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MANIFOLD-COUPLED LINAC STRUCTURE

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A manifold-coupled linac structure with excellent rf, mechanical, cooling, and vacuum properties will be described. The structure is a "high-β" structure, suitable for acceleration particles with β=v/c between 0.5 and 1. It consists of a sequence of shaped, single-cell accelerating cavities, each of which is βλ/2 long and independently slot-coupled to a coaxial manifold which surrounds the lot. The accelerating cavities operate in the lowest cavity mode (TM_{010}), which implies a maximum separation from other cavity modes such as the deflecting modes. The shunt impedance of this structure is essentially that of the shaped, βλ/2, accelerating cell, degraded by 10-15% for the dissipations in the slots and the manifold. The core of the structure is furnace-brazed copper assembly, which is supported and cooled from the ends (the slots need not be continuous). The outer shell of the structure is a copper-plated steel cylinder. A 20-cell aluminum frequency and field model of this structure is in fabrication. Results of cavity measurements will be presented.

Introduction

A manifold-coupled linac structure with excellent rf, mechanical, cooling, and vacuum properties is shown in Fig. 1. The structure is a "high-β" structure, suitable for acceleration particles with β=v/c between 0.5 and 1. It consists of a sequence of shaped, single-cell accelerating cavities, each of which is βλ/2 long and independently slot-coupled to a coaxial manifold which surrounds the lot.

For β=1, the standing wave in the unloaded manifold has the proper spacing and polarity to drive the accelerating cells with their spacing of βλ/2. The unloaded coaxial manifold has a phase and group velocity of c, implying good power propagation and stable field distributions.

For β<1, the manifold must be loaded to shorten the spacing between the magnetic field maxima in the manifold to match the cell spacing of βλ/2. A doubly-periodic loading has been chosen which operates in a π/2-like mode and offers good power propagation and stable field distributions. The manifold could also be loaded in a bi-periodic fashion (long cell/short cell) to achieve the same result.

The slot coupling between the manifold and each accelerating cell is not of the resonant type. This is thought to be satisfactory since there is only one such coupling between each accelerating cell and the stable field distribution of the manifold. The cavities are tuned so that the slot operates in the mode where the currents inhibited by the slot flow through the slot making up the currents need to support the oscillation in the adjoining cavity. In this mode, the slot makes almost no perturbation to the frequencies and fields of the individual uncoupled and unslotted cavities.

The accelerating cavities operate in the lowest cavity mode (TM_{010}), which implies a maximum separation from other cavity modes such as the deflecting modes. Considerable freedom is available in the cavity geometry to avoid harmonic overlap with undesirable higher frequency cavity modes.

Fig. 2 shows the electric field distributions, as calculated by SUPERFISH, for the accelerating mode and the coupling mode of this structure.

The shunt impedance of this structure is essentially that of the shaped, βλ/2, accelerating cell, degraded by 10-15% for the dissipation in the slots and manifold. The ratio of power losses in the manifold and accelerating cavities can be controlled by slot geometry and cavity tuning.

Table I defines a family of shaped, 1320 MHz accelerating cells, all with the same outer radius, lying near the maximum effective shunt impedance (ZT^2) for particle velocities (β) equal to 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0. Fig. 3 shows scale comparisons of the manifold coupled structure for six of these geometries. Having the same outer diameter and end flange configuration serves to standardize the mounting, alignment, rf drive, cooling and vacuum hardware.

The mechanical, cooling and vacuum properties of the structure add to its attractiveness. The core of the structure is furnace-brazed copper assembly, which is supported and cooled from the ends (the slots need not be continuous). The outer shell of the structure is a copper-plated steel cylinder.

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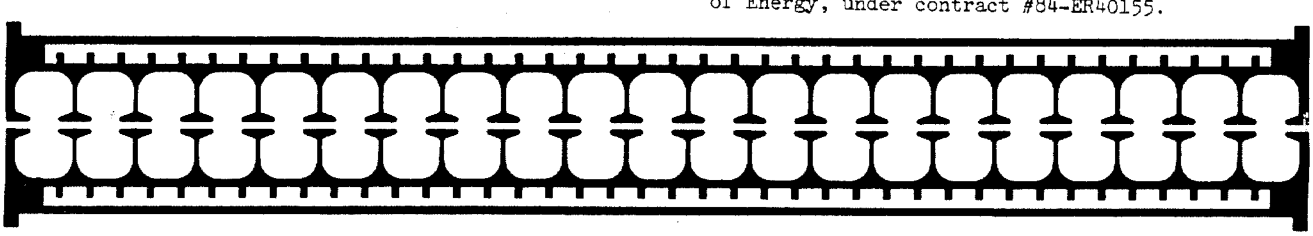

Fig. 1. Manifold-Coupled Linac Structure.

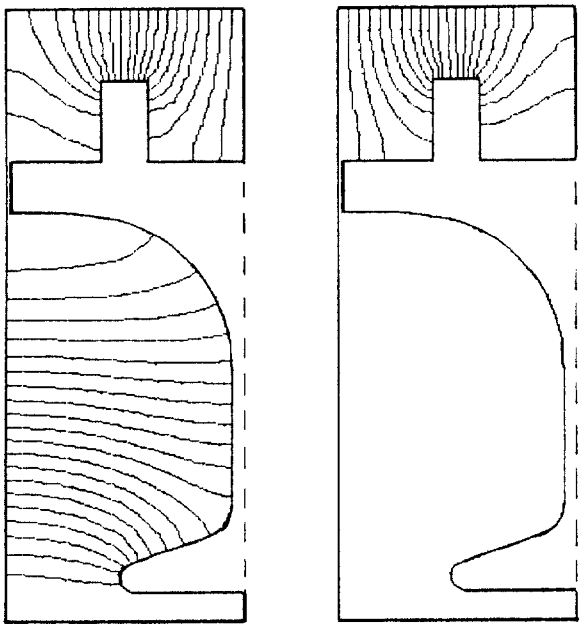

Fig. 2. Electric Field Distributions for the a) Accelerating Mode, and b) Coupling Mode.

The structure is powered by a single rf power connection to the outer cylinder, and the structure is evacuated by a single vacuum pump connected to the outer cylinder.

Table I

A Family of Shaped 1320 MHz Accelerating Cells for Beta = 0.4 to 1.0

β	L	R	G	Z	T	ZT^2	E_s/E_o
-	(cm)	(cm)	(cm)	$\left(\frac{M\Omega}{m}\right)$	-	$\left(\frac{M\Omega}{m}\right)$	-
0.4	4.542	8.000	1.392	68.5	0.90	56.1	5.20
0.5	5.678	8.000	1.924	81.1	0.91	67.6	5.21
0.6	6.814	8.000	2.572	89.6	0.91	74.1	5.18
0.7	7.950	8.000	3.430	98.0	0.89	78.2	5.04
0.8	9.084	8.000	4.328	103.6	0.88	79.5	5.35
0.9	10.220	8.000	5.252	108.4	0.86	79.9	5.00
1.0	11.356	8.000	6.212	112.6	0.84	79.8	5.07

For low- to medium-duty applications, the structure can be cooled by water passing through continuous tubes passing through holes in outer rim of the inner core, thus avoiding all water-to-vacuum joints. For higher duty applications, the furnace brazing technique that provides internal cooling channels in and between accelerating cavities is quite acceptable and reliable.

An alternate version of this structure has been identified where the coupling is accomplished by a rectangular coax tangent to one side of the accelerating cells. This coax could also serve as the vacuum manifold. This version of the structure is smaller in cross section and may offer a higher shunt impedance because of the reduced size of the manifold.

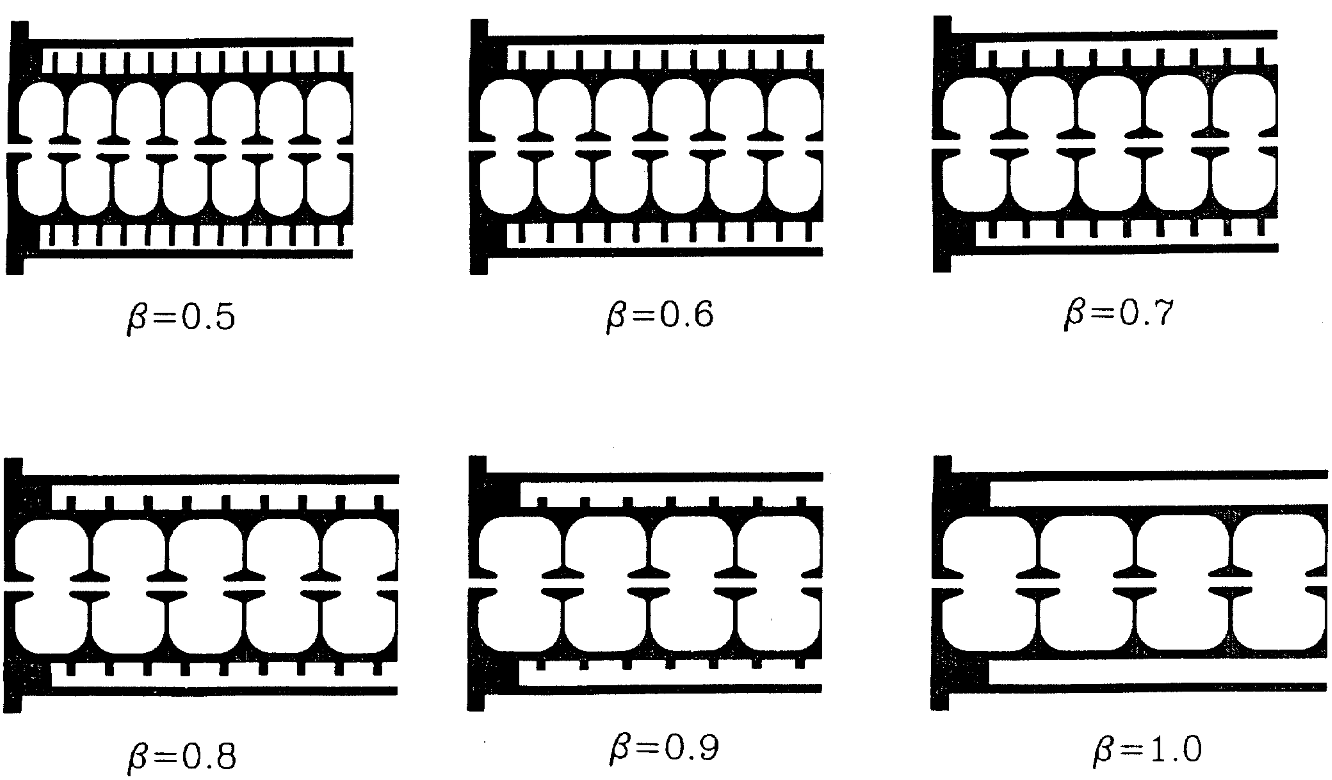

Fig. 3. Family of Manifold Coupled Linac Geometries for β = 0.5 to 1.0.

A 20-cell, aluminum, frequency and field model of the coaxial manifold-coupled structure with the $\beta = 0.8$ geometry shown in Fig. 4 has been fabricated. A 6-cell model of the tangential manifold-coupled structure at $\beta = 1.0$ has been fabricated. These models are shown in Figs. 5 and 6. Measurement of their mode spectra and tuning characteristics are scheduled for the near future. Fig. 6 shown the relative size of the disk and washer structure, the coaxial manifold coupled structure and the tangential manifold coupled structure, all at 2380 MHz.

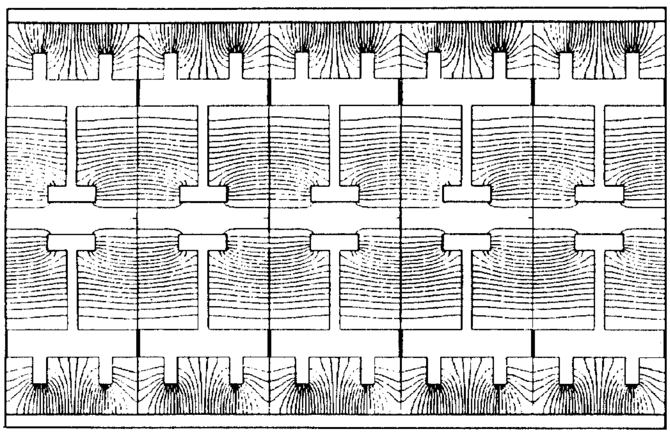

Fig. 4. Geometry and Fields the 20-cell Model of the Manifold-Coupled Linac Structure.

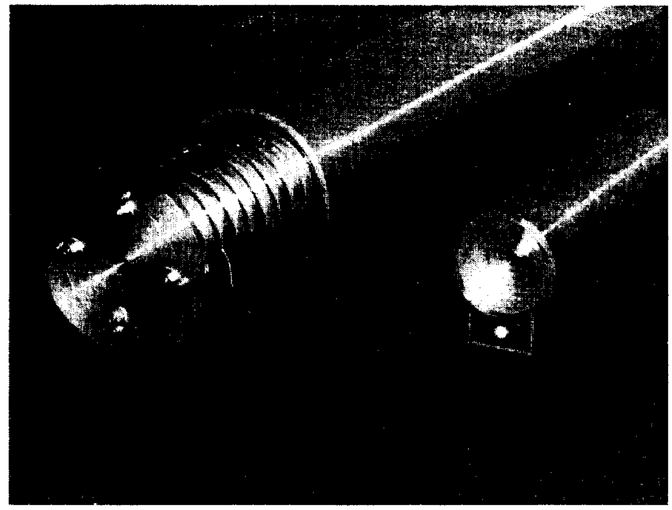

Fig. 5. Coaxial and Tangential Models of the Manifold-Coupled Linac Structure.

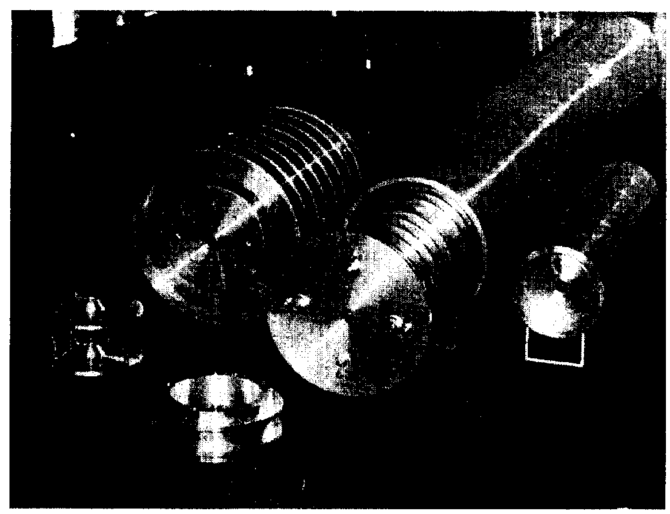

Fig. 6. Relative Size of Disk-and-Washer, and Manifold-Coupled Structures, all at 2380 MHz.

Acknowlegements

This structure bears a considerable similarity to the Type X, disk and washer cavity developed by S. Inagaki and coworkers at KEK.[1] The author is indebted to his close colleague, Y. Iwashita of Kyoto University and Los Alamos for many hours of fruitful discussions of coupled-cavity systems and his keen criticism of an inferior manifold loading scheme that I had been considering for this structure.

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[1] S. Inagaki, et al., "Development of Disk-and Washer Cavity in KEK", IEEE Trans. on Nucl. Sci. Vol. NS-30, No. 4, August 1983.

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