## *Appendix C*

# RADIO PROPAGATION, SKIP DISTANCES, AND RECEIVER SENSITIVITY

The strength of a received radio signal depends on many things, including the power of the transmitter, the gains and orientation of the transmitting and receiving antennas, the propagation loss between transmitter and receiver, and any gain in the receiver itself. The ability to read a signal also depended on the selectivity and sensitivity of the receiver; i.e., its ability to tune out unwanted out-of-band signals, and to detect wanted signals in the presence of in-band noise, respectively.

Nighttime propagation at Medium Frequencies (300 to 3000 KHz) has a far greater range than in daytime by about two to three times because of sky wave propagation caused by refraction off the F layer of the ionosphere. During the day, distance is limited by what is called ground wave propagation. There is no sky wave during the day at these frequencies because of absorption by the D layer of the ionosphere which disappears at night. On occasion, there can be multiple hops at night between the ionosphere and the Earth extending coverage to very great distances. Usually, there is much more propagation loss in these multiple hop situations requiring very sensitive receivers to detect transmissions, something not readily available in 1912.

The term "skip distance" is usually used in the wrong sense. It is the distance from the transmitter to the point where the sky wave is first returned to Earth. The skip zone is a region of silence, a dead zone, between the point where the ground wave becomes too weak to be detected and the point where the sky wave is first returned to Earth. When the skip distance is short enough so that there is no zone of silence, then there is no skip zone. However, in a region where the sky wave and ground wave may be of near equal intensity, there could be severe fading caused by the sky wave alternately reinforcing and canceling the ground wave. This is due to the longer path that the sky wave has to travel that brings it in and out of phase with the ground wave. This, at times, would make it difficult to detect signals in addition to any other impairments caused by interference from other stations fading in and out, as well as any added atmospheric noise disturbances.

The energetic particles that come from the sun to create the visible aurora alter the ionospheric layers that affect radio propagation. These incoming particles cause rapid radio signal fading called fluttering as a result of changes to the multiple paths that the radio waves take during these disturbances. During some peak sunspot periods, variations in the Earth's magnetic field up to about 2 degrees have been reported. 1912, as it turned out, was not a year of peak sunspot activity or magnetic disturbance. Nevertheless, the aurora borealis was very much active the night of April 14, 1912 as reported by several passengers that took to the lifeboats; e.g., second class passenger Lawrence Beesley's account.

On the night of April 14, 1912, conditions for radio reception were far from ideal. Consider what senior operator E. J. Moore of *Olympic* wrote in his PV:

> "10.50pm Hear MGY [*Titani*c] signaling to some ship about striking an iceberg, not sure it is MGY who has struck an iceberg, I am interfered by X's [atmospherics] and many stns wkg [stations working]."

In *Virginian*'s PV we find:

> "10:00pm Bi for CC. 10/30 press finished first received greater part of it X's strong."

*Virginian*'s operator was standing by (Bi) for the press report from Cape Cod (CC). The press report finished first at 10:30pm, and that he had received the greater part of it before being interfered with by strong atmospherics (X's).

Wireless signals from *Titanic* were being transmitted on a wavelength of 600 meters, or 500 kHz. We know that the land station at Cape Race was able to pick up *Titanic*'s transmissions that night. The operating frequency of 500 kHz is below what is called the critical frequency. The critical frequency is the highest frequency that a signal if sent straight up vertically will be refracted straight down. So at 500 kHz at night you will have sky waves that are refracted at all angles and theoretically there should not be any skip zone. However, if the there are some variations in the density of the F layer there can be some angles that refract differently creating some weird coverage effects. You can and do get regions of signal fade caused by destructive interference between ground wave and sky wave, or even between a double hop sky wave and a single hop sky wave.

As far as the ability to receive *Titanic*'s signals, the received signals would start to get lost in the background noise as the transmitting power was getting weaker near the end. Once the power became so low as to not support the development of a spark, transmission would simply come to a complete end. Harold Bride said that Jack Philips continued to send for a short time after making his last contact. When it became clear that nobody was responding anymore, that is when he shut things down and abandoned the wireless cabin.

As far as the selectivity of wireless receivers, they were essentially passive devices that were not very selective in terms of the bandwidth that was allowed to pass through. The Marconi multiple tuner worked in 4 switched ranges: 80-150 metres, 150-1600 metres, 1600-2000 metres, and 2000-2600 metres. This gives a total range from 115 kH to 3.75 MH. However, the bandwidth was not very sharp and therefore allowed a relative wide band of noise and interference to pass through to the magnetic detector compared to what later date superheterodyne receivers with multiple stages of amplification and passband filtering would allow. The other thing to keep in mind is the modulation method of wireless telegraphy was on-off keying, a simple form of amplitude modulation. Anything in the way of noise or interference was simply additive. If an interfering station came in at 1/3 the power of the desired signal (about 5 dB down) it was heard at 1/3 the level of the desired station, just like in AM radio broadcasting today with the automatic gain control cut out.

As far as the sensitivity of the magnetic detector, it was somewhat dependent on the setting of the magnets. This is because the detection principle depended on setting up a magnetized state in the iron band that ran through the device opposite the magnetic poles as it passed near them which was retained due to the hysteresis effect. If RF oscillations are produced in a coil that is wound over the iron band it tends to demagetize that part of the band passing through it while these oscillations last. This creates a small demagnetized length of band. So as the band is moving across at 7 to 8 cm/sec with areas that are magnetized and other areas that are demagnetized it induces a current in the separate telephone coil that is also wound over the moving iron band. After that, it depends on the sensitivity of the operator's ear to detect the sound. Strong RF oscillations will demagetize more of the iron than weak signals. Therefore a stronger induced current will be set up in the telephone coil and produce a louder sound. If the magnets are too close, weak signals would not demagnitize the iron enough to be heard. If they are too far away, then the iron would not be magnitized enough and again weak signals would not be heard. In addition, the magnetic detector, or Maggie as it was called, created its own noise by the movement of the iron band past the stationary magnets. It created a form of "hissing" sound in the background that made it difficult to read very weak signals.