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Field Stabilization of the Alvarez Linac by Post Coupler

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Field stabilization of the Alvarez drift tube linac by post couplers was studied. Post-coupler characteristic was measured on two types of the equal velocity models with different drift tube diameters, and with the variable number of post couplers.

KEY WORDS: Proton Linac/ Alvarez Linac/ Post Coupler/ Field Stabilization/

I. INTRODUCTION

The accelerating mode of the Alvarez structure for the proton linear accelerator at middle energy is TM_{010} , so the group velocity of TM_{010} wave is zero. This mode is susceptible to perturbations in electric field distributions due to manufacturing errors or beam loading. And the temperature shift of cavity causes the resonant frequency shift at operation, so the resonant frequency has to be adjusted to the initial value by tuners. But this adjustment tilts the flat electric field distribution on the axis. These distortions of field distribution during acceleration result in the increase of beam emittance and beam loss. So it is important to stabilize the field distribution by some means or other.

For this purpose the post coupler is considered.[1] Post coupler is a rod extending from the outer wall opposite the dirft tube to stabilize the on-axis electric field by adjusting the coupler length.

Post coupler is in principle a quarter-wave resonator, so there is a functional relation between the operating frequency and the distance between the inner tank wall and the drift tube.[2] Two types of models, which have same resonant frequency and same inner tank diameter but different drift tube diameters, were made. Field stabilization with post couplres was investigated using these models.

II. CONSTRUCTION OF ALVAREZ TANK

On-axis fields were measured on 9-cell tank models. Figure 1 shows the schematic diagram of unit cell and a drift tube. Dimensions of each cell were same for simplicity (equal velocity model). Cell length was 6 cm and tank inner diameter was 44 cm.

As the case of type 1 model, the drift tube diameter was 10 cm. In this model the distance between drift tube and tank wall was approximately equal to the quar-

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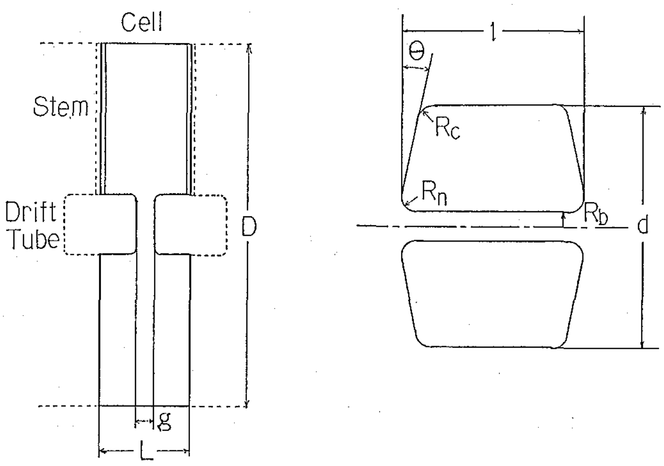

Fig. 1. Schematic diagram of unit cell and drift tube.

Table 1. Dimensions of unit cell and drift tube shown in Fig. 1 (unit is mm)

		Type 1		Type 2
D:	tank inner diameter		440.0	
L:	cell length		60.0	
g:	gap length	21.0		11.2
l:	drift tube length	39.0		48.8
d:	drift tube diameter	100.0		60.0
Rc:	corner radius		8.0	
Rn:	nose corner radius		4.0	
Rb:	bore radius		5.0	
θ:	face angle		0°	

ter-wave of resonant frequency 440 MHz. 6 cm diameter was chosen for type 2 to get the higher shunt impedance of cavity. The gap length between drift tubes was calculated by the computer code SUPERFISH to be resonant at 440 MHz. Table 1 shows the dimensions of Alvarez tank.

The length of half drift tube on each end plate could be changed to give perturbation to field distribution.

III. POST-COUPLER MEASUREMENTS

The field stabilization with post couplers was investigated as follows.[3]

(1) Without post couplers the original on-axis electric field distribution was measured. The bead perturbation methods were used to sample the on-axis electric fields. Figure 2 shows equipments for measurement. The bead was a plastic ball of 3 mm diameter covered with evaporated aluminum.

(2) When the length of half drift tube on one end plate was changed, the resonant frequency of cavity shifted by Δf. Then we adjusted the length of half drift tube on another end plate to restore the resonant frequency to the original value. The field

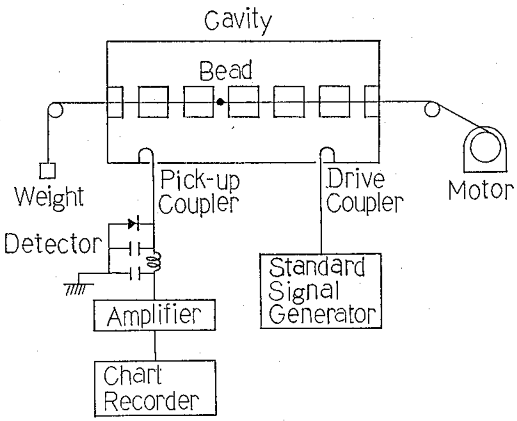

Fig. 2. Block diagram of system of measurement by bead perturbation methods.

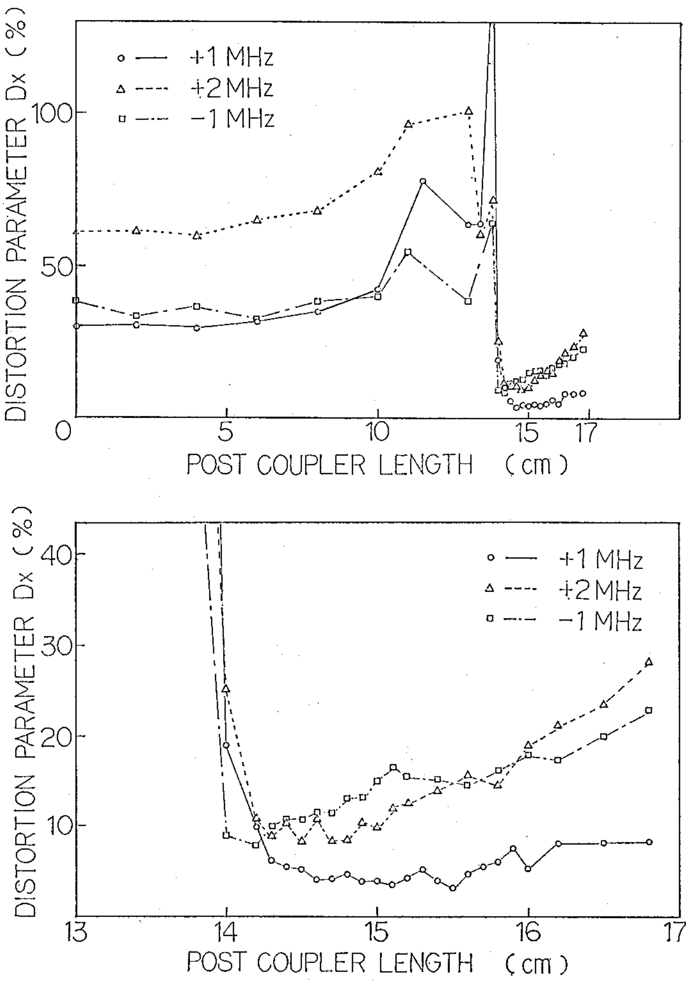

Fig. 3. Distortion parameter, D_x , as a function of post coupler length for +1 MHz, +2 MHz and −1 MHz end cell perturbations. Drift tube diameter is 10 cm.

distribution was measured for Δf end cell perturbation.

(3) Post couplers were installed in the cavity at the same length. The diameter of post coupler was 15 mm which was equal to the diameter of drift tube stem. A tab with the area 2.37 times the post coupler cross section was mounted at the end of post coupler. Changing the length of post couplers, we measured the on-axis electric field distribution for Δf end cell perturbation and compared with the original distribution.

A distortion parameter,[4] D_x , which indicates the effectiveness of field stabilization with post coupler, is defined as follows

$$D_x = \sum_n \frac{|E_{n,x}-E_{n,o}|}{E_{n,o}} \times 100\ (\%) \tag{1}$$

where $E_{n,o}$ is the original on-axis electric field of the n-th cell, and $E_{n,x}$ is the on-axis electric field of the n-th cell for Δf end cell perturbation with post coupler at the length of x. Measured field of each cell was divided by the average field of the 4th, 5th and 6th cells for normalization.

IV. RESULTS

For a first series of measurements post couplers were installed opposite each drift tube of 10 cm diameter. Successive couplers were located at alternate side of the tank. The on-axis field distributions were measured for +1 MHz, +2 MHz and −1 MHz end cell perturbations. Figure 3 shows a plot of D_x as a function

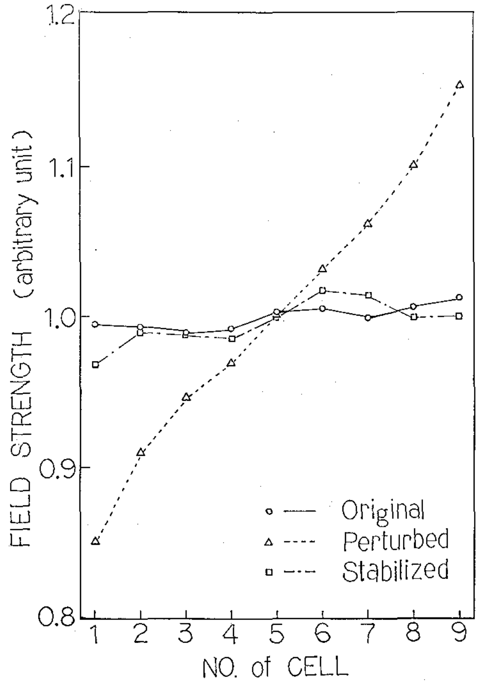

Fig. 4. On-axis field distribution. Drift tube diameter is 10 cm.

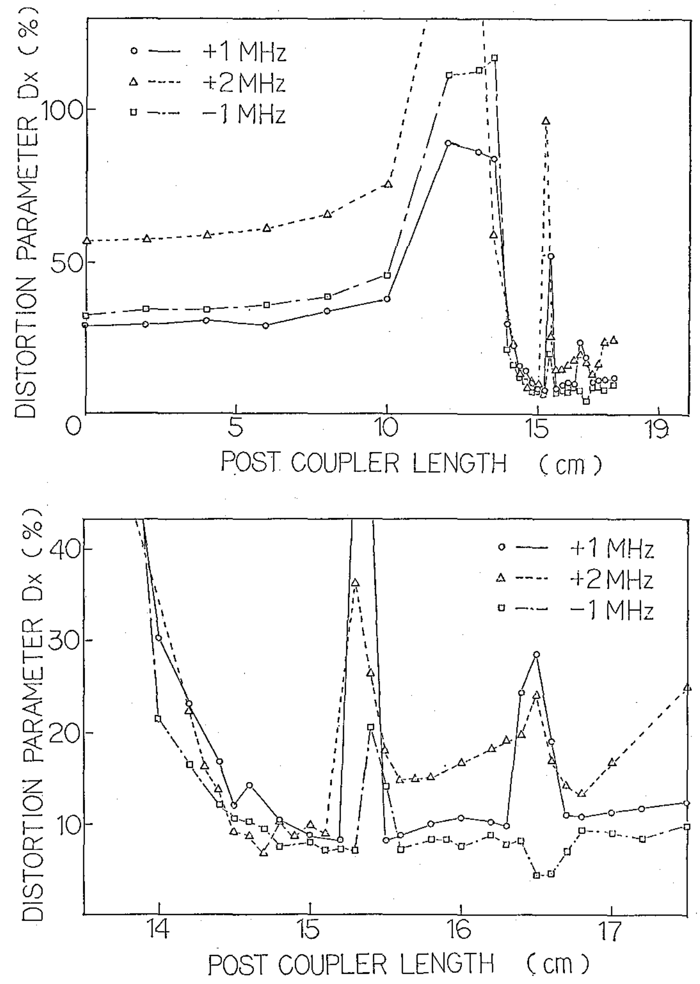

Fig. 5. Distortion parameter, D_x, as a function of post coupler length for $+1$ MHz, $+2$ MHz and -1 MHz end cell perturbations. Drift tube diameter is 6 cm.

of post coupler length. At 14.5 cm post coupler length the on-axis field distribution was stabilized. Figure 4 shows the on-axis electric field of each cell for the original, $+2$ MHz end cell perturbed and stabilized distributions respectively. For 6 cm diameter drift tube the same measurements as previously described were done. Figure 5 shows a plot of D_x as a function of post coupler length. At 15.0 cm post coupler length the on-axis electric field distribution was stabilized. Figure 6 shows the on-axis electric field of each cell same as Fig. 4.

For a second series of measurements we installed eight, four or two post couplers for $+2$ MHz end cell perturbation. As the case of eight post couplers they were installed opposite each drift tube, the case of four opposite the odd numbered drift tubes, and the case of two opposite the 3rd and 6th drift tubes. Successive couplers were located at alternate side of the tank for all the cases. Figure 7 and Figure 8

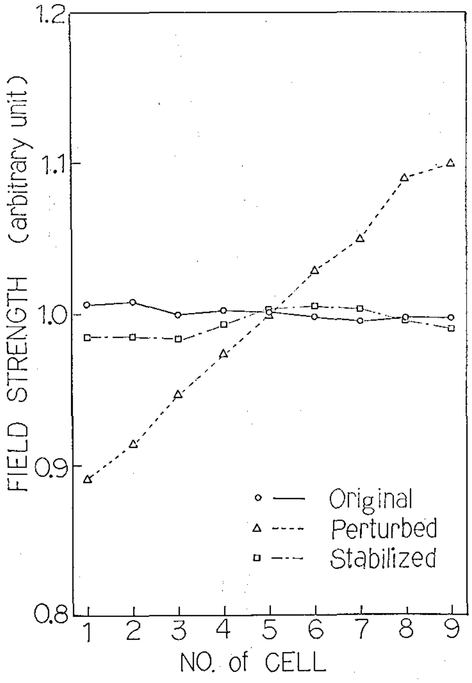

Fig. 6. On-axis field distribution. Drift tube diameter is 6 cm.

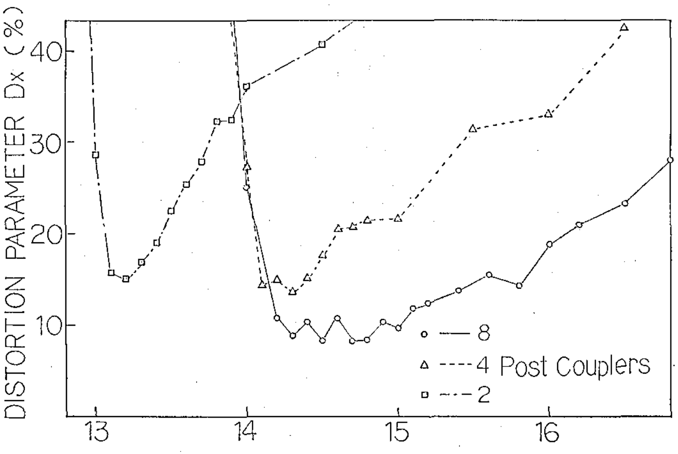

Fig. 7. Distortion parameter, D_x, as a function of post coupler length with eight, four or two post couplers for +2 MHz end cell perturbation. Drift tube diameter is 10 cm.

show polts of D_x in the case of drift tube diameters of 10 cm and 6 cm respectively. For eight, four, and two post couplers of 10 cm diameter drift tube field stabilizations were achieved at the post coupler length of 14.5 cm, 14.3 cm and 13.2 cm respectively, and for 6 cm diameter drift tube at the post coupler length of 15.0 cm, 14.3 cm and 13.4 cm respectively.

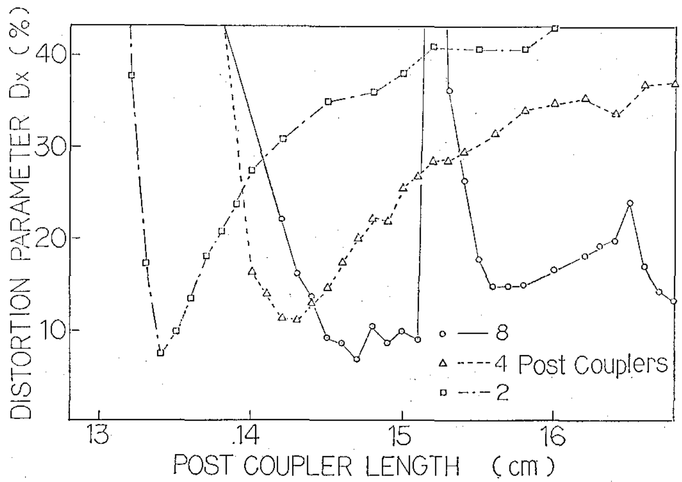

Fig. 8. Distortion parameter, D_x, as a function of post coupler length with eight, four or two post couplers for +2 MHz end cell perturbation. Drift tube diameter is 6 cm.

V. DISCUSSION

It was reported that the stabilization should be possible if the distance between the drift tube and the tank wall is between ~0.90 and ~1.03 times quarter-wave length of operating frequency in safety.[2] In our measurements the distance was 1.00 time quarter-wave length in type 1 and 1.12 times in type 2. So in both types stabilization was achieved, that ~1.1 times quarter-wave length could be chosen for stabilization in the case of short tank length, but it is not sure in the case of long one.

As the number of post couplers was decreased, the post coupler length for stabilization became shorter and the range of stabilization was more limited.

Although the drift tubes of 10 cm and 6 cm diameters were used in the experiments, the post coupler length for stabilization was nearly equal in both cases regardless of the number of post couplers. When the stabilization was achieved in these experiments, the capacitance between post coupler and drift tube changed much but the inductance of post coupler changed not much. And so to stabilize the field distribution by post couplers the inductance of post coupler might be more important than the capacitance between post coupler and drift tube. But if the capacitance is too small *i.e.* the end of post coupler is too far from the drift tube, the radial electric field between the end of post coupler and drift tube is too small to cause the enough energy flow along the axis. So if the distance between the drift tube and the tank wall is much different from the quarter-wave length, field stabilization might not be possible.

REFERENCES

(1) E.A. Knapp, J.M. Potter, E.J. Schneider and D.A. Swenson, unpublished.
(2) J.H. Billen, LANL memorandum.
(3) Y. Katayama and H. Takekoshi, *Bull. Inst. Chem. Res., Kyoto Univ.*, **61**, 1 (1983).
(4) J. Ungrin, S.O. Schriber and R.A. Vokes, *IEEE Trans. on Nucl. Sci.*, **30**, 3013 (1983).