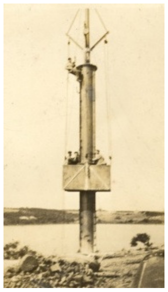
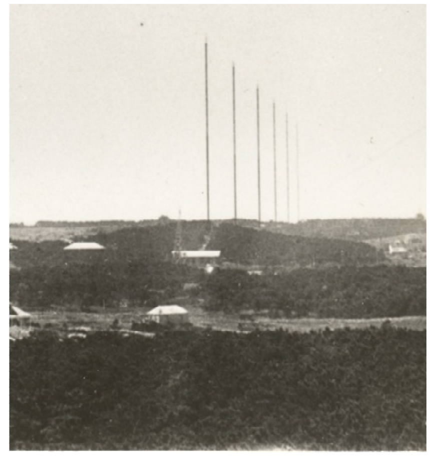
Antennas at Chatham

(Edited by J. Richard Kraycir, CMMC Executive Director]

The first antenna we know about at WCC Chatham was constructed in 1914 by the J.G. White Engineering Company. It consisted of six large towers (of a standardized Hollow Design) averaging 350 feet in height in a straight line about one mile long pointing at Stavanger Norway. There is no evidence that wires were strung along the top of this line of towers to complete the antenna as the station was not in use when taken over by the Navy in 1917. There is a description showing that two ¼" wires were to be strung on top of the masts. (See Appendix 1). The Marconi Corporation was using all its resources in Marion getting the 300kw spark gap transmitter working as it was the first of a new design.



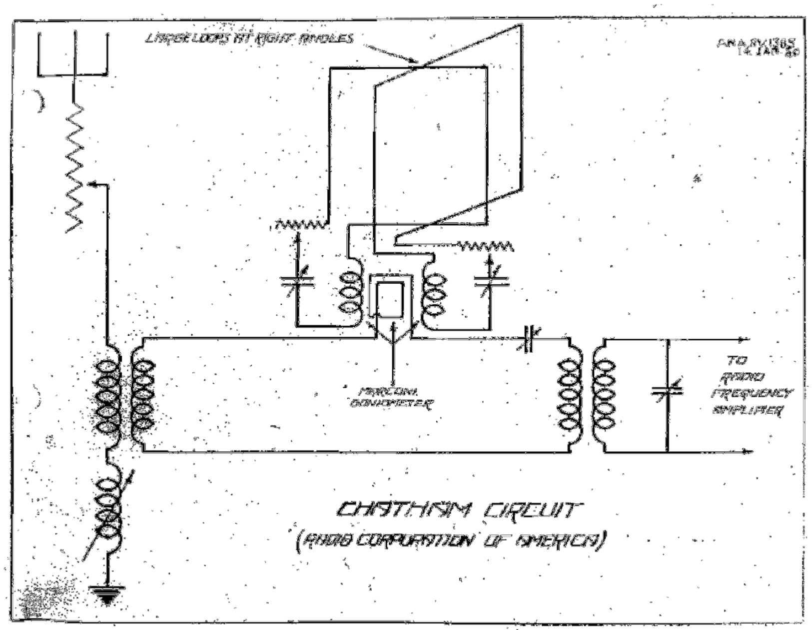


Supplementing this major receiving antenna was a 'balancing out aerial' pointing toward Marion where the remote transmitters were located. This antenna would receive the transmitted signal and that would be destructively mixed with the signal received on the main antenna so that one would be able to hear the weaker signal coming from Stavanger over the much more powerful (because it is so much closer) signal from Marion. (Bucher, 1917). See Appendix 1 for records from the Barnstable Recorder of Deeds. This 'aerial' was strung on the metal structures that still exist (although in different locations) on the property.

The Remote 300 kw spark gap transmitter in Marion MA, controlled and keyed from Chatham, used antennas supports of the same design as those described above. "There were 14 large tubular steel towers, 6 on a side, with one each centered at each end. Towers were 406 ft. high. The tower bases, as measured by the writer on-site, (Henry Brown, K1WCC), were concrete with 8 ea. 2" bolts within a 72" dia. circle footprint. Measured distance between tower lines was about 555 ft. with the towers being 900 ft. apart. The tower field was roughly 800 ft x 7000 ft. At the time of initial erection, it took 8 days to raise and stay a tower. Guys were 7/8' dia. plow steel wires. Copper coil houses were between the towers, with zinc plates buried in the ground vertically. The antenna field was oriented in the direction of Stavanger, the lone end towers apparently lining up on the great Circle bearing to the Norwegian city. Frequency of operation was 25.82 kHz and 22.35 kHz, now known as VLF (Very Low Frequency). Early photos of the antenna field show an amazing number of guy wires. (Brown, 2005)

There are notes indicting that experiments were being done from 1917 to 1918 (WW I) when the Navy was in charge of the Station, even though it was not operational. Interference between the Station in Chatham Port and the Naval Air Station a few miles to the East on Nickerson's Neck precluded routine operation. Documentation (Howeth-Appendix 2) indicates that the Chathamport station was maintained as a backup to the US Navy occupied Marconi station in Belmar New Jersey. Some literature refers to experimental underwater and underground antennas that had dramatically lower static and noise, although they were much less sensitive. Belmar was using underground antennas during much of that time.   Their documentation indicates that the underground antenna there was the prime listening antenna during WWI as it less sensitive to atmospheric static noise. More information on underground antennas can be found on the internet at http://www.rexresearch.com/rogers/1rogers.htm#220005

At Chathamport in 1919, five of the six vertical poles were removed. The remaining pole had a vertical antenna that was used when General Electric and then RCA returned to the Station. Removal started August 20th 1919 and continued through the year. It is likely that Marconi employees were still here doing the work. Those antennas were relocated (Robinson-Appendix 3)



In August of 1919, a 30 ' loop antenna was built that consists of two large loops. (This might have been the temporary loop used for the first traffic from LCM on Jan 8th 1920.) There is also an Engineers log entry on April of 1920 about a large Loop being installed. The earlier loop, evaluated by A.Hoyt Tayler of the USN Bureau of Steam Engineering on January 10, 1920 describes the Loop Antenna. The major loop was 12 turns of wire formed to 250' x 30' pointing at Stavanger. The minor loop was 12 turns of wire formed to 400' x 30' at right angles to the aforementioned. (Taylor, 1920) These loops were connected by a Marconi goniometer; a device that mixes the signals both adjusting the relative strength of signal and the phase relationship between the two. Adjusting the phase relationship is an electrical way of accomplishing the same thing as physically rotating the antenna to 'aim' it. Introducing an 'aerial' or sense antenna, as shown at the left side of the schematic drawing, is used to reduce the signal from the back side of the antenna making it receive as though it were rotating an antenna that was sensitive in only one direction.

This, and later reports, shows that the US Navy was involved with the station not only during WWI, but also in the period after the war and even during the time that RCA owned the station.

We are led to believe that this loop antenna was very important, and perhaps unique, as RCA featured it in their Advertising Brochure of the early 1920s

RADIO CORPORATION OF AMERICA

Chatham Receiving Station. Four superheterodyne receivers are shown; three for long wave and one for 600 meter reception

The transmission line connecting the loop antennas and receivers is seen entering the rear wall.

In the left foreground is shown the high-speed table with its ink recording equipment.

Forrest Robinson, an operator at Chatham just after WWI ended, indicated that RCA operators were at the station shortly after October 17, 1919 and working traffic from the Commercial circuits POZ (Berlin), LCM (Stavanger), and OUI (Hanover) along with continued traffic flow from the Navy Circuits. (Robinson)(Appendix 3)

Forrest also documented that a Beverage Wave Antenna was erected at Chatham (1921 or 1922) that was 8 Miles in length from Chathamport to the Swan River in West Harwich. Beverage antennas are very long antennas that are close to the ground (often only 6-8'). I include the following from Wikipedia which has a very detailed description and history.

The **Beverage Antenna** is a relatively inexpensive but very effective long wire receiving antenna used by amateur radio, shortwave listening, and longwave radio DXers and military applications. Harold H. Beverage experimented with receiving antennas similar to the Beverage antenna in 1919 at the Otter Cliffs Naval Radio Station.[By 1921, Beverage long wave receiving antennas up to nine miles (14 km) long had been installed at RCA's Riverhead, New York, Belfast, Maine, Belmar, New Jersey, and Chatham, Massachusetts receiver stations. The antenna was patented in 1921 and named for its inventor Harold H. Beverage. Perhaps the largest Beverage antenna—an array of four phased Beverages three miles (5 km) long and two miles (3 km) wide—was built by AT&T in Houlton, Maine for the first transatlantic telephone system opened in 1927.

We are sure that the creative engineers at Chatham and Marion continued to develop and experiment with other types of antenna, but our research has brought up little more until the appearance of the now historically significant Rhombic antennas.

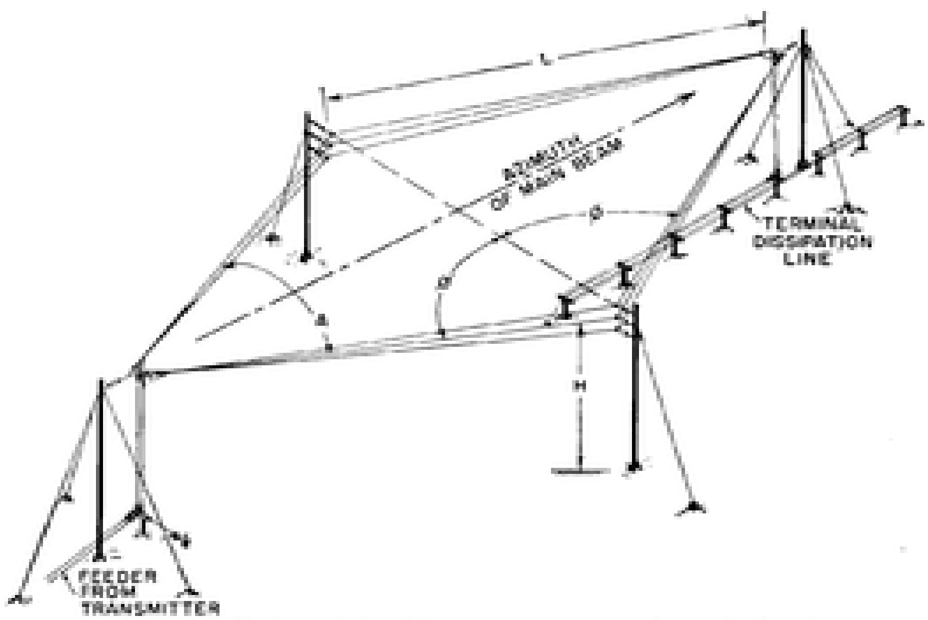
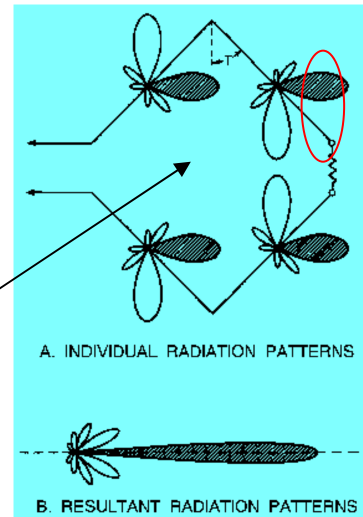


FIG. 3.77. Horizontal rhombic antenna (common three-wire form).

The first of the Rhombic antennas was put in service on December 24, 1937 (Letter Heiser to Costigan Dated December 31, 1937) and was pointed toward Paris. Design information is contained in the letter from Byrnes to Heiser dated October 14, 1937. Both are in Appendix 4)

The largest of the Rhombics on the East of Old Comer's Road, was built by the US Navy during WWII to monitor transmissions from Berlin. The Navy built three Rhombic antennas during their time to intercept land and U-Boat transmissions during the war. That information was forwarded to Washington for decoding and U-Boat locating.



Rhombic antennas had been developed by Edmond Bruce and Harald Friis at ATT and issued patent number 2,285,565 (Bruce). Considering that ATT was a major stockholder in RCA and RCA had the rights to all ATT patents, it is likely that Chatham WCC was among the earliest applications of this antenna. The illustration shows how the plots of sensitivity for each of the legs add and subtract so that there is little reception from the sides, but in the direction of the terminating resistor, the signals all add making the signal strong and intelligible.

Again, a bit of information from Wikipedia is on the following page:

A **rhombic antenna** is a broadband directional antenna co-invented by Edmond Bruce and Harald Friis,[1] mostly commonly used in HF (high frequency, also called shortwave) ranges.

Technical Detail

It is named after its "rhombic" diamond shape, with each side typically at least one wavelength (λ) or longer in length. Each vertex is supported by a pole, typically at least one wavelength high. It is typically fed at one of the two sharper angles through a balanced transmission line. Less commonly, it can be fed with coaxial cable through a balun transformer. The opposite end is either left open for bi-directional use, or terminated at the opposite sharp angle with a non-inductive resistor. It is directional towards the resistor end, so the termination end points towards the region of the world it is designed to serve. Even when unterminated (bi-directional) the rhombic is not perfectly bi-directional. This is because of losses in the system primarily caused by radiation, conductor resistance, and coupling to the lossy soil below the antenna.

The rhombic antenna can radiate at elevation angles close to the horizon or at higher angles depending on its height above ground relative to the operating frequency and its physical construction. Likewise, its beam can be narrow or broad, depending primarily on its length. A proper combination of size, height, and operating frequency make it fit for medium or long range communication.

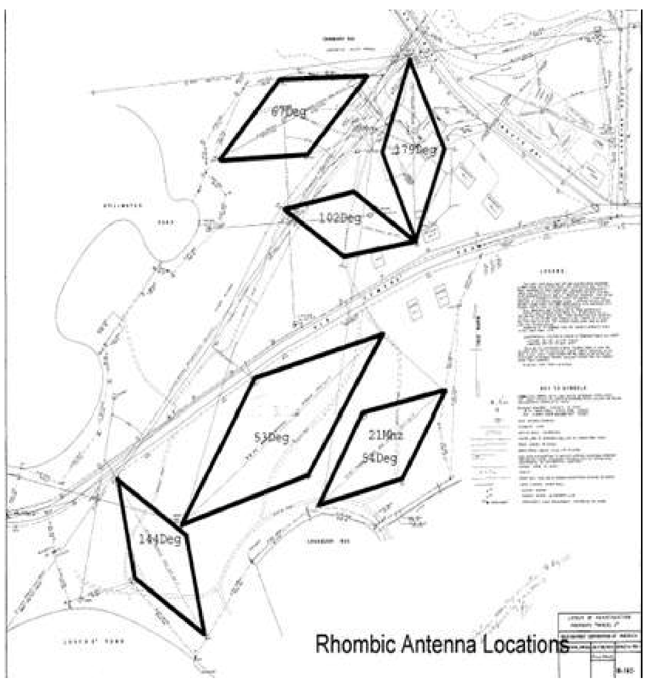
An inventory of equipment at the station when the Navy returned the station to RCA after WW II indicates there are 6 Rhombic Antennas at the site. The areas of coverage are as follows:

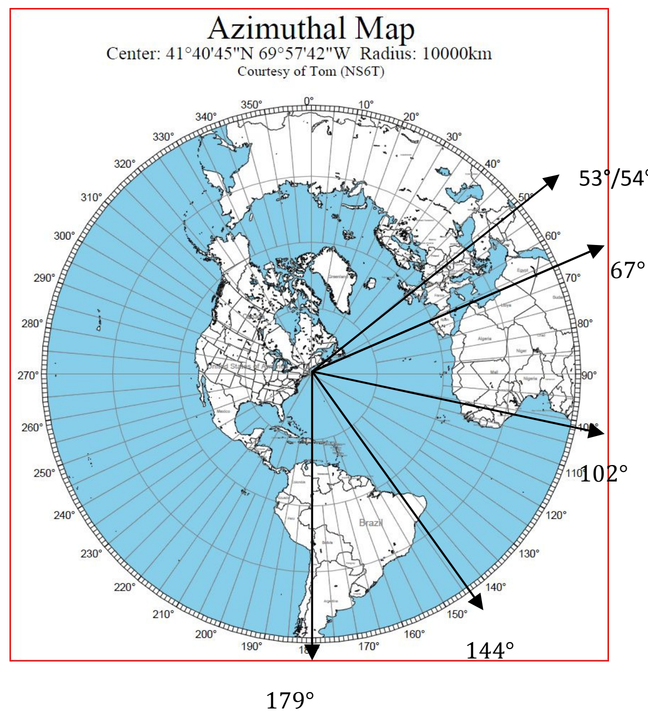
"The Rhombics at WCC were terminated to favor six different true bearings of 53, 54, 67, 102, 145, and 179 degrees.

The favorite antenna was the 67 degree rhombic. I think because of its size and bearing it favored most of the north Atlantic. You will note two of them are close in degrees, the 53 and 54, but these were vastly different in length. If my memory serves me right, the 54 degree was the longest of all the antennas. Looking at the globe, *the 53, 54, and 67 degree Rhombics enabled WCC to communicate across the North Atlantic, into the English Channel, the Mediterranean, Suez , Persian Gulf and Indian Ocean.*

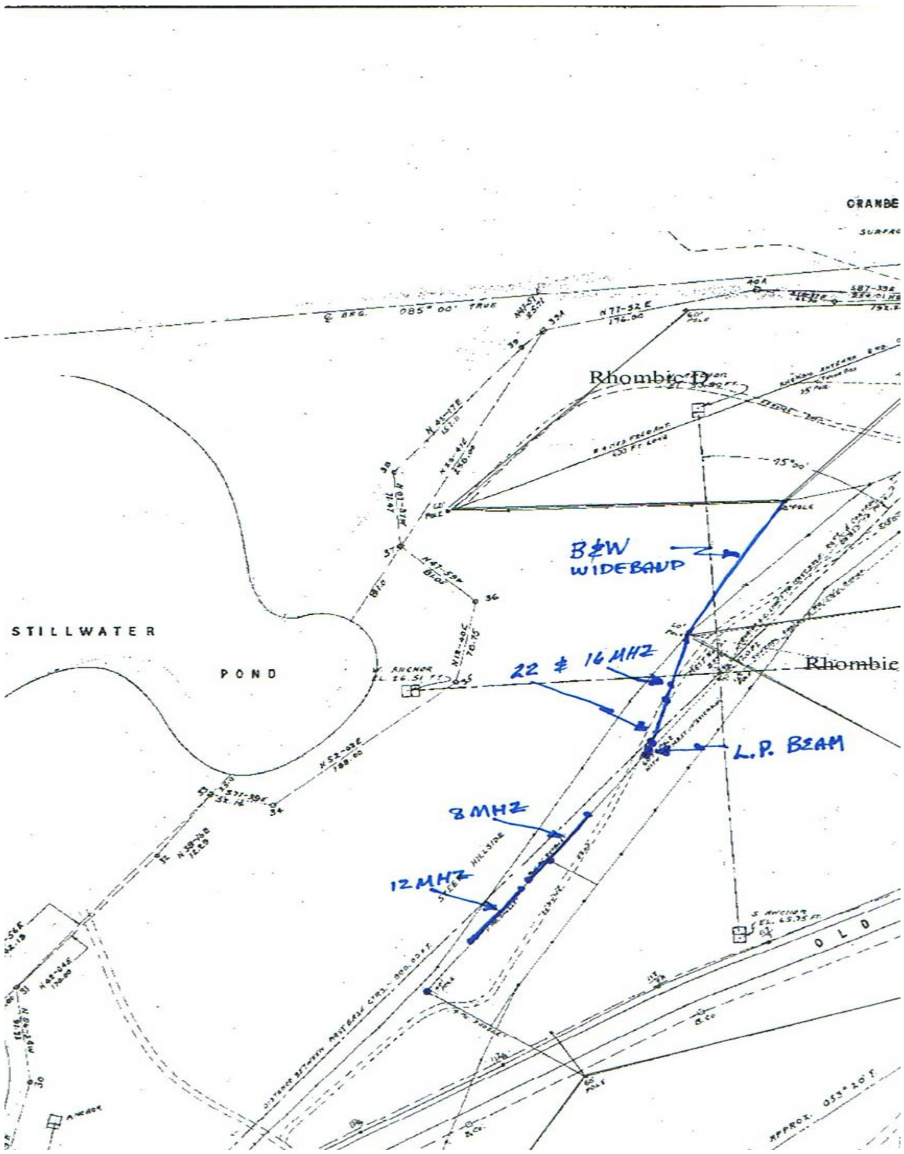
The 102 degree and 144 degree Rhombics allowed the station to receive signals from the South Atlantic, off the bulge of Africa and South America. And of course the 179 degree rhombic was used for the Caribbean, Panama, and points south. At one time the 179 degree antenna was not terminated, allowing it to be used for over the pole reception, especially during the Vietnam conflict." (Farris, 2004)

Some of these are on the Diorama of the site. Refer to the Azimuth chart to see where these antennas had their central sensitivity. The width of sensitivity is roughly 18°.





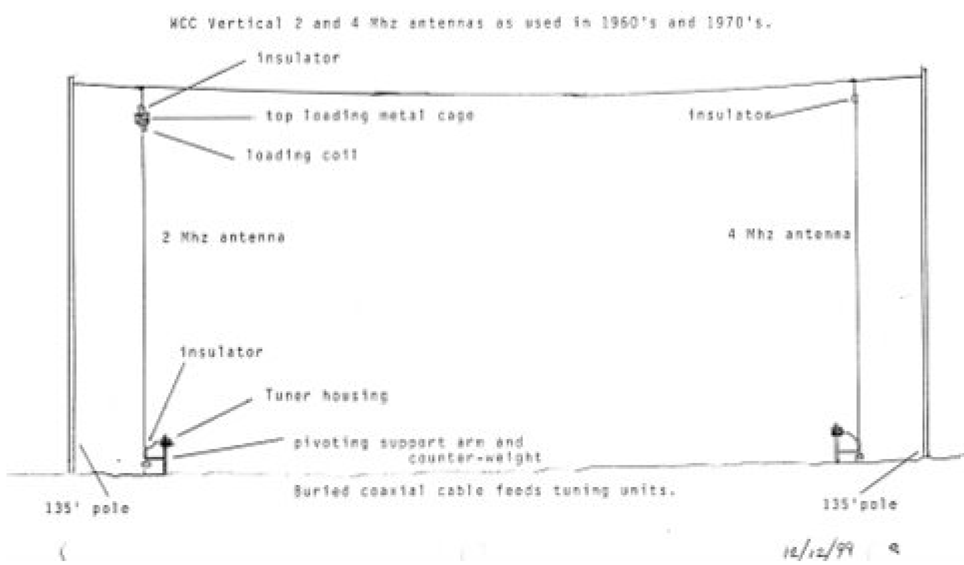
Numerous Dipole and Log Periodic (L.P.) Antennas were also on the site and operators would select the antenna they wanted using a control panel that was at their individual fingertips.



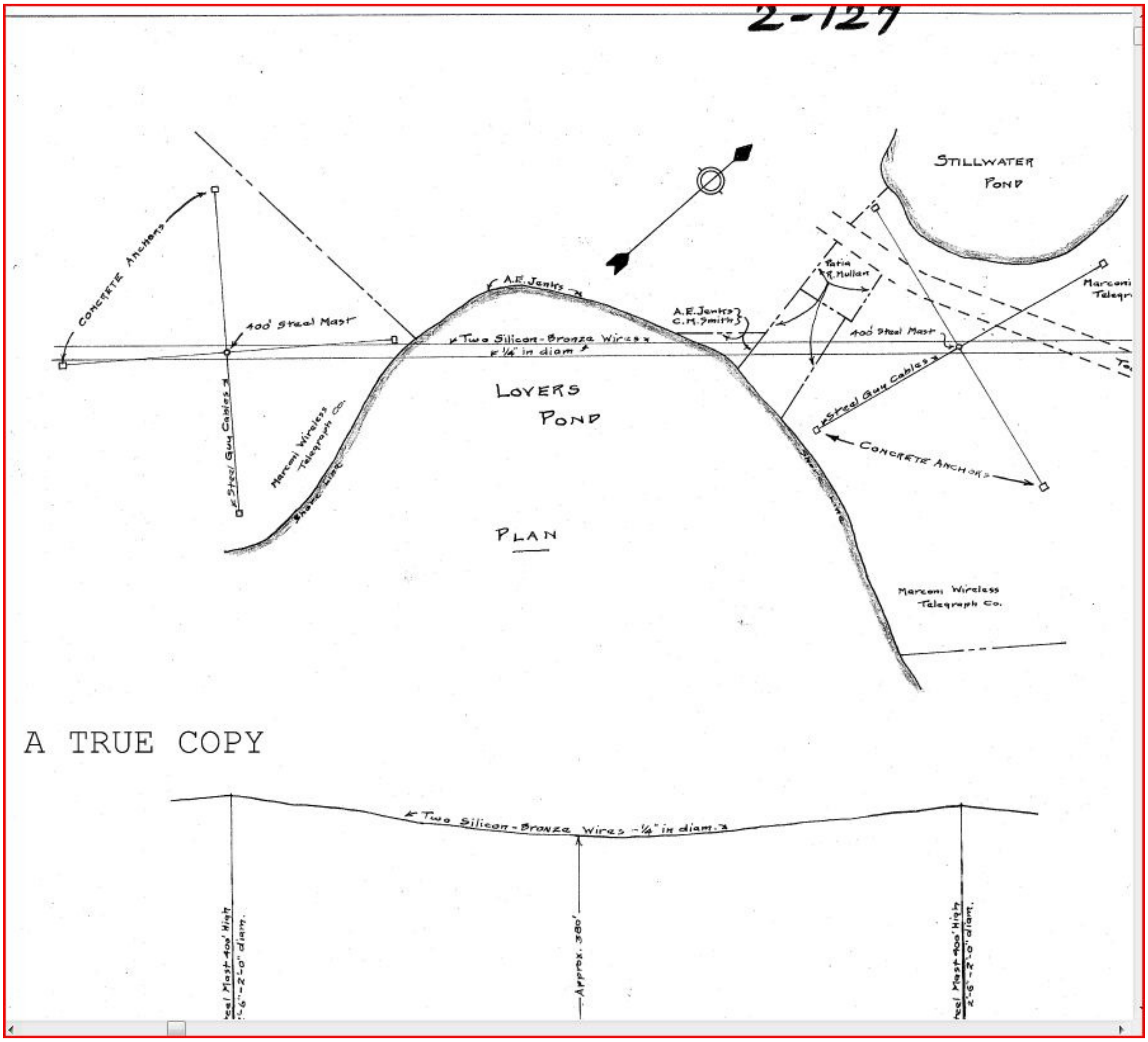
Another Antenna at the site was called a Marconi T, which is a non directional antenna consisting of a vertical wire that terminates in a Horizontal top wire. One would listen on this antenna for distress or hailing from ships at sea before selecting the proper directional antenna from among the various Rhombics or dipoles.

The Transmitter station in South Chatham had a graceful 300 foot non-directional antenna for the 500 kHz band to be used for the initial contact, or for broadcasts that were to go everywhere at one time. Unfortunately it no longer exists. The site is preserved as Conservation land and can be accessed from Forest Beach Road in South Chatham MA.

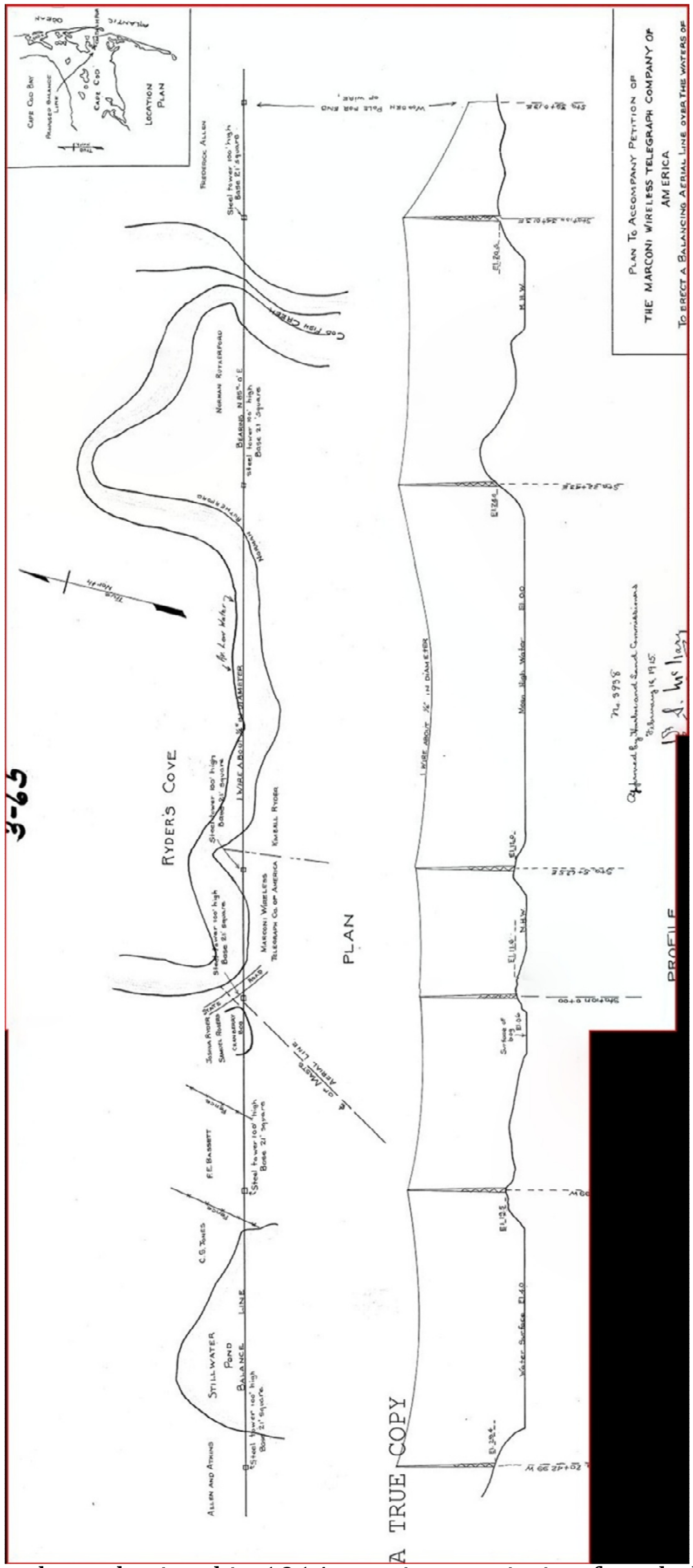
The H/2 Antennas gave roughly 10 times the signal strength compared to the prior antennas in use. The H/2 antennas were pointed at 60° which gave sufficiently wide coverage that the entire service area for WCC had good coverage.



Appendix 1:
Main and Balancing Aerial locations from the Barnstable Recorder of Deeds



The above document filed in 1914 shows that Marconi intended to string a pair of ¼ " dia Silicon Bronze wires along the 6 towers that stretched from the ChathamPort station on Ryder's Cove to the edge of Lizzie's Pond (Now called Schoolhouse Pond). The supporting tubes are gone, but the concrete blocks for guy wires remain in many of the locations. Due to problems with getting the Marion Spark Gap running and the silencing of Marconi's marine stations after contacting a British Warship in 1915, it is not clear if the wires were ever installed.



Above is a copy of the plan submitted in 1914 to gain permission for a balance aerial to be erected that would be used to null out signals from Marion. Much of this was no longer needed when loop antennas were developed and erected in Chathamport during the WWI when the navy kept the station silent but ready.

Appendix 2:
Howith Chapter XXV on maintaining Chatham during WWI
History of Communication in the US Navy available from
<earlyradiohistory.us>

Operation of the World's Largest Radio System

1. MOBILIZATION

The President's signature to the resolution declaring war was the signal to place in effect previously prepared war plans. Executive orders based upon the wartime powers of the Commander in Chief had been prepared and only awaited his signature for enactment. Most of these were signed on 6 April and placed into effect the following day.
The mobilization of naval communications, under the guidance of Bullard, had commenced sometime earlier with the voluntary acceptance of active duty by hundreds of reserves. The increased volume of radio traffic which resulted from the imminence of war necessitated the augmentation of facilities and the use of this previously trained group.
With the country at war, the remainder of the Communications Reserve was immediately called to active duty. They were augmented by the almost immediate enrollment of hundreds of commercial and amateur operators who had not previously joined but who now saw it as a patriotic duty. The closing of the commercial stations made additional hundreds of operators available for duty. The immediate requirements for trained operators were well met by these people. However, as the war progressed, more and more ships were built and commissioned, causing a constantly increasing demand for qualified radio operators and other communication personnel.

2. TRAINING OF WARTIME PERSONNEL

The electronic communication equipment of today is able to perform many mechanical brain functions, with its flashing red lights and ringing bells indicating electrical or mechanical difficulties or the rejection of some message because of a humanly generated error in routing instructions beyond its digestive capability. As advanced as this is, it is only as efficient as the personnel who operate it. In World War I all these functions had to be performed by additional thousands of men who required training to provide the communications necessary for the prosecution of the war.

To meet these requirements, radio schools were established in each naval district to provide preliminary training in radiotelegraphy and to eliminate those who lacked the essential aptitude. To provide advanced training two schools were established, one on each coast. Following the close of the college year of 1917, Harvard University offered buildings for classrooms, laboratories, and dormitories. This offer was gratefully accepted, the school was established and grew rapidly into an institution of mammoth size. A similar, but smaller one was established at Mare Island, Calif. By the end of 1917 almost 5,000 students were attending the 4-month intensive radio operating and indoctrination courses and were being graduated into service at a rate in excess of 100 a week. By early 1918 this was increased fourfold.[1] Amateur experimenters proved the best students since they already possessed an ability in manipulation gained by their previous activity.[2] However, many young men who had never before seen radio equipment were proficiently trained. Many of these later became actively engaged in the ever-expanding field of electronics.

3. OPERATION OF THE SHORE RADIO SYSTEM

The major problem of the Naval Communication System during the war was that of augmenting transoceanic communications facilities. The System was augmented by the commercial facilities taken over upon our entrance into the war.
With the new San Diego station in operation, and the Pearl Harbor and Cavite ones completed shortly after our entrance into the war, augmented by commercial circuits, the communication problem in the Pacific was relatively minor.

With no far-flung possessions in the Atlantic to protect, nor on which to erect a high-power station, improvements in communications had been limited to providing a reliable circuit between the Canal Zone and Washington and increasing the range of radio communication between the seat of government and the commanders of forces operating in the North Atlantic. Considerable transatlantic operating experience had been gained in operating the foreign-owned stations during the neutrality period and there were some improvements in equipment, which had increased reliability. Despite this, in 1917 not one transatlantic circuit was capable of providing continuous service. Main reliance for communications between the United States and her European Allies continued to be placed upon the cables. To improve conditions on the transatlantic circuits, both reception and transmission were accomplished at locations remote from Washington. Traffic between these points and the Navy Department was manually relayed over landlines. During the early months of the war, transatlantic signals were received primarily at Sayville, backed up by Tuckerton. Landlines connected the two stations in order that Sayville might operate the Tuckerton transmitters and for forwarding Tuckerton copy to Sayville for comparative and fill-in purposes.[3]
The summer of 1917 demonstrated that receiving in this manner was entirely unsatisfactory. The successful development at Great Lakes of the submarine and subterranean collector systems for reception induced the Bureau to install such a system at the Belmar, N.J., Marconi station which had been taken over but not used at the beginning of the war. Taylor, who had conducted the Great Lakes experiment, was ordered in command with the title of Transatlantic Communications Officer. He was dually responsible to the Director of Naval Communications and to the Chief of the Bureau of Steam Engineering. **By the end of October 1917, Belmar was in operation and became the control center for transatlantic communications. Early in November it was decided to utilize the Marconi receiving station at Chatham, Mass., as a backup for Belmar. The two stations were connected by landline for relaying Chatham's copy. It was soon discovered that Chatham was of no assistance to Belmar and it was closed in October 1918.** (Howith is quoting from 'History of the Bureau of Engineering, Navy Department, During World War I)
(http://www.archive.org/details/historyofbureauo00unitrich)

Appendix 3:
Forest Robinson's recollection of the original towers in ChathamPort.

CHATHAM/MARION, MASSACHUSETTS

The Radio Corporation of America was formed by the big "FOUR" - General Electric, Westinghouse Electric, American Telephone and Telegraph, and the United Fruit Companies, in early 1919.

These 4 moguls pooled their patents, put up financial support, and RCA was brought into being.

RCA took over the assets and properties of the Marconi Wireless Telegraph Company of America. Chatham, Massachusetts was one of several point to point stations used for receiving messages from Europe in competition to the underwater cables.

The Marconi Company also erected a huge complex at Marion, Massachusetts, as its transmitting Station, keying the alternators by overland wires from Chatham.

The towers at Chatham and Marion averaged about 350 feet in height. In 1913, when these stations were originally constructed by the J. G. White Engineering Company of New York, it was thought necessary to have the receiving antennas this high. The sight of these 6 towers at Chatham must have been an impressive sight to the few travelers to the Cape during those 6 years.

When I joined the staff at Chatham, March 24, 1921, there were 2 circuits from Germany, and 1 from Norway. Traffic to and from New York was handled on overland telegraph wires and transmitted manually to Berlin/POZ and Stavanger/LCM. Hanover/OUI was an overflow transmitting station for Berlin.

A staff was built up at Chatham shortly after RCA was Incorporated on October 17, 1919. On August 20, 1919, 4 riggers arrived to dismantle the towers. Again, October 8, 1919, 3 riggers from Marion joined to further this work. On November 18, 1919, towers 5 and 6 are noted as being down. Towers 2, 3, and 4 were dismantled shortly thereafter. These towers were shipped and re-erected at Tuckerton and possibly New Brunswick, New Jersey.

During the first 16 months of operation, we received traffic from LCM, POZ and OUI along with the Navy circuits, which took over this class of traffic after the Armistice, November 11, 1918.

August 1, 1920, POZ circuit started up.

Stavanger/LCM and Hanover/OUI were started up shortly thereafter.

November 10, 1921, POZ circuit turned over to RC New York.

November 28, 1921, LCM circuit turned over to RC New York.

Hanover/OUI circuit turned over to RC New York shortly thereafter.

Riverhead, N. Y. receiving station had been built and took over reception, piping the signals directly into Broad Street, New York.

Alexanderson alternators were in use at Marion during this period.

Call signs WSO and WRQ were assigned to the alternators' respective frequencies. A Beverage wave antenna was erected at Chatham, about 8 miles in length, ending at the bank of Swan River, West Harwich.

73,
FR.

March 24, 1966.

Robinson was one of the original employees at WCC and his picture is featured in several early pictures of the station. He does not mention the loop antenna or when the Beverage antenna was constructed.

Appendix 4: Letters with respect to the design and implementation of the first Rhombic in ChathamPort

Chatham

No such. According to published charts there are minor lobes in other directions which may be as good or doubtful

Anyway broadening it out to cover both England and Mediterranean

10/15

Mr. F.D. Heiser, October 14th 1937

Mr. I.F. Byrnes, 75 Varick Street,

Dear Mr. Heiser:

I have made a few calculations with regard to a suitable rhombic antenna for use at Chatham. A design based on 12.42 megacycle operation for maximum effeciency which will also provide good operation in the 8 and 16 megacycle ranges would have the following dimensions.

The length of wire in each of the four legs of the antenna would be 250 feet. The two poles which are in a line with the desired direction of reception should be 500 feet apart. The other two poles which will be at right angles to the direction of reception should be 190 feet apart. By using 250 feet of wire in each length and suitable sheaves at each pole, the antenna may then be adjusted so that the so-called tilt angle may be varied. In other words by lowering it on the halyards at the end poles and taking up on the side poles, the tilt angle may be increased, while by a reverse operation, the tilt angle may be decreased. If the antenna is adjusted after erection so that the distance from one end of the antenna to the other in the direction of reception is 470 feet and in the other direction 171 feet, this gives a tilt angle of 70 degrees and an angle of 40 degrees where the wires converge at the poles.

The theoretical height of the wire above ground shoule be 58 feet, which is equal to .73 wavelength at 12.42 megacycles. 65'foot poles will be satisfactory, although these should be buried seven or eight feet in the ground and not five feet for maximum stability. Will you ascertain if these poles can be obtained locally and what their cost erected will be?

The ends of the antenna which points to the direction of reception and which requires the terminating resistance should be brought down with a non-transposed line of 800 ohms impedence which can be led to a small weather-tight box mounted on the pole about six feet high in which the resistance can be located. This line for 800 ohms with #14 wire should be spaced 22 inches.

At the other end of the antenna where it is necessary to match to the 200 ohm four wire transmission line, I would recommend a quarter wave matching section. This would be a 400 ohm section twenty feet long and may be constructed of 3/8" copper tubing spaced five inches. This twenty foot section could be supported on small poles with suitable insulators about five or six feet above ground in a horizontal direction (so it is accessible for adjustment) or it may be mounted higher to conform to the height of the transmission line. The down lead from the end of the antenna to the quarter wave matching section should be an 800 ohm transmission line the same as used at the other end with the same spacing.

You will need more than 400 feet of 1/4" halyard cable according to our calculations, since there will be two halyards on each of the end poles and one halyard on each of the side poles. This would require approximately 700 feet of halyard cable.

I would like to receive a sketch showing how you propose to construct the four wire transmission line.

An antenna of this type will have a pattern for maximum reception about 18 degrees wide. It is therefore important that it is pointed accurately in the direction from which you expect to receive most of your traffic, and this direction must be accurately determined. Ordinary maps should not be used, accurate great circle maps or a globe are required. If the antenna is pointed on England it will not cover the Mediterranean or vice-versa.

The attached sketch shows the general construction which we suggest.

Very truly yours,

IFB

IFB:EVH

I.F. BYRNES

CC: Mr. A.J. Costigan.

Encl. 1.

Form 258M 10M 5-35

Mr Martin
Cab

very good! HB 1-4-38

RADIOMARINE CORPORATION
OF AMERICA
INTERDEPARTMENT CORRESPONDENCE

TO: Traffic Manager

FROM: Manager

SUBJECT:

DATE December 31, 1937.
Chatham, Mass. . OFFICE

FILE No.

1/3

Dear Mr. Costigan:-

You will undoubtedly be interested to hear of our experience so far with the new Rhombic receiving antenna.

This antenna was put in service, on a temporary basis, December 24th. There are several small jobs to be completed on the antenna, which are now temporary, but I feel that from our present experiences, this antenna will be very helpful in our endeavours.

We have had several cases so far where we have been able to clear ships who were absolutely unreadable on our other antennae. We find that for a ship in the correct location we are able to improve our reception which has been badly handicapped due to diathermy interference. We find it helpful due to interference from ships in opposite directions, and an outstanding improvement is noted on signals bothered with echo. The antenna has not been completely balanced throughout as yet, but we think that it will show up even better after it is more refined. I am well satisfied with the showing so far made.

We find also that it works almost as well on all the marine bands, although we find more refinement on the daylight waves.

We have this antenna pointing at Paris, and we note, so far, that ship signals from points around Great Britain, Copenhagen, German ports, part of the Mediterranean, and to the Far East and near Australia, are benefitted by its effects.

While this antenna is supposed to be effective within an eighteen degree angle, it is my opinion that we are getting improvement in reception over a much greater range. Of course it will take time to establish it's real range, we are of the opinion that it will prove much to our advantage.

Very truly yours,

F. D. Heiser