

CONFORMAL MICROSTRIP ANTENNAS

Robert E. Munson
Director of Advanced Programs
Ball Aerospace Systems Division
Boulder, Colorado

ABSTRACT

Microstrip antennas are ideal for telemetry applications, especially when a low profile thin conformal antenna is desirable. This paper discusses omni wraparound, directional fixed beam, and conformal electrically scanned microstrip antennas.

INTRODUCTION

During the past fifteen years, Ball has developed many telemetry antennas for missiles and ground stations. It is now possible to project a complete system of antennas for both transmit (on the missile) and receive (for the ground station), both ends of the link consisting of conformal microstrip arrays. This paper will discuss each type of antenna with regard to prior technology, present technology, and future technology.

The Airborne Transmit Telemetry Antenna for Missiles, Satellites and Projectiles

Prior Technology - For most cylindrical vehicles such as satellites and missiles, an array of 2, 3 or 4 discrete radiators (whips, blades, cavity backed slots, planar spirals, etc.) is an obvious way to achieve omnidirectional coverage from an airborne vehicle. The problem is that these discrete radiators will form an interferometer pattern in the roll plane of the vehicle. Many deep interference holes in the antenna pattern interrupt telemetry and disrupt tracking.

Present Technology - A continuous radiator, Figure 1, fed with a uniform phase and amplitude electric field will result in a uniform roll plane pattern with as small as 1 to 2 dB roll plane ripple. Ninety-nine percent spherical coverage with gain greater than -8 dBil is common. The simplicity and thinness of a monolithic microstrip antenna, as in Figure 1, results in an antenna ideally suited to a multitude of telemetry applications. This has already been demonstrated on more than 200 different satellites, missiles, and gun launched projectiles. Range operators have experienced tracking and telemetry from longer ranges than possible with the discrete radiator approach. Since all the microwave

components are photo etched from one side of one printed circuit board the resulting design is low cost, reliable, and conformal.

Future Technology - This technology is well developed and will probably see little change in the future with the exception of discrete amplifier and phase shifters being applied to the airborne antenna where increased link margins are required. Usually the increased gain will be attained in the ground or mobile receive telemetry antenna because the investment is not lost with each flight. A discussion of conformal phased arrays follows in the next section.

The Ground or Mobile Receive Telemetry Antenna

Prior Technology - Most ground station parabolic reflector antennas are mounted on gimbal drive mechanisms. They are equipped with a conical scan or monopulse feed that points the peak of the beam to receive maximum signal.

An example of a mobile receive telemetry antenna is a horn antenna placed behind the window on a P-3 Aircraft, Figure 2, location C. The aircraft is maneuvered so that the missile or re-entry vehicle is in the main lobe of the horn.

Present Technology - The antennas at locations A and B, Figure 2, are conformal microstrip arrays that provide additional receive gains of about 10 dB. All of the radiators, feed network and phase compensation networks (to compensate for the curvature of the aircraft) are photo etched from one side of a 1/16" printed circuit board. Antenna A is covered with a thin laminated teflon fiberglass radome, and Antenna B is painted to match the star. This antenna is pointed by flying the aircraft to point the antenna beam in the direction of the missile or re-entry vehicle. Antennas A and B are vertically and horizontally polarized, respectively, and provided 24 dB gain. The feed network, which is monolithically photo etched on the same surface as the radiators, provide phase compensation for the curvature of the aircraft, as shown in Figure 3.

Future Technology - Figure 4 is a conformal microstrip phased array. This array consists of a 16-way power divider, 16 radiators, and 16 three bit phase shifters. The phase shifters allow the receive antenna beam to be electrically pointed with the addition of 1 dB of loss. The antenna in Figure 3 is 1/32" thick but this does not include the beamsteering electronics required to control the phase shifters. This circuitry typically increases the thickness of the antenna to 1 or 1 1/2 inches, Figure 5. This type of antenna can be applied to the outside of an aircraft without significant protrusion into the airstream or intrusion into the skin or structure of the aircraft. The received antenna gain at broadside will be approximately:

$$G = 10 \log \left(4\pi \frac{H \cdot W}{\lambda^2} \right) - 1 \text{ dB} - \frac{.4 \text{ dB}}{\text{foot}} \cdot \frac{1}{2}(H+W) - .5 \text{ dB}$$

| | | | |
|------------------------|--------------------------|---|------------------|
| ↑ | ↑ | ↑ | ↑ |
| Antenna Directivity | Phase Shifter Loss | Monolithic Feed Network Loss at 2.2 GHz | Radiator Loss |

H = height in feet

W = width in feet

λ = wavelength in feet

The gain will fall off approximately as $10 \log \cos^{3/2} \theta$ as a function of scan angle θ away from broadside.

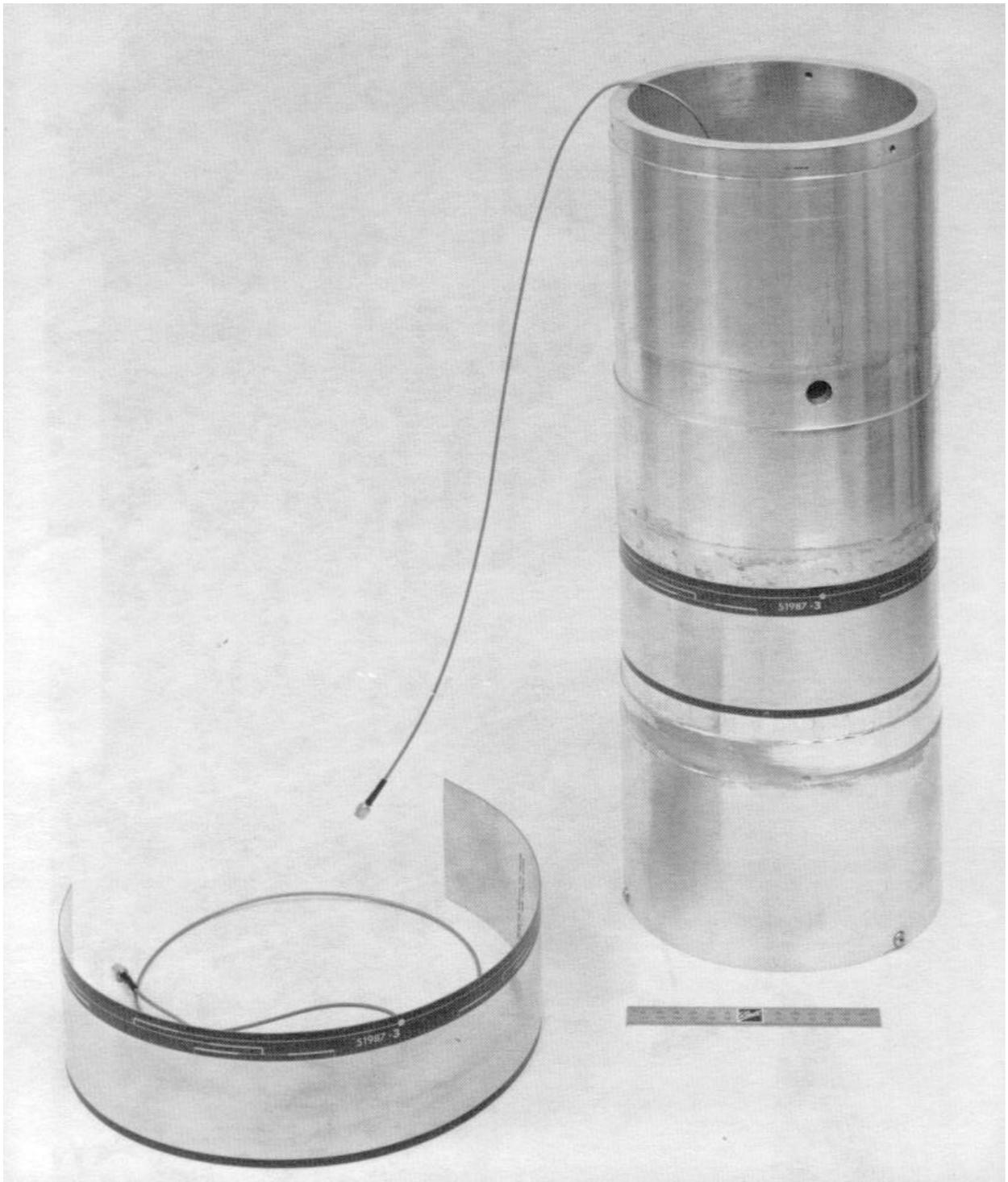


Figure 1. Omni Wraparound Conformal Telemetry Antenna



Figure 2. Conformal Microstrip Mobile Receive Telemetry Antenna Mounted on P-3 Aircraft

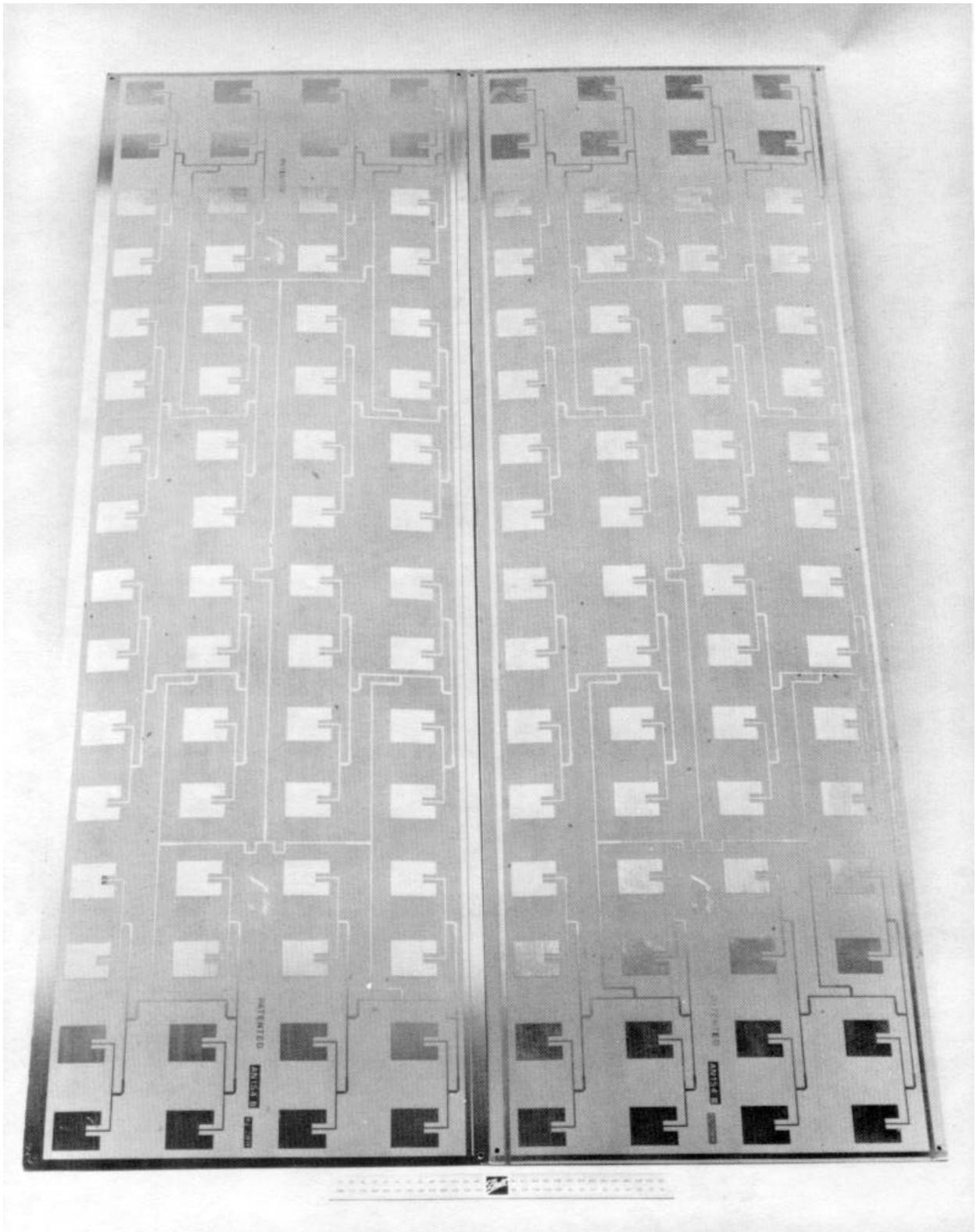


Figure 3. Conformal Microstrip Antenna Shown in Figure 2A and 2B before Application of Radome or Star

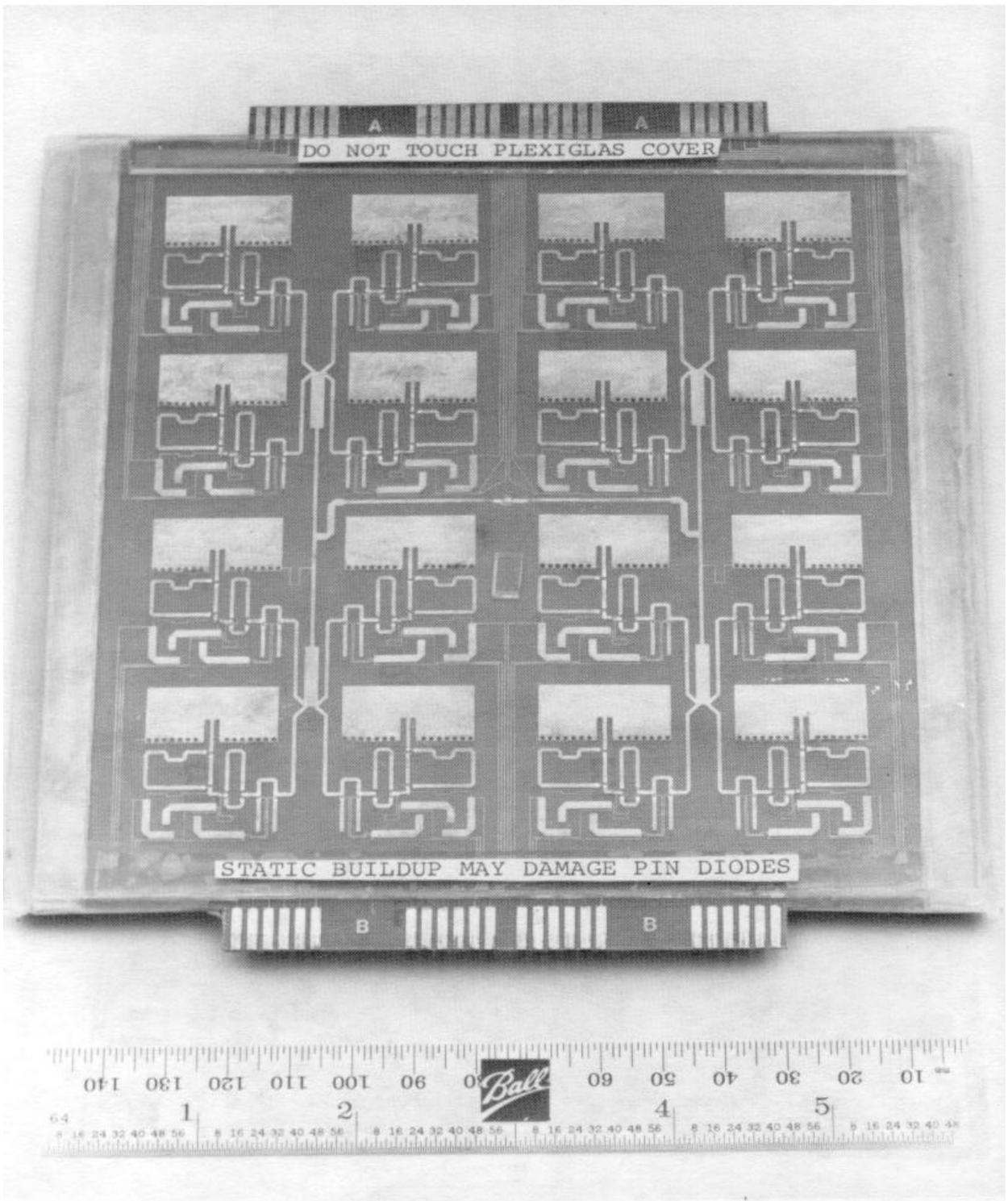
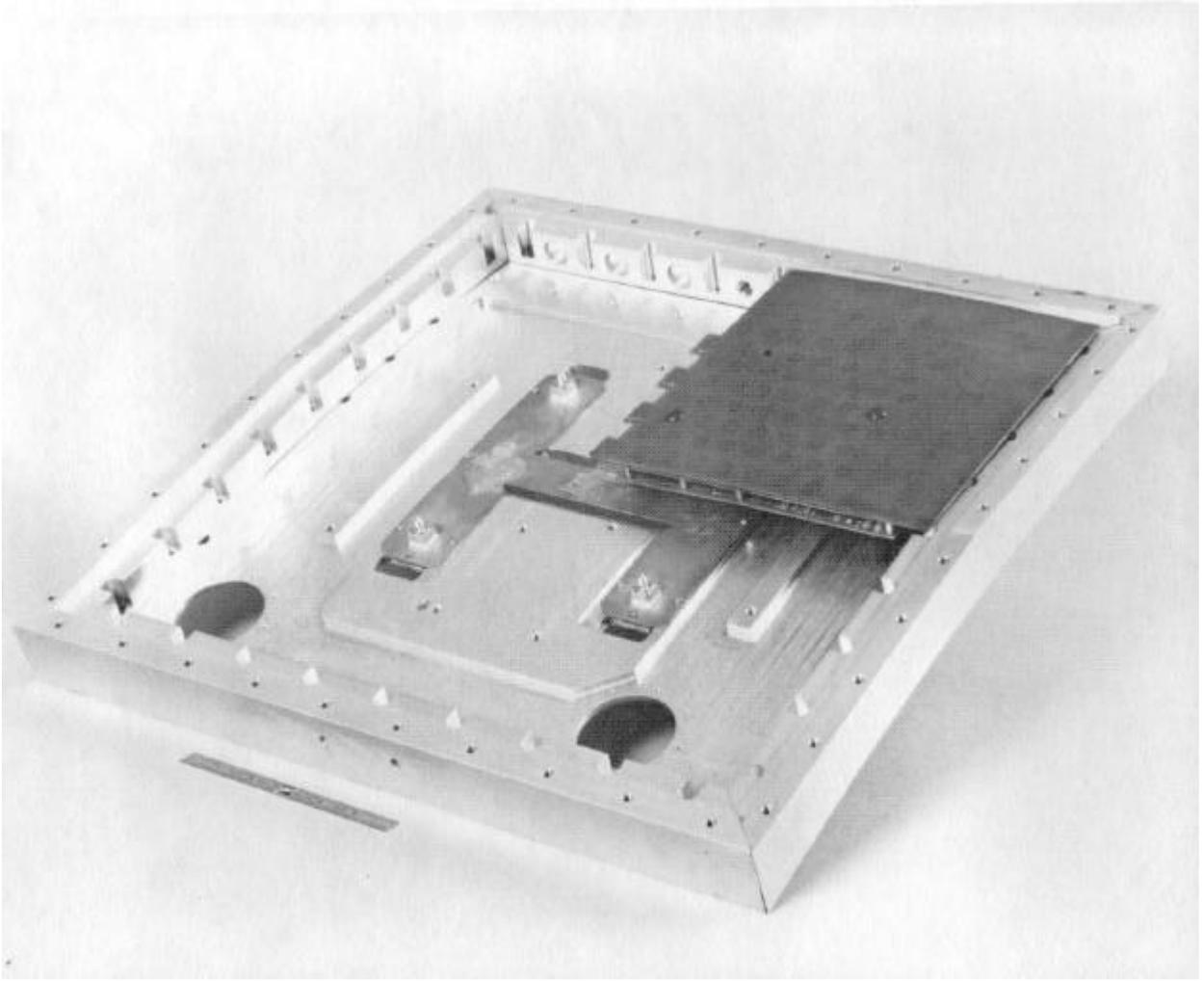


Figure 4. A Conformal Microstrip Phased Array



**Figure 5. A 256-Element X-band Conformal Phased Array.
(Only one tile containing 64-radiators covered with thin radome is shown)**