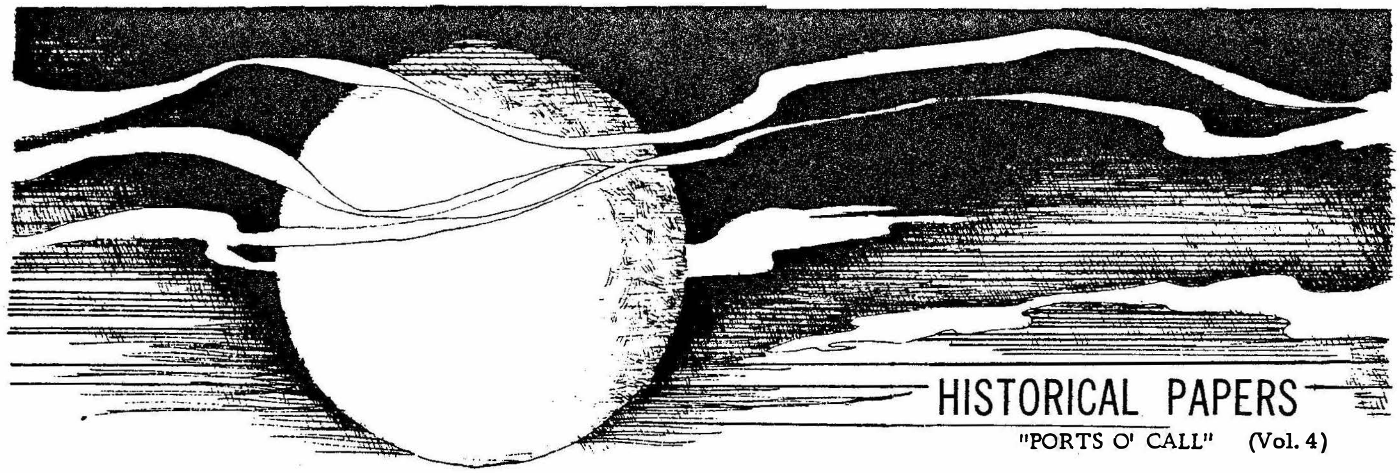


THE ALEXANDERSON 200-KW. HIGH-FREQUENCY ALTERNATOR TRANSMITTERS

BY THORN L. MAYES

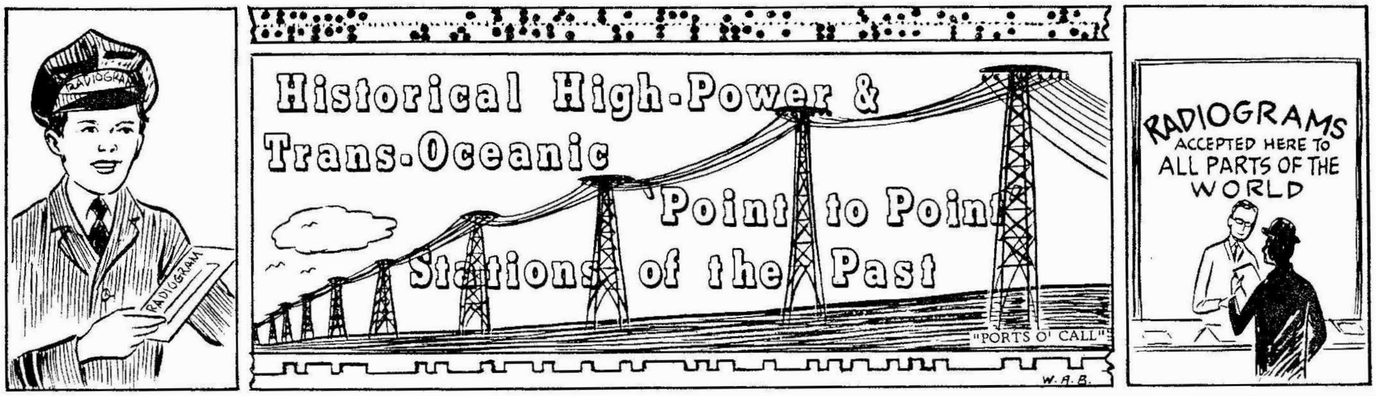
SOCIETY OF WIRELESS PIONEERS

APPENDIX D-11

"PORTS O' CALL"

DOCTOR ERNEST F. W. ALEXANDERSON—1878-1975

APPENDIX D-12



THE NEAR PERFECT SYSTEM

ALEXANDERSON ... AND HIS ALTERNATORS

By Thorn L. Mayes

Development of the Alexanderson 200 KW transmitters was a major breakthrough for wireless communication that was responsible for:

- The formation of the first major American controlled wireless communication company, Radio Corporation of America in 1919.
- Dependable day and night wireless contact with our allies in WW-1 through the Navy operated American Marconi station at New Brunswick, N.J.
- Our only reliable contact with Germany during the latter part of WW-1 as England cut the cables connecting the U.S. with Germany early in the War.
- R.C.A. setting up a world-wide communication system that superseded the British Marconi "Imperial Chain" of 300 KW timed spark transmitters.

This development has never received the credit it deserved for it came during a war time period when our main concern was with winning, and the relatively short life of the sets due to the early perfection of the short wave, high power, tube transmitters.

The purpose of this paper is to review the design and application of these transmitters, show their importance in our building a dependable world-wide wireless system and their contribution to communication in both WW-1 and WW-2.

The Alexanderson 200 KW transmitters were built from 1918 through 1921 and were initially installed by the end of 1923, over 50 years ago, but several of the engineers who installed them are still with us and have supplied much of the information in this paper. A year ago I had an hour's meeting with Dr. Alexanderson who recalled many incidents dealing with the design and operation of these sets. Several days spent in the Schaffer Library of Union College, Schenectady, with Dr. Alexanderson's papers and letter books, furnished the material on early design and tests.

I am also especially indebted to the following who provided essential data on location of stations, performance and later use of the transmitters: Capt. Hedley Morris, retired R.C.A. and Navy executive, who helped install the sets at Kahuku, Hawaii in 1920 and was engineer of the station through 1927. Later while serving with the Navy in WW-2, he selected the VLF site in Haiku Valley, Hawaii. W.W. Brown who was the General Electric engineer in charge of all of the initial installations. G.J. Eshleman, engineer in charge of R.C.A. Tuckerton station until it was closed, then civilian engineer of the Marion station while it was operated by the Air Force. T.M. Linville, General Electric research engineer. Bruce Kelley and Lincoln Cundall of Antique Wireless Association who visited Marion and Tuckerton in 1955 to take pictures and make notes on their operation. And to General Electric and R.C.A. for use of pictures and printed material.

Theory of the high frequency alternator was not new. Dr. J.A. Fleming in his 1906 edition of "The Principles of Electric Wave Telegraphy" says: "Designs for high frequency alternators began to be considered about 1889 or 1890 when attention was being directed to arc lighting by alternating currents. It had been found that most forms of alternating current arc lamps produced a disagreeable hum when actuated by an alternating current of a frequency of the order of 100. The notion therefore arose that if a frequency could be used higher than the highest audible note, the defect would be annulled. Prof. Elihu Thomson and Mr. Tesla were probably the first to construct such alternators, and Tesla, finding that he had in his machine a source of electric current capable of exhibiting many interesting electrical effects, pursued the subject and devised several forms of alternator capable of producing alternating currents of a strength of 10 amperes or so, having a frequency as high as 12,000 complete periods per second."

> Dr. Fleming concludes: "The great defects of all extra high frequency alternators so far produced are their small output, and the extremely high speed they have to run. High speeds may be practical for small machines, but would be dangerous if the revolving parts were at all heavy. On the whole, the prospect of being able to generate by purely mechanical means, high frequency currents of 100,000. and upwards with large power output is not very great."

Fleming lists the 1KW-5,000. Hz alternators built by both Thomson and Tesla in 1889 with a 1 KW-10,000. Hz machine by Steinmetz in 1903. This latter machine was used by Fessenden in experiments with wireless telephony who in 1904 ordered from General Electric Co. a unit to generate A.C. at a frequency of 100 KHz. This order was given to E.F.W. Alexanderson to design as he came with G.E. in 1902 and was in their A.C. Engineering Department.

Alexanderson made tests on special Swedish iron strips 1½ mills thick in strong magnetic fields at high frequencies and found the iron would operate satisfactorily at frequencies of 100 KHz so designed the alternator with an iron core.

Fessenden rejected the design, #1fn, insisting that the machine be built with a wooden core as he was sure iron would be melted in a strong field at such high frequency.

General Electric built a machine by mid 1906 with wooden core, that generated 1 KW at 50 KHz frequency, which Fessenden used for his famous tests made at Brant Rock, Mass., Christmas Eve of 1906 when he broadcast voice and music, heard as far as Norfolk, Virginia. #2fn.

Alexanderson in a memo dated March 13, 1924, #3fn, states, "In the meantime I did not give up the idea of a high frequency alternator with an iron armature. I believed it was a mistaken assumption of Fessenden's that iron could not be used, and I expected a higher efficiency with an iron armature. I therefore obtained an appropriation from General Electric to build a model alternator in accordance with my own ideas. When Fessenden made a visit to Schenectady, I showed him this machine and convinced him of its merits and he placed orders for two 100 KHz alternators of this type.

Fessenden about this time severed his relations with National Electric Signaling Company but his work was carried on by the management of the company and orders were placed for two 100 KHz and one 200 KHz alternators which we built and delivered. Two 100 KHz units were also built for Mr. John Hays Hammond."

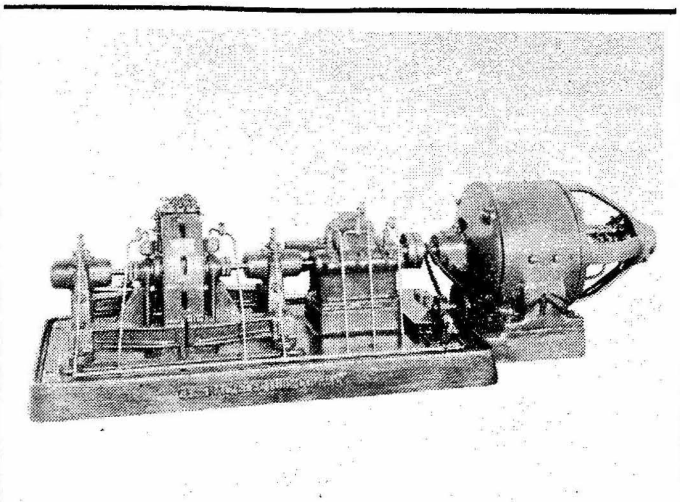


Figure 1 is of one of the 2 KVA-100 KHz machines with iron core driven by a 2,000. RPM direct current motor through a 10 : 1 increasing gear box.

Dr. A.N. Goldsmith in his book "Radio Telephony", page 118, makes these comments on these machines: "Since the speed of the rotor is 20,000. RPM or over 330 revolutions per second, the actual speed at the rim is nearly 12 miles per minute!! Such a machine must, accordingly, be considered a masterpiece of engineering design."

Dr. Alexanderson's memo continues: "Through Mr. John Hays Hammond, I became acquainted with the DeForest audion which is a three-electrode tube, and I saw in this device a possible realization of my ideas for telephonic modulation of the output of the high frequency alternator.

I bought a sample audion from Mr. Hammond, gave it to Dr. Langmuir explaining my intentions of developing it as a power modulator. Dr. Langmuir developed successfully the power tubes which we used for modulating the output of the high frequency alternators in our first radio telephone tests between Schenectady and Pittsfield, Massachusetts."

Based on these tests, a 50 KW-50 KHz experimental alternator was completed in 1915 and tested in Schenectady until Feb. 1917 when it was installed in the American Marconi station, New Brunswick, N.J. During these tests, Dr. Alexanderson and other specialists, perfected the magnetic amplifier with vacuum tube control for modulating with voice, and the design of the multiple tuned antenna.

Dr. Alexanderson continues, #4fn: "The 50 KW equipments were ready to test in the Marconi station the spring of 1917 at the time when America entered the great War. All radio stations including the New Brunswick station were taken over by the Government and it looked at first as if it would not be possible to carry out the tests of the 50 KW alternator. However we succeeded to convince the Navy that our experimental installation might be useful for military purposes and the station was placed at our disposal for experimental tests under the control of the Navy. The tests we made on both telegraphy and telephony proved very successful and the improvement in efficiency of radiation which we had expected from the use of the multiple tuned antenna proved to be correct. The signal reaching Europe from our experimental equipment proved to be better than any other American station.

Our tests of radio telephony and improvement of radiation efficiency were carried on during the summer of 1917 until the Naval Communications Department decided to take over the equipment for much needed communication with France. While the 50 KW alternator was thus used, work was in progress of installing a 200 KW alternator which in the meantime had been built in Schenectady. The 200 KW alternator was placed in service, superseding the 50 KW machine in the summer of 1918. Through the reliability and clearness of the signals sent out by the 200 KW set, the New Brunswick station became quite well known all over the world, and the press messages sent out by the station were copied by all the belligerant countries in Europe."

Because of its greater power, the 200 KW set was used by the Navy for communication as soon as it was installed in mid 1918 but it was released occasionally for short periods for testing. Dr. Alexanderson told me Oct. 2, 1974, that he and the installation engineer W.W. Brown were making some tests Oct. 20, 1918, when a Naval representative came in and said the Navy wanted to use the transmitter at once.

NFF, the call letters of New Brunswick under Naval control, immediately called POZ, the largest German station, and demanded the abduction of the Kaiser as a preliminary to Armistice negotiations. This was our first contact with the German radio since the War started, and NFF was used exclusively for the Armistice negotiations. Dr. Alexanderson said that because of the strong signals sent out by NFF, that all countries allied with Germany could easily hear our proposals and the German replies as all negotiations were carried out in English with no coded messages for our Government wanted all of Germany's allies to have the true story of the negotiations.

It is claimed, #5fn, that because of the power and coverage of station NFF that President Wilson's fourteen points and other pleas for termination of the War became known in spite of the censorship through all the countries of the Central Powers.

DESIGN

Four major elements contributed to the success of the Alexanderson transmitter, all four had to be developed and each required designs well ahead of current performances. They were:

1. Producing an alternating current generator that would generate sufficient power at radio frequencies.

2. An extremely precise speed control system.

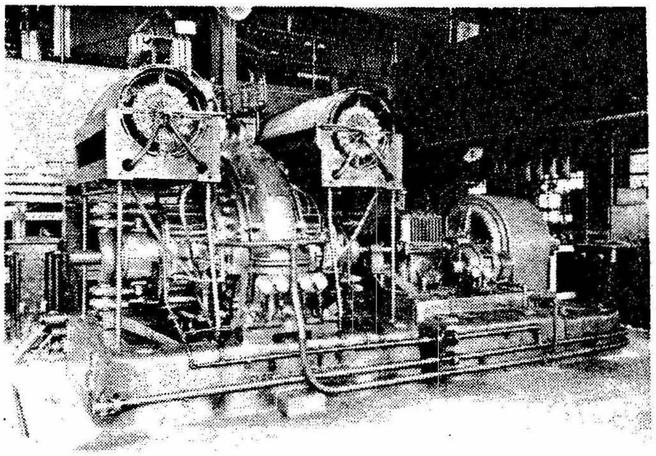
3. A modulation system that would control the full power of the generator, and

4. A multiple tuned antenna system that would result in a signal gain of 500% to 600% over the conventional flat top antenna.

Footnotes • 1fn, Etc.

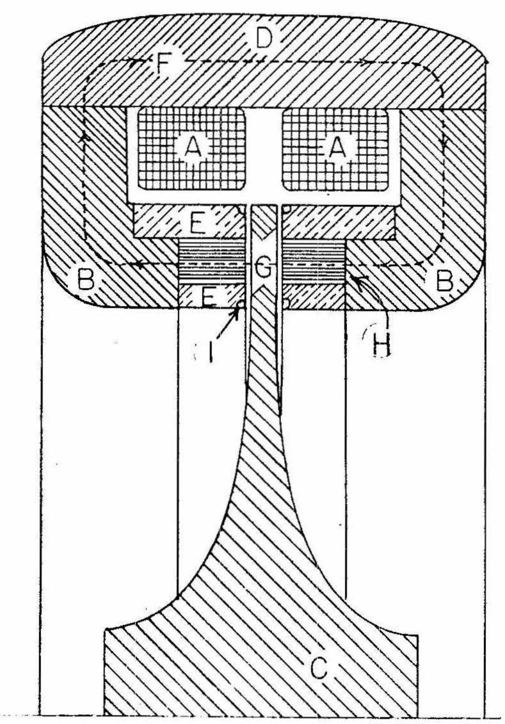
The author's footnotes - numbered from No. 1 to 17 are indicated in the text as... #1fn, #2fn, #3fn, etc. Explanatory notes will be found in keyed table at end of this paper.

'W I I' Transmitter   New Brunswick



ALTERNATOR

This is the first 200 KW set built, which was installed in the New Brunswick, N.J. station, June 1918. It consists of the 600 horse power driving motor on the right, connected to a 1 to 2.97 speed increaser which could give a maximum alternator speed of 2700 RPM. The alternator is on the left with the two R.F. open core transformers mounted on each side. These transformers boost the generated voltage of 128 to 2000 volts.



Schematic Section of Inductor Alternator

FIGURE 3 - Legend

A - Field Coils	D - Frame	G - Rotor Slot
B - Armatures	E - Support Rings	H - Sheet Iron Core
C - Rotor	F - Magnetic Flux	I - R.F. Winding

The alternator is of the inductor type with stationary armature and field coils. It consists of a steel disc C with thin rim which is slotted at G, the slots filled with non-magnetic metal. Windings A-A located inside the frame, generate a strong magnetic field F which passes through frame D, the armatures B-B, thin sheet iron cores H-H, the air gaps and the steel disc. The cores H*H are supported by non-magnetic rings E-E and the slots are milled in them to support the radio frequency windings I-I.

As the disc "C" rotates, the alternate steel and non-magnetic poles cause the flux to pulsate in cores H*H thus inducing a radio frequency voltage in Windings I-I.

Rotor C is a steel forging 64 inches diameter, 3 inches thick at the rim. To generate the required frequency of 25.8 KHz in the Marion, Mass. alternator, a rotor speed of 2538 RPM is necessary. At this speed, the rim of the rotor is moving at 8.3 miles per minute or just under 500 miles per hour.

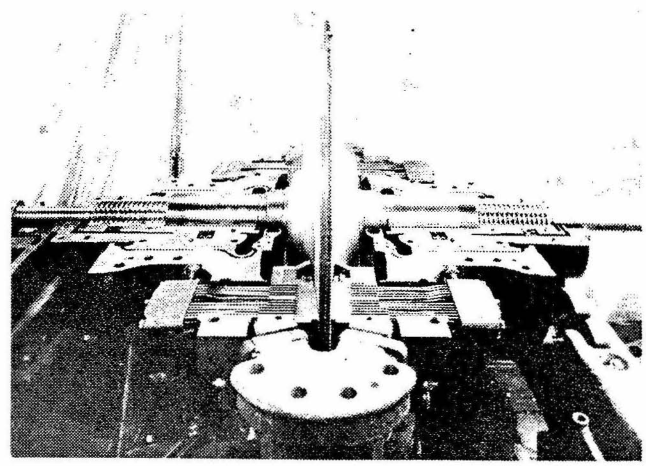
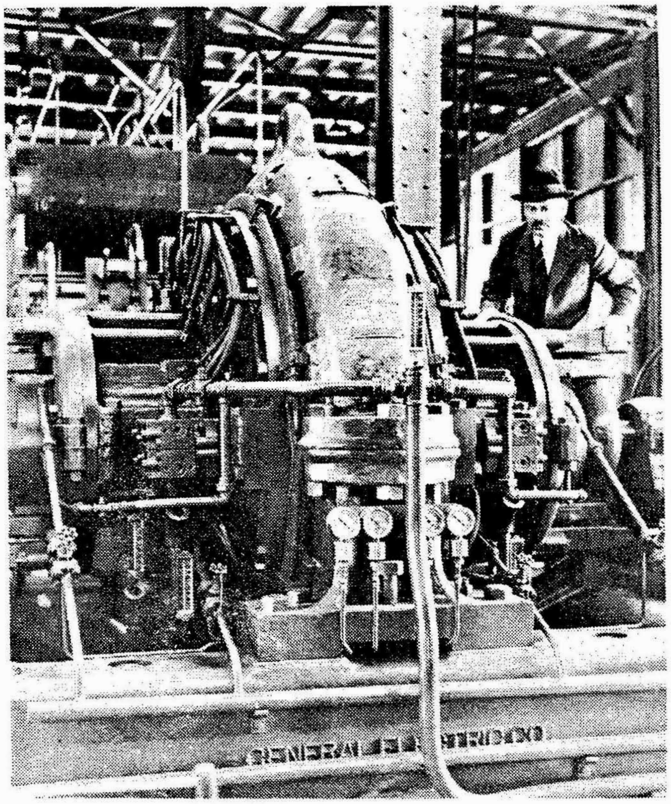


Figure #4. 200 Kilo-Watt Alternator, Top Half Removed.

Here is the 200 KW alternator with top half of stator removed but with rotor in place. Note leads on each side leading to radio frequency winding.

Dr. Alexanderson decided that a 200 KW size would be ideal for a high power transmitter. This meant 200 KW into the antenna whereas the spark and arc stations were rated in power input which with a 50% efficiency would mean only half the rated power to the antenna.

The sets were built to operate at wave lengths of 10,500 to 24,000 meters (28.57 to 12.5 KHz). This was accomplished by three design variables. The alternators were built with 1220 or 976 or 772 poles. Three gear boxes were available with ratios of 2.675- 2.973 and 3.324 and the 900 RPM driving motor was operated at slips of 4% to 20%, giving speeds of 864 to 720 RPM. Transmitters installed in Europe, operating on 50 cycle power, had a wavelength range of 12,500 to 28,800 meters because of the lower speed of the driving motor.



Dr. Alexanderson watching his invention at Radio Central May 26, 1922

This picture, Fig. 5, shows Dr. Alexanderson with one of the 200 KW alternators installed at Radio Central, which gives an idea of its size. They were always installed in pairs and the base foundation for the two sets were 43 feet long by 11 feet wide. The main frame steel casting was 7½ feet in diameter by 19¼ inches wide.

Weights of one set were as follows:

One alternator with base	30.0 tons
600 horse-power driving motor	5.4 tons
Auxiliaries	11.6 tons
Detailed parts	3.5 tons
Total weight, one set	50.5 tons

In a letter to Roy Weagant, chief Engr. of American Marconi dated Nov. 12, 1919, Dr. Alexanderson gives the following power requirements:

Alternator delivering 200 KW, key down	385 KW
Average load telegraphing at 200 KW	307 KW
Key up, alternator excited	116 KW
Running full speed, no field excitation	82 KW
Auxiliaries (estimated)	40 KW

SPEED CONTROL

The antenna system was closely tuned to the alternator frequency and if that frequency changed as much as ¼ of one percent the antenna current would be reduced by fifty percent. A system of speed control had to be devised that would hold the speed of the 900 RPM driving motor to a change of less than one RPM from no-load to full-load.

Dr. Alexanderson told me that in 1920 he gave the Japanese a full set of alternator drawings. They built one but were never able to devise the necessary speed control so it was never put into commercial service.

Jack Napier who was engineer in charge of the Bolinas station 1930 through 1955 wrote, "Because the Bolinas antenna was small for VLF (about 2700 feet long) the voltage was rather high, running about 120 KV. If a southwest wind blew it would raise the antenna and change the antenna to ground capacity, which was considerable, and detune things and the insulators would flash over with a crack like a fifty caliber machine gun. At each support point there were two insulators in series, each being about five feet long with rain shields and corona rings."

MODULATION

Dr. Alexanderson was very familiar with the difficulties experienced by Fessenden and others who attempted to modulate the carrier of their radiophone transmitters, and knew it would not be practical to build a modulator that would carry the full current of a 200 KW machine.

He developed a magnetic amplifier that included a variable impedance in shunt with the external circuit of the alternator. By detuning this circuit, the antenna current could be reduced by ninety percent with a small control current. This construction worked satisfactorily up to code speeds of 500 words per minute.

As the antenna current varied directly with control current, this small control current could be easily modulated with a vacuum-tube amplifier for radio telephony.

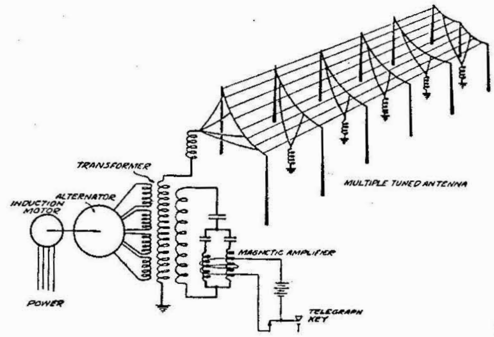


Figure 6

Alexanderson System Schematic

The Magnetic amplifier connected for telegraphy is here shown, Fig. 6, inductively coupled to the alternator.

MULTIPLE TUNED ANTENNA

This picture also shows the schematic diagram of the whole system feeding a multiple tuned antenna.

The objective of the multiple tuned design is to reduce antenna resistance which means reduction in loss. The New Brunswick antenna for example, which had a flat top over a mile long, had a resistance of 3.7 ohms. By multiple tuning this was reduced to 0.5 ohms. This was accomplished by connecting the antenna at six equally spaced locations, along the flat top, to ground through large inductances tuned to the required frequency.

The major loss in an antenna is equal to the current squared times the resistance. To maintain an antenna current of 600 amperes in the multiple tuned antenna requires 600 squared times 0.5 or 180 KW of power. To maintain the same current in the flat top design would require 600 squared times 3.7 ohms or 1330 KW, over seven times the power, and tests have shown that the signal strength was the same under both conditions.

For a detailed description of the design and operation of the 200 KW system, refer to Dr. Alexanderson's paper in the Proceedings of the AIEE for October, 1919, pages 1077 to 1094 or to E. E. Bucher's article in Wireless Age, July 1920, pages 10-17 and August 1920, pages 13-23.

THE FORMATION

OF

THE RADIO CORPORATION OF AMERICA

The War clearly demonstrated the importance of wireless communication to our nation. During the War, all commercial stations were operated by the Navy under Admiral Bullard. He realized an industry as important as wireless would soon be in the U.S. should be controlled by an American company, not the British dominated American Marconi Company. He knew from the performance of station NFF that whoever controlled the Alexanderson system would dominate world-wide communications. He knew that General Electric had paid for the development of the alternator and the various accessories and that the only company that could afford to buy the equipment was the British Marconi Company. He also knew that early in 1919 Marconi had offered General Electric an order amounting to five million dollars for Alexanderson transmitters.

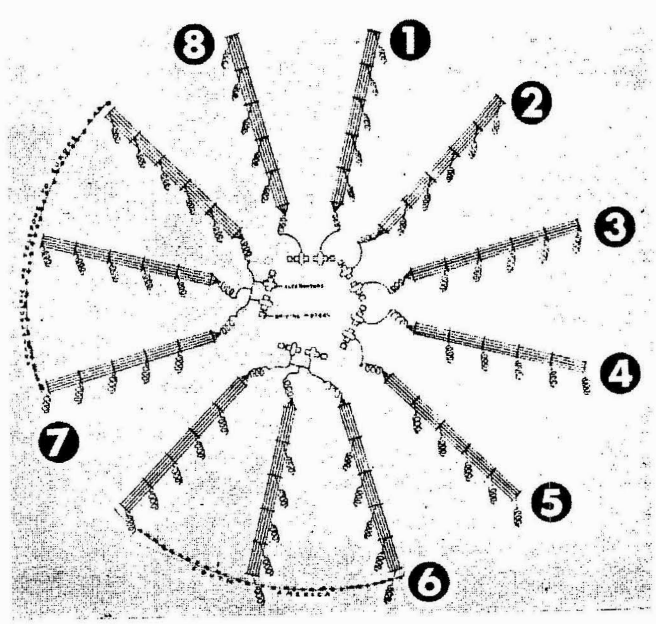
This story is told in the February 1921 Wireless Age in an interview with Admiral Bullard, who tells how he called a meeting of General Electric top management and asked them not to sell the sets and patents to Marconi on an exclusive basis as wanted. He then suggested that General Electric get into the wireless business by forming a separate company that would purchase control of the American Marconi Company, that could use the Alexanderson transmitters to set up a world-wide wireless communication system. (See Footnote fn-18)

General Electric did purchase the stock of American Marconi owned by the British Marconi Company, and turned down the Marconi order for transmitters. RCA was formed in October 1919 and in November the entire General Electric holding of American Marconi stock was taken over by RCA.

March 1, 1920, all stations were released by the Navy and RCA took over operation of the high power stations on both coasts. By this time preliminary plans had been made for installing Alexanderson sets in their main stations and setting up a Radio Central on Long Island for world-wide operation.

The original plan for Radio Central, #6fn, included central transmitter houses containing ten Alexanderson transmitters with twelve VLF antennas radiating out from the transmitters as shown in Fig. 7.

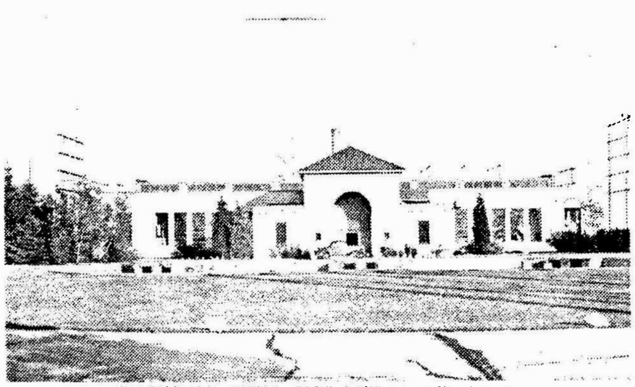
Work started at this Long Island site July 1920 and the formal opening of the station was held November 5, 1921, #7fn, when two antennas had been completed and two transmitters installed.



Following is the original plan for usage of each antenna or those coupled as noted in No. 6 and No. 7:

1. Denmark
2. Sweden
3. Germany
4. France
5.
6. South America
7. Trans-Pacific or telephone to Europe.
8. Poland

(Fig.7)



RADIO CENTRAL STATION - ROCKY POINT. LONG ISLAND. N. Y

Photo from collection of SOWP Member Arthur R. Anderson - 851-P

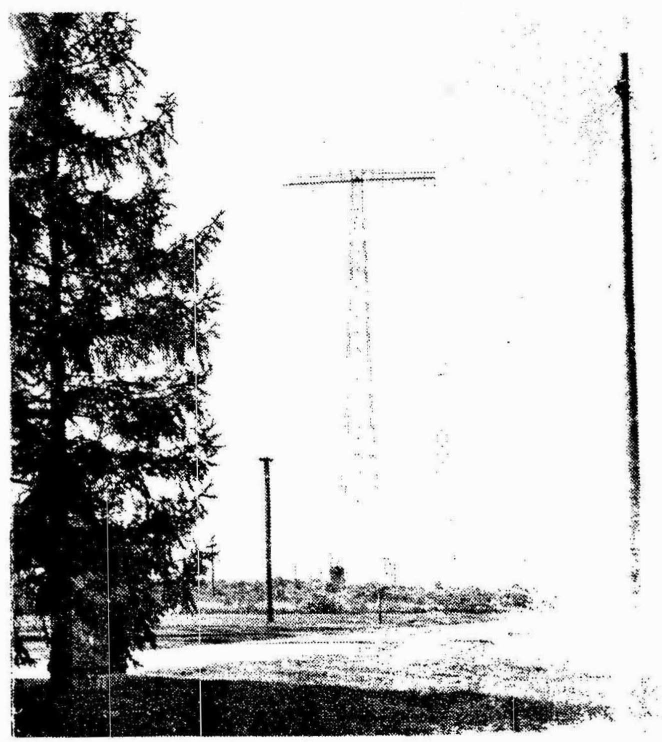


Figure 8.

Antennas at Rocky Point, Radio Central, 1959

Photo by Maurey Garber for RCA "Relay"

Because of the high speed transmission possible with these sets, initially over 100 words per minute, and the low down time for maintenance, the eight additional transmitters and ten VLF antennas were never added.

The towers supporting the VLF antennas were 400 feet high and the cross arms 150 feet long. Six towers spaced 1250 feet apart were needed for each antenna, a length of over one and one-third miles, Fig. 8.

Sites of former high power spark stations were selected for many alternator installations as they were in strategic locations and the costly masts could be used to support the multiple tuned antennas.

Marion, Mass. on Cape Cod had been a 300 KW timed spark station. Two alternator sets were installed there in 1921.

A second set was put in the New Brunswick station in 1921.

RCA took over the former German owned Tuckerton, N.J. station soon after the Navy released it in 1920, #8fn.

This picture of the Tuckerton mast, Fig. 9, 820 feet high, was taken by Hedley Morris in 1929. The guy wires show clearly, also the main antenna insulators above the guy wires. This antenna was converted to multiple tuned design and two alternator sets were installed in the station in 1921 and 1922.

The old timed spark sets at Bolinas, California, were scrapped in 1920 and two alternator sets installed in 1921, #9fn.

The station at Kahuku, #10fn, Hawaii had been a relay station to Japan and the Orient. Two alternator sets were installed there in 1920 and 1921.

To complete the world-wide network, the following sets were installed abroad:

Carnarvon, Wales, in April 1921, #11fn.
Warsaw, Poland, in 1923, #12fn.
Varberg, Sweden, in 1924, #13fn.

In 1924 two transmitters were shipped to Pernambuco, Brazil, but it took two years to find a contractor who could build the antenna towers and buildings and by that time, high frequency tube sets were available so the alternators were shipped back to Radio Central warehouse for storage, #14fn.

It was a tremendous task for the General Electric Turbine Dept. to build and test twenty of these transmitters in 1920 and 1921.

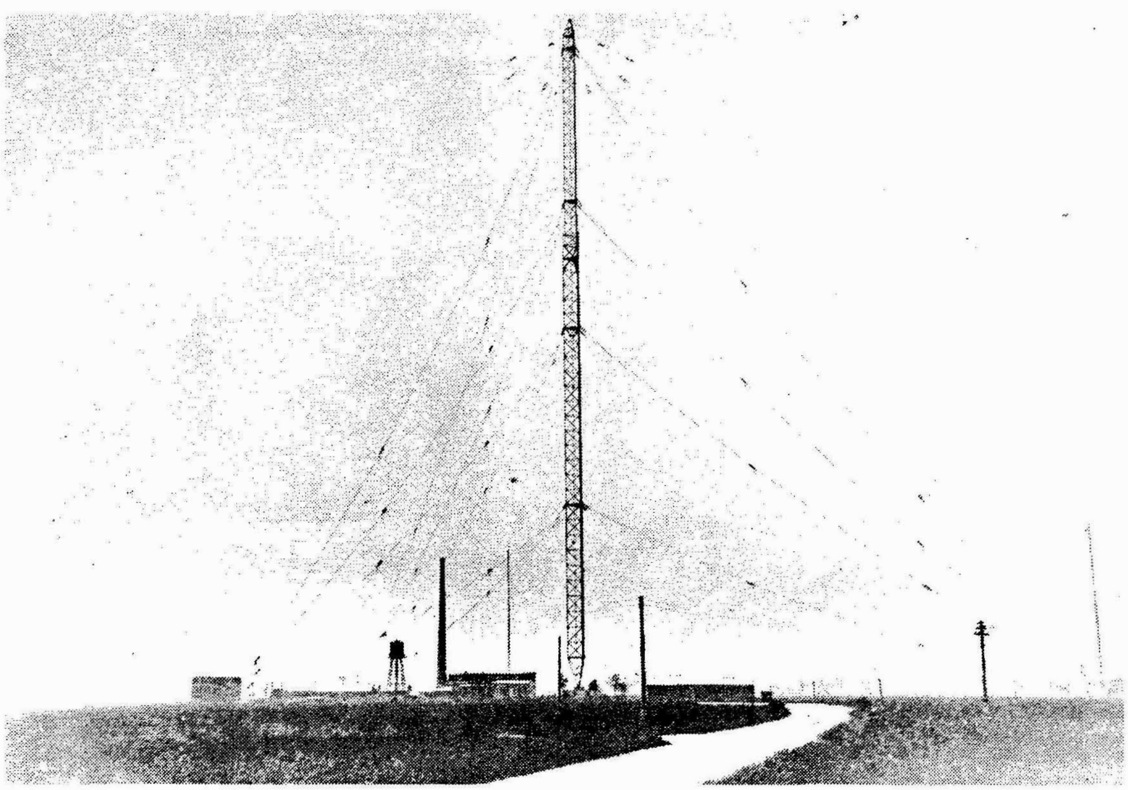
Fig. 10 is a picture of the radio test area during that period when four of the sets were in progress.

Performance of these eighteen VLF stations over the next ten years gave RCA an outstanding reputation for dependable, efficient, rapid handling of traffic. Regardless of weather conditions, or time of day, their signals came through on schedule.

High Frequency Tube Transmitters

An article by Irving Langmuir of the General Electric Research Lab. in September 1922 issue of Wireless Age, gives an indication of things to come. The title was "20 KW Transmitting Radiotrons," the most powerful tube ever made for use in radio communication.

Figure 9 below



Tuckerton Tower

Photo by Hedley B. Morris (195-P) while acting EiC circa 1929 for Gerald G. Eschelman. The 'umbrella' antenna of this Ex-German station was redesigned for the Alexanderson multiplex tuner.

Dr. Langmuir in this article states that by locating the large copper anode on the outside of the glass enclosure, rather than in the evacuated section, that it can be more easily water cooled which solves the problem of heat dissipation. They can be connected in parallel for generating high power. Ten of them will develop the same R.F. power as a 200 KW Alexanderson alternator, and in time they will probably replace the alternators as they are less costly, smaller in size, quiet in operation with lower operating cost. In addition the high frequency transmitter uses an antenna a fraction of the cost of the VLF antenna.

Radio News of August 1928 carries an article by Robert Hertzberg, "A Visit to Radio Central," which includes the picture of an Alexanderson alternator with its massive antenna almost a mile and a half long, and its long switchboard compared to a compact 20 KW tube transmitter with its low short antenna.

He comments: "Although great progress has been made in long distance communication on short waves with low power, the Alexanderson alternators, operating on wavelengths above 16,000. meters with an output of 200 KW each represent the backbone of transoceanic message service. The long waves are required for uninterrupted communication from daylight to darkness, for uniform and reliable transmission 24 hours a day regardless of weather. A single short wave transmitter working on one fixed wavelength cannot supply the same class of service; engineers are now conceding the necessity for a group of different transmitters which can be shifted at will to meet the peculiar effects of daylight and darkness on the carrying powers of their respective wavelengths. Marked economies are effected many times with the use of short waves instead of the longer ones, for less power is required and the transmitting speeds can be greatly increased.

At Radio Central short wave transmitters are handling more and more traffic to Europe and Latin America and are being used experimentally for directive transmission to selected countries.

Such have been the developments of a very few years; six since the inauguration of Radio Central, and twenty since the first commercial radio service was put in effect across the Atlantic between Clifden, Ireland, and Glace Bay, Nova Scotia."

By 1935 the bulk of all traffic had been taken over by tube sets and by 1940 the alternators were merely on standby. The sets at Kahuku, Hawaii, and Carnarvon, Wales, were scrapped before 1940 and the day of the VLF transmitters was thought to be over.

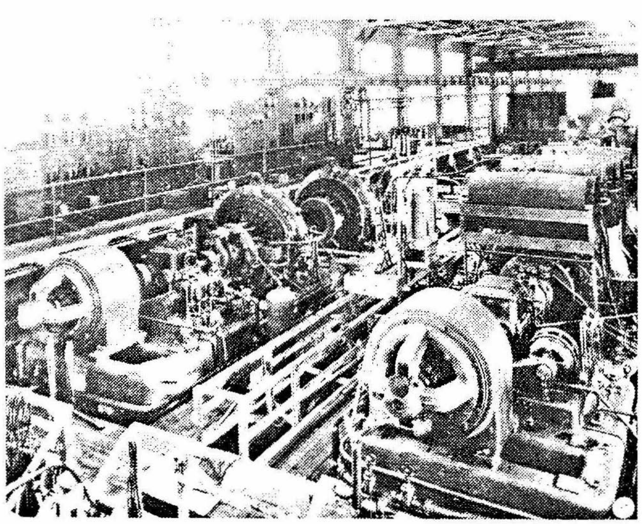


Figure # 10.
Radio Test at General Electric's Schenectady Works on Alexanderson Alternators circa 1920.

200 KW ALEXANDERSON ALTERNATOR TRANSMITTERS

(F-11)

No.	Location	Call	Wave Length	Installed	Idled	*Scrapped
1	New Brunswick, N.J.	WII	13,761	6-1918	1948	1953
2	New Brunswick, N.J.	WRT	13,274	2-1920	1948	1953
3	Marion, Ma.	WQR	13,423	4-1920	1932	
4	Marion, Ma.	WSO	11,628	7-1922	1932	To Haiku 1942
5	Bolinas, Ca.	KET	13,100	10-1920	1930	1946
6	Bolinas, Ca.	KET	15,600	1921	1930	To Haiku 1942
7	Radio Central	WQK	16,484	11-1921	1948	1951
8	Radio Central	WSS	15,957	1921	1948	To Marion 1949
9	Kahuku, Hi.	KGI	16,120	1920	1930	1938
10	Kahuku, Hi.	KIE	16,667	1921	1930	1938
11	Tuckerton, N.J.	WCI	16,304	3-1921	1948	1955
12	Tuckerton, N.J.	WGG	13,575	1922	1948	1955
13	Carnarvon, Wales	MUU	14,111	4-1921		1939
14	Carnarvon, Wales	GLC	9,592	1921		1939
15	Varberg, Swed.	SAQ	17,442	1924		
16	Varberg, Swed.			1924		
17	Warsaw, Poland	AXO	21,127	12-1923		
18	Warsaw, Poland	AXL	18,293	1923		
19 20	Shipped to Pernambuco, Brazil in 1924 then to Rocky Point warehouse in 1926.					1927

(*) disposition of each unit be scrapping or other action from records researched.

*Scrapped or Disposition

Call letters and wave lengths in meters from RCA listing Long Wave Stations, Dec. 5, 1928.

The table Fig. 11 gives the story of commercial operation of the twenty transmitters that were built. All domestic units had been scrapped by 1953 except the ones that were used by the Military in WW-II.

World War II

During time of war, vessels of beligerants operate under "radio silence" to guard against their location by enemy radio direction finders. Routing Orders and other combat operational information must be given to silenced vessels by transmission from shore, receipt of which obviously cannot be acknowledged. Transmissions of utmost reliability must, therefore, be used, and VLF transmission at high power, not subject to fading and periodic dropouts are used to supplement simultaneous transmissions by high frequencies which are less subject to interference by noise. VLF is also by far the best means of communicating with our submarines when they are submerged.

Soon after the start of WW-II it became evident to the Navy that their high power VLF tube set in Hawaii was inadequate to carry the communications load in the Pacific and there was not time to build new transmitters and VLF antenna towers.

Hedley Morris was on active WW-II duty with the Navy in Hawaii and was given the assignment of finding in Hawaii, a suitable VLF station location. He selected Haiku, a narrow

U shaped valley approximately two miles east of Kaneohe, on the north side of the island of Oahu, that had cliffs on three sides that were 2500 feet high. Four copper-clad steel cables were stretched across the valley approximately 4000 feet long, making the antenna, and a bomb-proof concrete transmitter house was built in the center of the valley to house two Alexanderson transmitters. Both sets at Kahuku had been scrapped so one set was shipped from Bolinas and one from Marion to power the Haiku station. This VLF installation provided the contact with our fleet and submarines in the South Pacific during the War, #15fn.

The Navy took over operations of the alternators at Marion and Tuckerton to provide VLF communications in the Atlantic thru 1948. Tuckerton was closed in 1949 and sets scrapped in 1955.

Marion was purchased by the Air Force in 1949 and an alternator set was obtained from Radio Central to replace the one shipped to Haiku in 1942.

Mr. G. J. Eshleman was for many years engineer in charge of the Tuckerton station, transferred to Marion as civilian engineer for the Air Force operation 1949 to 1957. He installed the set from Radio Central and changed the controls so the sets could be keyed by teletype as the receiving stations were equipped for teletype reception. In a letter he stated that the station was used to transmit international weather and other material to Air Force stations at Tule, Greenland, Labrador, Iceland and on ice islands in the Arctic region where reception of short waves was very erratic, #16fn.

Marion station was sold in 1961, one alternator was scrapped and one went to the Bureau of Standards. Some of the tuning gear from this set was used at Boulder, Colorado, for building the WWV-VLF transmitter.

The Navy operated the single VLF transmitter left at Bolinas, California, 1942 to 1946, for communication in the Pacific. When the set went on the air it put out of commission a large radar station on Mt. Tamalpais six miles away. The trouble was soon located and Jack Napier the Bolinas engineer in charge made this comment: "A poor connection between an insulator metal end-cap and a rain shield caused a spark between the two, and the rain shield acted like a 100 MHz doublet and jammed the radar station on Mt. Tamalpais on 105 MHz. How is that for a 105 MHz spark set?, #17fn.

The Bolinas transmitter was scrapped late 1946. Here is its name-plate, Fig. 12.

Table 13 shows the WW-II service of the Alexanderson transmitters and gives their final disposition.

In conclusion, I quote an appropriate article that appeared in the RCA Relay of December 1946 by L. E. Smith, one of the VLF engineers.

"Our Bolinas staff cheered lustily when the Navy decided to shut the alternators down, and from actual experience they had good reason to cheer. No more jumping on your car with both feet to avoid an unexpected jolt. No more avoiding wire fences and company-cottage clothes lines which snapped at you on occasions. No more corona discharge from the horns of local cattle, or metallic collar-buttons that would keep biting you in the back of the neck as you walked between the buildings. No more hot seats for the riggers while aloft in bosns chair. When the antenna system came down we cleared the atmosphere of the tremendous potential which prevailed when the alternator was in operation.

Who, having worked with an alternator, will ever forget the sound of the machine coming up to speed; listening to the gear-box noise; the pounding of the compensating contactors as they follow the keying under full load, or the sudden, comparative silence that accompanied a traffic lull? Then there was the warmth and peculiar fragrance--that's right, fragrance--that exuded from the whole contraption. The thing smelled good! And how many old timers have spent cold nights leaning against, or curled up alongside, the driving motor?

Yes, the Alexanderson's are through at Bolinas, and the masts are down. There is little possibility of the antenna ever being erected again. A period of radio history--some feel one of its greatest and most romantic--is gone.

Though the alternators are now classified as obsolete, those of us who have always had an inherent fondness for the massive contraptions will never admit it. For as late as 1945, in the age of VHF, UHF, and television, the Alexanderson Alternators put a steady signal through where nothing else would. They did it steadily, free of skip, fading, and most outage causing trouble, twenty-four hours a day.

Dr. Alexanderson's brainchild bows out with its head high. Science marches on!"

--T. L. Mayes

"PORTS O' CALL" (Vol. 4)

APPENDIX

INSTALLATION SITES—WW—II & LATER

200 KW ALEXANDERSON ALTERNATOR TRANSMITTERS
USE IN WW-II AND LATER (Fig. 13)

LOCATION	ORIGINAL LOCATION	NAVY OPERATION	AIR FORCE OPERATION	SCRAPPED
Haiku, Hi	Marion, Mass.	1942-1946		
Haiku, Hi	Bolinas, Calif.	1942-1946		
Marion, Ma	Marion, Ma	1942-1948	1949-1957	1961
Marion, Ma	Radio Cent.		1949-1957	To Bu Stds.
Tuckerton, N.J.	Tuckerton, N.J.	1942-1948		1955
Bolinas, Calif.	Bolinas, Calif.	1942-1946		1946

NUMBERED FOOTNOTES

FOOTNOTES FOR WIRELESS PIONEER ARTICLE

1. Letter June 29, 1915. E.F.W. Alexanderson to A.G. Davis, General Electric Patent Dept., Schaffer Library.
2. History of Radio to 1926, by Gleason Archer, page 86.
3. Memo by E.F.W. Alexanderson, March 13, 1924. Our Radio Activities before 1920, Schaffer Library.
4. Same Page 2.
5. Same page 3.
6. Wireless Age, August 1920, page 10-11.
7. Wireless Age, December 1921, page 18-22.
8. Wireless Age, March 1920, page 10.

FOOTNOTES, CONTINUED FROM PAGE 38

9. Wireless Age, December 1920, page 7.
10. Wireless Age, September 1923, page 36-38.
11. Letter from Marconi Company Ltd. to T. L. Mayes, Feb. 19, 1975.
12. Wireless Age, October 1922, page 57-61.
13. Wireless Age, June 1921, page 11-12 and March 1923, page 39-40.
14. Letter December 16, 1974, A.W. Aird to Hedley Morris.
15. Letter May 23, 1974, Hedley Morris to T.L. Mayes.
16. Letter June 24, 1975, G.J. Eshleman to T.L. Mayes.
17. Letter July 8, 1974, C.J. Napier to T.L. Mayes.
18. (Page 35) Re: license situation and cross-licensing following World War 1. (Quoted from records).

At this time, the Alexanderson Alternator and the Poulsen Arc were the only types of high powered, efficient transmitting apparatus, except for a French system. Without one or the other of these transmitting devices, the British Marconi stations were at a great disadvantage in a competitive market.

Of all the problems existent at this time, the patent situation was by far the worst. As an example, the vacuum tube involved patents issued to Fleming, DeForest, Arnold, Langmuir, and several others. The British Marconi Co. had purchased some rights of some inventors; the G.E. Co. held some most important patents, not the least of which was the Alexanderson Alternator patents; the Westinghouse Electric and Manufacturing Co. possessed the heterodyne device of Professor Fessenden and also the Armstrong feedback patents. The United Fruit Co. with its crystal detector patents controlled that field.

Interestingly, the Westinghouse, A.T. & T., United Fruit Co., and G.E. Co., all had patents, but not a one of them had in its control a complete system!

Concerned about the formation of RCA by the G.E. Co., the Westinghouse Co. bought outright the International Radio Telegraph Co. which previously was the National Electric Signaling Co. The International Co. owned some very useful patent rights for Westinghouse to acquire. These were the rights to the heterodyne method of reception and the rotary spark gap.

In addition to the above, the Westinghouse Co. obtained from Major Armstrong and from Professor Pupin the rights to four patents and to 16 patent applications relating to radio. The Armstrong Feedback cct. was one of these. However, at this time it was in litigation with the De Forest interests.

These rights, the rights to the Armstrong, Pupin patents greatly strengthened the International Company's position. By now, the Westinghouse officials felt that they were in a very advantageous position. The result was they directed the International Radio Telegraph Co. to see, if by making overtures to RCA, the Westinghouse Co. could make some agreements with RCA. The result was that in June of 1921 the Westinghouse Co. joined company with the RCA, The International Co. was bought out by RCA and a cross-licensing agreement was consummated between Westinghouse and RCA. Additional cross-licensing agreements were agreed upon between Westinghouse and the Telephone Co. and with the manufacturing part of the telephone company, the Western Electric Co.

The General Electric Co. acquired one half of the stock of the Wireless Specialty Apparatus Co. from the United Fruit Co. in Feb. 1921. The result of this manuever resulted in cross-licensing which resulted in control by RCA of all the patents of the Wireless Specialty Apparatus Co. including the important patents of Pickard.

It was some years, however, before many of these companies with their cross-licensing, acting cannibalistically against competitors finally settled down. After a period of time the 'in-fighting' ceased and the industry finally rested on an even keel. By this time, many basic patents began to expire one after the other. As these began to expire, cross-licensing began to have less and less significance. This resulted finally in the field being pretty well opened up. Much of it by this time became available to anyone.

FIGURES—INCLUDES PICTURES,CHARTS,ETC.

DR.ERNST FREDERIK WERNER ALEXANERSON

1878——1975

Dr. Alexanderson was born on Jan. 15, 1878 at Upsala, Sweden the son of Prof. A.M. Alexanderson, then on the faculty of Upsala University. Early interest was expressed in Electrical Engineering, stimulated by a year of technical work at the Univ. of Lund in 1896. He was graduated in 1900 as an Electrical-Mechanical Engineer from the Royal Inst. of Technology in Stockholm followed by a year of postgraduate schooling at the Technical Univ. in Berlin, Germany.

Dr. Alexanderson's high-frequency alternator which he initially developed for Prof. Fessenden after two years of work at the General Electric plant, was installed at Brant Rock and made possible the first voice and music broadcast which occurred on Christmas Eve 1906.

Encouraged by his father who was a Professor of languages, Dr. Alexanderson learned English, German, French and Latin in addition to his native Swedish. Thus, he was able to read a copy of Dr. Charles P. Steinmetz's paper on Alternating Current Phenomena while attending the Technical University in Berlin.

He was so impressed that he decided to move to America and seek work with Dr. Steinmetz which he was able to do in 1902. His first work was on the drafting table but after passing the GE Test Engineering course he became a member of the engineering staff, designing generators in 1904 under Dr. Steinmetz. It was in this year that Professor Reginald A. Fessenden (who was also a pioneer in wireless transmission experimentation) asked the G.E. Company to design and build a high-frequency machine that would operate at high speeds and provide continuous wave transmission/s. The project was turned over to Alexanderson. This was a two-kilowatt, 100,000 cycle machine.

News of the success of the Alexanderson alternator (with many improvements to Prof. Fessenden's original concept) reached the ears of Guglielmo Marconi in England so he visited the G.E. plant in 1915 and after a talk with Alexanderson, arranged for a 50-Kilowatt installation to be made at the New Brunswick, N.Y. Marconi Trans-Atlantic Station.

Not content with his development, he further perfected the unit to provide 200-KW of power. This powerful transmitter was also installed at New Brunswick and was used by President Wilson in the transmittal of messages to the war theatres of Europe since the cables had been cut. The historical test came on Oct. 20, 1918, when President Wilson used this station and its transmitter to send the Peace Ultimatum which brought the war to a close.

CONTINUED ON PAGE - 40

DR. ERNEST FREDERIK WERNER ALEXANDERSON

(C O N T I N U E D F R O M P A G E 39)

During 1923, Marconi tried to buy the exclusive world rights to the Alexanderson alternator and its improvements but President Wilson had a deep desire to keep the inventions 'American'. The end result was the formation of the R.C.A. which became the progenitor of what is now R.C.A. Inc.

Dr. Alexanderson was a prolific inventor as his inventive genius touched many fields. Some of his inventions in communications included the Magnetic Amplifier, the Electronic Amplifier, the Multiple Tuned Antenna, the Anti-Static Receiving Antenna, the Directional Antenna, Radio Altimeters. His inventive genius touched many other fields including TV (1928), First Facsimile used Trans-Atlantic on June 5, 1924. He sent a 'hand-written' greeting to his father in Sweden via Fax.

In other fields such as Power & Control, he designed single-phase motors for railway electrification (used on Pennsy R.R. System); worked out a system for regenerative braking by D-C series motors (used on CM&SP Railway locomotives); the Amplidyne and Thyratron motors were among some of the more than 320 patents issued during his 46-years with G.E., (one for every month, give or take a few days).

Dr. Alexanderson retired in 1948 but continued as consultant for another year. He was 97 when he died on May 14, 1975, at his home in Schenectady, N.Y. Dr. Alexanderson was widowed twice, is survived by his third wife Thyra and son Verner; also three daughters and nine grandchildren.

The honors and awards bestowed on Dr. Alexanderson were so many it would take quite a lengthy column to list them all.

Our Technical Editor, Thorn L. Mayes, was indeed fortunate in having been associated with this great man through various assignments with the General Electric Company. He has had a number of interviews with Dr. Alexanderson about the early days of the alternator and his experiences, therefore, able to bring a 'first-hand' report on many phases of the communication/s art including the alternators developed by him. Dr.

Alexanderson indeed stands tall among those in the field of invention and as a benefactor to all mankind--resulting from his brilliant ideas and his ability to translate them into practical use.

--W.A.B.

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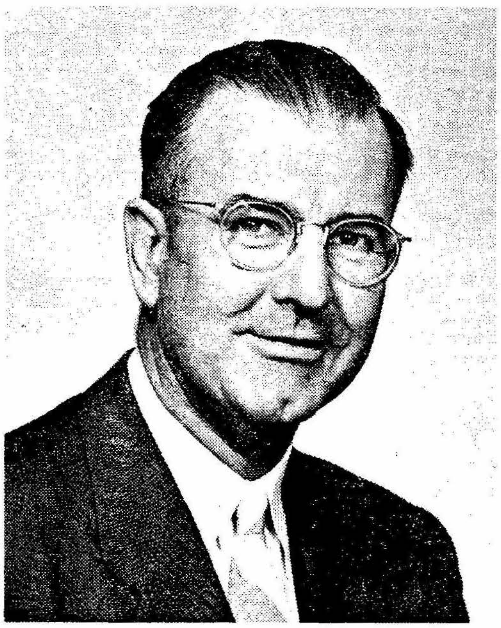

Thorn L. Mayes

It is unfortunate that our Technical Editor and Technical Consultant was so preoccupied in his early days with the 'learning process' that he did not have the time or opportunity to 'pound-brass' professionally, so he could qualify as a regular member of SOWP.

He did manage to take time out to receive his amateur call (6AX) back in 1921 and during his high-school days in Oakland bought or made equipment to commission station 6JR (1-KW spark transmitter and single audiotron regenerative receiver) which he operated until graduation in 1923. Thorn graduated from the University of California with a degree in Elec. Engineering in 1927.

Thorn has maintained an over-riding interest in communications all of his life and since retirement from the General Electric Company where he spent most of his professional years, he has devoted his time and attention to compiling a history of early day wireless and radio - especially the organizations involved in the field, tracing the fortunes of these organizations over the years--as has already been brought to the members in past issues of "SPARKS" and other Society releases.

"Thorn" has held some very important assignments with G.E. over the years, including that of Manager of Engineering in the motor plant at Lynn, Mass. and in 1952-58 at Fort Wayne, Ind. where first he was in charge of the building and equipment where induction motors (1-5HP) were built and then as General Manager of the plant. When this plant was combined, he moved to Shelbyville, Ind. as Manager of Engineering of the GE Industrial Heating Plant at that location.

His interest in radio and amateur radio never waned. He held call W2CE in Schenectady, then W1CX at his home in Marblehead, Mass. This was followed by W9AX at Fort Wayne and after his return to California, found his old call 6 AX vacant so now holds W6AX. He has received his 50-year award by QCWA and was a Director of OOTC. He was one of the Charter members of A.W.A. and has presented a number of papers at their annual meetings.

Thorn is also a collector of early communication/s artifacts. He has been most charitable with his time and has on many occasions brought some of his choice receivers and other pieces of early equipment for Society of Wireless Pioneer members to inspect - bringing back nostalgic memories of bygone days.

Mr. Mayes with his wife Lygia lives in Saratoga, California. He is an active member of the Space Science Center Advisory Committee of the De Anza & Foothill Community College and Vice President of the Perham Foundation of the Foothill College Electronics Museum.

The Mayes have a son living in Phoenix who has been an amateur since 1946. Their daughter, married to an Orthopedic Surgeon, also has held an amateur license for many years, hence the Mayes hold family reunions via the air-waves several times weekly - a wonderful way to keep in touch.