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UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

184-INCH CYCLOTRON DATA

C. W. Park

April 1, 1949

Berkeley, California

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY		JOB NUMBER	FILE NO.	PAGE
	ENGINEERING NOTES				1
SUBJECT		First Operation - Deuterons, 11/1/46	NAME		
184" CYCLOTRON DATA		First Operation - Protons, 12/22/48	DATE		
			4/1/1949		
		Proton	Alpha Particles	Deuterons	
Maximum useful radius	inches	81.5	81.5	81.5	
Maximum particle energy	mev	350	390	195	
Beta of Particles	$\beta: (\frac{v}{c})$	0.69	0.43	0.43	
Acceleration time	usec	1900	2400	2400	
Repetition rate	pps	60	60	60	
Initial Frequency rate (60 pps)	mc/sec	675		1000	
End frequency rate (60 pps)	mc/sec	3600		540	
Energy gain per turn @ 4" radius	kv	1	4	2	
Energy gain per turn @ 81" radius	kv	14	10	5	
Number of revolutions during accel.	miles	37,000	25,000	25,000	
Distance traveled during acceleration	miles	130	75	75	
Average beam current	u amps	0.75	0.1	0.75	
Peak beam current	u amps	120	16	120	
Average energy gain per turn	kev	9	16	8	
Orbit precessional freq. @ 81"	mc	1.3	1.3	1.3	
Range of full energy particles	inches of CU	4.3	0.53	1.06	
Starting freq. at 15,000 gauss	mc	22.9	11.57	11.5	
Mass increase at full energy	% of rest mass	37.4	10.4	10.4	
Acceptance time at 60 pps	usec	100	50	50	
Beam pulse length	usec	100	100	100	

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SUBJECT			NAME		
184" CYCLOTRON DATA Magnet (Dwg. 1214)					
			DATE		
			4/1/49		
			Ref Dwg.	4/1/49	Max or Range
Pole Gap (nominal)	inches			23	
Pole Gap (minimum)	inches			19½	
Pole Diameter	inches			182	
Pole Diameter useful	inches	2L7401 2L7411		163	
Pole Magnetic Field (center)	gauss	2L7381 2L7391		15,000	
Pole Magnetic Field (81")	gauss			14,175	
Iron	tons			4000	
Copper	tons	2505 2515		300	
Copper	ampere-turns	2L2194		1.88 x 10 ⁶	
Copper resistance, 25 deg. C	ohms			.3100	
Copper current	amps			1500	2000
Copper voltage	volts			500	666
Copper crossection	inches			½ x 4"	
Inductance @ 1500 amps	henries			9	
Current rise	graph	2L7421			
Stray field	plot	2Q2695			
Current decay	graph	2L7431			
Cables to MG	mcm			4-500	
Oil type				Wemco C	
Oil	gal			6000	
Oil temperature rise	deg C			30	40
Oil flow rate	gal/min			390	
Resistance magnet, leads, generators	ohms			.333	

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY		JOB NUMBER	FILE NO.	PAGE
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SUBJECT			NAME		
184" CYCLOTRON DATA			Oscillator		
			DATE		
			4/1/49		
			Ref Dwg.	4/1/49	Max or Range
<u>Osc. Plate Rectifier</u>			2L6085		
Primary power 3 phase			kva		300
Primary voltage			volts		240-480
Primary current 480 v			amps		360
Primary voltage range					168-624
Tests 18 kv @ 11.5 a d-c ΔY					
Line 480 v			330 amps		360
Ind. Reg. 620 v			240 amps		287
Plate transf. coil			155 amps		166
System reactance			10%		
Output d-c			kv	2L6981 7	3.5 to 20
Output avg.			amps	see Osc.	13.5
Output capacitor			mfd.	2L7371 40	-
<u>Osc. Positive Bias Rectifier</u>			2L6085		
Primary power 3 phase			kva		1.5
Primary voltage			volts		0-240
Output d-c ΔY			volts	2L5753 175	0-570
Output d-c ΔY			amps		2.6
Output d-c $\Delta \Delta$			volts		0-325
Output d-c $\Delta \Delta$			amps		4.4
<u>Osc. Negative Bias Rectifier</u>			2L6085		
Primary power 1 phase			kva	2L6092	1
Primary voltage					0-240
Output d-c			volts	1000	0-2100
Output d-c			amps		.5

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY		JOB NUMBER	FILE NO.	PAGE
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SUBJECT			NAME		
184" CYCLOTRON DATA			4A6575		
Oscillator - Protons			4A6585		
Dwg. 2L4945			4A6595	DATE 4/1/49	
			<u>Ref. DWG.</u>	<u>4/1/49</u>	<u>Max or Range</u>
Frequency range	mc	2L7351	22.9 to 15.8	23.2 to 14	
Rotary capacitor speed	rpm		600	2000	
Rotary capacitor blades			6		
Rotary capacitor rep. rate	pps		60	10-200	
Rotary capacitor useful range	% of 60 deg.		7.1	13.1	
Pulsed Osc. rep. rate	pps		60	25-200	
Dee R.F.	kv		17		
Osc. Filament R.F.	kv		1.4		
Osc. plate R.F.	kv		8		
Osc. grid bias	volts		500		
Osc. grid leak	ohms		900	500-2000	
Osc. filament voltage	volts		18.5	19.5	
Osc. filament current	amps		403	415	
Osc. 9021 air	cfm		640		
Osc. trans. air	cfm		410		
Osc. input 23 mc - scaled	kw			80	
Osc. input 14 mc - scaled	kw			150	
Osc. plate current avg.	amps		1.2		
Osc. plate current peak	amps		8		

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SUBJECT			NAME	DATE	
184" CYCLOTRON DATA			Oscillator - Deuterons	4A6575	
			Dwg. 2L4945	4A6585	
				4A6595	
			<u>Ref. Dwg.</u>	<u>4/1/49</u>	<u>Max or Range</u>
Frequency range	mc	2L7361	11.5 to 9.8	12.6 to 9.5	
Rotary capacitor speed	rpm		600	2000	
Rotary capacitor blades			6		
Rotary capacitor rep. rate			60	10-200	
Rotary capacitor useful range	% of 60 deg.		8.7	15.0	
Pulsed osc. rep. rate	pps		60	25-200	
Dee R.F.	kv		12		
Osc. filament R.F.	kv		1.7		
Osc. grid bias	volts		870		
Osc. plate R.F.	kv		6.6		
Osc. grid leak	ohms		900-1000	500-2000	
Osc. filament voltage	volts		18.5	19.5	
Osc. filament current	amps		403	415	
Osc. 9C21 air	cfm		640		
Osc. trans. air	cfm		410		
Osc. input 12.6 mc scaled	kw			230	
Osc. input 9.5 mc scaled	kw			175	
Osc. plate current avg.	amps		3		
Osc. plate current peak	amps		12		

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SUBJECT		Field Clearing Bias 2L6515	NAME		
184" CYCLOTRON DATA		Rotary Capacitor Dr. (2L6415 (3H8495)	DATE		
		Ref. Dwg.	4/1/49	Max or Range	
<u>Field Clearing Bias</u>					
Dee Bias Rect. primary power	kva			1	
Dee bias rect primary	volts			0-240	
Output d-c	kv	3Z1893	1.3 to 2.5	0-2.6	
Output d-c	amps		0	.3	
Output series resistor	ohms		25,000		
<u>Rotor bias rect. primary power</u>					
Rotor bias rect. primary	kva			1	
Rotor bias rect. primary	volts			0-240	
Output d-c	kv	3Z1893	1 - 1.5	0-2.6	
Output d-c	amps		0	.3	
Output series resistor	ohms		25,000		
<u>Clearing wire bias rect. primary power</u>					
Clearing wire bias rect. primary	kva			1	
Clearing wire bias rect. primary	volts			0-240	
Output d-c	kv	3Z1893	1-1.5	0-2.6	
Output d-c	amps		0	.3	
Output series resistor	ohms		25,000		
<u>Rotary Capacitor Drive</u>					
D-c motor size	hp			10	
D-c motor speed	rpm			88-1800	
D-c motor field voltage	volts		230	230	
D-c motor field current	amps			1.5	
D-c motor arm voltage (at 600 rpm)	volts		80	350	
D-c motor arm current (at 600 rpm)	amps		7	26	
Thymotrol input 240 v 3 phase (at 600 rpm)	amps		15-10-15		
Motor/Capacitor belting ratio			1:1.14		

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY		JOB NUMBER	FILE NO.	PAGE
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SUBJECT:	Tank Filament	Dwg. 2L1915	NAME		
184" CYCLOTRON DATA	Pulsed Arc	Dwg. 2L1915	DATE		
	Steady Arc	Dwg. 2L1915	4/1/49		
			<u>Ref. Dwg.</u>	<u>4/1/49</u>	<u>Max or Range</u>
<u>Tank Filament</u>					
2 Selenium rectifiers			16222		
Rectifiers d-c output (magnet off)	volts		*2.5		0-6
Rectifiers d-c output (magnet off)	amps		*225 + 180		300 + 300
Filament material				Tungsten	
Filament length	inches			1.0	
Filament diameter	inches			0.125	
			* Measured at Rev. Sw.		
<u>Pulsed Arc</u>					
Arc voltage	volts			200 ±	500
Arc current	amps			5-25	30
Arc pulse length	usec			50-150	2-150
Rectifier primary power	kva	1V6013			6
Rectifier primary 3 phase line	volts				0-240
Rectifier d-c output (pulse trans 12 to 1 stepdown)	kv			0.3 to 3	0-5
" " " average	amps			0 to .015	1.25
<u>Steady Arc</u>					
Selenium rectifier primary power	kva	3Z1793			3
Selenium rectifier primary 3 phase 240	volts				0-240
Selenium rectifier d-c output	volts				0-300
Selenium rectifier d-c output	amps				9

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SUBJECT		Deflector - Dwg. 2L6485, 17225		NAME	
184" CYCLOTRON DATA		Jet Vacuum Pumps, Dwg. 2L1365, 4335		DATE	
		Ref. Dwg. 4/1/49		4/1/49	
<u>Deflector</u>					<u>Max or Range</u>
Rectifier primary power		kva			25
Rectifier primary line 3 phase 240		volts			0-240
Rectifier primary line 3 phase 240		amps			75
Rectifier d-c output ΔY		kv	3Z1574		0-16.5
Rectifier d-c output ΔY		avg. amps		.15	1.5
Rectifier d-c output ΔY		peak amps		6	6
880 Regulator output		kv	2L6974	12	14
880 filament voltage		volts		9.5	12.6
Deflector Rep rate		pps		60	25-200
Deflector tank volts - protons		kv		250 \pm 20%	300 \pm 20%
Deflector tank volts - deuterons		kv		150 \pm 20%	300 \pm 20%
Deflector pulse length		us		.6	
Deflector pulse eff. rise time		us		.1	
<u>Jet Vacuum Pumps</u>					
DP-1 32" oil jet pump		liters/sec		9000	11,000
DP-1 32" oil heater current 240 v		amps		3500	
DP-1 32" oil heater power		kw		8.4	
DP-1 8" oil jet pump		liters/sec		-	-
DP-1 8" oil jet heater current 240 v		amps		9.7	
DP-1 8" oil jet heater power		kw		2.3	
DP-1 total heater power				10.7	
DP-2 32" oil jet pump		liters/sec		9000	11,000
DP-2 32" oil heater current 240 v		amps		32.5	
DP-2 32" oil heater power		kw		7.8	
DP-2 8" oil jet pump		liters/sec		-	-
DP-2 8" oil jet heater current 240 v		amps		9.4	
DP-2 8" oil jet heater power		kw		2.2	
DP-2 total heater power		kw		10	

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY			JOB NUMBER	FILE NO.	PAGE
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SUBJECT				NAME		
184" CYCLOTRON				Water Circuits - Dwg. 4A4774		
				DATE		
				4/1/49		
				Ref Dwg.	4/1/49	Max or Range
Rotor	Ilco	gpm	4A4774	2.1		
Rotor supports	"	"	"	3.5		
Dee tie rods	"	"	"	3.4		
Ground stem stator	"	"	"	5.2		
Ground stem	"	"	"	7.4		
Ground stem tank liner	"	"	"	7.5		
Plate supply	"	"	"	5		
Coupling loops	"	"	"	4.7		
Dee stem tank liner bottom	"	"	"	3.5		
Dee stem tank liner top	"	"	"	2.8		
Dee stem stator	"	"	"	5.75		
Dee stem	"	"	"	5.75		
Dee bottom	"	"	"	6.0		
Dee top	"	"	"	5.5		
Oscillator anode	"	"	"	11.5		
Tank liner top	Calgon	"	2Q1794	6.2		
Tank liner bottom	"	"	"	7.0		
Tank filament	"	"	"	1.3		
Ion source	"	"	"	4.5		
DP-1	"	"	"	0.9		
DP-2	"	"	"	0.7		
Deflector trans.	"	"	"	0.5		
Probe	"	"	"	.95		
380 regulator anode	Ilco	"		10.0		
MP-1	Calgon	"	3K7924	2		
MP-2	"	"	"	0.5		
MP-3	"	"	"	0.5		
MP-4	"	"	"	1.5		
550 kw shunt	Ilco	"		.5		

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY	JOB NUMBER	FILE NO.	PAGE
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SUBJECT	184" CYCLOTRON DATA	Oil and Water - Dwg. 2R7924	NAME	
		Mechanical Vacuum - Dwg. 2L1365	DATE 4/1/49	

Ref. DWG. 4/1/49 Max or Range

<u>Oil and Water Pumps</u>			Blk	Red	Blu	
Illco WP-1 Motor 15 hp, 3 phase, 240 v	amps	2L3804	*32	32	30	40
Illco WP-2 Motor 25 hp, 3 phase, 240 v	amps	"	*34	40	36	65
Calgon WP-3 Motor 15 hp, 3 phase, 240 v	amps	2L3794	*40	42	38	40
Calgon WP-4 Motor 20 hp, 3 phase, 240 v	amps	"	*34	36	34	52
Spray WP-5 Motor 10 hp, 3 phase, 240 v	amps	2L2205	22	24	23	28
Spray WP-6 Motor 10 hp, 3 phase, 240 v	amps	"	24	25	24	28
Oil OP-5 Motor 5 hp, 3 phase, 240 v	amps	"	12.5	13	12.5	13
Oil OP-6 Motor 5 hp, 3 phase, 240 v	amps	"	13	13.5	13	13

*Readings taken with 184" Magnet on

Mechanical Vacuum Pumps

MP-1 Motor 40 hp, 3 phase, 240 v	amps		42	47	43	100
MP-2 Motor 5 hp, 3 phase, 240 v	amps		5.3	7.5	6.6	15
MP-3 Motor 5 hp, 3 phase, 240 v	amps		6	7.3	6.3	15
MP-4 Motor 15 hp, 3 phase, 240 v	amps		22	24	23	40
MP-5 Motor 2 hp, 3 phase, 240 v	amps		3.4	3.3	3.4	6.4
Refrig. Motor 1 hp, 3 phase, 240 v	amps		2.5	2.5	2.3	3.5

DP-1 Refrig. baffle temp. degrees F +25

DP-2 " " " " " +14

MP-1 Pumping speed cfm 750

MP-2 " " " " 105

MP-3 " " " " 105

MP-4 " " " " 350

MP-5 " " " " 43

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY ENGINEERING NOTES	JOB NUMBER	FILE NO.	PAGE 11
SUBJECT: 184" CYCLOTRON DATA Motor Generators		NAME		
350 kw MG, 2L3785 550 kw MG, 2L4185		DATE		4/1/49
		<u>Ref. DWG.</u>	<u>4/1/49</u>	<u>Max or range</u>
<u>350 kw MG</u>				
Motor 550 hp 2450 volts 3 phase	amps	167		
350 kw generator armature	volts	170		
350 kw generator armature	amps	1500		
350 kw generator field	volts	108		
350 kw generator field	amps	5		
6 kw exciter armature	volts	220		
6 kw exciter armature	amps	5		
6 kw exciter field	volts	94		
6 kw exciter field	amps	0.38		
exciter motor 10 hp 240 v 3 phase	amps	25		
<u>550 kw MG</u>				
Motor 825 hp 2450 volts 3 phase	amps	143		
550 kw generator armature	volts	350		
550 kw generator armature	amps	1500		
550 kw generator field	volts	92		
550 kw generator field	amps	3.8		
5 kw exciter armature	volts	200		
5 kw exciter armature	amps	4.0		
5 kw exciter field	volts	105		
5 kw exciter field	amps	0.3		

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SUBJECT			NAME		
184" CYCLOTRON DATA Cloud Chamber - 3S1355 3S1455					
			DATE		
			4/1/49		
		Ref Dwg.	4/1/49	Max or Range	
Estimated total weight	tons		16		
Magnet core	tons	3C7944	8		
Magnet resistance	ohms	2C2155	0.05		
Magnet inductance	henries	"	0.008		
Magnet pole gap	inches	"	6.5		
Magnet pole diameter	inches	"	19.5		
Magnet pole flux	gauss	"	22000	22000	
Magnet coil turns			1200		
Magnet coil conductor	inches	"	1/8x1		
Magnet coil weight	tons	"	4		
Magnet coil current	amps	"	4000		
Heat exchanger water flow	gpm	2C6625	7	30	
Heat exchanger water pressure	lbs/sq. inch	"	60	100	
Heat exchanger water temperature in	degrees C	"	20	20	
Heat exchanger water temperature out	degrees C	"	28	30	
Heat exchanger oil flow	gpm	"	210	210	
Heat exchanger oil pressure	lbs/sq. inch	"	9	10	
Heat exchanger oil temperature in	degrees C	"	38		
Heat exchanger oil temperature out	degrees C		39	40	
Oil Pump 2 hp, 220 v, 3 phase	amps		8		
Water pump 1/4 hp, 115 v, 1 phase	amps		5		
Vacuum pump 3/4 hp, 230 v, 1 phase	amps		7.5		
Refrigerator Compressor, 1 1/2 hp, 220 v, 1 phase	amps		10		

CONT'D NEXT SHEET

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SUBJECT	184" CYCLOTRON DATA - Cloud Chamber 540 kw M.G. - Dwg. 3S1195	NAME		
		DATE	4/1/49	

		Ref. Dwg.	4/1/49	Max or Range
Motor 150 hp, 480 v, 3 phase	amps		183	183
540 kw generator armature, voltage	volts	3S1205 (loaded)	200 (no load)	300
540 kw generator armature, current	amps		4000	4200
540 kw generator armature, field, voltage	volts		250	
540 kw generator field, current	amps		40	
Exciter armature, voltage	volts		250	
Exciter armature, current	amps		24	

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SUBJECT			NAME		
184" CYCLOTRON DATA Beam Focus Magnet #1 20 kw MG - Dwg. 2L6494					
			DATE		
			4/1/49		
<u>Beam Focus Magnet #1</u>			<u>Ref. Dwg.</u>	<u>4/1/49</u>	<u>Max or Range</u>
Estimated total weight	tons			8	
Magnet core	lbs	4C1694		9250	
Magnet resistance	ohms	"		0.48	
Magnet inductance	henries	"			
Magnet pole gap	inches	"		2	
Magnet pole size	inches	4C2055		29x12	
Magnet pole flux	gauss			11,000	
Magnet coil turns		4C1955		672	
Magnet coil conductor	inches	4C1684		1/8 x 1	
Magnet coil weight	lbs			3600	
Magnet coil current	amps			97	155
Magnet coil power	kw			4.5	11.0
Magnet temperature above ambient	deg C			17	
Blower #1 $\frac{1}{2}$ hp 120 volt, 1 phase	amps			6	
Blower #1 air	cfm			484	
Blower #2 $\frac{1}{2}$ hp 120 volt, 1 phase	amps			6	
Blower #2 air	cfm			484	
<u>20 kw MG</u>					
Motor 30 hp 240 volts 3 phase	amps				75
20 kw generator armature voltage	volts			40	120
20 kw generator armature current	amps			97	165
20 kw generator field voltage	volts				120
20 kw generator field current	amps				2

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SUBJECT			NAME		
184" CYCLOTRON DATA			Shielding; Gas Flow (3B6614)		
			Rotary Capacitor (3H5145)		
			Proton Probe (4B7916); Deuteron (15725)		
			DATE		4/1/49
<u>Shielding</u>			Ref. Dwg.	4/1/49	Max or Range
Material			3B2315	concrete	
Wall thickness		feet		10	
roof thickness		feet		4	
<u>Rotary Capacitor</u>					
Nominal gap		inches		1/8	
Actual minimum gap		inches		.09	
No. of rows of teeth				6	
No. of teeth per row				72	
Material of teeth				mild steel	
CU plating thickness on teeth		inches		.004 to .007	
Weight of rotor		tons		1	
Minimum capacity		mmfd		100	
Maximum		mmfd		2760	
<u>Gas Flow</u>					
Rate Hydrogen		approx. liters/hr		.1	
Rate Deuterium		" "		.1	
Rate Helium		" "		.1	
<u>Proton Probe</u>					
Maximum target weight		lbs		4000	
Air lock opening height		inches		18	
Air lock opening width		inches		24	
Target length with airlock extension		inches		42.5	
Target length without airlock extension		inches		16.5	
<u>Deuteron Probe</u>					
Maximum target weight		lbs		100	
Air lock opening diameter		inches		9.5	
Target length with airlock extension		inches		16	
Target length without airlock extension		inches		10	

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SUBJECT	184" CYCLOTRON DATA Dee Tank (Dwg. 4955)	NAME		
		DATE	4/1/49	

		<u>Ref Dwg.</u>	<u>4/1/49</u>	<u>Max or Range</u>
Material			mild steel	
Plate thickness	inches		1 to 1.5	
Volume (including pump intakes, dee stem tank, ground stem tank)	CU feet		1970	
Dimensions	inches		240x240x50	
Operating pressure	microns	211455		.005 --.02
Operating pressure	ua			.05 - .2