Accelerator Department
Brookhaven National Laboratory
Associated Universities, Inc.
Upton, L.I., N.Y.

EP&S DIVISION TECHNICAL NOTE

No. 68

F.J. Thornhill
April 2, 1974

USE OF THE MULTI-PURPOSE TRANSFORMER UNITS

The Accelerator Department has recently obtained two (2) self-contained transformer and tap switch assemblies that have been purchased with the intention that they be used as spares for a wide range of our experimental magnet power supplies. They should be especially useful as a "jury-rig" to power supplies with main transformer and/or tap switch damage for which replacements are not readily available, or to power supplies that are so located that excessive technician and rigger time is required to affect a repair or replacement.

The units are intended for indoor use, but are designed so that they may be utilized outdoors in an emergency. If they are to be exposed for an extended period, it is recommended that a simple, unheated, well-ventilated shelter be placed over them.

The larger unit (designated TX-1) is rated at 590 KVA (440 V ac primary tapped to provide secondary voltages of 115, 100, 85, 70, 55, and 40 V ac; 2960 Amp line secondary). The Δ-Δ transformer can provide the power for rectifiers up to 3600 A dc rating.

The other unit (TX-2) is rated at 300 KVA (440 V ac primary tapped to provide secondary voltages of 70, 55, 40, 30, and 20 V ac; 2480 Amp line secondary). The Δ-Δ transformer can provide the power for rectifiers up to 3000 A dc rating.

Table A on page 6 gives a rough comparison of the maximum expected dc output voltages for SCR and Mag-Amp type power supplies if powered through the transformer units. A 440 V ac input and the internal losses at full rated current have been assumed.

It must be remembered that the tap voltages listed on the nameplates of the TX-units are the ac secondary voltages and not the equivalent dc output voltages that power supply tap switches are specified to produce. The maximum power supply dc output voltage will vary greatly between the different type supplies depending primarily upon their internal losses. In general the voltage drop will be greater in a Mag-Amp controlled power supply than in a SCR type.

Table B on pages 7-10 shows the various type power supplies and tap voltages to which each unit is best matched. The table assumes the maximum power supply output current. Additional options are possible at reduced current requirements. If a transformer unit is connected to a larger rated power supply, the ac overloads on the power supply must be set at a lower trip point to protect the transformer and tap switch.

The transformer units (TX-) are intended to be connected from the load side of the power supply main circuit breaker to the TX-primary and from the TX-secondary to the rectifying section ac busbars. Care must be taken to maintain proper phase relation. Opening and connecting to the power supply secondary will be the most difficult job in most of our power supplies. The schematics of the power supply should be checked for any additional circuits that must be maintained on the load side of the circuit breaker. The primary and secondary power connections to the TX-unit are made to tapped bus plates through mechanical cable strain reliefs similar to those in the power supply ac and dc compartments. All primary and secondary phases are labeled.

The transformer units are forced-air cooled with two blowers in TX-1 and one in TX-2. Air filters can be changed externally without shutting down. The blower motors are internally powered and start when the transformer is energized by the power supply circuit breaker. Protection from loss of air flow is provided by a time-delay relay actuated by an air flow vane switch(es). This circuit also allows a closed interlock so the power supply can be turned on without air flow in the transformer unit. Absence of air flow for five (5) seconds at any time after energizing causes the interlock series to open.

Also in the protective interlock circuit are transformer thermal contacts (3), tap switch thermal contact (1), blower motor overload relays (3 or 6), door microswitches (4), Kirk lock microswitch (1), and a local emergency trip button (1). An "Interlocks Open" indicator light has been provided on each unit. If the power supply interlocks indicate open, this light will determine if the problem is within the power supply module or the transformer unit. These control and protective circuits require a 4-wire hookup to the power supply for 115 V ac power and a series connection into the power supply interlock circuit as shown in the schematic on page 4 .

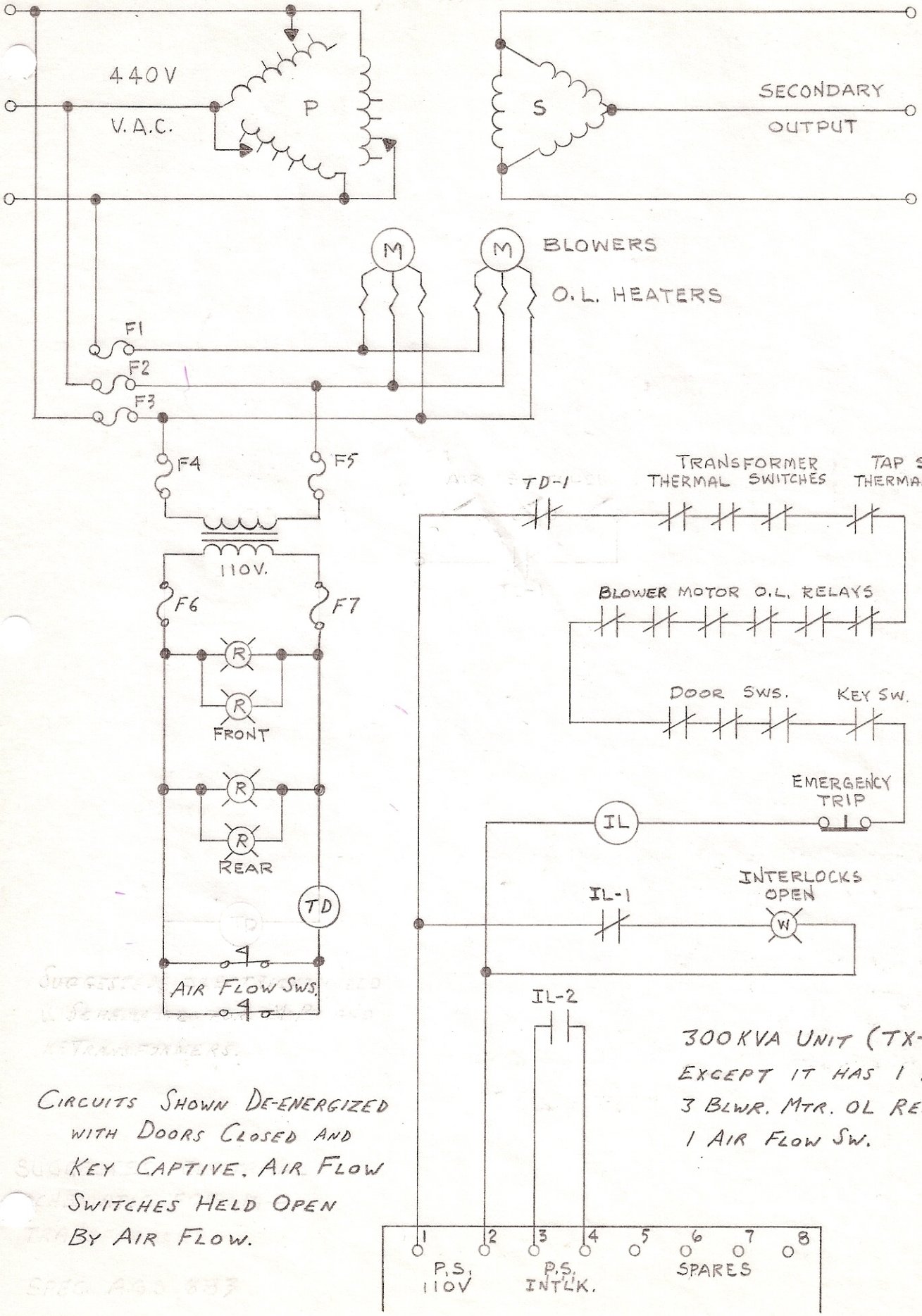
The units also have Kirk mechanical interlocks on the doors to the primary terminals, secondary terminals, and tap switch compartments. Access through these doors can be gained only by a key held captive in a lock in the control compartment. This lock cannot release the key until a backup lock from the power supply "P" lock series is unlocked, which can be done only by a key released when the power supply circuit breaker is locked open. The sketch on page 5 shows this safety lock and key sequence.

The TX-units are designed to be moved by either the lifting eyes or fork-lift. Movement by fork-lift should be done from the rear with the knowledge that the center of gravity is to the left (facing the rear) of center. The rear "Power On" indicator lights should also be protected.

The above described transformer units can be used as repair "by-passes" for 170 of the 200 EAO power supplies as direct replacements. In addition they can be used on the nine 600 KW units at reduced current requirements and used on the ten dual secondary (250 KW, 60 KW) units for half of the rectifying section. The only power supplies to which they cannot be readily adapted are the eleven 45 KW units (P.S.'s 201-211) which are SCR controlled with Y-Δ transformers. A 30° phase shift would have to be built into the SCR firing circuit to use them on these Δ-Δ transformers.

Distribution: Administration Group
AGS Rigging Supervisor
EAO Personnel
EP&S Staff

590 KVA TRANSFORMER UNIT (TX-1)



CIRCUITS SHOWN DE-ENERGIZED WITH DOORS CLOSED AND KEY CAPTIVE. AIR FLOW SWITCHES HELD OPEN BY AIR FLOW.

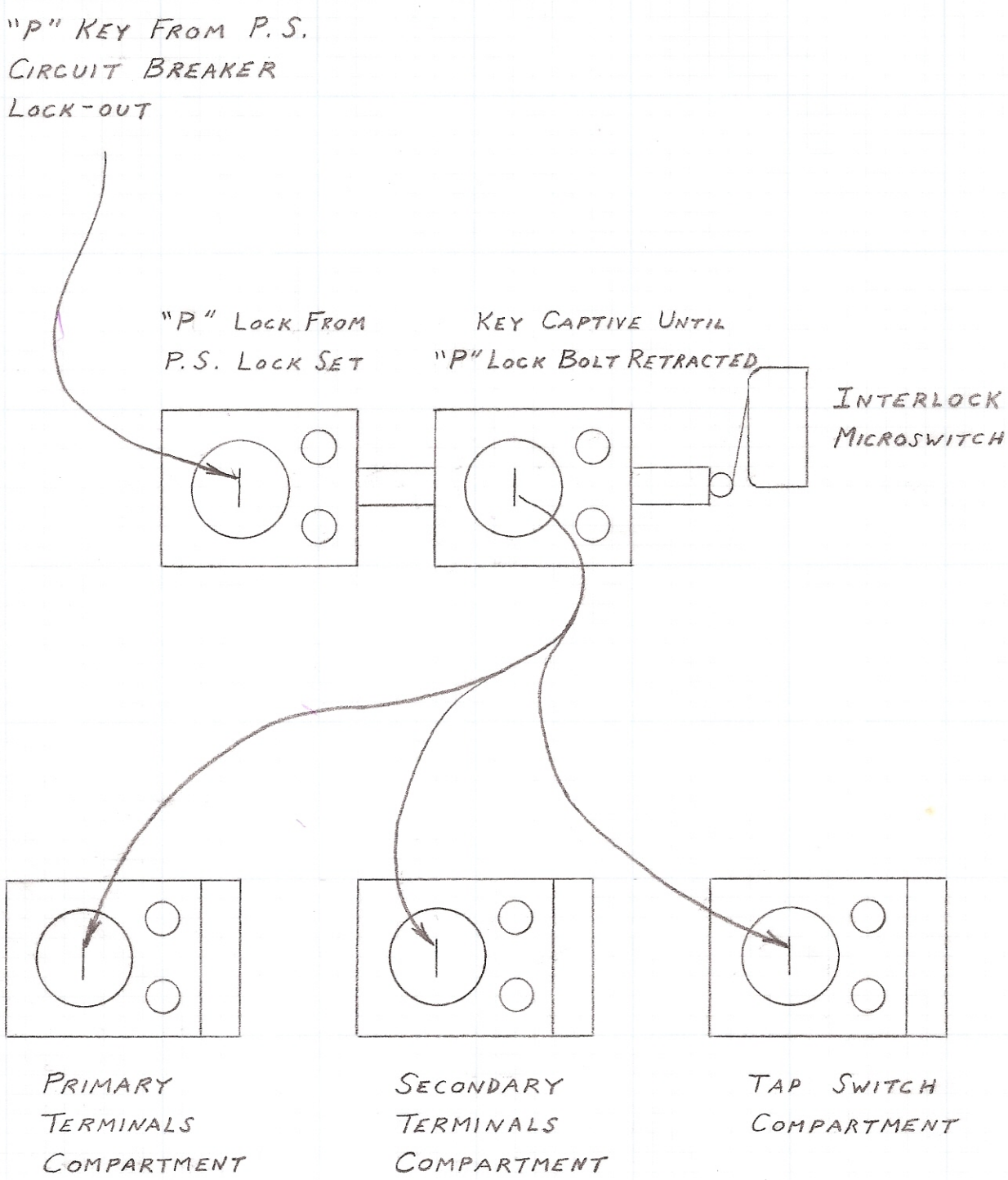
300 KVA UNIT (TX-2) IS SAME EXCEPT IT HAS 1 BLOWER, 3 BLWR. MTR. OL RELAYS, AND 1 AIR FLOW SW.

FJT
4-1-74

BROOKHAVEN NATIONAL LABORATORY

BY FJT DATE 4-1-74 SUBJECT KIRK KEY SEQUENCE FOR MULTI-PURPOSE TRANSFORMERS SHEET No. 5 OF

CHKD. BY DATE DEPT. OR PROJECT JOB No. NOT TO SCALE



SP 11037A

TABLE A

Secondary Voltages with Maximum Power Supply dc Voltage Outputs

	Tap	Secondary V ac	Mag-Amp P.S. V dc	SCR P.S. V dc
TX-1	1	115	125	145
	2	100	108	126
	3	85	92	107
	4	70	76	88
	5	55	60	69
	6	40	43	54
TX-2	1	70	76	88
	2	55	60	69
	3	40	43	54
	4	30	32	38
	5	20	22	25

Assumed: Full rated current load
440 V ac input

TABLE B

RECOMMENDED SUBSTITUTION OF MULTI-PURPOSE TRANSFORMER UNITS FOR VARIOUS POWER SUPPLY REQUIREMENTS

	POWER SUPPLY						TX UNIT			
P.S. CLASS	P.S. SERIES	TYPE CONTROL	MAX.D.C. AMPERES	TAP SW. POSITION	NOM. % Vdc	NOM.MAX. Vdc	M-P TX UNIT	TAP SW. POSITION	SECONDARY Vac	EST.MAX Vdc
600 KW	601-610 (1)	Mag-Amp	4800 (1)	1	100	125	TX-1	1	115	125
				2	85	106		2	100	108
				3	72	90		3	85	92
				4	60	75		4	70	76
	Note (1): P.S.s 601-610 can use TX-1 only if output is limited to 3600 Adc.									
450 KW	401-436	Mag-Amp	3600	1	100	125	TX-1	1	115	125
				2	85	106		2	100	108
				3	72	90		3	85	92
				4	60	75		4	70	76
	437-466	SCR	3600	1	100	125	TX-1	2	100	126
				2	85	106		3	85	107
				3	72	90		4	70	88
				4	60	75		4	70	88
	467-476	SCR	3600	1	100	125	TX-1	2	100	126
				2	75	94		3	85	107
				3	57	71		5	55	69
				4	43	54		6	40	54
				5	32	40	(2)	6	40	54
				6	24	30	(2)	6	40	54
	Note (2): Unit TX-2 can be used for lower voltages if P.S. output is limited to 3000 Adc.									
	477-484	SCR	3600	1	100	125	TX-1	2	100	126
				2	85	106		3	85	107
				3	72	90		4	70	88
				4	60	75		4	70	88

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TABLE B (CONT.)

		POWER SUPPLY						TX UNIT		
P.S. CLASS	P.S. SERIES	TYPE CONTROL	MAX. D.C. AMPERES	TAP SW. POSITION	NOM. % Vdc	NOM. MAX. Vdc	M-P TX UNIT	TAP SW. POSITION	SECONDARY Vac	EST. MAX Vdc
300 KW	301-324	Mag-Amp	2400	1	100	125	TX-1	1	115	125
				2	85	106		2	100	108
				3	72	90		3	85	92
				4	60	75	TX-1,2	4,1	70	76
DUAL 250 KW	251-254 ③	Mag-Amp	2000 Ea. Output ③	1	100	125	TX-1	1	115	125
				2	60	75	TX-1,2	4,1	70	76
250 KW	255-258 ③	Mag-Amp	2000 ③ (1000 Ea. Section)	1	100	125	TX-1	1	115	125
				2	57	71	TX-1,2	4,1	70	76
		Note ③: The TX- Units can be used onnly one section of these P.S.s as they are single primary, dual secondary type.								
				Sec.-Pri.						
175 KW	101-124	Mag-Amp	2333	1 - 1	100	75	TX-2	1	70	76
				1 - 2	90	68		1	70	76
				2 - 1	80	60		2	55	60
				2 - 2	73	55		2	55	60
				3 - 1	66	50		2	55	60
				3 - 2	59	44		3	40	43
				4 - 1	53	40		3	40	43
				4 - 2	48	36		3	40	43
				5 - 1	43	32		4	30	32
				5 - 2	38	29		4	30	32
	125-128	Mag-Amp	2333	1	100	75	TX-2	1	70	76
				2	90	68		1	70	76
				3	80	60		2	55	60
				4	73	55		2	55	60

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TABLE B (CONT.)

	POWER SUPPLY						TX UNIT			
P.S. CLASS	P.S. SERIES	TYPE CONTROL	MAX.D.C. CURRENT	TAP SW. POSITION	NOM. % Vdc	NOM.MAX. Vdc	M-P TX UNIT	TAP SW. POSITION	SECONDARY Vac	EST.MAX Vdc
	125-128 Cont.	Mag-Amp	2333	5	66	50	TX-2	2	55	60
				6	59	44		3	40	43
				7	53	40		3	40	43
				8	48	36		3	40	43
				9	43	32		4	30	32
				10	38	29		4	30	32
120 KW	501-506	Mag-Amp	3000	1	100	40	TX-2	3	40	43
				2	75	30		4	30	32
				3	57	23		5	20	22
				4	43	17		5	20	22
				5	32	13		5	20	22
				6	24	10		5	20	22
	507-511	SCR	3000	1	100	40	TX-2	3	40	54
				2	75	30		4	30	38
				3	57	23		5	20	25
				4	43	17		5	20	25
				5	32	13		5	20	25
				6	24	10		5	20	25
90 KW	901-923	Mag-Amp	1500	1	100	60	TX-2	2	55	60
				2	70	42		3	40	43
				3	50	30		4	30	32
				4	35	21		5	20	22
				5	25	15		5	20	22
				6	17	10		5	20	22
				7	8	5		Not Practical.		

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TABLE B (CONT.)

		POWER SUPPLY					TX UNIT			
P.S. CLASS	P.S. SERIES	TYPE CONTROL	MAX.D.C. CURRENT	TAP SW. POSITION	NOM. % Vdc	NOM.MAX. Vdc	M-P TX UNIT	TAP SW. POSITION	SECONDARY Vac	EST.MAX Vdc
DUAL 60 KW	61-62 (4)	Mag-Amp	1000 Ea. Output (4)	1	100	60	TX-2	2	55	60
				2	70	42		3	40	43
			Note (4): The TX-Units can be used on only one section of these P.S.s as they are single primary, dual secondary type.							
45 KW	201-211	SCR	750	1	100	60	TX-2	2	55	69
				2	70	42		3	40	54
				3	50	30		4	30	38
				4	35	21		5	20	25
				5	25	15		5	20	25
				6	17	10		5	20	25

This table was compiled by using average values of internal losses at 440 VAC input voltage and maximum output current. For a closer estimate of obtainable voltages on various taps for individual power supplies at a specific output current, contact the Power Supply Group.

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