NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

ELECTRONICS DIVISION TECHNICAL NOTE NO. 162

Title: **Assembly of 200-290 GHz Frequency Triplers**

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Date: August 28, 1990

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Assembly of 200-290 GHz Frequency Triplers

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This technical note describes in some detail the assembly of NRAO 200-290 GHz frequency triplers designed by John Archer [1]. By carefully controlling the cross section of the diode chip as well as the whisker post protrusion, choke protrusion and whisker length, consistent tripler performance can be obtained.

At NRAO there are two different mechanical configurations of this tripler. The first is the original Archer design (with "T- " serial numbers). The second configuration is the "Mirror Image" (or "left handed") version (with "ST- " serial numbers), made to replace the non-standard triplers currently used in the 225 GHz site test receivers [2]. The output waveguide position and the position of the bias connector have been mirrored about the center line of the pump waveguide.

The machinist's working drawings are the only prints that completely and accurately describe the T-series tripler hardware now in use. These are dated November 1983, but have several changes written in. These drawings are a little difficult to read. The only (intentional) differences between the new design and the T-series design are that when the tripler is held with the output waveguide flange facing toward you and the pump input guide flange facing to the left, the bias connector will be on top (rather than on the bottom) and the output guide will be above the center line (rather than below it). The substrate, the backshorts, the bias connector and the original backshort micrometer mounts were not redesigned, so no new prints were made. The micrometer mounts hold Starrett 261L micrometers.[1]

Fabrication of the output backshort is described in Archer's *MTT* paper [1]. Recent experience has shown that one must be rather careful in compressing the loop at the end of the output short; if the short fits easily in the guide, the tripler does not work well. The triplers seem to work best when the output shorts are very tight -- almost peeling the gold plating inside the waveguide. The fit is right when it is somewhat difficult to move the short with your fingers, but easy to move the short when using the micrometer.

The substrate was designed to be a little too long so the first section of the choke could be trimmed to compensate for the fringing capacitance of

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[1] Recent data indicates that the new, mirror imaged design indeed performs as well as the original design. Several units have been tested (one of which was tested over a wide frequency band), and the data are encouraging. Compare Fig. 3 to Fig. 2. The ST-triplers also are a mechanical success, fitting well into the site test receivers.

the diode chip. The substrate must be trimmed so that the first choke section is 8.5 mils long, making the overall substrate length 92 mils.

Figure 1 is a sketch showing the post and choke protrusion as well as the diode chip size. 5M2 varactor diodes from the University of Virginia Semiconductor Device Lab are used. The chip face of a 5M2 diode (which contains the anodes) is about 3 x 5 mils, but must be trimmed so the face is 3.5 mils wide x 2.5 mils high. The 2.5 mil chip height is particularly important; chips 3 mils high often short against the waveguide block! (The stripline channel is 6.5 mils deep and the substrate is 3 mils thick, leaving only 3.5 mils for the chip, solder and tolerances.) The chip length -- the dimension perpendicular to the face containing the anodes -- is not particularly important. It is shown as 2.5 mils in the sketch.

We have made 13 triplers using this configuration, carefully controlling the chip size as well as the whisker length, chip and post protrusion. Of these 13, 4 had bad contacts and, in one, the output waveguide wore badly. The performance of the remaining 8 is shown in Figure 2. Of these 8 triplers, 5 produced 1 milliwatt or more output power from 71-95 GHz (pump frequency), often with 2 mW or more from 75-79 GHz (when pumped with 50 milliwatts). One of the 8 dropped to .7 mW output power at 84 GHz pump and another dropped to about .8 mW at 85 GHz, but both otherwise produced 1 mW or more from 69-94 GHz. Only 1 of these 8 triplers was considered a "failure"; it had a large hole from 81-86 GHz where it produced less than 1 mW output.

These triplers will produce usable tripled power at output frequencies above 290 GHz. Sometimes they will produce a milliwatt or so at 300 GHz, but a cutoff waveguide must be added to the output port when using pump frequencies above 95 GHz (285 GHz out). This "high frequency" performance is not as repeatable as the performance over the 200-290 GHz band.

References:

[1] John Archer, "An Efficient 200-290 GHz Frequency Tripler Incorporating a Novel Stripline Structure," *IEEE MTT*, vol. MTT-32, pp. 416-420, April 1984.

[2] Zhong-Yi Liu, "225 GHz Atmospheric Receiver - User's Manual," NRAO Electronics Division Internal Report No. 271, August 1987.

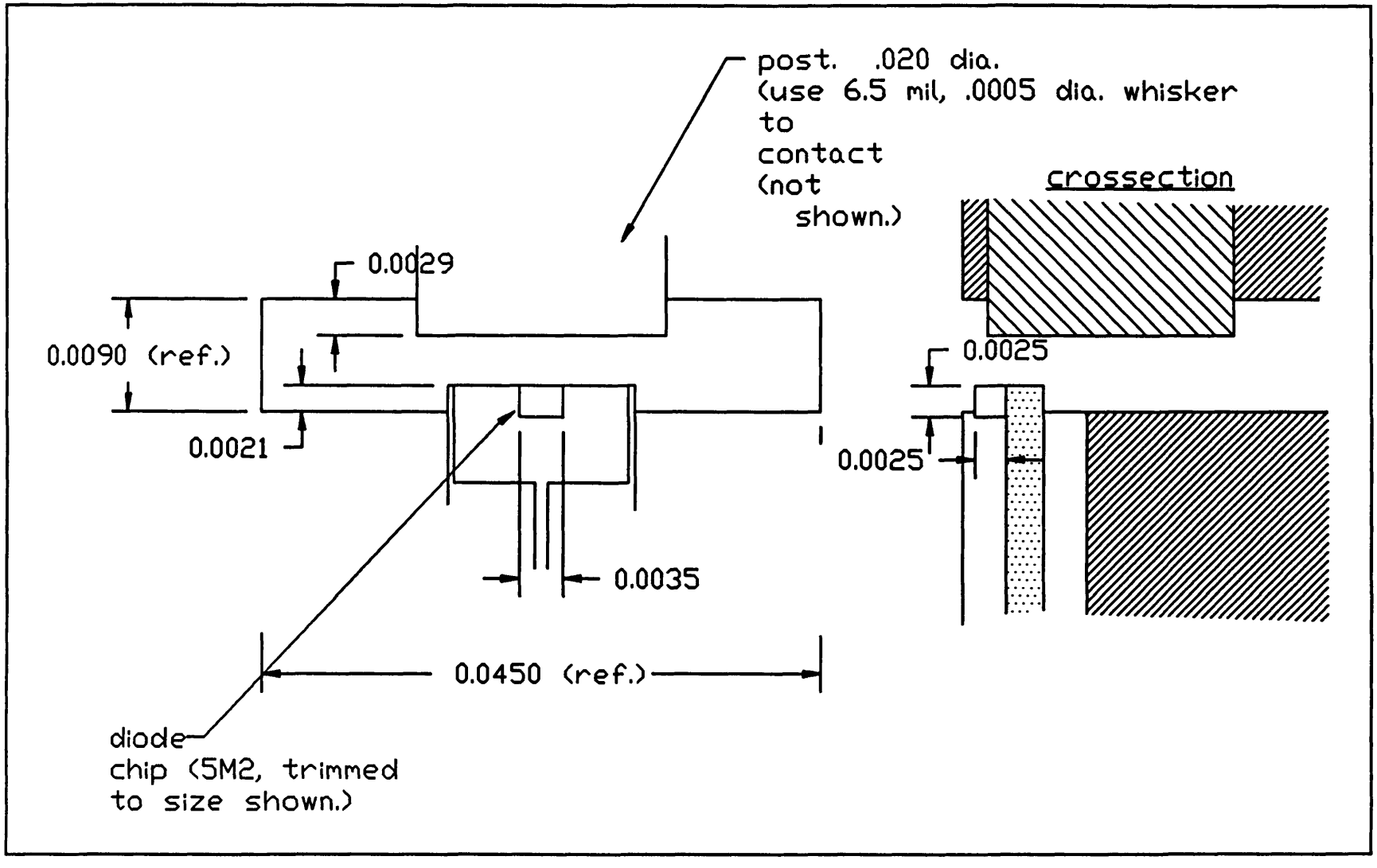

Fig. 1. Details of the diode contact area.

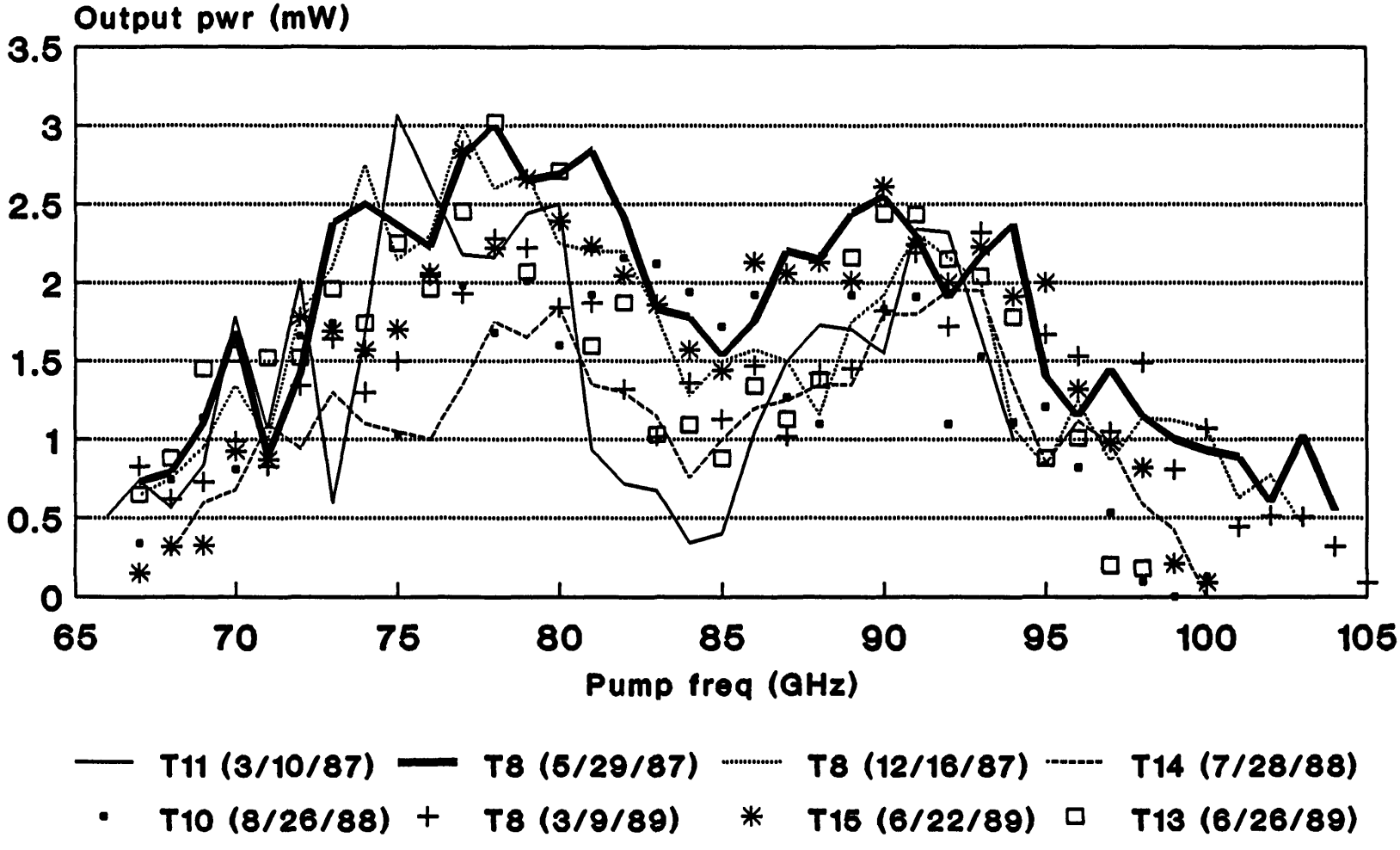

Fig. 2. Tripler output power vs. pump frequency for eight good triplers. The pump input power is 50 mW. (In cases where 50 mW pump was not available, a linear interpolation was made to "correct" the data). The cutoff waveguide was added at pump frequencies at or above 95 GHz.

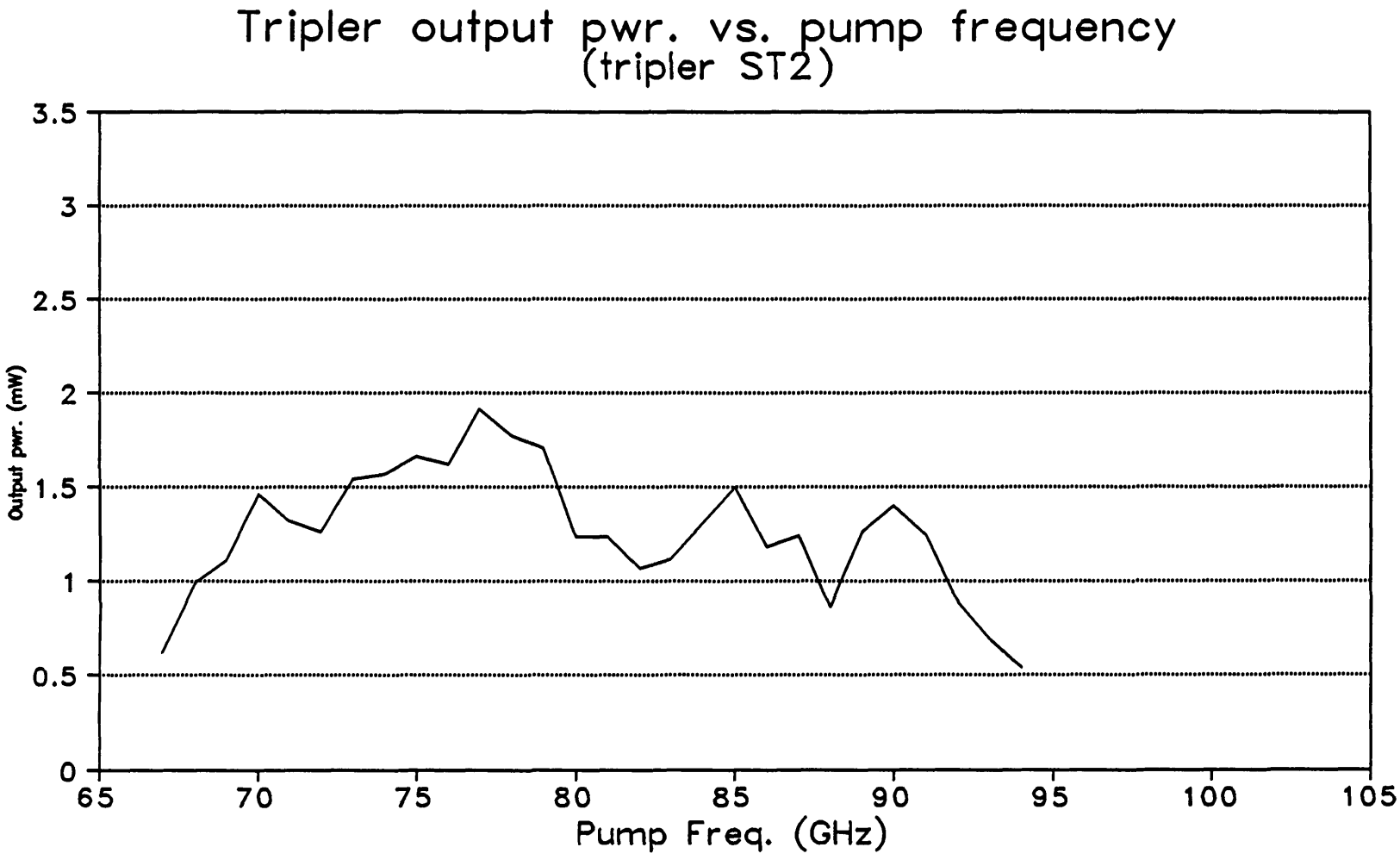

Fig. 3. Tripler output power vs. pump frequency for a mirror image tripler (ST-2). The pump input power is 50 mW. (In cases where 50 mW pump was not available, a linear interpolation was made to "correct" the data).