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UNIVERSITY OF CALIFORNIA

Radiation Laboratory

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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 ENGINEERING NOTES	JOB NUMBER	FILE NO.	PAGE
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SUBJECT: 184" CYCLOTRON DATA

First Operation - Deuterons, 11/1/46

First Operation - Protons, 12/22/48

NAME:

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

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY ENGINEERING NOTES	JOB NUMBER	FILE NO.	PAGE 2
SUBJECT 184" CYCLOTRON DATA Magnet (Dwg. 1214)		NAME DATE 4/1/49		

		Ref Dwg.	4/1/49	Max or Range
Pole Gap (nominal)	inches		23	
Pole Gap (minimum)	inches		$19\frac{1}{4}$	
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	1.88×10^6	
Copper resistance, 25 deg. C	ohms		.3100	
Copper current	amps		1500	2000
Copper voltage	volts		500	666
Copper crossection	inches		$\frac{1}{4}$ 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 ENGINEERING NOTES	JOB NUMBER	FILE NO.	PAGE 3
SUBJECT: 184" CYCLOTRON DATA Oscillator		NAME		
		DATE 4/1/49		

		Ref Dwg.	4/1/49	Max or Range
Osc. Plate Rectifier		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 △ Y				
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	-
Osc. Positive Bias Rectifier		2L6085		
Primary power 3 phase	kva			1.5
Primary voltage	volts			0-240
Output d-c △ Y	volts	2L5753	175	0-570
Output d-c △ Y	amps			2.6
Output d-c △ △	volts			0-325
Output d-c △ △	amps			4.4
Osc. Negative Bias Rectifier		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 ENGINEERING NOTES	JOB NUMBER	FILE NO.	PAGE 4
SUBJECT 184" CYCLOTRON DATA Oscillator - Protons Dwg. 2L4945	4A6575 4A6585 4A6595	NAME DATE 4/1/49		

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

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY ENGINEERING NOTES	JOB NUMBER	FILE NO.	PAGE
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SUBJECT: 184" CYCLOTRON DATA Oscillator - Deuterons Dwg. 2L4945 4A6575 4A6585 4A6595

NAME:

DATE: 4/1/49

		Ref.Dwg.	4/1/49	Max or Range
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-[illegible]	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	

PAGE	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY ENGINEERING NOTES	JOB NUMBER	FILE NO.	PAGE 6
SUBJECT 184" CYCLOTRON DATA	Field Clearing Bias 2L6515 Rotary Capacitor Dr. (2L6115 (3H8495	NAME DATE 4/1/49		

Field Clearing Bias		Ref. Dwg.	4/1/49	Max or Range
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	
Rotor bias rect. primary power	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	
Clearing wire bias rect. primary power	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	
Rotary Capacitor Drive				
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	

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SUBJECT			NAME
184" CYCLOTRON DATA	Tank Filament	Dwg. 2L1915	
	Pulsed Arc	Dwg. 2L1915	DATE 4/1/49
	Steady Arc	Dwg. 2L1915	

		Ref. Dwg.	4/1/49	Max or Range
Tank Filament				
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.		
Pulsed Arc				
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
Steady Arc				
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 184" CYCLOTRON DATA	Deflector - Dwg. 2L6485, 17225 Jet Vacuum Pumps, Dwg. 2L1365, 4335	NAME DATE 4/1/49		

		Ref. Dwg.	4/1/49	Max or Range
Deflector				
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 △ Y	kv	3Z1574		0-16.5
Rectifier d-c output △ Y	avg. amps		.15	1.5
Rectifier d-c output △ Y	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 ± 20%	300 ± 20%
Deflector tank volts - deuterons	kv		150 ± 20%	300 ± 20%
Deflector pulse length	us		.6	
Deflector pulse eff. rise time	us		.1	
Jet Vacuum Pumps				
DP-1 32" oil jet pump	liters/sec		9000	11,000
DP-1 32" oil heater current 240 v	amps		35	
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	

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SUBJECT: 184" CYCLOTRON — Water Circuits - Dwg. 4A4774

NAME:

DATE: 4/1/49

			Ref Dwg.	4/1/49	Max or Range
Rotor	Illco	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	Illco	"		10.0	
MP-1	Calgon	"	3K7924	2	
MP-2	"	"	"	0.5	
MP-3	"	"	"	0.5	
MP-4	"	"	"	1.5	
550 kw shunt	Illco	"		.5	

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SUBJECT: 184" CYCLOTRON DATA	Oil and Water - Dwg. 2R7924 Mechanical Vacuum - Dwg. 2L1365	NAME		
		DATE 4/1/49		

		Ref.Dwg.	4/1/49 Blk	Red	Blu	Max or Range
Oil and Water Pumps						
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

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SUBJECT: 184" CYCLOTRON DATA Motor Generators 350 kw MG, 2L3785 550 kw MG, 2L4185

NAME

DATE 4/1/49

	Ref. Dwg.	4/1/49	Max or range
350 kw MG			
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	
550 kw MG			
Motor 825 hp 2450 volts 3 phase	amps	143	
550 kw generator armature	volts	350	
550 kw generature 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 184" CYCLOTRON DATA Cloud Chamber - 3S1355 3S1455		NAME 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, 1½ 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	voltage		250	
540 kw generator field, current	amps		40	
Exciter armature, voltage	volts		250	
Exciter armature, current	amps		24	

SUBJECT: 184" CYCLOTRON DATA Beam Focus Magnet #1
20 kw MG - Dwg. 2L6494

NAME:
DATE: 4/1/49

Beam Focus Magnet #1		Ref. Dwg.	4/1/49	Max or Range
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 ½ hp 120 volt, 1 phase	amps		6	
Blower #1 air	cfm		484	
Blower #2 ½ hp 120 volt, 1 phase	amps		6	
Blower #2 air	cfm		484	

20 kw MG			
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 184" CYCLOTRON DATA	Shielding; Gas Flow (3B6614) Rotary Capacitor (3H5145) Proton Probe (4B7916); Deuteron (15725)	NAME DATE 4/1/49		

		Ref. Dwg.	4/1/49	Max or Range
Shielding				
Material		3B2315	concrete	
Wall thickness	feet		10	
roof thickness	feet		4	
Rotary Capacitor				
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	
Gas Flow				
Rate Hydrogen	approx. liters/hr		.1	
Rate Deuterium	" "		.1	
Rate Helium	" "		.1	
Proton Probe				
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	
Deuteron Probe				
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

		Ref Dwg.	4/1/49	Max or Range
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	2L1455		.005 - .02
Operating pressure	ua			.05 - .2