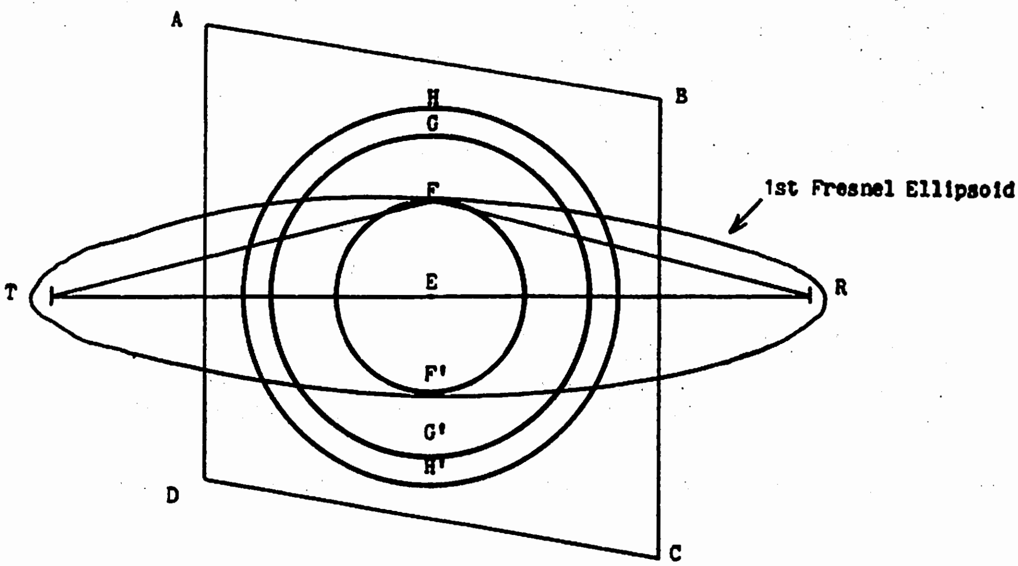
COMMUNICATIONS DATA SHEET 508

FRESNEL ZONES



The above figure shows a perpendicular plane ABCD placed mid-way on the line TR, where T is thr transmitter aerial and R the receiver aerial. E is a point at which TR intersects the plane ABCD. F is a point on the plane where the distance TFR exceeds the distance TER by half-a-wavelenth and the locus of F is a circle round E. The area within the circle of radius EF is called the 1st Fresnel zone. The distance TGR is one wavelength greater than TER and the ring-shaped area FG is termed the 2nd Fresnel zone. Similarly THR is one-and-a-half wavelengths greater than TER and the ring shaped GH is named the 3rd Fresnel zone, and so on. If the perpendicular plane ABCD is moved either towards T or R the increased pathlengths of $\frac{1}{2}\lambda$, λ , $\frac{3}{2}\lambda$ etc. with respect to the distance TR are ellipsoids with foci at T and R. The 1st Fresnel ellipsoid is shown on the figure.

The resultant signal over a propagation path may be considered as the vector sum of the direct path between the transmitting and receiving aerials and an indirect component from a reflecting surface along the path. The amplitude of the resultant signal will be a function of the phase relationship between the two components and the reflection co-efficient at the reflecting surface. If the reflecting surface is at 1st Fresnel clearance, that is at a point on the surface of the ellipsoid, because of the 180^{o} phase change at this surface, the direct and indirect signals will be in phase at the receiving aerial.

Referring once more to the figure; if there is an obstruction extending say, from the earth's surface to point H a very small signal would probably be received at R due to diffraction. As the obstruction is lowered towards E the received signal increases rapidly. At E the received signal will be 6 dB below the free space value. When the obstruction is withdrawn further to F' the signal is at a peak and, as it is lowered through the other Fresnel zones the signal oscillates by a few decibels about the free space value, assuming the reflection co-efficient is low at the reflecting surface. The propagation paths for radio link systems should therefore have 1st Fresnel clearance in order that the received signal is approximately the free space value. If the reflection co-efficient is high, as it is over water paths, there would be deep fades at alternate Fresnel clearances. For this reason over-water paths should be avoided.

The formula for calculating the 1st Fresnel clearance is:-

$$r = \frac{72.1}{\sqrt{f}} \cdot \sqrt{\frac{d1.d2}{d1+d2}}$$

where r is 1st Fresnel clearance in feet
where f is the frequency in GHz
where d1 is the distance in miles from transmitting aerial to reflecting point.
where d2 is the distance in miles from receiving aerial to reflecting point.

Another formula frequently quoted where the parameters are in metres is:-

$$r = \sqrt{\lambda . \frac{d1.d2}{d1+d2}}$$