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A ROTARY JOINT FOR MODEL AN/SPS-3 (XDK) RADAR

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A ROTARY JOINT FOR MODEL AN/SPS-3 (XDK) RADAR

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March 16, 1950

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ABSTRACT

A rotary joint has been developed for the model AN/SPS-3(XDK) shipborne hemispheric-search radar. This joint is of the conventional TM_{01} circular waveguide type with slightly different matching devices for the two different wavelengths used by the system. Particular features are high power-handling capacity (600 kilowatts), low voltage-standing-wave ratio (less than 1.10) over the operating frequency range, and negligible rotation effect.

PROBLEM STATUS

This is a final report on the development of the rotary joint, a single phase of the over-all problem. Work is continuing on the remainder of the problem.

AUTHORIZATION

NRL Problem R02-23R
NR 502-230

A ROTARY JOINT FOR MODEL AN/SPS-3(XDK)

INTRODUCTION

The model AN/SPS-3(XDK) shipborne hemispheric-search radar[1] provides azimuth coverage of 360 degrees and elevation coverage from 0 to 80 degrees. A dual Foster scan is employed for elevation coverage. The angle from 0 to 40 degrees is covered by one scanner and the angle from 40 to 80 degrees by the other. Each of these scanners is supplied by a separate rotary joint for azimuth scan. The development of waveguide-type joints for this purpose is described here.

REQUIREMENTS

This system calls for the design of a rotary joint to carry the output power of a 4J78 magnetron (9003 to 9168 megacycles) and another to carry the output of a 4J50 (9345 to 9405 megacycles). The nominal peak-power output of these tubes is approximately 250 kilowatts. In order to insure an adequate safety factor and to permit increase of system power to 500 or 1000 kilowatts if the appropriate transmitter tubes should become available, every effort was made to design the joint to handle as much power as possible. For this reason, it was found necessary to utilize two slightly different designs, the only difference being the location of matching irises.

It is of course necessary that the joint should have a low VSWR, 1.15 being selected as the maximum permissible figure. In addition to this the VSWR and power transmission must remain constant with rotation.

DESIGN PROCEDURE

For reasons of simplicity and power-handling capacity a rotary joint of the TM_{01} circular waveguide type was selected. In this case the rotating section is a simple circular pipe which has a comparatively large diameter for these wavelengths and is therefore capable of carrying higher power without breakdown than the rectangular input and output waveguides. Usually metallic rings are placed in the circular guide and concentric with it to suppress the TE_{11} lowest mode. Such a device, termed a mode-filter ring, markedly reduces the breakdown voltage of the circular guide section. By properly selecting the diameter of the shorting horseshoe (Figure 1), it was possible to eliminate the mode-filter ring and obtain the attendant large power-handling capacity. In addition, all corners were rounded and sharp points eliminated to remove high field-gradients.

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[1] *Blake, L. V., Interim Report on Development of Model SPS-3(XDK) Shipborne Hemispheric-Search Radar, Naval Research Laboratory Report R-3165, August 27, 1947 (Confidential)*

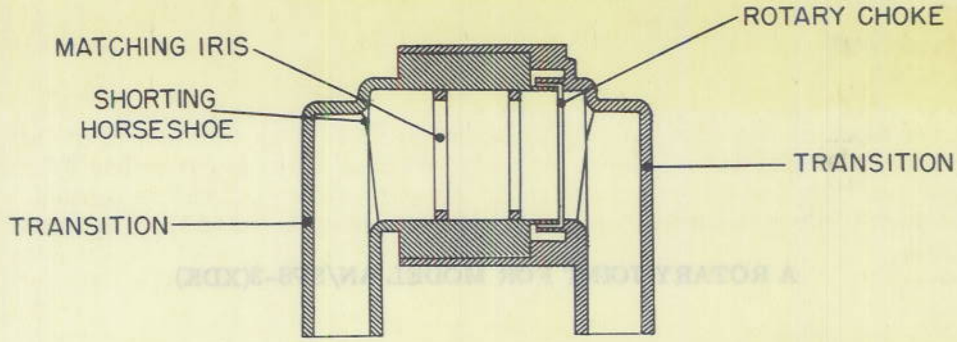

Figure 1 - Cross section of the rotary joint

Two identical transitions from 1-1/4-inch by 5/8-inch rectangular waveguide to 3-3/16-inch inside dimension circular guide are employed, and these, together with a choke-type rotating connection in the circular guide, make up the complete joint. A capacitive iris matches each of these transitions independently at the desired wavelength. In order to match impedance at 3.2 centimeters and at 3.3 centimeters respectively, it was necessary to locate the matching irises at slightly different points in the circular guide.

All dimensions including the iris positions for the two wavelengths are available at NRL.[2] No bearing design or other mechanical feature is included.

Figure 2 shows the rotary joint assembled, and Figure 3 shows it disassembled.

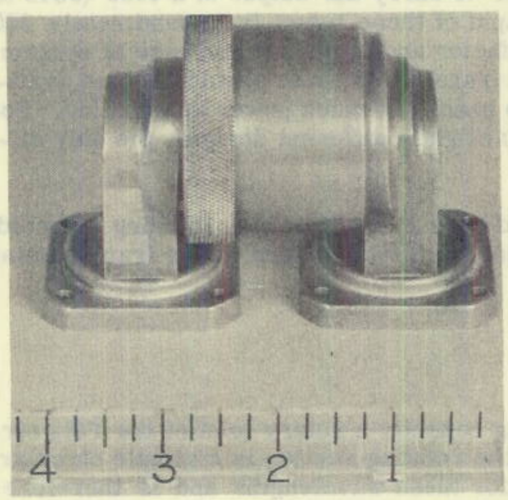

Figure 2

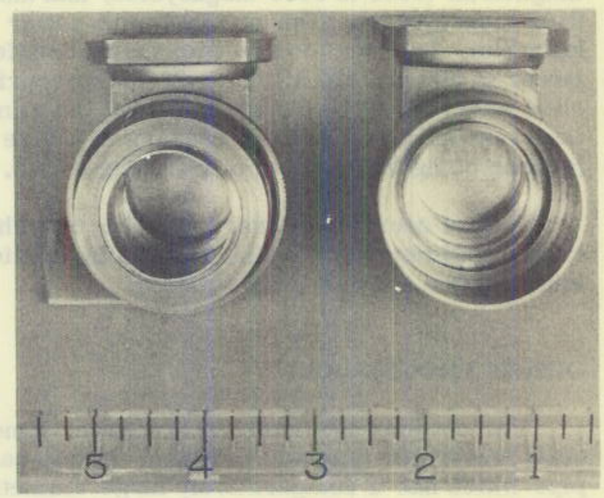

Figure 3

This rotary joint is of the type developed and designed at several laboratories in the past and is similar to those developed at MIT.[3] The one described here differs in no essential respect except dimensions (including choke dimensions) and the placement of matching irises.

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[2] *Naval Research Laboratory drawing RA62D450*

[3] *Ehlers, F. E., "E_0 Rotary Joints for the 3-Centimeter Band," Radiation Laboratory (MIT), Report 853, December 4, 1945 (Restricted)*

RESULTS

Rotation Effect

In order to check the effect of rotation, the input VSWR was measured for a number of different angular positions. The change in VSWR was never greater than 0.01 for full 360-degree rotation, and the output power did not vary by any detectable amount. Measurements were made at a number of frequencies covering the band from 8,800 to 9,680 megacycles.

Voltage Standing-Wave Ratio

The voltage standing-wave ratio was measured with the matching irises inserted in the two positions. Curves of VSWR versus wavelength are reproduced in Figure 4. With irises placed for 3.2 centimeter operation the VSWR is less than 1.15 from 3.075 centimeters to 3.265 centimeters, and does not exceed 1.05 for any frequency within the tolerance limits of the 4J50 magnetron. With irises placed for 3.3 centimeter operation the VSWR is less than 1.15 from 3.255 centimeters to 3.35 centimeters and does not exceed 1.10 for any frequency within the tolerance limits of the 4J78 magnetron.

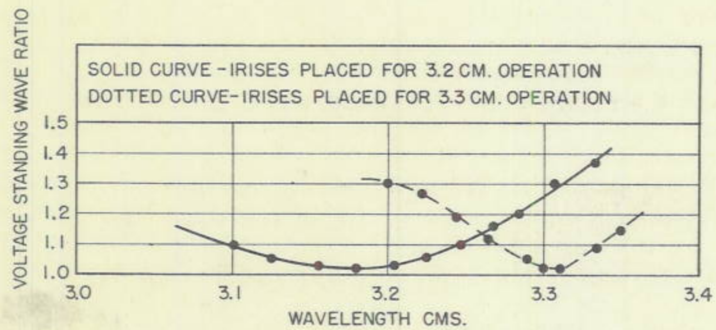

Figure 4 - Voltage-standing-wave ratio

Power-Handling Capacity

Power-handling capacity was tested by supplying the output from a 4J50 magnetron, about 250 kilowatts, to a water load through the rotary joint. The effective power available was increased by setting up a standing wave of adjustable phase, in which case the effective power at the electric field maximum is equal to the product of VSWR and the power supplied to the water load.

The joint carried an equivalent power of 600 kilowatts, the maximum effective value available from the experimental setup, with no sign of breakdown. It therefore seems justifiable to conclude that it will handle peak power in excess of 600 kilowatts.

CONCLUSIONS

The rotary joint described above appears to satisfy the requirements fully as regards to VSWR, negligible rotation effect, and power-handling capacity. Correct placement of the matching irises for either wavelength provides a considerably greater bandwidth than is required. The joint is capable of carrying more than twice the power currently available.

This bandwidth and power-handling capacity provides considerable latitude for utilizing greater transmitter power as it becomes available.

ACKNOWLEDGMENT

Acknowledgment is made to Mr. J. A. Kaiser for his assistance in carrying out the experimental work of this project.

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