Title
PEP TRANSPORT BEND MAGNET 22B3000 (B11)

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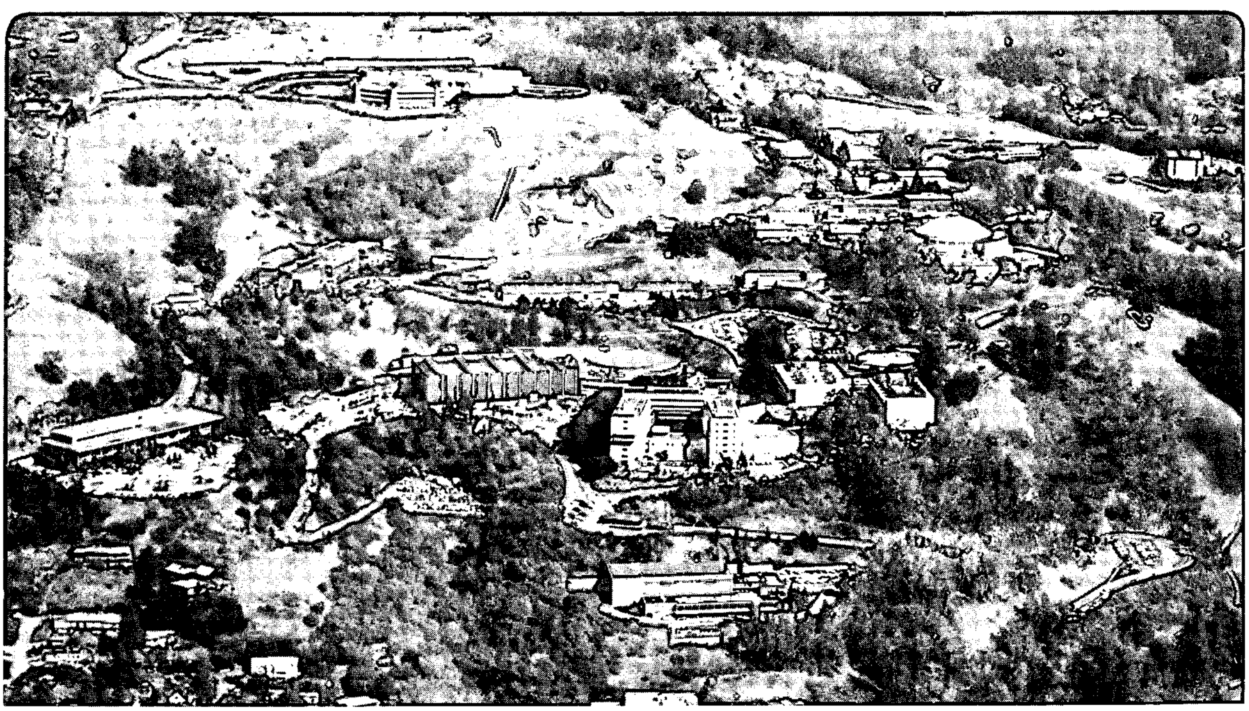

LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA ENGINEERING NOTE		CODE PE0103	SERIAL M5197 B	PAGE 1 of 9
AUTHOR M. Kaviany/A. Lake	DEPARTMENT M.E.	LOCATION Berkeley	DATE July 17, 1978	
PROGRAM — PROJECT — JOB PEP				
INJECTION				
TITLE PEP TRANSPORT BEND MAGNET 22B3000 (B11)				

A AM 9 AUG 78
B R. Reimers Oct. 25, 1979 R.R.

1. Magnet Function

Short, intense pulses of 4 to 18-GeV electrons and positrons from the SLAC linac will be transported to the PEP ring via two almost identical beam transport systems and injected into the ring by pulsed kicker magnets.

B The 22B3000 or B11 magnet is a d.c. iron-septum, dipole magnet which terminates each of the beam-transport lines. Its main function is to bend the injected beam in the vertical plane by .0418 radian. In order to minimize the magnetic disturbance to the nearby beam already stored in the PEP ring, one pole of the magnet has a notched, "septum" section.

2. Aperture and Good-Field Region

The beam aperture required in the main gap of the magnet for the injected beam is ± 8.5 mm in the horizontal direction (the magnetic field direction) and ± 13.5 mm in the vertical direction. See page 9. These dimensions cover emittance, sagitta, and possible dispersion requirements. Over this region the magnetic field is to be constant within ± 0.5 percent.

In the notched section of the magnet the PEP beam stay-clear dimensions are ± 40 mm horizontally and ± 20 mm vertically, the center being about 50 mm from the septum pole face in the horizontal direction. See page 9. In the stored-beam region $20 < x < 55$ (horizontal) from the pole face and $y \leq \pm 5$ mm (vertical), the dipole component of the stray field is required to be less than 2.5 gauss and the skew quadrupole component less than 2.5 gauss/cm.

3. Personnel Involved in the Design.

K. Brown (SLAC), J. Peterson, K. Halbach, M. Kaviany, A. Lake, R. Reimers.

4. Magnet Design Values.

The design values are shown in Appendix A.

5. Drawings.

The design is shown on the following PEP Dwg's:

Overall Ass'y, NIT	SA-204-225-01
Overall Ass'y, SIT	SA-204-225-02

6. Schedule.

B Procurement began April 1978.
Drawings and Specifications were completed in August, 1978.
Fabrication and testing will be finished in early 1979.
Installed Sep. 79. Field test, first positron beam 10-27-79.

7. Cost.

Projected direct costs against PEP funds will be as follows:
(without escalation)

COMPUTER DESIGN	$ 1,800	
MECHANICAL DESIGN	10,000	ED&I
CONSTRUCTION	46,488*	ED&I
TESTING AND MEASUREMENTS	700	B&H
2 Magnets Total	$ 58,988 = $3.69/Lb.	

8. Testing and Measurements.

A future note will describe the results of the LBL testing and measurements.

9. Operating Design Philosophy.

Initially the magnets will be operated up to the 15 GeV level only. If 20 GeV is desired in the future, power supplies and cables will be adequate.

* Construction Cost Breakdown

	Unit	Unit Cost	Qty	Matl Cost	Labor Cost	Total Cost	PO/JO	Date
Steel, annealed	lb	.344	3764	1296	263	1559	5000702	7-26-78
Conductor	lb	?	?	2670	?	≃ 2670(b)	2936802	7-1-77
Steel	lb	.34	13,800	.4654	---	4654	4017602	1-20-78
Anneal	-	-	---	--	1330	1330	4896902	6-27-78
Straighten	--	--	---	--	1300	1300	5011202	7-18-78
Core Fab	--	--	---	--	17,350	17,350	5772802	1-25-79
Coil Fab	--	--	---	--	9,960	9,960(a)	5122802	10-20-78
Spacers	--	--	---	--	135	135	6000102	1-29-79
Assy	--	--	---	--	4,000	~ 4,000	036868	5-1-79
Connectors	--	--	---	30	--	30	49956A2	6-29-78
End plates	--	--	---	--	--	~ 3,500	036196	12-21-78
TOTAL						$ 46,488		

(a) Includes $4,904 for tooling.

(b) 50% of P.O. cost, pro rata, rest used on B2 or stored.

$ per lb. = 46,488/16,000 = $2.91 per lb.

APPENDIX A- BEND MAGNET 22B3000 (B11)

	SYMBOL	VALUE 15 GeV	VALUE 20 GeV	UNITS	FOOT NOTES
1. MAGNETIC VALUES					
A. Beam Energy	E	15	20	GeV	
B. Size of Good Field Required, includes sagitta		27 vertical	x 17 horiz.	mm	
C. Effective Length	l_{eff}	3022	3022	mm	
D. Bend Angle	θ	.0418	.0418	radians	
E. Beam Stiffness	$B\rho$	500.4	667	kGauss-m	
F. Gap Field	B_g	6.921	9.229	kGauss	(1)
G. Ampere Turns, total (Measured)	NI	12,312	16,560	Ampere Turns	(3)
H. Yoke Field	B_y	7.5 (0.75)	10.0 (1.0)	kGauss (Teslas)	(2)
J. Magnet Efficiency (measured)	η	0.988	0.979	—	
K. Field Quality 14 mm From Center	$\Delta B/B$	0.005	0.005	—	
2. CORE VALUES					
A. Gap, measured	g	(.869/.872" actual NIT= 22.1..		mm	
B. Core Length	l_{core}	3000		mm	
C. Core Width, overall		475		mm	
D. Core Height, overall		334		mm	
E. Core Material		C1010 to C1020 Annealed			
F. Core Weight	W_{core}	2960		kg	
G. Total Magnet Weight		3120		kg (Core + Coils)	

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APPENDIX A - BEND MAGNET 22B3000 (B11)

	SYMBOL	VALUE 15 GeV	VALUE 20 GeV	UNITS	FOOT NOTES
3. COIL MECH VALUES					
A. Turns per Coil	N_{coil}	8		Turns	(3)
B. Conductor Material		Alum. Alloy 1060 F			
C. Conductor Dimension, Overall		16.6 x 25		mm	
D. Conductor I.D.		7.0		mm	
E. Conductor net Area	A	374.6		mm^2	
F. Conductor Length/Coil		52.83		Meters	(11)
G. Conductor Weight/Coil		53.36		kg	(10)
H. Conductor Length/magnet		158.5		Meters	
I. Conductor Weight/magnet		160.		kg	
J. Coil Packing Factor		0.72			(12)
K. Coil Electrical Arrangmt.		Series Connected			
L. Coils/magnet		3			
M. Conductor Dwg.		PF-204-222-01			
N. Conductor Specification		LBL#M505 as Revised			
4. COIL ELECTRICAL VALUES					
A. Current Mode		DC			
B. Current/Magnet	I	513	690	Amps. DC	
C. Current Density	I/A	1.37	1.84	$Amps/mm^2$	(9)
D. Resistance/Coil @ 45° C	R_c	0.004305		OHMS	(6)
E. Resistance/Magnet @ 45° C	R	0.01292		OHMS	
F. Voltage Drop/Coil	ΔV	2.21	2.97	VOLTS	(7)
G. Voltage Drop/Magnet	ΔV	6.63	8.91	VOLTS	
H. Power/Coil	P_c	1.13	2.05	kWatts	(8)
I. Power/Magnet	P_m	3.40	6.15	kWatts	

APPENDIX A - BEND MAGNET 22B3000 (B11)

	SYMBOL	VALUE 15 GeV	VALUE 20 GeV	UNITS	FOOT NOTES
5. COOLING (B) (See Table 1)					
A. Medium		Low Cond. Water			
B. Arrangement		1 Circuit/Coil			
C. Press Drop required	ΔP	27	27	psig	(4)
D. Max. Flow/Coil	F_c	.67	.67	GPM	(5)
E. Max. Flow/Magnet	F_T	2.0	2.0	GPM	
F. Temp. Rise Across Coil	ΔT	6.4	11.7	Deg. "C"	

FOOTNOTES TO APPENDIX A

1.) $B = \theta\, B\rho / l_{eff} = \dfrac{0.0418 \times 667.2}{3.022} = 9.229$

2.) 1 Tesla = 10 kGauss

3.) $NI = 79.5 \times B_g \text{ (kGauss)} \times \text{Gap (mm)}/\eta$

$NI = 79.5 \times 9.229 \times 22.1/.979 = 16{,}560$ Ampere Turns.

N = 24; I = 690 (measured)

4.) —

5.) —

6.) $R = \dfrac{\rho L}{A} = \dfrac{30.53 \times 10^{-6}\,\text{OHM-mm} \times 52{,}830\ \text{mm}}{374.65\ \text{mm}^2} = 0.004305$ OHM

7.) $\Delta V = IR = 690 \times 0.004305 = 2.97$ Volts (per coil)

8.) Power/Coil $= \Delta V \times I \times 10^{-3} = 2.97 \times 690 \times 10^{-3} = 2.05$ kW

9.) Current Density = I/A = J

$513/374.6 = 1.37$ Amperes/mm^2 @ 15 GeV

FOOTNOTES TO APPENDIX A (CONT.)

10.) Conductor Weight/Coil.

52.83 m x 1.01 kg/m = 53.36 kg

11.) Conductor Length/Coil

Length of Average Conductor

Straight Pieces: 2 x 2944	=	5888 mm	
Curves Pieces: π x 2 x 88	=	554	
End Pieces: 2 x 81	=	162	
		6604 mm	
Length/Coil: 6.604 (8)	=		52.83 m

12.) Coil Packing Factor

$$\frac{\text{Conductor Area: } 2997}{\text{Coil Cross-section: } 4166} = 0.72$$

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TABLE I - COOLING CALCULATIONS

A.	Beam Energy	E	15	18	20	GeV
B.	Heat removal rate/coil	P	1.13		1.98	kW
C.	Pressure drop avail/coil	p	70	70	150	psig
D.	Length of coolant circuit	L	173	173	173	feet
E.	Min. coolant ckt. I.D.	d	.264	.264	.264	inches
F.	Specific press. drop	k	15.6	15.6	15.6	psig/100 ft.
G.	Specific press. drop	k	36	36	36	ft/100 ft.
H.	Press. drop/coil actual	Δp	27	27	27	psig
I.	Flow/ckt = flow/coil	q	.67	.67	.67	gpm
J.	Flow/magnet	2q	2	2	2	gpm
K.	Coil temp. rise = $\frac{3.8P}{q}$	T	6.4		11.7	deg. C
L.	Water input temp.	T_{in}	35	35	35	deg. C
M.	Water output temp.	T_{out}	41.4		46.7	deg. C

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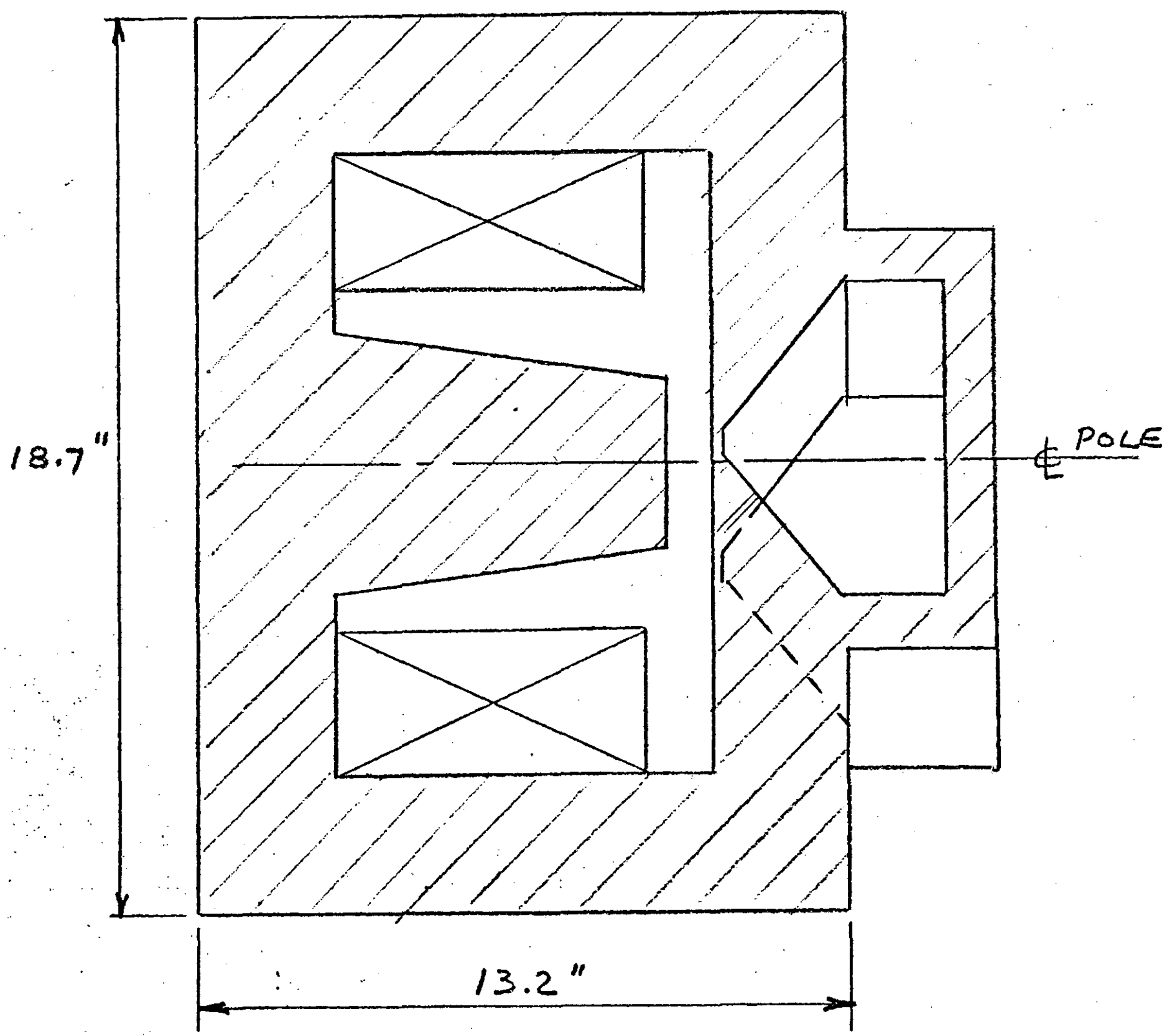

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ENGINEERING NOTE

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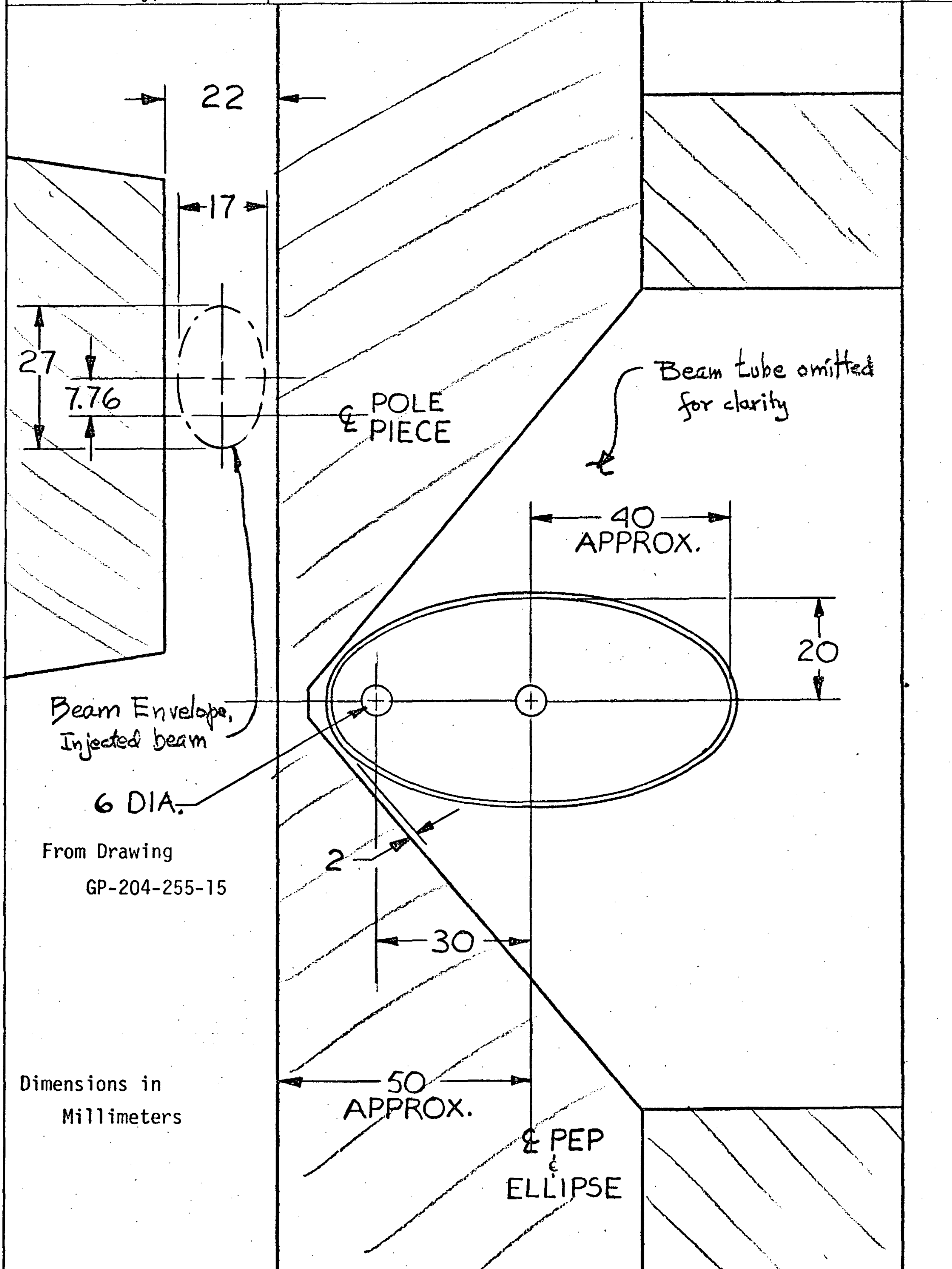
M. Kaviany/A. Lake	M.E.	Berkeley	July 17, 1978



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