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ASSEMBLYING AND TESTING PROCEDURE FOR A CRYOGENICALLY-COOLED 5-GHz CIRCULATOR

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Abstract

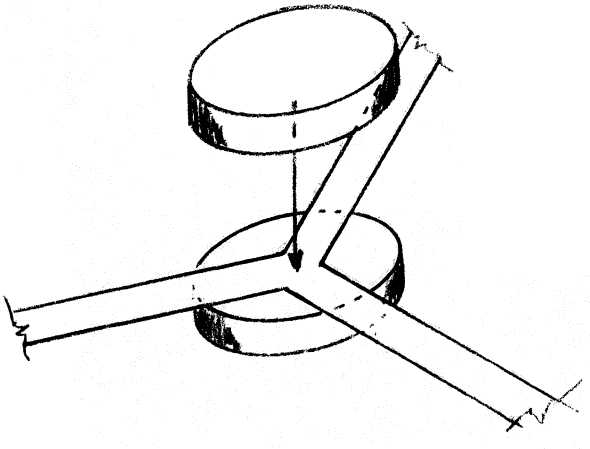
This report will describe the assembly and test procedure for the 4.5-5.0 GHz cryogenically-cooled circulator for the improvement of input and output match of FET amplifiers that we use in most of our receiver IF's.

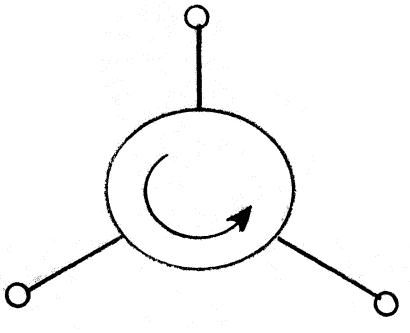
Introduction

Many of our receiver IF's are in the 4.5-5.0 GHz amplifiers. We are building FET amplifiers to replace the bulky and, at times, quite unstable parametric amplifiers that we have in these receivers. The input and output match to these FET amplifiers are very poor. To improve the match, the circulator is placed on the input and output of the amplifiers. In order to minimize the noise contribution by the circulator in a receiver, the circulators are cryogenically cooled to 20°K.

General Description of a Circulator

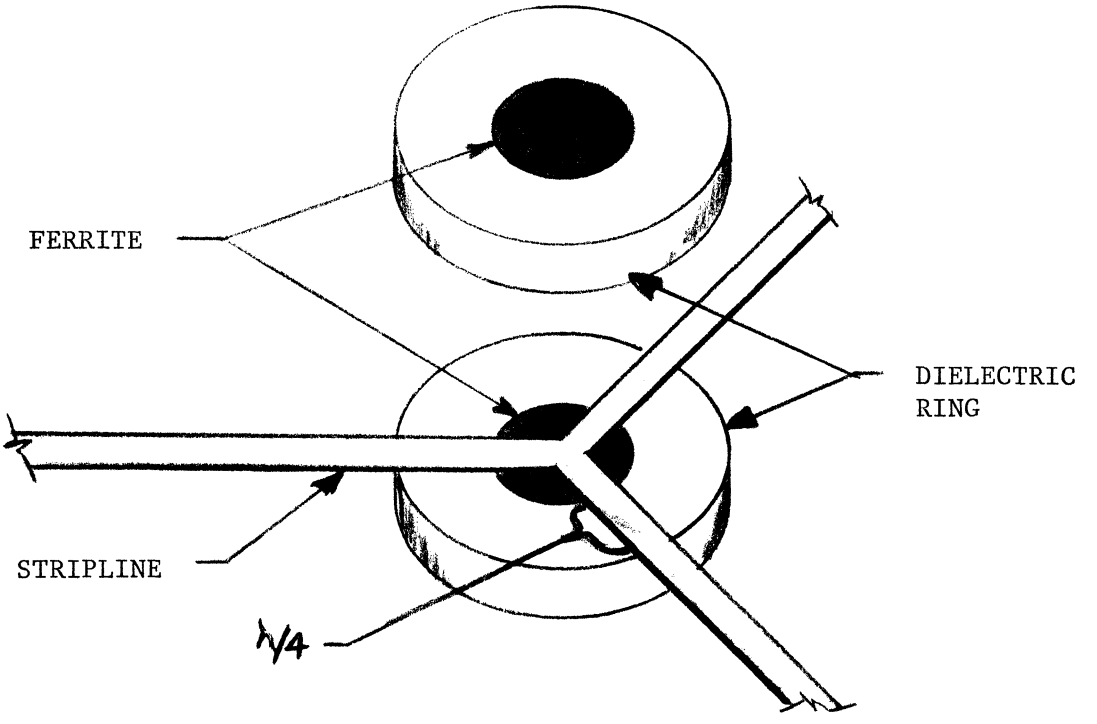
The circulator is a non-reciprocal device that presents very low loss in one direction for electromagnetic waves while presenting relatively high attenuation in the opposite direction. The ferrite discs are placed in the junction of three symmetric transmission lines spaced 120° apart. Circulator action is obtained by placing a proper magnitude of DC magnetic field along the axis of the ferrite discs.





SYMBOL

Although the ferrite is non-reciprocal, it does not represent a good match to the 50 Ω world that we establish in RF; therefore, we match into the ferrite with $\lambda/4$ transformers. In the Y junction circulator, this looks like a ring that surrounds the ferrite.



This particular circulator uses an aluminum-doped ferrite material with a saturation magnetization of 600 gauss at 25°C.

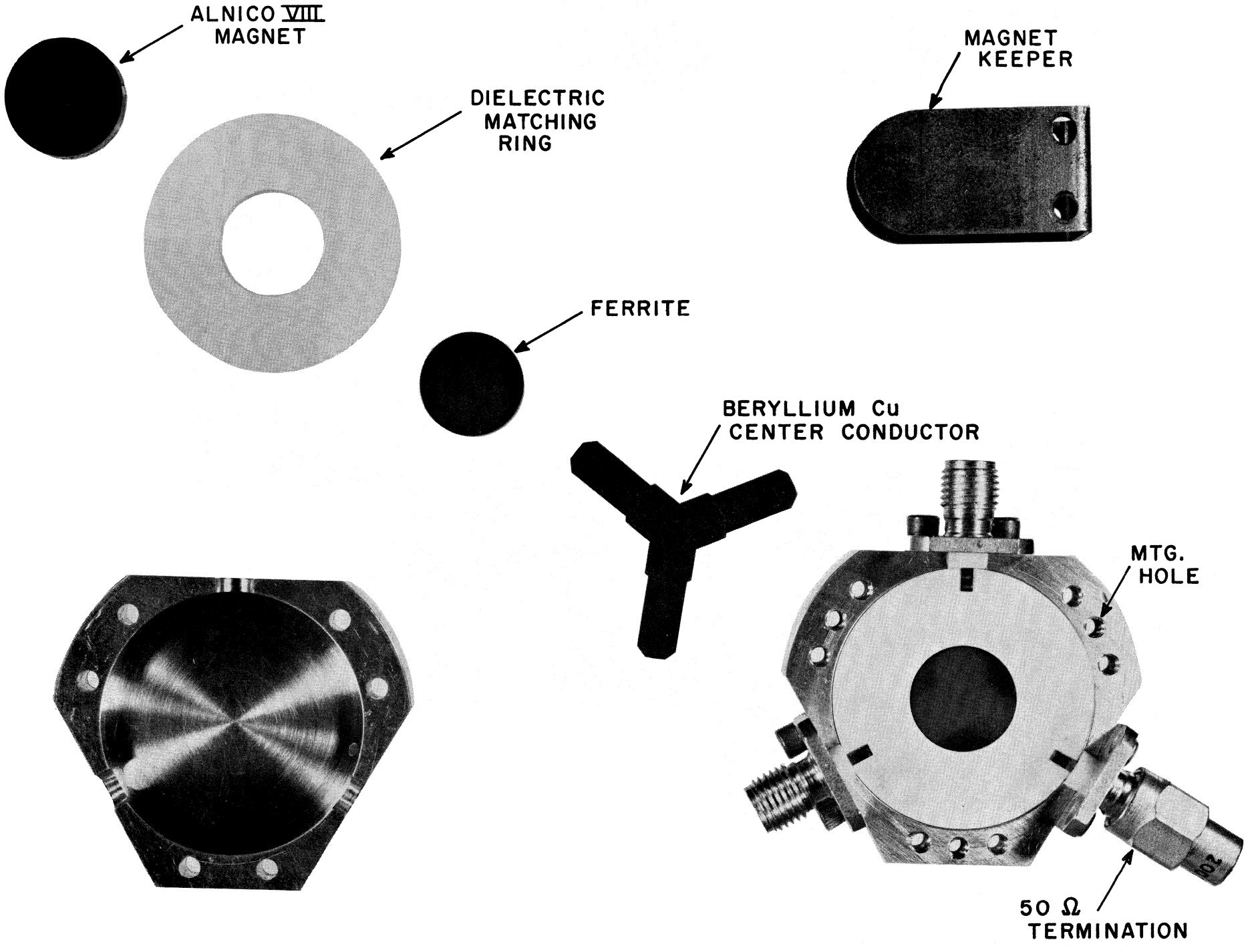
I have been most successful with Xtalonix Products (Crystal and Electronic Products Department) which is a division of the Harshaw Chemical Company located in Columbus, Ohio. The ferrite diameter is .435 inch x .100 inch thick. The stripline is etched out of 0.002 inch thick beryllium copper shimstock. The matching ring is made of polystyrene base filled with ceramic material known as "Stycase, High K Dielectric" with a dielectric constant of 4, manufactured by Emerson and Cummings of Canton, Massachusetts.

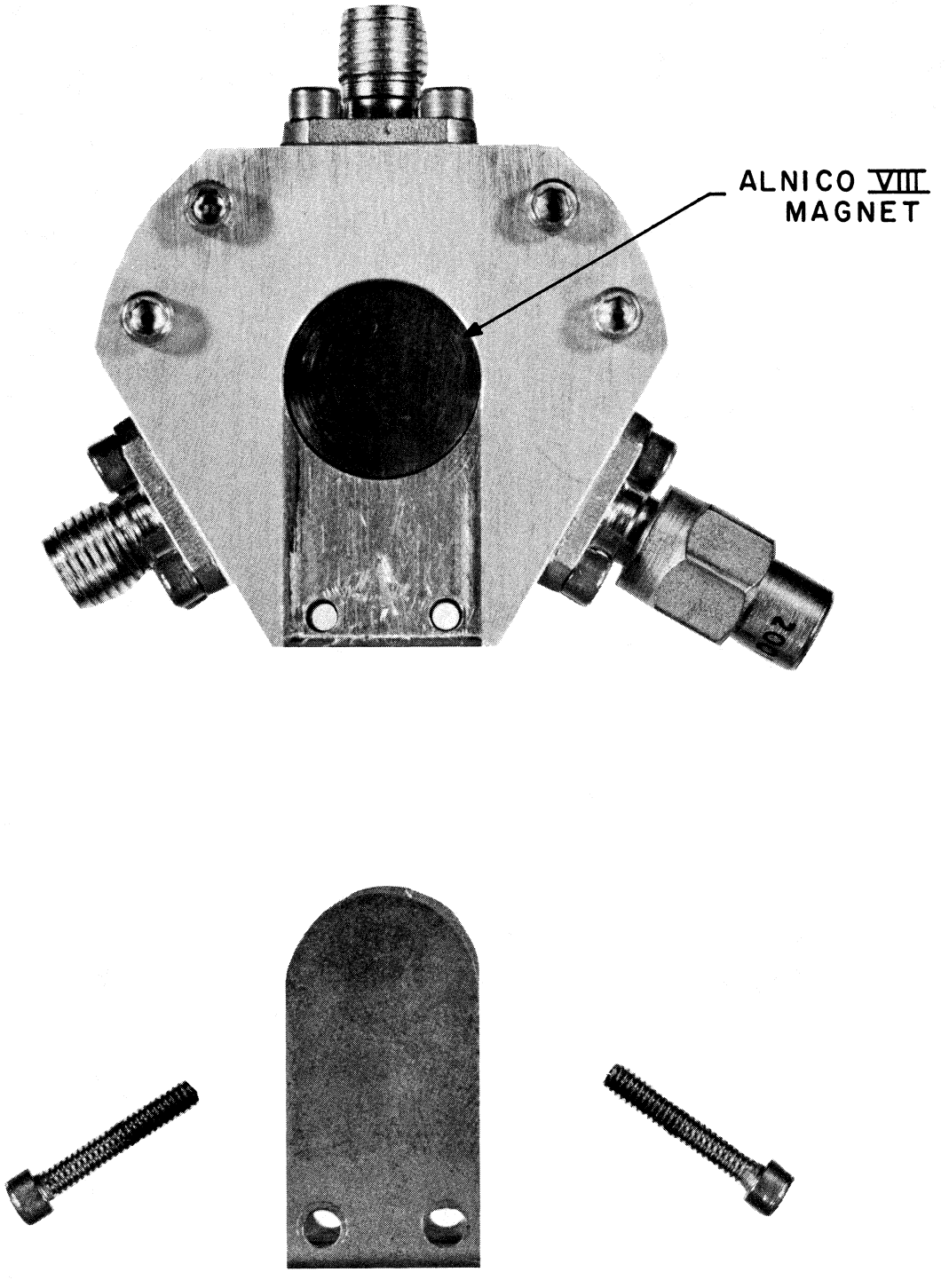
Assembly

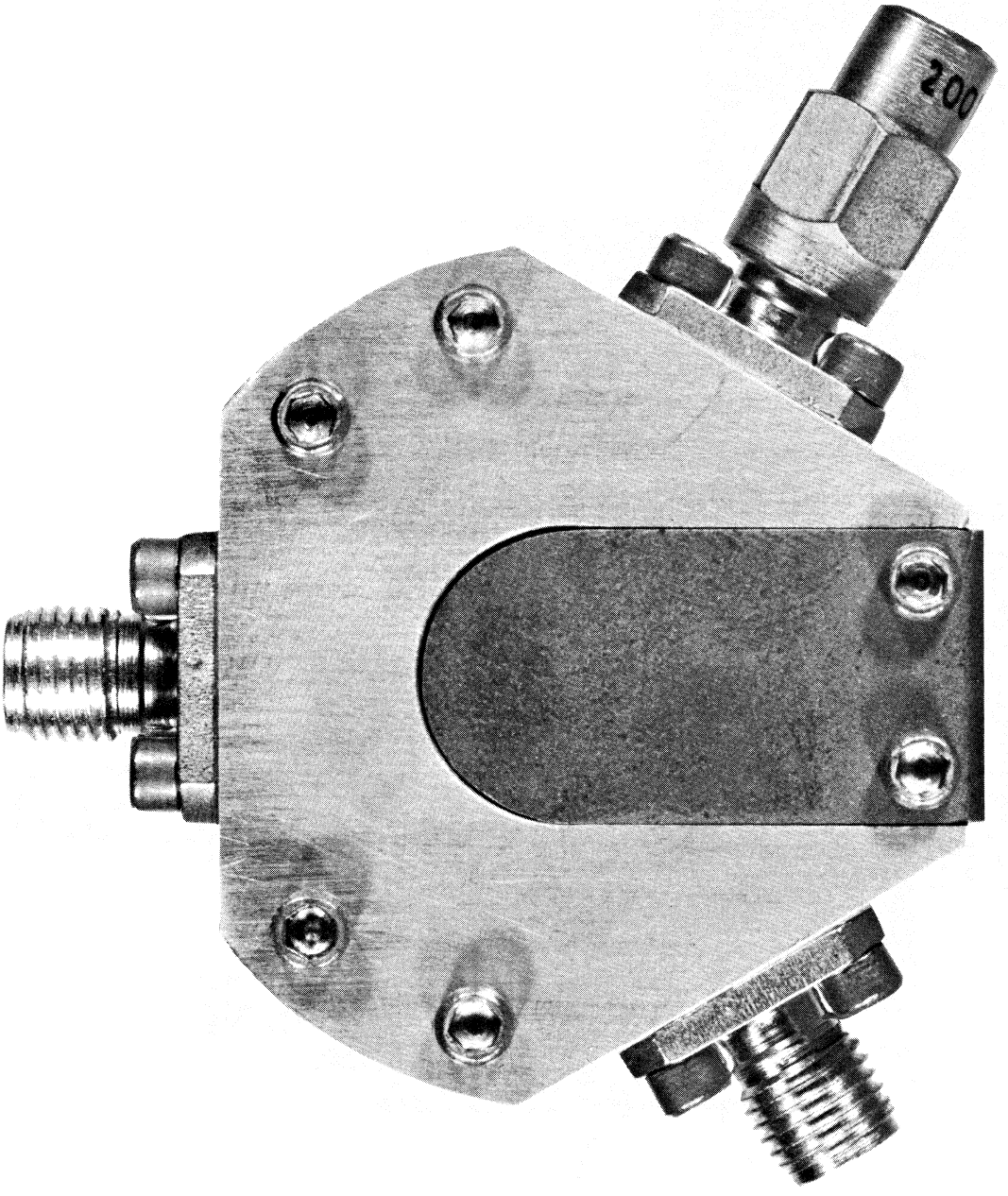
Insert the dielectric rings into the cavity of the two halves of the circulator housing. Insert ferrites into the center of the dielectric rings. Mount the three connectors to one side of the circulator housing. Place the stripline under the tabs of the connectors. Close the two halves of the circulator housing carefully by turning both up perpendicular and slide one half into place. Put in six 2-56 x 3/8 bolts into the housing and tighten down sequentially on the opposing corners. Place the two magnets in the cavities provided on the outside of the circulator housing. Slide the magnet keeper into place. Cool the circulator down to 20°K with external access to all three ports. The port with the best VSWR is used as the terminating port, and the worst one is used for the output of the circulator to the FET amplifier and the input of the circulator is the port with the mediocre VSWR.

Conclusion

There are approximately 20 of these circulators made thus far, and they all have better than 20 dB return loss over the 500 MHz band and insertion loss is approximately 0.25 dB.


ALNICO VIII
MAGNET
DIELECTRIC
MATCHING
RING
MAGNET
KEEPER
FERRITE
BERYLLIUM Cu
CENTER CONDUCTOR
MTG.
HOLE
50 Ω
TERMINATION


ALNICO VIII
MAGNET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