The Fading Question--Children's Sessions--How To Entertain With Radio--Advice To Novices

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Radio Waves and Natural Fading

Simple Explanation of the Heaviside Layer and its Effects

Beginners in Radio, and others, will find here a simple and understandable explanation of the transmission of radio waves, and will be particularly interested in the phenomena of natural fading. This subject is now attracting a great deal of attention. The explanation here given represents the fundamentals of natural fading, in relation to which, in some aspects, other factors may have a bearing.

(By R. J. Orbell, B.E. Assoc. A.I.E.E.)

Radio receiving sets may be divided into two distinct categories, those of the crystal type, designed primarily for reception of programmes from a local station, and those employing valves with, as a consequence, a more extended range. Owners of crystal sets experience steady an uninterrupted reception from the nearby station; whereas the more ambitious possessors of multi-valve receivers, anxious to find out what their sets can do, try to bring in the more distant broadcasts. While doing this, the valve user frequently meets with a variety of conditions which are unknown on the crystal set, principal among these being difficulty in eliminating the local stations, fading and atmospherics or static.

It is the purpose of this article, therefore, to give, with a minimum of technicality, the thory of what causes some of these effects, together with some idea of the fundamental principles of wave transmission as applied to broadcasting. In order to understand what happens when radio waves travel between a transmitter and a receiver, let us consider an analogy.

Imagine, firstly, a large pond of water with a perfectly calm surface. Now imagine two wooden sticks weighted each at one end, so that these will float vertically in the pond with about half of the sticks above water as in the accompanying sketch at "a" and "b" (See top figure of block).

Suppose that one of these sticks, which are to represent receiving aerials, is weighted in such a manner that, if given a momentary push on its top end, it will oscillate up and down in the still water exactly once in half a second. Let the other stick be so proportioned that it will move in this manner at the rate of once per second. This stick will naturally be longer and heavier than the first one. Let us call the number of times per second at which these "aerials" oscillate their "natural frequencies." These will be 2 for the first one, and 1 for the second one.

Now for our transmitting aerial. This we can conveniently represent as a tapered stick or plunger, mounted vertically in the water some distance away, as shown at "c" in the diagram, capable of being agitated vertically by any mechanical contrivance at any desired speed. Having arranged the above analogies of transmitting and receiving aerials in our imaginary pond, we can now set things in motion. Firstly imagine the "transmitter" to oscillate up and down exactly twice per second, so that every second two waves will be generated on the surface of the water. These will travel outwards in all directions in the form of a series of concentric rings gradually diminishing in intensity. At this stage we should note two important things, firstly, that no matter how small these waves become they always travel at the same velocity; and secondly, that as a consequence of this and the fact that the waves are being produced at a constant rate, there is a definite distance between any two consecutive rings. This definite distance is known as the wave-length, and will, of course, depend on the number of waves produced per second (or frequency) and on the velocity at which they travel.

We could thus establish, experimentally, the fundamental equation for wave propagation in any medium, viz.—

V equals NL.

Where V is the velocity of the waves.

Where N is the number of waves per second, or frequency.

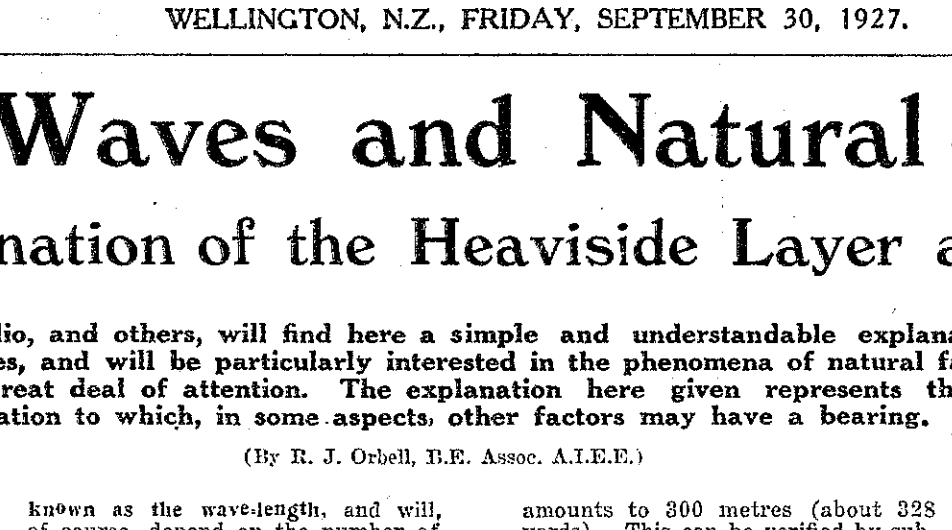
Where L is the wave length (or distance between successive waves).

Let us now see what happens when the two waves per second on our pond pass the two vertical floating sticks. Since one of them has been seen to bob up and down naturally twice per second, this one will be energised by the passing waves and will respond freely at that frequency, while the other one will not be greatly affected unless one wave per second passes it, in which case the first one would not respond.

The above anology indicates in principle what happens when a broadcasting station transmits energy to a receiver, and it also illustrates why a receiver will respond only when it is tuned to the frequency of the transmitter. The chief differences are that the oscillations are electric currents flowing up and down the aerials to the order of a million a second, and that the velocity of the invisible radio waves in ether is 186,000 miles per second instead of the slow velocity of the waves on the pond. Nevertheless there is still a fixed distance between them or wave-length which in the case of a frequency of a million amounts to 300 metres (about 328 yards). This can be verified by substituting the correct valves in the above equation.

This series of waves of constant amplitude continuously radiated from a broadcasting station is known as a carrier wave.

We shall now investigate the manner in which actual speech is transmitted. As already stated, the carrier frequency is, in actual practice, in the neighbourhood of a million per second, the exact figure depending on the wave length decided upon. This is at much too high a rate of oscillation to produce an audible effect in a receiver (about 15,000 vibrations per second being the highest audible note). Suppose, however, that at the station end this carrier is modulated or partially interrupted in accordance with words spoken into a microphone, which are, of course, of a pitch sufficiently low to be audible. It is not difficult to understand that these lower pitched sounds of the voice, superimposed on the carrier frequently can become audible in the receiver, due to fluctuations which they make in the otherwise inaudible carrier currents passing through the receiver. It is not within the scope of this article to discuss fully the actual operation of the receiver, which is not so simple as that touched on here. It is necessary, however, to obtain a clear idea of the above principles by which speech is transmitted, in order to more fully understand the explanations which are to follow.



The top drawing shows a cross-section of water waves on a pond, showing mechanical analogies of a transmitter and two receivers, the latter differently "tuned."

The bottom drawing shows waves from a Broadcasting Station "B" reach the distant receiver R2 by gradual reflection at P2 with comparatively little absorption. The closer receiver R1 receives by two paths, one reflected at a sharp angle, with consequent absorption at P1, and the other direct at "S," with attenuation by the obstacles on the earth's surface. Interference by the two weakened waves produces mushiness by night at R1. Fading is due to rapid variations in the reflective conditions at P2. By day, the "Heavyside Layer" is broken up by the sun.—Hence no reflection, no fading, and no distant reception can then occur.

THE FALLACY OF BROAD TUNING.

When a receiver is situated within a radius of a mile or so from a broadcasting station difficulty is frequently met with in tuning out that station, and when an attempt is made to receive a distant broadcast, both stations come through together.

This gives to the novice the erroneous impression that the local station is broadly tuned. He quite naturally believes that the modulation is being radiated many metres to either side of the wave length assigned to the station. The spark or damped (i.e. not continuous) wave stations, commonly in use on ships for morse communication, are capable of being somewhat broadly tuned, especially if a tight coupling to the aerial is employed. Broadcasting stations, however, utilise a continuous series of modulated waves as has been shown above; hence the frequency in the aerial must keep in step with that in the transmitter itself where the oscillations are generated.

Owing to an interaction of the speech and carrier frequencies (which are, as has been explained, of a greatly different value) there is a narrow margin on each side of the unmodulated carrier frequency, over which the modulation ranges. These two limits, the upper and the lower, are called sidebands, and consist of the sum and difference respectively of the carrier and speech frequencies. In actual practice these limits amount to approximately one meter as a maximum. It is apparent that speech (or music) cannot be radiated over a greater range than that determined by the limits of these narrow sidebands. In order to show why nearby unselective receivers pick up the transmission over a wider scale of wave lengths, let us refer once again to our analogy of water waves on the pond. Imagine that the two weighted sticks previously referred to are both situated a short distance only from the source of the waves. At this point, the impact of the passing of the waves will be so great that both sticks will be forced to rise and fall in sympathy with them, independent of the manner in which the sticks would naturally oscillate in still water. We thus have an illustration of two receivers, each tuned differently, picking up energy from a transmitter radiating one frequency only.

If a receiver is designed so that the coils in it are screened by metal shields to prevent waves from the transmitter from affecting them directly, and if a good wave-trap is use in the aerial wire, little difficulty will be had in tuning to a distant broadcast, not many metres different in tuning from the local station. A wave-trap alone will very greatly improve even a simple unscreened set.

A simple and effective trap may be made at a cost of less than ten shillings as follows:—To the ends of a two inch diameter coil of about 35 turns of any guage wire, join the two sets of plates of an ordinary variable condenser. Then, having removed the aerial from its terminal on the set, join the latter to one end of the coil and the aerial to the other end. To use it, first tune in the local station in the ordinary way,

(Continued on page 5 under "Fading.")