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DIGEST OF PAPERS

1.1: MILLIMETER WAVELENGTH RESONANT STRUCTURES

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At the Boulder Laboratories of the National Bureau of Standards we have been engaged in research in the millimeter wavelength region of the electromagnetic spectrum for several years. Under the direction of Dr. W. Culshaw, the Fabry-Perot interferometer was adapted for use at these wavelengths [1,2,3]. Using a plane parallel mirror Fabry-Perot interferometer a precision study of several dielectrics was undertaken at a wavelength of 6 mm [4]. At these wavelengths we have found that diffraction losses become significant when the mirror separation is comparable to the mirror dimensions. Following the suggestion of Fox and Li [5], we decided to make use of confocal mirrors in the Fabry-Perot interferometer in order to reduce diffraction losses and allow increased separation of the mirrors and consequent increased Q of the resonant structure.

The concave mirrors are made from 10 cm diameter fused quartz blanks with an inside radius of curvature of about 50 cm and an outside radius of curvature which collimates the emergent beam. The mirrors are made partially transparent by photoetching a pattern of small holes in the evaporated copper surface of the quartz mirror. Plane mirrors are obtained by stretching copper foil across a circular opening with a planar edge. Partial transparency is achieved by punching or photoetching an array of holes through it. Using these components we have conducted extensive measurements to ascertain the electromagnetic field distribution within the resonant structure and the extent to which it agrees with the theoretical work which has been reported in the literature [5,6,7]. Using the measured insertion loss of the interferometer, the insertion loss of a single mirror (transmittance) and the Q of the resonance, the actual reflectivity of the conducting mirrors as well as the losses due to the coupling mechanism (photoetched hole pattern) were determined.

A principle advantage of the confocal mirrors is the much simpler and less critical nature of the adjustment for resonance. This makes an interferometer having them a very useful laboratory instrument where ease and reliability of operation is important. We have made use of the confocal mirror resonator as a refractometer, microwave spectrometer, and a wavemeter with excellent results. As a transmission cavity, we have obtained a Q of 25,000 with an insertion loss of 4 db at 6 mm wavelength.

We are making use of a plane parallel Fabry-Perot interferometer as a reflection cavity in an experiment involving the Stark effect. The parallel mirrors are placed at different electric potentials producing a uniform electric field between the plates. The frequency of operation is about 100 Gc/s.

Still another type of resonator we have built is the biconical reentrant sphere[2]. This structure had been considered in the early days of klystron design for a klystron cavity. We have built two units which operate at 35 and 70 Gc/s respectively. The measured Q is of the order of 15,000 and the insertion loss in transmission is of the order of 9 db. The microwave energy is focused on the sphere by a lens and the coupling is made through a circular patch of small holes in the surface of the sphere. This resonant structure has interesting applications because of the concentrating effect of the re-entrant cones on the electromagnetic field at the center of the sphere.

In many applications it is desirable to eliminate standing waves in the adjacent regions outside the interferometer to obtain the best power transfer into or out of the interferometer. We shall discuss the optimum selection of hole size and spacing. In many cases the optimum hole diameter is too small to be practical. Under these conditions standing waves in the adjacent regions must be tolerated, and provision must be made for varying the spacings of the feed horns in order to obtain the most efficient power transfer that is available.

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