NEW 4-8 GHz CORE COOLING PICKUPS and KICKERS for the FERMILAB ACCUMULATOR

J. Petter, D. McGinnis, J. Marriner, J. Misek
Fermi National Accelerator Laboratory*

Introduction

The Antiproton Source Accumulator core stochastic cooling systems will be upgraded from 2-4 to 4-8 Ghz in the summer of 1989. This upgrade will provide faster cooling times [1]. The two present 2-4 GHz betatron systems will be replaced. A new 4-8 GHz momentum system will be added to the present 2-4 GHz system. This paper will give a brief overview of the pickup and kicker arrays.

Electrode Assembly

Both horizontal and vertical betatron pickup and kicker arrays contain 64 electrodes each. The momentum pickup array contains 128 electrodes and the kicker array consists of 256 electrodes. The total number of electrodes in the system is 640.

The 4-8 GHz electrodes are quarter wave directional loops as shown in Fig. 1. The difference mode current gain frequency response of an individual electrode is shown in Fig. 2 [2].

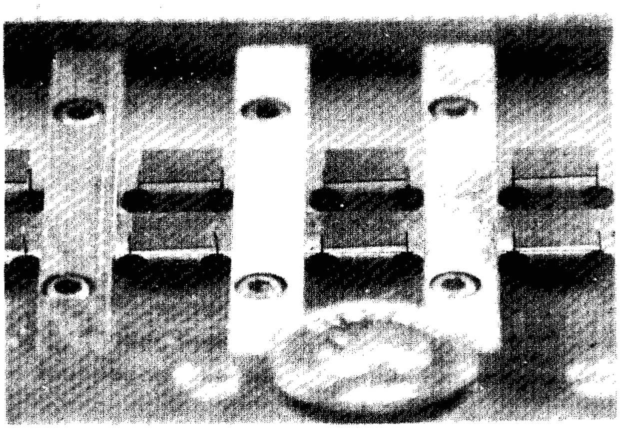

Figure 1 Side view of 4-8 GHz quarter wave directional coupler loops.

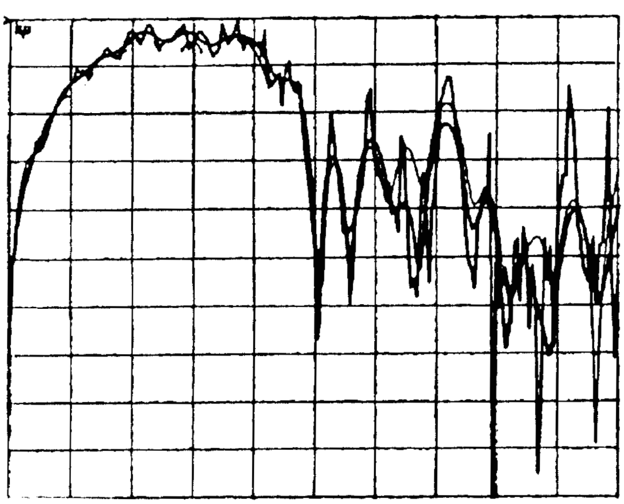

Figure 2 Gated and ungated difference mode current gain frequency response for the 4-8 GHz electrode. The vertical scale is 5 dB/div and the horizontal axis spans from 0 to 20 GHz.

*Operated by the Universities Research Association under contract with the United States Department of Energy.

The betatron cooling systems must accommodate a 1.2" by 1.2" aperture. To cover this aperture in the 4-8 GHz band, two loops are placed side by side as shown in Fig. 1. The optimum center to center spacing is 0.6". A cross sectional view of the electrode environment is shown in Fig. 3. The loop (0.010" thick copper) is 0.3" wide and to obtain a characteristic impedance of 100 Ω is 0.2" tall. The length is 0.39". Grounding blocks are incorporated provide the proper frequency response [2]. The loop is terminated with a 100 Ω resistor. The loop/resistor/tapered cup assembly begins with crimping the BeO rod resistor into the tapered copper cup. The cup is tapered for optimum heat transfer to the ground plane. A slotted cap is pressed onto the rod resistor. One of the loop legs is soldered into the cap slot. To eliminate microwave resonances, an iron filled epoxy encapsulates the rod resistor in the tapered cup. The other leg is soldered to the combiner board during board assembly. The solder used in the assembly is 96.5 Sn - 3.5 Ag.

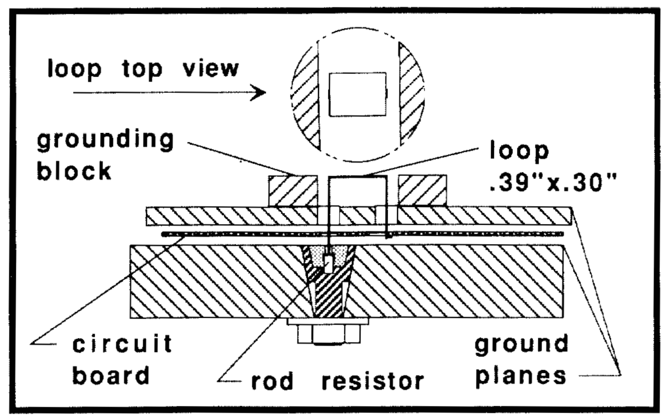

Figure 3 Cross sectional view of electrode termination resistor and combiner board.

Combiner Boards

The combiner board is a suspended stripline circuit. Suspended stripline was chosen because of its high propagation velocity, low loss and low cross talk. The ground plane spacing is 0.145". The center conductor (0.002" thick copper) is suspended on .020" thick RT/Duriod-5880 substrate. The substrate is centered between aluminum ground planes by Teflon buttons.

The first part of the combiner board is a matching network connected to the loop as shown in Fig. 4. The return loss of the loop was measured using de-embedding techniques and an automated network analyzer (HP-8510B). The matching circuit was synthesized and optimized using microwave CAD programs (E-SYN and Touchstone by EEsof). High impedance levels in the matching network were attained using single sided suspended stripline. The return loss of the loop with and without the matching network is shown in Fig. 5. Ferrite pill boxes are placed between matching networks to damp unwanted microwave modes (See Fig. 6).

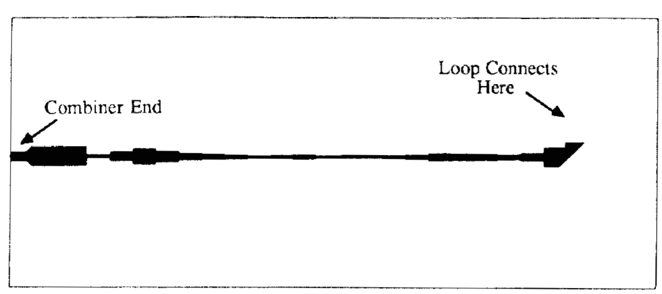

Figure 4 Electrode matching network

CH2669-0/89/0000-0648$01.00©1989 IEEE

At the transition between the single sided matching circuit and the double sided combiner network is a 0.020" via-hole. Double sided suspended stripline is used achieve high signal velocity in the combiner network.

As shown in Fig. 6, the signals from eight 100 Ω loops are phased and combined in three levels into one 50 Ω transmission line. Impedance matching between combiner levels is accomplished with three quarter-wave transformer sections. This combiner board is phased to within ± 2 pS.

The signals from set of two or four primary combiners are combined in secondary combiners. The locations of the primary and secondary combiner boards are shown in Fig. 9. The ports of the primary secondary combiner boards have flexible transitions to SMA connectors as shown in Fig. 8. These flexible transitions are needed to compensate for the thermal expansion of the combiner boards. These transitions are made of 0.005" copper strips inside a Teflon shell which prevents shorting to the ground plane. The width of the copper strip was adjusted to obtain a VSWR less than 1.2.

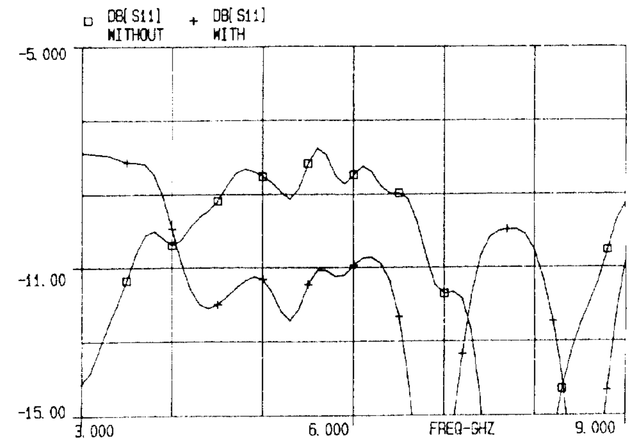

Figure 5 *Return loss of the loop with and without the matching network.*

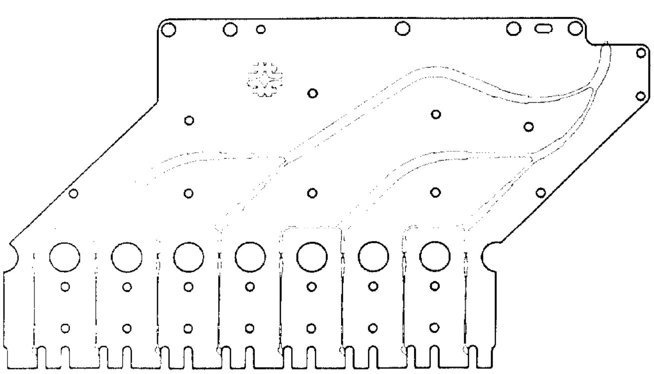

Figure 6. Primary combiner board. The beam travels from left to right for a pickup.

Waveguide Mode Absorbers

Because of the large aperture, many waveguide modes can be excited. To reduce the possibility of excitation, the transitions between the beam pipe and the array were made smooth and the image currents have a continuous path through beryllium copper spring fingers. The microwave transitions are shown in Fig 9. Any modes that are launched are damped by resistive microwave absorbers. The absorbers are placed on both sides of the aperture as shown in the end view in Fig 9. The absorbers are fabricated by silk screening resistive epoxy (300 Ω per square) onto a 0.005" thick Kapton film. The absorbers are held in place by Teflon-glass boards.

Momentum Systems

The momentum system is different from the betatron systems. The first difference is that the lateral center to center spacing between the pickups is 0.8" instead of 0.6". The pickups are placed in a high dispersion region off the Accumulator. The momentum signal is obtained from the difference between the two sets of electrodes. The entire pickup array can be moved laterally as shown in Fig. 10. This lateral movement is necessary to permit cooling in the center of the aperture. Because the aperture is large in the dispersion region, the absorbers must have a low profile. This is achieved by stretching the resistive Kapton film over the tops of the grounding blocks.

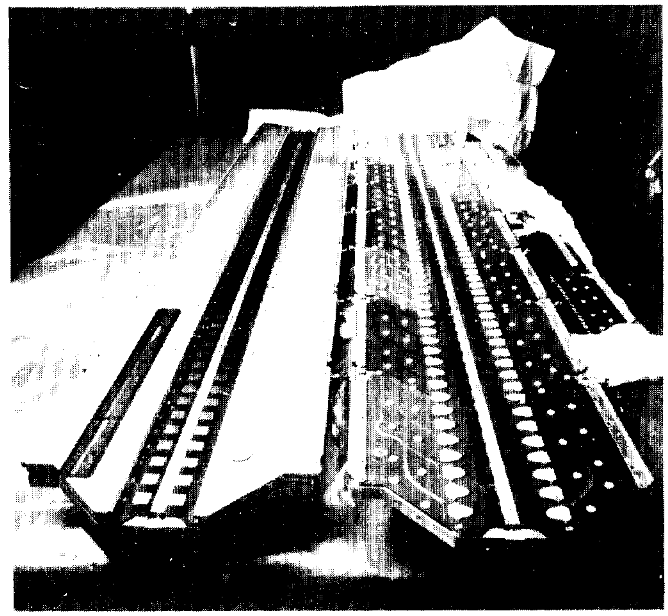

Figure 7 *Combiner boards in a stochastic cooling array.*

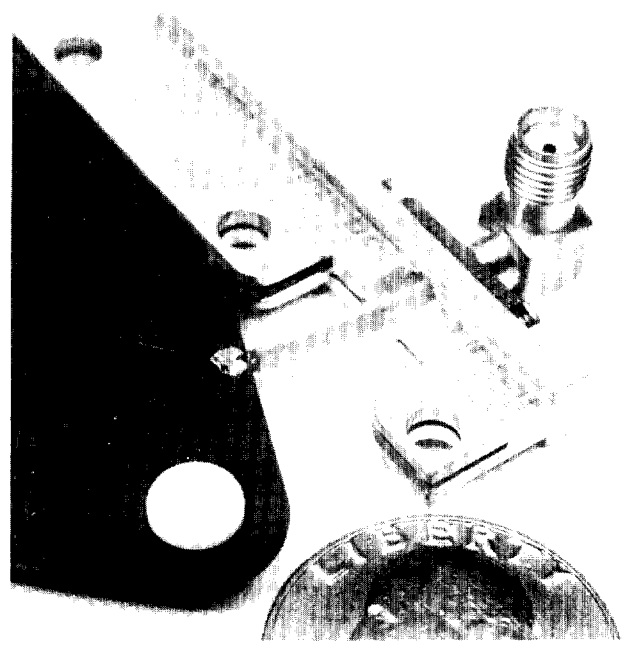

Figure 8 *Flexible transition from suspended stripline to coaxial line*

Vacuum Testing

Vacuum testing of the array was done to verify the material and assembly acceptability when installed in the accumulator ring. The test array was housed in a stainless steel vacuum tank. The tank is 14" in diameter and 60" long. It is fitted with one 270 liter/sec ion pump and 4 titanium sublimation pump filaments equally spaced along the length. All stainless steel parts were hydrogen degas baked to 950 degrees centigrade. The array and tank were baked for 24 hours at 150 degrees centigrade after

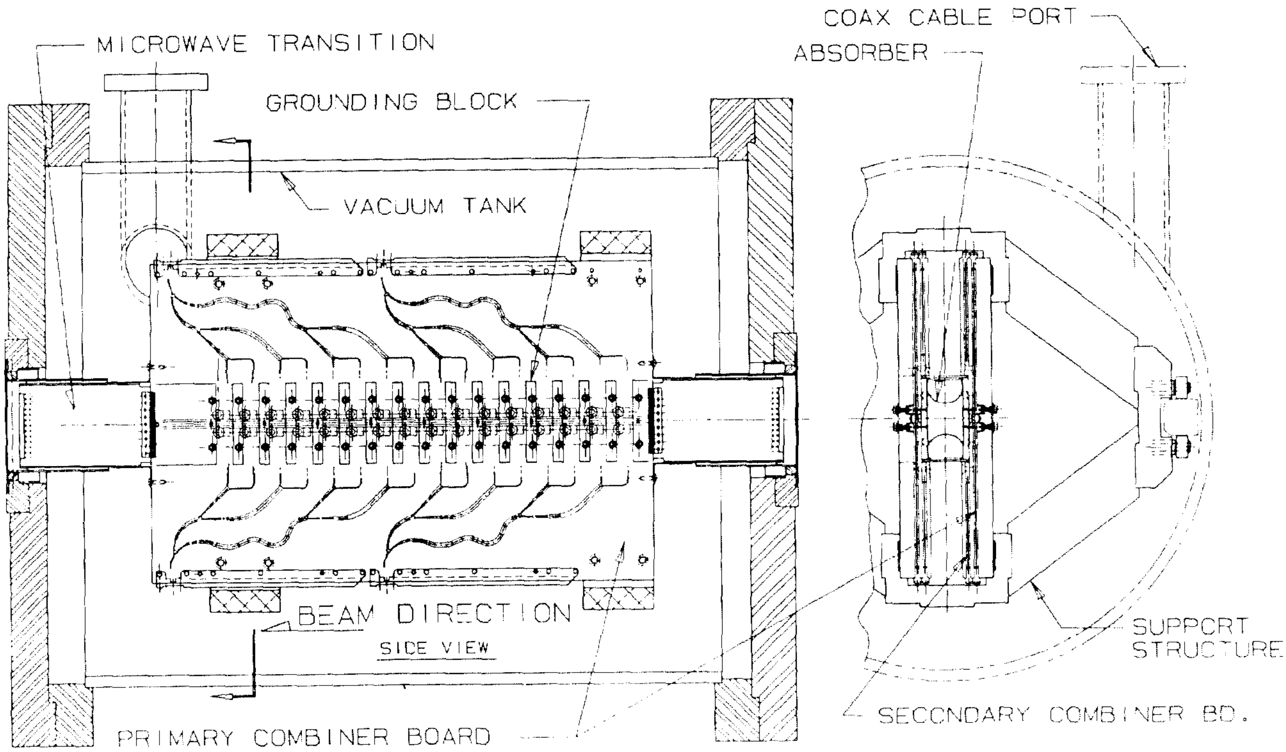

Figure 9. Betatron stochastic cooling tank.

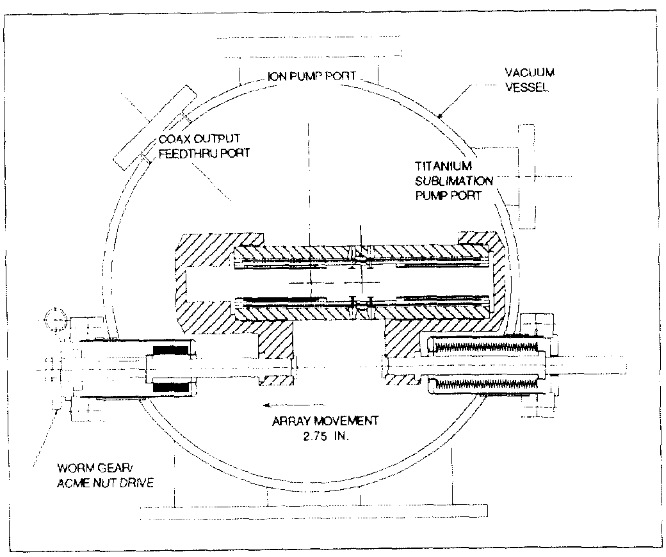

Figure 10. Movable momentum system pickup tank.

which, when cooled to room temperature, attained a pressure of 2 x 10-8 torr. Subsequent firing of the titanium sublimation pumps at a frequency of 2 to 3 times per day brought the pressure down to 4 x 10-10 torr after two weeks. A final liquid nitrogen cooldown of the array lowered the pressure to 1 x 10-10 torr.

References

[1] J. Marriner, "Stochastic Cooling at Fermilab," presented at the XIIIth International Conference on High Energy Accelerators, Novosibirsk, USSR, August 7-11,1986.
[2] D. McGinnis, J. Petter, J. Marriner, J. Misek , S. Y. Hsueh, Frequency Response of 4-8 GHz Stochastic Cooling Electrodes, Presented elsewhere in these proceedings