

THE ALEXANDERSON ALTERNATOR STORY



This article was one of a series by the authors on RCA's "Radio Central" operations at Riverhead and Rocky Point New York. The series was published in the Spring, 1992 issue (Vol. 20, No. 1) of The Antique Radio Gazette. More parts of the series will be published in future issues of the Journal.

In researching the story of the Alexanderson alternators used by RCA at the Radio Central transmitting site in Rocky Point, New York, it seemed necessary to compare the machines at that location to all that were produced by General Electric. In addition, this writer is interested in the technical details of alternator construction and the source of the technology. And so, the authors decided that we should review of the early development and history of the Alexanderson machines.

The idea of using a rotating machine to generate radio waves goes back almost to the beginning of wireless, when several experimenters began to work with wave trains generated by an open spark discharge. Shortly after the turn of the twentieth century, scientists like Lodge and Fessenden, who understood the difference between the characteristics of broad-band waves (spark) and continuous waves (like the output of a very high-speed machine) could see two major advantages in using the latter.

One was that the narrow-band wave could be voice-modulated and detected without losing nearly all the intelligence that was being transmitted. The second was that, by using tuning techniques in the receiver, the desired wave could be easily separated from the other narrow-band waves. Thus, the amount of power necessary to accomplish satisfactory message transmission could be greatly reduced.

The problem involved with rotating machines was that increasing the frequency from that associated with power lines (50 or 60 or even 400

Hertz) meant increasing the rotational speed to values that were excessive for typical salient-pole, wound-rotor machines.

Benjamin Lamme, a very early experimenter who worked at Westinghouse, developed an alternator that pushed the technology of low frequency machines about as far as typical power generation devices could go. In 1903, his alternator reliably produced 10 kilohertz energy at a 2 kilowatt rate. In a report written by Lamme in 1904, he credits M. LeBlanc, a French engineer, with the preliminary description of the design.

The development of this equipment grew out of a need for high-frequency energy for special telephone work. Lamme observed that the machine was a laboratory device without present (1904) commercial value. That he was right is

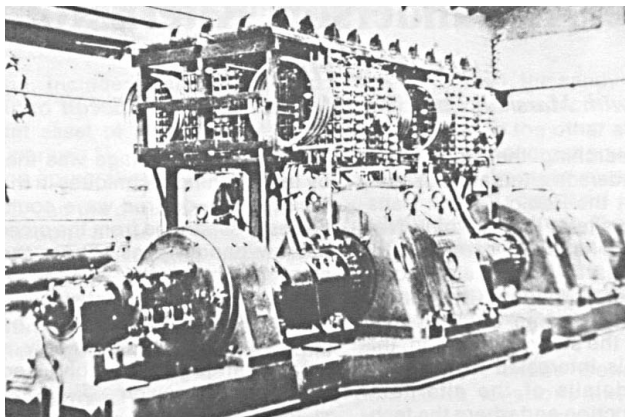


Fig. 1. Goldschmidt alternators.

shown by the development of the next two alternators to be discussed.

Reginald Fessenden was a member of the Westinghouse organization at the same time that Lamme built his alternator. No record of interaction between the two men has turned up as yet, but it is easy to believe that Fessenden knew of Lamme's work and its limitations.

Fessenden recognized that a substantially higher frequency could be generated by only by changing the magnetic path characteristics (vari-

able reluctance) and keeping the wires stationary. His designs resulted in a slotted radial rotor that moved between fixed pole-pieces (a slotted stator). The coils in which the output voltage was induced did not move but were carried by the fixed, slotted stator. More about this approach will be included in the description of designs of Ernst F. W. Alexanderson.

In Germany, Rudolf Goldschmidt was also working on a rotating machine that could generate radio-frequency energy. One of his designs used a wound rotor, not unlike Lamme's, with very closely spaced slots parallel to the rotational axis. There were corresponding slots in the stator. The rotor slots carried multi-stranded fine wire (Litz wire) and the stator slots carried a single 0.2 inch wire. The rotor diameter was nearly three feet so that at a rotational rate of 4000 rpm the peripheral speed was about 600 feet per second.

The unique feature of the Goldschmidt design was that a part of the output was used to energize the rotor winding. (In the Lamme machine, the stator was excited by direct current with no feedback of the alternating component to the rotor.) The feed from stator to rotor resulted in a double frequency (harmonic) component in the output.

By careful manipulation of the amplitudes of the rotor and stator currents against the magnetic characteristics of the iron from which both rotor and stator were fashioned, the predominant output was made to be twice the frequency directly produced by the rotational speed. For the numbers given above, an output of 50 kilowatts at 50 kilohertz was possible.

Figure 1 shows a Goldschmidt alternator with its antenna tuning coils mounted immediately above the machine. Another German company, Telefunken, produced an alternator based on the variable reluctance principle (also used by Fessenden) and included in its application the idea of using the saturation characteristics of iron to generate a second harmonic. Their frequency changer (an onboard device) used the alternator output in an external circuit to produce a second harmonic substantially larger in magnitude than the fundamental.

The rotor was a short cylinder of large diameter whose face was slotted. The stator had similar slots that carried the windings. In a variable reluctance alternator the slots and faces of both the rotor and stator pass by each other and cause the path character of the magnetic path to change substantially. The intensity of the magnetic field (produced by a field winding) increases when the faces line up and decreases when the slots come into line. The changing magnetic field induces an alternating voltage in the stator coils.

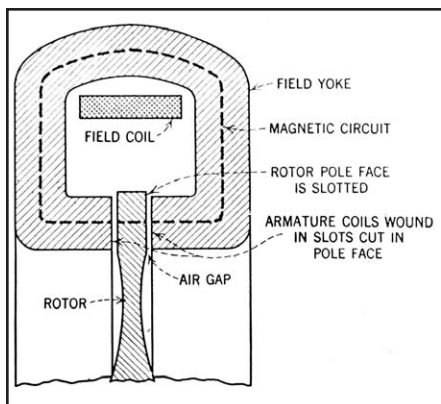


Fig. 2. A sketch of the Alexanderson inductors.

As with the Goldschmidt machine, the speed of the Telefunken rotor was limited the capability of the iron to withstand the centrifugal force on it. The efficiency of the machine was limited by the iron and copper losses but even more by the windage losses of the rotor's irregular surface. The external circuit used two transformers with primaries fed from the alternator, secondaries connected in series to select a double frequency output from the non-linear currents circulating in two transformer cores.

The windings included a third set arranged with a bias from a direct current source. The direct current forced the iron into partial saturation so that the field produced by the primaries was flattened on one half of the cycle and sinusoidal on the other. The secondaries summed the results which included a high-level second harmonic. When the output circuit was tuned to this double frequency, the rejection of the fundamental was enough to provide reasonable efficiency at the high frequency.

Results from this system were comparable to those of the Goldschmidt alternator. Fessenden was certain that his alternator had the potential to exceed the performances of the competitive systems. He needed a manufacturing facility to make operating samples and chose General Electric. After some differences of opinion about the presence of iron in the alternator, a series of machines was constructed by Ernst Alexanderson. (Fessenden felt, perhaps on the basis of Lamme's work, that the characteristics of iron would not accommodate the high frequency he sought while Alexanderson, backed by Charles Steinmetz felt that iron could be made that would provide exactly what was required).

The central part of the design was the rotor, a flat-edged disk whose outer periphery was

pierced to provide an iron-free series of radial slots. When the rotor moved, the slots around its outer annulus passed between the slots around the periphery of the stator. Each pole-piece with its adjacent slots was arranged in an inverted “U,” with coils embedded in the grooves cut in the legs of the “U” (Figure 2).

The entire stator was magnetized by a direct-current-field produced by an annular coil located in the curve of the “U” and going around the inside of the entire stator. The coils experienced a change in magnetism as the slots in the rotor passed through the slots of the closed ends of the “U”.

The author is impelled to make a comment here that has little to do with the Alexanderson machine, but does say something about GE. The principle of the GE Reluctance Pickup, a much touted high-fidelity recording groove-to-electricity transducer produced sixty years later, is identical to that employed in the Alexanderson alternator. It suggests that a good idea is timeless, especially if it is applicable to the production of profit.

The slots of the German alternators were cut in the peripheries of their rotors, parallel to the axis of rotation. The slots of the Fessenden/Alexanderson machines were cut along radii in the rotors, perpendicular to the axis of rotation. A remarkable feature of the Alexanderson designs is the way the problem of air resistance in the slots was solved.

Fessenden originally wanted wood included in the rotor so as to present a smooth high speed surface. Wood could not be retained in the iron rotor slots (centrifugal forces were far above the strength of wood). So Alexanderson substituted bronze, which was bonded intimately to the rotor and machined smooth with the rotor surfaces in the final shaping and polishing. The peripheral speed of the larger Alexandersons was just below the speed of sound. Any irregularity generated a shock wave which increased the windage force beyond the capacity of the driving motor and, even worse, beyond the strength to withstand the extra load.

Experience with the rotors revealed that they were self-polishing in service, which strongly suggests that the sound (shock) waves removed the minor marks left by the machining process. Alternators were produced by GE in sizes be-

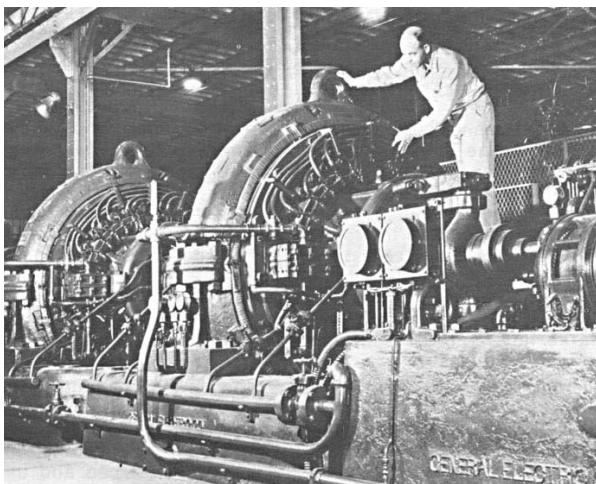


Fig. 3. The Alexanderson alternators at Rocky Point.

ginning with two kilowatts and reaching 50 kilowatts by 1917, when the Navy installed one of these machines in the old American Marconi station in New Brunswick. The equipment was entirely satisfactory, providing service equal to the best arcs of that time. Development on the alternators continued until the biggest version, 200 kilowatts, was produced in 1918 and sent to New Brunswick to operate with the 50-kW unit.

Alexanderson alternators figured centrally in the process that convinced British Marconi to sell its stock in American Marconi to General Electric Company. British Marconi had made overtures toward buying enough alternators to equip its major stations throughout the world. However, U.S. Navy executives suggested that, for reasons arising from national interest, GE should not support such a transaction.

Since the Navy was blocking the deal and its wishes were critical, GE managed to satisfy(?) all parties by offering to purchase all American Marconi stock owned by British Marconi and transfer it to a new American company set up to receive it. The arrangement was approved and the Radio corporation of America was born. At the same time British Marconi was now free to buy Alexandersons for its own use.

Two of the 200 kilowatt Alexanderson alternators went to a new RCA transmitting facility at Rocky Point, Long Island, NY. (Figure 3 shows them with their operator). RCA bought nearly all the other units that were produced and used them at its other stations in the United States and Hawaii. For a good picture of exactly where all of them went, see *Wireless Communication in the United States* by Thorn Hayes.