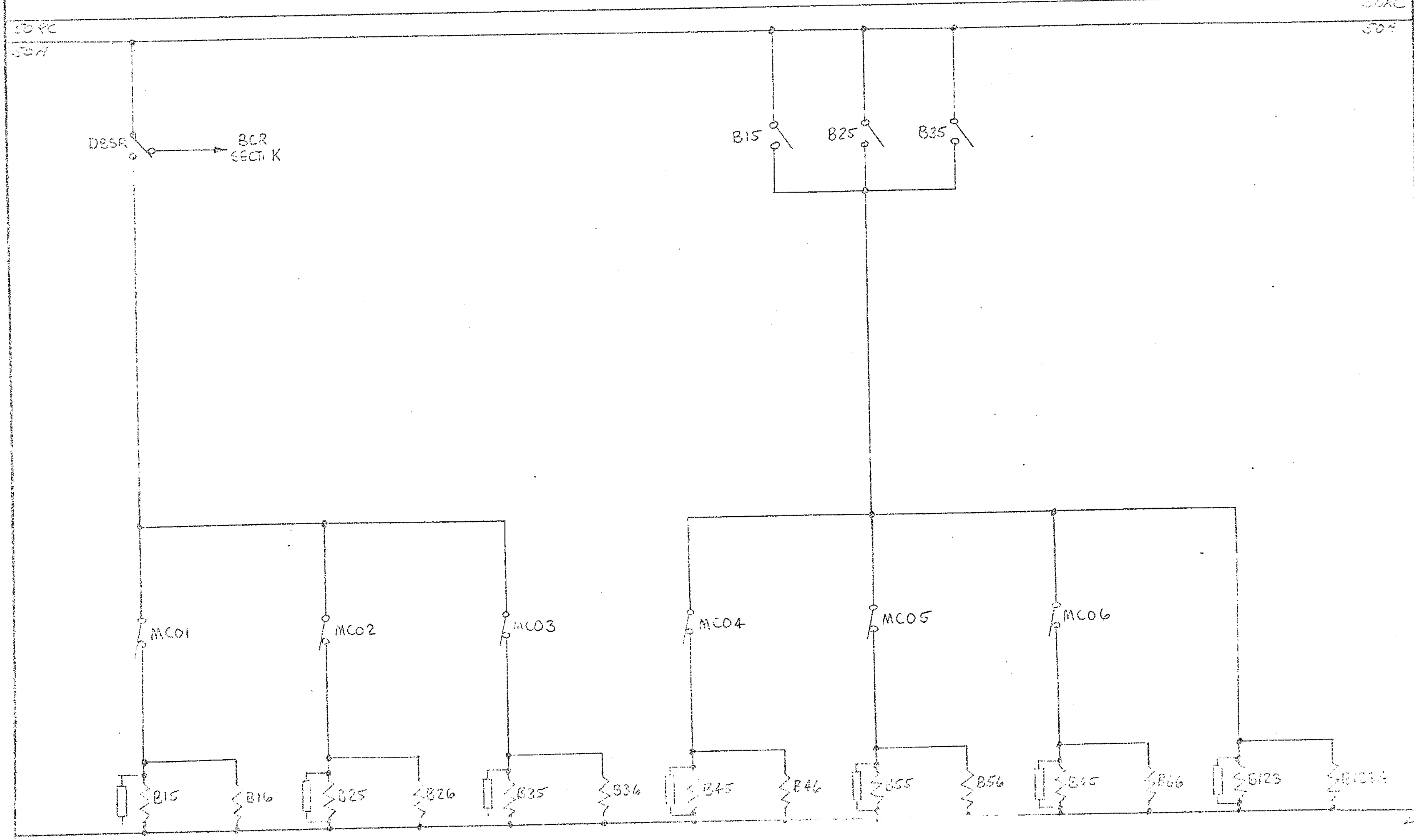
CONT. ON SH.	SH. NO.	PROPULSION CONTROL	SECT. H4	SECT. H5	PROPULSION CONTROL	REV. NO.



TITLE	MADE BY	APPROVAL		ERIE
SCHEMATIC DIAGRAM	ISSUED		GENERAL ELECTRIC CO.	PLANT
FIRST MADE FOR				CONT ON SH. / SH. NO.

H4 | H5

CONT. ON SH.	SH. NO.	PROPULSION CONTROL	SECT. H6	SECT. H7	PROPULSION CONTROL	REV. NO.



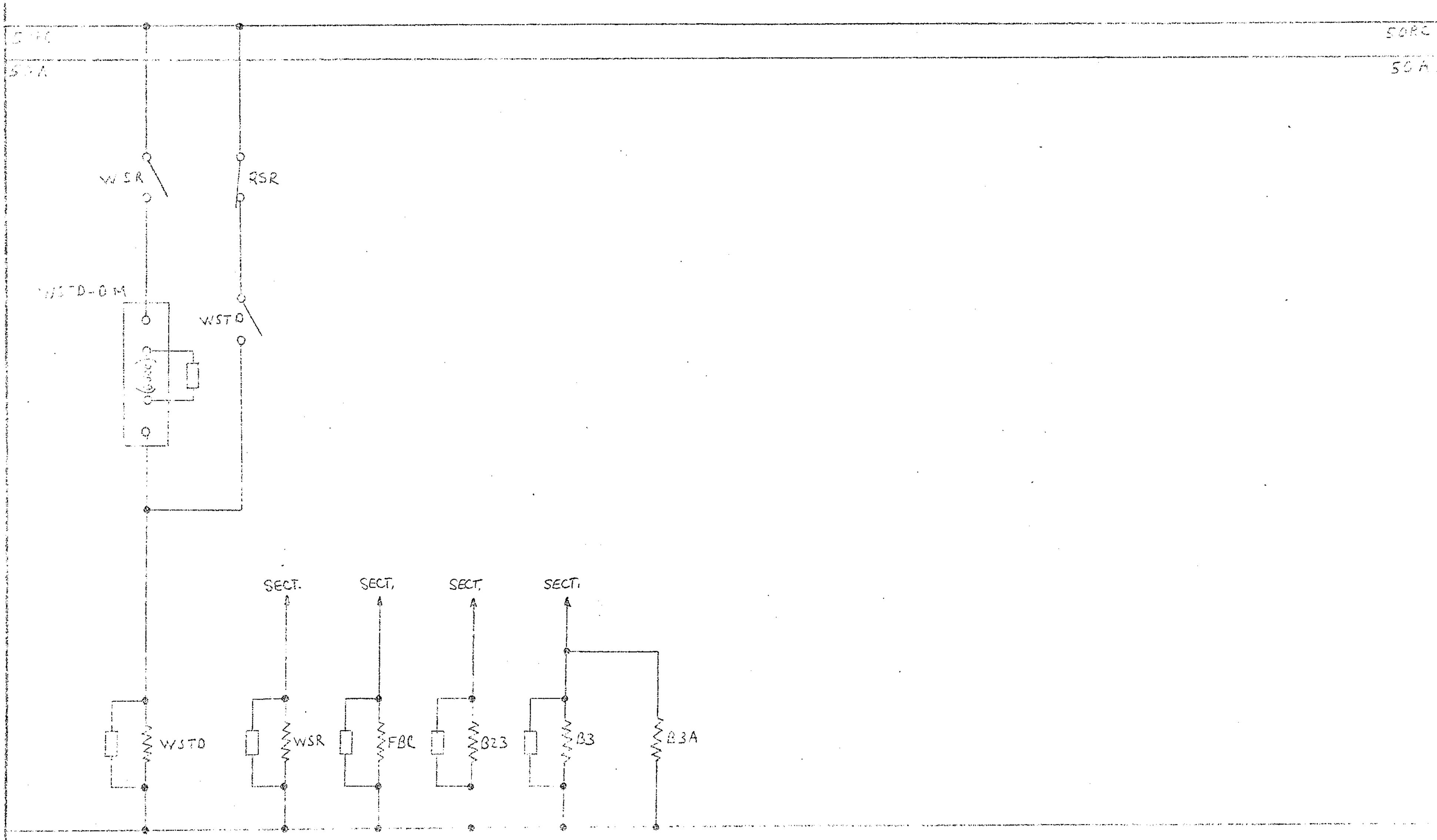
SCHEMATIC DIAGRAM
CONTRACT DOT-FR-9087

9/14/72

4125A1084

H6 : H7

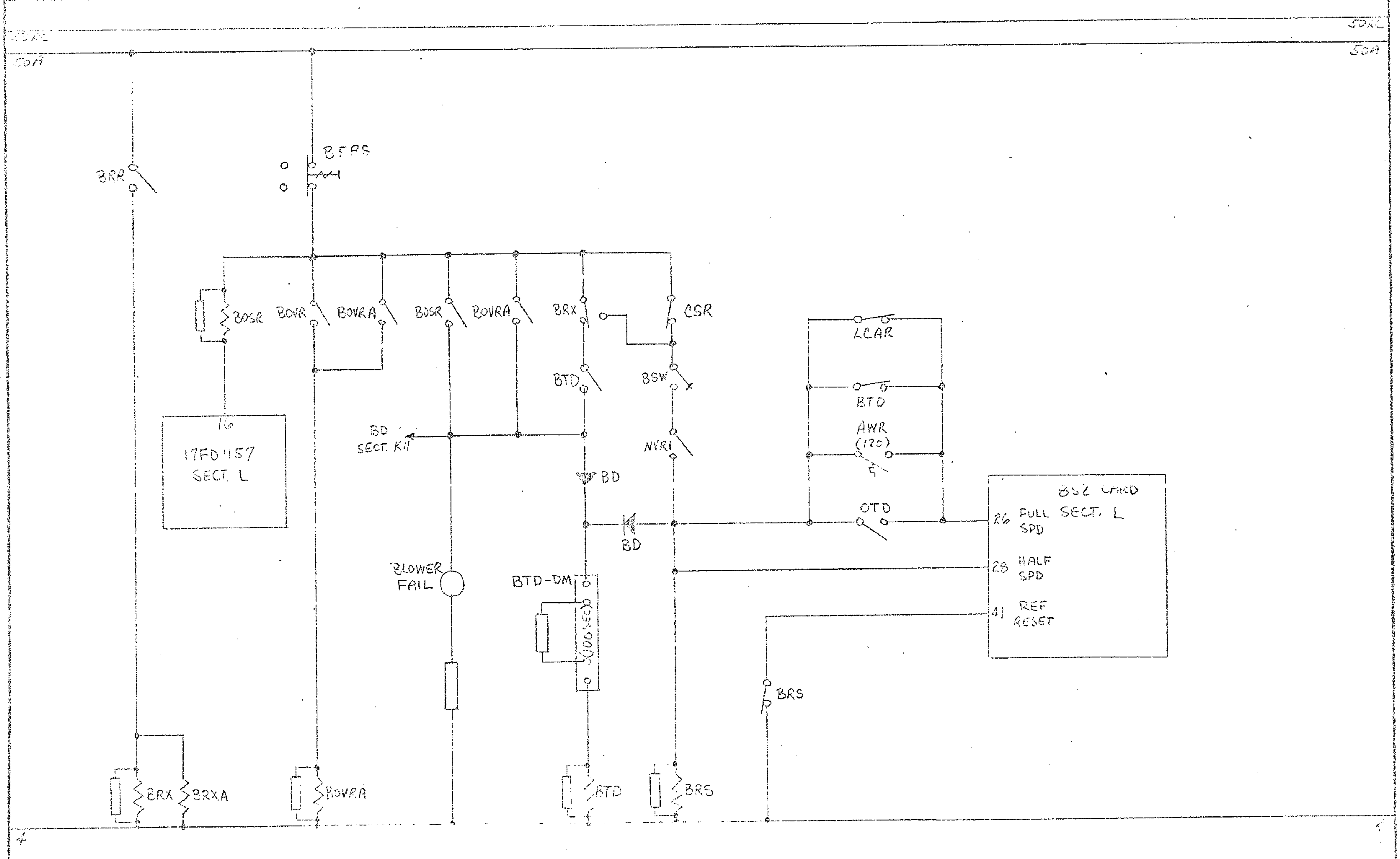
CONT. ON SH.	SH. NO	PROPULSION CONTROL	SECT. H8	SECT. H9	PROPULSION CONTROL	REV. NO



TITLE SCHEMATIC DIAGRAM E60 CHOPPER
FIRST MADE FOR AMTRAK & DOT

MADE BY Hopkins 10/22/79
ISSUED
APPROVAL
GENERAL ELECTRIC CO.
41B541054
H8 | H7

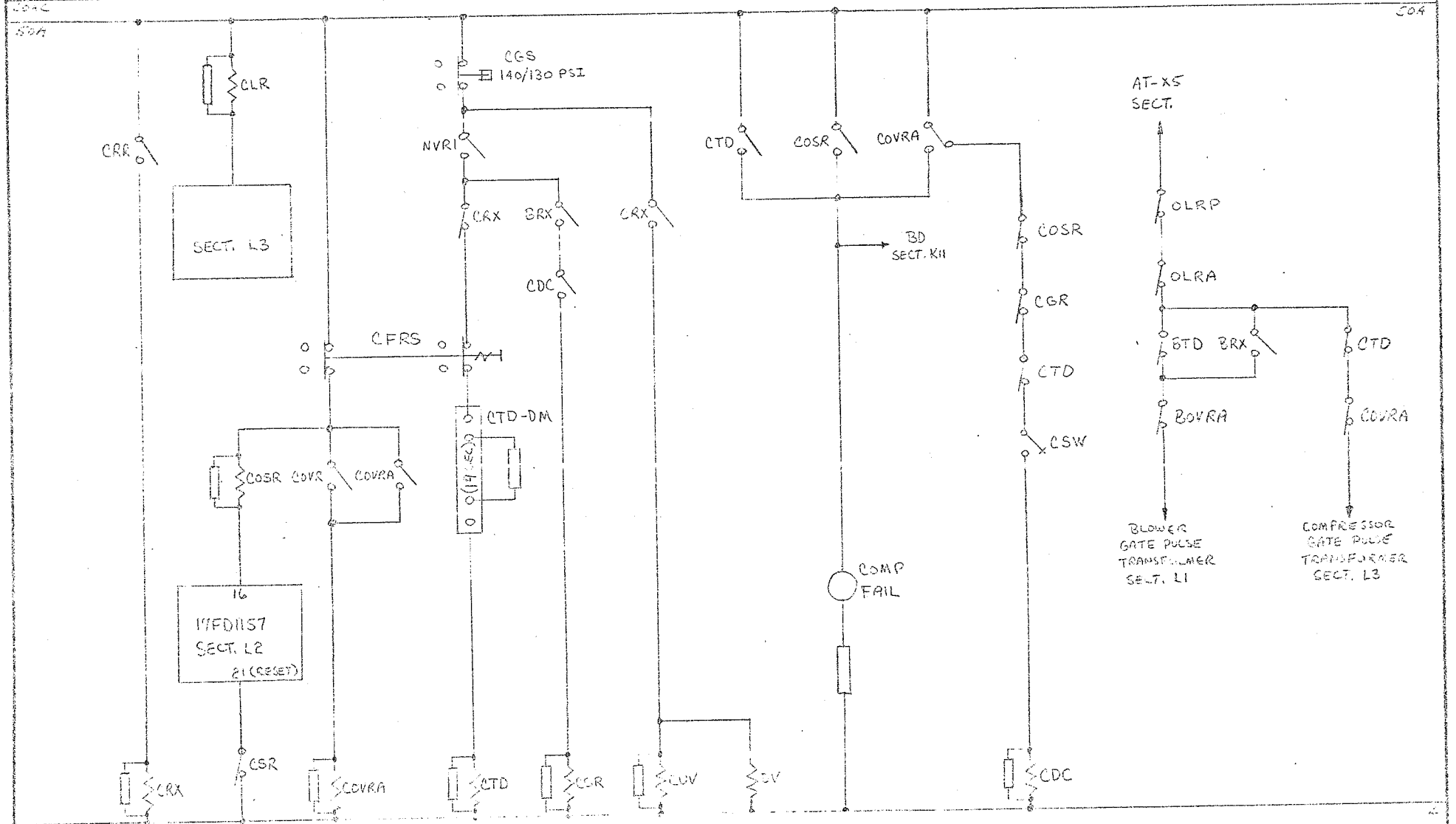
CONT. ON SH.	SH. NO.	BLOWER CONTROLS	SECT. J	SECT. J1	BLOWER CONTROLS	REV. NO.



TITLE	MADE BY	APPROVAL		ERIE PLANT	
SCHEMATIC DIAGRAM E60 CHOPPER FIRST MADE FOR CONTRACT #-DOT-FR-9027	Hopkins 9/15/71 ISSUED		GENERAL ELECTRIC CO.		41B541084 CONT. ON SH. SH. NO.

J | J1

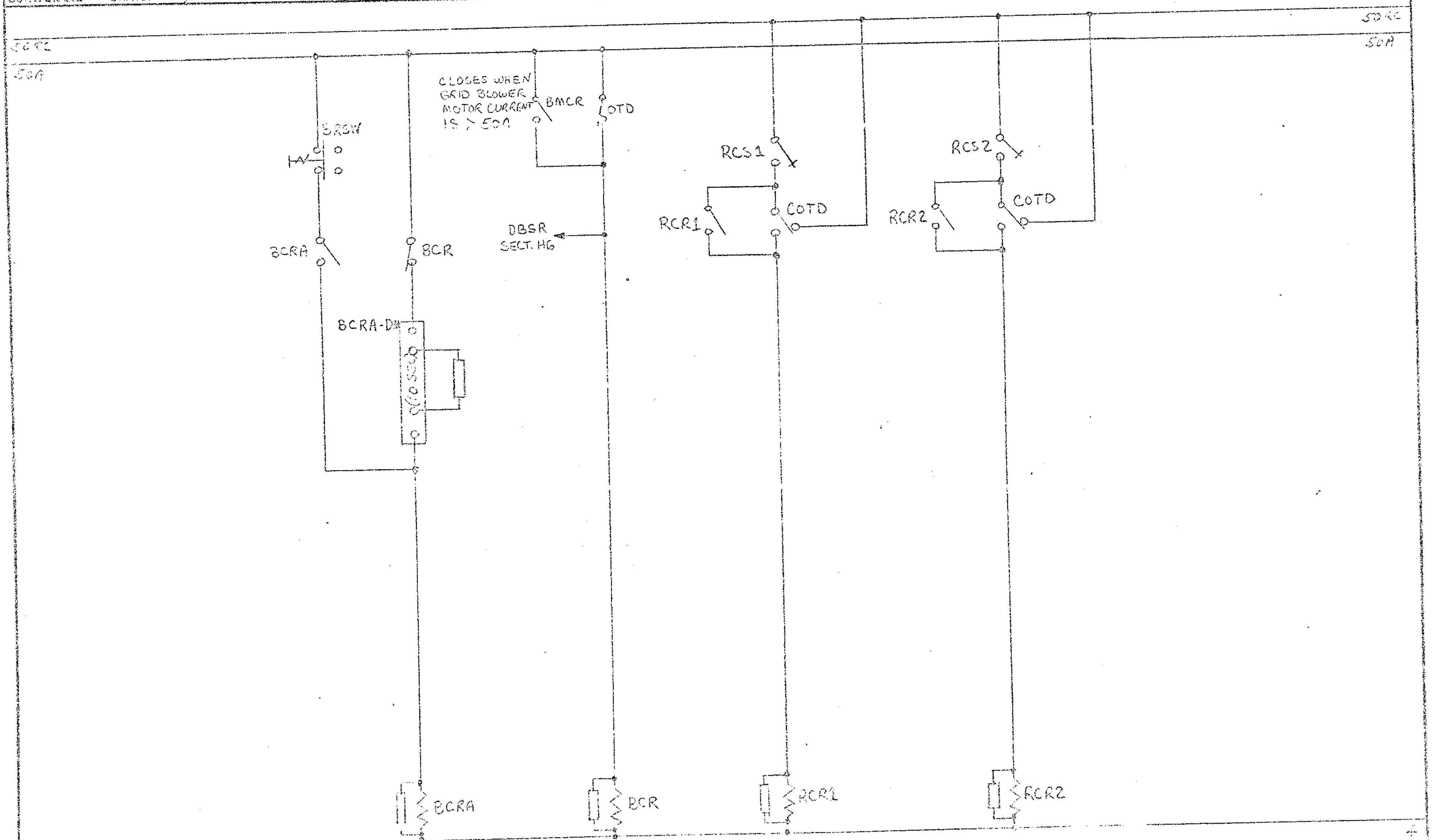
CONT. ON SH.	SH. NO.	COMPRESSOR CONTROLS	SECT. J2	SECT. J3	COMPRESSOR CONTROLS	REV. NO.



	TITLE	MADE BY	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT
		ISSUED			CONT. ON SH. SH. NO.

J2 | J3

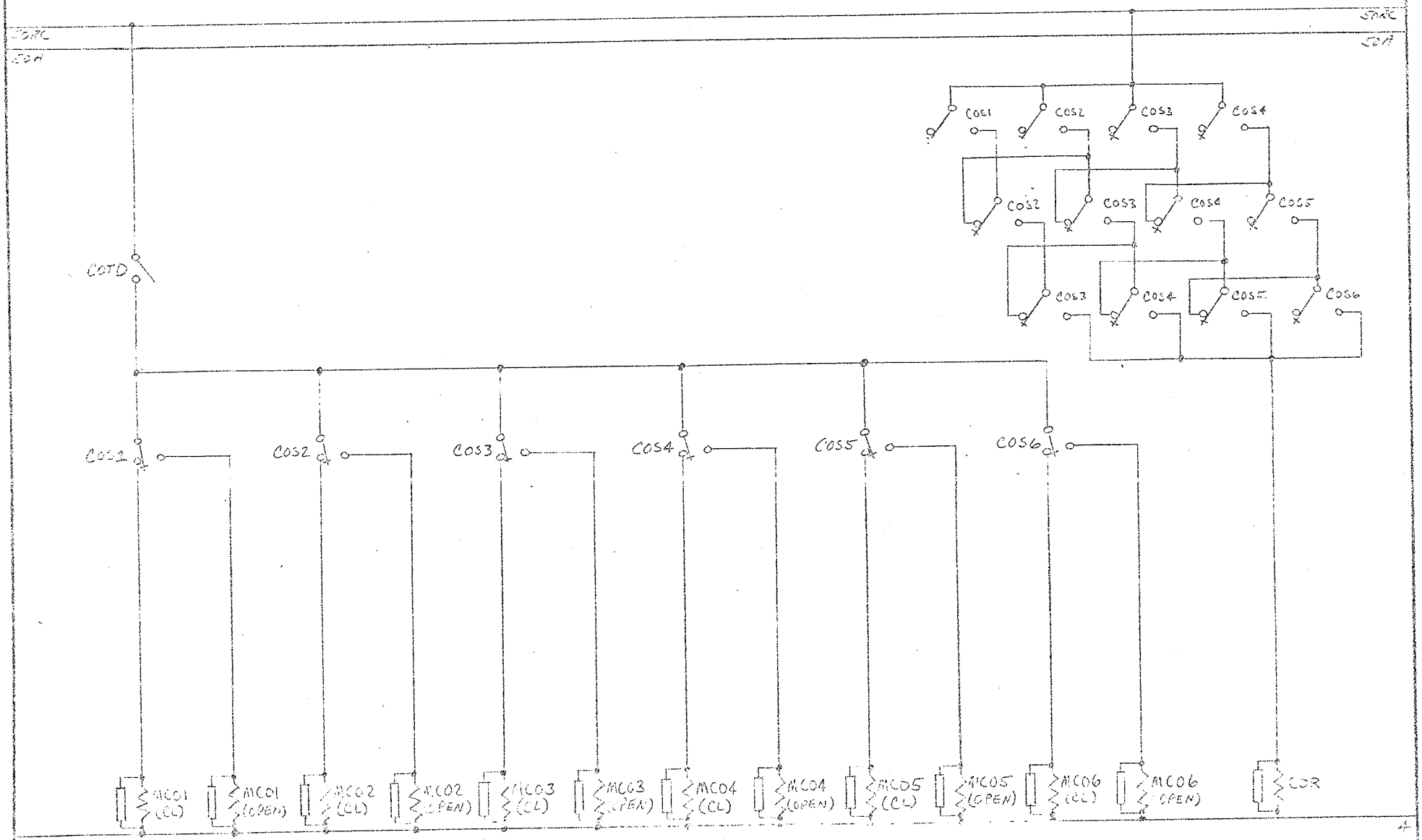
CONT. ON SH.	SH. NO.	BRAKING GRID PROTECTION	SECT. K	SECT. K1	RECTIFIER CUTOUT	REV. NO.



TITLE	SCHEMATIC DIAGRAM
FIRST MADE FOR	SANTA FE
MADE BY	
ISSUED	
APPROVAL	
GENERAL ELECTRIC CO.	ERIE PLANT
CONT. ON SH.	SH. NO.

K | K1

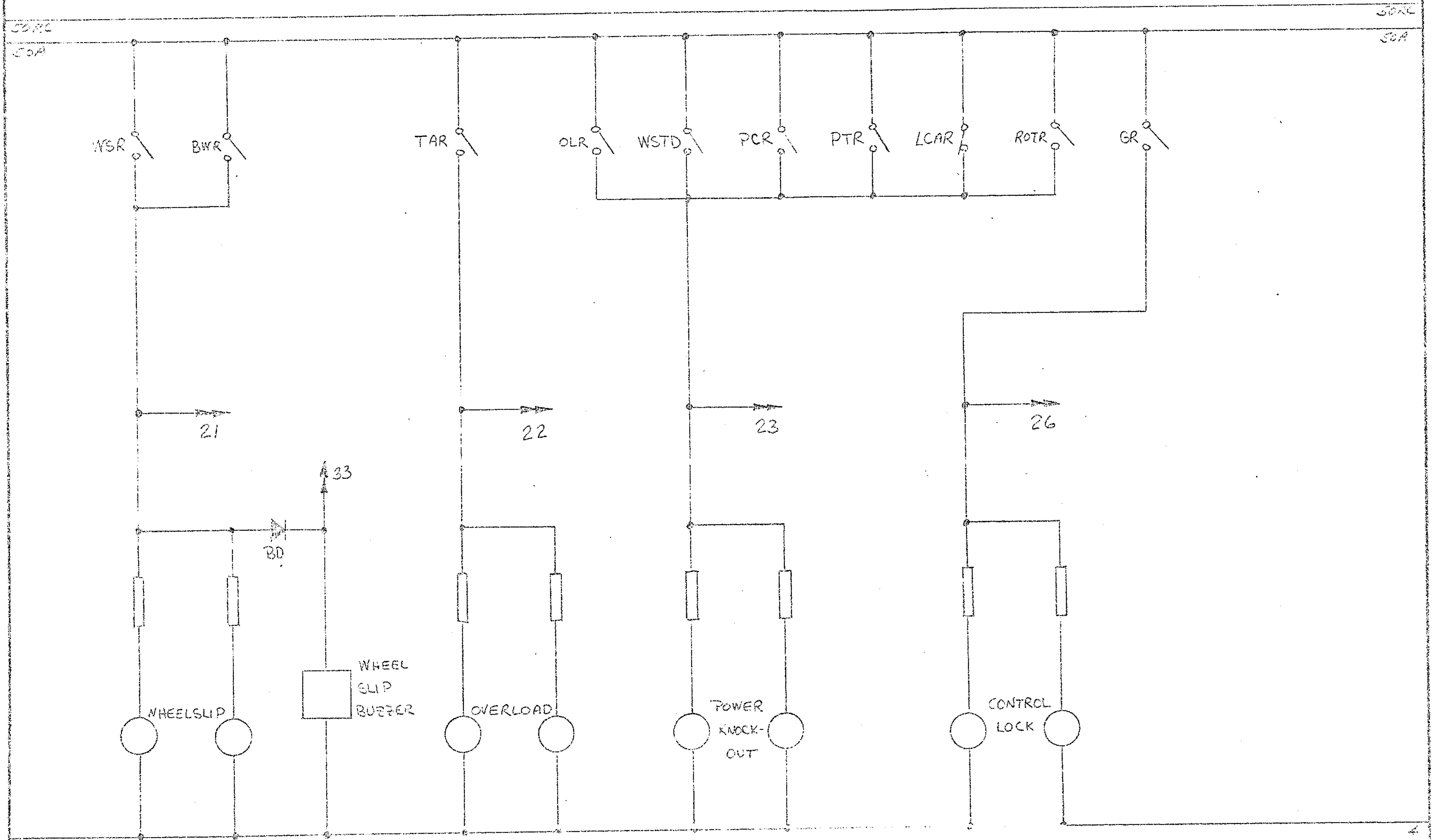
CONT. ON SH.	SH. NO.	MOTOR CUTOUT	SECT. K2	SECT. K3	MOTOR CUTOUT	REV. NO.



DESIGN	TITLE: SCHEMATIC DIAGRAM ELD CONTROL FIRST MADE FOR	MADE BY ISSUED	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT CONT. ON SH.

K2 & K3

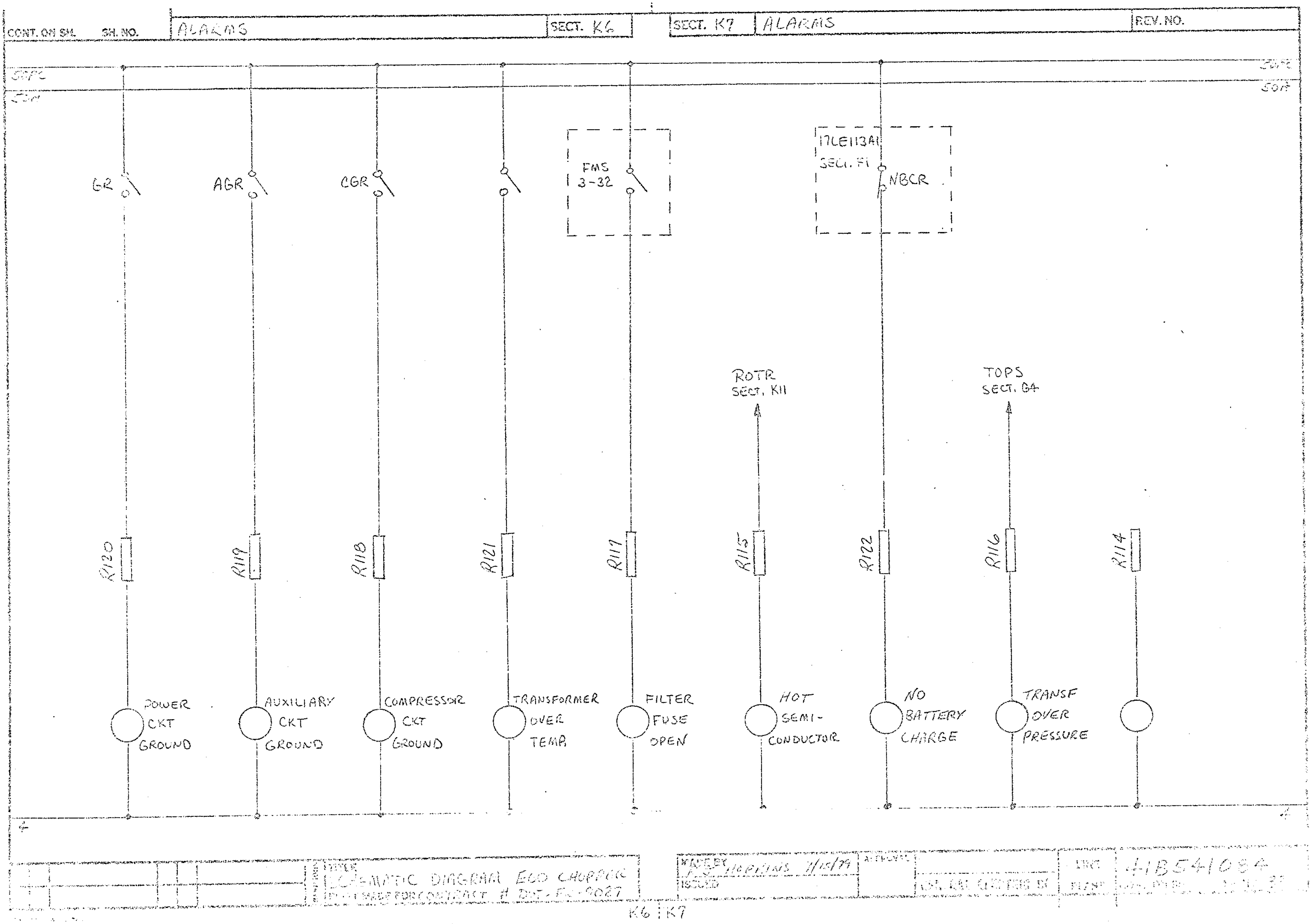
CONT. ON SH.	SH. NO.	CONSOLE LIGHTS	SECT. K4	SECT. K5	CONSOLE LIGHTS	REV. NO.

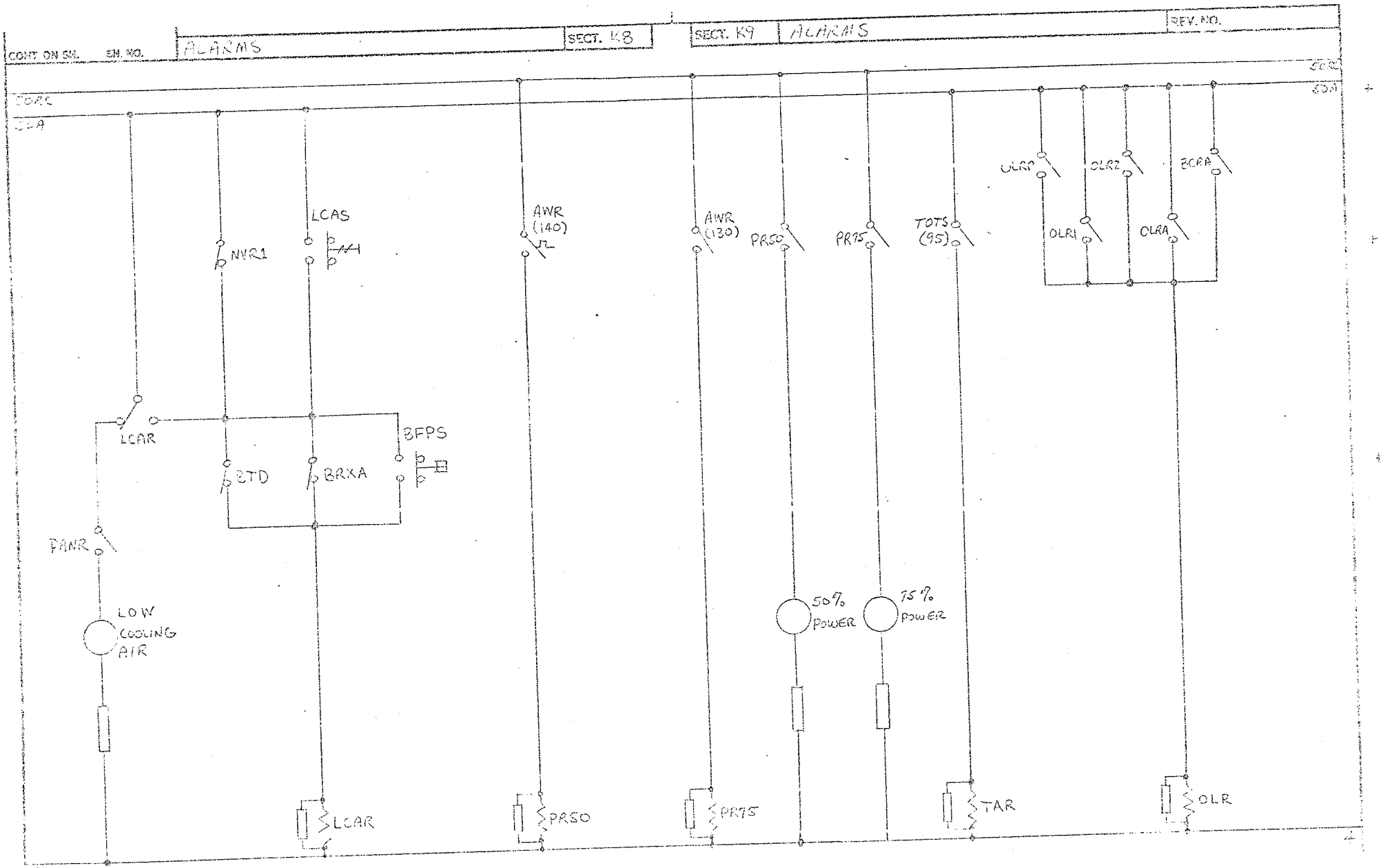


TITLE [illegible] DIAGRAM E.O. CHOPPER
FIRST MADE FOR [illegible]

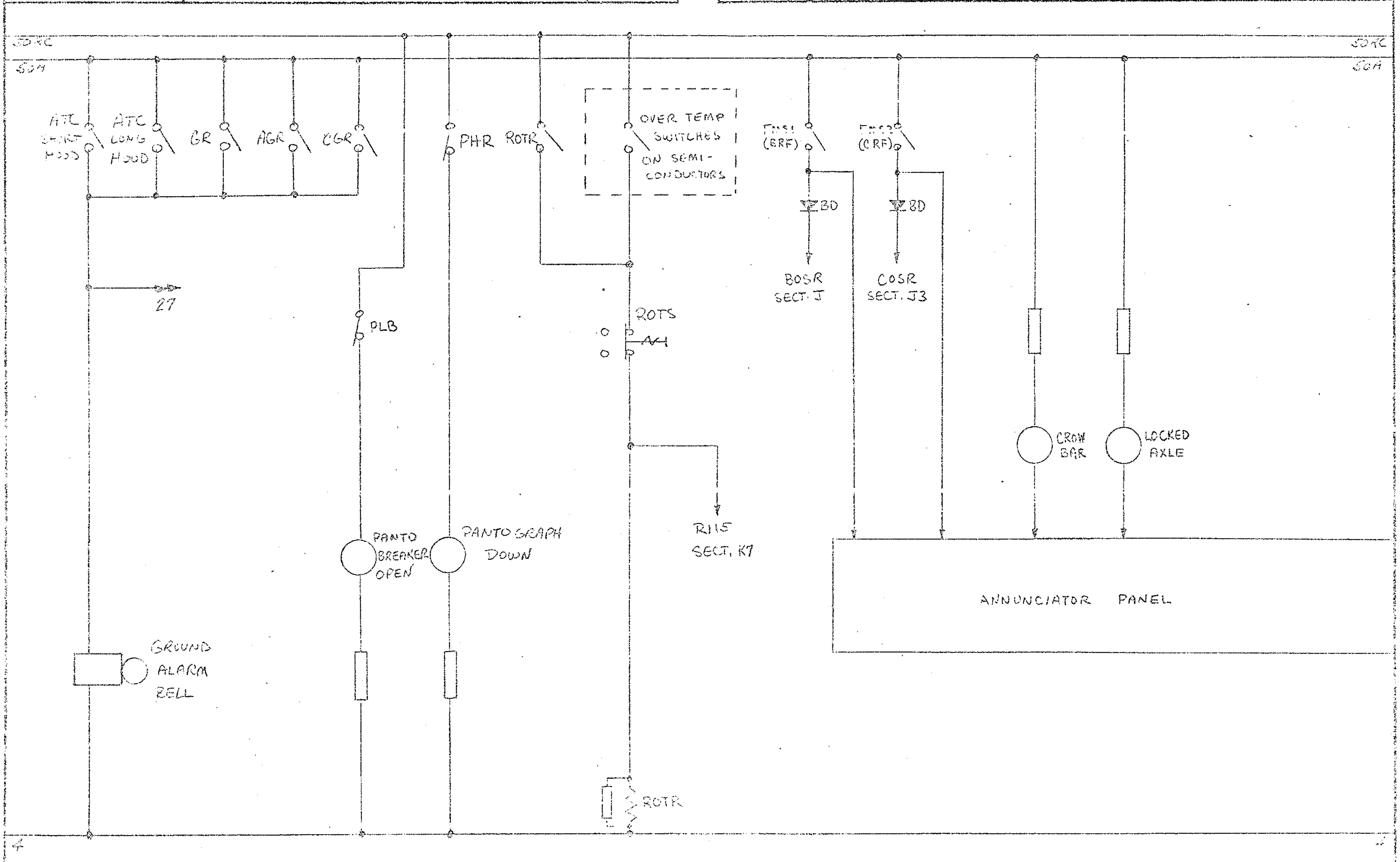
MADE BY [illegible] [illegible]
ISSUED
APPROVAL
GENERAL ELECTRIC CO.
PLANT
41B541284
CONT. ON [illegible]

K4 | K5


CONT. ON SH.
SH. NO.
ALARMS
SECT. K6
SECT. K7
ALARMS
REV. NO.
GR
AGR
CGR
FMS 3-32
17LE113A1 SECT. F1
NBCR
ROTR SECT. K11
TOPS SECT. G4
R120
R119
R118
R121
R117
R115
R122
R116
R114
POWER CKT GROUND
AUXILIARY CKT GROUND
COMPRESSOR CKT GROUND
TRANSFORMER OVER TEMP.
FILTER FUSE OPEN
HOT SEMI-CONDUCTOR
NO BATTERY CHARGE
TRANSF OVER PRESSURE
41B541084
K6 K7


CONT ON SH.
SH. NO.
ALARMS
SECT. K8
SECT. K9
ALARMS
REV. NO.
50R
50A
NVR1
LCAS
AWR (140)
AWR (130)
PR50
PR75
TOTS (95)
OLR1
OLR2
OLR3
OLR4
LCAR
BFPS
ETD
BRXA
PANR
LOW COOLING AIR
50% POWER
75% POWER
LCAR
PR50
PR75
TAR
OLR

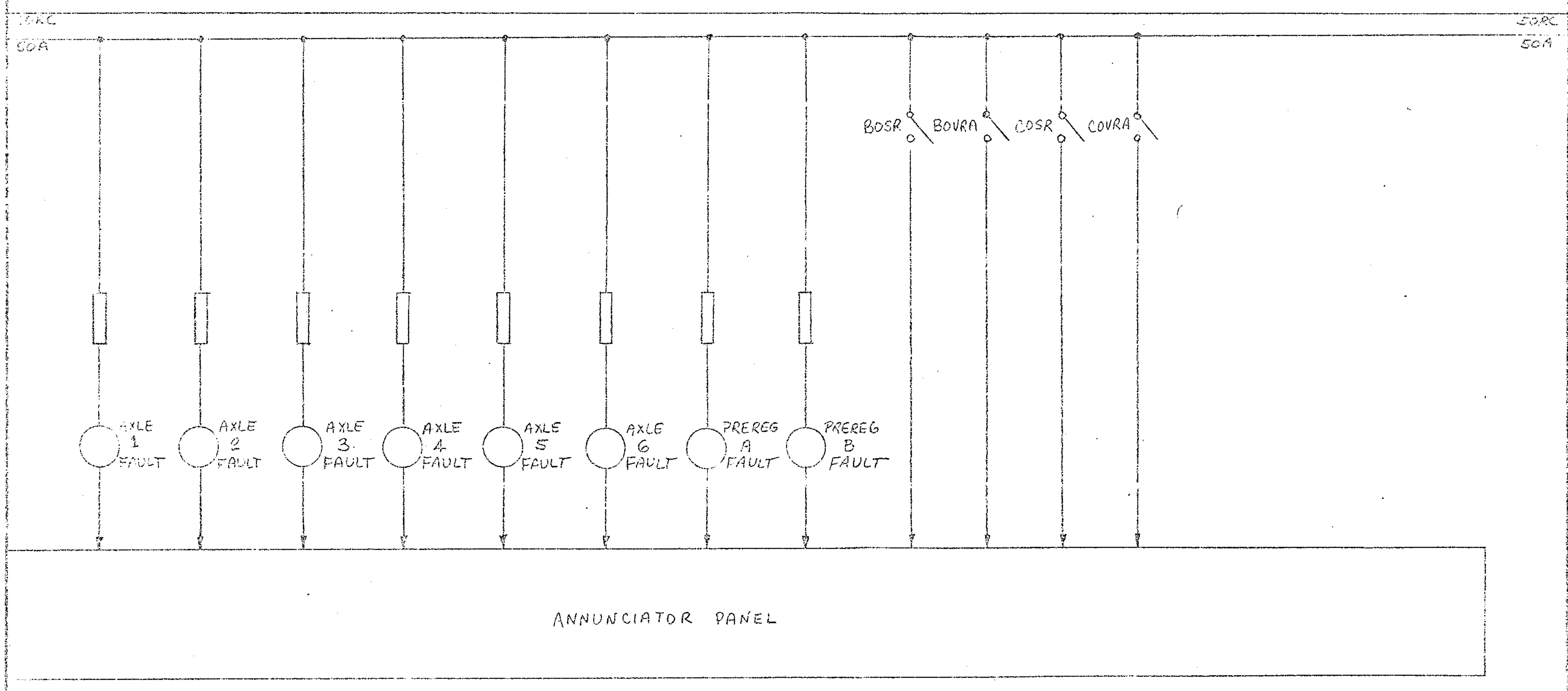
CONT. ON SH. SH. NO. | ALARMS | SECT. K10 | SECT. K11 | ALARMS | REV. NO.



TITLE | FIRST MADE FOR | MADE BY | ISSUED | APPROVAL | GENERAL ELECTRIC CO | ERIE PLANT | 41B541084 | CONT. ON SH. | SH. NO.

K10 | K11

CONT. ON SH.	SH. NO.	ALARMS	SECT. K12	SECT. K13	ALARMS	REV. NO.

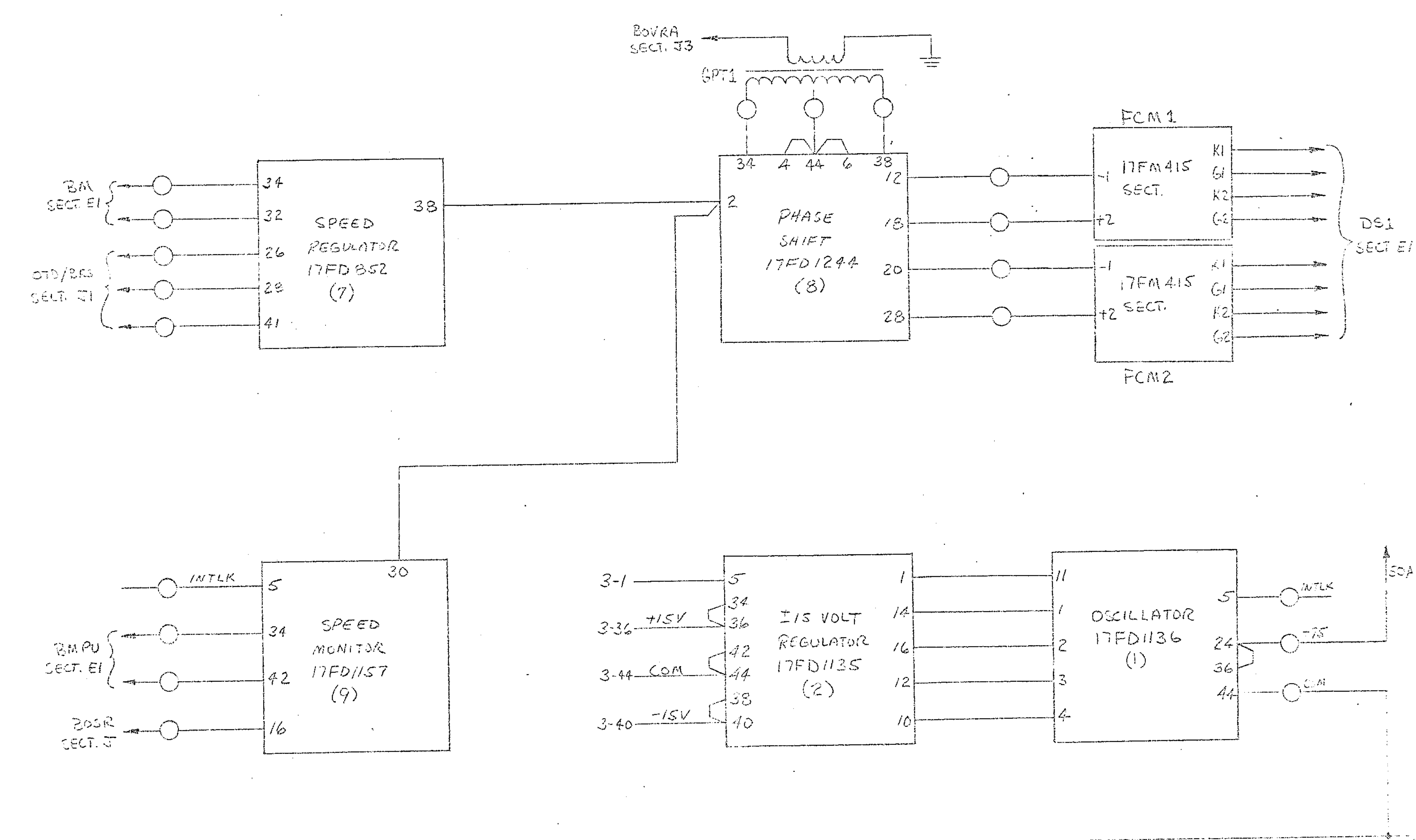


TITLE SCHEMATIC DIAGRAM E60 CHOPPER FIRST MADE FOR	MADE BY 12/6/77 ISSUED	APPROVAL
GENERAL ELECTRIC CO.	ERIE PLANT	41BJ41084 CONT. ON SH. SH. NO.

K12: K13

CONT. ON SH. | SH. NO. | BLOWER BLOCK DIAGRAM | SECT. L

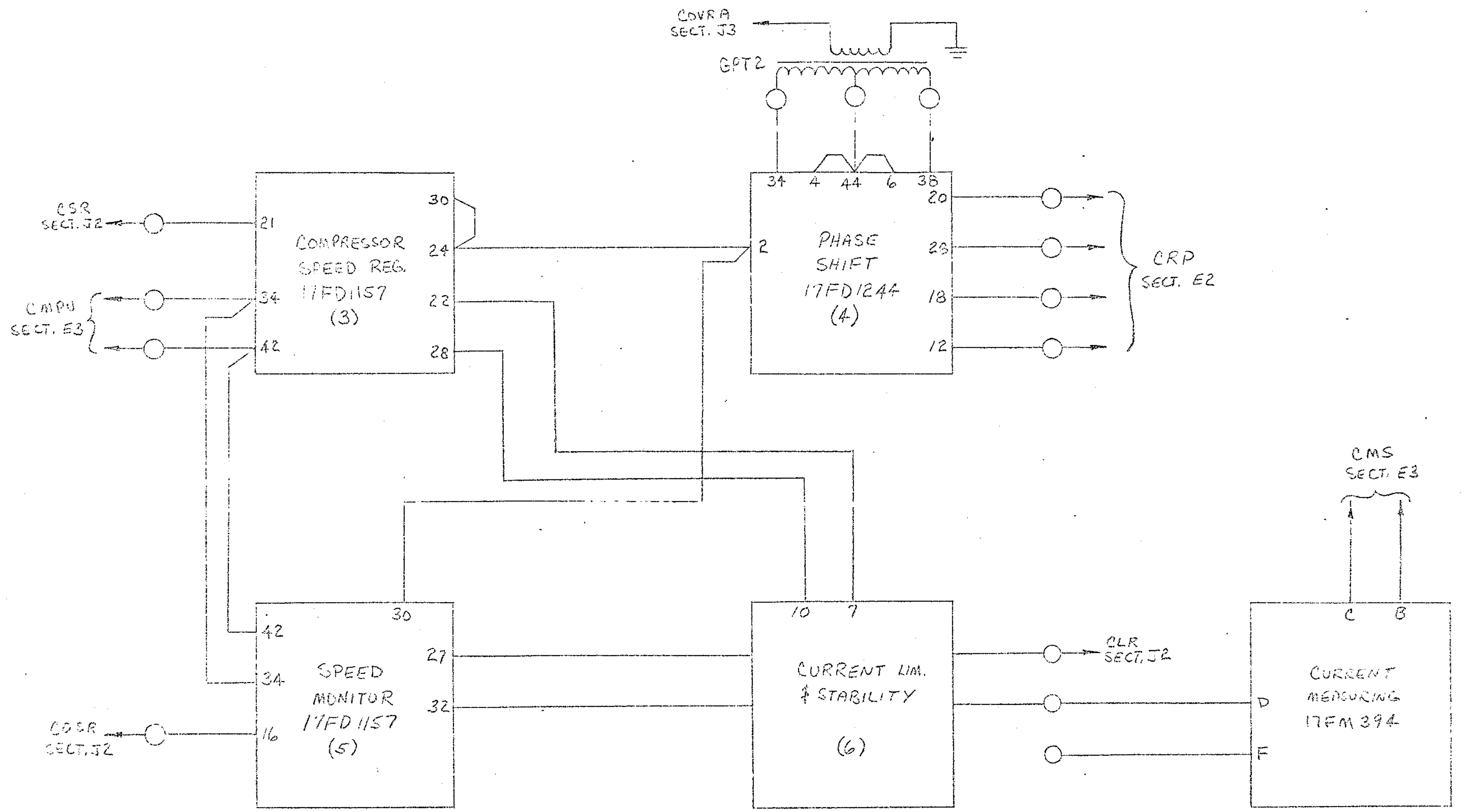
SECT. L1 | BLOWER BLOCK DIAGRAM | REV. NO.



TITLE	SCHEMATIC DIAGRAM FOR CHOPPER
FIRST MADE FOR	
MADE BY	HOPKINS 9/23/74
ISSUED	
APPROVAL	
GENERAL ELECTRIC CO.	ERIE PLANT
41B541C84	CONT. ON SH. / SH. NO.

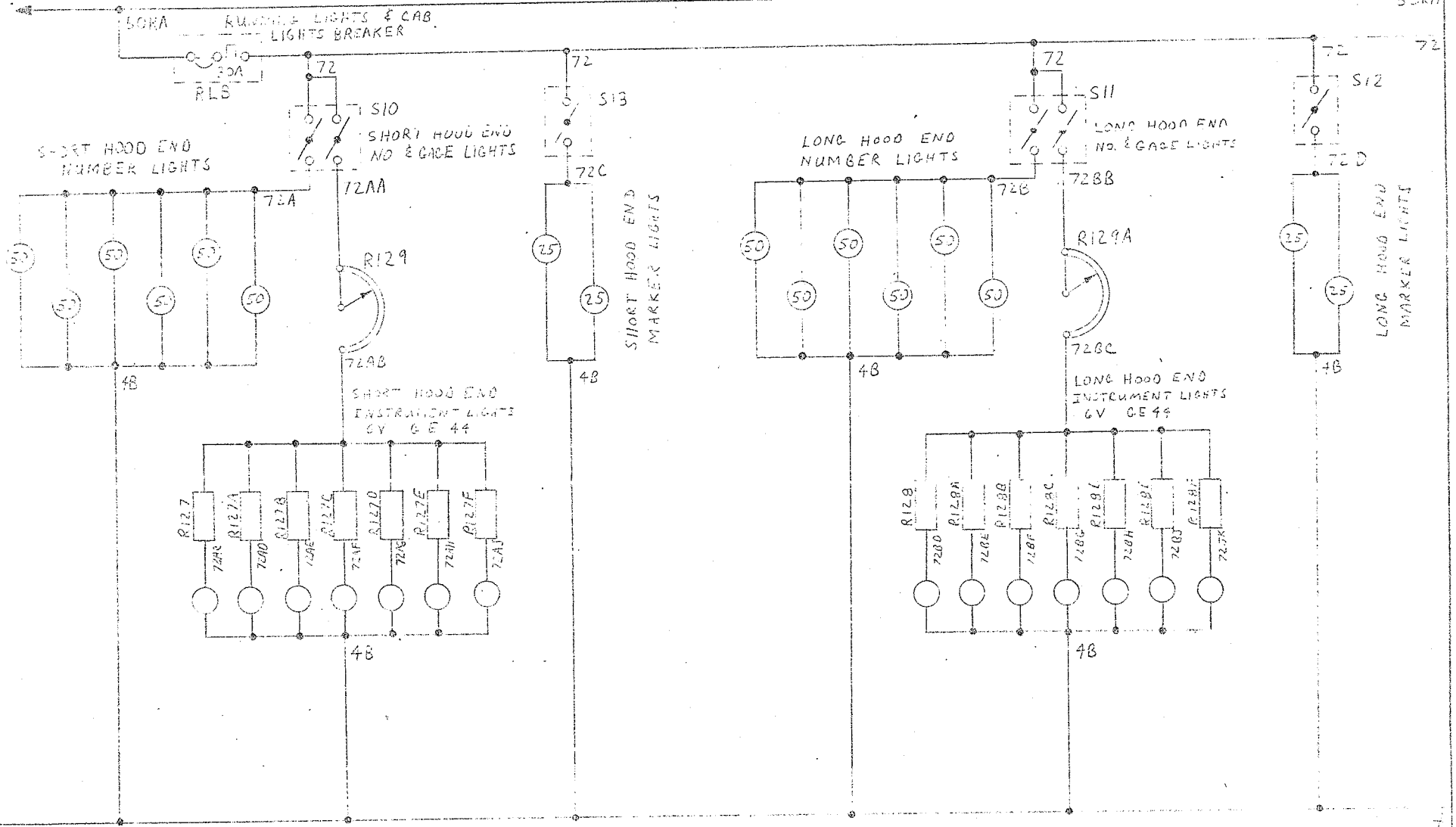
L | L1

CONT. ON SH.	SH. NO.	COMPRESSOR BLOCK DIAGRAM	SECT. L2	SECT. L3	COMPRESSOR BLOCK DIAGRAM	REV. NO.



TITLE SCHEMATIC DIAGRAM EGO CHOPPER	MADE BY ... 4/27/79	APPROVAL		SP'E	41B541084
FIRST MADE FOR CONTRACT # DOT-TR-1027	ISSUED		GENERAL ELECTRIC CO.	PLANT	CONT. ON SH.

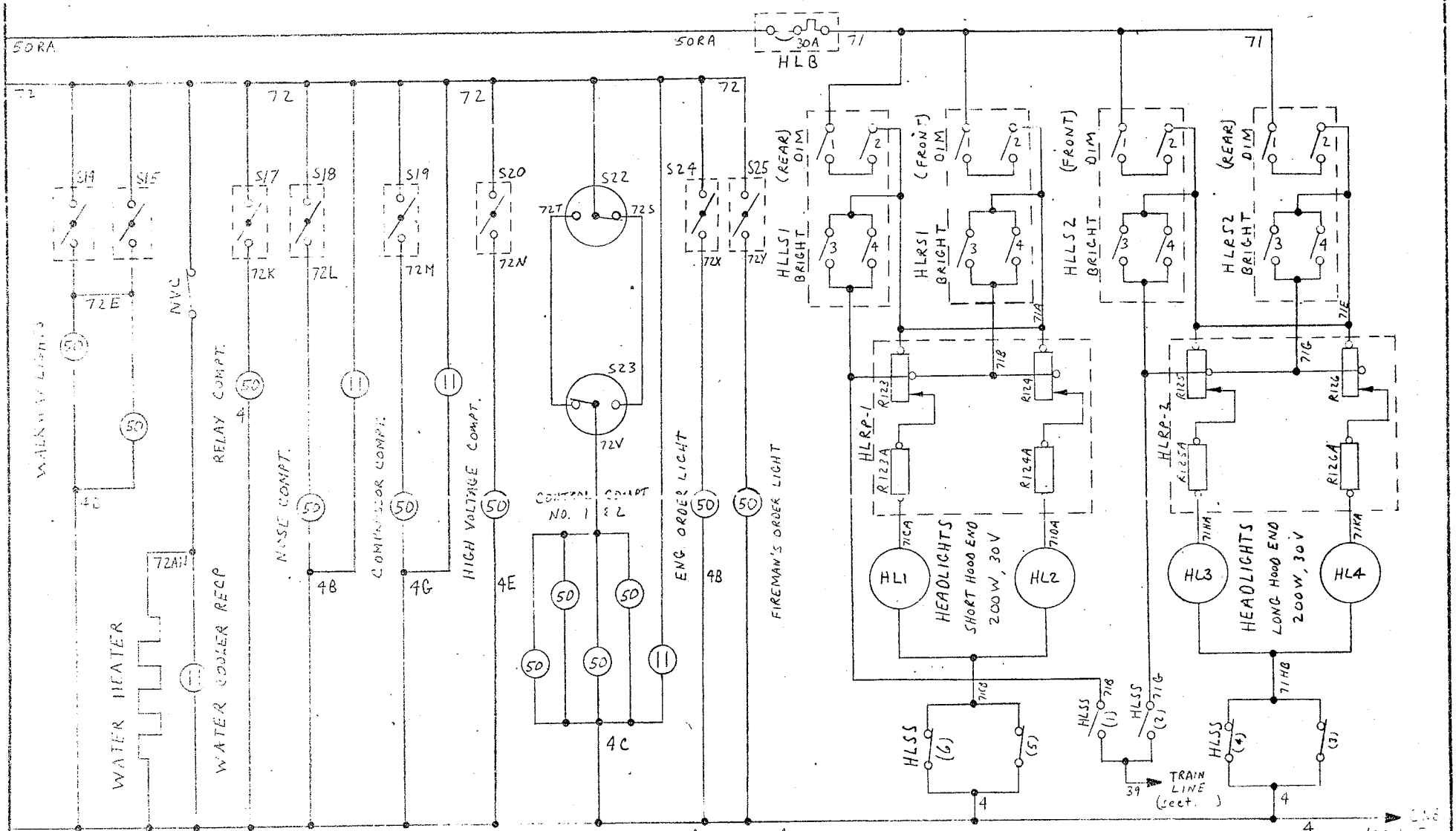
L2 : L3



REVISIONS	TITLE	MADE BY	APPROVAL	TRANS. SYSTEMS BUS. DIV.	ERIE	4185410G4
		ISSUED		GENERAL ELECTRIC	PLANT	CONT. ON SH. SH. NO.

M M1

CONT. ON SH.	SH. NO.	LIGHTING	SECT. M2	SECT. M3	LIGHTING	REV. NO.



TITLE: SCHEMATIC DIAGRAM EGO CHOPPER FIRST MADE FOR CONTRACT # DOT-FR-9027	MADE BY R.J. HOPKINS 10/22/79 ISSUED	APPROVAL	GENERAL ELECTRIC CO.	ERIE PLANT	4185541084 CONT. ON SH. SH. NO. 40

M2 : M3

CONT. ON SH.	SH. NO.	RELAY LOCATIONS	SECT. Z

RELAY	COIL	COIL OHM	L-CONTACTS-R 1	2	3	4	5
AGR	E	5.08(T)	–	–	–	–	
AGR	G3	293(R)	G4	K6	K10		
BCR	K	2860	K				
BCRA	K	2860	K	K9	H4		
BMCR	D1		K				
BOSA	J	2860	G4	J			
BOVR	E1	180	J	–	–	–	–
BOVRA	J	2860	G4	J	J	J3	
BPR	E1	180	J	–	–	–	–
BPC	J	2860	J1				
BRX	J	463	E1	J	J2	J3	
BRXA	J	2860	K8	K8			
BTO	J	463	J	J1	J3	K8	
BVR	D1	180	K4	–	–	–	–
BVRA	K	2860	H4				
CER	D1		G4				
CGR	E2	5.08(T)	–	–	–	–	
CGR	G3	293(R)	J3	K6	K10		
CLR	J2	2860					
COR	K2	2860	H4				
CDCR	J2	2860		J3	J3		
COTC	H4	463	K1	K1	K2		
COVR	E3	180	J2	–	–	–	–
COVRA	J2	2860		J2	J3	J3	
CPR	E3	180	J2	–	–	–	–
CRX	J2	463	E3	J2	J2		
CCR	J2	2860	J	J2			
CTD	J2	2860	J3	J3	J3		
DSCR	H4	463	H	H	H4	H6	
DIR	G2	2860	G2	G3	G5		
FFR	K11	2860	H				
FRLS	G2	463	E1	E1	E1	E1	
FRTD	G2	463	E1	E1	E1	E1	
GR	C	5.08(T)	–	–	–	–	
GR	G2	293(R)	G4	H	K6	K10	K5
LCAR	K3	463	–	J	K5	K3	K3

RELAY	COIL	COIL OHM	L-CONTACTS-R 1	2	3	4	5
MR	H	463	H1	H4			
NBCR	F1	2860	K7				
NBR	H1	463	H2				
NVR1	E1	2860	H	J	J2	K8	
NVR2	E1	2860					
OFFR	H5	463	H4				
OLR	K9	463	G1	K4			
OLR1	G5	2860	G5	K9			
OLR2	G5	2860	G5	K9			
OLRA	G5	2860	G5	J3	K9		
OLRP	G5	2860	G5	J3	K9		
OTD	H3	620	H1	J1	K		
PANR	G3	2860	G1	G3			
PDR	G1	2860	G1				
PHR	G1	2860	G1	G2	K10		
PCR	H3	463	H	K5			
POCR	C	0.08	G4				
PR50	K8	2860	K9				
PR75	K9	2860	K9				
PTR	G4	2860	G1	G3	H	K5	
PUR	G1	2860	G1				
PUTD	G2	2860	G2				
RCR	H	620	H				
RCR1	K1	463	H1	H5	K1		
RCR2	K1	463	H1	H5	K1		
ROTR	K10	2860	H3	K10			
RSR	H4	2860	G3	K			
SOCR1	C	0.0032	G5				
SOCR2	C	0.0032	G5				
SOCRA	C	0.0032	G5				
THR	H3	463	H2				
WSR	H3	463	H3	K4			
WSTD	H3	463	H1	H3	K4		
AWR	C		T1	K8	K9		
VSR	G3		G3				
TAR	K9	463	G5	K4			

SECT. Z1	RELAY LOCATIONS	REV. NO.

RELAY	COIL	COIL OHM	L-CONTACTS-R 1	2	3	4	5	RELAY	COIL	COIL OHM	L-CONTACTS-R 1	2	3	4	5

CONTACTOR	COIL	COIL OHM	L - CONTACTS - R 1	2	3	4	5	6	7	8

REVISIONS

TITLE SCHEMATIC DIAGRAM EGO CHOPPER
FIRST MADE FOR CONTRACT # DOT-FR-9027

MADE BY S.J. HOPKINS 10/22/79
ISSUED
APPROVAL
GENERAL ELECTRIC CO.
ERIE PLANT
41B541084
CONT. ON SH. SH. NO.

Z | Z1