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THE PROPAGATION OF ULTRA SHORT WAVES
ROUND HILLS AND OTHER OBSTACLES

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THE PROPAGATION OF ULTRA SHORT WAVES ROUND HILLS AND OTHER OBSTACLES.

It has been found, rather to the surprise of the experimenters, that big obstacles, like Snowdon, for instance, have very little effect upon the range of vertically polarised ultra short wave transmitters working on frequencies between 30 and 50 mc/s, with powers of the order of 0.7 or 0.8 of a watt. The range over a flat plane is of the order of 10 miles, and 6 miles could be obtained over a peak of 3,000 ft. or so from one valley to an adjacent one. This is thought to be in complete contradiction to the effect of diffraction, because the wave, in passing over the hill, is diffracted through an angle of at least 22°.

A considerable advantage lies with these ultra short waves as compared with 8 mc/s waves, in virtue of the fact that these ultra short waves are practically unjammed. The 8 mc/s waves are badly jammed and suffer a great deal of interference. It was realised that the very much higher frequencies, 30 to 50 mc/s would be much quieter, but it was thought that they would have the very considerable disadvantage of being cut off by obstacles, and being therefore unusable. But much to the surprise of the experimenters, the obstacles did not prove to be a serious matter, although the ranges between adjacent valleys was a good deal less than the ranges down a valley. The previous beneficial effect might be attributed to the bending of the rays round the mountain by a cap of air or water vapour of varying refractive index, in which this reduces rapidly with the height. This would not always happen, and there would be no security that you would get the ranges over the hill. This security, I think, can only be given by analysis and cannot be given by an experimental test, unless very prolonged. If we look at the curves of transmission of these ultra short waves, it will be observed that for heights of less than 2,000 ft, ground absorption is a major factor, and not diffraction. There is no sudden kink in the curve representing field strength as a function of the distance, a kink which might be expected to occur at the visual range. It is therefore as if the controlling factor were not the effect of bending round obstacles, or the shadows they cast, but is due to earth absorption. At first sight, the analysis does seem to suggest that the hills would be big obstacles. This is because the attenuation of a single term of the diffraction formula round a big hill of radius of curvature R is large compared with the attenuation round the earth, ($R \ll R_o$ the earth's radius) and should be the same for the long as for the short wave lengths so long as ρ is the same for them both. It is, in fact, for a given distance, proportional to $\frac{1}{R^{2/3}} \times \frac{1}{\lambda^{1/3}}$, so that in the case of the hill of the order of 6 kms radius of curvature, the attenuation $e^{-\rho\frac{k}{\lambda^{1/3}}}$ for a given distance is nearly 100 times that over the earth, and we should expect the obstacle to cause a very marked shadow. But we can show that one term of the diffraction analysis will not suffice, and in fact, the higher order terms are of at least as great significance at distances of a few kms. The variation of field strength with distance is a complicated function of the sum of all these terms, and does not necessarily vary in attenuation at the rapid rate of a single term. A complete analysis of the significance of the various terms will have to be made, but at least it is clear that it is not analytically necessary to have a big attenuation due to objects like hills.

Each of the terms are of the form $e^{\frac{-k}{\rho}}$, but this only occurs when the hills are small enough and the conductivity is fairly high. This may be derived from the analysis on page 303, Phil. Trans. Royal Soc. No.778, Vol. 237, 10th June, 1938. It is shown that the amplitude of each term depends on the quantity

$$C = 1 - \frac{|g|}{2\rho}^{2} \exp\left(-\frac{1}{6}i\pi\right) + \frac{(g)}{4\rho}_{2} \exp.\left(\frac{5}{12}i\pi\right)$$

$$\text{where } g = \frac{x}{|\delta|} = \frac{(2\pi r_o)^{1/3}}{\sqrt{(2c)}} \sigma^{-\frac{1}{2}} x\lambda^{-5/6}$$

When the third term of c is dominant, which only occurs when r_o is small enough, and the earth conductivity is high, the term is of the form of that given above; that is, $\rho e^{-k\rho}$, where ρ is a number dependent upon the proper value of transmission. varies from term to term, and we wish to see which term is a maximum, that is to say which of the terms $\rho_n \; e^{-k\rho_n}$ is the largest. For this purpose, we may consider ρ as a continuous variable, and find out when this quantity is a maximum. This occurs when $\rho_n k = 1$. In these conditions, diffraction attenuation is e^{-1}, and this occurs at a few kilometres away from the transmitter. Thus, at this distance, the first term is not predominant, and we may have a total attenuation which does not depend upon the attenuation of a single term alone, and will depend upon the earth's constants rather than the curvature of the hills between the transmitter and the receiver. This is the reason why I think that it is rather a matter of the earth's surface and not of the diffraction, which determines the strength of the signals at the receiver. A full working out of the analysis is really required, but at least we have shown that the experimental conclusions may be in agreement with the theoretical ones on the assumptions involved.