UPC No. 96

Fermilab

TM-874
1700.000

The Great Doubler Shift

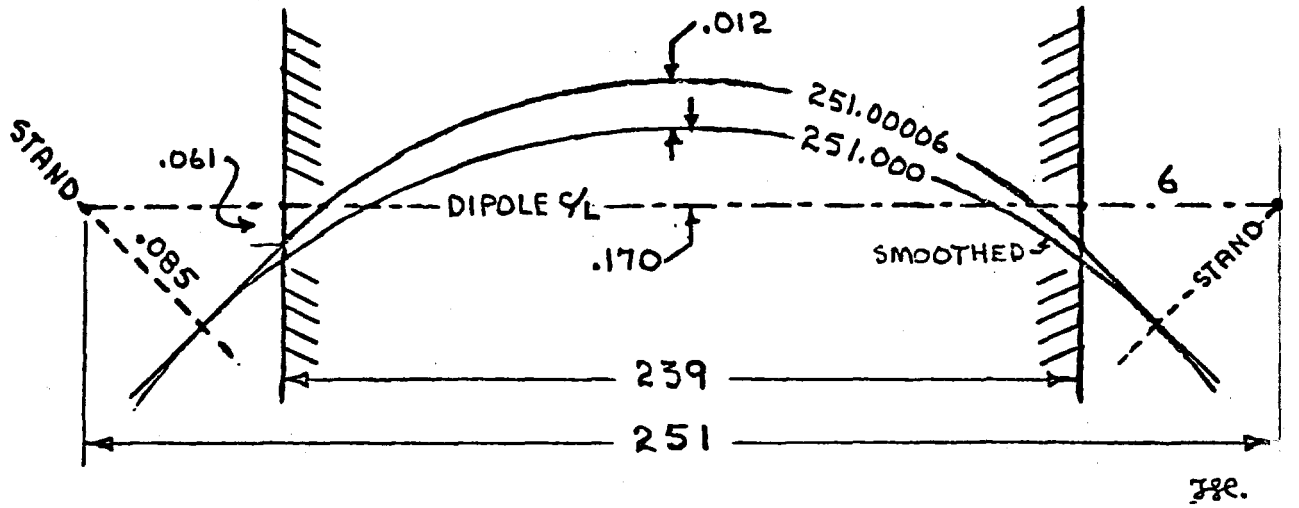
T. L. Collins

April, 1979.

It is desired to shift the Doubler with respect to the Main Ring longitudinally by at least 13½ inches. I have found a system of rotations about 12 separate group centers which accomplishes this shift so that every regular cell of the doubler has the same relation to the main ring. Special larger shifts are needed at medium and long straight sections to close the orbit. In addition I have included a slight increase in the doubler radius to facilitate P-P collisions at 150 on 1000 Gev/c.

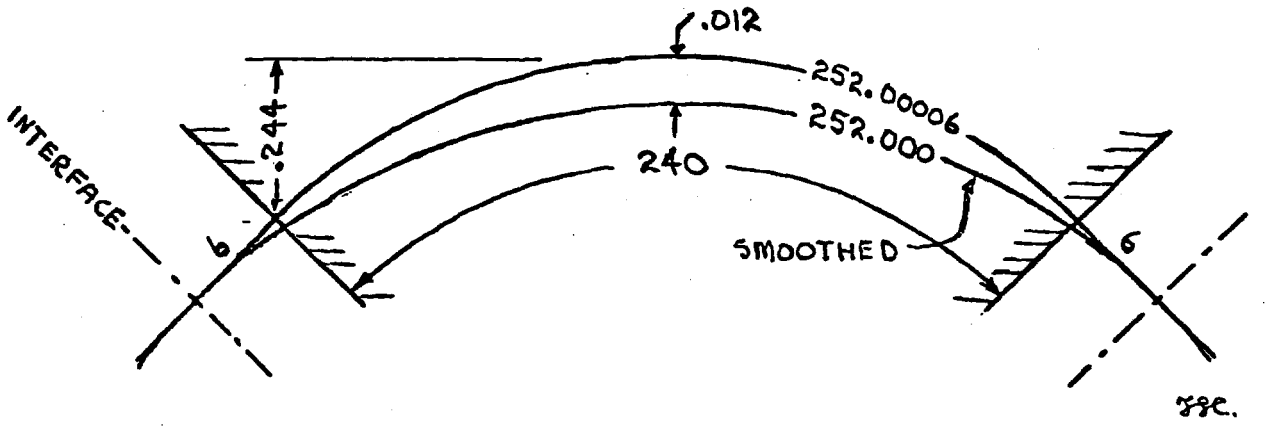
ASSUMED MAGNET GEOMETRIES.

MAIN RING: 251 INCH STRAIGHT "SLOT".



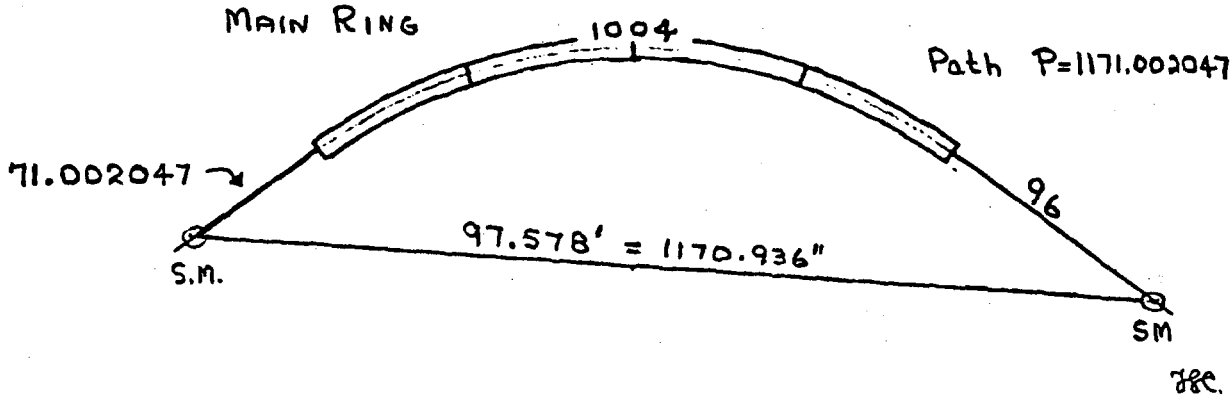
(ANGLES ARE GROSSLY EXAGERATED)

DOUBLER: CURVED MAGNETS WITH STRAIGHT CONNECTIONS

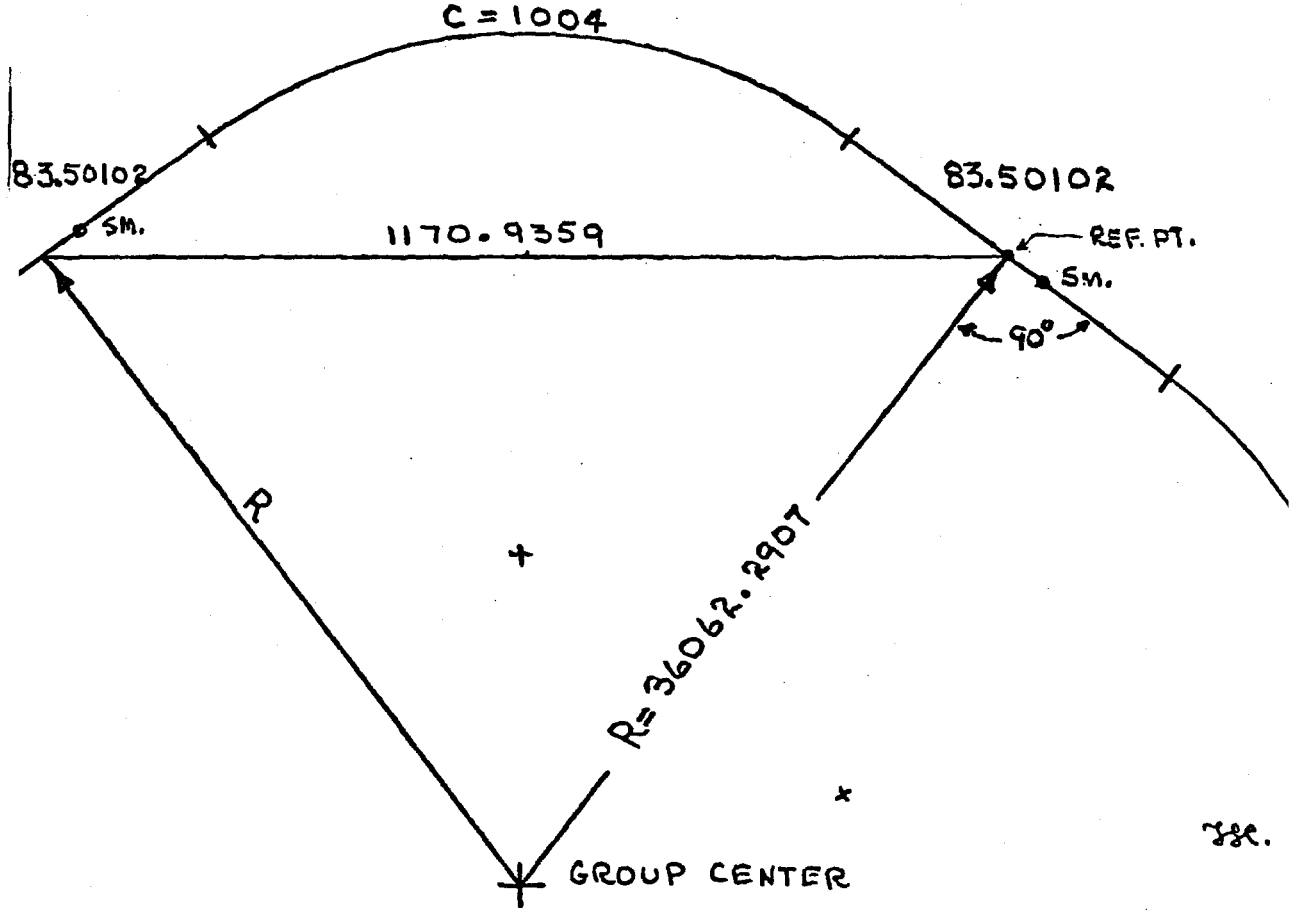


IN ALL SUBSEQUENT COMPUTATIONS I REPLACE MAGNETS BY SIMPLE ARCS OF $2\pi/774$ RADIANS AND 251 OR 252" LENGTH. THE DIAGRAMS SHOW THE RELATION BETWEEN THESE "SMOOTHED" ORBITS AND ACTUAL ORBITS IN IDEAL MAGNETS

THE DEFINED STATION MARKS DETERMINE THE GEOMETRY

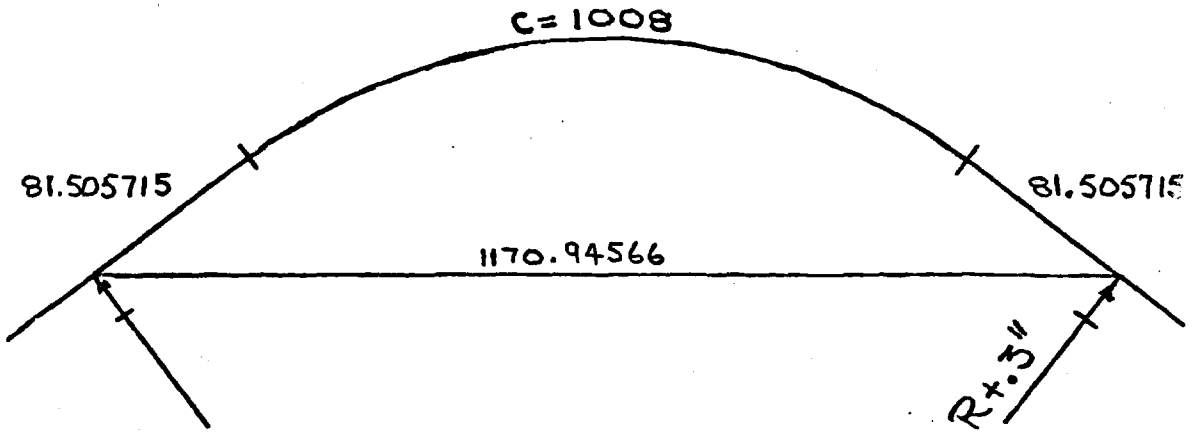


WE WILL NOW USE A CELL WITH SYMMETRIC ENDS AND THE END PT. AS A COMPUTATION REFERENCE. ERECT PERPENDICULARS:

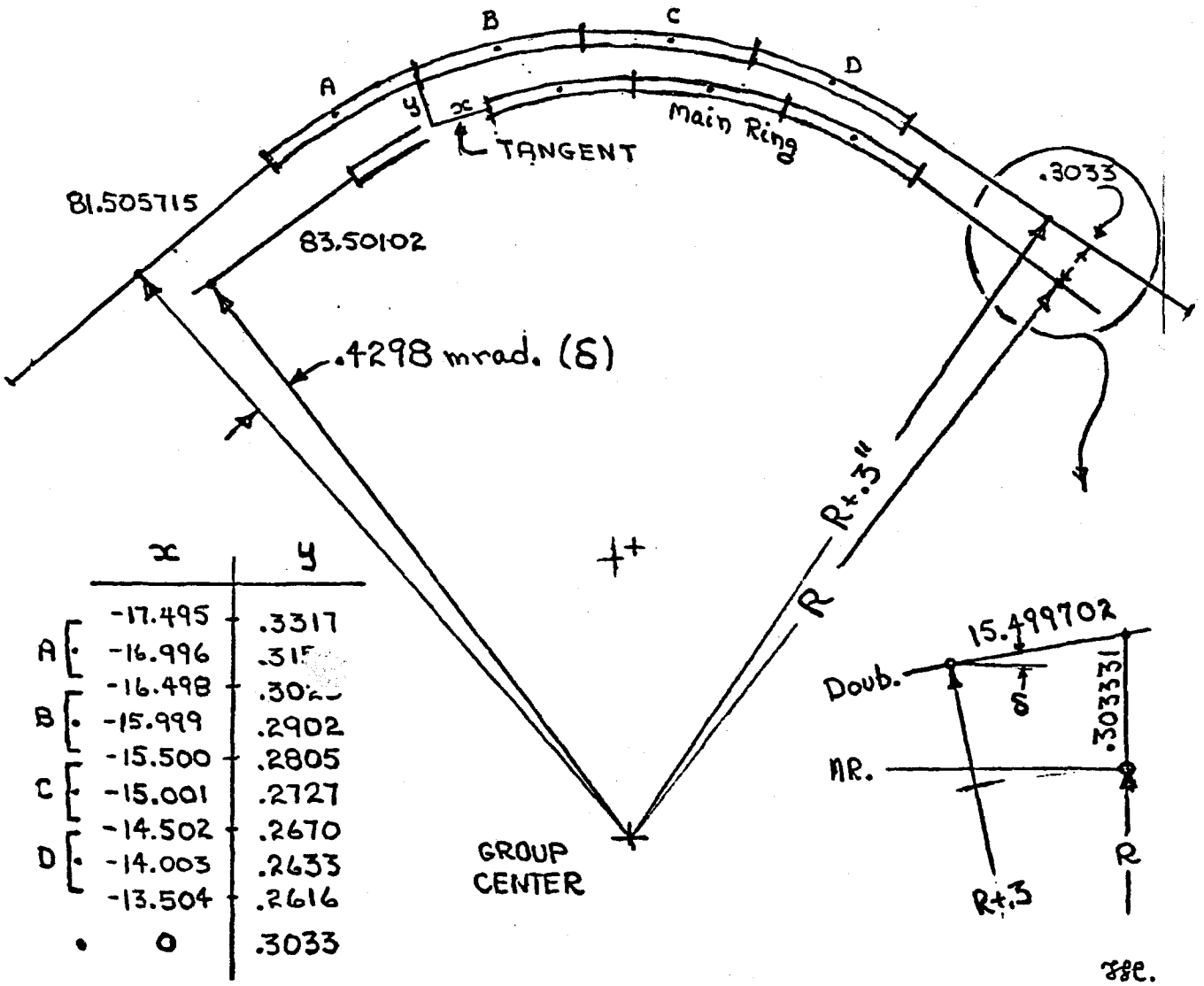


ALL CELLS IN ONE GROUP (MED. TO LONG ST. SECT., SAY) HAVE SAME CENTER. OTHER GROUPS ARE SIMILAR EXCEPT THE CENTER SHIFTS AT EACH ST. SECTION.

FOR DOUBLER, INCREASE PATH LENGTH (ΔR) AND ROTATE EACH GROUP.



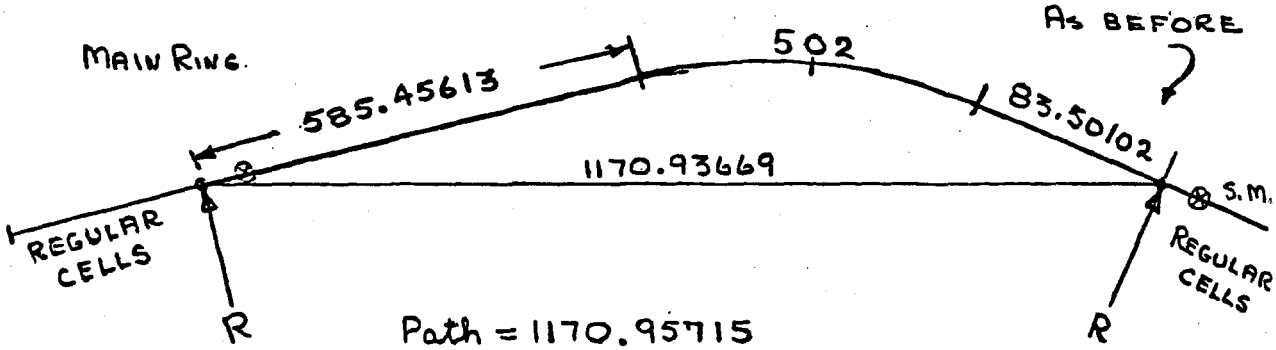
$$\Delta path = \left(2\tan\frac{\theta}{2}\right)\Delta R - \left(\frac{\tan \theta/2}{\theta/2} - 1\right)\Delta C = .0324741\,\Delta R - .00008787\,\Delta C$$
$$= .0093907''$$



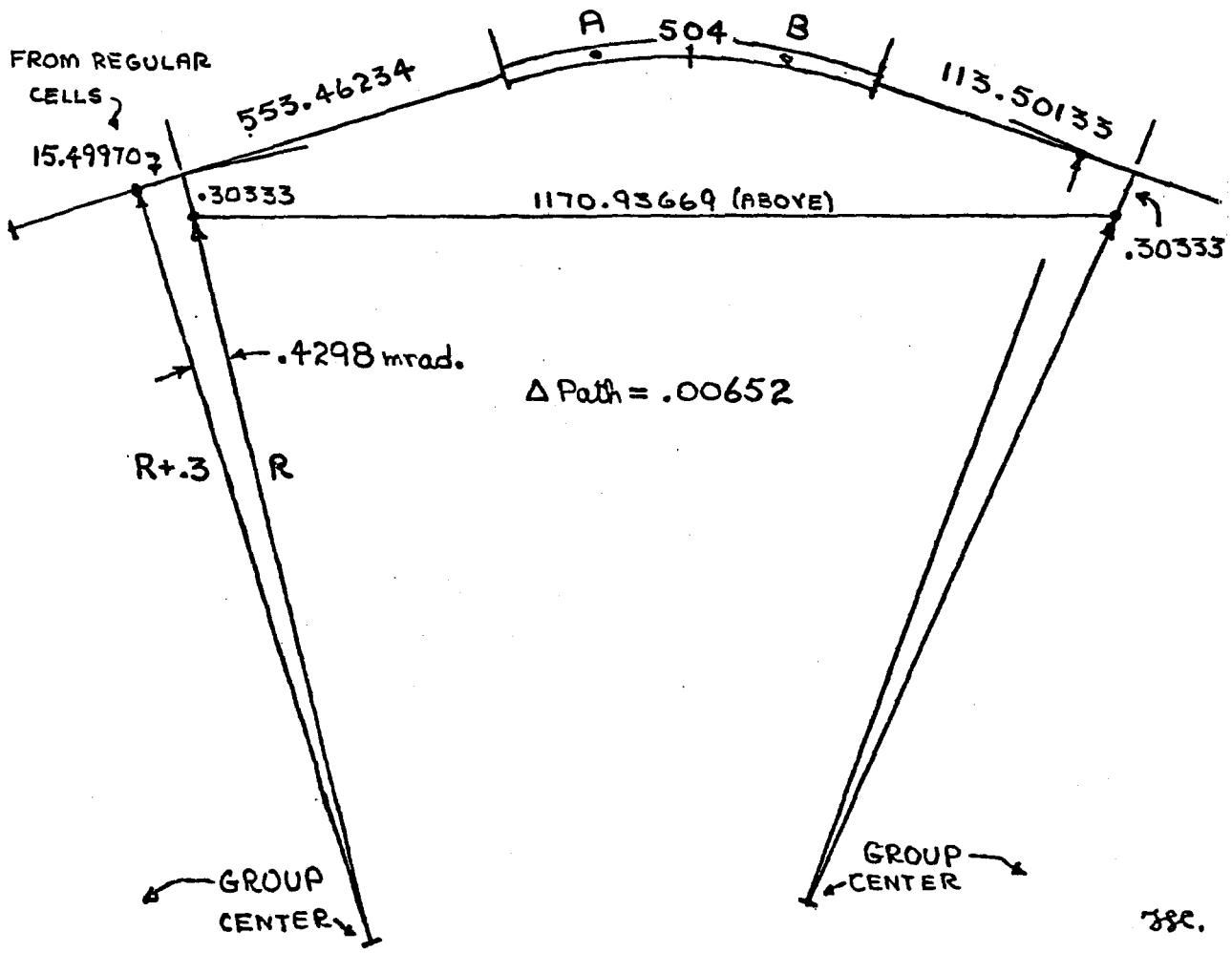
	x	y
A	-17.495	.3317
	-16.996	.315[illegible]
	-16.498	.30[illegible]
B	-15.999	.2902
	-15.500	.2805
C	-15.001	.2727
	-14.502	.2670
D	-14.003	.2633
	-13.504	.2616
•	0	.3033

POSITION OF DOUBLER DIPOLES (SMOOTHED) WITH RESPECT TO M.R. (SMOOTHED).

MEDIUM ST. SECTION. 97.578' BETWEEN STATION MARKS.



DOUBLER. ADD REGULAR CELL ENDS TO ABOVE. SHIFT DIPOLES TO CLOSE.

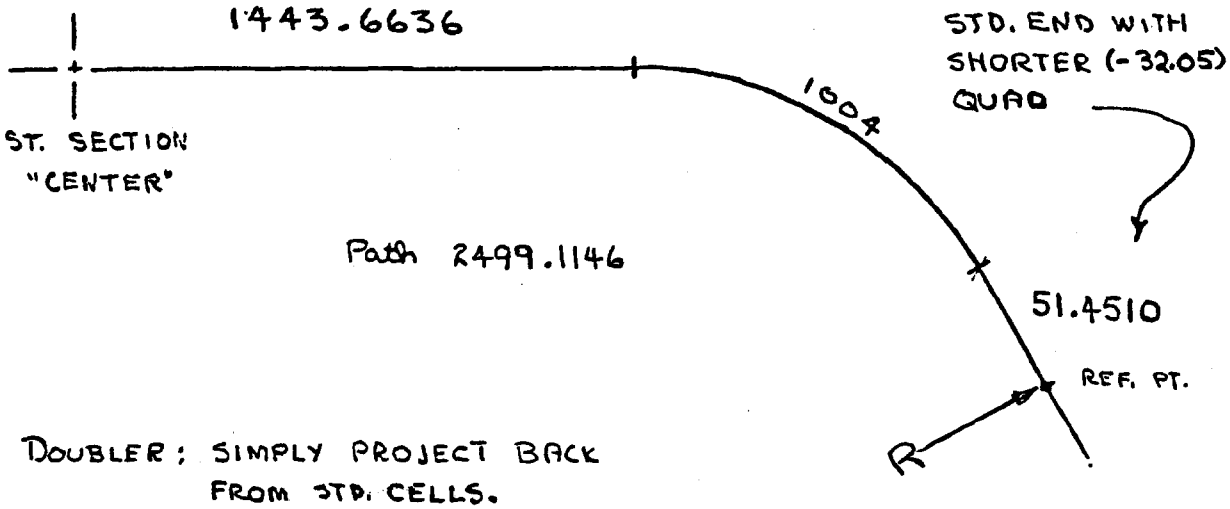


"SMOOTHED" DOUBLER DIPOLES WITH RESPECT TO "SMOOTHED" M.R.

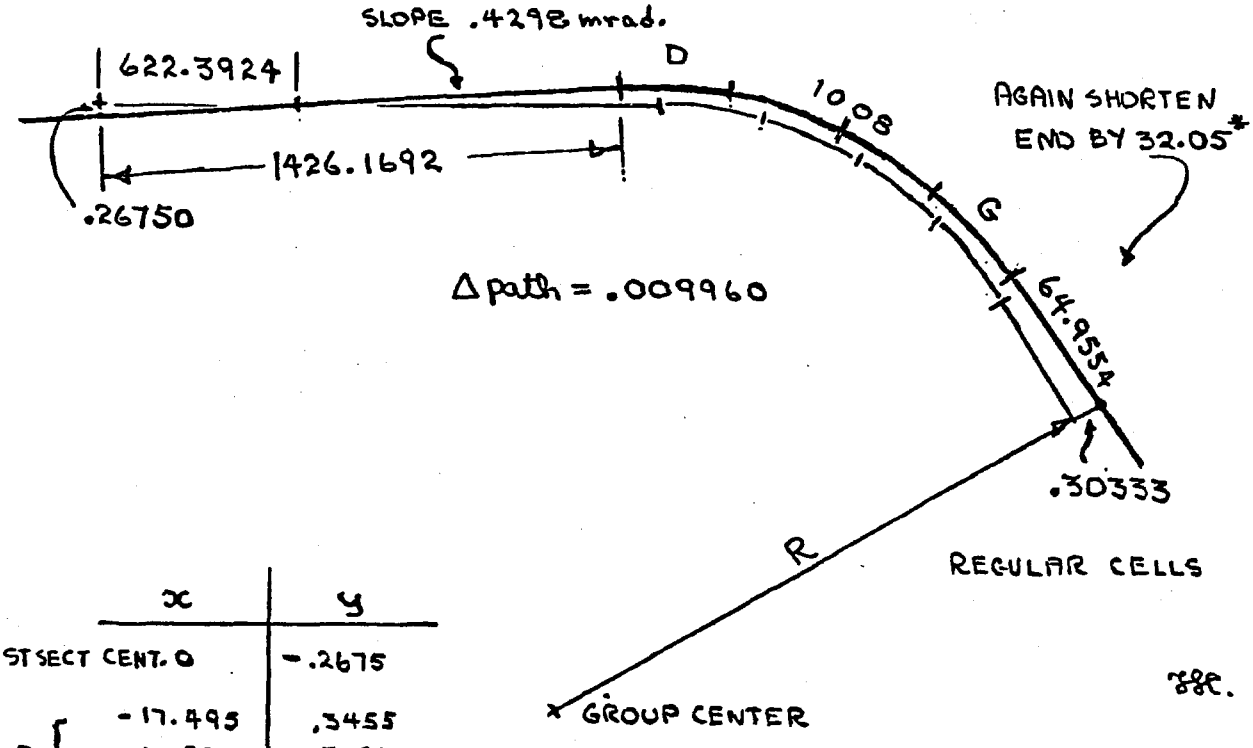
	x	y
A	-31.994	.5412
	-31.496	.4665
	-30.998	.3938
B	-30.499	.3232
	-30.000	.2545

LONG STRAIGHT SECTION — DOWNSTREAM END

MAIN RING GEOMETRY AS DETERMINED BY STATION MARKS.



DOUBLER; SIMPLY PROJECT BACK FROM STD. CELLS.

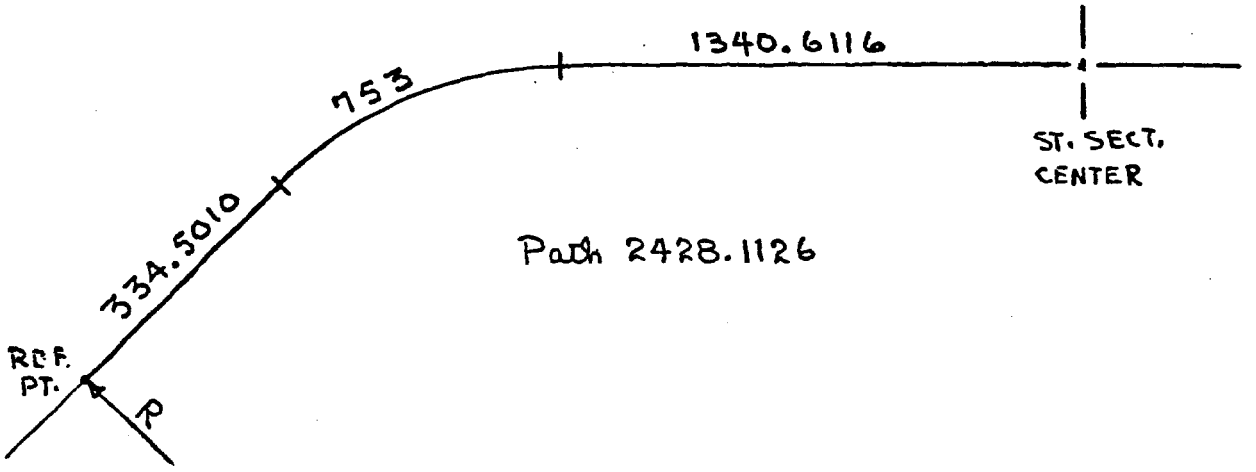


	x	y
ST SECT CENT. 0		-.2675
D	-17.495	.3455
	-16.996	.3296
	-16.497	.3158
E	-15.999	.3040
	-15.500	.2942
F	-15.001	.2865
	-14.502	.2808
G	-14.003	.2771
	-13.504	.2754
REF. PT	0	.3033

* IMPORTANT — SEE LATER TABLE FOR ADDITIONAL MOVEMENT

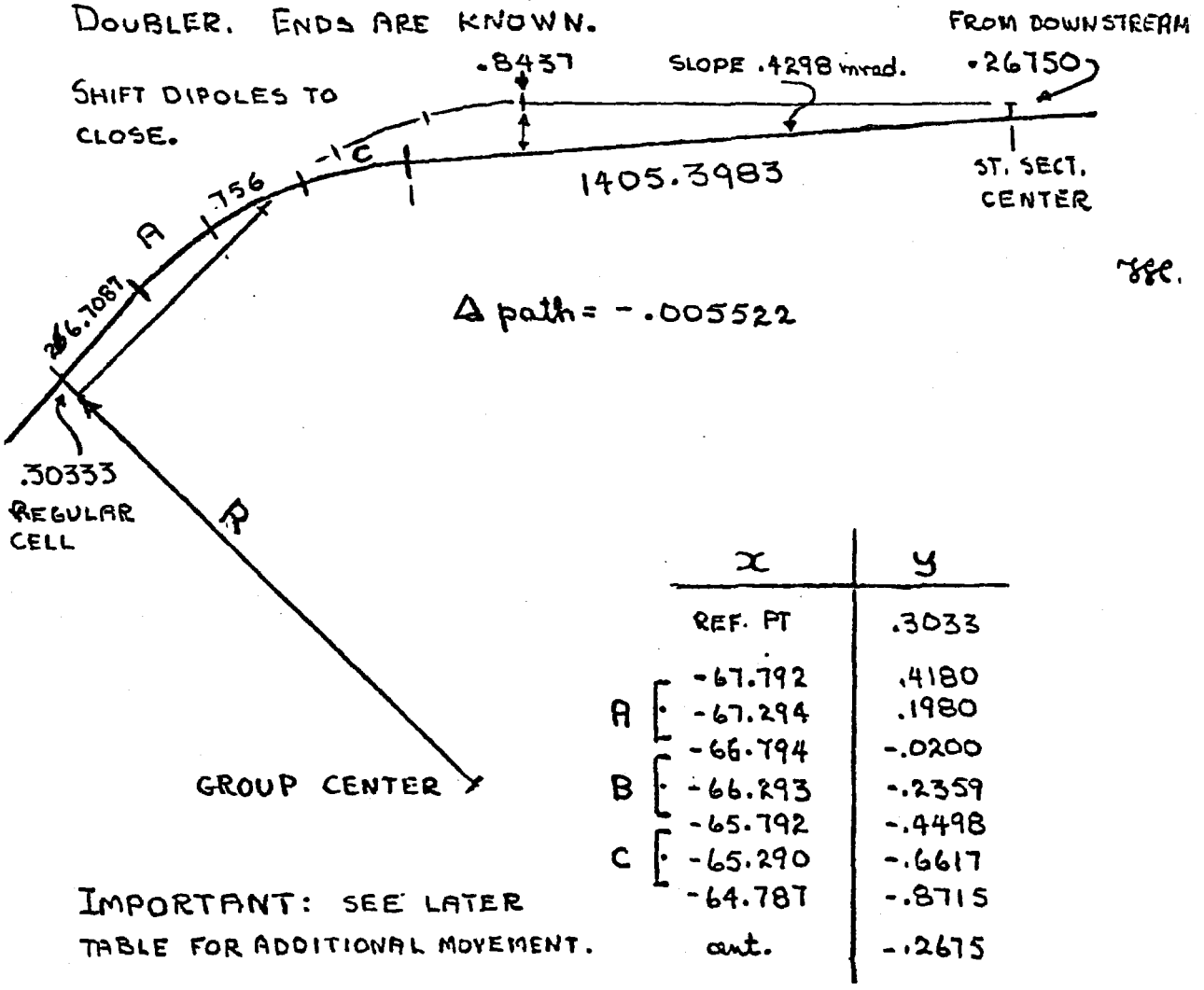
LONG STRAIGHT SECTION: UPSTREAM END.

MAIN RING (FROM STATION MARK GEOMETRY)



DOUBLER. ENDS ARE KNOWN.

SHIFT DIPOLES TO CLOSE.

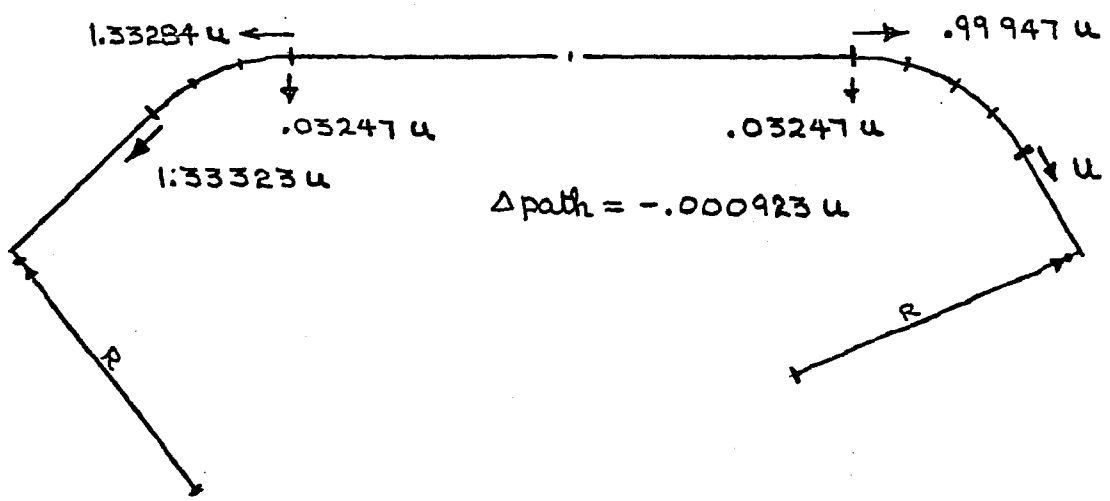


	x	y
	REF. PT	.3033
A	-67.792	.4180
	-67.294	.1980
	-66.794	-.0200
B	-66.293	-.2359
	-65.792	-.4498
C	-65.290	-.6617
	-64.787	-.8715
	cent.	-.2675

IMPORTANT: SEE LATER TABLE FOR ADDITIONAL MOVEMENT.

ADDITIONAL DOUBLER MOVEMENT.

I ASSUMED THAT THE SHORT END QUAD, IN THE DOUBLER, IS 32.05" SHORTER THAN THE NORMAL DOUBLER QUAD. IF IT IS EVEN SHORTER, BY AN AMOUNT u, AND THE DIPOLES ARE MOVED TO CLOSE THE GAP, THEN THE UPSTREAM DIPOLES MUST BE MOVED ALSO AS SHOWN. FOR PRESENT DESIGNS $\begin{cases} u = 1.98'' & \text{NORMAL L.S.S.} \\ u = 8.55'' & \text{HI-BETA L.S.S.} \end{cases}$



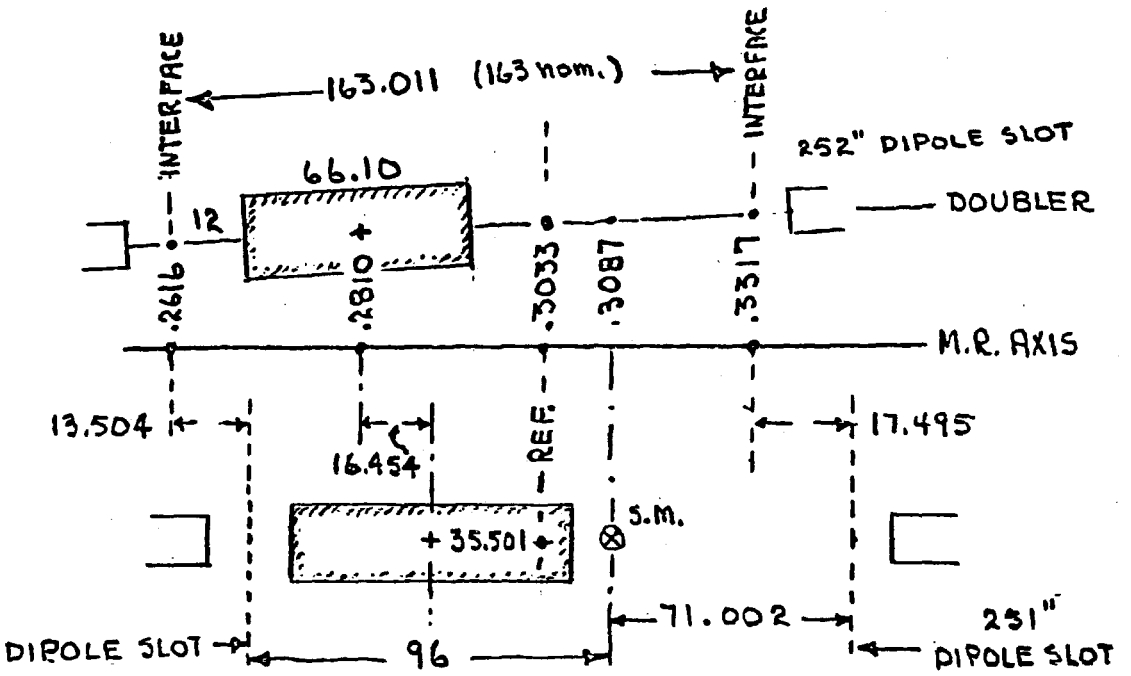
AS SEEN FROM THE MAIN-RING, THIS MOTION MODIFIES LONG ST. SECT.

TABLES BY:

	$\Delta x/u$	$\Delta y/u$
	REF PT	0
A	-1.3332	-.00057
	-1.3332	-.00598
B	-1.3332	-.01140
	-1.3331	-.01681
C	-1.3330	-.02222
	-1.3329	-.02763
	-1.3328	-.03304
	CENTER	-.03247

	$\Delta x/u$	$\Delta y/u$
	CENTER	-.03247
D	.9995	-.03204
	.9996	-.02798
E	.9997	-.02392
	.9998	-.01986
F	.9999	-.01581
	.9999	-.01175
G	1	-.00769
	1	-.00363
	1	+.00043
	REF. PT	0

RELATIVE QUADRUPOLE PLACEMENT (PRESENT DESIGN QUAD)



JJC 4/79.

PATH LENGTH SUMMARY — 1 SECTOR (NO ADDITIONAL SHIFT)

	30 CELLS	MED. S.S.	UPSTREAM LSS	DOWNSTREAM LSS	TOTAL
MR Path	35130.0614	1170.9572	2428.1126	2499.1146	41228.246
Doub. ΔPath	.28172	.00652	-.00552	.00996	.29268

NOMINAL PATH $R_0 = 1$ kM. → 41228.250. DOUBLER $\Delta R/R_0 = 7.099 \times 10^{-6}$

MOMENTUM ADJUSTMENT

FOR	MAIN RING		DOUBLER	
	$\Delta p/p$ %	$\overline{\Delta R}/R_0$ (10^{-6})	$\Delta p/p$ %	$\overline{\Delta R}/R_0$ (10^{-6})
NORMAL INJECTION	.250	7.099	ON AXIS	7.099
STACKING INJECTION	.049	1.401	-.200	1.401
150×1000 p-p̄ COLL. (NEEDS $\frac{\Delta R}{R} = 19.122 \times 10^{-6}$)	-.323	-9.174	+.100	9.948