DANE COUNTY DEPARTMENT of PUBLIC WORKS, HIGHWAY and TRANSPORTATION

County Executive
Joseph T. Parisi

1919 Alliant Energy Center Way ◆ Madison, Wisconsin 53713
Phone: (608) 266-4018 ◆ Fax: (608) 267-1533

Commissioner / Director
Gerald J. Mandli

May 5, 2014

ATTENTION ALL REQUEST FOR PROPOSALS (RFP) HOLDERS

RFP NO. 314012 - ADDENDUM NO. 1

GAS ENGINE – GENSET FUEL BLENDING CONTROL SYSTEM

BIDS DUE: THURSDAY, MAY 15, 2014, 2:00 PM. DUE DATE AND TIME ARE NOT CHANGED BY THIS ADDENDUM.

This Addendum is issued to modify, explain, or clarify the original Request for Proposals (RFP) and is hereby made a part of the RFP. **Proposers must acknowledge all Addenda in their Proposal.**

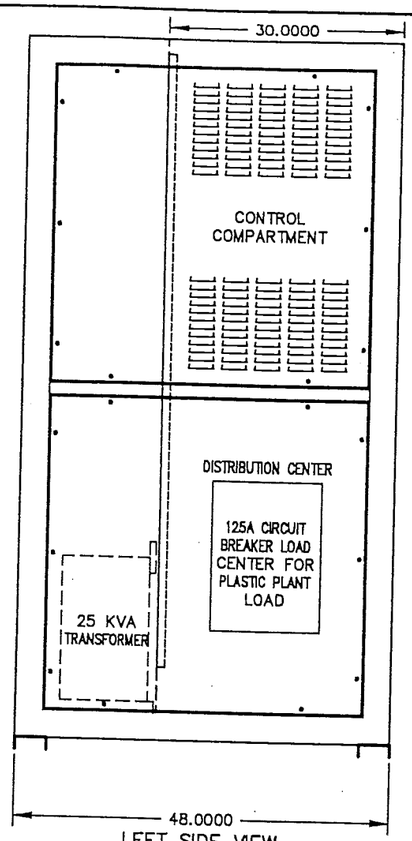
PLEASE MAKE THE FOLLOWING CHANGES:

This Addendum Provides the Following Additional Information on the Existing Gas to Energy System:

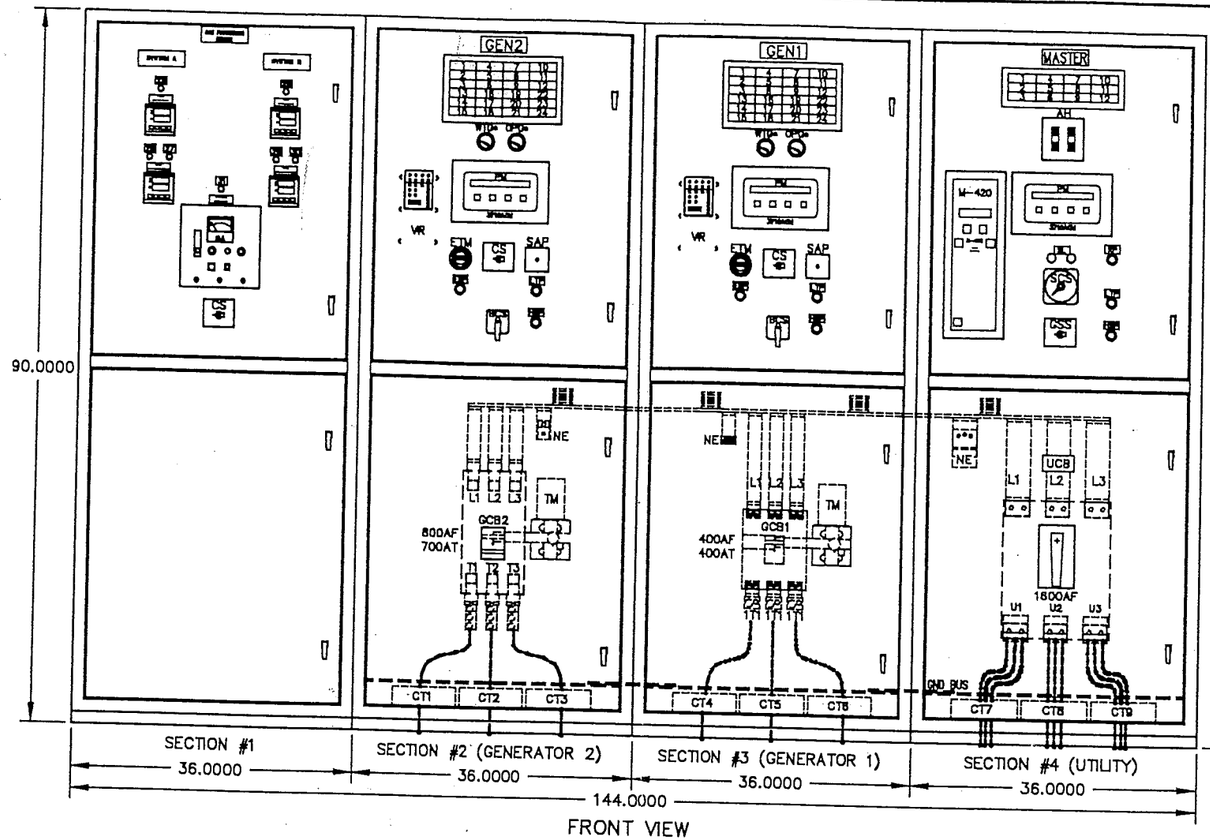
1. **Control Schematics**

2. **Woodward 2301A Electronic Load Sharing and Speed Controls Manual**

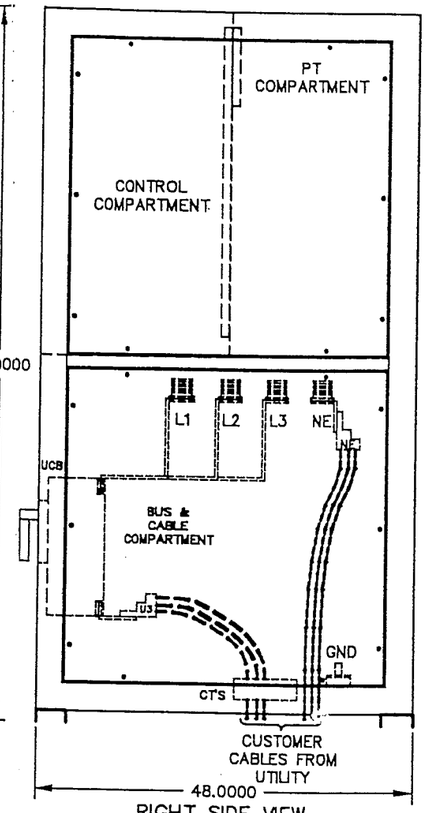
Enclosures:
1. Control Schematics for the existing landfill gas to energy system
2. Woodward 2301A Electronic Load Sharing and Speed Controls Manual



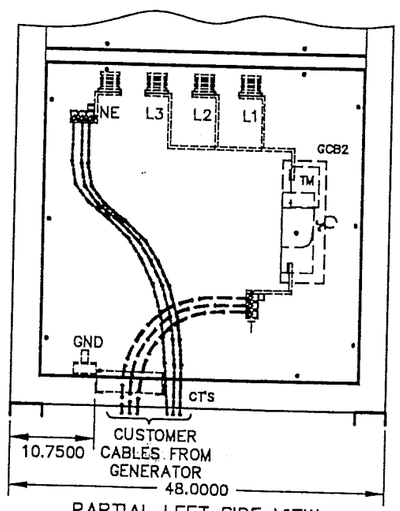
LEFT SIDE VIEW
(Showing Detail of Sec 1)



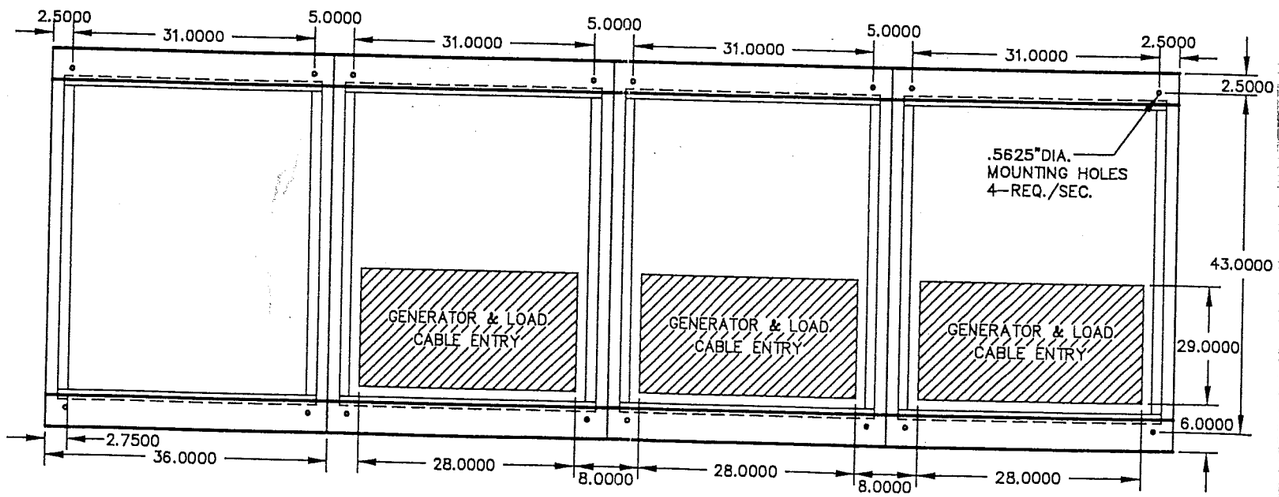
FRONT VIEW



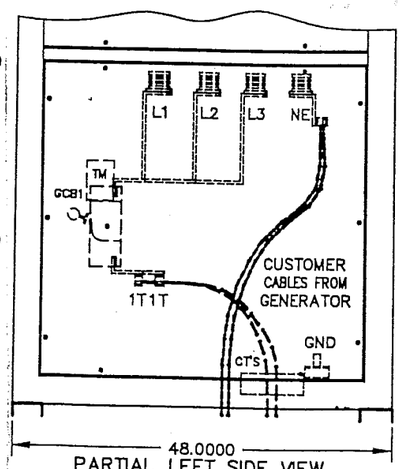
RIGHT SIDE VIEW
(Showing Detail of Sec 4)



PARTIAL LEFT SIDE VIEW
(Showing Detail of Sec 2)



BOTTOM VIEW
(Showing Mounting Holes & Recommended Cable Access Areas From Bottom)



PARTIAL LEFT SIDE VIEW
(Showing Detail of Sec 3)

DANE COUNTY
CUSTOMER

TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE .075=1	REVISIONS	BY	DATE
DATE 121384			
DR'N DM CK'D	2) CLARIFY DRAWING	WD	022095
APP'VD	1) ADDED GAS PROCESSING CTR	DJA	021495

TITLE: GENERATOR SWITCHBOARD OUTLINE

NO. 952-0148-02
SHT 1 OF 2

OUTLINE NOTES

1) SPECIFICATIONS:
   A) SWITCHGEAR IS FOR USE WITH (1) 420KW & (1) 250KW GENERATOR SETS AT 480/277VAC 3PHASE 4WIRE 60HZ.
   B) ALL CIRCUIT BREAKERS, CONTACTORS & DISCONNECT SWITCHES, IF APPLICABLE, ARE 3POLE (UNLESS NOTED).
   C) NOMENCLATURE DESCRIPTIONS, IF NOT ON THIS DRAWING (REFER TO LAKE SHORE DRAWING #952-0148-10)
   D) * = EQUIPMENT SUPPLIED BY CUSTOMER.

2) ENCLOSURE CONSTRUCTION:
   A) NEMA 1, FREE-STANDING, 14GA. SHEET METAL WITH 1.5"x4" 7 GA. CHANNEL BASE.
   B) (2) HINGED FRONT DOOR(S),
      (2) REMOVABLE REAR PANEL(S),
      (1) REMOVABLE ROOF PANEL,
      (2) REMOVABLE SIDE PANELS PER SIDE EACH SECTION AND OPEN BOTTOM FOR CABLE ENTRY.
   C) ENCLOSURE TO BE BUILT AS (1) UNIT(S), INDIVIDUAL SECTIONS CAN NOT BE SEPARATED.
   D) MOUNTING DIMENSIONS ARE ±.125" ALL OTHER DIMENSIONS ARE APPROXIMATE.

3) ENCLOSURE FINISH:
   A) PRIMED AND PAINTED ANSI 61

4) BUSING CONSTRUCTION:
   A) TO BE BUSSED PER NEC.
   B) BUS SUPPORTS TO BE GLASTIC INSULATORS (GLASTIC#1461-1A LS#3152804).
   C) BUS SUPPORT SPACING TO BE 30"MAX.
   D) MAIN BUS TO BE (1) .375"x3" COPPER BUS PER PHASE & NEUTRAL (LS#0238300).
   E) 1600A FEEDERS (UCB) TO BE (1) .375"x3" COPPER BUS PER PHASE (LS#0238300) (UNLESS NOTED).
   F) 800A FEEDERS (GCB2) TO BE (1) .375"x1.75" COPPER BUS PER PHASE (LS#0238175) (UNLESS NOTED).
   G) 400A FEEDERS (GCB1) TO BE (1) .375"x1.75" COPPER BUS PER PHASE (LS#0238175) (UNLESS NOTED).
   H) MAIN GROUND BUS TO BE (1) .25"x2" COPPER BUS (LS#0225200) (UNLESS NOTED).
   I) BUS CLEARANCES TO BE AS FOLLOWS (MIN.):
      PHASE TO PHASE 1"
      PHASE TO GROUND 1"
      NEUTRAL TO GROUND 1"

5) LUG SCHEDULE:
   A) (1) 3HOLE LUG 3/0-500MCM (LS#1553301 GE#TCAL81) PER PHASE & NEUTRAL.
   B) (1) 3HOLE LUG 300-750MCM (LS#3320113 GE#TPLUG308) PER PHASE & NEUTRAL.
   C) (1) 2HOLE LUG 2/0-600MCM (LS#1552100 GE#TCAL43) PER PHASE & NEUTRAL.
   D) (3) 1HOLE LUG 6-250MCM (LS#1551209 DA 250) PER BREAKER (GROUNG LUG).

CIRCUIT BREAKERS

BREAKERS	FRAME	TRIP	SERVES	LUGS
GCB1	400	400	GENERATOR 1	NOTE"C"
GCB2	800	700	GENERATOR 2	NOTE"A"
UCB	1600	1600	UTILITY	NOTE"B"

GENERATOR ANNUNCIATOR

1 LOPL – LOW OIL PRESSURE LIGHT (RED)
2 PLOPL – PRE-LOW OIL PRESSURE LIGHT (AMBER)
3 LOLL – LOW OIL LEVEL LIGHT (AMBER)
4 HWTL – HIGH WATER TEMPERATURE LIGHT (RED)
5 PHWTL –PRE-HIGH WATER TEMPERATURE LIGHT (AMBER)
6 LWLL – LOW WATER LEVEL LIGHT (AMBER)
7 OSL – OVERSPEED LIGHT (RED)
8 O/UFL – OVER/UNDER FREQUENCY LIGHT (RED)
9 O/UVL – OVER/UNDER VOLTAGE LIGHT (RED)
10 OCL – OVERCRANK LIGHT (RED)
11 FPL – FAILED TO PARALLEL LIGHT (RED)
12 RPL – REVERSE POWER LIGHT (RED)
13 BOL – BREAKER OPEN LIGHT (GREEN)
14 BCL – BREAKER CLOSED LIGHT (RED)
15 BTL – BREAKER TRIPPED LIGHT (AMBER)
16 BCFL – BATTERY CHARGER FAILURE LIGHT (AMBER)
17 LBVL – LOW BATTERY VOLTAGE LIGHT (AMBER)
18 SPARE – SPARE LIGHT (AMBER)
19 GFL – GROUND FAULT LIGHT (RED)
20 LWLAC – LOW WATER LEVEL AFTER COOLER LIGHT (AMBER)
21 SPARE – SPARE LIGHT (AMBER)
22 SPARE – SPARE LIGHT (AMBER)
23 SPARE – SPARE LIGHT (AMBER)
24 SPARE – SPARE LIGHT (AMBER)

LIGHTS

25 LGPL1 – LOW GAS PRESSURE LIGHT SYSTEM A (RED)
26 LGTL1 – LOW GAS TEMPERATURE LIGHT SYSTEM A (RED)
27 HGTL1 – HIGH GAS TEMPERATURE LIGHT SYSTEM A (RED)
28 LGPL2 – LOW GAS PRESSURE LIGHT SYSTEM B (RED)
29 LGTL2 – LOW GAS TEMPERATURE LIGHT SYSTEM B (RED)
30 HGTL2 – HIGH GAS TEMPERATURE LIGHT SYSTEM B (RED)
31 HOCL – HIGH OXYGEN CONTENT LIGHT (RED)

UTILITY ANNUNCIATOR

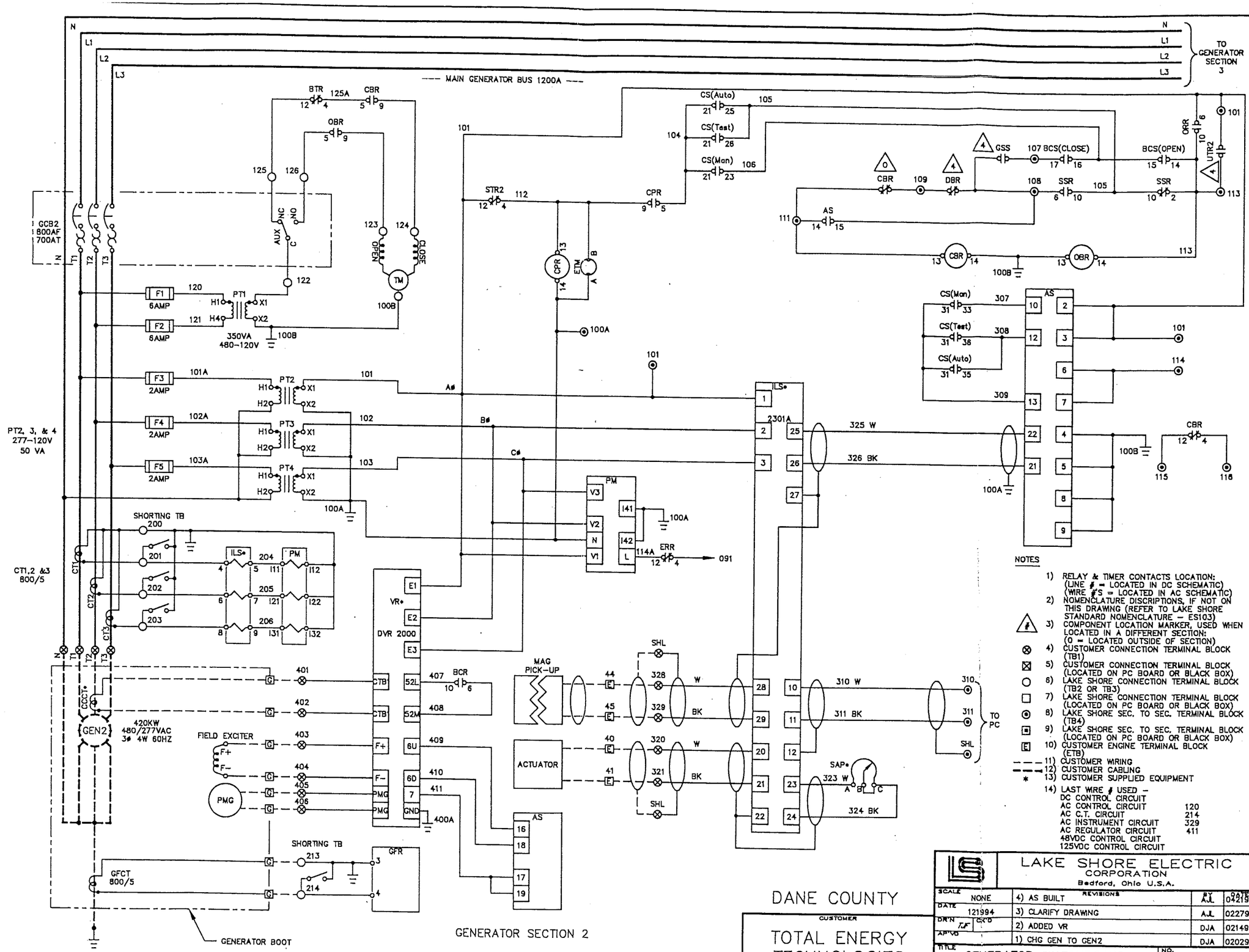
1 UBCL – UTILITY BREAKER CLOSED LIGHT (RED)
2 UBOL – UTILITY BREAKER OPEN LIGHT (GREEN)
3 SPARE – SPARE LIGHT (RED)
4 UO/UVL – UTILITY OVER/UNDER VOLTAGE LIGHT (RED)
5 UO/UFL – UTILITY OVER/UNDER FREQUENCY LIGHT (RED)
6 SPARE – SPARE LIGHT (RED)
7 RPL – REVERSE POWER LIGHT (RED)
8 PRTL – PROTECTIVE RELAY (M420) TRIPPED LIGHT (RED)
9 PRFL – PROTECTIVE RELAY (M420) FAILED LIGHT (RED)
10 PRFLL – PROTECTIVE RELAY (M420) FUSE LOSS LIGHT (RED)
11 PRPOL – PROTECTIVE RELAY (M420) POWER OK LIGHT (RED)
12 SPARE – SPARE LIGHT (RED)

DANE COUNTY
CUSTOMER
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	121694	3) CLARIFY NOTES	AJL	030295
DR'N	CH'D	2) ADDED LWLAC LIGHT	DJA	021495
APV'D		1) ADDED LIGHTS	DJA	020295

TITLE: GENERATOR SWITCHBOARD OUTLINE
NO. 952-0148-02
SHT 2 OF 2



NOTES

1) RELAY & TIMER CONTACTS LOCATION:
(LINE # = LOCATED IN DC SCHEMATIC)
(WIRE #'S = LOCATED IN AC SCHEMATIC)
2) NOMENCLATURE DISCRIPTIONS, IF NOT ON THIS DRAWING (REFER TO LAKE SHORE STANDARD NOMENCLATURE – ES103)
3) COMPONENT LOCATION MARKER, USED WHEN LOCATED IN A DIFFERENT SECTION:
(0 = LOCATED OUTSIDE OF SECTION)
4) CUSTOMER CONNECTION TERMINAL BLOCK (TB1)
5) CUSTOMER CONNECTION TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
6) LAKE SHORE CONNECTION TERMINAL BLOCK (TB2 OR TB3)
7) LAKE SHORE CONNECTION TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
8) LAKE SHORE SEC. TO SEC. TERMINAL BLOCK (TB4)
9) LAKE SHORE SEC. TO SEC. TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
10) CUSTOMER ENGINE TERMINAL BLOCK (ETB)
11) CUSTOMER WIRING
12) CUSTOMER CABLING
13) CUSTOMER SUPPLIED EQUIPMENT
14) LAST WIRE # USED –

DC CONTROL CIRCUIT	
AC CONTROL CIRCUIT	120
AC C.T. CIRCUIT	214
AC INSTRUMENT CIRCUIT	329
AC REGULATOR CIRCUIT	411
48VDC CONTROL CIRCUIT	
125VDC CONTROL CIRCUIT	

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

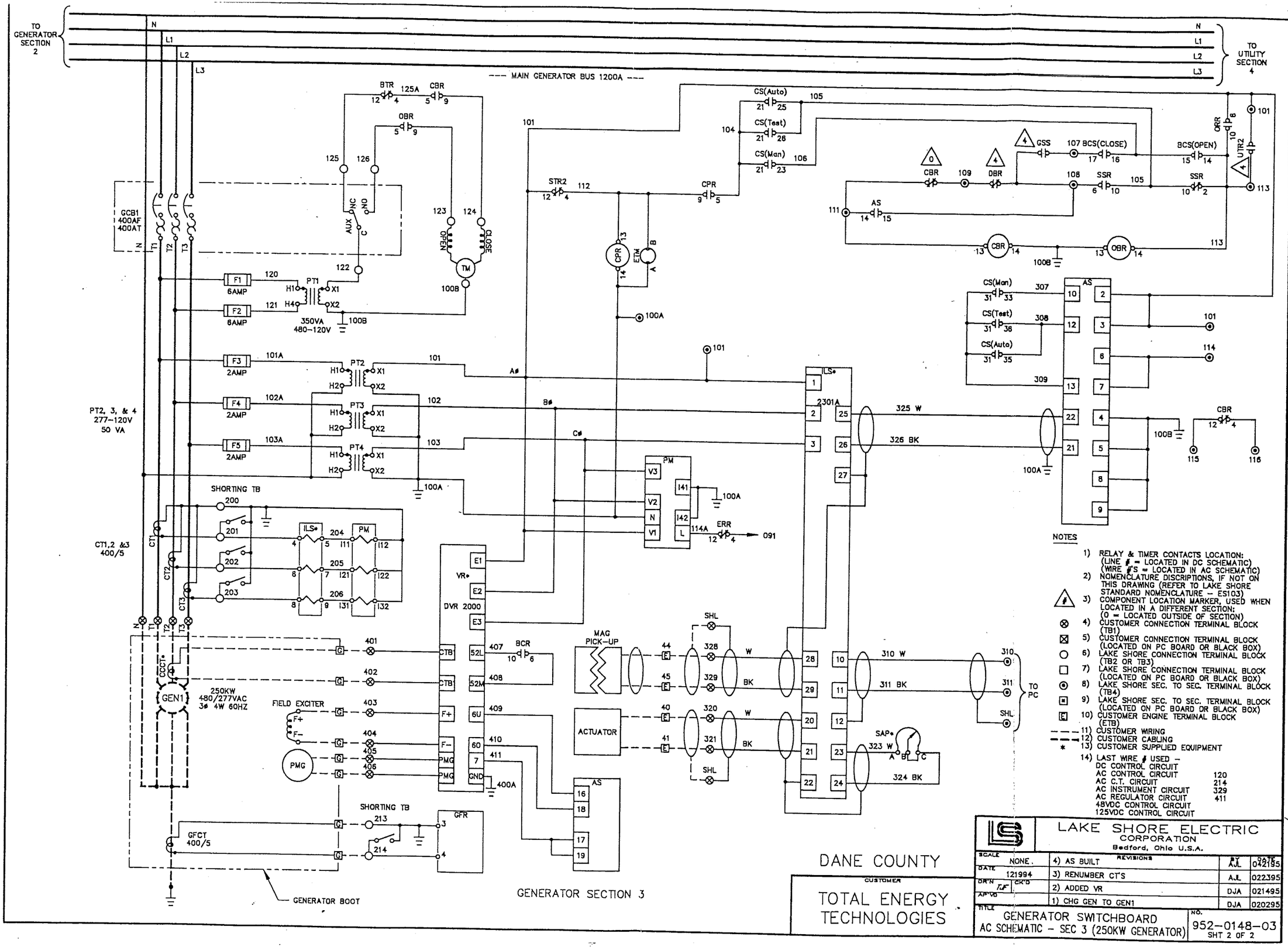
REVISIONS	BY	DATE
4) AS BUILT	AJL	042195
3) CLARIFY DRAWING	AJL	022795
2) ADDED VR	DJA	021495
1) CHG GEN TO GEN2	DJA	020295

SCALE: NONE
DATE: 121994
DR'N: TF CK'D:
APV'D:

CUSTOMER: DANE COUNTY
TOTAL ENERGY TECHNOLOGIES

TITLE: GENERATOR SWITCHBOARD
AC SCHEMATIC – SEC 2 (420KW GENERATOR)

NO. 952–0148–03
SHT 1 OF 2


TO GENERATOR SECTION 2
N
L1
L2
L3
--- MAIN GENERATOR BUS 1200A ---
TO UTILITY SECTION 4
GCB1 400AF 400AT
BTR 125A
CBR
OBR
AUX
NC
NO
C
OPEN
CLOSE
TM
100B
F1 6AMP
F2 6AMP
PT1
350VA 480–120V
F3 2AMP
F4 2AMP
F5 2AMP
PT2
PT3
PT4
PT2, 3, & 4 277–120V 50 VA
SHORTING TB
ILS*
PM
CT1,2 &3 400/5
CT1
CT2
CT3
GEN1
250KW 480/277VAC 3ø 4W 60HZ
FIELD EXCITER
PMG
GFCT 400/5
GFR
GENERATOR BOOT
DVR 2000
VR*
STR2
CPR
ETM
100A
CS(Auto)
CS(Test)
CS(Man)
GSS
BCS(CLOSE)
BCS(OPEN)
SSR
ORR
UTR2
AS
ILS*
2301A
325 W
326 BK
MAG PICK-UP
ACTUATOR
SAP*
323 W
324 BK
310 W
311 BK
TO PC
SHL
BCR
400A
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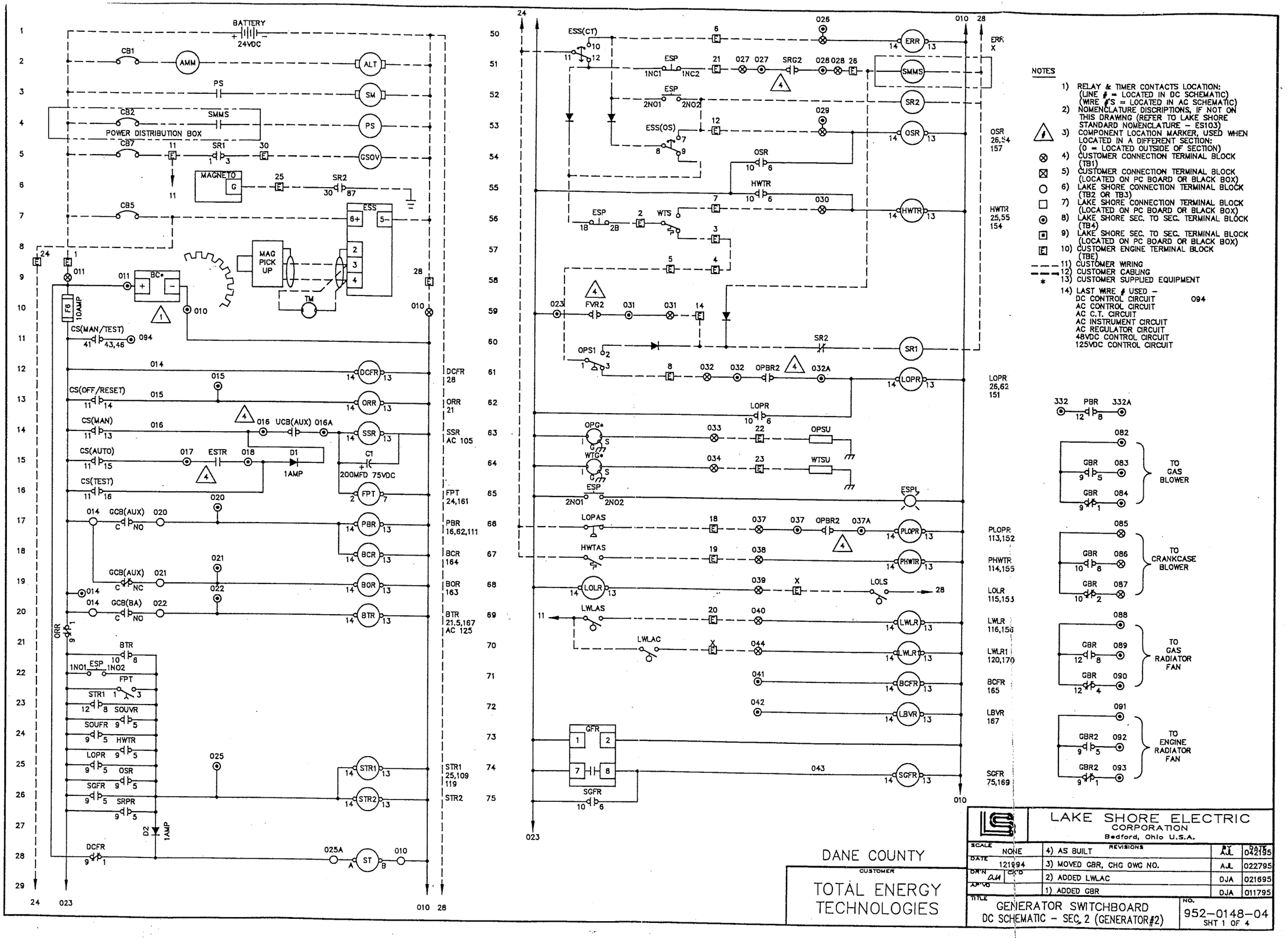
11) CUSTOMER WIRING
12) CUSTOMER CABLING
13) CUSTOMER SUPPLIED EQUIPMENT
14) LAST WIRE # USED –
DC CONTROL CIRCUIT 120
AC CONTROL CIRCUIT 214
AC C.T. CIRCUIT 329
AC INSTRUMENT CIRCUIT 411
AC REGULATOR CIRCUIT
48VDC CONTROL CIRCUIT
125VDC CONTROL CIRCUIT
LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.
SCALE NONE
DATE 121994
DR'N TJF CK'D
APV'D
REVISIONS
4) AS BUILT AJL 042195
3) RENUMBER CT'S AJL 022395
2) ADDED VR DJA 021495
1) CHG GEN TO GEN1 DJA 020295
TITLE GENERATOR SWITCHBOARD AC SCHEMATIC – SEC 3 (250KW GENERATOR)
NO. 952–0148–03
SHT 2 OF 2
DANE COUNTY
CUSTOMER
TOTAL ENERGY TECHNOLOGIES
GENERATOR SECTION 3

216 232
6200



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11) CUSTOMER WIRING
12) CUSTOMER CABLING
13) CUSTOMER SUPPLIED EQUIPMENT
14) LAST WIRE # USED –
DC CONTROL CIRCUIT 094
AC CONTROL CIRCUIT
AC C.T. CIRCUIT
AC INSTRUMENT CIRCUIT
AC REGULATOR CIRCUIT
48VDC CONTROL CIRCUIT
125VDC CONTROL CIRCUIT

DANE COUNTY

CUSTOMER

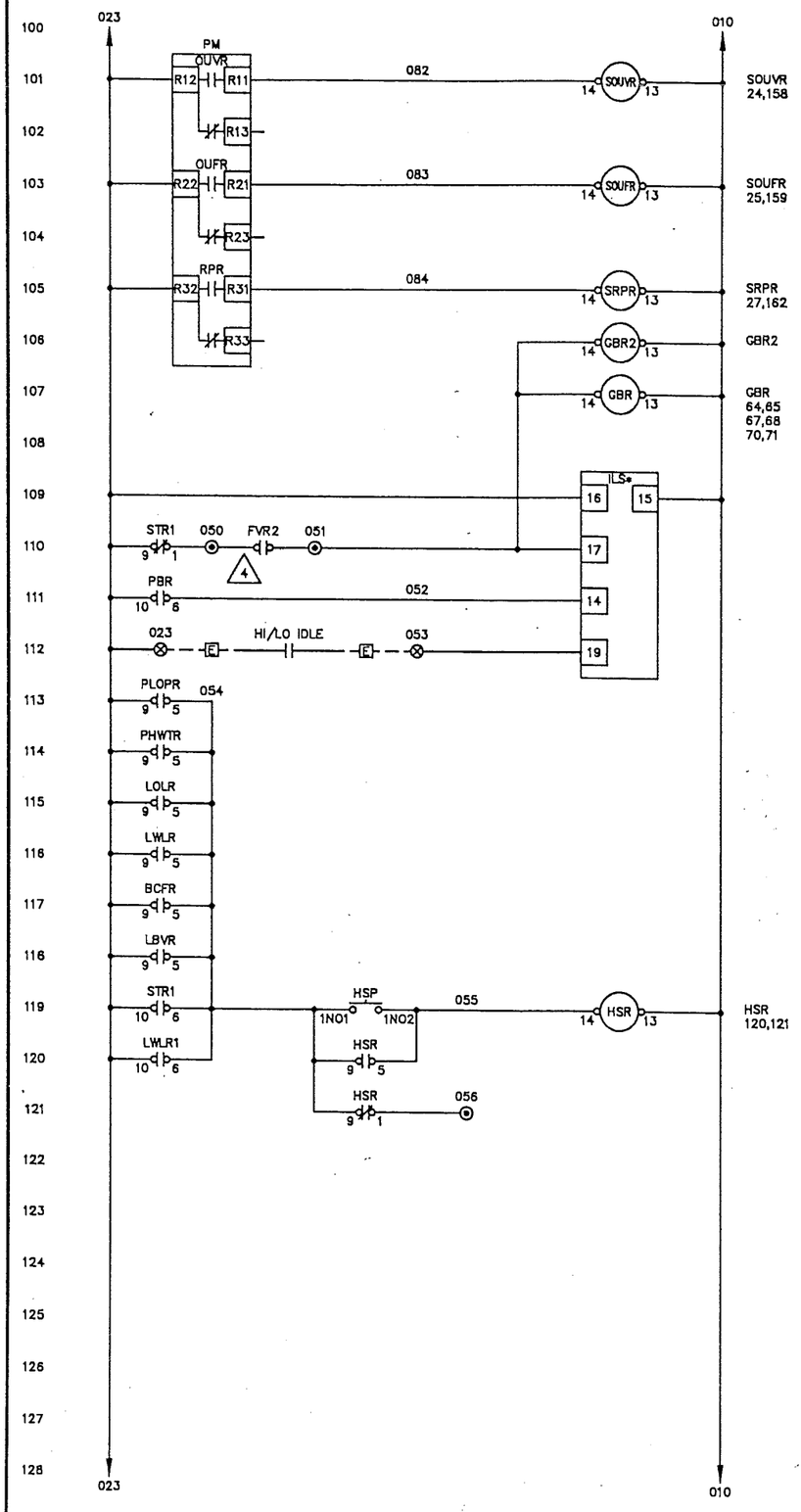
TOTAL ENERGY TECHNOLOGIES

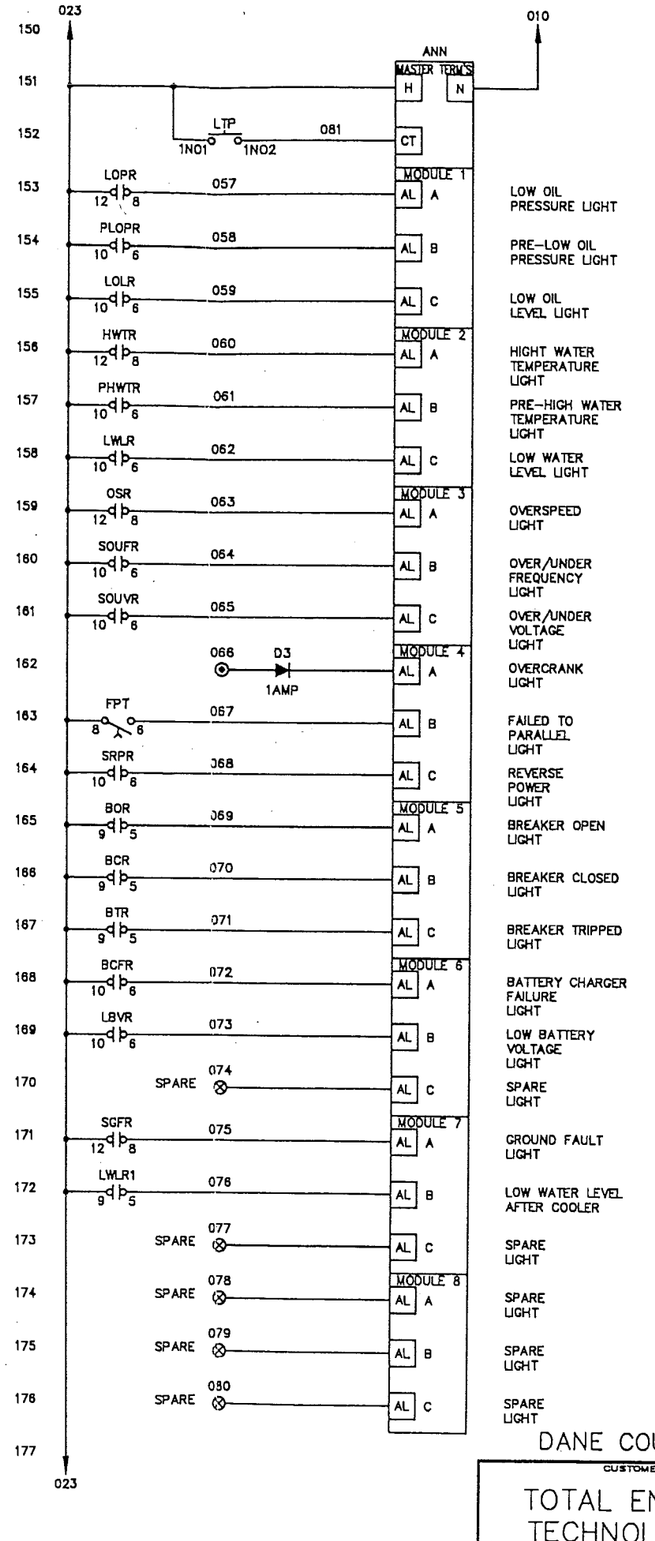
LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	121894	4) AS BUILT	AJL	042195
DR'N	CHK'D	3) MOVED GBR, CHG DWG NO.	AJL	022795
APV'D		2) ADDED LWLAC	DJA	021695
		1) ADDED GBR	DJA	011795

TITLE: GENERATOR SWITCHBOARD DC SCHEMATIC – SEC. 2 (GENERATOR #2)

NO. 952–0148–04 SHT 1 OF 4





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13) CUSTOMER SUPPLIED EQUIPMENT
14) LAST WIRE # USED -
DC CONTROL CIRCUIT 094
AC CONTROL CIRCUIT
AC C.T. CIRCUIT
AC INSTRUMENT CIRCUIT
AC REGULATOR CIRCUIT
48VDC CONTROL CIRCUIT
125VDC CONTROL CIRCUIT

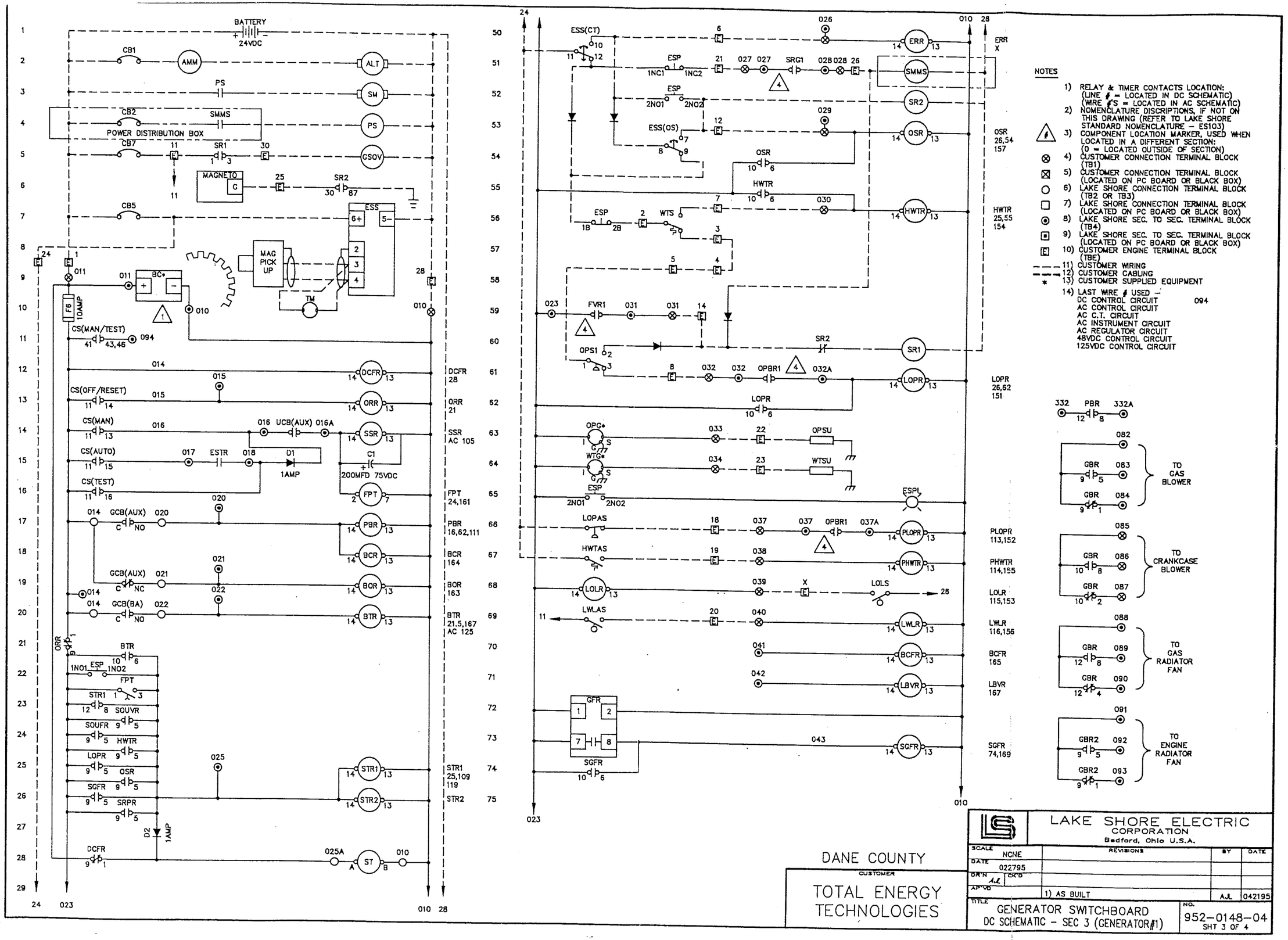
DANE COUNTY
CUSTOMER

TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	121994	3) AS BUILT	AJL	042195
DR'N DJA	CK'D	2) ADD GBR & GBR2, CLARIFY	AJL	022795
APVD		1) ADDED LWLR1	DJA	021695

TITLE: GENERATOR SWITCHBOARD DC SCHEMATIC - SEC 2 (GENERATOR #2)
NO. 952-0148-04 SHT 2 OF 4



DANE COUNTY

CUSTOMER

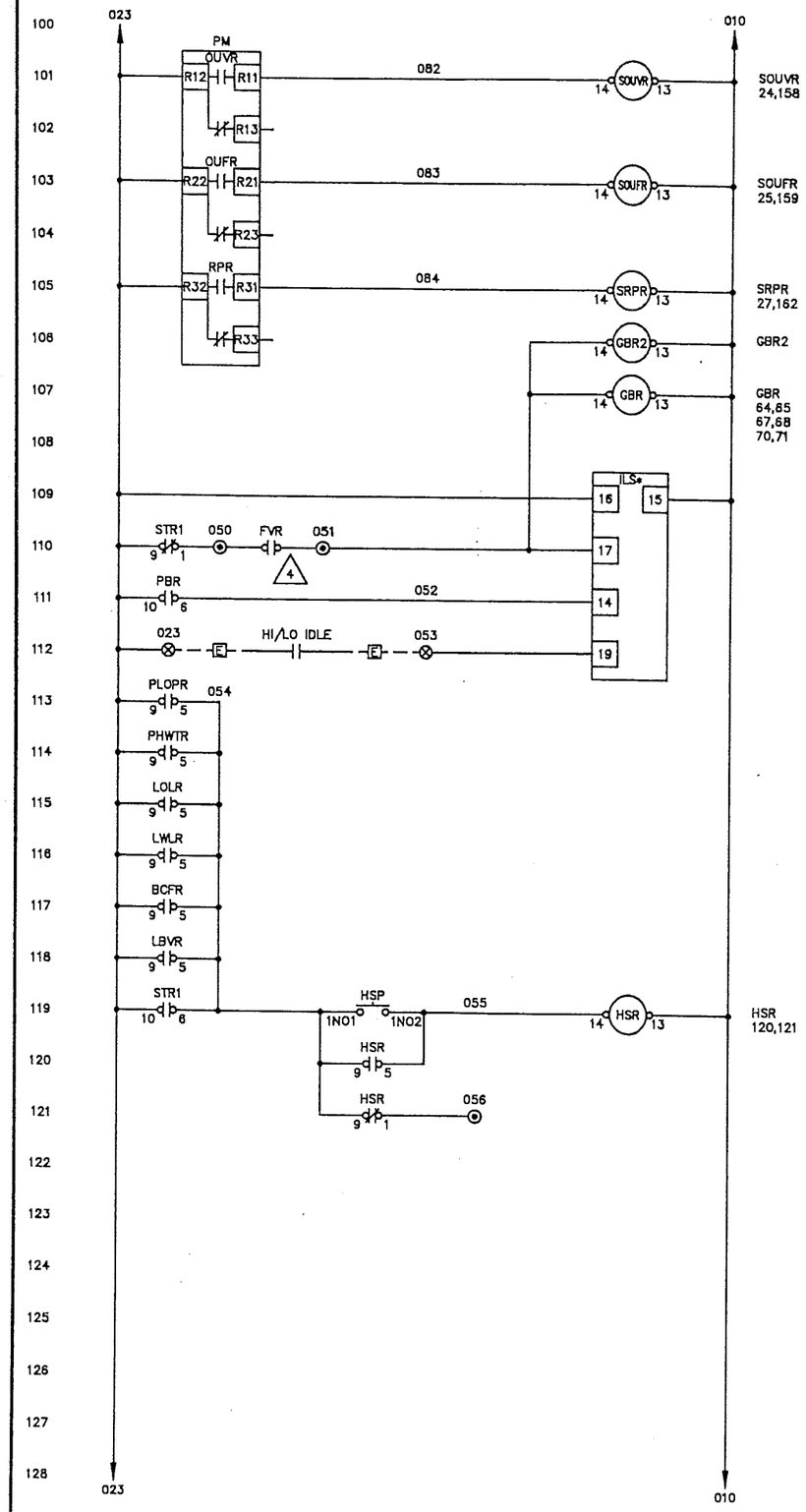
TOTAL ENERGY TECHNOLOGIES

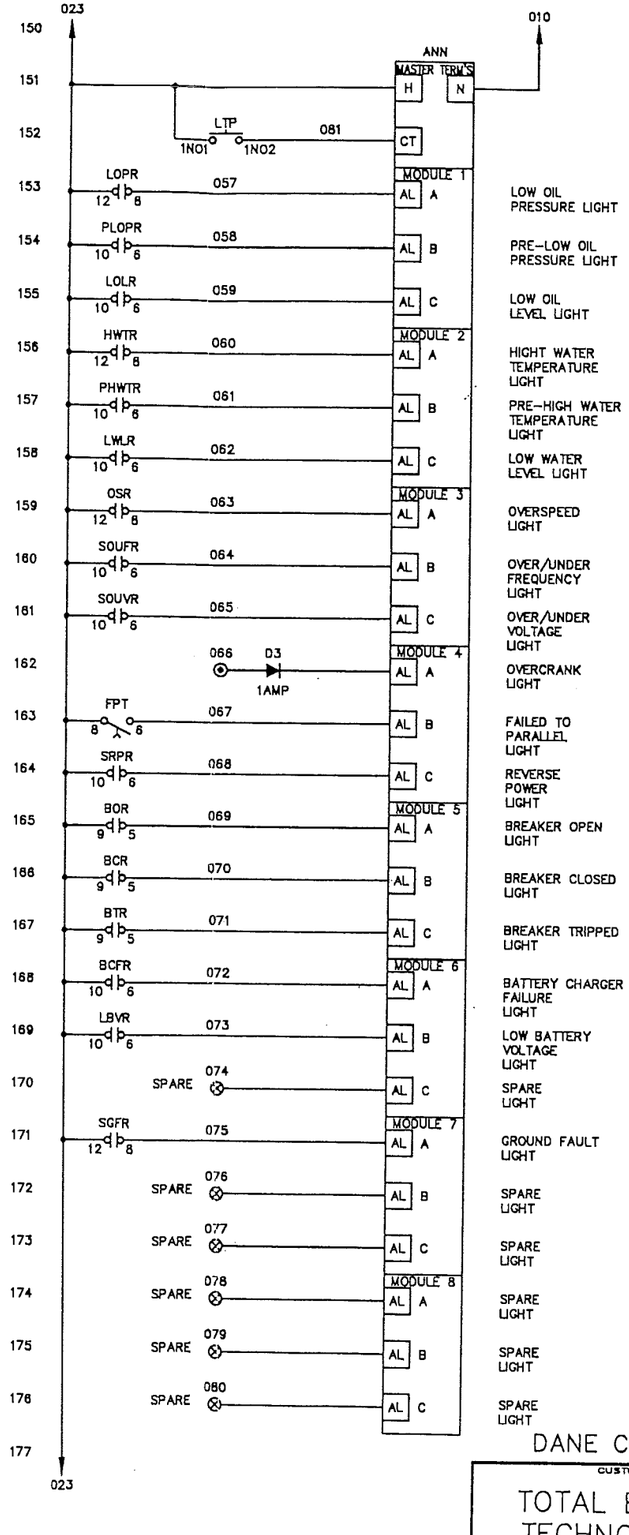
LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	022795			
DR'N AJL	CK'D			
APVD		1) AS BUILT	AJL	042195

TITLE: GENERATOR SWITCHBOARD DC SCHEMATIC – SEC 3 (GENERATOR#1)

NO. 952-0148-04 SHT 3 OF 4





NOTES

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11) CUSTOMER WIRING
12) CUSTOMER CABLING
13) CUSTOMER SUPPLIED EQUIPMENT
14) LAST WIRE # USED -
DC CONTROL CIRCUIT 094
AC CONTROL CIRCUIT
AC C.T. CIRCUIT
AC INSTRUMENT CIRCUIT
AC REGULATOR CIRCUIT
48VDC CONTROL CIRCUIT
125VDC CONTROL CIRCUIT

DANE COUNTY

CUSTOMER

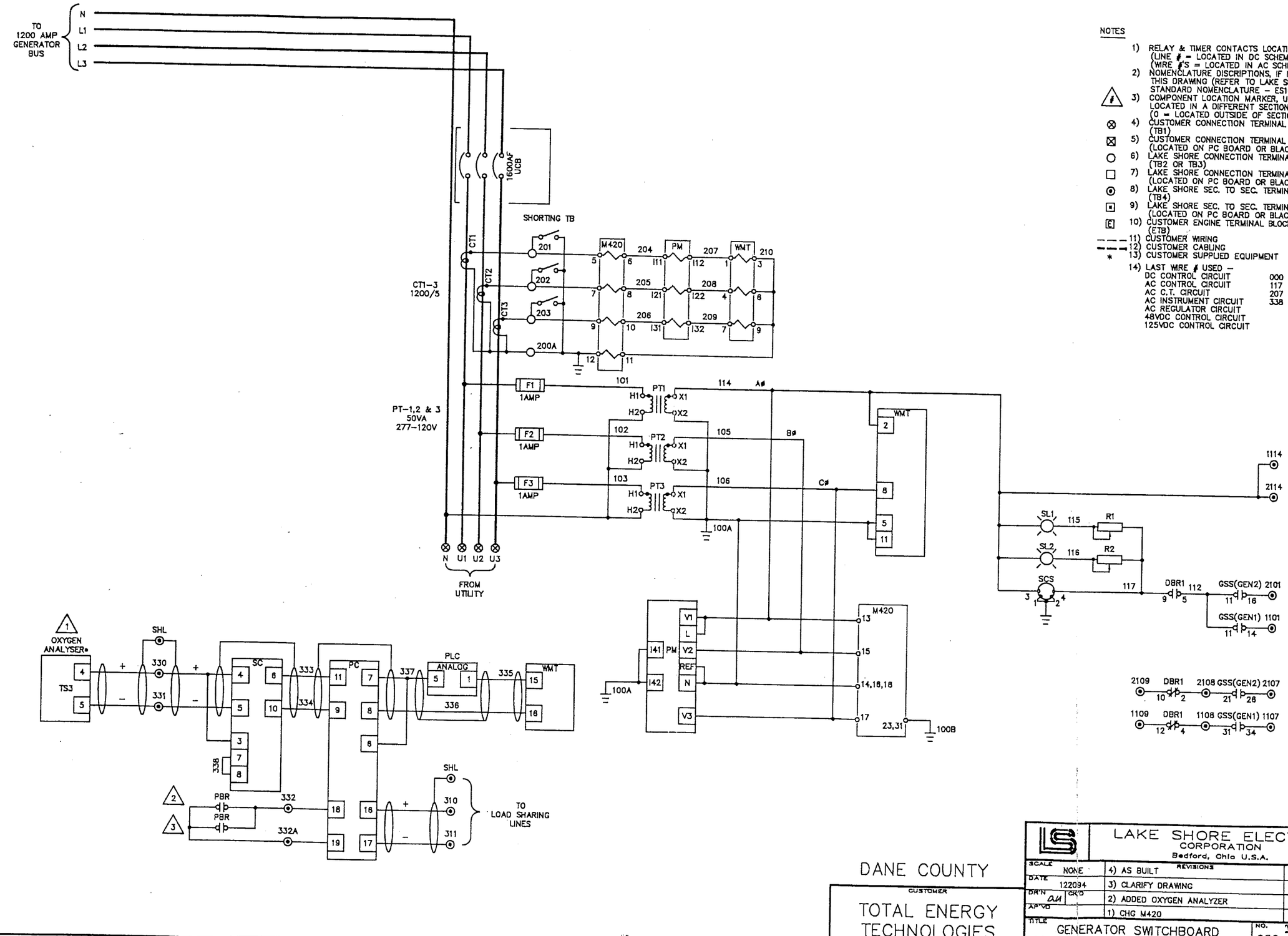
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	022795			
DR'N AJL	CK'D			
APVD		1) AS BUILT	AJL	042195

TITLE: GENERATOR SWITCHBOARD DC SCHEMATIC - SEC 3 (GENERATOR #1)

NO. 952-0148-04 SHT 4 OF 4



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9) LAKE SHORE SEC. TO SEC. TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
10) CUSTOMER ENGINE TERMINAL BLOCK (ETB)
11) CUSTOMER WIRING
12) CUSTOMER CABLING
13) CUSTOMER SUPPLIED EQUIPMENT
14) LAST WIRE # USED –

DC CONTROL CIRCUIT	000
AC CONTROL CIRCUIT	117
AC C.T. CIRCUIT	207
AC INSTRUMENT CIRCUIT	338
AC REGULATOR CIRCUIT	
48VDC CONTROL CIRCUIT	
125VDC CONTROL CIRCUIT	

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

REVISIONS	BY	DATE
4) AS BUILT	AJL	042195
3) CLARIFY DRAWING	AJL	022795
2) ADDED OXYGEN ANALYZER	DJA	021695
1) CHG M420	DJA	020295

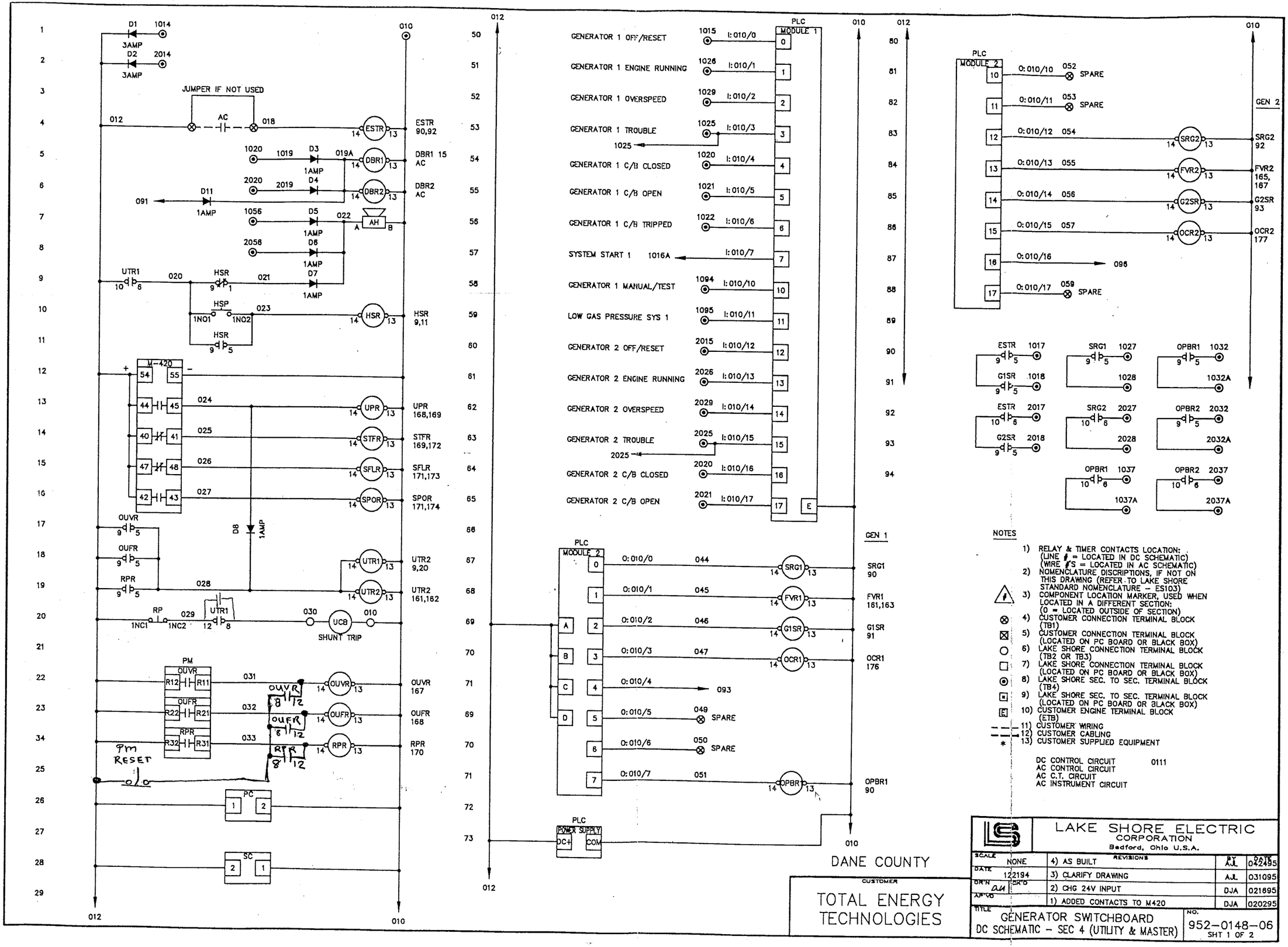
SCALE NONE
DATE 122094
DR'N aa CK'D
APP'D

CUSTOMER
DANE COUNTY

TOTAL ENERGY TECHNOLOGIES

TITLE
GENERATOR SWITCHBOARD
AC SCHEMATIC – SEC 4 (UTILITY & MASTER)

NO. 1 of 2
952-0148-05



NOTES

1) RELAY & TIMER CONTACTS LOCATION: (LINE #'S = LOCATED IN DC SCHEMATIC) (WIRE #'S = LOCATED IN AC SCHEMATIC)
2) NOMENCLATURE DISCRIPTIONS, IF NOT ON THIS DRAWING (REFER TO LAKE SHORE STANDARD NOMENCLATURE – ES103)
3) COMPONENT LOCATION MARKER, USED WHEN LOCATED IN A DIFFERENT SECTION: (0 = LOCATED OUTSIDE OF SECTION)
4) CUSTOMER CONNECTION TERMINAL BLOCK (TB1)
5) CUSTOMER CONNECTION TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
6) LAKE SHORE CONNECTION TERMINAL BLOCK (TB2 OR TB3)
7) LAKE SHORE CONNECTION TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
8) LAKE SHORE SEC. TO SEC. TERMINAL BLOCK (TB4)
9) LAKE SHORE SEC. TO SEC. TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
10) CUSTOMER ENGINE TERMINAL BLOCK (ETB)
11) CUSTOMER WIRING
12) CUSTOMER CABLING
13) CUSTOMER SUPPLIED EQUIPMENT

DC CONTROL CIRCUIT 0111
AC CONTROL CIRCUIT
AC C.T. CIRCUIT
AC INSTRUMENT CIRCUIT

DANE COUNTY

CUSTOMER
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE NONE	REVISIONS		BY	DATE
DATE 122194	4) AS BUILT		AJL	042495
DR'N DM CR'D	3) CLARIFY DRAWING		AJL	031095
APV'D	2) CHG 24V INPUT		DJA	021895
	1) ADDED CONTACTS TO M420		DJA	020295

TITLE: GENERATOR SWITCHBOARD DC SCHEMATIC – SEC 4 (UTILITY & MASTER)

NO. 952-0148-06 SHT 1 OF 2

012

PLC MODULE 3

100	GENERATOR 2 C/B TRIPPED	2022	I:011/0	0
101	SYSTEM START 2	2016A	I:011/1	1
102	GENERATOR 2 MANUAL/TEST	2094	I:011/2	2
103	LOW GAS PRESSURE SYSTEM 2	2095	I:011/3	3
104	SPARE	063	I:011/4	4
105	SPARE	064	I:011/5	5
106	SPARE	065	I:011/6	6
107	SPARE	066	I:011/7	7
108	SPARE	067	I:011/10	10
109	SPARE	068	I:011/11	11
110	SPARE	069	I:011/12	12
111	SPARE	070	I:011/13	13
112	SPARE	071	I:011/14	14
113	SPARE	072	I:011/15	15
114	SPARE	073	I:011/16	16
115	SPARE	074	I:011/17	17
116				E

PLC MODULE 4

117	0	O:011/0	075 SPARE
118	1	O:011/1	076 SPARE
119	2	O:011/2	077 SPARE
120	3	O:011/3	078 SPARE
121	4	O:011/4	0103
122	5	O:011/5	080 SPARE
123	6	O:011/6	081 SPARE
124	7	O:011/7	082 SPARE

A, B, C, D

GEN 2 — 14 OPBR2 13 — OPBR2 93

012

010

012

PLC MODULE 4

150	10	O:011/10	083 SPARE
151	11	O:011/11	084 SPARE
152	12	O:011/12	085 SPARE
153	13	O:011/13	086 SPARE
154	14	O:011/14	087 SPARE
155	15	O:011/15	088 SPARE
156	16	O:011/16	089 SPARE
157	17	O:011/17	090 SPARE

010

ANN MASTER TERM'S H N

LTP 1NO1 1NO2 090A → CT

012 UCB(AUX1) 091 → MODULE 1 AL A

UCB(AUX1) 092 → AL B

093 → AL C

OUVR 10 6 — 094 → MODULE 2 AL A

OUFR 10 6 — 095 → AL B

096 → AL C

RPR 10 6 — 097 → MODULE 3 AL A

UPR 10 6 — 098 → AL B

STFR 10 6 — 099 → AL C

SFLR 10 6 — 0101 → MODULE 4 AL A

SPOR 10 6 — 0102 → AL B

0103 → AL C

OCR1 9 5 — D9 — 1AMP — 1025 — 1066

OCR2 9 5 — D10 — 1AMP — 2025 — 2066

UTILITY BREAKER CLOSED LIGHT	1101 UTR2 1113
UTILITY BREAKER OPEN LIGHT	2101 UTR2 2113
GENERATOR 1 FAULT	1016 UCB(AUX2) 1016A → 1016A
UTILITY OVER/UNDER VOLTAGE LIGHT	2016 UCB(AUX3) 2016A → 2016A
UTILITY OVER/UNDER FREQUENCY LIGHT	UPR 0104 → 0105
GENERATOR 2 FAULT	SFLR 0108 → 0109
UTILITY REVERSE POWER LIGHT	FVR1 1023 → 1031
UTILITY PROTECTIVE RELAY LIGHT	FVR1 1050 → 1051
UTILITY PROTECTIVE RELAY SELF TEST FAIL LIGHT	FVR2 2023 → 2031
UTILITY PROTECTIVE RELAY VT FUSE LOSS LIGHT	FVR2 2050 → 2051
UTILITY PROTECTIVE RELAY POWER OK LIGHT	STFR 0106 → 0107
HIGH OXYGEN LEVEL MODE	SPOR 0110 → 0111

DANE COUNTY

CUSTOMER

TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	122194	3) AS BUILT	AJL	042495
DR'N	DJA / CK'D	2) CLARIFY DRAWING	AJL	031095
APV'D		1) ADDED LIGHTS	DJA	020295

TITLE: GENERATOR SWITCHBOARD DC SCHEMATIC - SEC 4 (UTILITY & MASTER)

NO. 952-0148-06 SHT. 2 OF 2

GENERATOR CONTROL PANEL – SECTIONS 2 & 3 (GENERATOR)
(CUSTOMER CONNECTIONS)
REF DWG'S – #952-0148-03 & 04, SHEETS 1&2

TB1 DETAIL

010 011 012 013 023 026 027 028 029 030 031 032 033 034 037 038 039 040 044 053 (GEN 2 ONLY) 074 076 (GEN 1 ONLY) 077 078 079 080 085 086 087 320 321 SHL 328 329 SHL 401 402 403 404 405 406

SPARE ANNUNCIATOR INPUTS

GENERATOR CONTROL PANEL – SECTIONS 1 (GAS PROCESSING)
(CUSTOMER CONNECTIONS)
REF DWG'S – #952-0148-13, SHEETS 1&2

TB1: 187 188 189 190 191 192 193 194

SYSTEM 1: 187 188 191 192

SYSTEM 2: 189 190 193 194

UTILITY & MASTER CONTROL PANEL – SECTION 4
(CUSTOMER CONNECTIONS)
REF DWG'S – #952-0148-06, SHEETS 1&2

TB1 DETAIL

012 018 049 050 052 053 053 059 063 064 065 066 067 068 069 070 071 072 073 074 075 077 078 080 081 082 083 084 085 086 087 088 089 090 0104 0105 0106 0107 0108 0109 0110 0111

SPARE PLC OUTPUTS
SPARE PLC INPUTS
SPARE PLC OUTPUTS
SPARE ANNUNCIATOR INPUTS

AC

401 402 403 404 405 406

GENERATOR TERMINAL BLOCK

011 013 012 053 026 030 032 029 031 037 038 040 044 027 028 010 039 085 086 087 033 034 SHL 320 321 SHL 328 329

ENGINE TERMINAL BLOCK: 1 X X X 2 3 4 5 6 7 8 9 11 12 14 18 19 20 X 21 24 25 26 28 30 X 22 23 40 41 44 45

TO CRANKCASE BLOWER

ACTUATOR

MPU

ESS 2 3 4 5 6+

CB5 CB2 CB1 SMMS PS SM AMM ALT

BATTERY 24VDC

ESP HI/LO IDLE

ESS(CT) WTS OPS1 ESS(OS) SR2 SR1 LWLAS LWLAC ESP SR SMMS QSOV SR1 SR2 LOLS CB7 MAGNETO G LOPAS HWTAS

OPSU WTSU

MPU

DANE COUNTY

CUSTOMER
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	122294	3) AS BUILT	AJL	042495
DR'N	TJF	2) ADDED GAS RADIATOR	DJA	021895
APP'VD		1) ADDED GAS BLOWER	DJA	011795

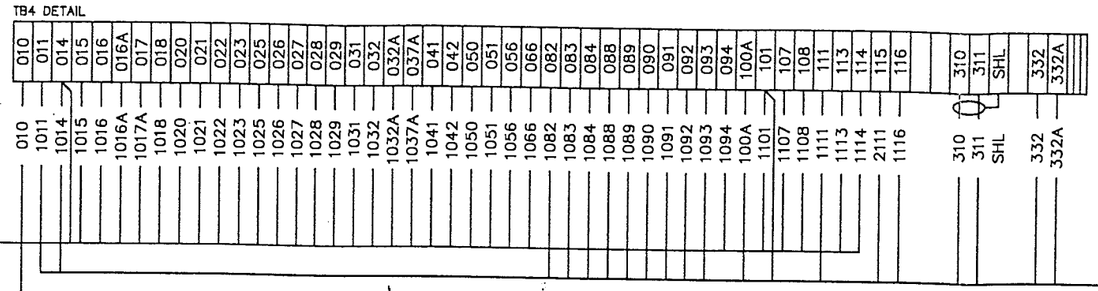
TITLE: GENERATOR SWITCHBOARD CUSTOMER CONNECTIONS

NO. 952-0148-07

1 of 1

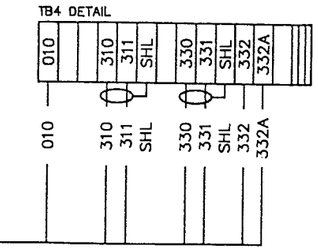
GENERATOR CONTROL PANEL – SECTION 3 (GENERATOR 1)
(INTERCONNECTIONS)
REF DWG'S – #952–0148–03 & 04, SHEETS 1&2

TB4 DETAIL

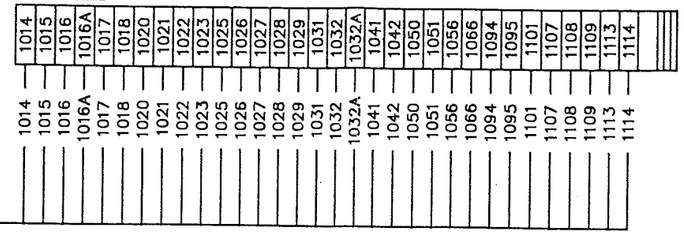


UTILITY & MASTER CONTROL PANEL – SECTION 4
(INTERCONNECTIONS)
REF DWG'S – #952–0148–06, SHEETS 1&2

TB4 DETAIL

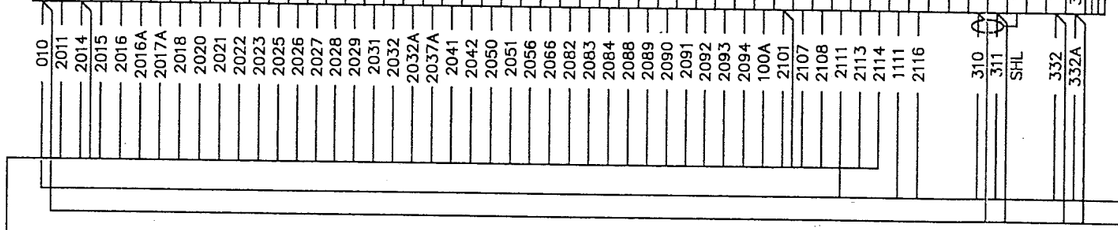


TB4–1 DETAIL

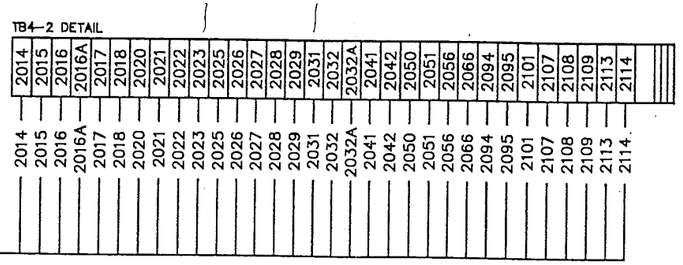


GENERATOR CONTROL PANEL – SECTION 2 (GENERATOR 2)
(INTERCONNECTIONS)
REF DWG'S – #952–0148–03 & 04, SHEETS 1&2

TB4 DETAIL

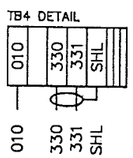


TB4–2 DETAIL

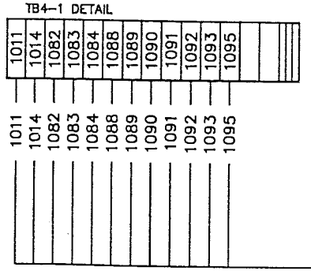


GENERATOR CONTROL PANEL – SECTION 1 (GAS PROCESSING)
(INTERCONNECTIONS)
REF DWG'S – #952–0148–13, SHEETS 1&2

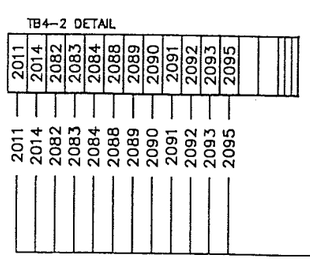
TB4 DETAIL



TB4–1 DETAIL



TB4–2 DETAIL



DANE COUNTY
CUSTOMER

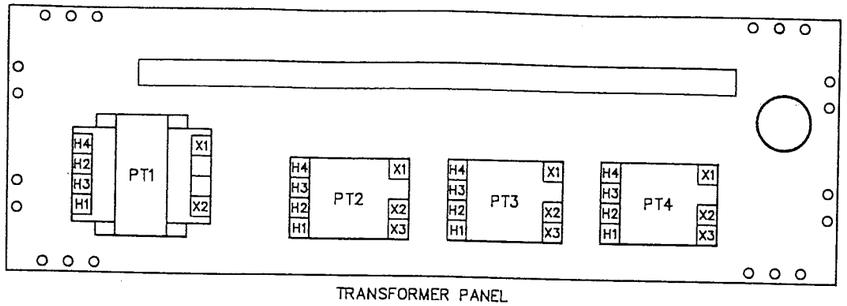
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

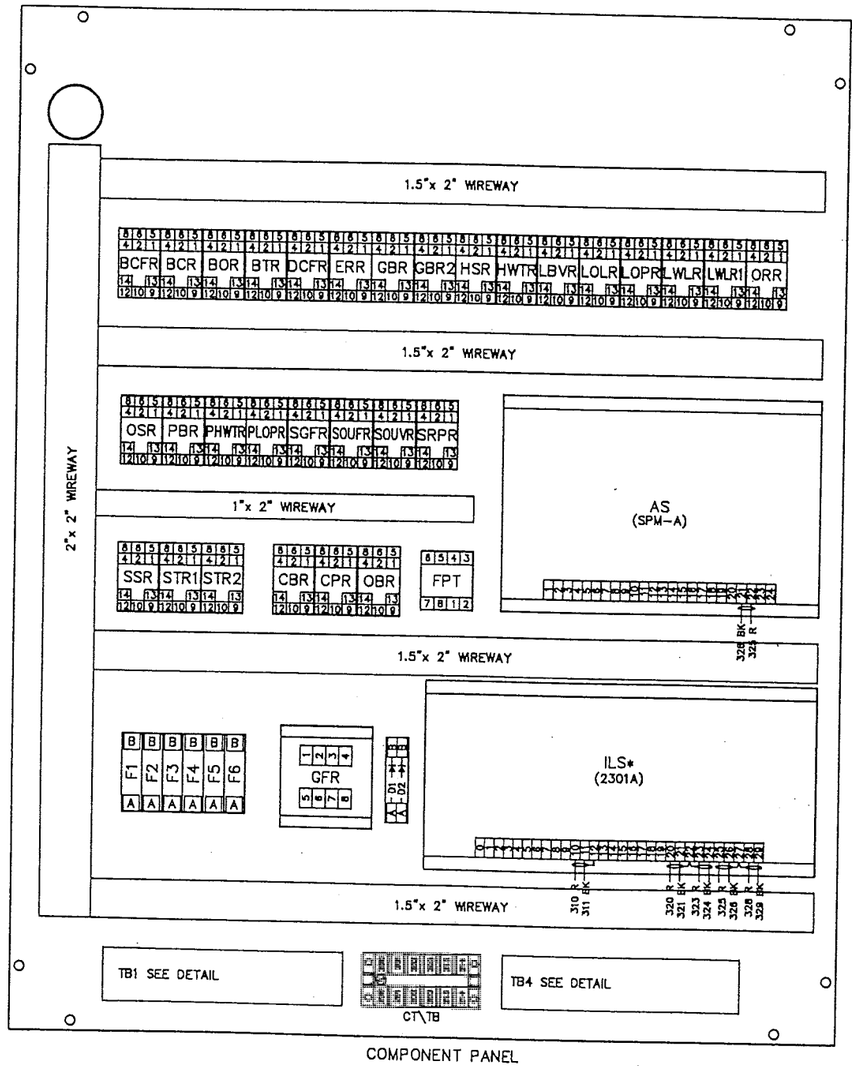
SCALE	NONE	REVISIONS	BY	DATE
DATE	122294	3) CLARIFY DRAWING	AJL	042495
DR'N	DJA CK'D	2) REVISED INTERCONNECTIONS	AJL	022895
APP'VD		1) ADDED GAS PROCESSING	DJA	021695

TITLE: GENERATOR SWITCHBOARD INTERCONNECTIONS

NO. 952–0148–08
2 of 2



TRANSFORMER PANEL

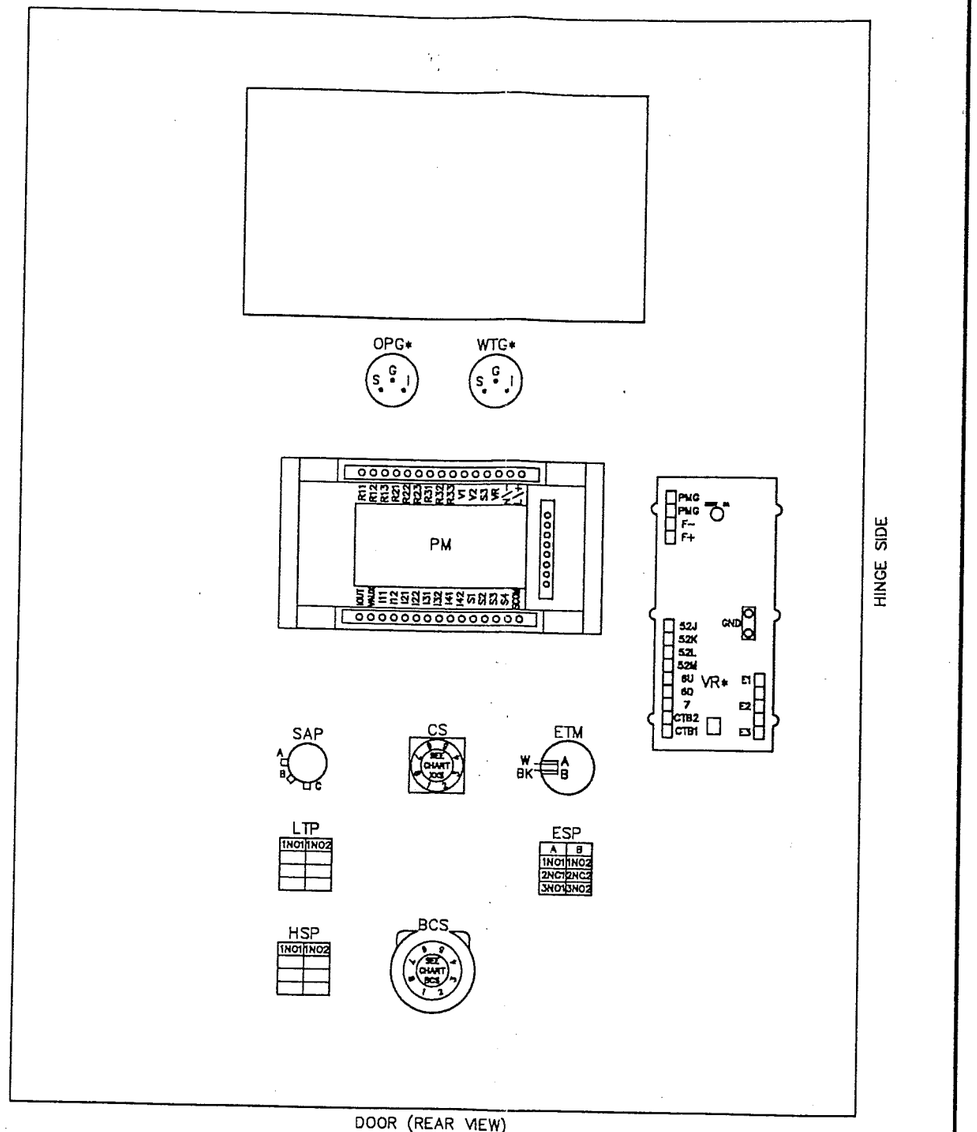


COMPONENT PANEL

NOTE: LWLR1 IN GENERATOR SECTION 2 ONLY.

TB1 DETAIL (BREAKER TB'S)

010	014	014	020	021	022	025	AUX3	AUX3	AUX3	100B	122	123	124	125	126



DOOR (REAR VIEW)

TB1 DETAIL

010	011	012	013	023	026	027	028	029	030	031	032	033	034	037	038	039	040	041	042	044	053	074	076	077	078	079	080	085	086	087	320	321	SHL	328	329	SHL	401	402	403	404	405	406

TB4 DETAIL

010	011	014	015	016	016A	017	018	020	021	022	023	025	026	027	028	029	031	032	032A	037A	050	051	056	066	082	083	084	088	089	090	091	092	093	094	100A	101	107	108	111	113	114	115	116	310	311	SHL	332	332A

5) CLARIFY DRAWING AJL 042495

DANE COUNTY

CUSTOMER

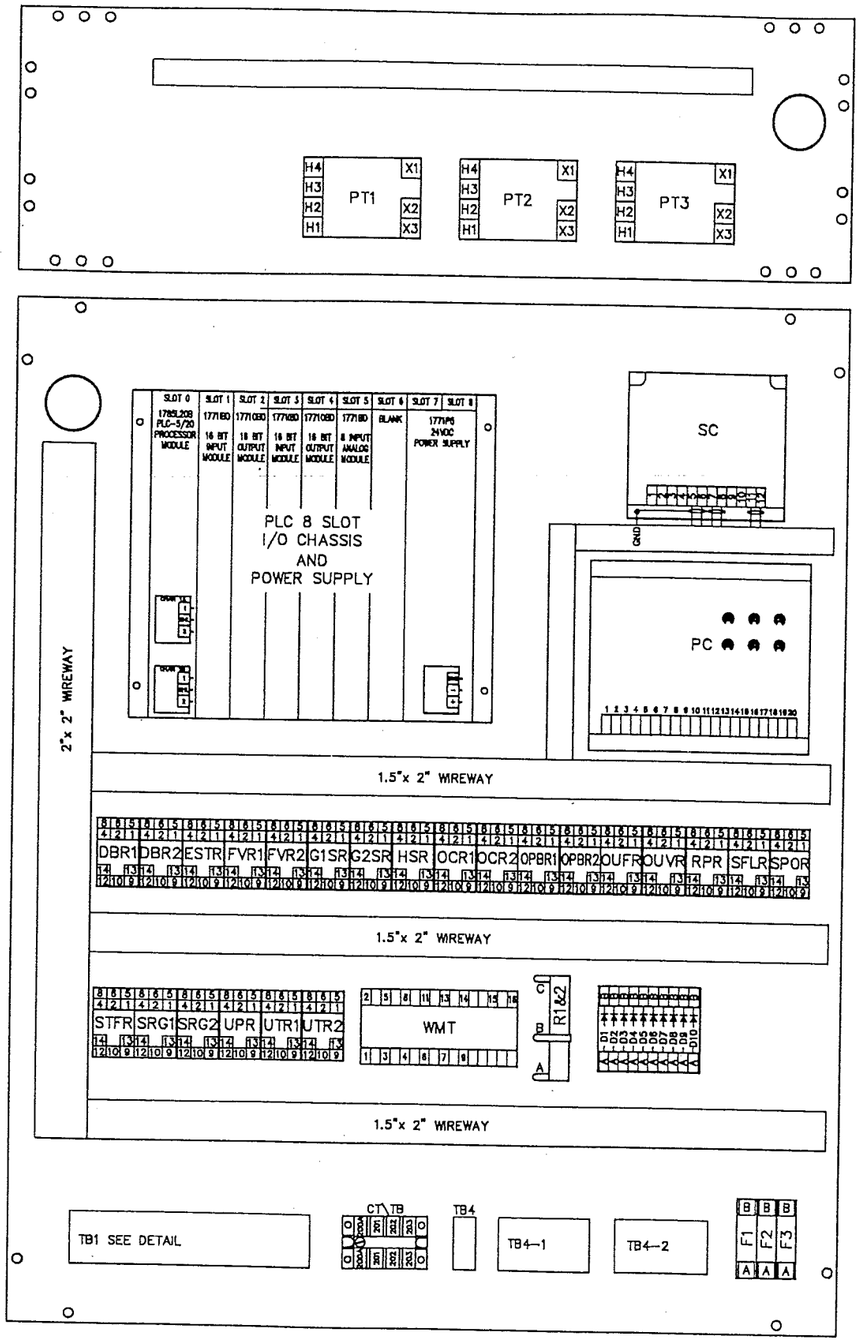
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

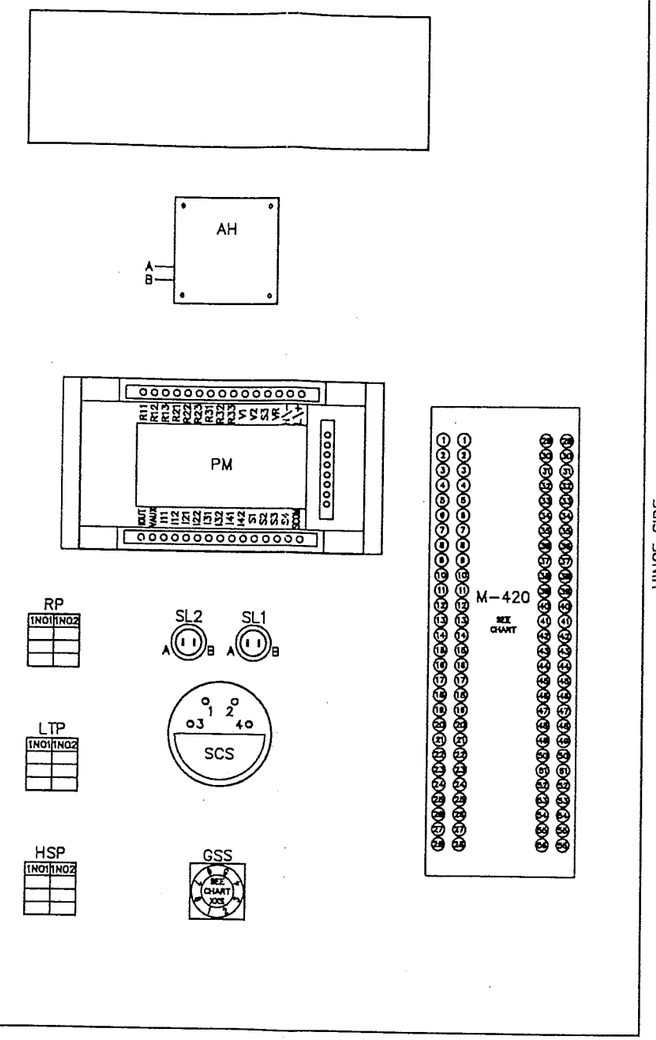
SCALE	.25=1	REVISIONS	BY	DATE
DATE	122294	4) ADDED TB'S, DPT SHORTING TB	AJL	032995
DR'N	AJL CK'D	3) ADD GBR, CLARIFY PART LAYOUT	AJL	022795
APV'D		2) ADDED VR	DJA	021695
		1) ADDED CT/TB	DJA	020295

TITLE: GENERATOR SWITCHBOARD PART LAYOUT – SEC. 2&3 (GEN.)

NO. 952-0148-09 SHT 1 OF 4



COMPONENT PANEL



DOOR (REAR VIEW)

TB1 DETAIL

012	018	048	049	050	052	053	058	059	063	064	065	066	067	068	069	070	071	072	073	074	075	077	078	079	080	081	082	083	084	085	086	087	088	089	090	093	096	0103	0104	0105	0106	0107	0108	0109	0110	0111

TB4 DETAIL

010		310	311	SHL	330	331	SHL	332	332A	SHL

TB4-1 DETAIL

1014	1015	1016	1016A	1017	1018	1020	1021	1022	1023	1025	1026	1027	1028	1029	1031	1032	1032A	1050	1051	1056	1066	1094	1095	1101	1107	1108	1109	1113	1114

TB4-2 DETAIL

2014	2015	2016	2016A	2017	2018	2020	2021	2022	2023	2025	2026	2027	2028	2029	2031	2032	2032A	2050	2051	2056	2066	2094	2095	2101	2107	2108	2109	2113	2114

TB2 DETAIL (BREAKER TB'S)

010	012	030	091	092	AUX2	AUX2	AUX2	AUX3	AUX3	AUX3	AUX3	AUX4	AUX4	AUX4

DANE COUNTY

CUSTOMER

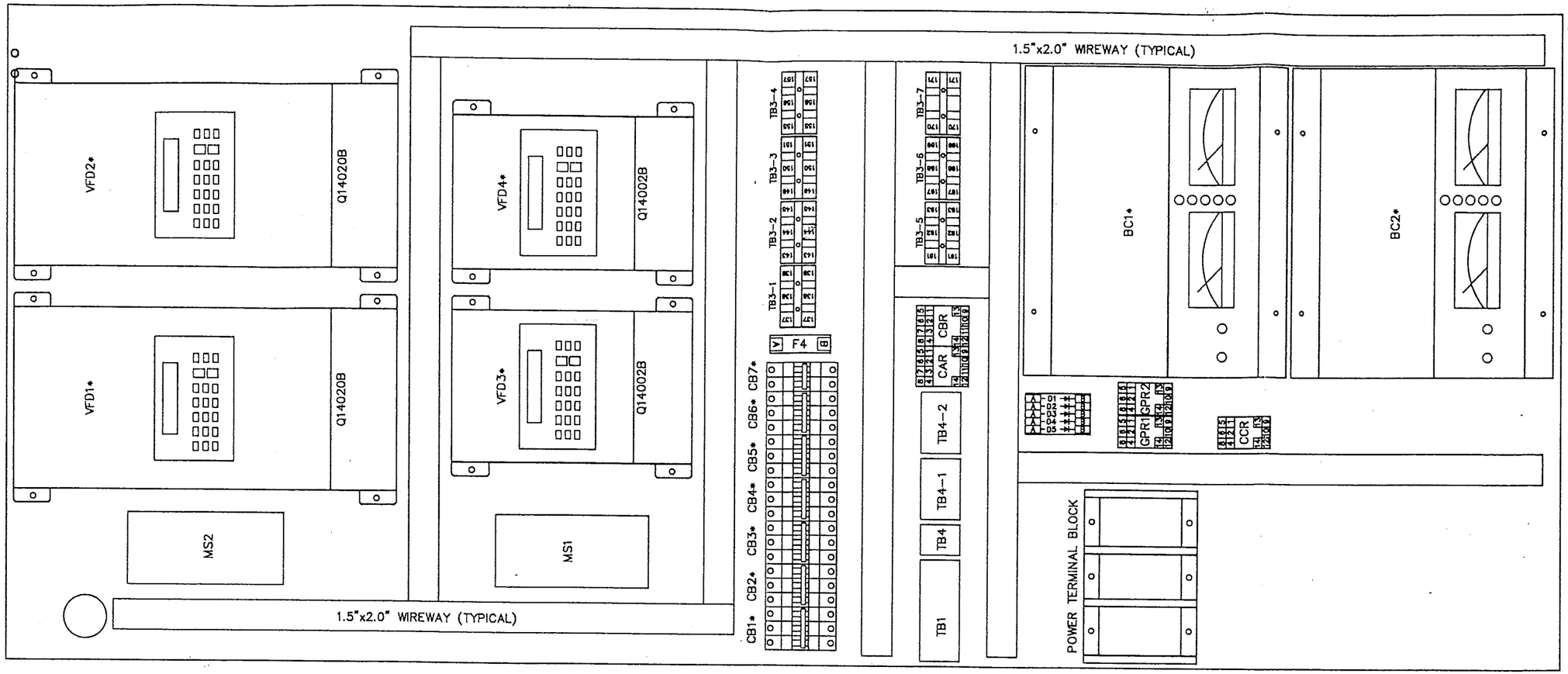
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

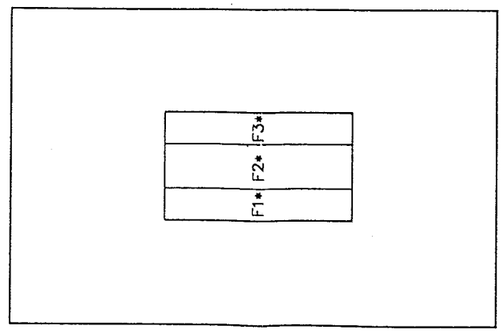
SCALE	.25=1	REVISIONS	BY	DATE
DATE	122294	4) AS BUILT	AJL	042495
DR'N	CR'D	3) CLARIFY PART LAYOUT	AJL	022795
		2) CHG TB4	DJA	021695
APV'D		1) ADDED RELAYS	DJA	020295

TITLE: GENERATOR SWITCHBOARD PART LAYOUT – SEC. 4 (UTILITY & MASTER)

NO. 952-0148-09 SHT 2 OF 4



COMPONENT PANEL



FUSE BLOCK PANEL

TB1

187	188	SHL	189	190	SHL	191	192	SHL	193	194	SHL

TB4 DETAIL

010	330	331	SHL

TB4-1 DETAIL

1011	1014	1082	1083	1084	1088	1089	1090	1091	1092	1093

TB4-2 DETAIL

2011	2014	2082	2083	2084	2088	2089	2090	2091	2092	2093

SYSTEM 1

187	188	191	192

SYSTEM 2

189	190	193	194

DANE COUNTY

CUSTOMER

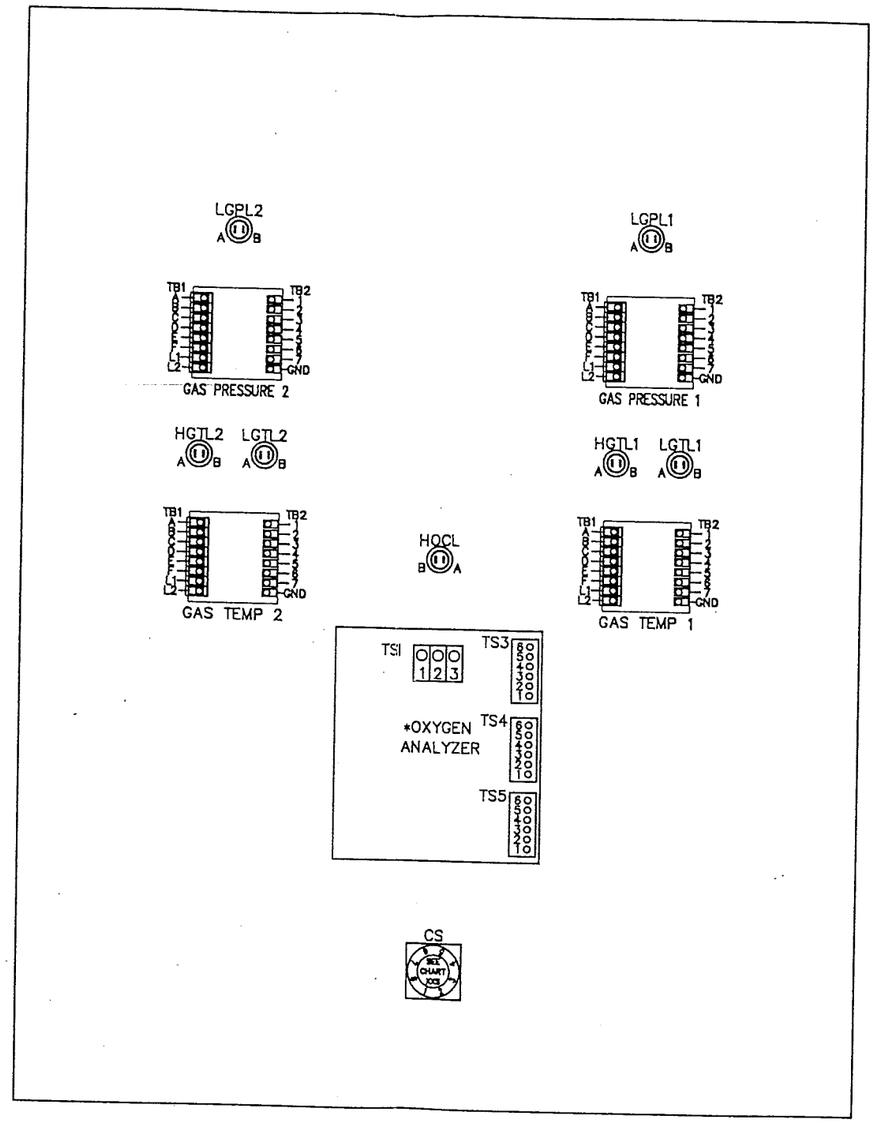
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	.25=1	REVISIONS	BY	DATE
DATE	021695	3) REVISED PART LAYOUT	AJL	042495
DR'N AH	CK'D	2) PART LAYOUT AS BUILT	AJL	032995
APP'D		1) REVISED PART LAYOUT	AJL	030195

TITLE: GENERATOR SWITCHBOARD PART LAYOUT - SEC. 1 (GAS PROCESSING)

NO. 952-0148-09 SHT 3 OF 4



DANE COUNTY

CUSTOMER

TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	.25=1	REVISIONS	BY	DATE
DATE	021795			
DWN AM	CK'D			
APVD		1) REVISED PART LAYOUT	AJL	022895

TITLE: GENERATOR SWITCHBOARD PART LAYOUT – SEC. 1 (GAS PROCESSING)

NO. 952-0148-09
SHT 4 OF 4

SWITCHBOARD

SYM	DESCRIPTION
ABR	AUXILIARY BREAKER RELAY
AC	ACTUATING CONTACT
AH	ALARM HORN
AHL	ALARM HORN LIGHT
AHR	ALARM HORN RELAY
AM	AMMETER
AMS	AMMETER SWITCH
APL	ALTERNATE POWER ON LIGHT
APR	ALTERNATE POWER ON RELAY
AS	AUTOMATIC SYNCHRONIZER
ASR	AUTOMATIC SYNCHRONIZER RELAY
ATS	AUTOMATIC TRANSFER SWITCH
AUX	CIRCUIT BREAKER AUX SWITCH
AVS	AMMETER/VOLTMETER SWITCH
B	BLUE
BA	BELL ALARM
BC	BATTERY CHARGER
BCFL	BATTERY CHARGER FAILURE LIGHT
BCFR	BATTERY CHARGER FAILURE RELAY
BCL	BREAKER CLOSED LIGHT
BCM	BACKUP CONTROL MODULE
BCR	BREAKER CLOSED RELAY
BCS	BREAKER CONTROL SWITCH
BCVM	BATTERY CHARGER VOLTMETER
BK	BLACK
BOL	BREAKER OPEN LIGHT
BOR	BREAKER OPEN RELAY
BR	BROWN
BTL	BREAKER TRIP LIGHT
BTM	BEARING TEMP. MONITOR
BTMR	BEARING TEMP. MONITOR RELAY
BTMSS	BEARING TEMP. SELECTOR SWITCH
BTR	BREAKER TRIP RELAY
C	CAPACITOR
CB	CIRCUIT BREAKER
CBR	CLOSE BREAKER RELAY
CCT	CROSS CURRENT TRANSFORMER
CGR	CLOSE GENERATOR BREAKER RELAY
CLT	CRANK LENGTH TIMER
CNTR	COUNTER
CNTL	CONTROL
CPB	CRANK PUSHBUTTON
CPR	CONTROL POWER RELAY
CS	CONTROL SWITCH
CT	CURRENT TRANSFORMER
CTD	CAPACITOR TRIP DEVICE
CTR	CRANK TERMINATION RELAY
CUL	CURRENT LIGHT
CUR	CLLOSED UTILITY BREAKER RELAY
D	DIODE
DBR	DEAD BUS RELAY
DBT	DEAD BUS TIMER
DECS	DIGITAL EXCITATION CONTROL SYSTEM
DFL	DIFFERENTIAL FAULT LIGHT
DR	DIFFERENTIAL RELAY
DS	DISCONNECT SWITCH
ECR	ENGINE CRANK RELAY
EMT	ENGINE MAINTAIN TIMER
EPAL	EMERGENCY POWER AVAILABLE LIGHT
EPL	EMERGENCY POWER ON LIGHT
EPR	EMERGENCY POWER ON RELAY
ERL	ENGINE RUN LIGHT
ERR	ENGINE RUN RELAY
ESL	EMERGENCY STOP LIGHT
ESP	EMERGENCY STOP PUSHBUTTON
ESPP	ENGINE STOP PUSHBUTTON
ESPR	ENGINE STOP RELAY
ESR	EMERGENCY STOP RELAY
ESTP	ENGINE START PUSHBUTTON
ESTR	ENGINE START RELAY
ETM	ELAPSED TIME METER
F	FUSE
FBR	FUSE BLOWN RELAY
FES	FLOAT EQUALIZER SWITCH
FLR	FLASHING RELAY
FM	FREQUENCY METER
FPG	FUEL PRESSURE GAUGE
FPL	FAIL TO PARALLEL LIGHT
FPT	FAIL TO PARALLEL TIMER
FR	FREQUENCY RELAY
FVR	FUEL VALVE RELAY
G#SR	GENERATOR # STOP RELAY
GCB	GENERATOR CIRCUIT BREAKER
GCBR	GENERATOR CIRCUIT BREAKER RELAY
GDCT	GENERATOR DIFFERENTIAL CURRENT TRANSFORMER
GFCT	GROUND FAULT CURRENT TRANSFORMER
GFL	GROUND FAULT LIGHT
GFP	GROUND FAULT RESET (PUSHBUTTON)
GFR	GROUND FAULT RELAY
GFS	GROUND FAULT SENSOR

SWITCHBOARD

SYM	DESCRIPTION
GOFL	GENERATOR OFF LIGHT
GOL	GENERATOR ON LIGHT
GOLL	GENERATOR ON LINE LIGHT
GPBR	GENERATOR PHASE BALANCE RELAY
GPLL	GLOW PLUG LIGHT
GPLR	GLOW PLUG RELAY
GPLS	GLOW PLUG SWITCH
GPLT	GLOW PLUG TIMER
GPR	GENERATOR PREFERRED RELAY
GPS	GENERATOR PREFERRED SWITCH
GRL	GENERATOR RUNNING LIGHT
GSS	GENERATOR SYNCHRONIZING SWITCH
GTL	GENERATOR TROUBLE LIGHT
GVB	GENERATOR VACUUM BREAKER
H	HEATER
HBTL	HIGH BEARING TEMPERATURE LIGHT
HBTR	HIGH BEARING TEMPERATURE RELAY
HBVL	HIGH BATTERY VOLTAGE LIGHT
HBVR	HIGH BATTERY VOLTAGE RELAY
HBVT	HIGH BATTERY VOLTAGE TIMER
HFLL	HIGH FUEL LEVEL LIGHT
HFLR	HIGH FUEL LEVEL RELAY
HGWTL	HIGH GEN. WINDING TEMPERATURE LIGHT
HGWTR	HIGH GEN. WINDING TEMPERATURE RELAY
HOTL	HIGH OIL TEMPERATURE LIGHT
HOTR	HIGH OIL TEMPERATURE RELAY
HS	HEATER SWITCH
HSL	HORN SILENCE LIGHT
HSP	HORN SILENCE PUSHBUTTON
HSR	HORN SILENCE RELAY
HSS	HORN SILENCE SWITCH
HWTL	HIGH WATER TEMPERATURE LIGHT
HWTR	HIGH WATER TEMPERATURE RELAY
ILS	ISOCHRONOUS LOAD SHARING MODULE
K	CONTROL RELAY
L	INDUCTOR
LAR	LOAD ADD RELAY
LBD	LAMP BOARD
LBS	LOAD BANK SWITCH
LBVL	LOW BATTERY VOLTAGE LIGHT
LBVR	LOW BATTERY VOLTAGE RELAY
LBVT	LOW BATTERY VOLTAGE TIMER
LDC	LOAD DEMAND CONTROLLER
LDR	LOAD DEMAND TIMER RELAY
LDT	LOAD DEMAND TIMER
LER	LOSS OF EXCITATION RELAY
LFLL	LOW FUEL LEVEL LIGHT
LFLR	LOW FUEL LEVEL RELAY
LL1L	LOW LEVEL 1 LIGHT
LL1R	LOW LEVEL 1 RELAY
LL2L	LOW LEVEL 2 LIGHT
LL2R	LOW LEVEL 2 RELAY
LOLL	LOW OIL LEVEL LIGHT
LOLR	LOW OIL LEVEL RELAY
LOPL	LOW OIL PRESSURE LIGHT
LOPR	LOW OIL PRESSURE RELAY
LSL	LOAD SHED LIGHT
LSR	LOAD SHED RELAY
LSTL	LOW STORAGE TANK LIGHT
LSTR	LOW STORAGE TANK RELAY
LTP	LAMP TEST PUSHBUTTON
LWLL	LOW WATER LEVEL LIGHT
LWLR	LOW WATER LEVEL RELAY
LWPL	LOW WATER PRESSURE LIGHT
LWPR	LOW WATER PRESSURE RELAY
LWTL	LOW WATER TEMPERATURE LIGHT
LWTR	LOW WATER TEMPERATURE RELAY
MCS	MASTER CONTROL SWITCH
MMR	MANUAL MODE RELAY
MO	MOTOR OPERATOR
MVC	MANUAL VOLTAGE CONTROL
MVL	MANUAL VOLTAGE LIGHT
MVR	MANUAL VOLTAGE RELAY
N	NEUTRAL
NAL	NOT IN AUTO LIGHT
NAR	NOT IN AUTO RELAY
NCT	NEUTRAL CURRENT TRANSFORMER
NGR	NEUTRAL GROUNDING RESISTOR
NPAL	NORMAL POWER AVAILABLE LIGHT
NPL	NORMAL POWER ON LIGHT
NPR	NORMAL POWER ON RELAY
O	ORANGE
OBR	OPEN BREAKER RELAY
OCL	OVERCRANK LIGHT
OCR	OVERCRANK RELAY
OCUL	OVERCURRENT LIGHT
OCUR	OVERCURRENT RELAY
OFL	OVERFREQUENCY LIGHT
OGR	OPEN GENERATOR BREAKER RELAY
OPBL	OIL PRESSURE BYPASS LIGHT

SWITCHBOARD

SYM	DESCRIPTION
OPBR	OIL PRESSURE BYPASS RELAY
OPBT	OIL PRESSURE BYPASS TIMER
OPG	OIL PRESSURE GAUGE
ORPB	OVERRIDE PUSHBUTTON (ATS)
ORR	OFF/RESET RELAY
OSL	OVERSPEED LIGHT
OSR	OVERSPEED RELAY
SUFR	SLAVE UNDERFREQUENCY RELAY
SUVR	SLAVE UNDERVOLTAGE RELAY
OUR	OPEN UTILITY BREAKER RELAY
P	POTENTIOMETER
PAL	PRE-ALARM LIGHT
PAR	PRE-ALARM RELAY
PBR	PARALLEL BUS RELAY
PBT	PARALLEL BUS TIMER
PC	PROCESS CONTROL
PFM	POWER FACTOR METER
PFR	PHASE FAILURE RELAY (U/VOL)
PFRO	PHASE FAILURE RELAY (O/VOL)
PHWTL	PRE-HIGH WATER TEMPERATURE LIGHT
PHWTR	PRE-HIGH WATER TEMPERATURE RELAY
PLC	PROGRAMABLE LOGIC CONTROLLER
PLOPL	PRE-LOW OIL PRESSURE LIGHT
PLOPR	PRE-LOW OIL PRESSURE RELAY
PLS	PANEL LIGHT SWITCH
PLWLL	PRE-LOW WATER LEVEL LIGHT
PLWLR	PRE-LOW WATER LEVEL RELAY
PLWTL	PRE-LOW WATER TEMP. LIGHT
PLWTR	PRE-LOW WATER TEMP. RELAY
PM	POWER MONITOR
PR	PILOT RELAY
PSR	PHASE SEQUENCE RELAY
PT	POTENTIAL TRANSFORMER
PVBL	PRE-VIBRATION LIGHT
PVBR	PRE-VIBRATION RELAY
Q	SOLID STATE SWITCH
R	RESISTOR
RB	RECTIFIER BRIDGE
RBD	RELAY BOARD
REC	RECEPTACLE
RIR	RECRANK INHIBIT RELAY
RP	RESET PUSHBUTTON
RPL	REVERSE POWER LIGHT
RPR	REVERSE POWER RELAY
RPT	REVERSE POWER TIMER
RR	RESET RELAY
RST	RACK SOLENOID TIMER
RTSR	READY-TO-SYNCRONIZE RELAY
S	SWITCH
SAP	SPEED ADJUST POTENTIOMETER
SAR	SLAVE ACTUATING RELAY
SC	SIGNAL CONDITIONER
SCR	SYNCHRONIZING CHECK RELAY
SCS	SYNCHROSCOPE
SCUR	SLAVE CURRENT RELAY
SFLR	SLAVE FUSE LOSS RELAY
SGFR	SLAVE GROUND FAULT RELAY
SHWTR	SLAVE HIGH WATER TEMP. RELAY
SL	SYNC LIGHT
SLER	SLAVE LOSS OF EXCITATION RELAY
SLOPR	SLAVE LOW OIL PRESSURE RELAY
SLS	SYNC LIGHT SWITCH
SLSR	SLAVE LOAD SHED RELAY
SM	STARTMASTER
SOBR	SLAVE OPEN BREAKER RELAY
SOCR	SLAVE OVERCRANK RELAY
SOSR	SLAVE OVERSPEED RELAY
SOVR	SLAVE OVERVOLTAGE RELAY
SPBR	SLAVE PARALLEL BUS RELAY
SPFR	SLAVE POWER FAILURE RELAY
SPOR	SLAVE POWER OK RELAY
SRG#	START RELAY GENERATOR #
SRPR	SLAVE REVERSE POWER RELAY
SS	SELECTOR SWITCH
SSR	SYSTEM START RELAY
ST	SHUNT TRIP
STR	SYSTEM TROUBLE RELAY
STFR	SLAVE TEST FAIL RELAY
SUPR	SLAVE UTILITY PROTECTIVE RELAY
SUVR	SLAVE UNDERVOLTAGE RELAY
SYR	SYNCRONIZE RELAY
T	TRANSFORMER
TB	TERMINAL BLOCK
TM	TRANSFER MOTOR
TR	TROUBLE RELAY
UCB	UTILITY CIRCUIT BREAKER
UCBR	UTILITY CLOSED BREAKER RELAY
UOBR	UTILITY OPEN BREAKER RELAY
UPBR	UTILITY PHASE BALANCE RELAY
UPR	UTILITY PROTECTIVE RELAY

SWITCHBOARD

SYM	DESCRIPTION
UTR	UTILITY TROUBLE RELAY
UCB	UTILITY CIRCUIT BREAKER
UCUR	UNDERCURRENT RELAY
UCUT	UNDERCURRENT TIMER
UFL	UNDERFREQUENCY LIGHT
UFR	UNDERFREQUENCY RELAY
UFT	UNDERFREQUENCY TIMER
UVB	UTILITY VACUUM BREAKER
UVL	UNDERVOLTAGE LIGHT
UVR	UNDERVOLTAGE RELAY
UVT	UNDERVOLTAGE TIMER
V	VIOLET
VBL	VIBRATION LIGHT
VBM	VIBRATION MONITOR
VBR	VIBRATION RELAY
VCB	VACUUM CIRCUIT BREAKER
VCS	VOLTAGE CONTROL SWITCH
VM	VOLTMETER
VMS	VOLTMETER SWITCH
VMT	VOLTMETER TRANSDUCER
VR	VOLTAGE REGULATOR
VRM	VARMETER
VRMT	VARMETER TRANSDUCER
W	WHITE
WHM	WATTHOUR METER
WM	WATTMETER
WMT	WATTMETER TRANSDUCER
WTG	WATER TEMPERATURE GAUGE
WUT	WARM UP TIMER
Y	YELLOW
Z	ZENER DIODE

ENGINE

SYM	DESCRIPTION
ALT	ALTERNATOR
AMM	AMMETER
ASOS	AIR SHUT-OFF
ASSV	AIR START SOLENOID VALVE
AVS	ALTERNATOR VOLTAGE REGULATOR
AVRPS	ALTERNATOR VOLT. REG. PRES. SWITCH
B-	BATTERY NEGATIVE
B+	BATTERY POSITIVE
BATT	BATTERY
CB	CIRCUIT BREAKER
CM	CRANKING MOTOR
CMC	CRANKING MOTOR CONTACTOR
CT	CRANK TERMINATION
D	DIODE
DM	DIODE MODULE
DSS	DUAL SPEED SWITCH
EGA	ELECTRIC GOVERNOR ACTUATOR
EGC	ELECTRIC GOVERNOR CONTROL
ESS	ELECTRIC SPEED SWITCH
FOPS	FUEL OIL PRESSURE SWITCH
FSOS	FUEL SHUT-OFF SOLENOID
GM	GOVERNOR MOTOR
GOV	GOVERNOR
GP	GLOW PLUG
GSM	GOVERNOR SYNC. MOTOR
HCCPS	HIGH CRANK CASE PRESSURE SWITCH
HM	HOUR METER
HMMPU	HOUR METER MAGNETIC PICK-UP
HWTA	HIGH WATER TEMPERATURE ALARM
HWTS	HIGH WATER TEMPERATURE SWITCH
HVS	HIGH VIBRATION SWITCH

ENGINE

SYM	DESCRIPTION
LFLA	LOW FUEL LEVEL ALARM
LFLAS	LOW FUEL LEVEL ALARM SWITCH
LOLA	LOW OIL LEVEL ALARM
LOLAS	LOW OIL LEVEL ALARM SWITCH
LOPA	LOW OIL PRESSURE ALARM
LOPAS	LOW OIL PRESSURE ALARM SWITCH
LWLA	LOW WATER LEVEL ALARM
LWLAS	LOW WATER LEVEL ALARM SWITCH
LWTA	LOW WATER TEMPERATURE ALARM
LWTAS	LOW WATER TEMPERATURE ALARM SWITCH
MPU	MAGNETIC PICK-UP
OPG	OIL PRESSURE GAUGE
OPI	OIL PRESSURE INDICATOR
OPS	OIL PRESSURE SWITCH
OPSS	OIL PRESSURE STEP SWITCH
OPSU	OIL PRESSURE SENDING UNIT
OS	OVERSPEED
OSI	OVERSPEED INDICATOR
OSS	OVERSPEED SWITCH
PB	PUSHBUTTON
PP	PRELUBE PUMP
PPMS	PRELUBE PUMP MAGNETIC SWITCH
PPPS	PRELUBE PUMP PRESSURE SWITCH
PR	PRE-REGULATOR
PS	PINION SOLENOID
RES	RESISTOR
RLS	RAISE-LOWER SWITCH
RNS	REMOTE NORMAL SHUT-OFF SWITCH
RNSS	REMOTE NORMAL STOP SWITCH
RSAS	REMOTE STARTING AID SWITCH
RSC	REMOTE SPEED CONTROL
RSS	REMOTE START SWITCH
SA	STARTING AID
SAMS	STARTING AID MAGNETIC SWITCH
SAS	STARTING AID SWITCH
SASV	STARTING AID SOLENOID VALVE
SATS	STARTING AID TEMPERATURE SWITCH
SM	STARTING MOTOR
SMMS	STARTING MOTOR MAGNETIC SWITCH
SR	STARTER RELAY
SS	START SWITCH
SSMPU	SPEED SWITCH MAGNETIC PICK-UP
SSS	START-STOP SWITCH
TD	TIME DELAY
TM	TACHOMETER
TMMPU	TACHOMETER MAGNETIC PICK-UP
TMS	TACHOMETER
TS	TERMINAL STRIP
TSDV	THROTTLE SOLENOID DUMP VALVE
TSS	TACHOMETER SPEED SENSOR
WTG	WATER TEMPERATURE GAUGE
WTI	WATER TEMPERATURE INDICATOR
WTS	WATER TEMPERATURE SWITCH
WTSU	WATER TEMPERATURE SENDING UNIT

DANE COUNTY

CUSTOMER

TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

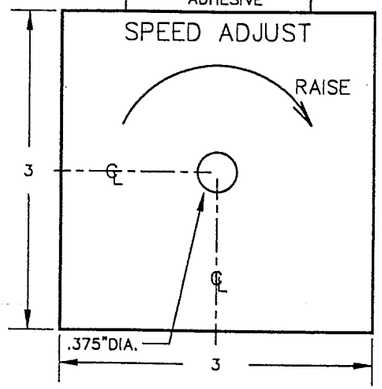
SCALE	NONE	REVISIONS	BY	DATE
DATE	122394			
DR'N	TLF	CK'D		
APP'VD		1) ADDED NOMENCLATURE	DJA	020295

TITLE: GENERATOR SWITCHBOARD NOMENCLATURE

NO. 952-0148-10

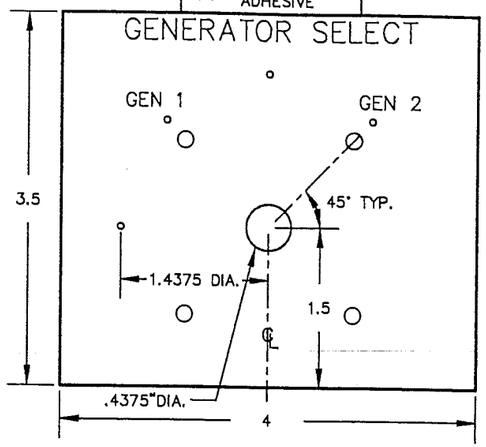
ITEM# 1 | QTY. 2
MAT. BLK/WHT/.063
MTG. ADHESIVE

SPEED ADJUST

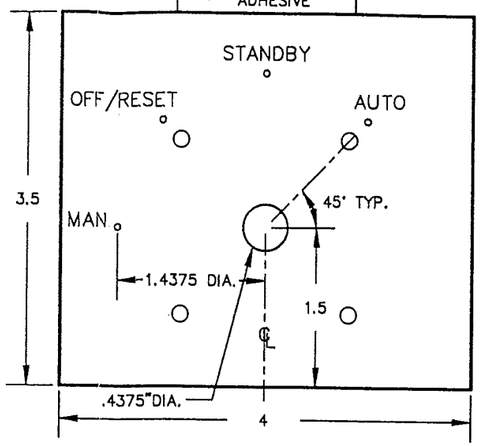


ITEM# 1 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE

GENERATOR SELECT



ITEM# 1 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE



ITEM# 5 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE

MASTER

2
6

ITEM# 6 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE

GENERATOR#1

2
6

ITEM# 7 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE

GENERATOR#2

2
6

ITEM# 8 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE

GCB-1

2
6

ITEM# 9 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE

GCB-2

2
6

ITEM# 10 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE

UCB

2
6

ITEM# 11 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE

SYNCHRONIZED WHEN DARK

1
2

ITEM# 12 | QTY. 3
MAT. BLK/WHT/.063
MTG. ADHESIVE

LAMP TEST

1
2

ITEM# 13 | QTY. 3
MAT. BLK/WHT/.063
MTG. ADHESIVE

HORN SILENCE

1
2

ITEM# 14 | QTY. 2
MAT. BLK/WHT/.063
MTG. ADHESIVE

EMERGENCY STOP

1
2

DANE COUNTY
CUSTOMER

TOTAL ENERGY TECHNOLOGIES

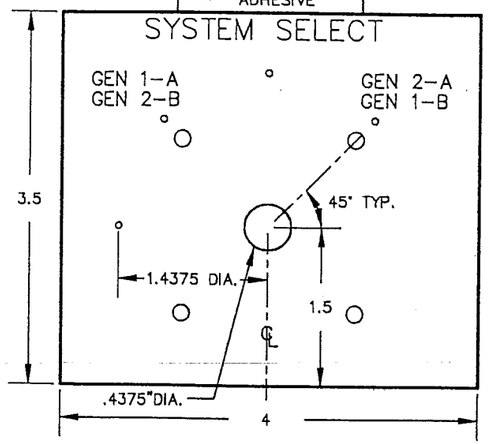
LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	122394			
DR'N TJF	CK'D	2) CHANGE QUANTITY	TJF	041095
APP'VD		1) DELETE BREAKER CONTROL	TJF	040595

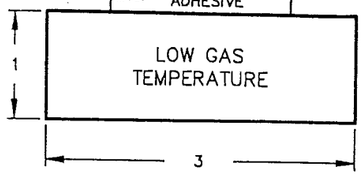
TITLE: GENERATOR SWITCHBOARD NAMEPLATES

NO. 952-0148-11
SHT 1 OF 2

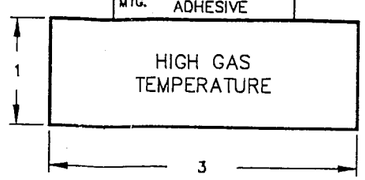
ITEM#15 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE



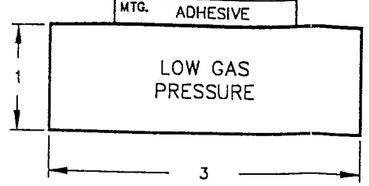
ITEM#16 | QTY. 2
MAT. BLK/WHT/.063
MTG. ADHESIVE



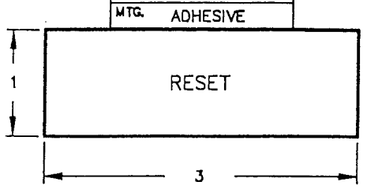
ITEM#17 | QTY. 2
MAT. BLK/WHT/.063
MTG. ADHESIVE



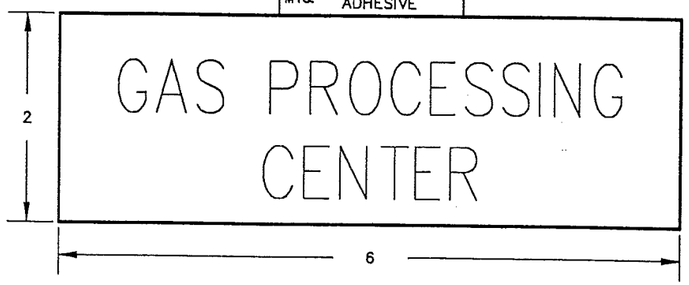
ITEM#18 | QTY. 2
MAT. BLK/WHT/.063
MTG. ADHESIVE



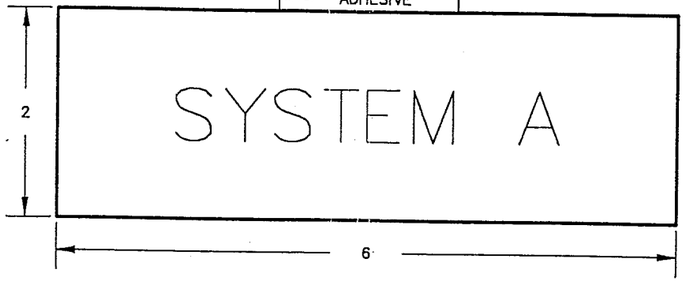
ITEM#18A | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE



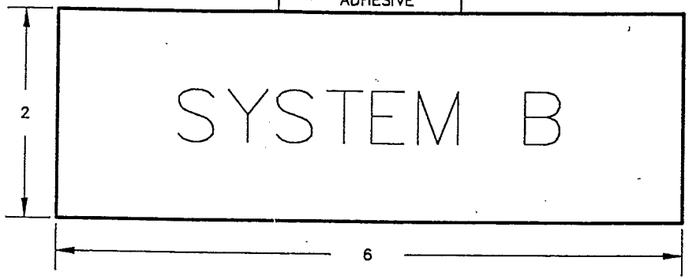
ITEM#19 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE



ITEM#20 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE



ITEM#21 | QTY. 1
MAT. BLK/WHT/.063
MTG. ADHESIVE



DANE COUNTY
CUSTOMER

TOTAL ENERGY
TECHNOLOGIES

LAKE SHORE ELECTRIC
CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	122394			
DR'N TJF	CK'D	2) CLARIFY	TJF	041095
APP'VD		1) SYSTEM SELECT NAMEPLATE	TJF	040595

TITLE: GENERATOR SWITCHBOARD NAMEPLATES

NO. 952-0148-11
SHT 2 OF 2

GENERATOR 1

0 — CS1(OFF):I:010/0 → N7:0/0 ORR1 — GEN 1 OFF/RESET RELAY

1 — SSR1(I:010/7) G1SR(O:010/2) CS1(MAN,TEST):I:010/10 → N7:0/1 SSSR 1 — SLAVE SYSTEM START RELAY1

2 — SSSR1(N7:0/1) → TON T4:1 (1 SEC, 180 SEC) DN — ENGINE MAINTAIN TIMER1

3 — SSSR1(N7:0/1) T4:1/DN STR1(I:010/3) T4:26/DN ORR1(N7:0/0) EMR1(N7:0/2) → TON T4:23 (1 SEC, 45 SEC) DN — 45 SEC. DELAY TO CRANK

4 — T4:23/DN OCR1(O:010/3) → N7:0/2 EMR1 — ENGINE MAINTAIN RELAY1

5 — EMR1(N7:0/2) → N7:0/3 PR1 — PILOT RELAY1

6 — EMR1(N7:0/2) SSSR1(N7:0/1) STR1(I:010/3) T4:26/DN → O:010/1 FVR1 — FUEL VALVE RELAY1

7 — PR1(N7:0/3) RIR1(N7:0/4) T4:3/DN ORR1(N7:0/0) → TON T4:2 (1 SEC, 15 SEC) DN — CRANK CYCLE TIMER1

8 — PR1(N7:0/3) RIR1(N7:0/4) T4:2/DN → O:010/0 SR1 — START RELAY1

9 — PR1(N7:0/3) RIR1(N7:0/4) T4:2/DN → TON T4:3 (1 SEC, 10 SEC.) DN — CRANK REST TIMER1

10 — PR1(N7:0/3) RIR1(N7:0/4) T4:4/DN ORR1(N7:0/0) → TON T4:4 (1 SEC, 115 SEC.) DN — TOTAL CRANK TIMER1

11 — EMR1(N7:0/2) RIR1(N7:0/4) ORR1(N7:0/0) ESS1(CT):I:010/1 → N7:0/4 RIR1 — RECRANK INHIBIT RELAY1

12 — T4:4/DN → O:010/3 OCR1 — OVERCRANK RELAY1

13 — ESS1(OS):I:010/2 → N7:0/6 OSR1 — OVERSPEED RELAY1

14 — EMR1(N7:0/2) RIR1(N7:0/4) ORR1(N7:0/0) → TON T4:5 (1 SEC, 3 SEC.) DN — OIL PRESSURE BYPASS TIMER1

15 — T4:5/DN → O:010/7 OPBR1 — OIL PRESSURE BYPASS RELAY1

GENERATOR 2

16 — CS2(OFF):I:010/12 → N7:1/0 ORR2 — GEN 2 OFF/RESET RELAY

17 — SSR2(I:011/1) G2SR(O:010/14) CS2(MAN,TEST):I:011/2 → N7:1/1 SSSR 2 — SLAVE SYSTEM START RELAY2

18 — SSSR2(N7:1/1) → TON T4:6 (1 SEC, 180 SEC) DN — ENGINE MAINTAIN TIMER

19 — SSSR2(N7:1/1) T4:8/DN STR2(I:010/15) T4:27/DN ORR2(N7:1/0) EMR2(N7:1/2) → TON T4:24 (1 SEC, 45 SEC) DN — 45 SEC. DELAY TO CRANK

20 — T4:24/DN OCR2(O:010/15) → N7:1/2 EMR2 — ENGINE MAINTAIN RELAY2

21 — EMR2(N7:1/2) → N7:1/3 PR2 — PILOT RELAY2

22 — EMR2(N7:1/2) SSSR2(N7:1/1) STR2(I:010/15) T4:27/DN → O:010/13 FVR2 — FUEL VALVE RELAY2

23 — PR2(N7:1/3) RIR2(N7:1/4) T4:8/DN ORR2(N7:1/0) → TON T4:7 (1 SEC, 15 SEC) DN — CRANK CYCLE TIMER2

24 — PR2(N7:1/3) RIR2(N7:1/4) T4:7/DN → O:010/12 SR2 — START RELAY2

25 — PR2(N7:1/3) RIR2(N7:1/4) T4:7/DN → TON T4:8 (1 SEC, 10 SEC.) DN — CRANK REST TIMER2

28 — PR2(N7:1/3) RIR2(N7:1/4) T4:9/DN ORR2(N7:1/0) → TON T4:9 (1 SEC, 115 SEC.) DN — TOTAL CRANK TIMER2

27 — EMR2(N7:1/2) RIR2(N7:1/4) ORR2(N7:1/0) ESS2(CT):I:010/13 → N7:1/4 RIR2 — RECRANK INHIBIT RELAY2

28 — T4:9/DN → O:010/15 OCR2 — OVERCRANK RELAY2

29 — ESS2(OS):I:010/14 → N7:1/6 OSR2 — OVERSPEED RELAY2

30 — EMR2(N7:1/2) RIR2(N7:1/4) ORR2(N7:1/0) → TON T4:10 (1 SEC, 3 SEC.) DN — OIL PRESSURE BYPASS TIMER2

31 — T4:10/DN OIL PRESSURE BYPASS RELAY 2 → O:011/1 OPBR2

SYSTEM OPERATION

32 — SSR1(I:010/7) T4:14/DN → TON T4:11 (1 SEC, 600 SEC, 10 MIN) DN — 10 MIN TIMER

33 — COMP GRT (SOURCE A N7:10, SOURCE B 2466) → N7:3/0 370KW (> 370KW) — START GEN 1

34 — COMP GEQ (SOURCE A N7:10, SOURCE B 1808) T4:17/DN → N7:3/1 225KW (≥ 225KW) — START GEN 2

35 — COMP GEQ (SOURCE A N7:10, SOURCE B 1200) → N7:3/2 100KW (≥ 100KW) — START GEN 1

36 — COMP LES (SOURCE A N7:10, SOURCE B 1258) G1RR(N7:3/8) → N7:3/6 100KW (< 100KW) — START 24 HR. SHUTDOWN

37 — COMP LES (SOURCE A N7:10, SOURCE B 1698) ESS1(CT):I:010/1 T4:17/DN → N7:3/3 200KW (< 200KW) — STOP GEN 2

38 — COMP LIM (LOW LIMIT 1917, TEST N7:10, HIGH LIMIT 2466) ESS1(CT):I:010/1 CS2(OFF):I:010/12 <100KW(N7:3/2) → N7:3/5 250-370 (≤ 250KW, ≤ 370KW) — STOP GEN 1

39 — 250-370(N7:3/5) → TON T4:25 (1 SEC, 300 SEC, 5 MIN) DN — 5 MIN STOP GEN 1

DANE COUNTY

CUSTOMER

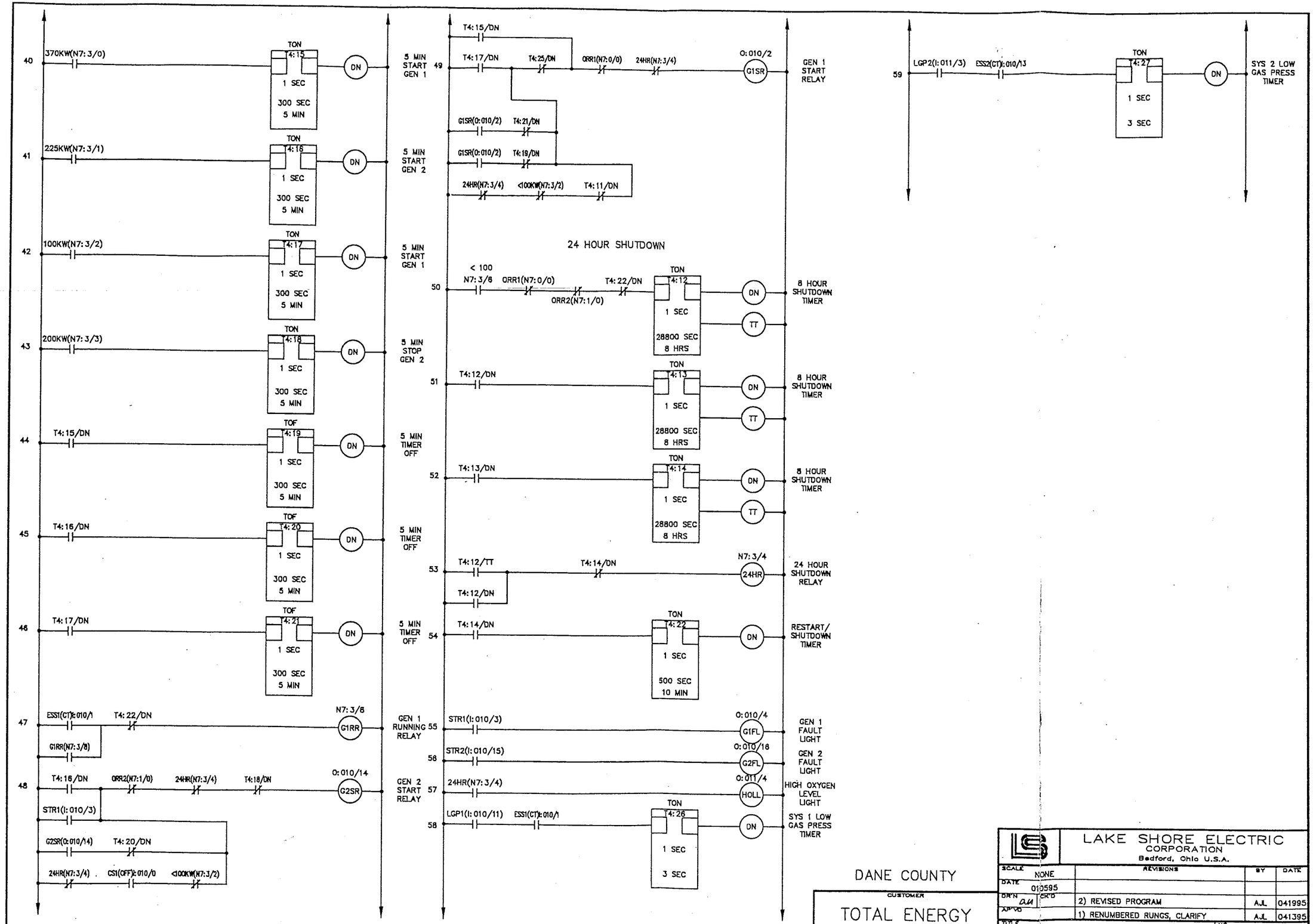
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	010395	3) REVISED PROGRAM	AJL	041995
DR'N AJL	CK'D	2) ADDED RUNGS FOR EMR'S	AJL	041395
APV'D		1) ADDED TD'S	DJA	021795

TITLE: GENERATOR SWITCHGEAR PLC SCHEMATIC

NO. 952-0148-12 SHT 1 OF 2



DANE COUNTY

CUSTOMER

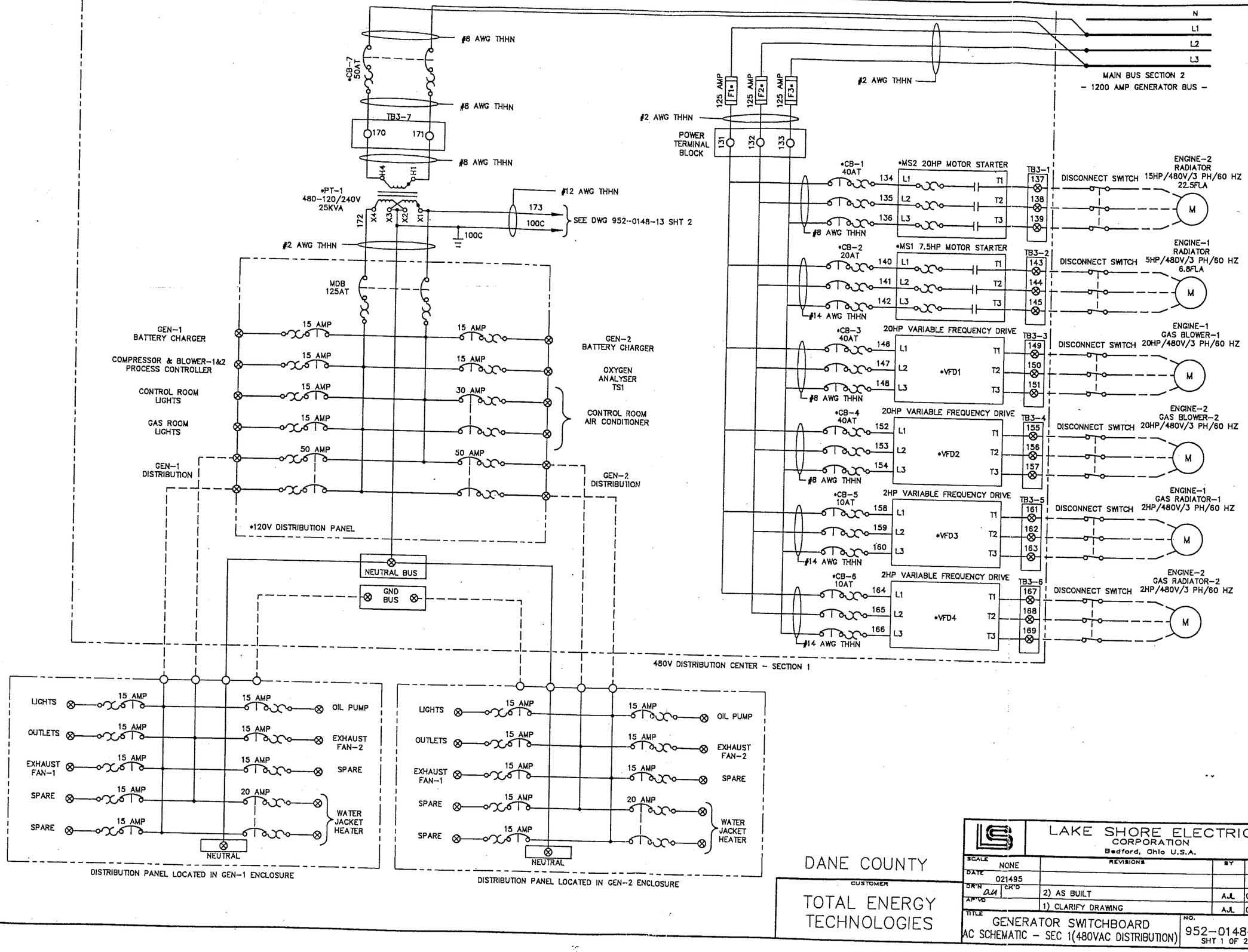
TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	010595			
DR'N	AM	2) REVISED PROGRAM	AJL	041995
CK'D		1) RENUMBERED RUNGS, CLARIFY	AJL	041395
APV'D				

TITLE: GENERATOR SWITCHGEAR PLC SCHEMATIC

NO. 952-0148-12 SHT 2 OF 2



DANE COUNTY

CUSTOMER

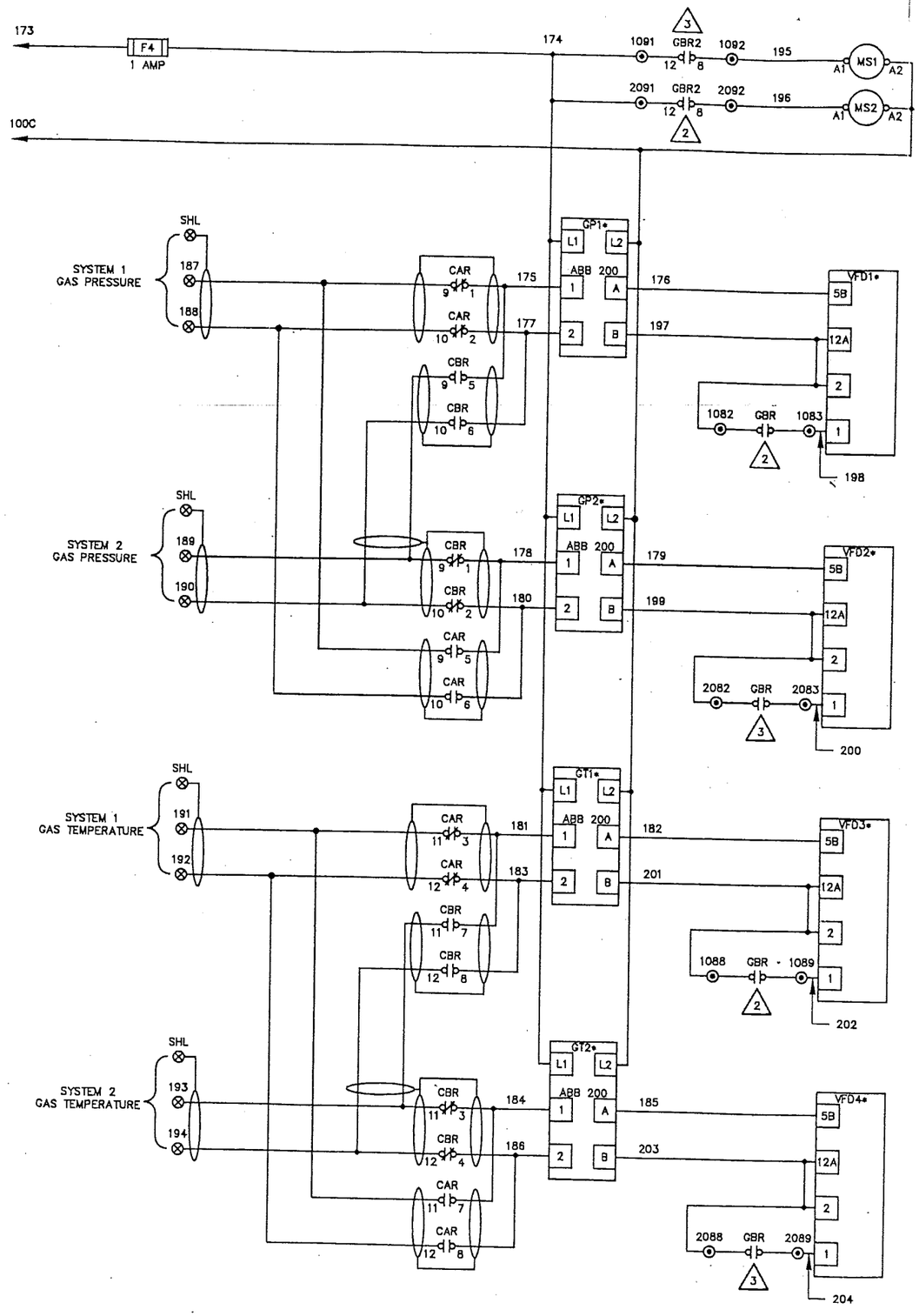
TOTAL ENERGY TECHNOLOGIES

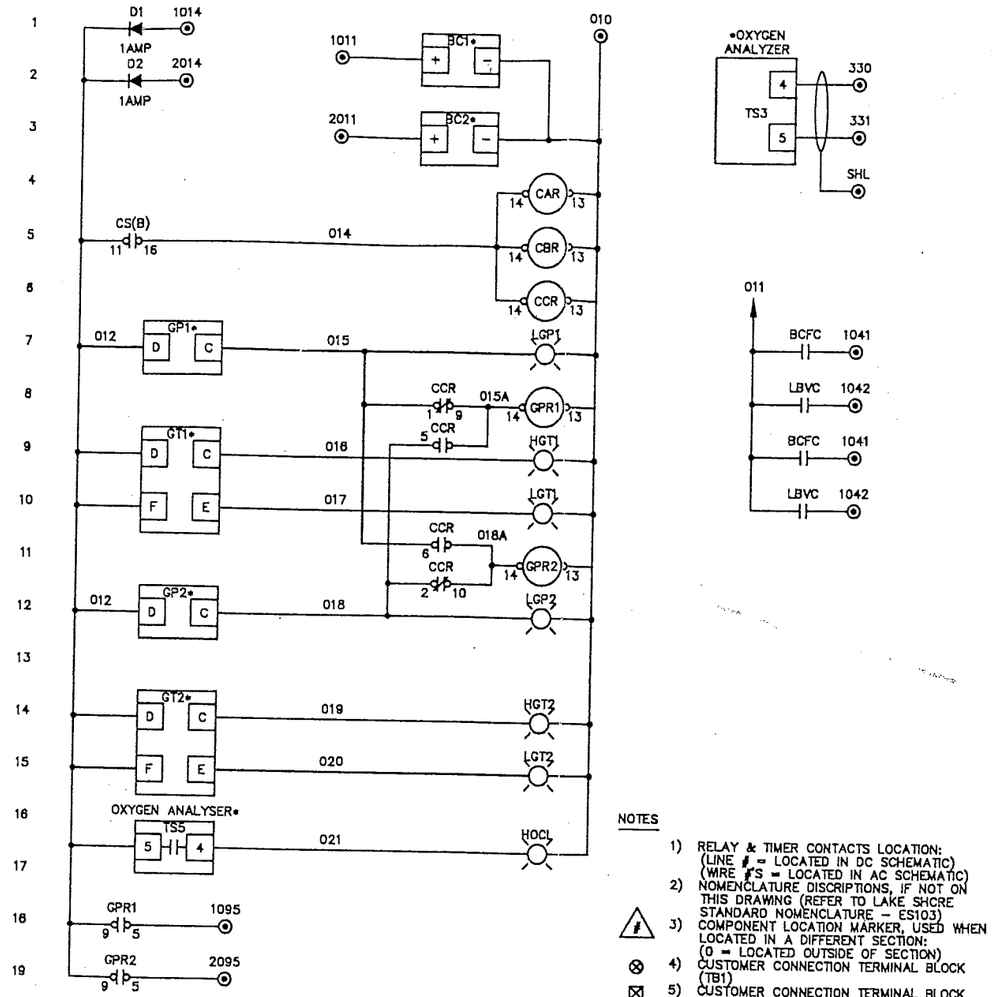
LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	021495			
DR'N AM	CK'D	2) AS BUILT	AJL	042495
APV'D		1) CLARIFY DRAWING	AJL	022895

TITLE: GENERATOR SWITCHBOARD AC SCHEMATIC - SEC 1(480VAC DISTRIBUTION)

NO. 952-0148-13 SHT 1 OF 2





NOTES

1) RELAY & TIMER CONTACTS LOCATION: (LINE # = LOCATED IN DC SCHEMATIC) (WIRE #'S = LOCATED IN AC SCHEMATIC)
2) NOMENCLATURE DISCRIPTIONS, IF NOT ON THIS DRAWING (REFER TO LAKE SHORE STANDARD NOMENCLATURE – ES103)
3) COMPONENT LOCATION MARKER, USED WHEN LOCATED IN A DIFFERENT SECTION: (0 = LOCATED OUTSIDE OF SECTION)
4) CUSTOMER CONNECTION TERMINAL BLOCK (TB1)
5) CUSTOMER CONNECTION TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
6) LAKE SHORE CONNECTION TERMINAL BLOCK (TB2 OR TB3)
7) LAKE SHORE CONNECTION TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
8) LAKE SHORE SEC. TO SEC. TERMINAL BLOCK (TB4)
9) LAKE SHORE SEC. TO SEC. TERMINAL BLOCK (LOCATED ON PC BOARD OR BLACK BOX)
10) CUSTOMER ENGINE TERMINAL BLOCK (ETB)
11) CUSTOMER WIRING
12) CUSTOMER CABLING
13) CUSTOMER SUPPLIED EQUIPMENT
14) LAST WIRE # USED –

DC CONTROL CIRCUIT	021
AC CONTROL CIRCUIT	194
AC C.T. CIRCUIT	200
AC INSTRUMENT CIRCUIT	300
AC REGULATOR CIRCUIT	400
48VDC CONTROL CIRCUIT	500
125VDC CONTROL CIRCUIT	600

DANE COUNTY

CUSTOMER

TOTAL ENERGY TECHNOLOGIES

LAKE SHORE ELECTRIC CORPORATION
Bedford, Ohio U.S.A.

SCALE	NONE	REVISIONS	BY	DATE
DATE	021495			
DR'N	CR'D	2) AS BUILT	AJL	042495
APP'VD		1) ADDED MS1&MS2, CLARIFY DRAWING	AJL	030195

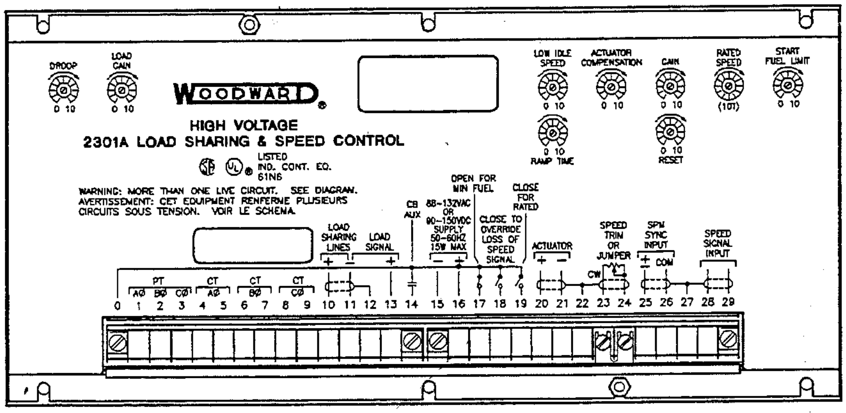
TITLE: GENERATOR SWITCHBOARD AC & DC SCHEMATIC – SEC 1

NO. 952-0148-13
SHT 2 OF 2

WOODWARD

ENGINE CONTROLS

2301A Electronic Load Sharing and Speed Controls 9905/9907 Series



UL Listed E97763

Installation, Operation, and Calibration Manual

WOODWARD GOVERNOR COMPANY

Manual 82389J

WARNING

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage.

The engine, turbine, or other type of prime mover should be equipped with an overspeed (overtemperature, or overpressure, where applicable) shutdown device(s), that operates totally independently of the prime mover control device(s) to protect against runaway or damage to the engine, turbine, or other type of prime mover with possible personal injury or loss of life should the mechanical-hydraulic governor(s) or electric control(s), the actuator(s), fuel control(s), the driving mechanism(s), the linkage(s), or the controlled device(s) fail.

CAUTION

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

CAUTION

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts.

- Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).
- Avoid all plastic, vinyl, and styrofoam (except antistatic versions) around printed circuit boards (PCBs).
- Do not touch the components or conductors on a PCB with your hands or with conductive devices.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

2301A Load Sharing and Speed Controls
9905/9907 Series

Low-Voltage Models (20 to 40 Vdc)

Part Number	Actuator Current (mA)	Forward/ Reverse Acting	Actuator Tandem/Single	Decel Ramp
9905-020	0–200	Forward	Single	No
9905-021	0–200	Reverse	Single	No
9905-022	0–400	Forward	Single	No
9905-023	0–400	Reverse	Single	No
9905-024	0–200	Forward	Tandem	No
9905-025	0–200	Reverse	Tandem	No
9905-026	0–20	Forward	Single	No
9905-027	0–20	Reverse	Single	No
9905-028	0–200	Forward	Single	Yes
9905-029	0–200	Reverse	Single	Yes
9907-018*	0–200	Forward	Single	Yes
9907-019*	0–200	Reverse	Single	Yes
9907-023*	0–200	Forward	Single	Yes
9907-024*	0–200	Reverse	Single	Yes

High-voltage Models (88–132 Vac or 90–150 Vdc)

Part Number	Actuator Current (mA)	Forward/ Reverse Acting	Actuator Tandem/Single	Decel Ramp
9905-030	0–200	Forward	Single	No
9905-031	0–200	Reverse	Single	No
9905-032	0–400	Forward	Single	No
9905-033	0–400	Reverse	Single	No
9905-034	0–200	Forward	Tandem	No
9905-035	0–200	Reverse	Tandem	No
9905-036	0–20	Forward	Single	No
9905-037	0–20	Reverse	Single	No
9905-038	0–200	Forward	Single	Yes
9905-039	0–200	Reverse	Single	Yes
9907-020*	0–200	Forward	Single	No
9907-021*	0–200	Reverse	Single	No

*—EU Directive compliant part numbers/non-UL

Declaration of Incorporation

In accordance with the EMC Directive 89/336/EEC and its amendments, this controlling device, manufactured by the Woodward Governor Company, is applied solely as a component to be incorporated into an engine prime mover system. Woodward Governor declares that this controlling device complies with the requirements of EN50081-2 and EN50082-2 when put into service per the installation and operation instructions outlined in the product manual. **NOTICE:** This controlling device is intended to be put into service only upon incorporation into an engine prime mover system that itself has met the requirements of the above Directive and bears the CE mark.

Speed Ranges

On these Woodward 2301A models, any one of the following speed ranges may be selected by a switch:

500 to 1500 Hz
1000 to 3000 Hz
2000 to 6000 Hz
4000 to 12 000 Hz

Power Supply Voltage

These Woodward 2301A controls accept either a high-voltage or a low-voltage power source. The low voltage models operate on 20 to 40 Vdc, and the high voltage models operate on either 88 to 132 Vac or 90 to 150 Vdc.

SECTION 1
GENERAL INFORMATION

INTRODUCTION

This manual has seven sections: General Information, Static Discharge Awareness, Installation, Operation and Adjustment, Description of Operation, Troubleshooting, and Repair and Replacement Procedures.

DESCRIPTION

The 9905 Series of the Woodward 2301A controls load sharing and speed of generators driven by diesel or gasoline engines, or steam or gas turbines. These power sources are referred to as "prime movers" throughout this manual.

The control is housed in a sheet-metal chassis and consists of a single printed circuit board. All potentiometers are accessible from the front of the chassis.

The 2301A provides control in either isochronous or droop mode.

The isochronous mode is used for constant prime mover speed with:

- Single-prime-mover operation or
- Two or more prime movers controlled by Woodward Governor Company load sharing control systems on an isolated bus.
- Base loading against an infinite bus with the load controlled by an Automatic Power Transfer and Load (APTL) Control, an Import/Export Control, a Generator Loading Control, a Process Control, or another load-controlling accessory.

The droop mode is used for speed control as a function of load with:

- Single-prime-mover operation on an infinite bus or
- Parallel operation of two or more prime movers.

The 2301A system for a single prime-mover generator includes:

- A 2301A electronic control,
- An external 20 to 40 Vdc (low voltage); or 90 to 150 Vdc or 88 to 132 Vac (high voltage) power source,
- A speed-sensing device,
- A proportional actuator to position the fuel- or steam-metering device, and
- Current and potential transformers for measuring the load carried by the generator.

APPLICATIONS

The 2301A 9905 Series electronic controls have switch-selectable speed ranges. Any of these control models can be set to operate within one of the following rated speed ranges:

- 500 to 1,500 Hz
- 1,000 to 3,000 Hz
- 2,000 to 6,000 Hz
- 4,000 to 12,000 Hz

WARNING

Speed range factory set for 2000 Hz to 6000 Hz. Refer to inside cover to change speed range and prevent possible overspeed. Using the wrong speed range could cause an overspeed with resulting damage to equipment and/or personal injury or death.

These controls are available for forward- or reverse-acting applications, and for use with either single or tandem actuators. Models for three different actuator current ranges are available, as well as a high-voltage model (90 to 150 Vdc, or 88 to 132 Vac — 45 to 440 Hz), and a low-voltage model (20 to 40 Vdc). The high voltage model is identified as such on the front; the low voltage model is not.

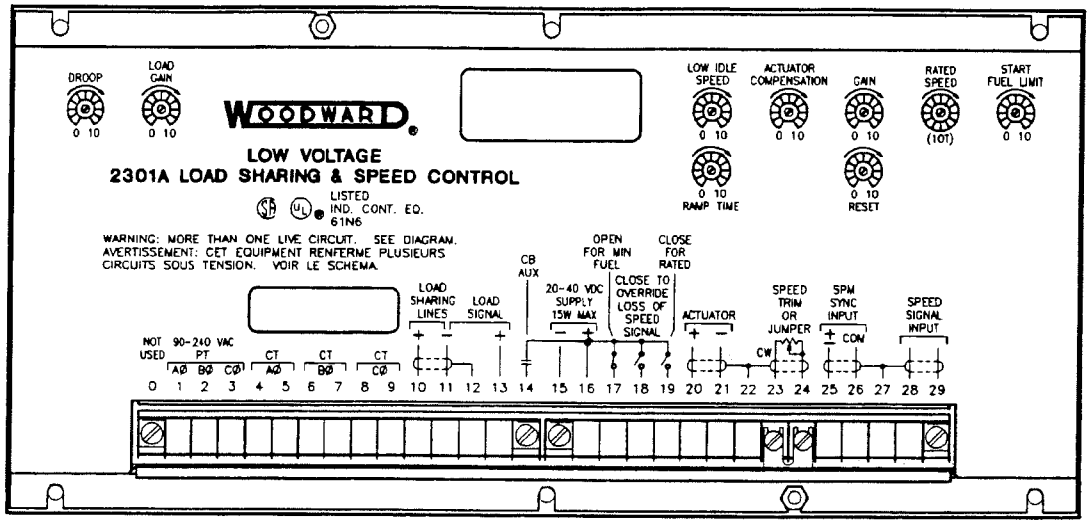
In reverse-acting systems, the actuator calls for more fuel when the actuator voltage decreases. Complete loss of voltage to the actuator will drive the actuator to full fuel. This allows a backup mechanical ballhead governor to take control rather than shut down the prime mover as would a direct-acting system.

An optional deceleration ramp is also offered. When this option is present, the time to ramp from rated speed to idle speed is approximately 20 seconds. If this option is not present, this happens instantly.

Insert Sheet ii shows part numbers and features of all 9905 Series 2301A load sharing and speed controls.

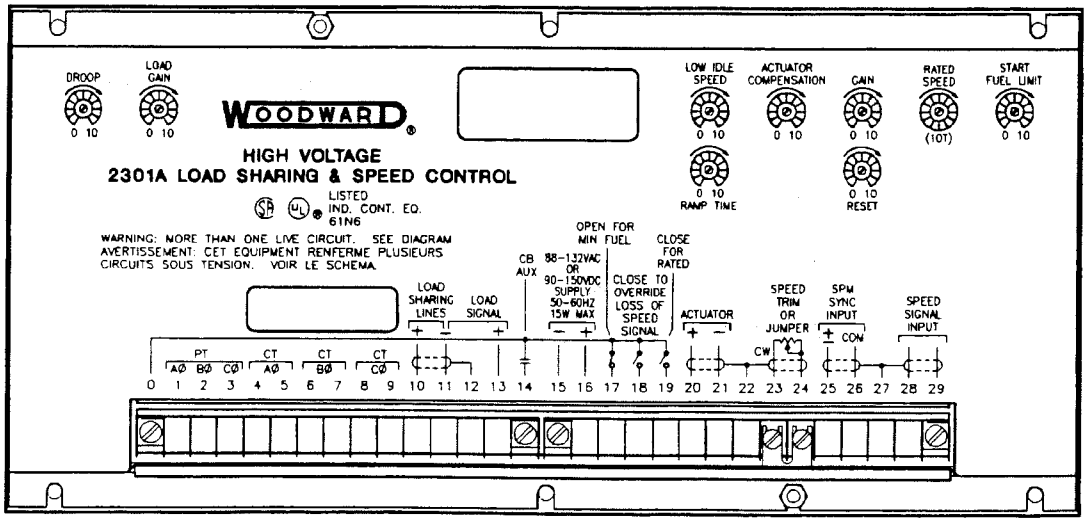
NOTE

External wiring connections for reverse-acting controls are identical to those for direct-acting controls.



82300-A-234

Figure 1-1. 2301A Load Sharing and Speed Control (Low Voltage Model)



82300-A-234

Figure 1-2. 2301A Load Sharing and Speed Control (High Voltage Model)

The relationship between prime mover speed and sensor output frequency is expressed in the formula: Sensor Frequency in Hz equals the number of teeth on the speed sensing gear times the rated prime mover speed in revolutions per minute divided by 60.

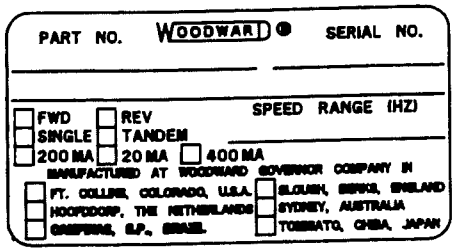


Figure 1-3. Control Identification Tag

Woodward Governor Company application engineers always are available to assist you in selection of the correct control for your system, or to answer questions concerning control installation, operation, or calibration. Contact any Woodward office listed on the back cover.

REFERENCES

The following publications contain additional product or installation information on Load Sharing and Speed Controls, and related components. They can be ordered from any Woodward Governor Company office listed on the back cover.

MANUAL	*TITLE*
25031 Part 3	Parallel Operation of Alternators
25070	Electric Governor Installation Guide
82384	SPM-A Synchronizer 9905-001 through 9905-004
82510	Magnetic Pickups for Electric Governors
82514	Speed Setting Potentiometers Used on 2301 Systems
82715	Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules

PRODUCT SPECIFICATION	*TITLE*
82390	2301A Load Sharing and Speed Controls, 9905 Series
82383	SPM-A Synchronizer 9905-001 through 9905-004
82457	Import/Export Control
82516	EG-3P and EG-3PC Actuator
82575	EGB-2P Governor/Actuator

SECTION 2
ELECTROSTATIC DISCHARGE AWARENESS

All electronic equipment is static-sensitive, some components more than others. To protect these components from static damage, you must take special precautions to minimize or eliminate electrostatic discharges.

1. Before performing maintenance on the electronic control, discharge the static electricity on your body to ground.
   - Discharge body static by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).
   - If you are wearing clothing made of synthetic materials, be especially careful to discharge the static electricity on your body before touching the control. Wear cotton or cotton blend materials if possible, because these do not store static electric charges as much as synthetics do.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. When handling the PCB, follow these instructions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components on a PCB with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic bag (that it comes in) until you are ready to mount it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag in which the new PCB was shipped.
3. Keep all plastic, vinyl, and styrofoam away from the control, the modules and the work area. These materials tend to generate and store static-electric charges.
   - These materials include plastic/styrofoam coffee cups, coffee cup holders, cigarette packages, cellophane candy wrappers, vinyl books or folders, plastic bottles, and plastic ash trays.

SECTION 3
INSTALLATION

This section contains general installation instructions for the 2301A control. Power requirements, environmental precautions, and location considerations are included to determine the best location for the control. Additional information includes unpacking instructions, electrical connections, and an installation check-out procedure.

UNPACKING

Before handling the control, read Section 2 "Electrostatic Discharge Awareness". Be careful when unpacking the electronic control. Check the control for signs of damage such as bent or dented panels, scratches, and loose or broken parts. If any damage is found, immediately notify the shipper.

POWER REQUIREMENTS

The 2301A control requires a voltage source of 20 to 40 Vdc, 90 to 150 Vdc, or 88 to 132 Vac for operating power. If a battery is used for operating power, an alternator or other battery charging device is necessary to maintain a stable supply voltage.

CAUTION

To prevent damage to the control, make sure that the alternator or other battery-charging device is turned off or disconnected before disconnecting the battery from the control.

LOCATION CONSIDERATIONS

Consider these requirements when selecting the mounting location:

- Adequate ventilation for cooling
- Space for servicing and repair
- Protection from direct exposure to water or to a condensation-prone environment
- Protection from high-voltage or high-current devices, or devices which produce electromagnetic interference
- Avoidance of vibration
- Selection of a location that will provide an operating temperature range of -40 degrees C (-40 degrees F) to +85 degrees C (+185 degrees F)

The control must NOT be mounted on the engine.

ELECTRICAL CONNECTIONS

External wiring connections and shielding requirements for a typical control installation are shown in the Plant Wiring Diagram, Figure 3-2. These wiring connections and shielding requirements are explained in the balance of this section.

SHIELDED WIRING

All shielded cable must be twisted conductor pairs. Do not attempt to tin the braided shield. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Connect the shields to the control terminals as shown in Figure 3-1, and the Plant Wiring Diagram, Figure 3-2. Wire exposed beyond the shield should be as short as possible, not exceeding two inches. The other end of the shields must be left open and insulated from any other conductor. Do not run shielded signal wires with other wires carrying large currents. See PMCC 821D, "Interference Control in Electronic Governing Systems," for more information.

Where shielded cable is required, cut the cable to the desired length and prepare the cable as instructed below and shown in Figure 3-1.

1. Strip outer insulation from BOTH ENDS exposing the braided or spiral wrapped shield. DO NOT CUT THE SHIELD.
2. Using a sharp, pointed tool, carefully spread the strands of the shield.
3. Pull inner conductor(s) out of the shield. If shield is the braided type, twist to prevent fraying.
4. Remove 1/4 inch of insulation from the inner conductor(s).
5. Connect wiring and shield as shown.

In installations with severe electromagnetic interference (EMI), shielded wire run in conduit, double shielded wire, or other precautions may be required. Contact Woodward Governor Company for more information.

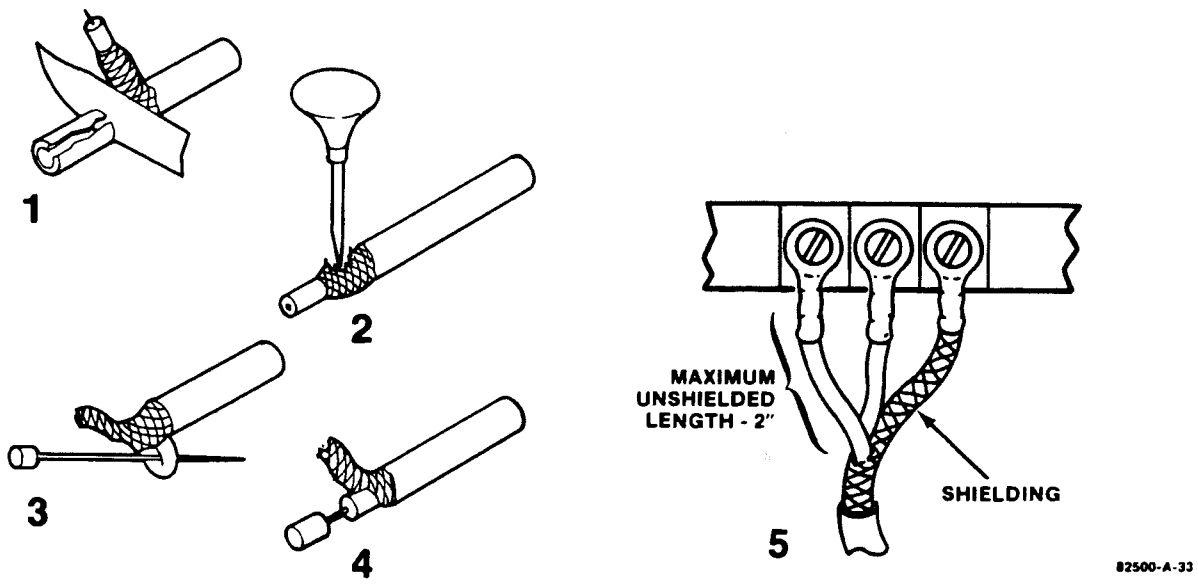


Figure 3-1. Preparation and Installation of Shielded Cables

SETTING SPEED RANGE

The speed range to be selected is determined by the maximum desired prime mover speed. Calculate the frequency of the speed sensor signal at the maximum prime mover speed by multiplying the gear speed in revolutions per minute times the number of teeth on the speed sensing gear and dividing by 60. Select the lowest speed range which contains this maximum speed sensor frequency.

Figure 3-2 shows the four sections of Switch S1 and their corresponding speed ranges. Set the proper section of Switch S1 to the ON position and the other three positions of Switch S1 to the OFF position.

WARNING

Speed range factory set for 2000 Hz to 6000 Hz. Refer to inside cover to change speed range and prevent possible overspeed. Using the wrong speed range could cause an overspeed with resulting damage to equipment and/or personal injury or death.

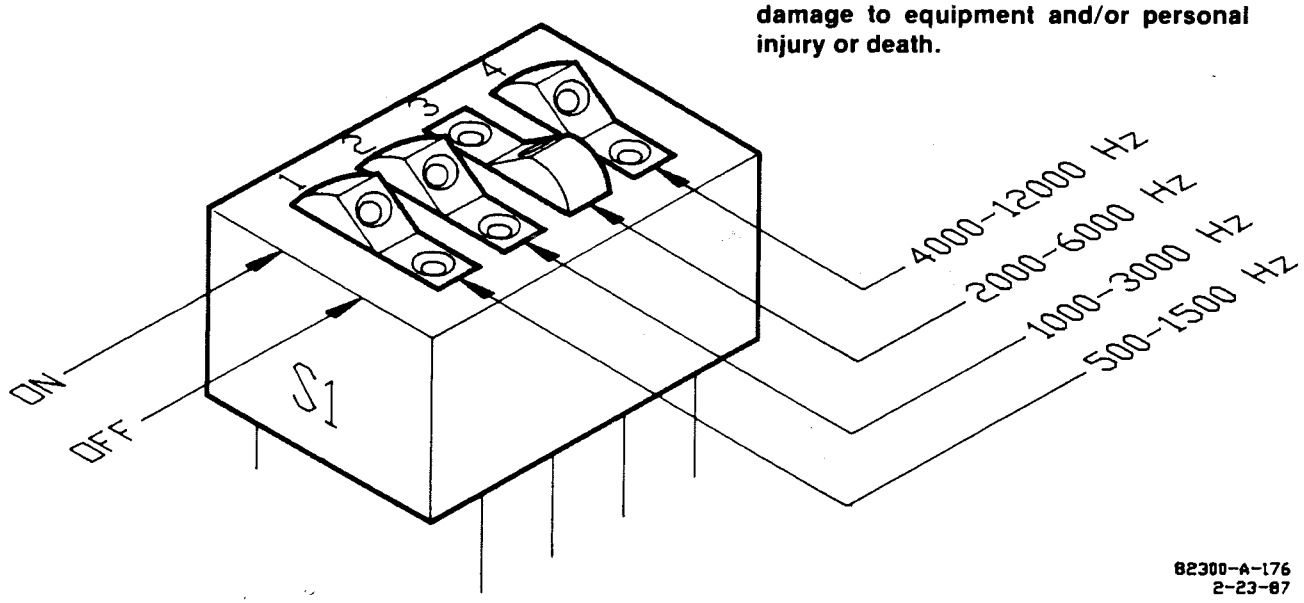
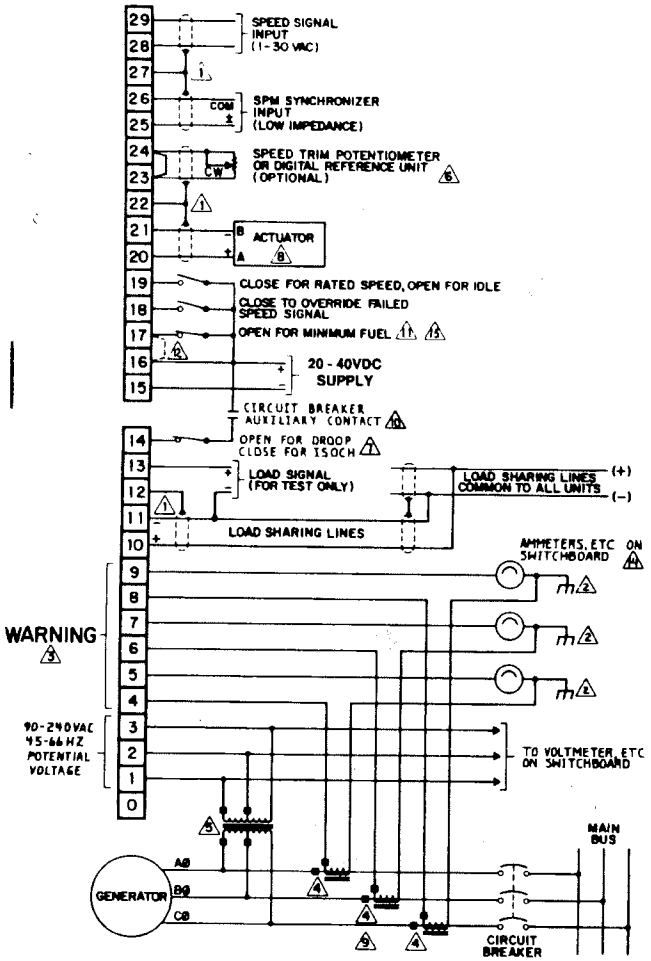
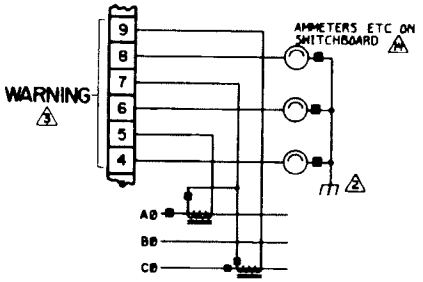


Figure 3-2. Switch S1

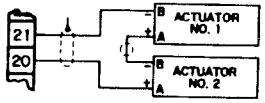


NOTE

THIS DRAWING REFLECTS THE LATEST ENGINEERING CHANGE AT THE TIME OF PUBLICATION. CONTACT WOODWARD GOVERNOR COMPANY FOR POSSIBLE LATER CHANGES.



DETAIL "A"
OPTIONAL CURRENT TRANSFORMER CONNECTION

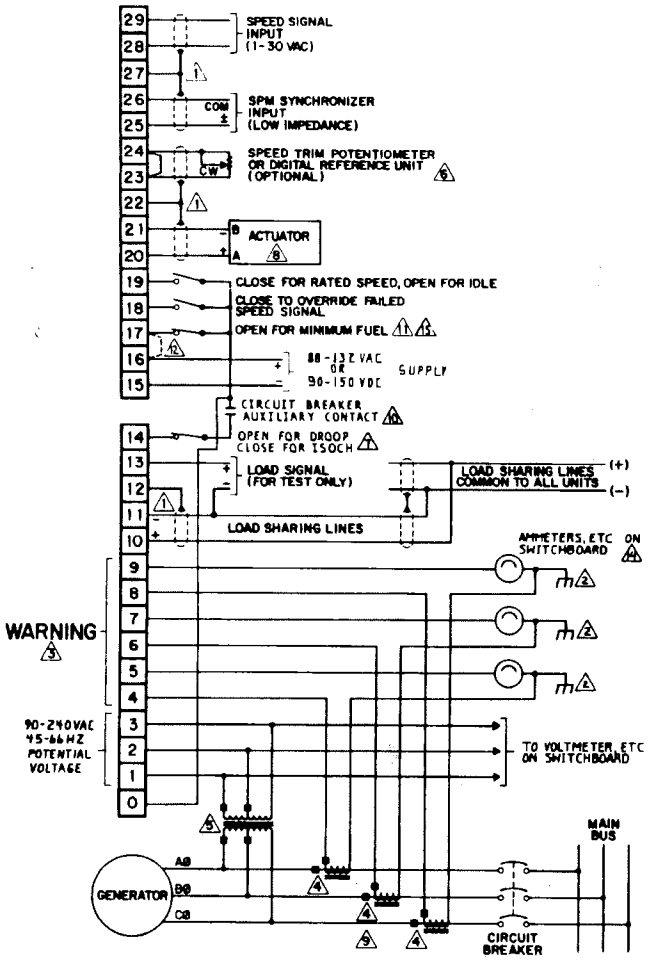


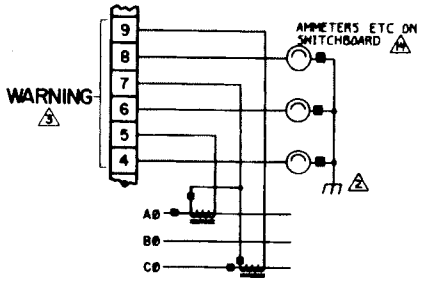
DETAIL "B"
CONNECTION FOR SERIES OR TANDEM OPERATION

NOTES:

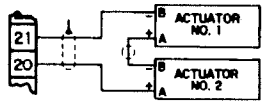
1. SHIELDED WIRES TO BE TWISTED PAIRS, WITH SHIELD GROUNDED AT CONTROL END ONLY.
2. POINT OF GROUNDING IF REQUIRED BY WIRING CODE.
3. INTERNAL CURRENT TRANSFORMER BURDEN MUST BE CONNECTED ACROSS POWER SOURCE CURRENT TRANSFORMERS AT ALL TIMES, TO PREVENT LETHAL HIGH VOLTAGES.
4. POWER SOURCE CURRENT TRANSFORMERS SHOULD BE SIZED TO PRODUCE 5A SECONDARY CURRENT WITH MAXIMUM GENERATOR CURRENT. CURRENT TRANSFORMER BURDEN IS LESS THAN 0.1 VA PER PHASE.
5. WITH A BALANCED THREE PHASE LOAD AND UNITY POWER FACTOR, THE CURRENT TRANSFORMERS SHOULD BE WIRED IN THE CORRECT POTENTIAL LEG AND MUST BE PHASED AT THE CONTROL AS FOLLOWS:
   PHASE A: POTENTIAL TERMINAL 1, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 4(⊕) TO 5.
   PHASE B: POTENTIAL TERMINAL 2, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 6(⊕) TO 7.
   PHASE C: POTENTIAL TERMINAL 3, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 8(⊕) TO 9.
6. REMOVE JUMPER BETWEEN TERMINALS 23 & 24, IF SPEED TRIM POTENTIOMETER OR DIGITAL REFERENCE UNIT IS USED. IF SPEED TRIM POTENTIOMETER IS USED, A HIGH QUALITY 100 OHM, 10 TURN, POTENTIOMETER SIMILAR TO WOODWARD P/N 1657-537 IS RECOMMENDED. 100 OHMS WILL GIVE APPROXIMATELY ±5% SPEED ADJUSTMENT.
7. FOR ISOCH CONTROL, WITHOUT ISOCH/DROOP SWITCH, SET DROOP POTENTIOMETER MAX CCW AND REPLACE DROOP SWITCH WITH JUMPER. IF DROOP POTENTIOMETER IS NOT MAX CCW, CONTROL IS IN DROOP WHEN ISOCH/DROOP SWITCH OR CIRCUIT BREAKER AUXILIARY CONTACT IS OPEN.
8. FOR SERIES OR TANDEM OPERATION, SEE DETAIL "B".
9. FOR OPTIONAL CURRENT TRANSFORMER CONNECTION, SEE DETAIL "A".
10. CIRCUIT BREAKER AUXILIARY CONTACT CLOSES WHEN CIRCUIT BREAKER CLOSES.
11. **WARNING:** DO NOT USE FOR EMERGENCY SHUTDOWN. THE PRIME MOVER SHOULD BE EQUIPPED WITH A SEPARATE OVERSPEED, OVERTEMPERATURE OR OVERPRESSURE SHUTDOWN DEVICE(S), TO PROTECT AGAINST RUNAWAY OR DAMAGE TO THE PRIME MOVER WITH POSSIBLE PERSONAL INJURY OR LOSS OF LIFE.
12. REMOVE JUMPER IF MINIMUM FUEL SWITCH IS USED. JUMPER MUST NOT BE USED ON HIGH VOLTAGE SUPPLY UNITS, SEE FIGURE 3-4.
13. IF METERS ARE NOT USED, JPRS MUST BE INSTALLED IN PLACE OF METERS SHOWN.
14. IF MINIMUM FUEL SWITCH IS NOT USED

Figure 3-3. Plant Wiring Diagram (Low Voltage Supply)





DETAIL "A"
OPTIONAL CURRENT TRANSFORMER CONNECTION



DETAIL "B"
CONNECTION FOR SERIES OR TANDEM OPERATION

NOTES:

1. SHIELDED WIRES TO BE TWISTED PAIRS, WITH SHIELD GROUNDED AT CONTROL END ONLY.
2. POINT OF GROUNDING IF REQUIRED BY WIRING CODE.
3. INTERNAL CURRENT TRANSFORMER BURDEN MUST BE CONNECTED ACROSS POWER SOURCE CURRENT TRANSFORMERS AT ALL TIMES, TO PREVENT LETHAL HIGH VOLTAGES.
4. POWER SOURCE CURRENT TRANSFORMERS SHOULD BE SIZED TO PRODUCE 5A SECONDARY CURRENT WITH MAXIMUM GENERATOR CURRENT. CURRENT TRANSFORMER BURDEN IS LESS THAN 0.1 VA PER PHASE.
5. WITH A BALANCED THREE PHASE LOAD AND UNITY POWER FACTOR, THE CURRENT TRANSFORMERS SHOULD BE WIRED IN THE CORRECT POTENTIAL LEG AND MUST BE PHASED AT THE CONTROL AS FOLLOWS:
   PHASE A: POTENTIAL TERMINAL 1, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 4(■) TO 5.
   PHASE B: POTENTIAL TERMINAL 2, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 6(■) TO 7.
   PHASE C: POTENTIAL TERMINAL 3, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 8(■) TO 9.
6. REMOVE JUMPER BETWEEN TERMINALS 23 & 24, IF SPEED TRIM POTENTIOMETER OR DIGITAL REFERENCE UNIT IS USED. IF SPEED TRIM POTENTIOMETER IS USED, A HIGH QUALITY 100 OHM, 10 TURN, POTENTIOMETER SIMILAR TO WOODWARD P/N 1857-537 IS RECOMMENDED. 100 OHMS WILL GIVE APPROXIMATELY ±5% SPEED ADJUSTMENT.
7. FOR ISOCH CONTROL, WITHOUT ISOCH/DROOP SWITCH, SET DROOP POTENTIOMETER MAX CCW AND REPLACE DROOP SWITCH WITH JUMPER. IF DROOP POTENTIOMETER IS NOT MAX CCW, CONTROL IS IN DROOP WHEN ISOCH/DROOP SWITCH OR CIRCUIT BREAKER AUXILIARY CONTACT IS OPEN.
8. FOR SERIES OR TANDEM OPERATION, SEE DETAIL "B".
9. FOR OPTIONAL CURRENT TRANSFORMER CONNECTION, SEE DETAIL "A".
10. CIRCUIT BREAKER AUXILIARY CONTACT CLOSES WHEN CIRCUIT BREAKER CLOSES.
11. **WARNING:** DO NOT USE FOR EMERGENCY SHUTDOWN. THE PRIME MOVER SHOULD BE EQUIPPED WITH A SEPARATE OVERSPEED, OVERTEMPERATURE OR OVERPRESSURE SHUTDOWN DEVICE(S), TO PROTECT AGAINST RUNAWAY OR DAMAGE TO THE PRIME MOVER WITH POSSIBLE PERSONAL INJURY OR LOSS OF LIFE.
12. APPLY SWITCH POWER FROM TERMINAL "0" ONLY. TERMINAL 16 MUST NOT BE JUMPERED TO TERMINAL 17 ON HIGH VOLTAGE MODEL.
13. IF METERS ARE NOT USED, JPRS MUST BE INSTALLED IN PLACE OF METERS SHOWN.
14. IF MINIMUM FUEL SWITCH IS NOT USED — JUMPER TERMINA 17 TO 0

Figure 3-4. Plant Wiring Diagram (High Voltage Supply)

POTENTIAL TRANSFORMER CONNECTIONS

Connect the potential transformer secondary leads to the following terminals:

- Phase A to terminal 1
- Phase B to terminal 2
- Phase C to terminal 3

The potential transformer secondary line-to-line voltage must be in the 90 to 240 volt RMS range. Refer to the Plant Wiring Diagram, Figure 3-3.

CURRENT TRANSFORMER CONNECTIONS

The standard method of connecting the current transformers is shown in the Plant Wiring Diagram, Figure 3-3. An alternate method is the open delta connection shown in the insert in the Plant Wiring Diagram.

DROOP CONTACT (ISOCH-DROOP) AND LOAD SHARING LINES

Because the load-sharing-line relay is contained in the control, no relay is required between the control and the load-sharing-line bus. Use shielded cable and connect the load-sharing lines directly to terminals 10 (+) and 11 (-). Connect the shield to terminal 12. When all controls in the system are of the 2301A type, the shields may be connected continuously between controls. When load sharing with different controls, do not connect the shields at the point where connections are made to the load-sharing-line bus.

The droop contact for selecting droop or isochronous operation is wired in series with the circuit-breaker auxiliary contact between terminal 14 and terminal 16 (terminal 0 on high-voltage controls). When both the droop contact and circuit-breaker auxiliary contact are closed, the control is in the isochronous load-sharing mode, Figure 3-4A. In this mode the internal load-sharing-line relay is energized, the droop signal is disabled permitting isochronous load sharing, and the load-matching circuit is connected to the load-sharing lines.

The control is in the droop mode when EITHER the droop contact or the circuit-breaker auxiliary contact is open, Figure 3-4B. If the droop contact is open, the control remains in the droop mode even when the circuit-breaker auxiliary contact is closed.

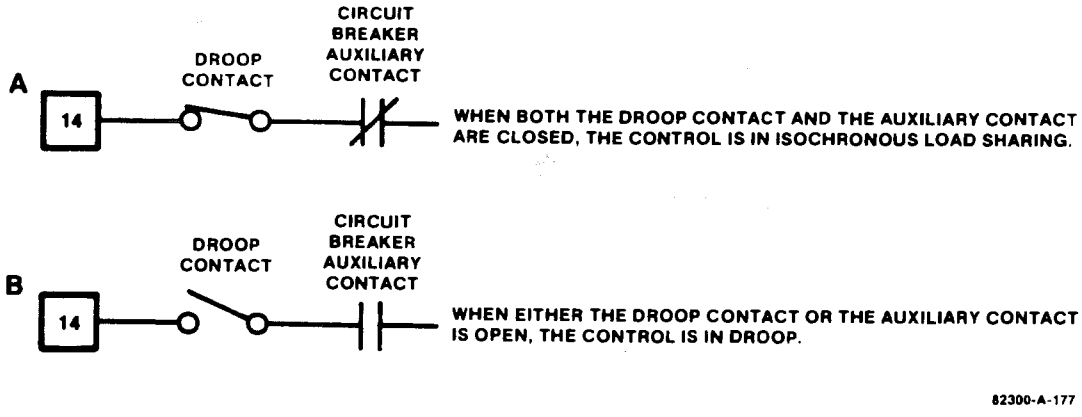


Figure 3-5. Droop Contact and Circuit Breaker Auxiliary Contact

NOTE

The control is in the droop mode whenever the circuit-breaker auxiliary contact is open. If a single prime mover is required to run isochronously with an isolated load, turn the DROOP potentiometer fully counterclockwise.

Droop operation is required when the generator is paralleled with an infinite bus without a Generator Loading Control, Process Control, Automatic Power Transfer and Load Control, Import/Export Control, or other load controlling accessory, or when paralleled with incompatible governors. (All Woodward electric load-sharing systems are compatible.) When running a single unit on an infinite bus with a Generator Loading Control or Import/ Export Control, terminal 14 must be connected to terminal 16 (terminal 0 on high-voltage controls) to connect the Load Matching Circuit to the load-sharing lines. The load-sharing lines must be wired to the Generator Loading Control or Import/Export Control. The circuit-breaker auxiliary contact will then be connected to the Generator Loading Control or Import/ Export Control and not to the 2301A Load Sharing And Speed Control.

POWER SUPPLY

Run the power leads directly from the power source to the control, connecting the negative lead to terminal 15, and the positive lead to terminal 16. If the power source is a battery, be sure the system includes an alternator or other battery-charging device.

WARNING

DO NOT apply power to the control at this time.

Applying power before a control is completely connected may damage the control.

MINIMUM FUEL CONTACT

The minimum-fuel contact is intended as an optional means for a normal shutdown of the prime mover. It is connected in series with terminal 16 (terminal 0 on high-voltage controls) and terminal 17 as shown in the Plant Wiring Diagram, Figure 3-3. Do NOT remove this jumper from terminal 17 unless a minimum fuel contact is installed; the control will not operate without 20 to 40 Vdc applied to terminal 17.

When the contact is closed, the voltage applied to terminal 17 allows the control to move the actuator to any position required for operating conditions.

WARNING

Do NOT use the minimum-fuel contact as part of any emergency stop sequence.

FAILED SPEED SIGNAL OVERRIDE

A contact to override the failed-speed-signal circuit can be installed in series with terminal 18 and the dc power to the control. When the contact is open, the control operates normally, turning the control output off in the event of a loss of speed signal. Closing the contact overrides the failed-speed-signal circuit as may be required for start-up.

Prior to start-up of the prime mover, the speed signal is nonexistent. On prime movers with cranking motors, the cranking speed is usually sufficient to provide a speed signal, so an override contact on terminal 18 is not needed for starting. On some steam turbine systems, the Close to Override Failed Speed Signal contact must be closed in order to allow the actuator to open and provide steam for starting.

If a failed-speed-signal-override contact is used, it should be of the momentary type to ensure that the failed-speed-sensor shut-down circuit is enabled after start-up.

IDLE/RATED RAMP CONTACT

Connect a single-pole, single-throw contact from terminal 16 (terminal 0 on high-voltage controls) to terminal 19, the Close For Rated (open for idle, close for rated) terminal. Oil pressure is often used to close this contact. When closed, 20 to 40 Vdc is applied to terminal 19, and the prime mover can be operated at a speed higher than idle. When the contact is open, the voltage is removed from terminal 19, and the prime mover's speed immediately decelerates to idle.

ACTUATOR OUTPUT

The actuator wires connect to terminals 20 (+) and 21 (-). Use shielded wires with the shield connected to terminal 22. Do not connect the shield to the actuator or any other point. The shield must have continuity the entire distance to the actuator, and must be insulated from all other conducting surfaces. Refer to the manuals listed in the "References" table for additional information on actuator installation.

EXTERNAL SPEED TRIM

A jumper must be connected to terminals 23 and 24 unless an optional remote Speed Trim potentiometer is used. If a Speed Trim potentiometer is used, connect it as shown in the Plant Wiring Diagram, Figure 3-3, using shielded wire. Connect the shield to terminal 22. Make sure the shield has continuity the entire distance to the potentiometer, and that the shield is insulated from all other conducting surfaces. A 100 ohm potentiometer will provide ±5% speed adjustment. If less adjustment is desired, potentiometers of smaller values may be used. Potentiometers of the multiturn type are recommended.

SPEED AND PHASE MATCHING (SPM) SYNCHRONIZER

Connect the SPM Synchronizer (optional equipment) wires to terminals 25 (+) and 26 (-). Use shielded wire, and connect the shield to terminal 27. Make sure the shield has continuity the entire distance to the SPM Synchronizer, but do not connect the shield to the synchronizer. The shield must be insulated from all other conducting surfaces.

SPEED SENSOR

Connect a speed-sensing device, such as a magnetic pickup, to terminals 28 and 29 using shielded wire. Connect the shield to terminal 27, making sure the shield has continuity the entire distance to the speed sensor, and that the shield is insulated from all other conducting surfaces.

INSTALLATION CHECK-OUT PROCEDURE

With the installation completed as described in this section, perform the following check-out procedure before beginning the start-up adjustments in Section 4.

1. Visual Inspection

   A. Check the linkage between the actuator and the prime mover for looseness or binding. Refer to the appropriate actuator manual, and Manual 25070 "Electric Governor Installation Guide" for additional information on linkage.

   WARNING

   The actuator lever should be near but not at the minimum position when the fuel or steam rack is at the minimum position.

   If the actuator lever gets to its minimum position before completely shutting off fuel or steam, the control may not be able to shut the turbine down, causing damage to equipment or injury or death.

   B. Check for correct wiring per the Plant Wiring Diagram, Figure 3-3.

   C. Check for broken terminals and loose terminal screws.

   D. Check the speed sensor for visible damage. If the sensor is a magnetic pickup, check the clearance between the gear and the sensor, and adjust if necessary. Clearance should be between 0.010 and 0.040 inch (0.25 and 1.0 millimeter) at the closest point. Make sure the gear has less than 0.020 inch (0.5 millimeter) diametric runout. See Manual 82510 "Magnetic Pickups for Electric Governors."

2. Check for Grounds

   Make sure power is off. Check for grounds by measuring the resistance from terminal 11 to chassis, and from terminal 15 to 11. The resistance should be infinity. If a resistance other than infinity is obtained, remove the connections from each terminal one at a time until the resistance is infinity. Check the line that was removed last to locate the fault.

SECTION 4
OPERATION AND ADJUSTMENT

INTRODUCTION

This section contains information on control calibration. It includes initial prestart-up and start-up settings and adjustments, and a current-transformer phasing procedure.

WARNING

Read this entire procedure before starting the prime mover.

INITIAL PRE-START SETTINGS

1. RATED SPEED

   A. Set the RATED SPEED potentiometer to minimum (fully counterclockwise).

   B. Set the external Speed Trim, if used, to mid-position.

2. RESET — Set at mid-position.

3. GAIN — Set at mid-position.

4. RAMP TIME — Set at maximum (fully clockwise).

5. LOW IDLE SPEED — Set at maximum (fully clockwise).

6. LOAD GAIN — Set at mid-position.

7. DROOP — Set at minimum (fully counterclockwise).

8. ACTUATOR COMPENSATION.

   A. Set the ACTUATOR COMPENSATION potentiometer at 2 on the 0 to 10 potentiometer scale for diesel, gas turbine, or fuel-injected gasoline prime movers.

   B. Set the ACTUATOR COMPENSATION potentiometer at 6 on the 0 to 10 potentiometer scale for carbureted-gas or gasoline prime movers, and steam turbines.

9. START FUEL LIMIT — Set at maximum (fully clockwise).

10. Be sure the actuator is connected to terminals 20 and 21.

START-UP ADJUSTMENTS

1. Complete the installation checkout procedure in Section 3, and the initial prestart settings above.

   CAUTION

   Be sure the speed range switch is set on the right speed range for your application as described in Section 3.

2. Close the Close For Rated contact. Set the control for isochronous operation by closing the droop contact.

   NOTE

   This is for initial prime mover start-up only. For normal start-up, the Close For Rated contact (open for idle/close for rated) should be open if the prime mover is to start at idle.

3. Apply input power to the control.

4. Preset rated speed.

   If a signal generator is not used, set the RATED SPEED potentiometer at minimum (fully counterclockwise).

   When using a signal generator to set rated speed, set the signal generator for the frequency of the speed sensor at rated speed, and connect it to terminals 28 and 29. (The rated speed frequency in Hz equals the rated prime mover speed in RPM times the number of teeth on the speed sensing gear divided by 60.) Put the Close For Rated contact in the rated (closed) position. Set the speed trim potentiometer, if used, to mid-position. Connect a dc analog voltmeter to terminals 20 (+) and 21 (-) to read actuator voltage.

   If the actuator voltage is at minimum (minimum will be approximately 0 volts), slowly turn the RATED SPEED potentiometer clockwise (counterclockwise for reverse acting controls) until the voltage just begins to move to maximum.

If the actuator voltage is at maximum, slowly turn the RATED SPEED potentiometer counterclockwise (clockwise for reverse-acting controls) until the voltage just begins to move to minimum.

Continue to very slowly adjust the RATED SPEED potentiometer in the appropriate direction, trying to stop the actuator voltage between the minimum and maximum voltages. Because it is not possible to stop the motion, cease adjusting when the voltage changes slowly. The RATED SPEED potentiometer is now set very close to desired speed. A slight adjustment when the engine is running will achieve the exact speed.

5. Check the speed sensor.

Minimum voltage required from the speed sensor to operate the electronic control is 1.0 volts RMS, measured at cranking speed or the lowest controlling speed. For this test, measure the voltage while cranking, with the speed sensor connected to the control. Before cranking, be sure to prevent the prime mover from starting. At 5% of the lower value of the control's speed range, the failed speed sensing circuit is cleared. For example 100 Hz is required on the 2000 to 6000 Hz speed range (2000 Hz x .05 = 100 Hz).

WARNING

TO PROTECT AGAINST POSSIBLE PERSONAL INJURY, LOSS OF LIFE, and/or PROPERTY DAMAGE WHEN STARTING the engine, turbine, or other type of prime mover, BE PREPARED TO MAKE AN EMERGENCY SHUTDOWN to protect against runaway or overspeed should the mechanical-hydraulic governor(s), or electric control(s), the actuator(s), fuel control(s), the driving mechanism(s), the linkage(s), or the controlled device(s) fail.

6. Start the prime mover.

ADJUST FOR STABLE OPERATION

If prime-mover operation is stable, go to the "Speed Setting Adjustment" procedure.

If the prime mover is hunting at a rapid rate, slowly decrease the GAIN (turn the potentiometer counterclockwise) until performance is stable. Adjusting the GAIN may cause a momentary speed change which can be minimized by turning the GAIN potentiometer slowly.

If the prime mover is hunting at a slow rate, increase the RESET (turn the potentiometer clockwise) until the prime mover stabilizes. If increasing the RESET potentiometer does not stabilize the prime mover, it also may be necessary to either:

- Slowly decrease the GAIN (turn the potentiometer counterclockwise) or
- Slowly decrease the GAIN and increase the ACTUATOR COMPENSATION.

SPEED SETTING ADJUSTMENT

With the prime mover operating stably, and the external speed trim potentiometer (if used) set at mid-position, adjust the RATED SPEED potentiometer to bring the prime mover to the desired operating speed.

DYNAMIC ADJUSTMENT

The object of the GAIN and RESET potentiometer adjustment is to obtain the optimum, or desired, stable prime-mover-speed response.

Connect a dc analog voltmeter to terminals 20 (+) and 21 (-) to monitor the actuator voltage.

NOTE

Adjusting the GAIN may cause momentary changes in speed which can be minimized by turning the GAIN potentiometer slowly.

Increasing the setting of the GAIN potentiometer provides faster transient response (decreases the

magnitude of the speed change from a sudden change in load). To achieve optimum response, slowly increase the GAIN (turn the potentiometer clockwise) until the voltage on the voltmeter becomes slightly unstable, then slowly turn the GAIN back counterclockwise as necessary to stabilize the meter reading. Step load the generator, or bump the actuator terminal shaft, to make sure that the prime mover returns to the proper speed with little overshoot or undershoot of the speed setting. To reduce overshoot, increase the RESET (turn the potentiometer clockwise).

When the RESET potentiometer is in the lower part of its adjustment (0 to 3 on the potentiometer scale), increasing the RESET clockwise may require decreasing the GAIN (turning the GAIN potentiometer counterclockwise) to maintain stable operation.

If the prime mover is slow in returning to the proper speed, decrease the RESET by turning the potentiometer counterclockwise.

Figure 4-1 illustrates prime mover starts with the RAMP TIME potentiometer fully counterclockwise (no ramp), step loadings at four different RESET potentiometer settings, and stable, steady-state running conditions. These are typical performance curves on a naturally aspirated (nonturbocharged) diesel engine.

NOTE

Optimum performance is not necessarily obtained with the GAIN potentiometer at the maximum stable clockwise position. In some cases, the gain must be reduced slightly to ensure stability under widely varying conditions.

ACTUATOR COMPENSATION ADJUSTMENT

If the ACTUATOR COMPENSATION is set as described under INITIAL PRESTART SETTINGS, no further adjustment is normally required. If a slow periodic instability remains, slightly increase the ACTUATOR COMPENSATION (turn the potentiometer clockwise), and repeat the GAIN and RESET adjustments. Continue to increase the ACTUATOR COMPENSATION and readjust the GAIN and RESET until stability is achieved.

If a fast instability or extremely active actuator is evident, slightly decrease the ACTUATOR COMPENSATION (turn the potentiometer counterclockwise). If necessary, the ACTUATOR COMPENSATION may be set fully counterclockwise. This may be required when engine torsionals cause excessive fuel-linkage movement.

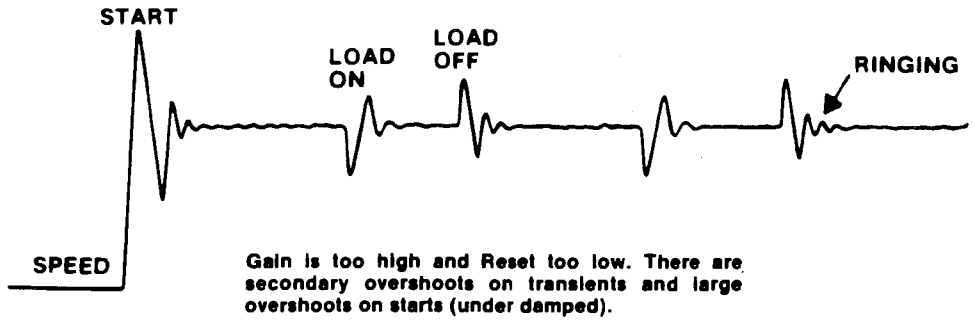
LOW IDLE SPEED ADJUSTMENT

1. The prime mover should be approximately at rated speed with the LOW IDLE SPEED potentiometer set at maximum (fully clockwise). Open the external CLOSE FOR RATED contact.

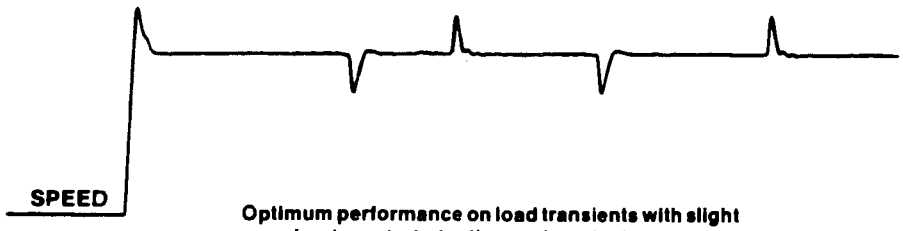
2. Decrease the LOW IDLE SPEED (turn the potentiometer counterclockwise) until the recommended idle speed is reached.

NOTE

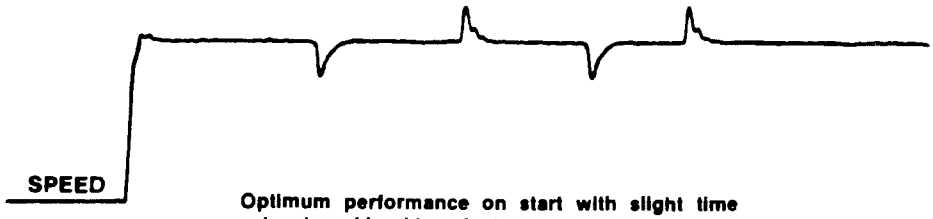
Make certain that the prime-mover speed is controlled by the LOW IDLE SPEED potentiometer in a range above the minimum-fuel position (mechanical stop) of the actuator or prime-mover fuel rack.



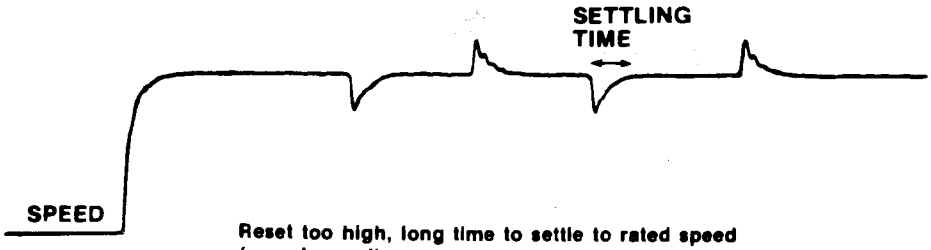
Gain is too high and Reset too low. There are secondary overshoots on transients and large overshoots on starts (under damped).



Optimum performance on load transients with slight overshoot on starts (optimum damping).



Optimum performance on start with slight time extension of load transients (optimum damping).



Reset too high, long time to settle to rated speed (over damped).

82500-A-303

Figure 4-1. Diesel Engine Performance Curve

RAMP TIME ADJUSTMENT

Adjust the RAMP TIME potentiometer to achieve satisfactory prime mover acceleration to rated speed with minimum overshoot. First start at the fully clockwise (maximum ramp time) position and work back in the counterclockwise direction until the unit ramps as rapidly as desired.

START FUEL LIMIT ADJUSTMENT

NOTE

Start-fuel limit is not recommended for use with reverse-acting controls. With loss of speed signal, the reverse-acting control will position the actuator at the start-fuel level if the failed-speed-signal override is activated. Reverse-acting systems normally require the control to demand full fuel on loss of speed signal to allow the mechanical backup governor to control the system. The Start Fuel Limit can be deactivated by turning the potentiometer fully clockwise.

With the prime mover operating at rated speed and no load, record the voltage across actuator terminals 20 (+) and 21 (-). Shut down the prime mover and activate the Failed Speed Signal Override by closing the override contact. The voltage to the actuator should now be adjustable by the START FUEL LIMIT potentiometer. Set the actuator voltage approximately 10% higher than the voltage obtained at rated speed for forward-acting controls and 10% lower than rated speed voltage for reverse-acting controls. Remove the Failed Speed Signal Override contact if not required to start the prime mover.

Start the prime mover and observe the start time, overshoot of speed setting, and smoke emissions obtained. The START FUEL LIMIT may be adjusted as required to optimize the prime-mover starting characteristics. The fuel-limiting function is turned off automatically when the speed control takes over.

NOTE

For prime movers not requiring start-fuel limiting, the START FUEL LIMIT function can be deactivated by turning the potentiometer fully clockwise.

SPEED SENSOR CHECK

If the sensor is a magnetic pickup, measure the voltage across terminals 28 and 29 to be sure there is a minimum of 1.0 volts at cranking speed, and a maximum of 30 volts RMS at rated speed. If the voltage exceeds 30 volts, increase the gap of the speed sensor, and be sure that there is still a minimum of 1.0 volts at cranking speed.

CURRENT TRANSFORMER (CT) PHASING CHECK

NOTE

This control contains internal current transformers. Due to their low impedance, shorting their inputs is not effective. The current input must be removed from the control and shorted externally.

WARNING

Never disconnect any wire attached to load sensor terminals 4 through 9 when the prime mover is running unless temporary 1 ohm, 5 watt resistors are installed as shown in Figure 4-2, and all load is removed. The current transformers can develop dangerously high voltages when open circuited while the prime mover is running.

1. Connect a dc voltmeter to control terminals 11 (-) and 13 (+) to measure the load signal.

2. Start the prime mover. With the generator operating in the isochronous mode and not paralleled, load the generator to as near to full load as possible. Measure the load-signal voltage.

3. Unload and shut down the prime mover. Disconnect the wire from terminal 5 and connect both wires from phase A CT to terminal 4.

4. Start the prime mover, apply full load (or the same load as obtained in Step 2) and again measure the load signal at terminals 11 and 13. If the load signal voltage is not 1/3 lower than

the reading obtained in Step 2, the phasing is incorrect. Unload and shut down the prime mover. Reconnect phase A CT wire from terminal 4 to terminal 5, maintaining the original polarity.

If the phasing is incorrect, proceed to the Phase Correction Procedure.

If the phasing appears correct, skip the Phase Correction Procedure and go to the Load Gain Adjustment procedure.

NOTE

If after completing the LOAD GAIN and DROOP adjustments, the control loading is extremely sensitive to changes in the power factor when operating in parallel, complete the phase-correction procedure.

PHASE CORRECTION PROCEDURE

NOTE

This procedure requires a minimum power factor of (.9). If a (.9) power factor cannot be obtained, tracing through the wiring is the only means of correcting the current-transformer phasing.

The highest positive voltage will be obtained when the CTs are correctly matched to the load-sensor terminals in both phase and polarity. The following procedure will assure the correct connection of the current transformers. It is required only if the phasing check indicates incorrect phasing, or loading stability is extremely sensitive to the power factor.

Trial connections of the first CT to all three load-sensor inputs, polarized both ways, are made (a total of six connections). The load-signal voltage is recorded for each connection and the first CT is then connected to the terminals that produce the highest positive voltage, and with the polarity that produces the highest positive voltage.

The second CT is tried on each of the remaining two CT input terminals, in each polarity, and the voltage recorded. The second CT is then connected to the terminals that produce (and with the polarity that produces) the highest positive voltage.

The last CT is then tried on the remaining input terminals, polarized both ways, and the voltage recorded. Connecting the last CT in the polarity that produces the highest voltage completes the procedure.

The Phase Correction Procedure requires that the prime mover be shut down many times to disconnect the current transformers. For convenience, a temporary method of connecting the current transformers shown in Figure 4-2 is recommended. Connecting a 1 ohm, 5 watt burden resistor across each current transformer allows the current transformers to be disconnected from the terminal strip with the prime mover running, after removing all load.

WARNING

The current transformers can develop dangerously high voltages. Do not disconnect a current transformer while the prime mover is running unless temporary 1 ohm, 5 watt resistors are installed as shown in Figure 4-2, and all load is removed.

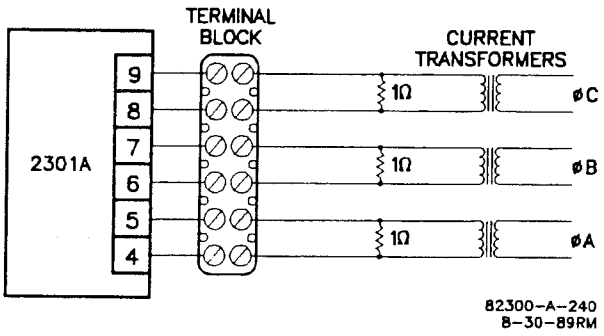


Figure 4-2. Temporary Wiring for Transformer Phase Correction

If the temporary burden resistors described above and shown in Figure 4-2 are not used, the prime mover MUST be shut down in addition to removing the load in the following procedure.

Measure the load-signal voltage in this procedure by connecting a voltmeter across the Load Signal terminals 11 (-) and 13 (+).

1. Shut down the prime mover.
2. Label each CT wire with the phase and polarity that you think it should be. Even though this identification may prove to be incorrect, this step is necessary so that the individual wires may be identified during the description of the procedure.
3. Disconnect the phase B CT wires from terminals 6 and 7. Connect these two wires together using a small screw and nut, and tape the connection.
4. Disconnect the phase C CT wires from terminals 8 and 9. Connect and tape these two wires together as in Step 3.
5. Connect the two wires from the phase A CT to the phase A input terminals 4 and 5.
6. Start the prime mover, apply full load, and measure the load signal voltage. Start a list and record this voltage.
7. Unload the system and reverse the phase A CT wires on terminals 4 and 5.*
8. Apply full load, measure the load signal, and record this voltage.
9. Unload the system, remove phase A CT wires from terminals 4 and 5, and connect them to phase B input terminals 6 and 7.*
10. Apply full load, measure the load signal, and record this voltage.
11. Unload the system and reverse the phase A CT wires on terminals 6 and 7.*
12. Apply full load, measure the load signal, and record this voltage.
13. Unload the system, remove phase A CT wires from terminals 6 and 7, and connect them to phase C input terminals 8 and 9.*
14. Apply full load, measure the load signal, and record this voltage.
15. Unload the system and reverse the phase A CT wires on terminals 8 and 9.*
16. Apply full load, measure the load signal, and record this voltage.
17. Unload the system and compare the six voltage readings.*
18. Remove the phase A CT wires from terminal 8 and 9 and connect the phase A wires to the pair of terminals that produced the highest positive load-signal voltage and in the polarity that produced the highest positive load-signal voltage.
19. Untape and disconnect the phase B CT wires. Connect the phase B CT wires to one pair of the two remaining pair of CT input terminals on the load sensor.
20. Apply full load and measure the load signal. Start a new list and record this voltage.
21. Unload the system, and reverse the phase B CT wires on the same terminals.*
22. Apply full load, measure the load signal, and record this voltage.
23. Unload the system, remove phase B CT wires, and connect them to the other pair of terminals.*
24. Apply full load, measure the load signal, and record this voltage.
25. Unload the system and reverse phase B CT wires on the same terminals.*
26. Apply full load and measure the load signal. Record this voltage, and compare the four voltages on the list.
27. Unload the system. Remove the phase B CT wires and connect them to the pair of CT input terminals that produced the highest positive load signal voltage and with the polarity that produced the highest positive load signal voltage.*
28. Untape and disconnect the phase C CT wires. Connect these two wires to the remaining pair of CT input terminals.
29. Apply full load, measure the load signal, and record this voltage.
30. Unload the system and reverse the phase C CT wires on the same terminals.*
31. Apply full load, measure the load signal, and record this voltage.
32. Unload and shut down the system. Compare the two voltages.*
33. Connect the phase C CT wires to the same pair of CT input terminals, but in the polarity that produced the highest positive load-signal voltage.

34. Relabel each wire with the phase designation of the terminal that it is now connected to.

35. Remove the burden resistors and terminal block.

* Be sure to shut down the prime mover if the temporary burden resistors are not used.

LOAD GAIN ADJUSTMENT

For this procedure, the generator must be running isochronously and not paralleled. Connect a dc voltmeter across terminals 11 (-) and 13 (+) to measure the load-signal voltage.

Start the prime mover and apply full load. Measure the load signal voltage and adjust the LOAD GAIN potentiometer for 6.0 volts.* If full load is not obtainable, decrease the LOAD GAIN proportionally to the load. For example, at 50% load adjust the LOAD GAIN to 3 volts.

When paralleled in the isochronous mode or on an isolated bus, generator speeds must be the same. If they are not equal, load sharing will not remain proportional as the load varies. Any difference in loads between the units can be corrected by adjusting the Load Gain Potentiometer. Increasing the LOAD GAIN (turning the potentiometer clockwise) will cause that generator to carry less load. If stability problems occur when paralleled at a particular load-signal voltage, reduce the voltage by reducing the LOAD GAIN (turn the potentiometer counterclockwise), and reduce the load-signal voltage setting of all other generators in the system to the same voltage. When the load-signal voltages of all generators in a system are reduced, the load-sharing gain will be reduced and this may result in some loss of load-sharing sensitivity.

* If 6 volts at full load (or a lower voltage proportional to a load less than 100%) cannot be obtained, and the phasing has been checked and is correct, the current transformers are probably the wrong size. The current-transformer output must be from 3 to 7 amps (5 amps nominal) at full load.

It may be necessary to reduce the load-signal voltage of each unit in the system to as low as 3 volts in cases of extremely poor system dynamics. If your system requires a load-signal voltage as low as 3 volts, consult Woodward Governor Company for suggestions for possible remedies.

DROOP ADJUSTMENT

Adjustment of the DROOP potentiometer is necessary when the generator set is to be operated in the droop mode. Droop in a load sensor is usually expressed as a percentage and calculated by the following formula.

$$\% \text{ Droop} = \frac{\text{No Load Speed-Full Load Speed}}{\text{No Load Speed}} \times 100$$

The method of setting droop depends on whether the load of the generator set is an isolated load or an infinite bus.

SETTING DROOP FOR AN ISOLATED LOAD

1. Open the droop contact connected to terminal 14.

2. Start the prime mover and adjust the RATED SPEED potentiometer for rated speed with no load.

3. Apply full load.*

4. Adjust the DROOP potentiometer to give the desired speed.

   Example: Operating at 60 Hz, 57 Hz at full load indicates 5% droop.

* If only 50% loading is possible, 58.5 Hz would indicate 5% droop. See Figure 4-3.

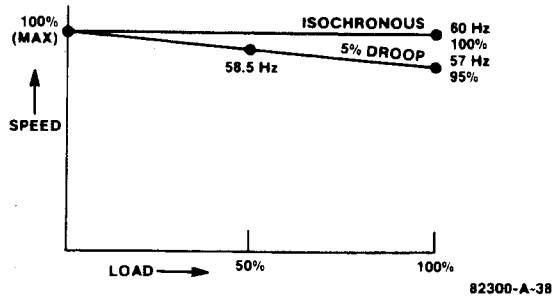
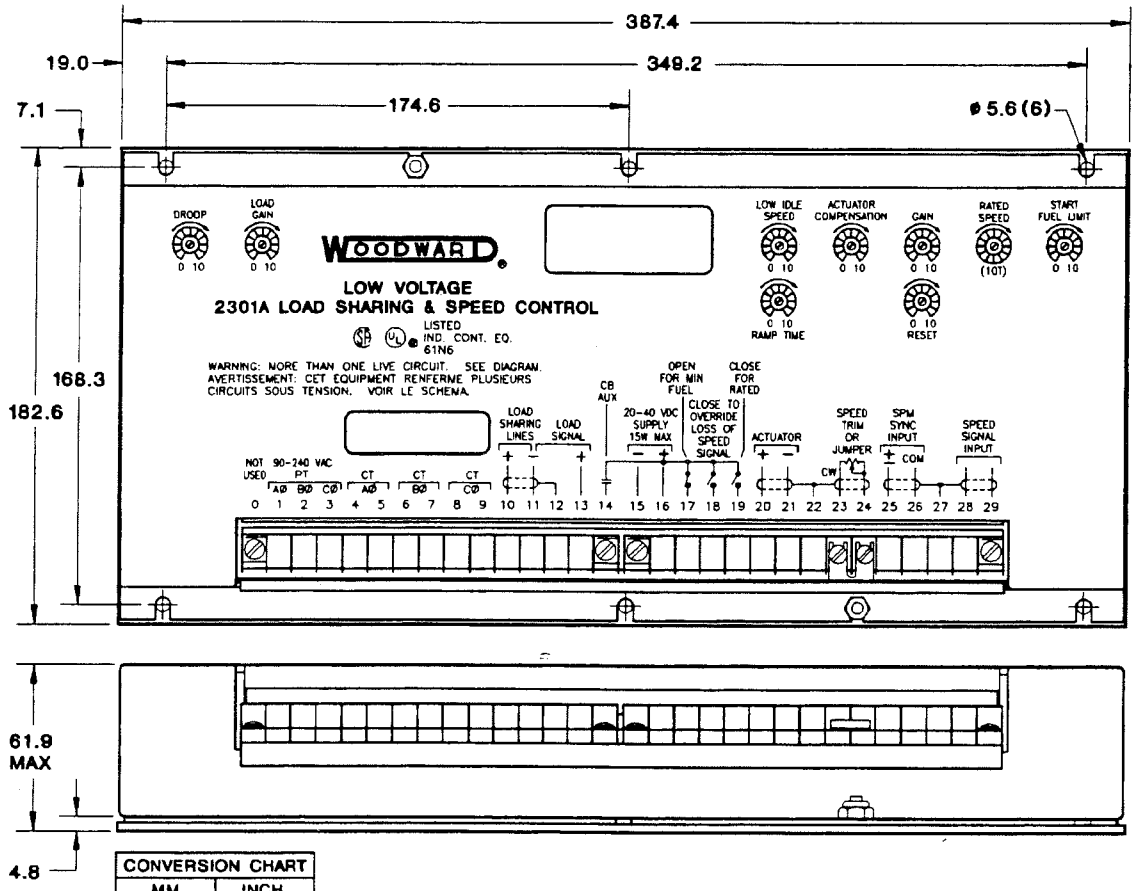


Figure 4-3. Droop Adjustment



CONVERSION CHART	
MM	INCH
4.8	.188
5.6	.219
7.1	.279
19.0	.748
61.9	2.437
168.3	6.625
174.6	6.874
182.6	7.188
349.2	13.748
387.4	15.251

METRIC

82300-A-234
89-09-05 MCL

Figure 4-4. 2301A Control Outline Drawing.

SETTING DROOP WHEN AGAINST UTILITY

Use the following procedure to set the Droop and Load Gain potentiometers with the utility as the only load.

1. Calculate the fully loaded speed (or frequency) of the generator when running at 100% load.

   No Load frequency = rated frequency x (1 + droop %)

   Example: Rated frequency = 60.0 Hz
   Desired droop = 3% (.03)

   No Load Frequency = 60 x (1 + .03)
   No Load Frequency = 61.8

2. Run the generator at the speed calculated in Step 1, with no load. Record the setting of your speed-setting device:

   - Potentiometer - record setting with a pencil mark.
   - MOP or Other - measure and record the value of the speed-setting voltage (at the control).

3. Reduce system speed to rated speed (frequency).

4. Preset both the Load Gain and Droop potentiometers fully clockwise.

WARNING

If when you close the breaker, the load on the unit increases rapidly, open the breaker and shut the unit down. Check the phasing of the CTs and PTs. Permitting the unit to continue to pick up load or continuing to operate the system without correcting this condition may cause damage to equipment, and injury or death to personnel.

5. Synchronize, close the generator breaker, and increase the load by increasing the speed setting to the setting recorded in Step 2.

NOTE

The adjustments in Steps 6 and 7 are non-linear; make changes in small increments to prevent overload.

6. Increase the load on the unit by turning the Droop potentiometer counterclockwise until the Load Gain Voltage reads *6.0 Vdc.

7. Increase load by turning the Load Gain potentiometer counterclockwise until the load is at the desired * 100% value.

*** NOTE**

Most systems use a Load Gain Voltage of 6.0 Vdc at full load. To perform this procedure at less than full load, use a Load Gain Voltage value that is proportional to the percent load used. For example, if the Load Gain Voltage at full load is 6.0 Vdc, you would adjust for a Load Gain Voltage of 3.0 Vdc. at 50% load.

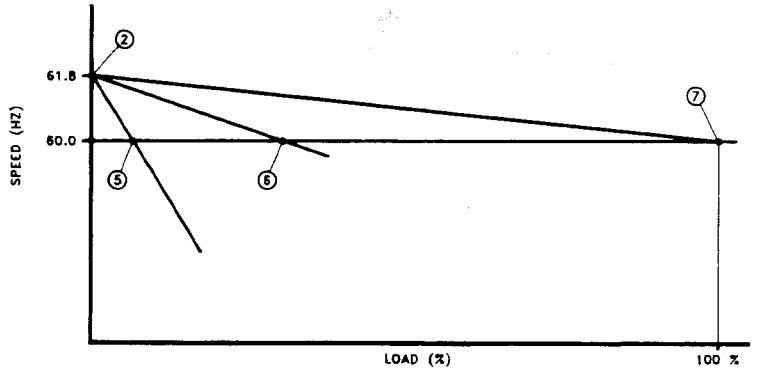


Figure 4-5. 3% Droop at 60 Hz.

NOTES

SECTION 5
DESCRIPTION OF OPERATION

The speed and load sharing section of these 2301A models monitors and controls two functions.

Speed: The speed control section keeps the prime mover at the correct speed.

Load Sharing: During parallel operation of two or more generators, the load sharing section senses the load carried by its generator and causes the loads of all generators in the system to be shared proportionally.

SPEED CONTROL

The Speed Control system as shown in Figure 5-1 consists of:

- A device (1) to sense the speed of the prime mover.
- A Frequency to Voltage Convertor (2).
- A Speed Reference (3) to which the prime mover speed can be compared.
- A Speed Summer/Amplifier (4) with an output proportional to the amount of fuel or steam required to maintain the desired speed at any given load.
- An Actuator (5) to position the fuel or steam mechanism of the prime mover.

A speed-sensing device, such as a magnetic pickup, senses the speed of the prime mover, and converts it to an ac signal with a frequency proportional to prime-mover speed.

The frequency-to-voltage convertor receives the ac signal from the speed sensor and changes it to a proportional dc voltage.

A speed-reference circuit generates a dc "reference" voltage to which the speed-signal voltage is compared.

- See reference table for more information on magnetic pickups.

The speed-signal voltage is compared to the reference voltage at the summing point. If the speed-signal voltage is lower or higher than the reference voltage, a signal is sent by the control amplifier calling for an increase or decrease in speed.

The actuator responds to the signal from the control amplifier by repositioning the fuel or steam rack, changing the speed of the prime mover until the speed-signal voltage and the reference voltage are equal.

A failed-speed-signal circuit monitors the speed-signal input. When no signal is detected, it calls for minimum fuel. The minimum-fuel signal is sufficient to cause the actuator to go to the minimum position if not restricted. However, due to linkage adjustment or other restrictions in the external system, minimum actuator position may not permit prime-mover shutdown.

For controls with actuator current of 20 to 160 milliamps (mA), minimum fuel is defined as:

- Actuator current less than 10 mA for forward-acting controls.

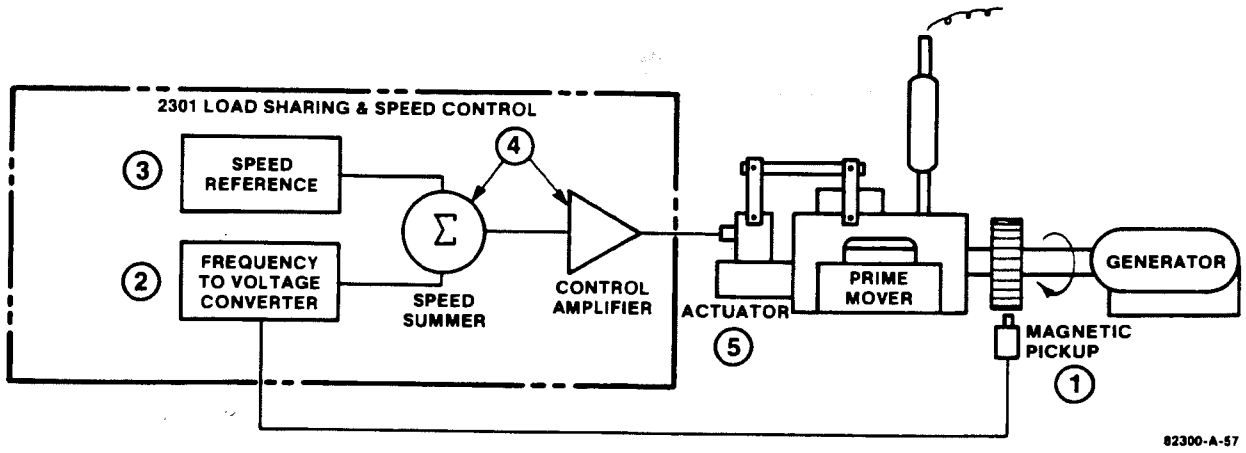


Figure 5-1. Speed Control System

- Actuator current greater than 180 mA for reverse-acting controls.

For controls with actuator current of 40 to 320 mA, minimum fuel is defined as:

- Actuator current less than 20 mA for forward-acting controls.
- Actuator current greater than 360 mA for reverse-acting controls.

A contact to override the failed-speed-signal circuit can be connected in series with terminal 18 and terminal 16 (or terminal 0 on high voltage controls). Temporarily closing the contact overrides the failed-speed-signal circuit as may be required for start-up.

Because of the variety of installations, plus system and component tolerances, the control must be tuned to each system for optimum performance. The potentiometers for setting and adjusting these circuits are located in the upper right corner of the control as shown in Figure 5-2 They include:

- The RATED SPEED potentiometer
- The START FUEL LIMIT potentiometer.
- RESET, GAIN, and ACTUATOR COMPENSATION.
- RAMP TIME and LOW IDLE SPEED potentiometers.

The RATED SPEED potentiometer is adjusted so that at rated speed, the convertor-speed voltage and the reference-speed voltage are equal.

The START FUEL LIMIT potentiometer provides a means of limiting the fuel-rack position when starting diesel engines. Adjustment of the potentiometer sets the maximum actuator position desired. This limit position is automatically enabled prior to start-up, and is turned off when speed control takes over.

RESET, GAIN and ACTUATOR COMPENSATION potentiometers adjust the control amplifier to accommodate various types of prime-mover systems. RESET adjustment affects prime mover reaction time when recovering after a sudden load change. The magnitude of the speed change resulting from a sudden change in load is controlled by adjusting the GAIN. ACTUATOR COMPENSATION compensates for the time the actuator and prime mover system takes to react to signals from the control.

The time taken by the prime mover to accelerate from idle to rated speed, and the recommended idle speed, are set with the RAMP TIME and LOW IDLE SPEED potentiometers respectively.

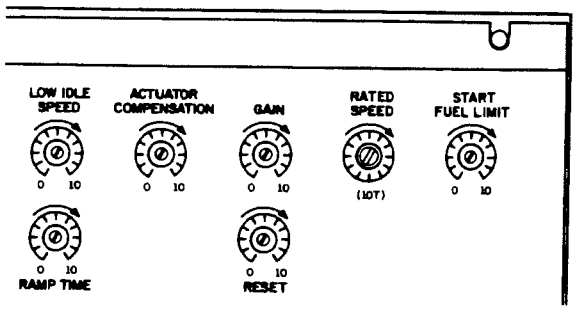
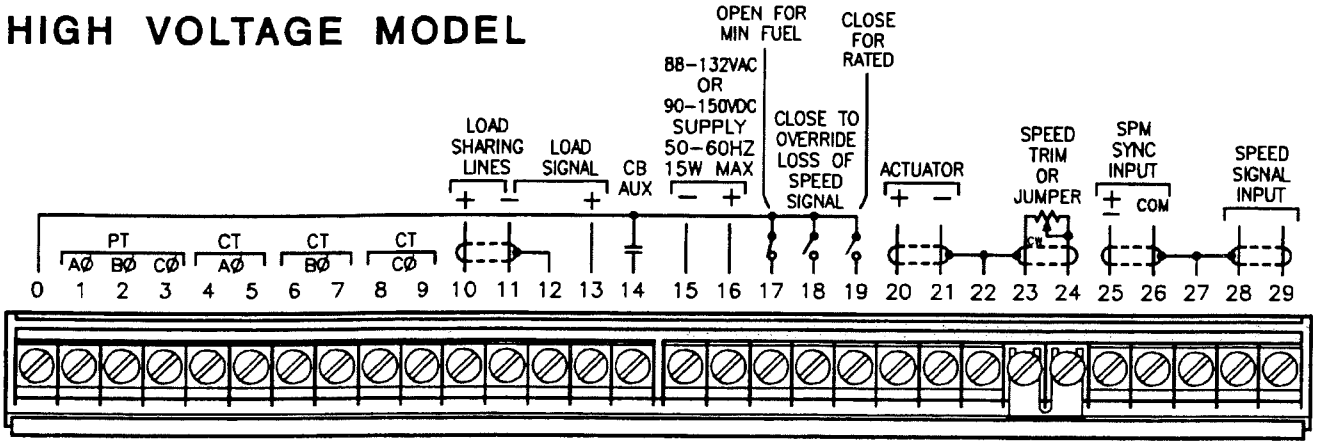


Figure 5-2. Speed Control Adjustments

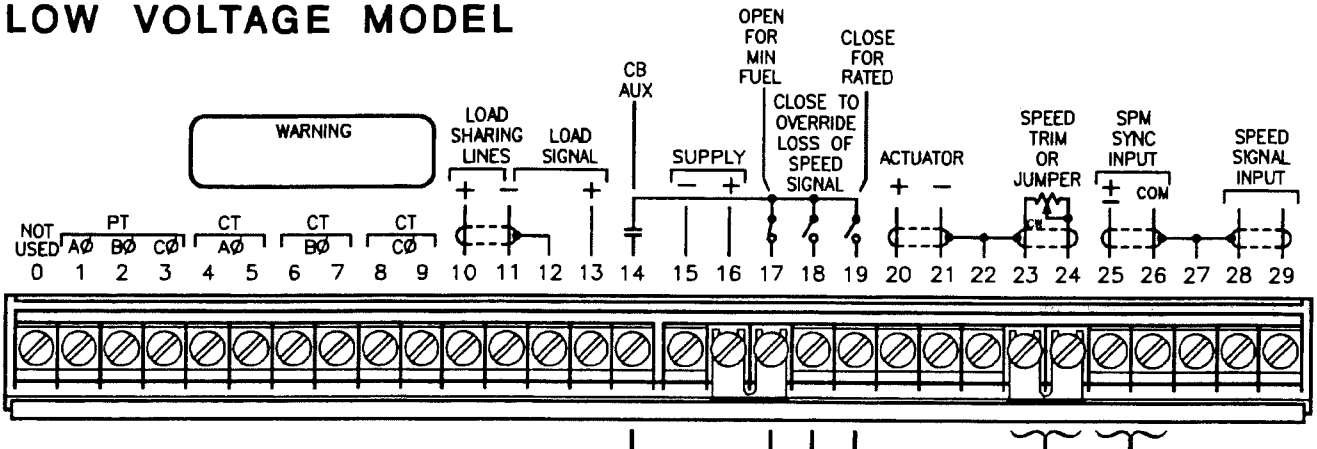
TERMINALS FOR EXTERNAL DEVICES

Terminal blocks for wiring the control to the system are at the lower front panel of the control. Additional terminals are included for connecting other external devices as shown in Figure 5-3.

HIGH VOLTAGE MODEL



LOW VOLTAGE MODEL



TERMINAL 14 - WHEN CONTACT IS CLOSED, CONTROL IS IN ISOCHRONOUS AND THE LOAD SHARING LINES ARE ACTIVE. WHEN OPEN, CONTROL IS IN DROOP AND LOAD SHARING LINES ARE DISABLED.

TERMINAL 17 - A CONTACT TO DRIVE THE OUTPUT TO MINIMUM FUEL WHEN REQUIRED FOR SHUTDOWN.* THE JUMPER MUST NOT BE USED ON HIGH VOLTAGE MODELS.

TERMINAL 18 - A CONTACT TO OVERRIDE THE FAILED SPEED PROTECTIVE CIRCUIT FOR START-UP AND START FUEL SET UP CALIBRATION.

TERMINAL 19 - A CONTACT TO ACCELERATE FROM IDLE TO RATED SPEED WHEN THE CONTACT IS CLOSED.

TERMINALS 23 AND 24 - AN EXTERNAL MEANS OF REMOTELY FINE TUNING THE SPEED SETTING. IT ALSO MAY BE USED FOR MANUAL SYNCHRONIZATION OR FOR LOADING THE GENERATOR WHEN OPERATING IN THE DROOP MODE.

TERMINALS 25 AND 26 - PROVIDE FOR USE OF AN OPTIONAL SPEED AND PHASE MATCHING (SPM) SYNCHRONIZER. AN SPM SYNCHRONIZER AUTOMATICALLY GENERATES A SIGNAL TO BIAS THE SPEED OF THE PRIME MOVER OF AN OFF-LINE GENERATOR SO ITS FREQUENCY AND PHASE MATCH THOSE OF THE BUS.**

* DO NOT USE THE MINIMUM FUEL CONTACT OPTION AS PART OF ANY EMERGENCY STOP SEQUENCE.

** SEE REFERENCE TABLE FOR MORE INFORMATION ON SPM SYNCHRONIZERS.

823-266
92-1-24 GA

Figure 5-3. Terminal Connections

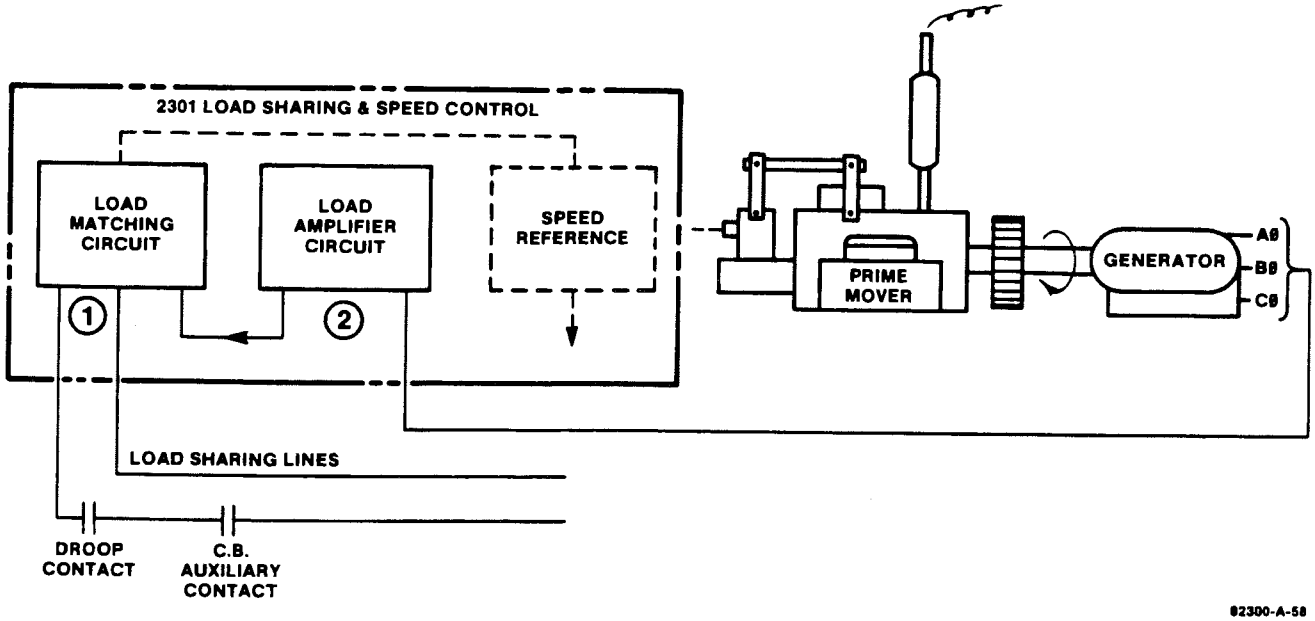


Figure 5-4. Paralleling System

PARALLELING

There are two basic methods used for paralleling: droop, where speed decreases with load, and isochronous, where speed remains constant. The paralleling system as shown in Figure 5-4 consists of:

- Load Matching circuit (1).
- A Load Amplifier circuit (2).

An auxiliary contact on the generator tie-breaker connected from terminal 16 (or terminal 0 on high voltage controls) to terminal 14 is used to select isochronous load-sharing operation. A contact in series with the auxiliary contact may be used to select either the droop or isochronous mode of operation.

If either the auxiliary contact or the droop contact is open, the control is in droop. When they are both closed, the control is in isochronous load sharing.

With only one unit on line, the generator picks up the available load and remains at the isochronous speed. If additional units are on line, the Load Matching circuit corrects the fuel output to proportion load.

An amplifier in the load-sensing circuit computes the load carried by each phase of the generator. The current load on each phase is multiplied by the cosine of the phase difference between the current and the voltage, and the three phases are added to determine the total load.

The output of the load amplifier is adjusted by the LOAD GAIN potentiometer shown in Figure 5-5. By setting the load-gain voltage on each unit to the same level at full load, proportional load sharing is achieved. Regardless of differences in generator-set capacities in the system, each generator set is loaded to the same percentage of its capacity. A final adjustment of the individual LOAD GAIN potentiometers will compensate for minor differences in the generator sets.

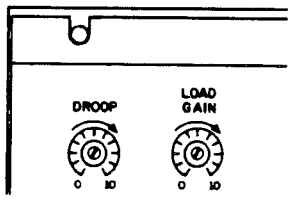


Figure 5-5. Paralleling Adjustments

As mentioned in the general information section, droop mode allows operation of a generator on an infinite bus or in parallel with other engine generator units using hydromechanical governors. In droop, speed changes as the load on the generator changes. An increase in load results in a decrease in speed. The amount of speed change or droop is expressed in percent, and is set by the DROOP potentiometer shown in Figure 5-5.

The 2301A Load Sharing and Speed Control is powered by a dc-dc isolated power supply, which allows operation over a wide voltage range without generating excessive heat. This isolation protects the system from interference caused by ground loops, particularly through the load-sharing lines, and allows load sharing with earlier models of Woodward Governor Company load-sharing controls.

SECTION 6
TROUBLESHOOTING

The following troubleshooting guide is an aid in isolating trouble to the control box, actuator, plant wiring, or elsewhere. Troubleshooting beyond this level is recommended ONLY when a complete facility for control testing is available.

NOTE

The control can be damaged with the wrong voltage. When replacing a control, check the power supply, battery, etc., for the correct voltage.

TROUBLESHOOTING PROCEDURE

Table 6-1 is a general guide for isolating system problems. This guide assumes that the system wiring, soldering connections, switch and relay contacts, and input and output connections are correct and in good working order. Make the checks in the order indicated. Various system checks assume that the prior checks have been properly done.

WARNING

TO PROTECT AGAINST POSSIBLE PERSONAL INJURY, LOSS OF LIFE, and/or PROPERTY DAMAGE WHEN STARTING the engine, turbine, or other prime mover, BE PREPARED TO MAKE AN EMERGENCY SHUTDOWN to protect against runaway or overspeed should the mechanical-hydraulic governor(s), or electric control(s), the actuator(s), fuel control(s), the driving mechanism(s), the linkage(s), or the controlled device(s) fail.

Table 6-1. Troubleshooting

SYMPTOM	CAUSE	REMEDY
Prime mover will not start. Actuator not moving to start-fuel position. **NOTE** *If the actuator moves to start position, a problem with the prime mover fuel supply is indicated.*	Supply voltage polarity reversed (dc only), or no supply voltage.	Check for proper voltage from terminals 16 (+) to 15 (-). Reverse leads if polarity is incorrect (dc only).
	Actuator not responding to input signal from control. **NOTE** *The hydraulic actuator must have oil pressure and gear rotation to operate (respond).*	If there is a voltage output at control terminals 20 (+) and 21 (-), but the actuator does not move, the wiring to the actuator should be checked for opens or shorts. With the EG3P actuator, remember that terminals C and D of the mating plug should be jumpered. Make resistance checks at the actuator. Coil resistance on Woodward actuators is approximately 35 ohms. (Read with leads at T 20 and T 21 disconnected.)
	Start fuel limit set too low.	Turn start fuel limit cw until prime mover starts.
	Actuator or Linkage.	Check actuator and linkage for proper installation and operation. Problems may be oil supply, direction of rotation, insufficient drainage, linkage, worn actuator components or improper adjustment.

SYMPTOM	CAUSE	REMEDY
Prime mover will not start. Actuator not moving to start-fuel position (cont.)	If no actuator voltage at terminals 20 and 21.	Check for shorted or grounded actuator leads by removing wires to terminals 20 and 21. Stop prime mover. Close the switch on terminal 18, short terminal 23 to 24. Check for 18 to 22 volts at terminals 20 and 21 for forward acting controls, and 0 to 1 volt for reverse acting controls. Check for at least 1 V RMS at terminals 28 and 29, and at least 5% of the minimum rated speed frequency range.
	Speed setting too low on initial start.	Control may be the wrong speed range. Check speed sensor frequency versus control part number. Speed setting may be lower than cranking speed. Control should be set for rated speed. Increase RATED SPEED setting clockwise (cw). **CAUTION** **If adjusting RATED SPEED setting cw does not produce the correct output, return RATED SPEED setting to normal start position-full counter-clockwise (ccw).**
	LOW IDLE SPEED setting may be set too low.	Adjust LOW IDLE SPEED potentiometer cw.
	Minimum Fuel contact open. See "MINIMUM FUEL CONTACT" in Section 3.	Check T 17. Minimum-fuel contact must be closed for normal operation. Check for 20 to 40 Vdc from terminal 17 (+) to 15 (-).
	Speed sensor signal not clearing failed speed signal circuit.	Check wiring for proper connection. Check shields for proper installation. Speed sensor not spaced properly-check for at least 1.0 V ac at terminals 28 and 29 during cranking. If less that 1.0 V ac, magnetic pickup may be spaced too far from gear. Make sure there are no metal chips on end of pickup. If no voltage is present, magnetic pickup may be open-circuited or shorted. Make resistance check with the leads disconnected from control. Should be about 100 to 300 ohms.

SYMPTOM	CAUSE	REMEDY
Prime mover will not start. Actuator not moving to start-fuel position. (cont.)		Failed speed-signal circuit may be disabled by connecting terminal 16 (or terminal 0 on high voltage controls) to terminal 18. ***WARNING*** **TO PROTECT AGAINST POSSIBLE PERSONAL INJURY, LOSS OF LIFE, and/or PROPERTY DAMAGE when starting the engine, turbine, or other type of prime mover, BE PREPARED TO MAKE AN EMERGENCY SHUT-DOWN to protect against runaway or overspeeding should the mechanical-hydraulic governor(s), electric control(s), actuator(s), fuel control(s), driving mechanism(s), linkage(s), or controlled device(s) fail.**
	Terminals 23 and 24 are open.	Verify that terminals 23 and 24 are jumpered if optional external speed trim is not used.
	Faulty speed trim potentiometer.	With power OFF, check speed trim potentiometer(s) with an ohmmeter.
	Faulty 2301A control.	Replace.
Prime mover will not start (high-voltage control).	Common + source for contacts connected to terminals 14, 17, 18, and 19 taken from terminal 16 instead of from terminal 0.	Connect + source for these terminals to terminal 0, not 16.
Prime mover overspeeds only on starts.	Ramp adjustment.	Increase RAMP TIME (cw). This decreases acceleration rate (from low idle to rated).
	RATED SPEED setting too high.	Set RATED SPEED as described in Section 4.
	Amplifier adjustment.	Amplifier may be adjusted for sluggish operation causing overspeed on start. Slowly adjust GAIN for fastest stable response. RESET may be adjusted too low. Increase RESET setting.
	Determine if engine is malfunctioning.	Verify that fuel rack is not binding and linkage is properly adjusted. Determine if the fuel rack is quickly following the actuator input voltage. Check operation of overspeed protection device(s).

SYMPTOM	CAUSE	REMEDY
Prime mover overspeeds or causes excessive smoke only on starts.	Start Fuel Limit is inactive.	On power up, Fuel Limit can be bypassed if MPU signal clears in less than 1 second. Power up 2301A before cranking engine.
	2301A control.	If the control does not cut back the actuator voltage [T 20 (+) and T 21(-)] until the speed setting is completely ccw (or does not reduce fuel at any position), the 2301A control may be faulty, or may have the wrong speed range. If the voltage is cut back, look for a problem in the linkage or actuator.
Prime mover overspeeds after operating at rated speed for some time.	Prime mover.	Check for proper operation of prime-mover fuel system. If actuator moves toward minimum fuel during overspeed, problem is in fuel system.
	Magnetic pickup and 2301A control.	Check the magnetic-pickup output voltage at speeds above idle-at least 1.0 V rms. If magnetic pickup should fail and the override-failed-speed-signal circuit is disabled, the 2301A control will call for maximum fuel.
	2301A control amplifier.	Control the prime mover manually at rated speed and adjust the RATED SPEED setting fully ccw. If the output voltage is not zero, check for proper speed range switch adjustment as described in Section 3. If speed range is correct for the application, replace the control.
Prime mover has momentary speed change when adjusting GAIN.	GAIN adjustment made too quickly.	Make GAIN adjustment slowly. Small momentary speed changes when adjusting GAIN is normal.
Low speed is not regulated by LOW IDLE SPEED potentiometer.	**NOTE** *On carbureted prime movers, the minimum fuel stop rpm setting will vary with prime mover temperature. An improper cold setting may give interference with the LOW IDLE SPEED setting when the prime mover is hot.*	The LOW IDLE SPEED setting may be below the minimum-fuel position of the actuator or prime-mover fuel stop. In this case, the output voltage to the actuator will be zero. The engine will be maintained at the minimum-fuel position by the actuator or the prime mover minimum-fuel stop. The conditions above indicate that the prime mover minimum-fuel position should be decreased by linkage adjustment (diesel engine) or low-idle set screw (gas engine), or the LOW IDLE SPEED setting should be raised. If the above action does not correct the problem, the 2301A control may be faulty.

SYMPTOM	CAUSE	REMEDY
Low speed is not regulated by LOW IDLE SPEED potentiometer. (cont.)	LOW IDLE SPEED potentiometer.	If adjustment of the LOW IDLE SPEED potentiometer causes erratic behavior, replace the control.
Prime mover does not decelerate when Close for Rated contact is open.	Faulty Close for Rated contact.	Check Close for Rated contact. Remove wire from terminal 19. Prime mover should decelerate.
	LOW IDLE SPEED set fully cw.	Turn LOW IDLE SPEED setting ccw with terminal 19 open.
	2301A control ramp circuitry.	A faulty Close for Rated contact may remain in the accelerate position with the contact open. If the Close for Rated contact is operative, loss of idle control may be due to a faulty circuit. In general, adjustment of LOW IDLE SPEED will vary the speed of the prime mover with the Close for Rated contact in the decelerate (open) position. Adjustment of LOW IDLE SPEED should not affect prime mover speed when the Close for Rated contact is closed. **CAUTION** **The speed-setting controls have sufficient range to override the ramp and bring the prime mover speed up to rated while still in the low-idle mode (either by defect or switching). Therefore, a Close for Rated contact that is intermittent may cause the prime mover to overspeed if the RATED SPEED setting is adjusted for rated speed with T 19 open.**
Prime mover will not stabilize at rated no load speed. The instability may occur at no load or it may vary with load. Control may be erratic.	2301A control.	Adjust GAIN, RESET, and ACTUATOR COMPENSATION as described in "Adjust for Stable Operation" and "Dynamic Adjustment" in Section 4.

SYMPTOM	CAUSE	REMEDY
Prime mover will not stabilize at rated no load speed. The instability may occur at no load or it may vary with load. Control may be erratic (cont.)	Speed setting controls.	If adjustment of external speed trim causes instability, check potentiometer with ohmmeter for erratic behavior (turn power off). Use nonlubricating electrical cleaner if necessary. If internal speed potentiometer is faulty, replace control.
	Improper linkage adjustment.	Make sure that actuator moves approximately 2/3 of its travel from no load to full load. Be sure linkage is linear on turbine, diesel, and fuel-injected prime movers. Be sure linkage is nonlinear on carbureted prime movers. Refer to actuator manual for proper installation.
	Necessary external wires not properly shielded. Electrical noise, caused by wiring carrying an ac voltage, stray magnetic fields from transformers, etc., can be picked up by improperly shielded wire. Noise will cause instability if picked up by lines associated with the amplifier summing point such as external speed trim, paralleling lines, droop contact, magnetic pickup lines, and synchronizer input.	The following tests will isolate noise and interference. **CAUTION** **Do not perform these tests in other than single-unit operating configuration.** Jumper terminal 19 to terminal 16 (terminal 0 on high voltage controls), and remove wires to the Close for Rated contact. Where an external speed trim is used, jumper terminals 23 and 24, and remove wires to the potentiometer. ***WARNING*** **Prime mover may overspeed if jumper is installed while running.** Remove wires to terminals 10, 11, 12, 14, 25, and 26. Jumper 14 and 16. Remove the wires to the minimum-fuel contact at terminal 17. Verify that the switchgear frame, governor chassis, and prime mover have a common ground connection. Temporarily remove the battery-charger cables from the control battery system.

SYMPTOM	CAUSE	REMEDY
Prime mover will not stabilize at rated no-load speed. The instability may occur at no load or it may vary with load. Control may be erratic. (cont.)		If the prime-mover operation is significantly improved by the above modifications, replace the wiring one at a time to locate the source of the trouble. External wiring may require additional shielding or rerouting from high-current lines or components. If the problem cannot be resolved by the above checks, it will be necessary to remove the 2301A control from the switchgear. Temporarily mount it next to the prime mover and connect only a battery, magnetic pickup, and actuator, to the control (use a separate battery placed next to the prime mover). After starting the prime mover, place a small jumper wire across terminals 19 and 16 to cause the prime mover to accelerate to rated speed. If necessary, apply load to check stability. If stability occurs when control is mounted next to the prime mover, return the control to the switchgear. Run new magnetic pickup, actuator, and battery power lines. Shield all wires to the control. Route all wires through conduit or an outer shield. Tie the outer shield to system ground at end opposite of the control.
	Prime mover may not be receiving fuel as called for by the actuator voltage.	Check actuator linkage to fuel controlling mechanism for any lost motion, binding, or excessive loading. Verify a steady fuel pressure of proper value. Check actuator per appropriate actuator manual.
	Prime mover not operating properly.	Prime mover may be causing speed variations. Control engine manually to determine if instability is in prime mover or governor control. Verify proper adjustment of fuel control linkage.
	Input voltage low.	Check supply voltage. It should be at least 18 Vdc on low voltage controls and 90 Vdc or 88 Vac on high voltage controls.

SYMPTOM	CAUSE	REMEDY
Speed-setting control does not regulate speed.	Faulty RATED SPEED or Speed Trim potentiometer.	Check by replacing Speed Trim with jumper and setting speed with main speed potentiometer.
Prime mover does not share load with other units.	Prime mover not receiving fuel as called for by the governor.	If voltage to actuator is maximum (minimum for reverse acting), visually determine if actuator shaft is at maximum position. If it is not, an actuator problem is indicated, or the linkage or fuel system is restricted.
	Unequal speed settings.	Be sure that speed settings of all units at no load are identical.
	Unequal load-gain voltages.	With the prime mover operating in single-unit configuration, LOAD GAIN must be set at 6.0 V dc. See LOAD GAIN ADJUSTMENT in Section 4.
	Circuit breaker auxiliary contact or droop contact is open.	Check auxiliary circuit breaker and droop contacts. Check for 20 to 40 Vdc from terminal 14 to 15 on low voltage controls. **NOTE** *High voltage controls can only be measured from terminal 14 to 18 if the close to override failed speed signal contact is not closed.*
	Improper load-sensing phasing.	Perform phasing procedure in Section 4.
	Circulating currents between generators.	Refer to appropriate voltage regulator manual.
Prime mover does not maintain constant speed (isochronous).	Actuator.	If actuator has a ballhead backup, verify that its hydraulic governor section, speed setting, and speed droop adjustments are properly set (see the applicable governor manual).
	Prime mover.	If the droop occurs near the full-load point only, it is possible the prime mover is not producing the horsepower called for by the fuel control, or is being overloaded. Either is indicated if the fuel control is at maximum position.

SECTION 7
REPAIR AND REPLACEMENT PROCEDURES

INSTRUCTIONS FOR RETURNING EQUIPMENT FOR REPAIR

If any part of the electronic control is to be returned to Woodward Governor Company for repair, attach a tag to the part with the following information:

- Name and location where the control is installed.
- Complete Woodward Governor Company part number(s) and serial number(s).
- Description of the problem.
- Instructions describing the desired type of repair.

NOTE

Before handling any electronic component, read Manual 82715, "Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules

Use the following materials when returning a complete control:

- Antistatic packing materials that will not damage the surface of the unit.
- At least four inches of tightly packed, industry-approved packing material.
- A packing carton with double walls.
- A strong tape around the outside of the carton for increased strength.

REPLACEMENT PARTS INFORMATION

When ordering replacement parts for electronic controls, include the following information:

- The part number (9905-XXX) from the enclosure nameplate.
- The unit serial number, which is also on the nameplate.

For more information on replacement parts, contact Woodward Governor Company, Engine and Turbine Controls Division, PO Box 1519, Fort Collins, CO 80522-9990, USA. Telephone (303)-482-5811, or contact your nearest Woodward Governor Company service facility.

Ordering Manuals

Order manuals from your nearest Woodward Governor Company location.
Please include the following information:

- Your name
- The name and address of your company
  (write on letterhead or include business card if available)
- The address where you want the manuals sent (if different from above)
- The quantity wanted of each manual
- The manual number for each manual you are ordering OR the part number and serial number from the name plate on your Woodward Equipment.

We appreciate your comments about the content of our publications.
Please send comments to:

Woodward Governor Company/Engine Controls
Attention Engine Marketing
P.O. Box 1519
Fort Collins, Colorado 80522-1519 USA

WOODWARD

ENGINE CONTROLS

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Registered Firm
ISO 9001:1994/Q9001-1994
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DUTCH COUNCIL FOR CERTIFICATION

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Aken, **Germany**	Phone 49-34909-880-0	Fax 49-34909-880-201
Ballabgarh, **India**	Phone 91-129-232840/41	Fax 91-129-232842
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Tomisato, **Japan**	Phone 81-476-93-4661	Fax 81-476-93-7939
Hoofddorp, **The Netherlands**	Phone 31-23-5661111	Fax 31-23-5636529
Warsaw, **Poland**	Phone 48-22-264156	Fax 48-22-264156
Asia/Pacific Regional Office, **Singapore**	Phone 65-270-0081	Fax 65-271-6250
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