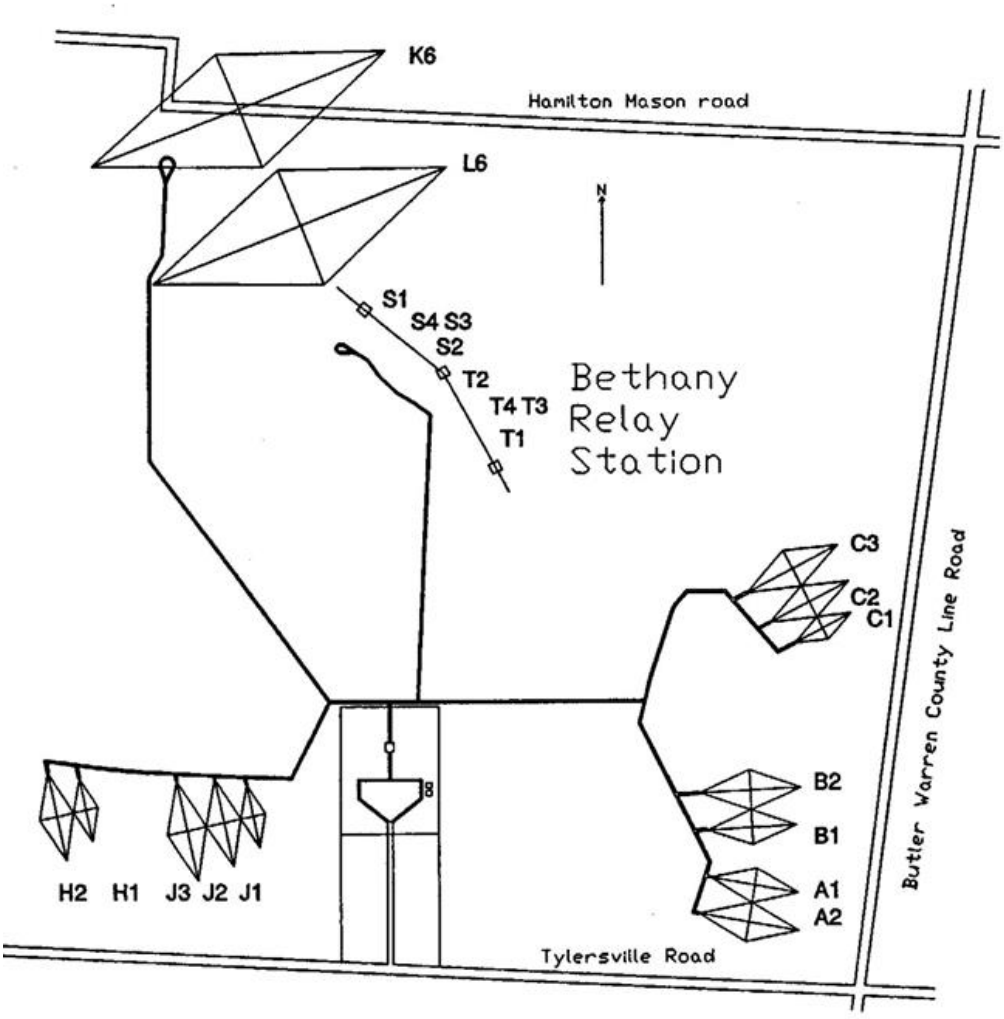
Antennas

The Bethany Relay Station used 22 directional antennas pointing in 24 directions. Fourteen were rhombic type in groups of 2 or 3, and eight are curtain type antennas. Two of the rhombic antennas were reversable.

Curtain Antennas - 250 KW	**Beam Center**	**Area Covered**
S1, S2, S3, S4	57.5 Degrees	Southern Europe, North Africa
T1, T2, T3, T4	74.5 Degrees	West and Central Africa

Rhombic Antennas - 250 kW		
A1, A2	100 Degrees	South Africa
B1, B2	87 Degrees	West and Central Africa
C1, C2, C3	62 Degrees	Spain and North Africa
H1, H2, J1, J2, J3	168 Degrees	Caribbean and South America
K6, L6	66 Degrees	Spain and North Africa
K6, L6 (Reversed)	246 Degrees	North Mexico, New Zealand

BY-9 connected to Antenna C1 only, BY-10 connected to Antenna A2 only.



The antenna switching matrix (6 X 22) consists of 232 manually-operated switches that allow connection of any of the six broadcast transmitters to be connected to any of the 22 antennas and test load. There were more than 1000 wood poles ranging in height up to 150 feet, supporting antennas and transmission lines.

Note the small building to the left-hand side of the picture, (between the poles). That is the *Clift House* (named after Len Clift who suggested building it) that housed a couple of hot sticks. Occasionally an insulator on the end of a pushrod would break. The switch could be manually moved with the hot stick. In the winter we would leave a propane torch lashed to the end of a hot stick that could melt ice on a switch contact, so the switch could be closed during an ice storm. Good old Ohio weather. For many years the small building had a *half-moon* painted on the door. (Source: Dave Snyder)

TRANSMITTERS	Manufacturer	Power	Freq. Range

All VOA transmitters were given a 2 or 3 letter designation, i.e.: DL1, Delano transmitter #1; GB4, Greenville Plant B Transmitter #4. The BY stands for Bethany.

BY-1, BY-2, BY-3	Asea Brown Boveri SK53-C3	250 kW	6-22 MHz
BY-4, BY-5, BY-6	Collins Radio 821-A-1	250 kW	6-26.5 MHz
BY-7	Collins ANFRT-5	15 kW	

BY-7 was a Collins ANFRT-5 5 kW transmitter, originally Amplitude Modulation. The Bethany techs converted this to linear operation with a 15 kW ISB rating. This transmitter was connected to a dipole antenna directly without passing through the switching matrix. It was driven with a spare exciter located in BY-10. It was heard in Africa, but I don't think it was ever used except for maybe a few minutes when BY-9 or BY-10 may need a quick repair. (Source: Dave Snyder)

BY-8 Collins 231-D AM then ISB

BY-8 was a Collins 231-D AM transmitter which was probably sitting around in a warehouse and was surplus. Both transmitters were too low powered to cross an ocean and probably should not have been installed. (Source: Dave Snyder)

BY-9, BY-10	Continental 617-A SSB	50 kW PEP	2-30 MHz

Changing frequencies: 3 people spent at least 7 minutes to remove the loading caps and coils, along with the antenna change switching.

The Crosley transmitters operated from 1944-1989 and were replaced by the ABB transmitters.

The three WWII transmitter plants were owned by commercial broadcasting companies; Crosley, NBC and CBS. Therefore, each transmitter was licensed and had call letters. Crosley's three transmitters were WLWL, WLWR, WLWS. The federal government took ownership in 1963 so the transmitters fell under the Department of Commerce and no longer required licensing.
(Source: Dave Snyder)

Exciter was a 6V6 crystal-oscillator stage, using broadcast-type temperature controlled oven feeding two 6V6 multiplier-buffer stages and a final 807 amplifier for a 15W output. Then 807 to 813's to 891 to F-125 finals.

Final Class C (DC input power= 320 KW, Output = 250 KW, Efficiency= 78%)
Tube: F-125-A
Plate voltage up to 14,250 Vdc
Plate current = 22.5 A
Filament= 3 phase 13.6 V @ 65 A per phase

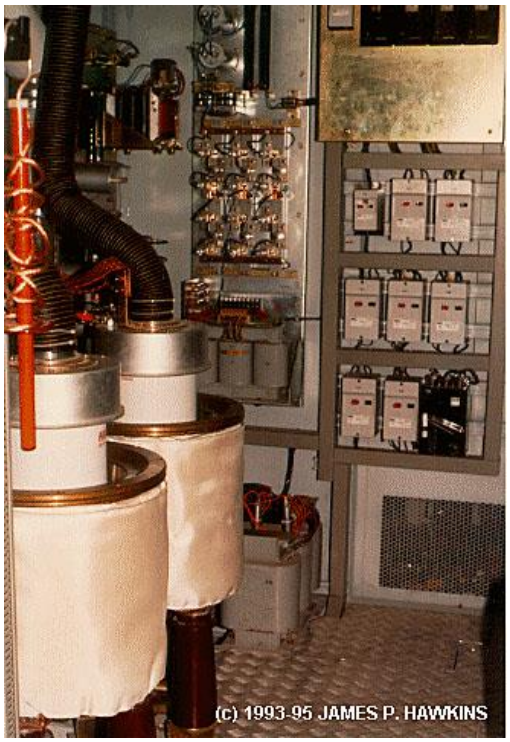
Output feedline to the antenna switch was 300 Ohm, 2-inch copper pipe spaced at 13 inches. A matching section connected the 300 Ohm switch to the 500 Ohm antenna feed line. The 500 Ohm feed line was 4-wire construction consisting of two pairs of number 2 copper weld wire, each pair spaced 3/4" as one conductor, with 20" spacing between pairs, and with all four wires in the same horizontal plane about 15 feet off ground. They also used a line consisting of a 4-wire construction, using two pairs of 1/0 copper weld (each pair as one conductor) spaced 2-1/8" one above the other, and 7" between pairs, which is the same spacing as used in the 300-Ohm switch structure, where two I" copper pipes are used for each line. To maintain spacing between wires on each side of the line, cast clamps are used at intervals of about 10'.

Modulator
Push-Pull Modulator using a F-125-A tube, three push-pull voltage-amplifier stages; and a multiple-tube class B power stage capable of delivering 180 kW of audio power

Cooling
The finals were water vapor cooled and the rest of the transmitter was forced air cooled. All waste heat was captured and used to heat the building in the winter and wasted to atmosphere in the summer. A 50-gallon-perhour still in the boiler room fed a 400-gallon storage tank in the guard tower providing a common gravity feed to all systems for supply distilled cooling water. Gravity feed was selected over a pump feed to prevent cooling issues if a pump failed.

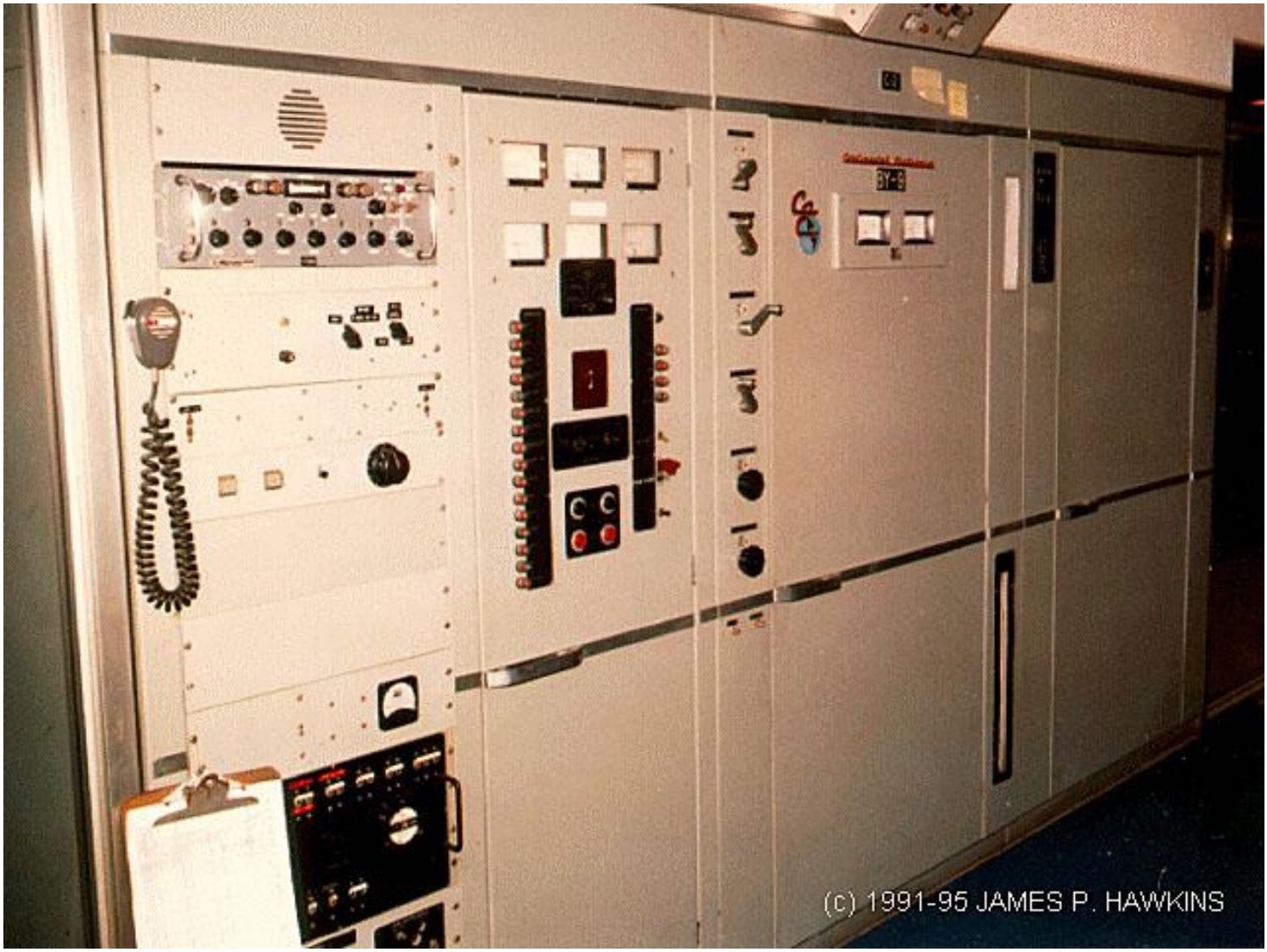
The original WWII transmitters used water cooling for all their tubes which was the technology of the day. About 30 gallons of non-conducting water was circulated past the anodes of the tubes for heat removal. The Collins and ABB transmitters used vapor-phase cooling. When the anodes of the tubes reached 100 degrees C, the liquid water would boil. The phase change from liquid to vapor absorbed the waste heat. The vapor was condensed back to liquid by a vapor to liquid loop condenser fan coil mounted above the transmitters for the Collins and ABB transmitters.

Each Crosley transmitter had 10 water-cooled tubes (out of 17). Each Collins transmitter had 4 vapor-cooled tubes (out of 10). Each ABB transmitter had 3 vapor-cooled tubes (out of 6). All the rest of the tubes in the transmitters were air-cooled.
(Source: Dave Snyder)



Shown right are vapor cooled modulator tubes courtesy of Jim Hawkins.

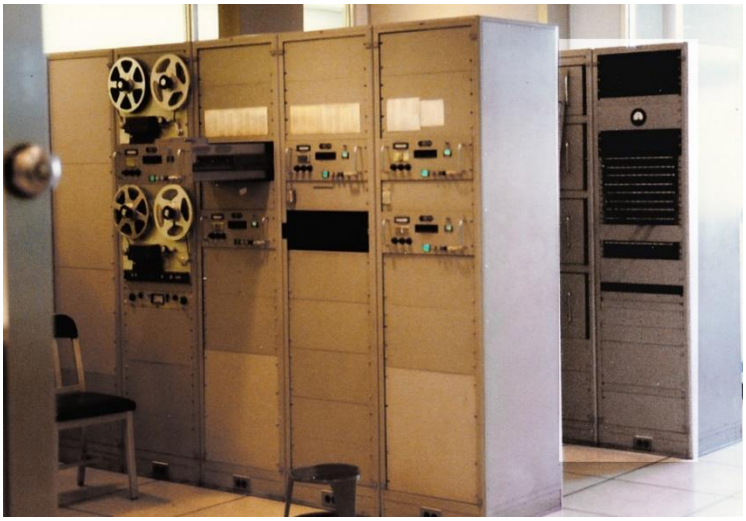
Collins Radio 821A-1, 250 KW, Transmitter



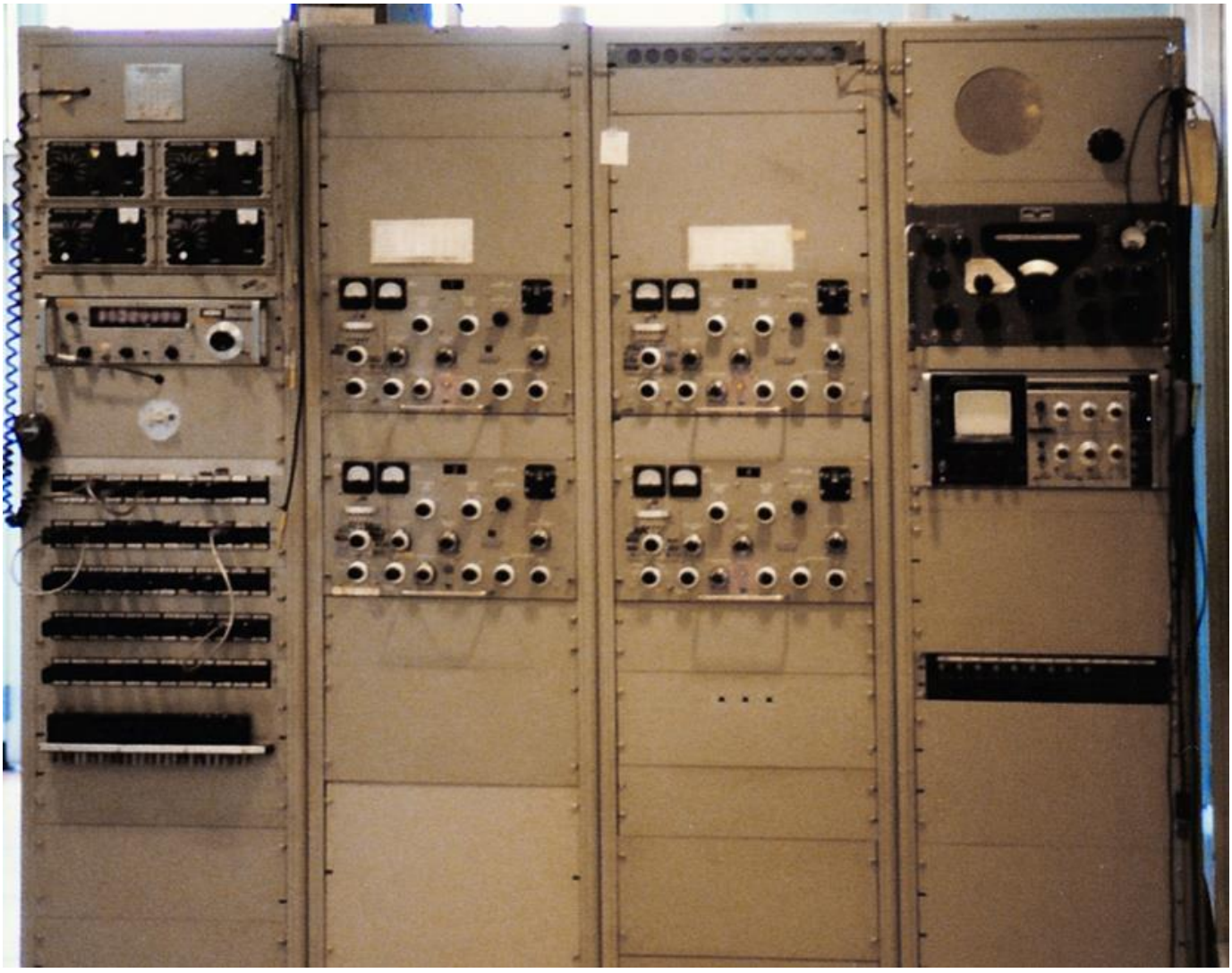
Continental 617-A Transmitter, 250 KW, SSB

Satellite Interconnect - provided 12 program channels from Washington Studios. In September 1988, engineers at VOA inaugurated a Satellite Interconnect System (SIS) linking headquarters in Washington, D.C., and VOA relay stations in Greenville, North Carolina, and Delano, California. The Washington-Greenville-Delano link was only the beginning of SIS. In the last few years, VOA expanded this satellite network to include every relay station in the United States and around the world.

Audio Circuit: The audio circuits originate in the control. room, where the modulating signal is taken from 12 incoming telephone lines or local electrical transcriptions via 3M computer-controlled audio matrix switch. A transmitter circuit includes a limiting line amplifier, to amplify the audio voltage and compress high level peak; peak clipper to chop both positive and negative peaks at a preset level, usually equivalent to 100% transmitter modulation; and the usual level controls and volume indicators, From the control room, AF voltage is fed at zero level to the modulator unit of the transmitter.



Audio Circuits



Power Supply Vault
Only during war time, a dual power feed was maintained from Cincinnati and Dayton to the power supply substation, 3,000 KVA to 3-phase 2,400/240V 3-phase filament transformer. All 240-V power contactors for filaments, low voltage supplies, etc., and a 240 V breaker and distribution panel are in the wall cabinet behind the transmitter. All equipment dangerous to personnel was completely interlocked both electrically and mechanically.

Plate transformer = 750 kVA, three-phase unit with a special high-speed motor-operated tap switch, connected in its secondary winding, which operates under load. The transformer windings and taps to provide variable dc voltages at the load from 5500 to 15,000 V in 32 steps.


VOA - Views of Transmitter Power Supply and Modulation Components.

Photo courtesy of Jim Hawkins

Sample Operating Schedule

TRANSMITTER	FREQUENCY	ANTENNA	LANGUAGE	TIME EDST
BY-1	11930 kHz	H2/168	R. MARTI	7:00 PM - 10:00 PM
BY-1	6055 kHz	H2/168	R. MARTI	10:00 PM - 12:00 MN
BY-1	6055 kHz	J3/168	R. MARTI	12:00 MN - 2:00 AM
BY-1	11815 kHz	H2/168	R. MARTI	8:00 AM - 10:00 AM
BY-2	17800 kHz	A1/100	ENGLISH	2:00 PM - 5:30 PM
BY-2	17800 kHz (Su-Fr)	A1/100	ENGLISH	5:30 PM - 6:00 PM
BY-3	6030 kHz (Mo-Fr)	J3/168	SPANISH	9:00 PM - 10:00 PM
BY-3	9530 kHz	A2/100	ENGLISH	2:00 AM - 2:30 AM
BY-3	9530 kHz (Sa-Su)	A2/100	ENGLISH	2:30 AM - 3:00 AM
BY-4	9775 kHz	J2/168	ENGLISH	8:00 PM - 10:00 PM
BY-4	9775 kHz (Mo-Fr)	J2/168	ENGLISH	10:00 PM - 10:30 PM
BY-4	7405 kHz	L6/66	ENGLISH	11:00 PM - 2:30 AM
BY-4	7405 kHz (Sa-Su)	L6/66	ENGLISH	2:30 AM - 3:00 AM
BY-4	5975 kHz (Mo-Fr)	J3/168	BBC SPAN	7:00 AM - 7:30 AM
BY-4	9600 kHz	J3/168	R. MARTI	8:00 AM - 10:00 AM
BY-5	11730 kHz (Mo-Fr)	J1/168	OAS ENGL	6:45 PM - 7:00 PM
BY-5	11730 kHz	J1/168	OAS SPAN	7:30 PM - 8:00 PM
BY-5	11730 kHz (Sa-Su)	J1/168	OAS PORT	8:00 PM - 8:30 PM
BY-5	13740 kHz (Mo-Fr)	J1/168	SPANISH	9:00 PM – 10:00 PM
BY-5	9670 kHz (Mo-Fr)	H1/168	BBC SPAN	7:00 AM - 7:30 AM
BY-6	9575 kHz	T1/74	ENGLISH	11:00 PM - 1:00 AM
BY-6	9665 kHz	T1/74	ENGLISH	1:00 AM - 2:30 AM
BY-6	9665 kHz (Sa-Su)	T1/74	ENGLISH	2:30 AM - 3:00 AM
BY-6	7405 kHz	J2/168	ENGLISH	6:00 AM - 8:00 AM
BY-6	15315 kHz (Mo-Fr)	H1/168	BBC SPAN	9:00 AM - 9:30 AM

Available for download:

VOA - 50 Years of Broadcasting by Dave Snyder, 1.8 Meg, PDF
By Dave Snyder, 1994 (An extensive and very interesting account for VOA Bethany)

OWI 200 kW HF transmitters at Bethany Relay Station, by R. J. Rockwell, 6.2 Meg, PDF
By R. J. Rockwell (Reprinted from November and December 1944 Communications Magazine)

How Time Balls Worked (See page 12 explaining how the Nation Weather Service began in Cincinnati because of telegraphy) 3.6 Meg, PDF

Narrative of History for VOA Bethany PDF

VOA Today 85K, PDF

The Crosley Story by Jack Gray 14.5 Meg, PDF

VOA Bethany Pocket Fact Sheet by Lee Hite, PDF

Crosley Products 10 K, PDF

How Spark Transmitters Work by Dave Snyder 28 Meg, PDF

VOA Museum of Broadcasting, "Flickr" pictures
By Lee Hite

Voice of America Museum Special Tour, YouTube
By George Thomas, W5JDX and crew with considerable help from Dave Snyder, Date ?

WLW 500,000-Watt Transmitter, YouTube, 2013

Part 1 of 5 Tour of Voice of America Transmitter Plant, Greenville, NC, YouTube
By Jim Hawkins, 2009

Bits of Wireless History from Gray History Of Wireless Museum
By Jack Gray (G. J. Gray) 1969

Gray History of Wireless Museum "Flickr" pictures
By Lee Hite

Media Heritage Museum at the VOA, "Flickr" pictures
By Lee Hite