Radio Amateur Moonbounce

A Nostalgic Look Back at the Early Days

(Before WSJT)

Gordon Pettengill - W1OUN/KP4BPZ

Moonbounce Radar Equation

Transmit power: P_t

with antenna gain: G_t

R~240,000 mi;

Flux at Moon
$= P_t G_t / 4\pi R^2$

MOON

Radar cross section
$\sigma = 0.07\pi a^2$

Receiving antenna
capture area: A_r

$$P_r = P_t G_t A_r \sigma / (4\pi R^2)^2$$

Using the radar equation, we can calculate the lunar echo strength

- Note: effective antenna capture area is related to gain by: $A = G\lambda^2/4\pi$ (λ is wavelength)

- Putting in the numbers for moonbounce at 2 meters, then, we get for the received power: $P_r = P_t G_t G_r \lambda^2 \sigma / 64\pi^3 R^4 = \sim 6 \text{ x} 10^{-26} P_t G_t G_r$ watts

- Now, returning echo power must compete with receiver noise power: $P_n = kTB$, where k is Boltzmann's constant, T is total receiver noise temperature (system plus sky, in Kelvins), and B is the receiver bandwidth.

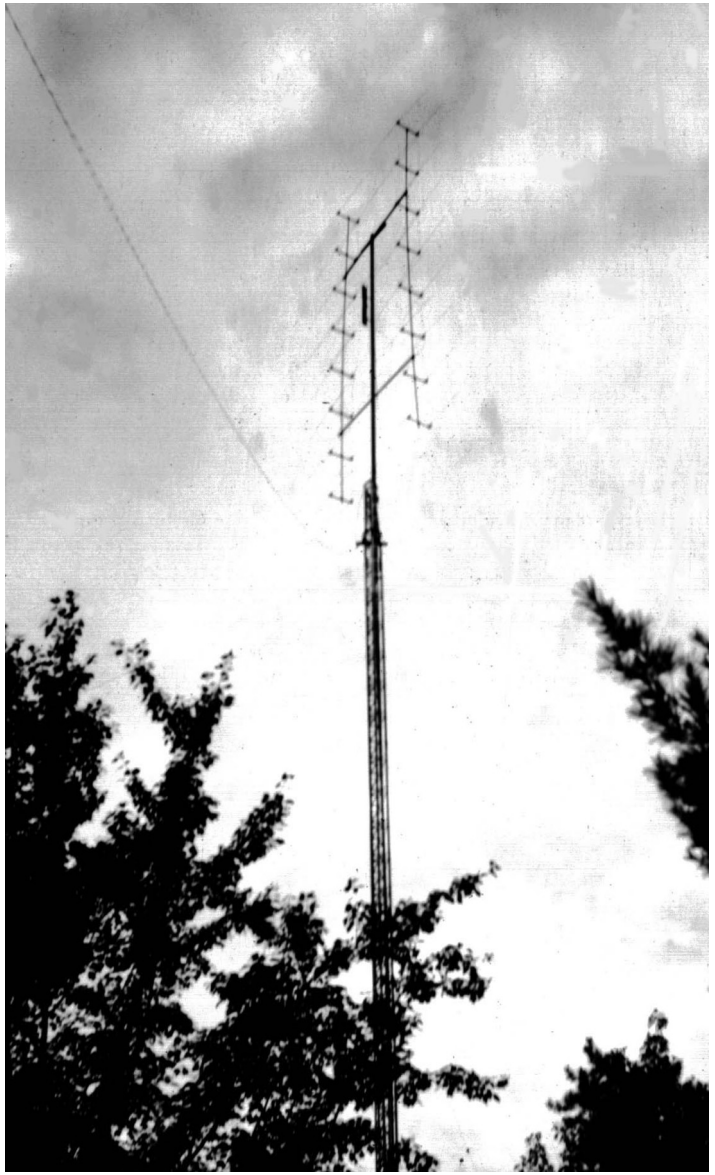
What does it take to do moonbounce at 2 mtrs?

- Assume:Transmitted power of 700 watts;
  Receiver system + sky noise of 150K;
  Receiving bandwidth of 100 Hz;
  Post-detection integration of 1 sec;

- Putting in numbers says for a reliable detection (5 std devns above noise background), we need G_tG_r= 2000, or a pair of beams each having a gain of ~16 dBi – approximately what a 32-element broadside array provides.

Hearing Your Own Lunar Echo

- A group of us young hams centered around Sam Harris, W1FZJ, became interested in moonbounce around 1957.
- We used the fact that it takes 2.5 secs for the echo to come back, to listen to our own signals.
- Initially, we used Sam's existing 32-element 2-meter array to observe the moon as it rose or set on the local horizon (since we didn't have an elevation control!). Results were marginally successful!



The Rhododendron Swamp VHF Society

- It was around this time that Sam founded the Rhododendron Swamp VHF Society, located at his isolated multi-acre spread off Causeway St in Medfield, Mass.
- He managed to convince the FCC that we should be assigned the call W1BU (despite some complaints from the Boston University Amateur Radio Club!)

Tracking the Moon Full-Time!

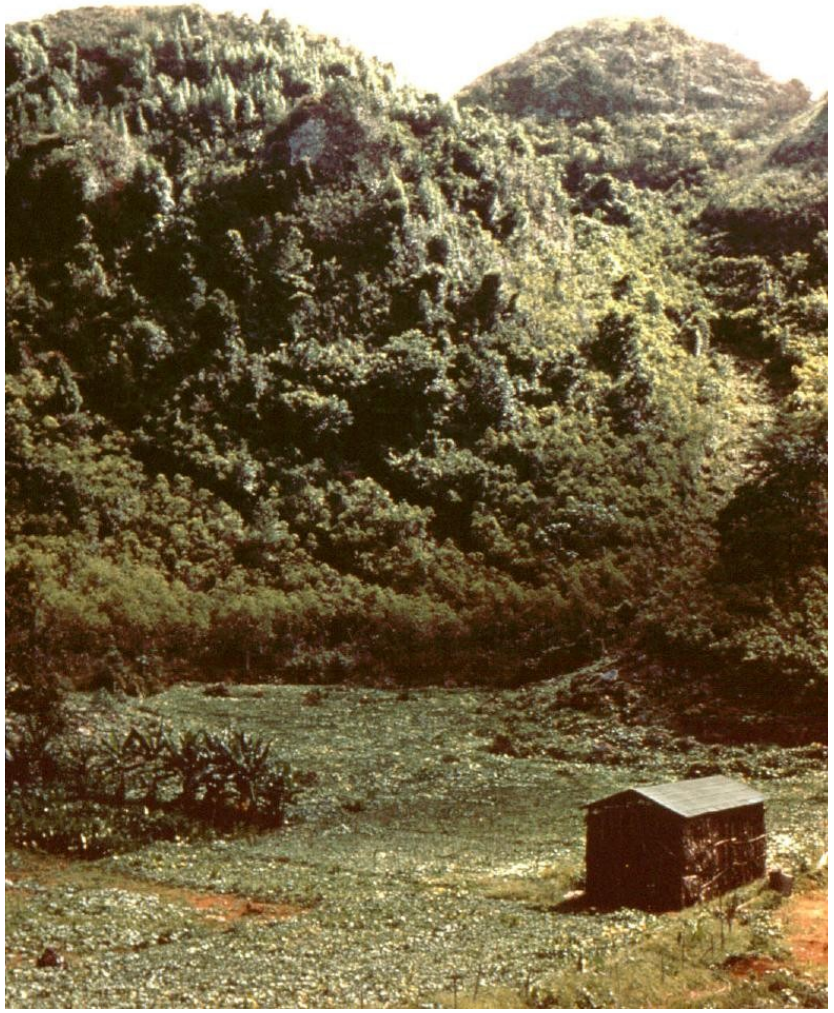
- Over the next few years, Sam managed to build a 64-element 2-m array that could be tilted in elevation and swung on tracks in azimuth.
- Meanwhile, he had found a 10-ft dish to use at 432 and, eventually, at 1260 MHz, as well.

Carrying the High-Voltage Transformer

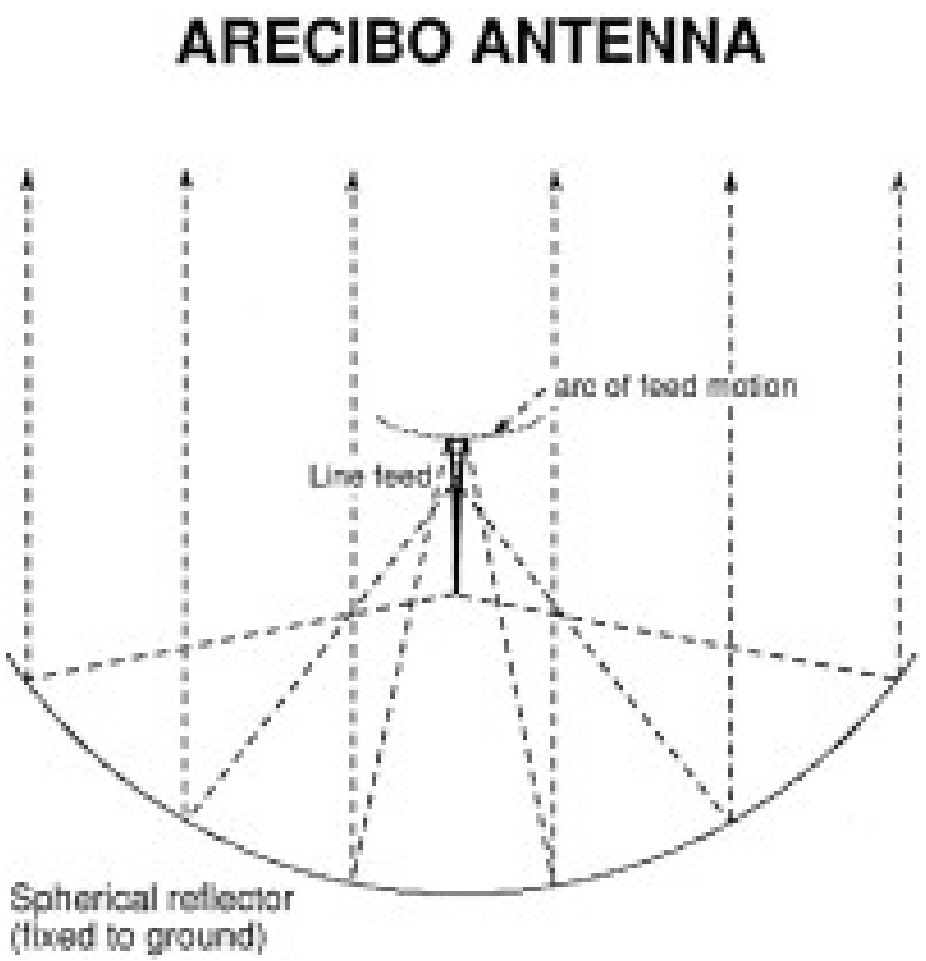
- This is a view of the W1BU antenna farm in August 1960, during the construction of the 432 MHz transmitter. Note the rails providing azimuth motion for the 2-m array

The 1000-ft Arecibo Antenna

- About this time, in June 1960, I first visited the site of the future 1000-ft Arecibo Ionospheric Observatory in Puerto Rico. It was a tobacco farm, located in a natural cavity formed by eroded limestone (geologically called “Karst”).



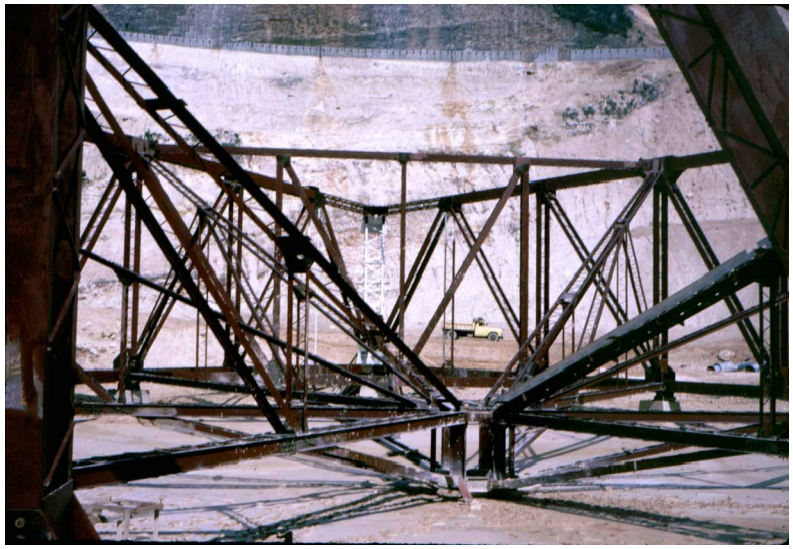
How a Spherical Reflector Works



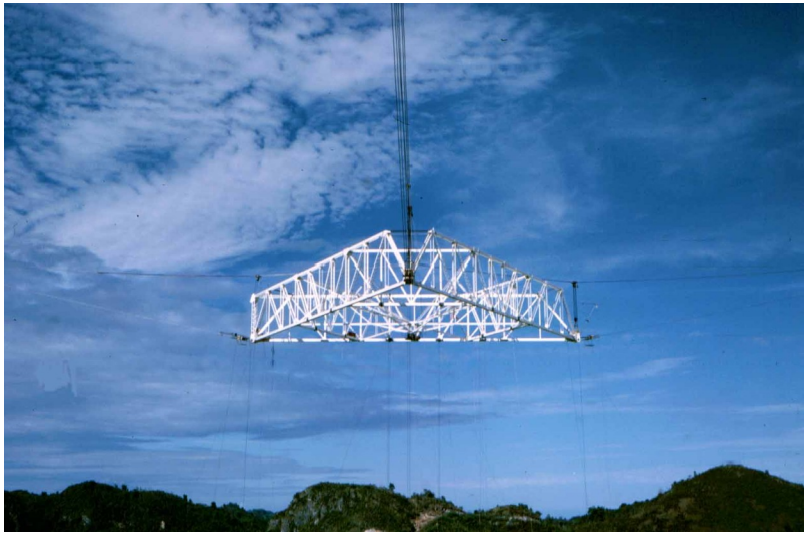
- Showing how the rays reflected by a spherical surface from an incident plane wave come together at different points along a “focal line.”

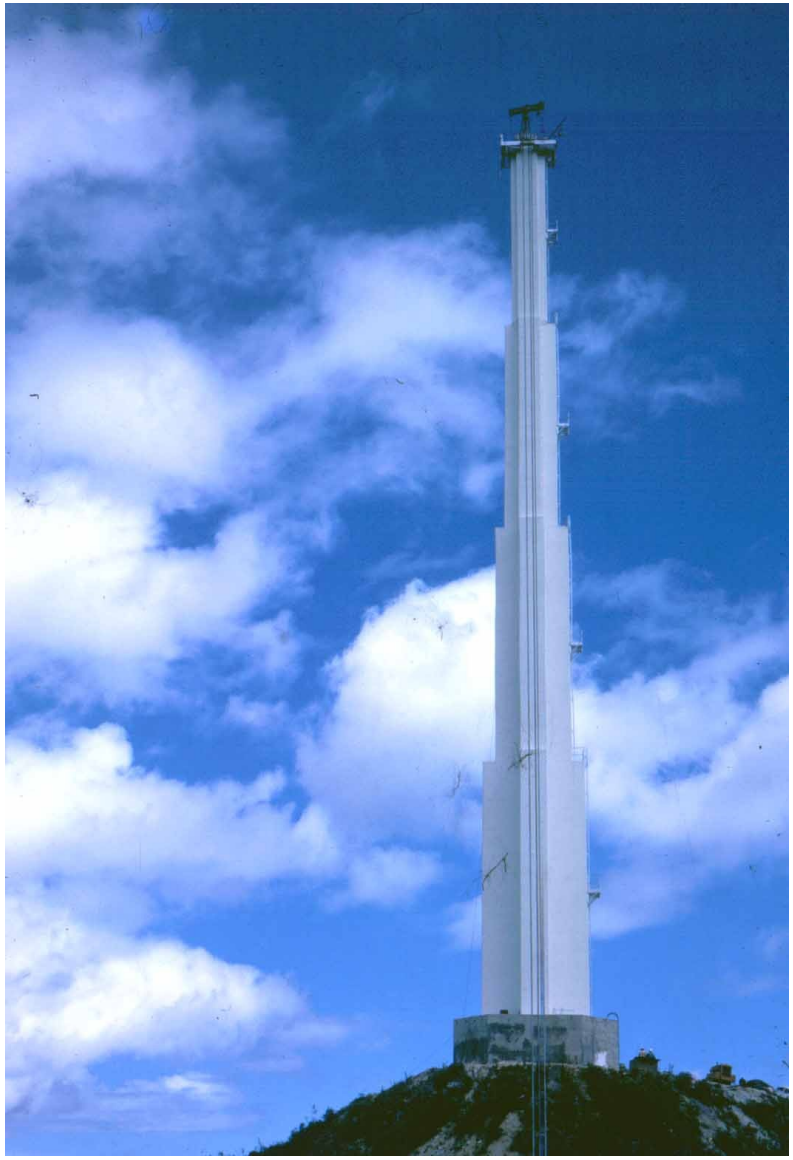
1000′ Spherical Arecibo Reflector in 1963

Arecibo Construction, 1961

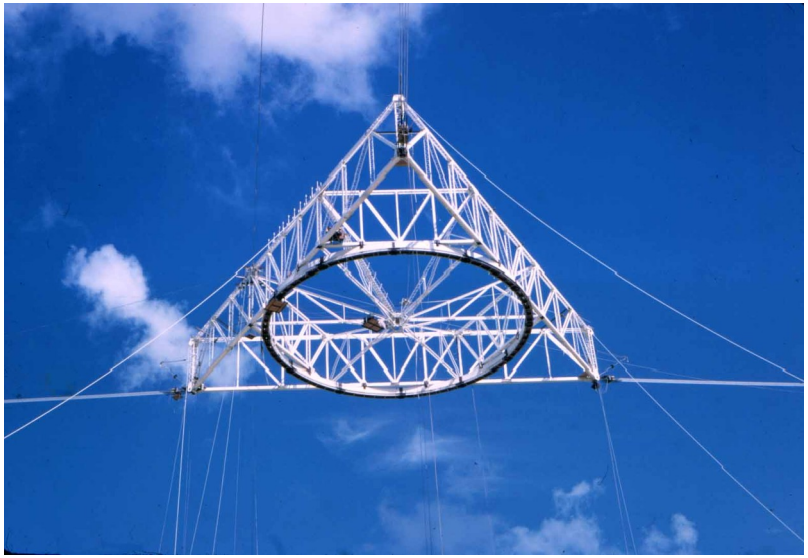


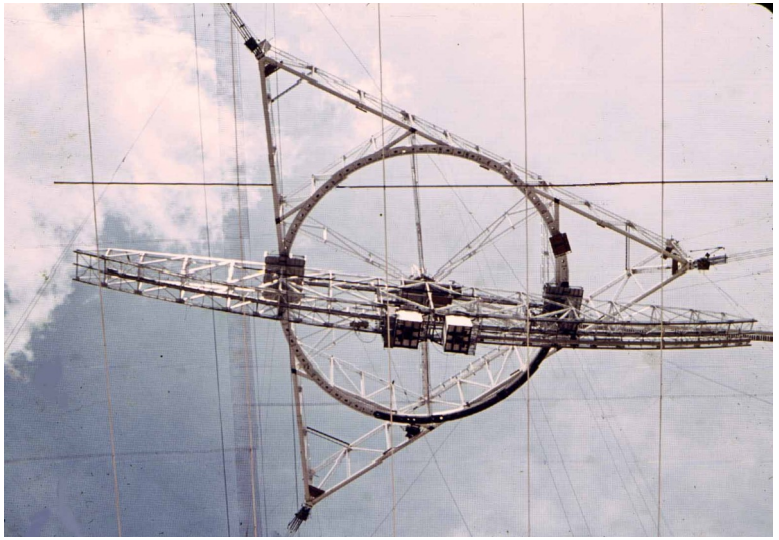
Arecibo Construction, 1962





Arecibo Construction, 1963





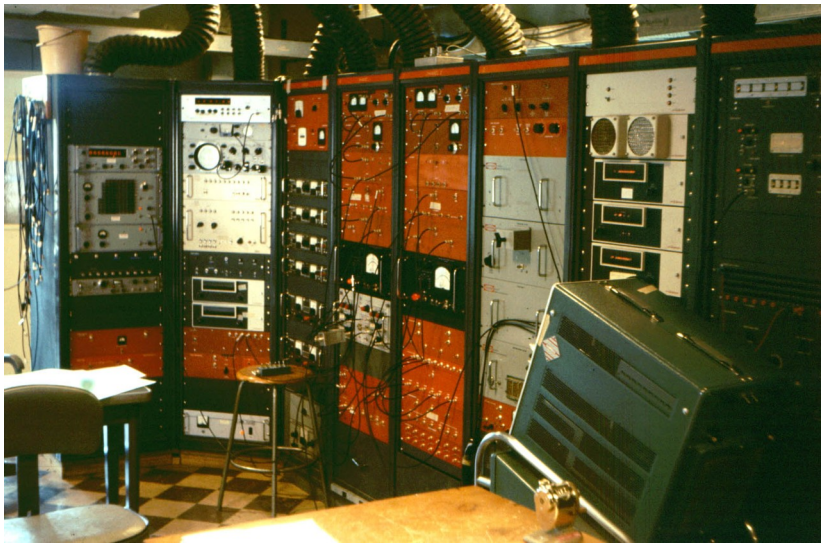
Installing the 430-MHz Line Feed

- With the installation of the 430-MHz Line Feed in Nov. 1963, the system was up and running. When Venus moved into the Arecibo antenna coverage in February 1964, we got our first planetary echoes: some 10,000 times stronger than at Millstone just 4 years earlier!

W1OUN in the New Control Room, 1963

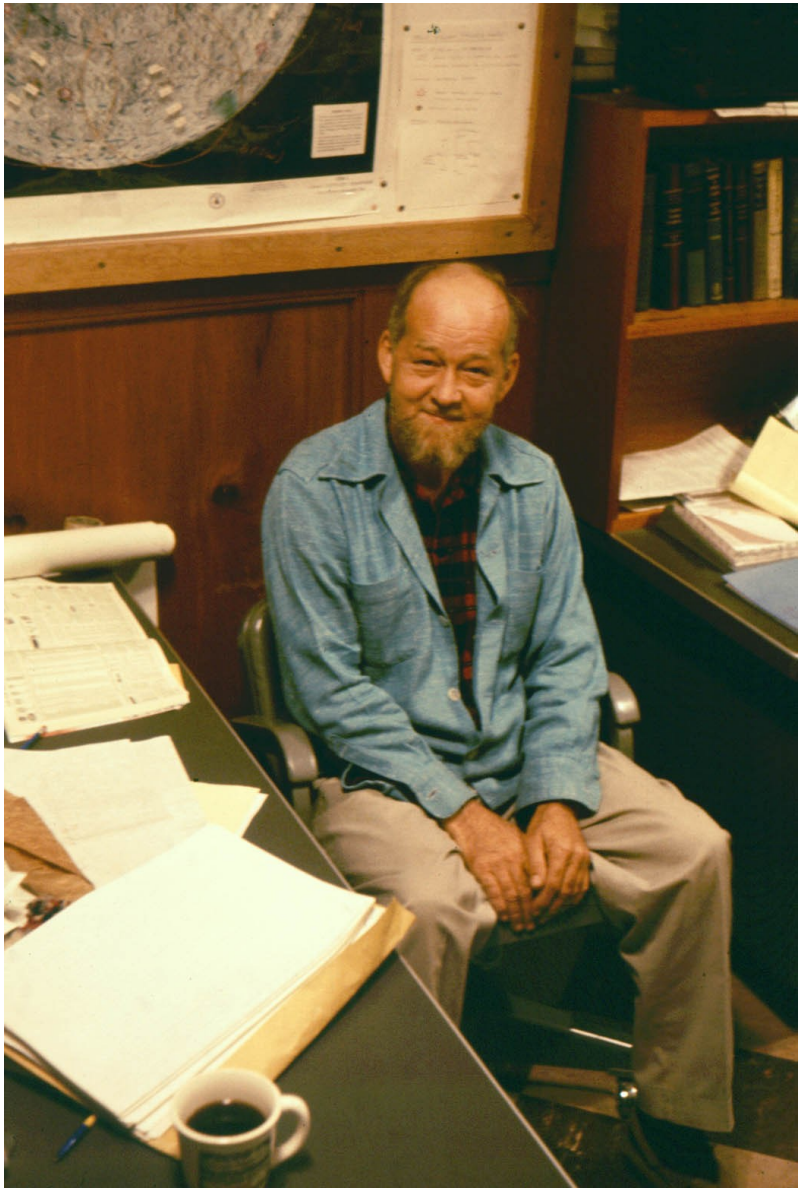
The Heart of the Arecibo Radar System

- Upper: Receiver Room, showing master clock and frequency standards.
- Lower: The controls for the 430-Mhz klystron transmitter: 2.5 Mw peak, 150 kw average.



Sam Harris Moves to Arecibo, 1965

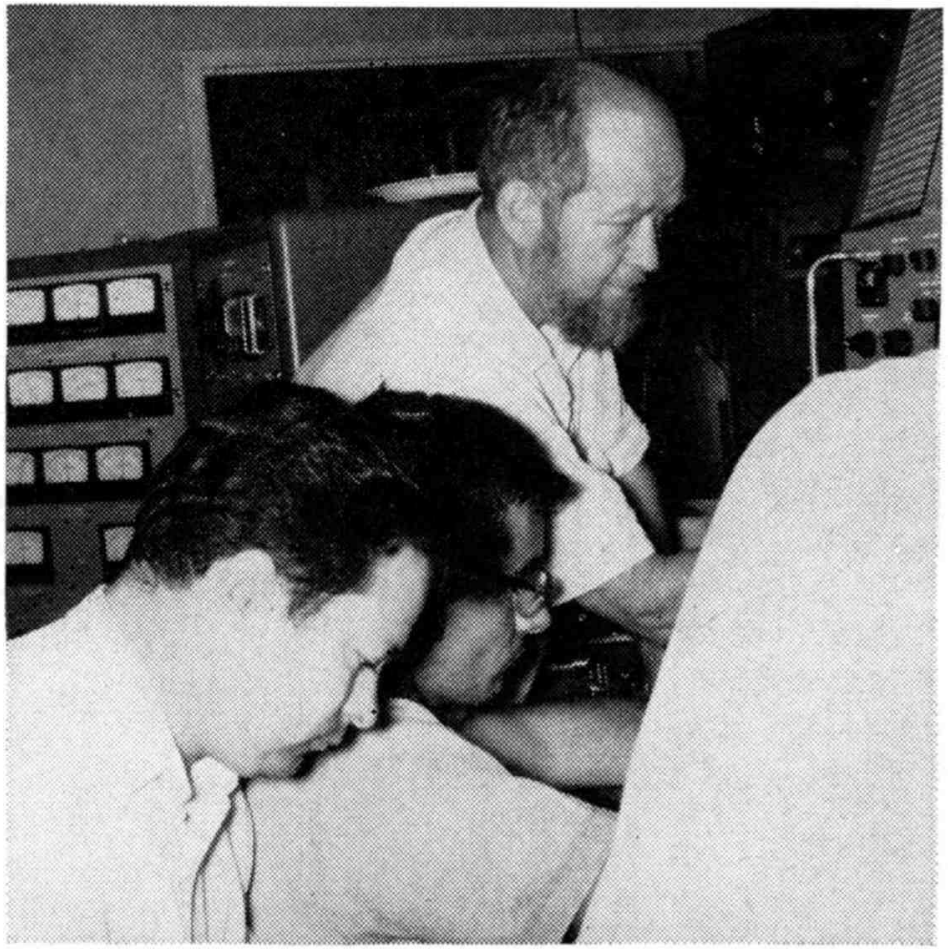
- In 1965, I was able to convince Sam Harris, W1FZJ, to move to Arecibo as the on-site RF electrical engineer.



Harris' Little Arecibo Antenna

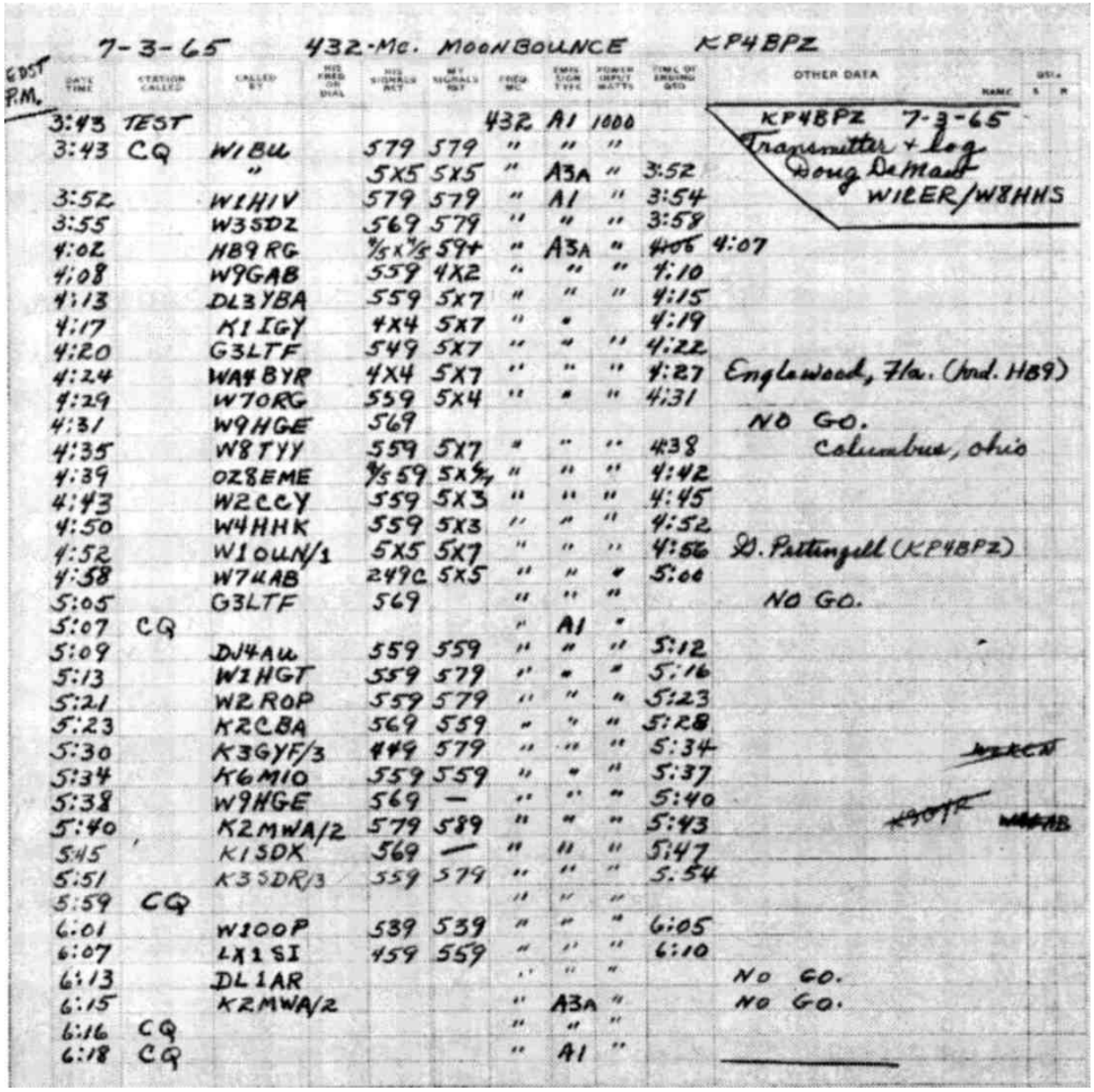
- In addition to his work on Arecibo instrumentation, Sam built a "Little Arecibo" antenna, 100-ft across, near his home in an adjacent valley

Sam & Colleagues, Arecibo Moonbounce, 1965



KP4BEU, K2KWL and W1FZJ during the height of the excitement. Sam is energetically tuning in a signal on the Collins R-390A receiver.

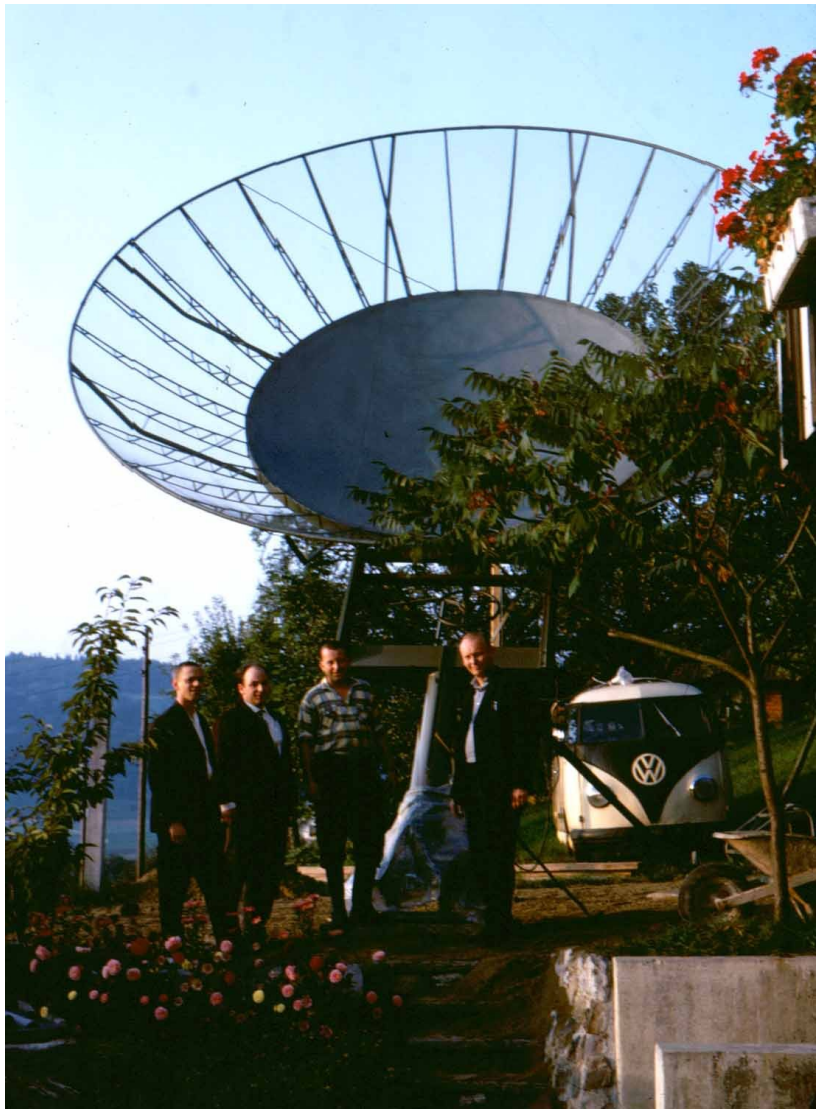
The Moonbounce Log of KP4BPZ: July 3, 1965



7-3-65 432-Mc. MOONBOUNCE KP4BPZ

EDST P.M.	DATE TIME	STATION CALLED	CALLED BY	HIS FREQ ON DIAL	HIS SIGNALS ACT	MY SIGNALS RST	FREQ MC	EMISSION TYPE	POWER INPUT WATTS	TIME OF ENDING QSO	OTHER DATA	QSL'd S	R
	3:43	TEST					432	A1	1000		KP4BPZ 7-3-65 Transmitter + log Doug DeMaw WILER/W8HHS		
	3:43	CQ	W1BU		579	579	"	"	"				
			"		5X5	5X5	"	A3A	"	3:52			
	3:52		W1HIV		579	579	"	A1	"	3:54			
	3:55		W3SDZ		569	579	"	"	"	3:58			
	4:02		HB9RG		3/5X3/5	59+	"	A3A	"	4:06	4:07		
	4:08		W9GAB		559	4X2	"	"	"	4:10			
	4:13		DL3YBA		559	5X7	"	"	"	4:15			
	4:17		K1IGY		4X4	5X7	"	"		4:19			
	4:20		G3LTF		549	5X7	"	"	"	4:22			
	4:24		WA4BYR		4X4	5X7	"	"	"	4:27	Englewood, Fla. (Ind. HB9)		
	4:29		W7ORG		559	5X4	"	"	"	4:31			
	4:31		W9HGE		569						NO GO.		
	4:35		W8TYY		559	5X7	"	"	"	438	Columbus, Ohio		
	4:39		OZ8EME		3/5 59	5X3/5	"	"	"	4:42			
	4:43		W2CCY		559	5X3	"	"	"	4:45			
	4:50		W4HHK		559	5X3	"	"	"	4:52			
	4:52		W1OUN/1		5X5	5X7	"	"	"	4:56	D. Pettingell (KP4BPZ)		
	4:58		W7UAB		249C	5X5	"	"	"	5:00			
	5:05		G3LTF		569		"	"	"		NO GO.		
	5:07	CQ					"	A1	"				
	5:09		DJ4AU		559	559	"	"	"	5:12			
	5:13		W1HGT		559	579	"	"	"	5:16			
	5:21		W2ROP		559	579	"	"	"	5:23			
	5:23		K2CBA		569	559	"	"	"	5:28			
	5:30		K3GYF/3		449	579	"	"	"	5:34			
	5:34		K6MIO		559	559	"	"	"	5:37			
	5:38		W9HGE		569	—	"	"	"	5:40			
	5:40		K2MWA/2		579	589	"	"	"	5:43			
	5:45		K1SDX		569	—	"	"	"	5:47			
	5:51		K3SDR/3		559	579	"	"	"	5.54			
	5:59	CQ					"	"	"				
	6:01		W100P		539	539	"	"	"	6:05			
	6:07		LX1SI		459	559	"	"	"	6:10			
	6:13		DL1AR				"	"	"		NO GO.		
	6:15		K2MWA/2				"	A3A	"		NO GO.		
	6:16	CQ					"	"	"				
	6:18	CQ					"	A1	"				

The Swiss Moonbounce Gang: HB9RG & Colleagues, 1962



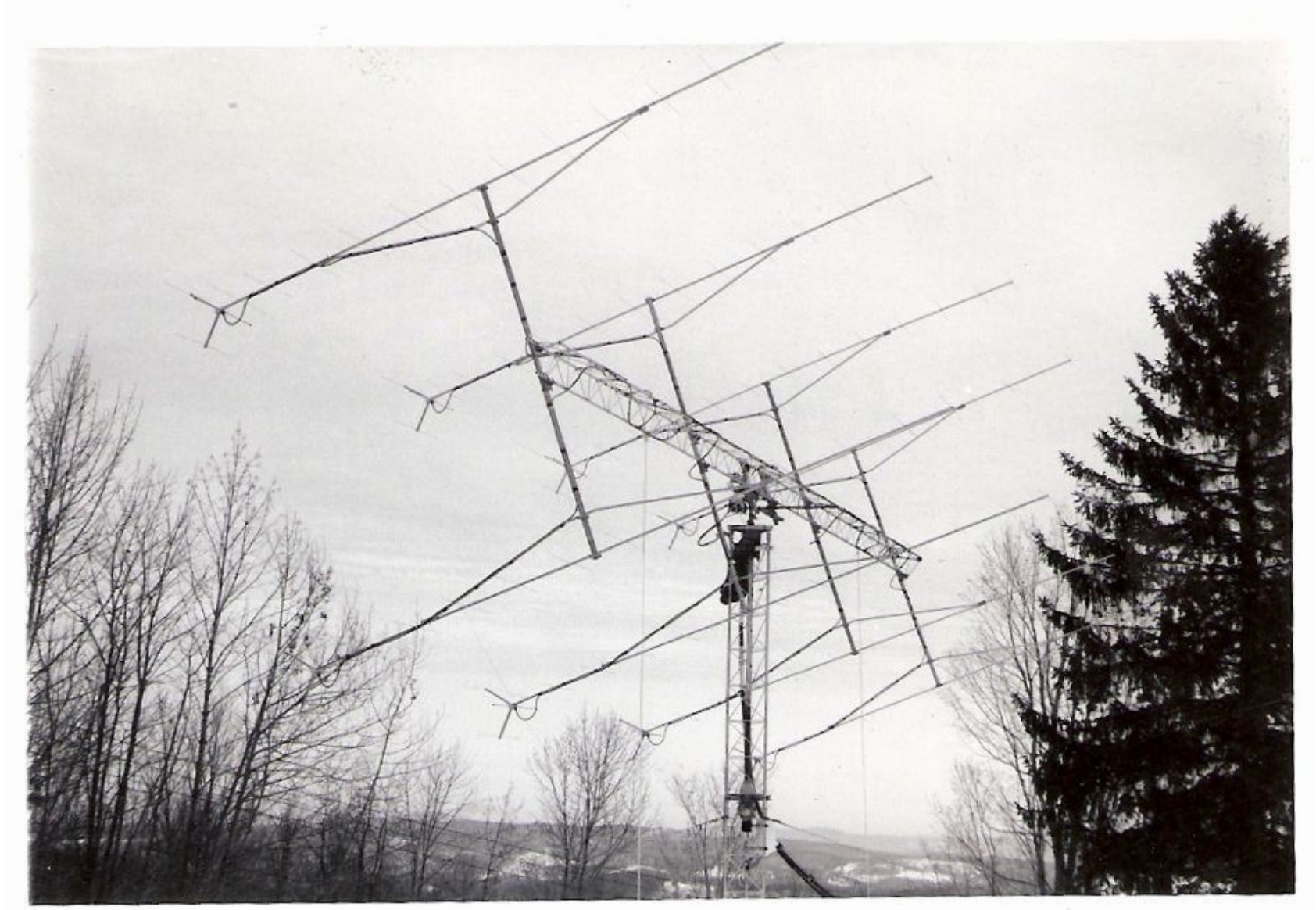
K1KKP's 60-ft Helix

- Al Parrish, K1KKP, one of the early moonbouncers, built a pair (LC & RC) of 60' helices in Peru, VT, to send and receive signals to & from the moon in 1965. (Al was later a graduate student working at Arecibo in 1969!)

- Warren, K1BKK, set up a 2-m moonbounce system several years after K1KKP, for the second Vermont EME. He successfully used a 160-el Cushcraft collinear with well over 20-dBd gain in an az-el mount.

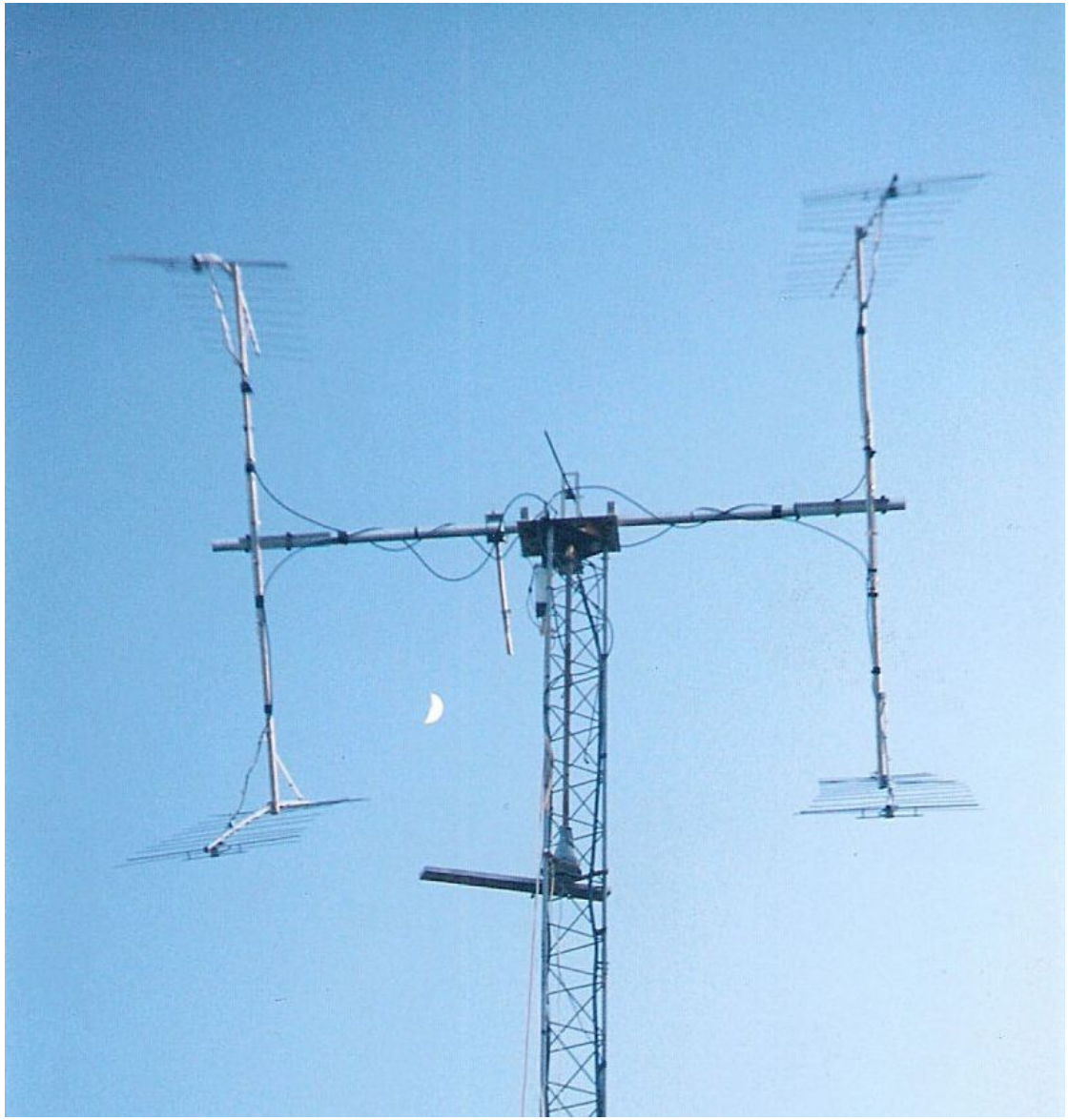
WA1JXN's 2-m array of 8 17-el yagis

(Now, as W7GJ in MT, has 16 of them!)



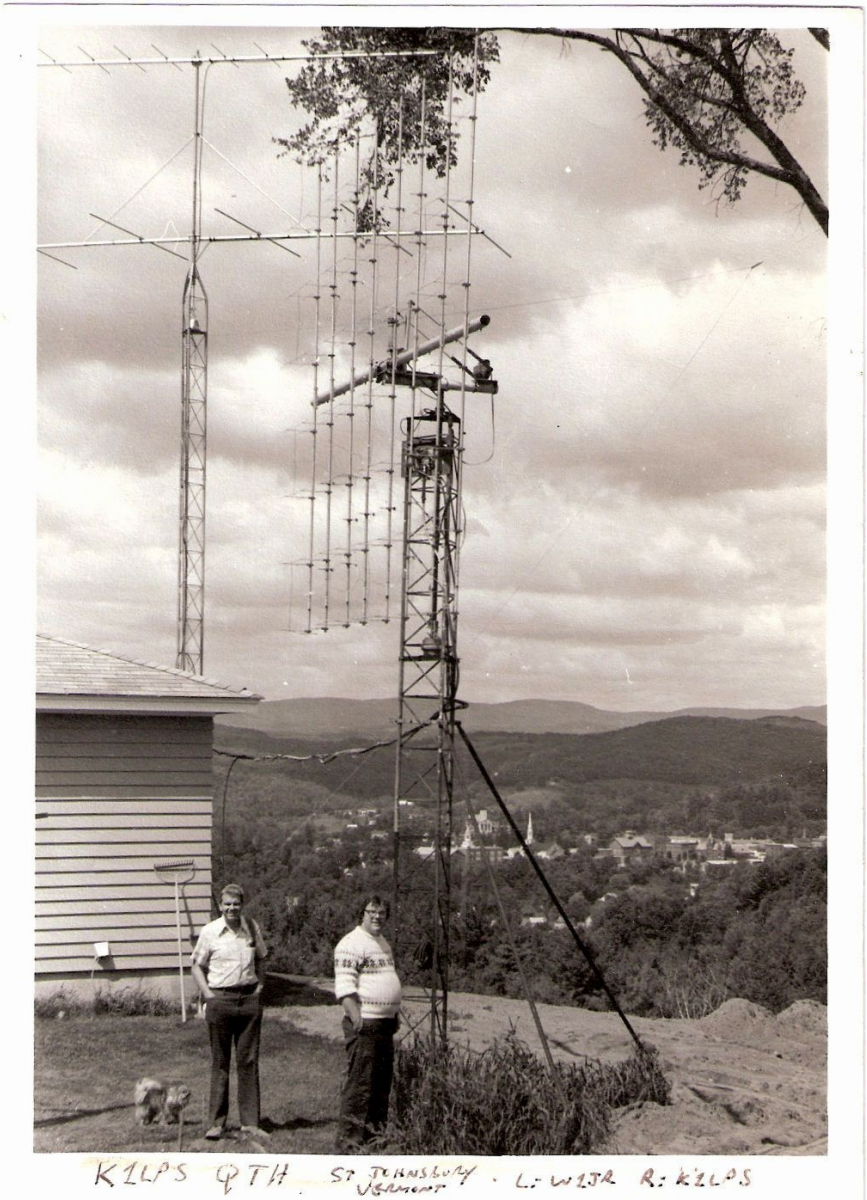
W1AIM's array of 4 17-el 2-m Boomers

- This 144-Mhz system by Chip Taylor, W1AIM, was used in the fourth successful Vermont EME attempt!



W1JR & K1LPS with their 70-cm EME array

- This is the 128-el collinear array used by Larry, K1LPS, and built by W1JR for Vermont EME communication.



- Note that all these (cumbersome!) antennas had gains of 20dBd or more, as required before the days of Joe Taylor's (K1JT) weak-signal coherent detection software. Today, a 10-el yagi and 100 watts can put you into the EME business!

THE END