Instruction Book

IL 19-616-A

INVERTER POWER SUPPLY

LOAD SHARING CONTROL

November 1973

Westinghouse Electric Corporation
Industrial Equipment Division
Buffalo, N.Y.

LOAD SHARING CONTROL MODULE

WITH DC ISOLATION

INDEX

INTRODUCTION

This equipment uses input from a shunt to obtain an amplified, isolated load sharing tie voltage signal proportional to the current in the shunt. If two or more rectifiers have their load sharing tie signals connected in parallel, this signal will adjust to a value corresponding to the share of the total current desired in each rectifier. This adjusted voltage signal is compared with a similar signal proportional to the actual load of the rectifier, and an error signal is brought out for connection to the rectifier control to cause the required correction.

ARRANGEMENT

This equipment consists of three printed circuit boards and a single phase supply transformer all mounted in a supporting frame work.

DRAWINGS AND DIAGRAMS

General Drawing	1712A44G01
Schematic and Block Diagram	2950D02
Main Wiring Diagram	3616C41

Sub-Assemblies:

Power Supply Board	1649A77G01
Load Sharing & Power Supply Board	2950D17
Isolator No. 1 & No. 2 Board	2950D20

OPERATION

1. Schematic diagram 2950D02 shows the circuit arrangement. The load sharing control consists of two isolated circuits. The shunt input amplifier A1 of the load sharing board, the input (terminals 2 and 3) of isolator #1 and the output (terminals 11 and 12) of isolator #2 from isolated circuit #1 and the output (terminals 6 and 7) of isolator #1 and the input (terminals 15 and 16) of isolator #2 form isolated circuit #2. Refer to Figure 2.

   This arrangement enables the DC power of each power supply to be isolated.

   The load sharing printed circuit board includes isolated ±15 volt zener regulated DC power circuit for isolated circuit #1, shunt amplifier circuit, input circuit to the gating controller, and load sharing tie relays CR1 and CR2.

   The power supply board contains the ±15 volt zener regulated DC power circuit for isolated circuit #2 and 24 volt unregulated DC power source for the coils of relays 1CR and 2CR.

   Isolator #1 and 2 are similar in detail and are located on the third printed circuit board in the assembly.

2. This equipment uses a DC voltage signal from a shunt and first amplifies it to obtain a proportional voltage at the output of operational amplifier A1, on the load-sharing board. The gain of this amplifier is 196 as determined by resistors R5 and R7.

3. This voltage is converted by the isolator to an isolated DC current signal proportional to the original shunt voltage (and rectifier current). Isolation is obtained by transmitting an equivalent AC signal of frequency about 20 KHz, generated by unijunction transistor oscillator #1 (device C3, Q1, Q2, etc.) and modulated by amplifier A1 and transistor Q3, through isolating transformer T1. The current in the secondary of transformer T1 is rectified; a shunting diode is provided to obtain the base current to transistor Q5, which then carries an isolated collector-emitter current proportional to the shunt voltage.

4. The transistor Q5 circuit, with common emitter, is essentially a constant current circuit, with its current dependent upon its base drive, which is derived from the shunt voltage as described in the preceding two numbered paragraphs.

5. The isolated direct current signal flows from isolator board terminal 7 (COM-F) through diode D1, resistor R15, adjustable pot. P1, transistor Q5, transformer T1 secondary, diodes D2 and D3, and choke CH1 and returns to the isolated supply circuit terminal 5 (-15F). The voltage drop across resistor R15 and pot. P1 is proportional to the isolated current signal and can be calibrated by pot. P1.

6. This voltage at terminals 6 (negative) and 7 (positive) on the isolator board is connected to the load sharing board terminals 10 and 13, through relay contacts CR1 and CR2, and to the load sharing tie, terminals 8 and 12 of load sharing board. If the load sharing tie circuit is connected to similar circuits of one or more other rectifiers, and if these voltages of each rectifier are not equal before the connections are made, currents will flow in these tie circuits when they are connected together until the voltage drops across each set of resistor R15 and pot. P1 are equal for all of the rectifiers involved. Note that the currents flowing in the load sharing tie circuits do not affect the current flowing through the transistors Q5 of each rectifier, which are proportional to the actual rectifier shunt currents.

7. The voltage across the load sharing tie (and also across each set of resistors R15 and pot. P1 on the isolator board) is now proportional to the share of the total current desired in the given rectifier and is isolated from the shunt circuit of the rectifier. This voltage is also connected to the input of DC isolating circuit #2 at terminals 15 (COM-F) and 16 (V-IN-F, negative), on isolator board. This isolator circuit with oscillator #2, etc. is identical to that described in paragraph 3 except for polarity of secondary circuit of transformer T11 and the use of PNP transistor Q15, whose emitter-collector current is proportional to the load sharing tie voltage (COM-F to V-IN-F).

8. The output current for the second isolator circuit flows from the +15V supply (isolator terminal 13) through choke CH11, diode D12 and D13, transformer T11 secondary, transistor Q15, pot. P11, resistor R35, and diode D11 to COM (isolator terminal 11). This current is proportional to the current desired in this rectifier. It produces a proportional voltage V-OUT to COM across resistor R35 and calibrating pot P11 on the isolator board. These circuits are at the level of the shunt circuit and are isolated from the load sharing tie.

9. The voltage V-OUT to COM is connected in series aiding the output of amplifier A1 on the load sharing board, with resistors R10 and R9 in series between them. This arrangement is a comparator circuit, and the error signal voltage is taken between the common point of R9 and R10 and COM. This output represents the required correction signal for use in the rectifier control circuits and is designated INPUT (terminal 12). This circuit is connected to the summing junction of the voltage loop amplifier in the gating controller/regulator (SJ2).

10. Potentiometers P2 and P12 in isolator #1 and isolator #2 circuit are offset adjustments to permit adjustment of isolator output voltages (terminals 6 and 7 and 11 and 12) at low voltage outputs, thus enabling isolator outputs of each paralleled power supply to be adjusted approximately equal over complete current range.

INPUT-OUTPUT REQUIREMENT

1. The secondary of single phase transformer (T) has three isolated windings. Winding X1-X2-X3 supplies single phase bridge rectifier (D1 through D4) and 15 volt zener diodes to provide regulated voltages +15 volts and -15 volts with respect to (COM-F). This power circuit provides isolated voltage for the output circuits of isolator #1 and the input circuits of isolator #2.

   Winding X4-X5-X6 supplies single phase bridge (D31 through D34) to produce +15 volts and -15 volts with respect COM. This power circuit provides isolated voltage for the input of isolator #1 and the output circuits of isolator #2.

   Windings X7-X8 supplies single phase bridge (D35 through D38). This power circuit provides isolated 24 volts unregulated DC voltage for the coils of relays 1CR and 2CR located on the load sharing board.

2. SHUNT CIRCUIT INPUT

   Terminals 7 (positive) and 6 (COM, Negative) on the load sharing board are designed for an input DC signal of 50 MV or less. Terminals 7 and 6 of the load sharing board are terminal blocks 10 and 11 respectively of the control module.

3. LOAD SHARING CONNECTIONS

   Terminals 8 (negative) and 12 (positive) on the load sharing board (terminal blocks 17 and 18 on the control module) are for connection to corresponding terminals of associated paralleled rectifiers for the load sharing tie.

   24 volts DC is applied to the coils of relays 1CR and 2CR, terminals 9 and 11 on the load sharing board. Terminal 11 is connected internally to common of supply rectifier, terminal 7 on the power supply board. Terminal 9 is brought out to control module terminal block 1-15 and the positive of supply rectifier terminal 6 is brought out to control module terminal block 1-16 to enable relay sequencing to complete the circuit.

4. LOAD SHARING ERROR CORRECTIONS

   This circuit is connected between terminals 1 (INPUT) and 6 (COM) on the load sharing board and is the error signal based on comparison of a signal proportional to the rectifier DC load current with one proportional to the desired current. The connection from terminal 1 (terminal block 1-12 of control modules) is made to the SCR gating controller/regulator as outlined in Section III, paragraph 9 above.

LOAD SHARING MODULE TEST PROCEDURE

1. Apply AC voltage of correct rating and frequency to terminal blocks #1 and #2. Refer to Figure #1.

2. CHECK RECTIFIER VOLTAGES

   A. Power supply board 1649A77G01

Terminal 6 to 7	+24 volts ±5%
Terminal 2 to 1	+14.2 to 15.8 volts DC
Terminal 3 to 1	-14.2 to 15.8 volts DC

   B. Load sharing board 2950D17

Terminal 14 to 13	+14.2 to 15.8 volts DC
Terminal 15 to 13	-14.2 to 15.8 volts DC

3. Apply 50 millivolts DC to terminal blocks 10 and 11 on load sharing module (terminal 10 positive with respect to 11). The voltage between terminals 3 and 6 on the load sharing P/C board should measure between -8.8 and -10.8 volts DC.

4. ISOLATOR BOARD (2950D20) TESTS

   A. Isolator #1 - with 6.15 volts DC applied to terminals 2 and 3 on isolator board (terminal 2 at negative potential with respect to 3), voltage from terminal 7 to terminal 6 should read approximately 9.6 volts when pot P1 is fully CCW, and approximately 6.7 volts when pot P1 is fully CW.

   B. Isolator #2 - with 9 volts DC applied to terminals 15 and 16 of isolator board (terminal 16 at negative potential with respect to 15), voltage from terminal 11 to terminal 12 should read approximately -14 volts DC when pot P11 is fully CCW, and approximately -5.8 volts DC when pot P11 is CW.

5. TROUBLE SHOOTING

   A. If trouble shooting is necessary, inspect the unit for the following:

      1. Correct mounting of transistors, diodes and amplifiers.

      2. Poor terminal/solder connections.

3. Broken components or component leads.

4. Improper connections to board.

B. TROUBLE SHOOTING WITH SCOPE

1. At zero MV input, observe a 10 volt sawtooth waveform with period approximately 40 μsecs. Across C3 and C13.

2. Observe a 1 to 2 volt peak-to-peak waveform with period of approximately 40 μ S. across primaries T1 and T11. Observe 3 to 5 volt peak-to-peak waveform across secondaries of T1 and T11.

INITIAL STARTUP PROCEDURE

1. CALIBRATION OF LOAD SHARING MODULE IN POWER SUPPLY

A. Disconnect shunt lead at terminal 1-10 of load sharing module and connect a 50 millivolt adjustable voltage DC power supply to terminal blocks 10 and 11 of module (terminal 10 positive with respect to terminal 11). Disconnect load sharing tie lead at terminal block 17 of module.

B. Open DC output breaker of power supply and energize power supply by closing the AC input breaker.

C. To insure proper operation and load sharing ability, the following adjustments and measurements must be done with care. Make measurements with a digital voltmeter preferably, or high resistance millivolt meters and voltmeters.

NOTE: For proper load sharing ability, it is important that the load sharing module in each power supply be adjusted identically.

1. Apply 50 MV to terminals 10 and 11 ~~of isolator~~ and adjust pot. P1 on isolator #1 circuit to provide 9 volts output measured from terminal 7 to terminal 6 on isolator board.

2. Adjust pot. P11 on isolator #2 circuit to provide zero volts output as measured from terminal block 12 to terminal block 11. Do not overadjust. This should result in a voltage of approximately 9.8 volts measured from terminal 12 to terminal 11 on the isolator board.

3. Reduce MV input to 5 MV's and set pot. P2 at 50 percent and measure and record the DC output from terminal 7 to terminal 6 on isolator board.

4. Set pot. P12 on isolator #2 at 50 percent and measure and record the DC output from terminal 11 to terminal 12 on isolator board.

5. Disconnect MV power supply and reconnect shunt lead to terminal 10 of load sharing module and load sharing tie lead to terminal 17.

2. LOAD TEST

A. Disconnect the load sharing tie between the three power supplies by removing leads to terminal 17 on each load sharing module.

B. With DC breakers open, close AC input breaker to each parallel power supply and adjust DC output voltages to the rated DC bus voltage.

C. Close DC breakers on the three power supplies and apply a DC load equal to approximately three times 50 to 100 percent of the rating of one power supply.

D. Observe the DC ammeter of each unit. If one unit is carrying little or no load, adjust the DC voltage of that until the three units are carrying load within at least 40 percent of each other.

E. Turn off each power supply as follows:

1. Open the AC breaker.
2. Then open DC breaker.

F. Reconnect load sharing tie leads to terminal 17 on each load sharing module.

G. Turn on each power supply as follows:

1. With DC breaker open, close AC input breaker.
2. Then close DC breaker.

H. Apply load as specified in Par. 3-C. Load current between power supplies should share within 10% of each other. Should current balance be out more than 10%, adjust pot. P11 slightly on isolator board in power supply with maximum current unbalance to bring current within range.

CAUTION: DO NOT OVERADJUST AS THIS COULD EFFECT THE DC VOLTAGE REGULATION OF POWER SUPPLY.

I. Reduce the DC load current to approximately 15 to 20 percent of rated current per power supply and observe that units load share with 25% of each other. If DC current unbalance is greater than 25%, adjust pot. P12 on isolator board in power supply that has the greatest unbalance. To bring unbalance within 25%, it may be necessary to adjust pot. P12 in other units as well.

J. Recheck load balance at load specified in par. H above.

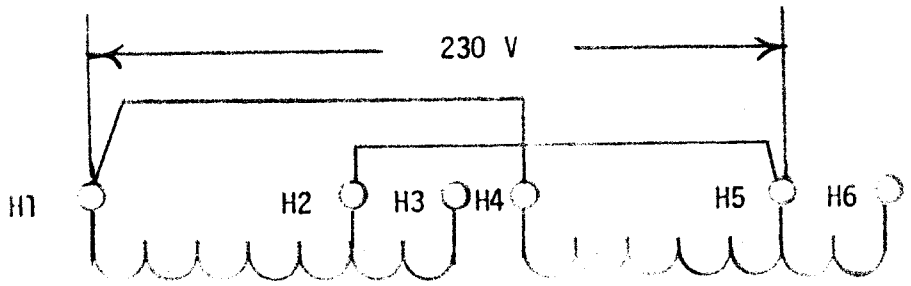
K. Next, take one power supply off the line and check load sharing between any combination of two power supplies. (Units #1 and #2, units #1 and #3 and units #2 and #3). Maximum load should not exceed two times the rated current rating of individual power supplies.

WESTINGHOUSE ELECTRIC CORPORATION

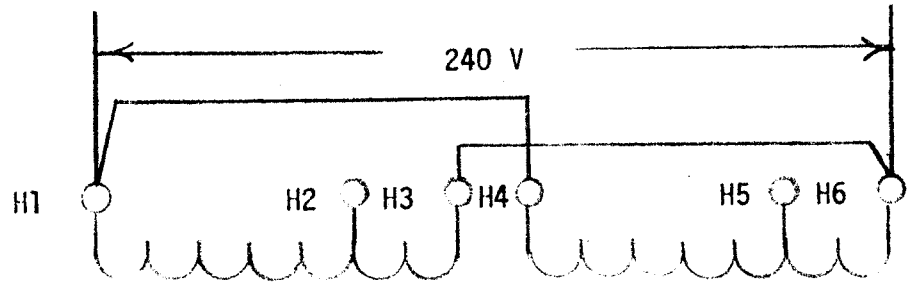
LOAD SHARING MODULE CONTROL TRANSFORMER
PRIMARY AC VOLTAGE TAP CONNECTION

Transformer S# 1596A99G01

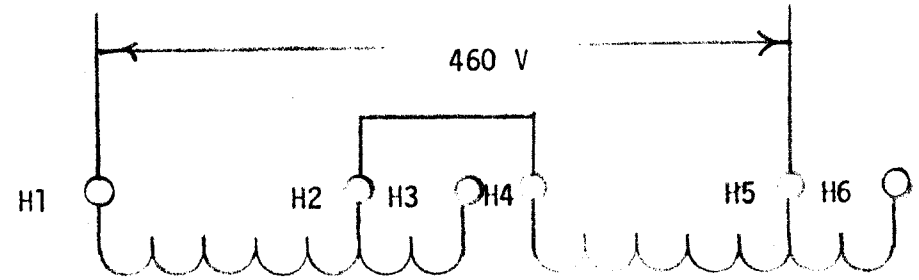
230 Volt Tap Connection



240 Volt Tap Connection



460 Volt Tap Connection



480 Volt Tap Connection

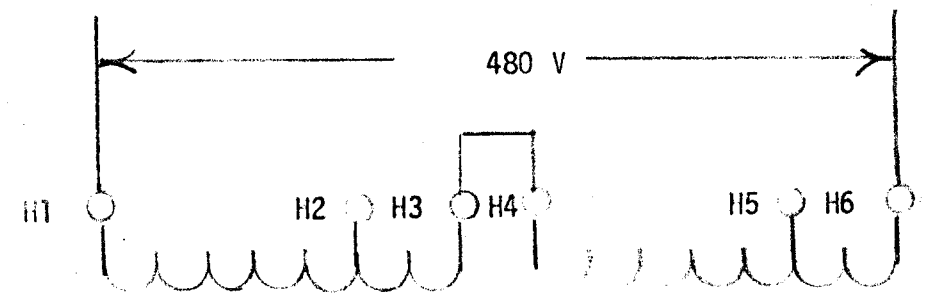


FIGURE #1

WESTINGHOUSE ELECTRIC CORPORATION

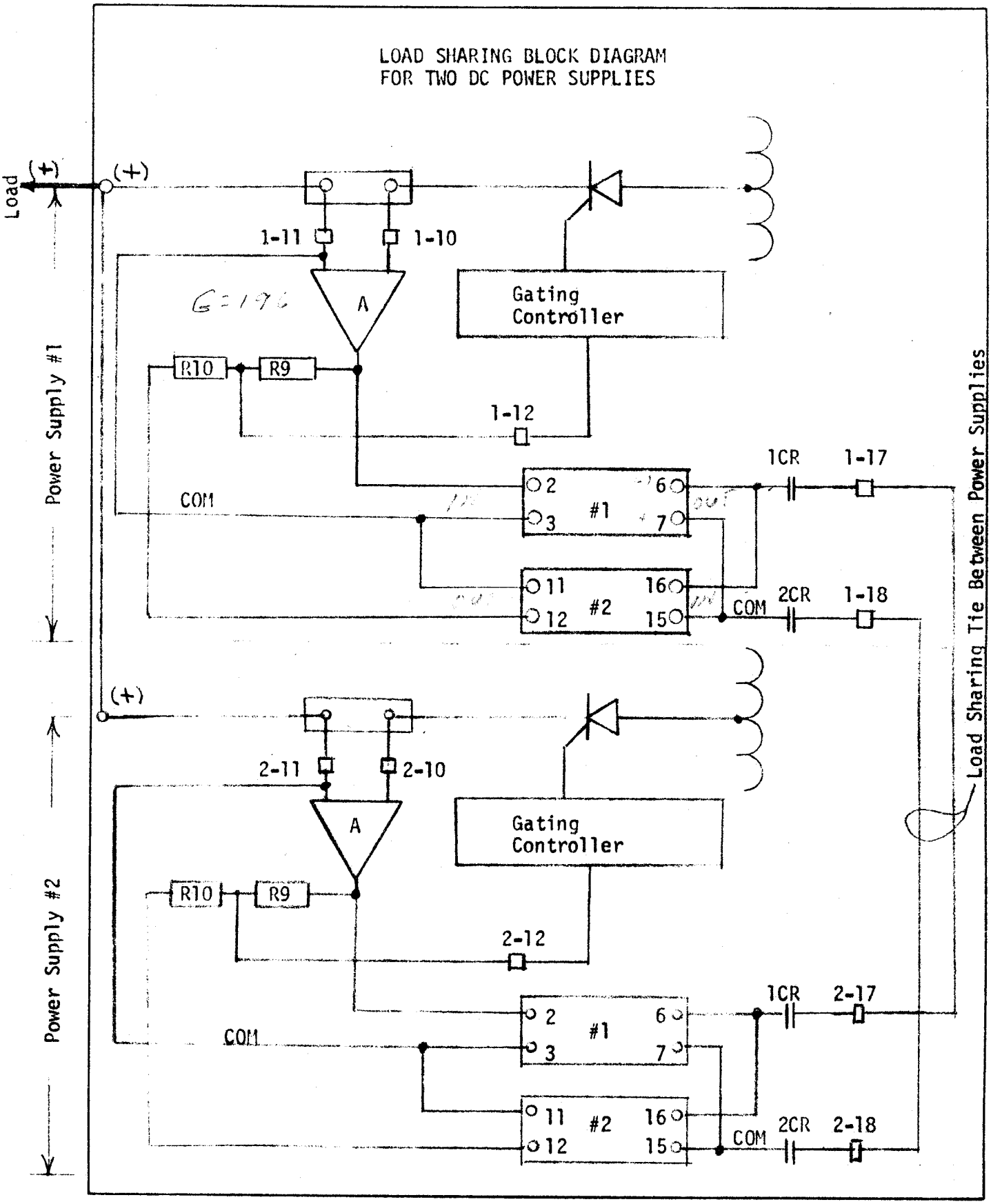
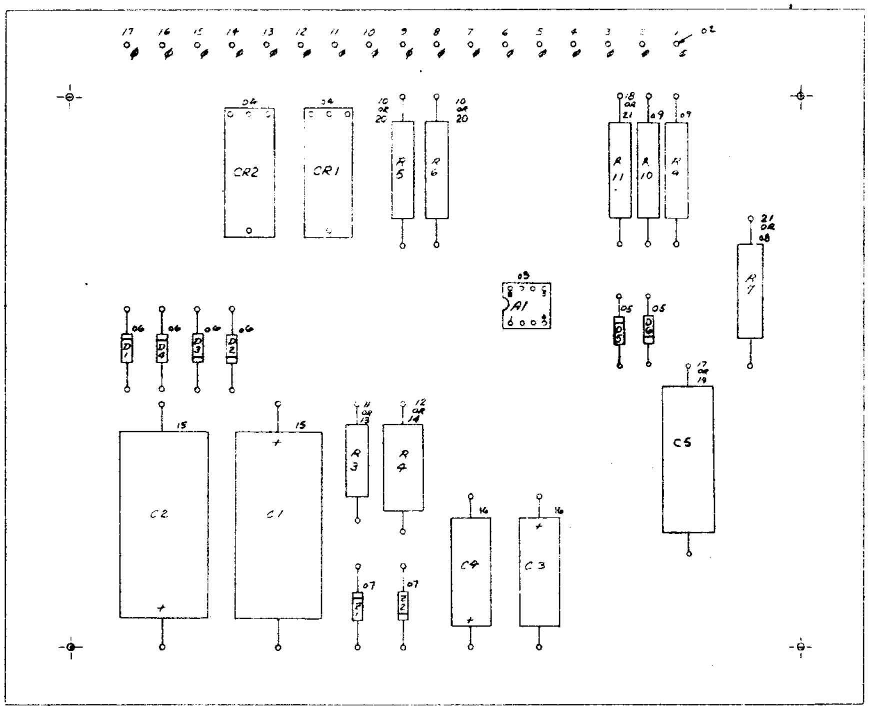


FIGURE #2



TITLE LOAD SHARING P/C BOARD GENERAL ASSY

DWG 2950D17 SUB 1 FINISH CHART

ITEM	DESCRIPTION · MATERIAL DIMENSIONS IN INCHES	PATT NO OR REF DWG	STYLE NO	REQ	TOOL RECORD
01	PRINTED CIRCUIT BOARD		2069A21H01F	1	
02	TERMINALS		2LD9E8H02	7	
03	AMPLIFIER TYPE 741 (MINI-DIP)		1590A41H01	1	A1
04	CONTROL RELAY		1898A9H01	2	CR1, CR2
05	DIODE		406A728H01	2	D5, D6
06	DIODE		1521A17H03	4	D1, D2, D3, D4
07	ZENER		1590A19H20	2	Z1, Z2
08	RES 1MEG ½W 1%		443A259H01	1	R7
09	RES 10K ½W 1%		443A257H01	2	R9, R10
10	RES 5.11K - ½W 1%		443A256H69	2	R5 R6
11	RES 120Ω - 1W 5%		436A135H41	1	R3
12	RES 39Ω - 2W 5%		436A138H29	1	R4
13	RES 100Ω - 1W 5%		436A135H39	1	R3
14	RES 33Ω - 2W 5%		436A138H27	1	R4
15	CAP 500 MFD 50V		455A174H11	2	C1, C2
16	CAP 100 MFD 20V		454A838H09	2	C3 C4
17	CAP 1 MFD 100V		486A738H16	1	C5
18	RES 1K - ½W 1%		443A256H01	1	R11
19	CAP .047 MFD 100V		486A738H06	1	C5
20	RES 1K - ½W 1%		443A256H01	2	R5 R6
21	RES 200K ½W 1%		443A258H30	1	R7
22	TEST SPECIFICATION		1657A76	R	

GRP	DESCRIPTION		ITEMS OF THIS DWG	MULT
01	BOARD COMP	(120Ω)	01 TO 10 - 13 TO 18	1
02	BOARD COMP	(100Ω)	01 TO 12 - 15 TO 18	1
03	BOARD COMP		01 TO 03 - 05 TO 08 - 10 13 TO 16 - 18 - 19	1
04	FAST RESPONSE		01 TO 03 - 05 TO 07 13 TO 16 - 18 TO 21	1

ASSEMBLED BOARD TO BE FLOW SOLDERED PER P.S. BU 293614 & COATED WITH PROTECTIVE VARNISH (P.S. 8334ZYW) AFTER TEST

SCHEMATIC DIAG. 2950D18

STANDARD DRAWING
CHANGED ONLY BY IND. SYS. DIV. PRODUCTS DEV. DEPT.

WESTINGHOUSE ELECTRIC CORPORATION

TITLE LOAD SHARING P/C BOARD GENERAL ASSY

DIMENSIONS IN INCHES — SCALE N.T.S.

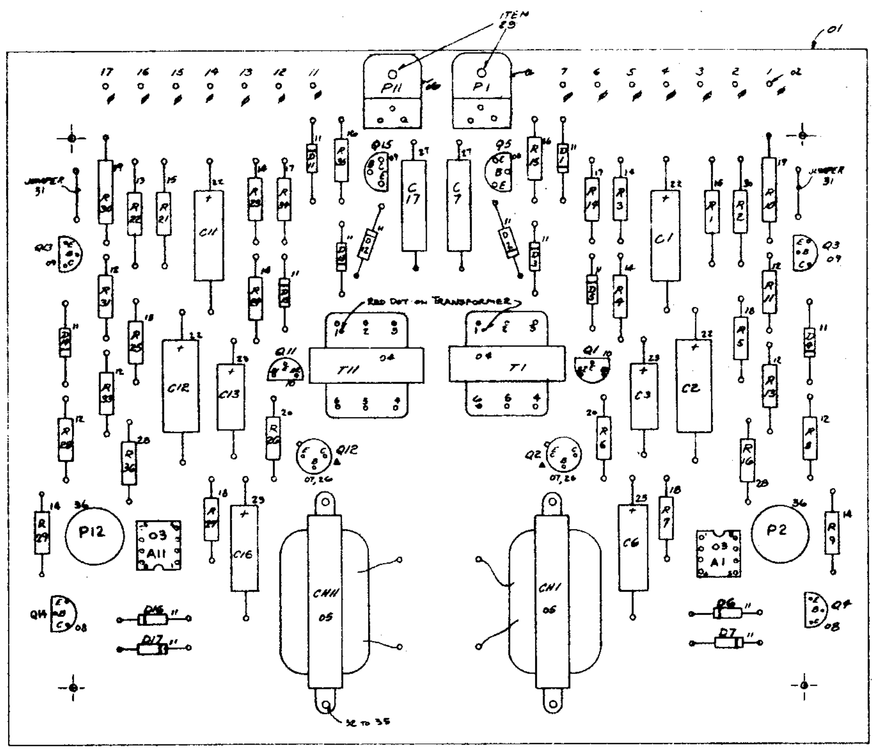
DFTM BUDZYNSKI | APPD

DIV. & PLANT LOCATION I.S.D.

1668A08

2950D17

21



CROMAFLEX FROM DWG 3437D30

TITLE ISOLATOR BOARD GENERAL ASSY

DWG. 2950D20 SUB 1 FINISH CHART

QTY	ITEM	DESCRIPTION · MATERIAL DIMENSIONS IN INCHES	PATT NO. OR REF DWG.	PM. CH. LINE NO.	STYLE NO.	REQ.	TOOL REQD.
	01	PRINTED CIRCUIT BOARD			[illegible]	1	
	02	TERMINALS			[illegible]	16	
	03	AMPLIFIER			[illegible]	2	A1, A11
	04	TRANSFORMER			[illegible]	2	T1, T11
	05	CHOKE 1.2 h			[illegible]	2	CH1, CH11
	06	POT 500 Ω			[illegible]	2	P1, P11
	07	TRANSISTOR			[illegible]	2	Q2, Q12
	08	TRANSISTOR			[illegible]	4	Q4, Q14, Q5
	09	TRANSISTOR			[illegible]	4	Q3, Q15
	10	TRANSISTOR			[illegible]	2	Q1, Q11
	11	DIODES			486A728	16	[illegible]
	12	RES. 10K - ½W 5%			[illegible]	6	[illegible]
	13	RES. 2.15K - ¼W 1%			[illegible]	1	R22
	14	RES. 1K - ½W 5%			[illegible]	6	[illegible]
	15	RES. 68 - ½W 1%			[illegible]	2	R1, R21
	16	RES. 870 - ½W 5%			[illegible]	2	R16, R36
	17	RES. 220 - ½W 5%			[illegible]	2	R10, R30
	18	RES. 100 - ½W 5%			[illegible]	4	R5, R7, R25, R27
	19	RES. 68.1 - ¼W 1%			[illegible]	2	R10, R30
	20	RES. 22 - ½W 5%			[illegible]	2	R6, R26
	21						
	22	CAP. 1.0 MFD 35V			[illegible]	4	C1, C2, C11, C12
	23	CAP. .033 MFD			[illegible]	4	C6, C3, C16, C13
	24						
	25	TEST SPEC 1657A78				REF	
	26	TRANSIPAD			[illegible]	2	
	27	CAP. .068 MFD 00V. 5%			[illegible]	2	C7, C17
	28	RES. 10K ¼W 1%			443A282H01	2	R16, R36
	29	PLASTIC RIVET			[illegible]	2	
	30	RES. 1.0K ½W 1%			443A256H01	1	R2
	31	JUMPER FR. [illegible] .0253 WIRE #[illegible]				1	
	32	.112-40 x .375 Lg. Fil. Hd. Stl. Scr. 70001BV				4	
	33	.112-40 HEX NUT 70200 SV				4	
	34	.112 STL. WASHER 70500 BD				4	
	35	.112 STL. L. WASHER 70510 CV				4	
	36	POT 10K			491A786H04	2	P2, P12

GROUP	DESCRIPTION	ITEMS ON THIS DWG	REQ.
01	BRD. COMP.	01 TO 20 - 22 - 23 - 25 TO 36	1

ASSEMBLED BOARD TO BE FLOW SOLDERED PER PROCESS SPEC BU 293614 & COATED WITH PROTECTIVE VARNISH PS 63342 AFTER TEST

SCHEMATIC DIAG. 2950D8

WESTINGHOUSE ELECTRIC CORPORATION

TITLE ISOLATOR P/C BRD GENERAL ASS'Y

DIMENSIONS IN INCHES - SCALE N.T.S.

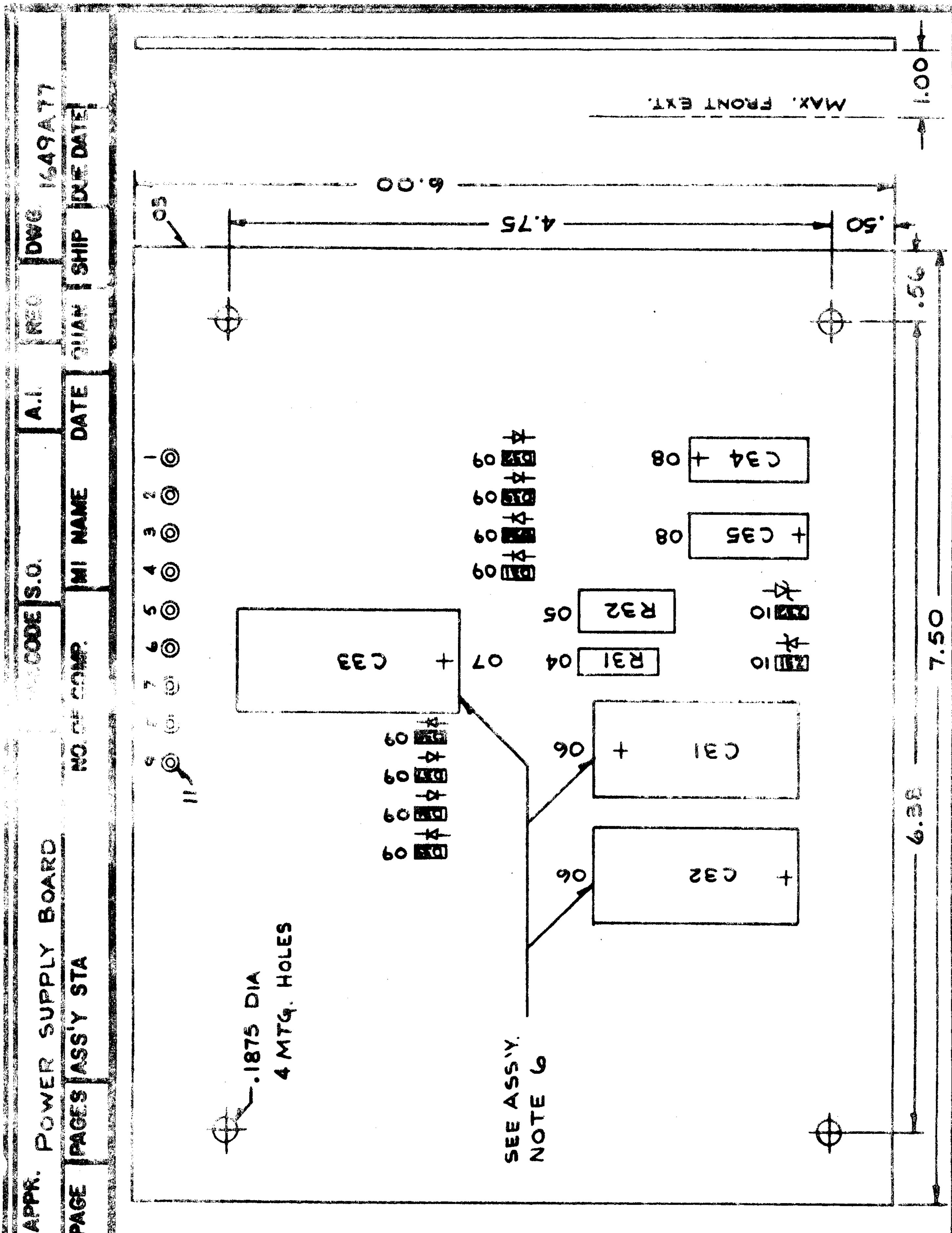
DFTR. D. LOWES

1668A08

DIV. & PLANT LOCATION IND. SYS. DEV.

2950D20

S.O. 6-2145



WESTINGHOUSE - BUFFALO | BU892C | DWG. 1649A77 | SUB 2 | SHT. 2 | SHTS. 5

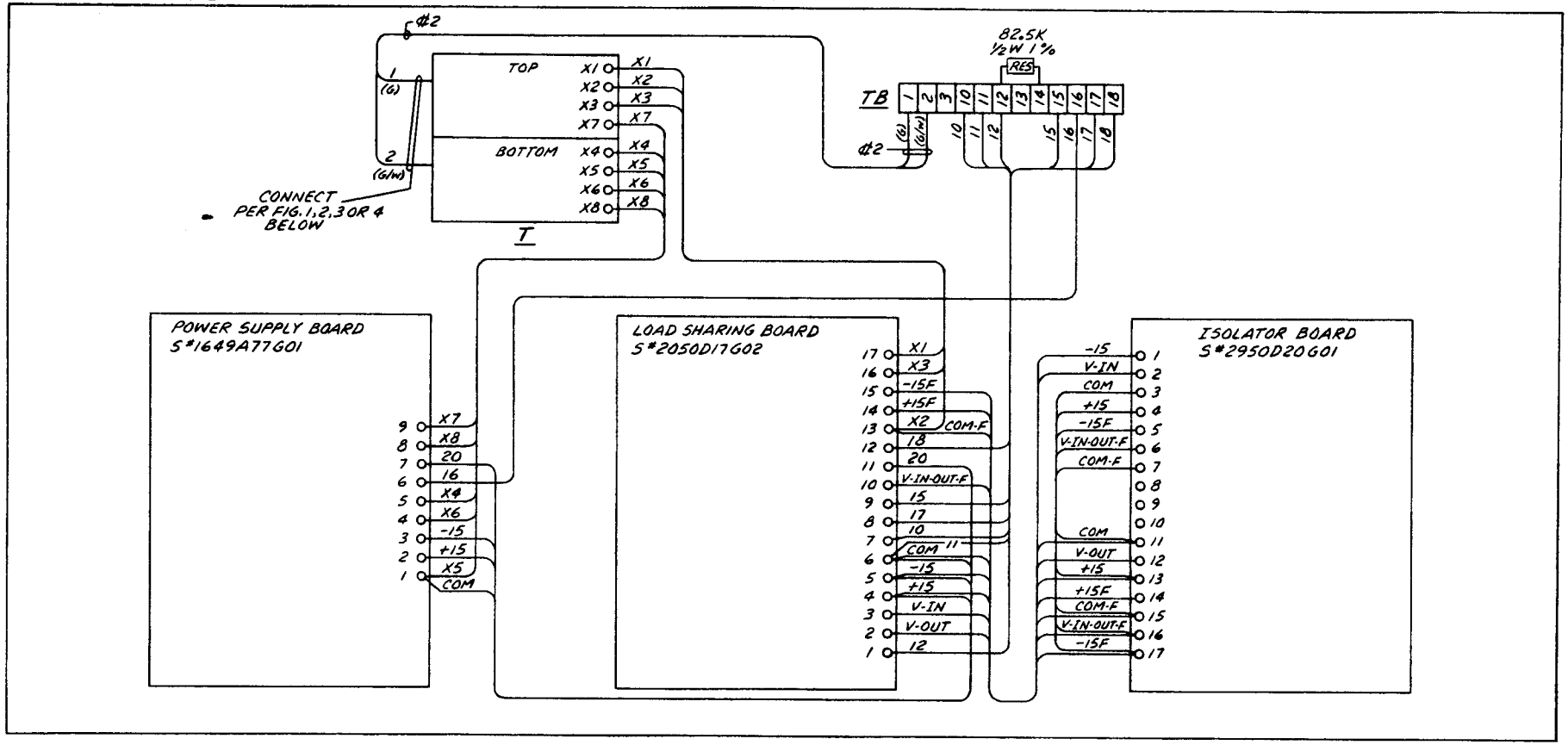
$$G = \frac{FDBK_2}{INPUT_2}$$

$$= \frac{1 \; M\Omega}{5.11 \; K\Omega}$$

$$= 196$$

DWG 3616C41 SUB 1

PANEL - FRONT VIEW



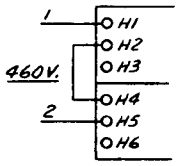


FIG. 1

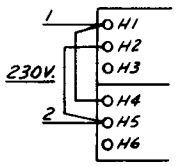


FIG. 2

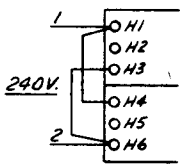


FIG. 3

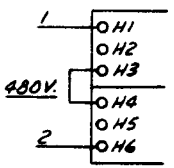


FIG. 4

WIRE LEGEND

#2 = #18, 16-.010 TWO COND. TWISTED 62121 BB GRAY & GRAY/WHITE. (RUN SEPARATE FROM ALL OTHER WIRES)

ALL UNMARKED WIRE TO BE - #20, 10-.010, 6211NJD-WHITE

S.D. 30K1579 1 CHANGE

TOOL DWG. 8/M-1712A44 ENG. REF. DWG. SCHEME 2950D02

WESTINGHOUSE ELECTRIC CORPORATION 01

TITLE LOAD SHARING ASS'Y. WITH SELF CONTAINED POWER SUPPLIES - WIRING DIAGRAM

DIMENSIONS IN INCHES – SCALE N.T.S.

DFTM. K. SCHARF 3-24-78 APPD. APPD. APPD.

3616C41

DIV. & PLANT LOCATION ISD-EPC BUFFALO DIVISIONS, BUFFALO, N.Y., U.S.A.