CERN-PS/LINAC 3/INT
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Numbering of Drift-tubes and Polarity of Magnets.

Drift-Tubes.

Tank I contains 41 complete drift-tubes and two half-drift-tubes at the ends. In all drawings and data sheets * the complete drift-tubes are numbered one to forty-one and the two halves numbered zero and forty-two.

The corresponding figures for the other tanks are included in the table below:

TABLE I

Tank I	42 cells	41 and two half-drift-tubes	
	Drift-tube numbers	0 =	half-drift-tube
		1 . . 41	complete drift-tubes
		42 =	half-drift-tube
Tank II	41 cells	40 and two half-drift-tubes	
		0 =	half-drift-tube
		1 . . 40	complete drift-tubes
		41	half-drift-tube
Tank III	27 cells	26 and two half-drift-tubes	
		0 =	half-drift-tube
		1 . . 26	complete drift-tubes
		27 =	half-drift-tube

* The reports on the Bevatron injector, and the report CERN/PS/MGV 1, relate to a tank that has one more drift-tube at the beginning.

The space between Tank II and Tank III corresponds exactly to one unit cell (of two half-drift-tubes and an R.F. gap). That between Tank I and Tank II corresponds to two unit cells (two half-drift-tubes, two gaps, one complete drift-tube).

It is convenient for some purposes to number all drift-tubes in all tanks with one series of numbers, and the proposed system is indicated in the first columns of the Table II. Note that the complete "missing drift-tube" between Tank I and Tank II has been given a number (43). There is not much reason for this, but it may have advantages in the fact that we then have a length λg always corresponding to an increase of one in the drift-tube number.

Magnets.

The focusing system is a ++-- magnet structure with the two modes of oscillation vertical and horizontal*.

The half-drift-tubes of the D.C. focusing system contain magnets (Nos.44, 85, 86, 113). Except for No.44, These are shorter than their neighbours, but can be given enough current to have the appropriate focusing strength. Thus the only disturbance of the focusing system at the junction Tank II to Tank III is the absence of one R.F. gap, and the fact that the mid-points of these magnets are not quite on the proper position along the axis. These are both small effects.

At the junction between Tank I and Tank II there is a missing drift-tube, and it would be difficult to put a pulsed quadrupole in No.42 half-drift-tube. Some calculations by Johnsen show that the effect of omitting these magnets is not serious, providing that it is done in such a way that one has an extra-long drift-space inserted in a symmetry point of the focusing structure. This is illustrated below:

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   39                        + -
   40                        + -
   41                        - +
- - - - - - - - - - - - - - - - - - -  }
   42 (half) no magnet                 }  additional drift-space
   43 (missing) no magnet              }
- - - - - - - - - - - - - - - - - - -  }
   44                        - +
   45                        + -
   46                        + -
                             H V
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* I.e., the magnet poles at 45° from vertical and horizontal.

TABLE II

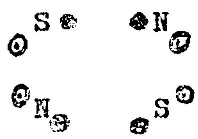
	Number within Tank	Number within Linac	Comments	Magnet (horizontal plane)	Comments
	0	0	half	none	
	1	1		F	
	2	2		F	
	3	3		D	
	4	4		D	
	.	.		.	
	.	.		.	
Tank I	n	n		.	
	.	.		.	
	.	.		.	
	.	.		.	
	.	.		.	
	39	39		D	
	40	40		D	
	41	41		F	
	42	42	half	none	
	—	43	missing	none	
	0	44	half	F	displaced
	1	45		D	
	2	46		D	
	3	47		F	
	.	.		.	
	.	.		.	
Tank II	31	75		.	adjustable *
	.	.		.	
	.	.		.	
	n	n + 44		.	
	.	.		.	
	40	84		F	adjustable *
	41	85	half	D	short
	0	86	half	D	short
	1	87		F	
	2	88		F	
	.	.		.	
	.	.		.	
	n	n + 86			
Tank III	.	.		.	
	.	.		.	
	16	102			adjustable *
	.	.			
	.	.			
	26	112		F	adjustable *
	27	113	half	D	short

* These magnets are adjustable in vertical and horizontal position, in order to correct for the effect of misalignments in their Tank.

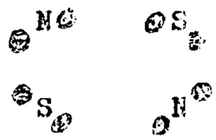
Once adopted, this arrangement at the Tank I - Tank II junction fixes the positions of the symmetry points and antisymmetry points throughout the linac: the only choice remaining is in relation to the vertical and horizontal planes.

The arrangement is one that ends approximately at a symmetry point of the focusing structure. Since we inject into the synchrotron at the middle of a (horizontally) defocusing sector, it is probably desirable to end the linac at a point of the same type. Then the matching is by a moderate factor in both planes, while the opposite choice would involve a big factor for the vertical plane and a small one in the horizontal plane.

Subject therefore to possible change when the matching is calculated in more detail, the linac focusing system should be as in the fifth column of Table II, with F and D referring to the horizontal plane. The polarity of the magnets and energising current directions are sketched below, viewed in a direction with the beam:



(horizontally)F



(horizontally)D

The reference plane in which the linac focusing structure may be considered to stop and the first drift-space of the matching optics to begin, is located $\lambda_g/2 = 23$ cm beyond the end liner skin, and is a (horizontally)D symmetry point if two small effects are neglected:

(a) Half an R.F.gap is missing from what is necessary to complete the perfect focusing structure pattern up to this point.

(b) The last magnet is a little shorter, and its centre is displaced a little towards the ion source, compared with a perfect pattern.

With no magnet in the first half-drift-tube of Tank I, this structure begins F F D D F....etc., i.e. it begins in an antisymmetry point (neglecting the small effect of the half R.F. gap that exists in addition to a perfect structure continued back to this point).

Matched injection into such a point requires a beam with the same width in both planes, and numerically the same angular spread in both planes, but it should be diverging in the horizontal plane and converging in the vertical plane.

It is difficult to say whether it is easier to make a good approximate match into such an antisymmetry point than it would be into a symmetry point, but one can say two things:

(a) If a symmetry point is much easier, one can switch off the first quadrupole, regard the focusing structure as beginning at the middle of the second gap, and add a little isotropic convergence to the injected beam to compensate the R.F. defocusing in the first 1.5 gaps.

(b) A perfect match into this antisymmetry point would be obtained by injecting an isotropic beam with no systematic convergence or divergence (i.e. a "neck") at this point, and placing a D quadrupole at this point. Such a D quadrupole cannot be put here, as this is the first R.F. gap, but it seems likely that a suitable reduction in strength of the very close first quadrupole (which is F) together with a weak D quadrupole outside the tank would make a good approximation to what is required.

The most interesting possibility to keep in mind as a possible alternative to the above scheme would be to put an F quadrupole in the last half-drift-tube of Tank I, and move the whole pattern in that tank one unit towards the synchrotron. Nothing would change in Tanks II and III, but Tank I would begin at a symmetry point.

H.G.Hereward.

/jdw.