MULTI-CAVITY BRIDGE COUPLER

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ABSTRACT

A so-called bridge coupler is a useful device for power feed and transfer among a train of accelerating tanks. It not only saves microwave circuit parts but also promises automatic phase matching and requires no large input openings distorting accelerating fields. The conventional bridging cavity of a long cylindrical shape, operated in any TM01 mode, suffers a modal coupling with the neighboring modes. The modal mixing is avoided by partition into short flat cells by bored disks. A stable operation is ensured by the TM010 $\pi/2$ mode with a large inter-cell coupling. Thus a multi-cavity bridge coupler was designed for coupled-cavity accelerating tanks of the Japanese Hadron Project linac and a high power model of the coupler, together with a pair of accelerating tanks, was fabricated and is being tested.

FEEDING AND BRIDGING OF ACCLERATING STRUCTURES

The final accelerating section of the Japanese Hadron Project (JHP) linac is supposed to consist of newly developed 1296 MHz annular coupled structure (ACS) cavity tanks[1] with focusing magnets in between. A bridging method is effective for power feed and transfer. Namely power is fed through a vacuum-tight WR-650 waveguide window into a bridge coupler and transferred to a train of accelerating tanks coupled with bridge couplers. A bridge coupler is composed of a pair of coupling cavities side-coupled to two adjacent accelerating tanks and a bridging cavity also side-coupled to the coupling cavities, looking as if it were a bridge over the magnets.

The bridging method has the following favorable features.

1) Automatching of Phase. The couplers and the accelerating structures make a $\pi/2$ mode coupled resonator chain and keep a consecutive phase relation.

2) Conservation of Field Symmetry. The accelerating cavity is free of a large input coupling geometry which is in charge of the bridge coupler.

3) Saving of Microwave Circuit Parts. A power source and a group of accelerating tanks are connected by a single branchless system of waveguides.

DESIGN

The only example of the bridge coupler is found in the LAMPF coupled-cavity linac, where a long cylindrical single cavity was used as the bridging cavity and operated in TM_{010} mode. The feasibility of a similar bridging cavity was first investigated for simplicity but in a higher order mode TM_{012} operation for higher stability. A simulation of the bridge coupler by the code MAFIA was tried and led to the conclusion that a stable and controllable operation of the conventional bridging cavity cannot be expected in any mode[2]. The eigenmodes in such a long cavity are degenerately close in frequency and the presence of the coupling to another cavity (like the coupling cavity) easily induces modal coupling resulting in complicated field patterns of mixed modes. The single cavity model was given up and modified to a multi-cavity structure operated in TM_{010} $\pi/2$ mode. The modal mixing is suppressed by bored disks partioning the bridging cavity into cells.

The present bridge coupler was designed so as to satisfy the following conditions.

1) The operation mode is separated far from the other modes in frequency is free from mode mixing with any other mode.

2) The inter-cell coupling is strong enough to gain a large group velocity for stabilization.
3) The power loss in the bridge coupler is possibly small.
4) The frequency shift coming from dimensional error in design and fabrication and also from thermal deformation during operation is compensated by a tuning system.

In the above order the main part of the design is outlined below. The cavity radius is roughly determined from the driving frequency although modified by the disk loading condition. A short disk spacing less than the radius gives a sufficient mode separation better than a frequency ratio of 1.5 to avoid modal mixing. On the other hand a large disk bore makes a large inter-cell coupling but too large a bore brings about a modal mixing. The upper limit of the bore radius is about 55 % of the cavity radius and the corresponding coupling coefficient attains 12 %. The power loss in the bridge coupler is reduced with a large value of coupling coefficient. The ratio of stored energy in the bridging cavity and that in the accelerating cavity is the inverse square ratio of coupling coefficients of the coupling cavity to the bridging cavity and to the accelerating cavity. The ratio of coupling coefficients was set 1:2 and therefore the ratio of power 1:4. The cavity dimensions were determined from the computation with the codes SUPERFISH and MAFIA.

The designed values of RF characteristics are as follows.

Component Cavity Frequency	1296 MHz ± 5 MHz
Inter-Cell Coupling Coefficient	12 %
Bridging-Coupling Cavity Coupling Coefficient	8 %
Coupling-Accelerating Cavity Coupling Coefficient	4%
Input Coupling Factor	1.0 ± 0.1

The essential RF structure of the test 5-cell coupler is presented in Figure.

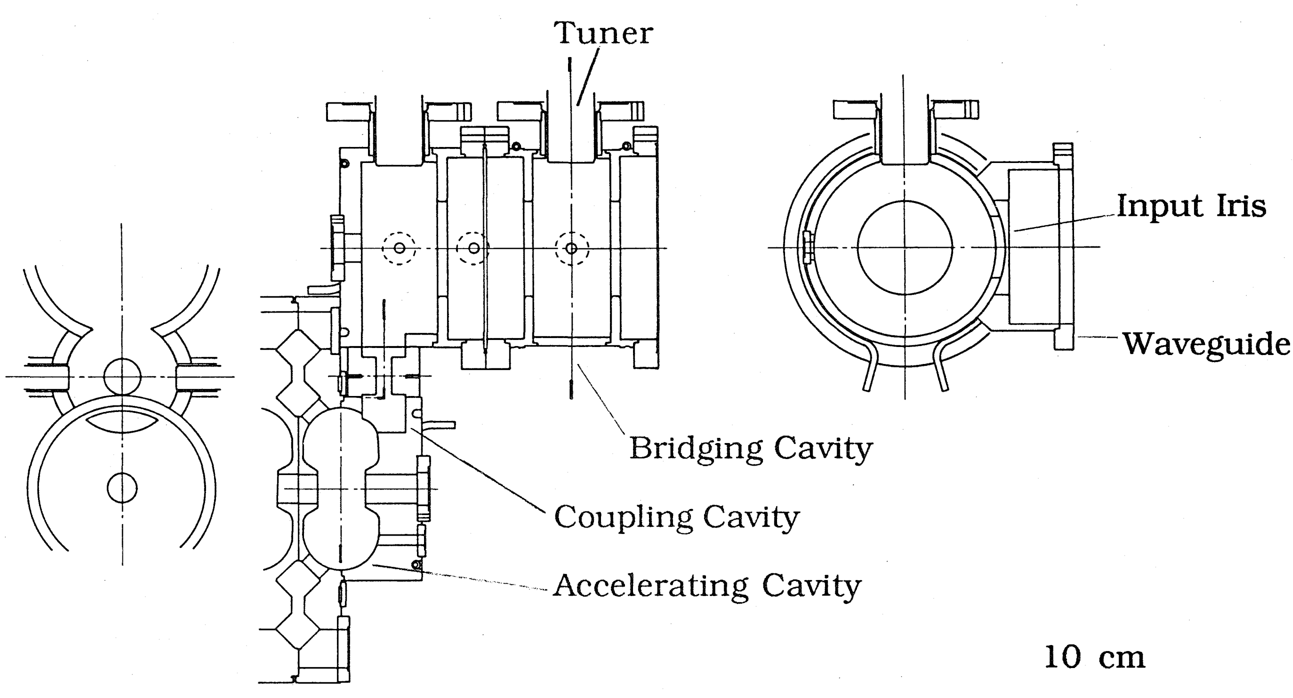

FIGURE RF Structure of Bridge Coupler

FABRICATION

Specially processed high-grade oxygen free copper was cut into the parts and precisely finished. The parts were brazed in a vacuum furnace with gold and silver filling alloys. Details are described elsewhere[3]. Photo shows the assembled whole system of bridge coupler-accelerating tanks (the input waveguide port is closed for a vacuum-tight test).

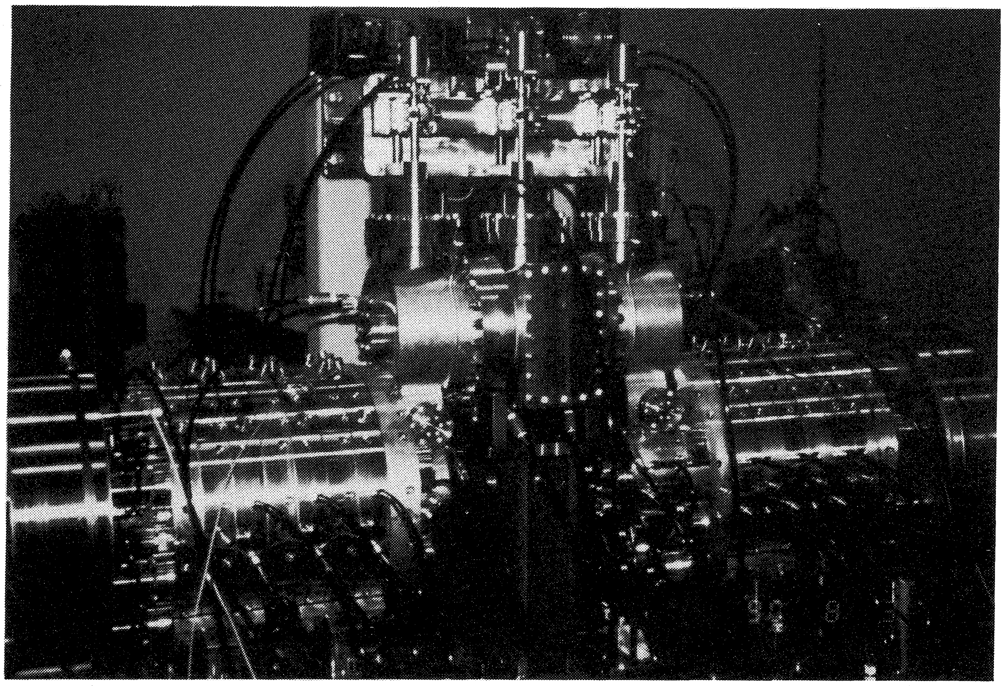

PHOTO Assembled Bridge Coupler-Accelerating Tank System

TUNING

During and after fabrication the frequency of each component cavity was measured to tune to the design values. The detuning plunger method was applied to the frequency measurement. The frequency of the component cavity was measured detuning the neighboring cavities by conductive plungers with some correction based on computer simulation. The frequencies and coupling coefficients of the cavities were confirmed to be as designed. The coupling factor of wave guide to the whole cavity system was measured to be 0.9 within the allowable range.

POWER TEST

The test model of the bridge coupler-accelerating tank system was set up in a radiation shield room equipped with an evacuation and cooling systems and was linked to the waveguide from a klystron. The preparation for an operation test with power is under way. When this report is presented, some data will be resulted from the test.

REFFERENCES

1 T. Kageyama et al., in these proceedings ; K. Yoshino et al., ibid
2 Y. Morozumi et al., Proc. 14th Linear Accelerator Meeting in Japan
3 T. Iwata et al., in these proceedings