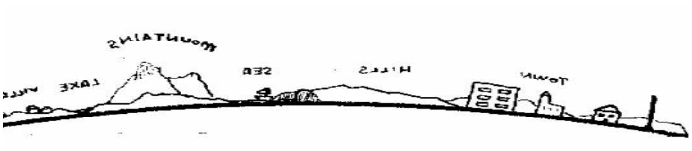
PROPAGATION

Propagation - or what happens to the radio signal between it leaving the transmitter aerial and it arriving at the receiver aerial.

Ground Wave

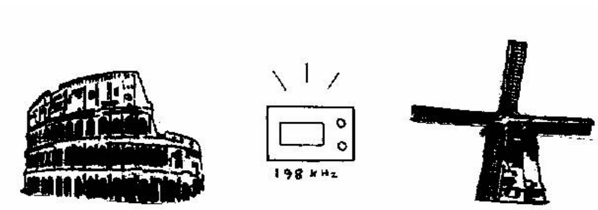
This is the simple case of the signal traveling across the ground (or sea) to the receiving aerial. The actual distance possible will depend on the conductivity of the terrain. It will be best over salty water or over boggy ground and worse over a sandy desert.



The distance covered by the ground wave will depend very much on the frequency. For example 2 MHz may travel hundreds of km and yet 21 MHz barely cover 10 to 1~ km.

Before you pick up the telephone to say you have heard USA on 21 MHz, remember that the present subject is ground weave propagation.

How far?



Low frequencies can have considerable ground wave coverage. You can listen to Radio 4 on 198 kHz at most of your holiday destinations... And the very low standard frequency time signal on 16 kHz goes right round the world.

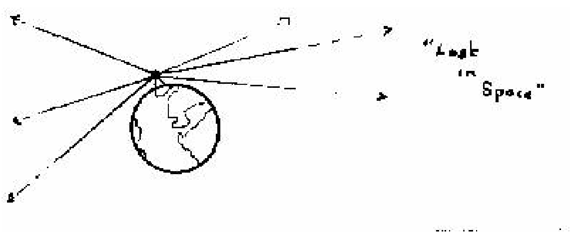
If very low frequencies are so good for world wide communication, why are they not used more often?
Two reasons:

(a) The frequency is too low to carry the bandwidth of speech modulation.

(b) Being low, there are not many frequencies available.

IONOSPHERIC PROPAGATION

So higher frequencies have to be used and therefore a mode of propagation other than the Ground Wave. The answer, as will be seen later in the lesson, is to use ionospheric **refraction.**

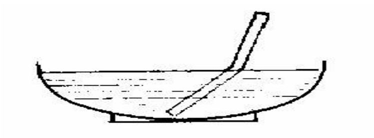


If the world had absolutely nothing around it the radio waves would carry on in straight lines and disappear into space... lost for ever.

Luckily, our world is not in a total vacuum, it is surrounded by oxygen & nitrogen that can be ionized by the X-rays and Ultra Violet rays from the sun. Radio waves are refracted by these ionized layers - the ionosphere.

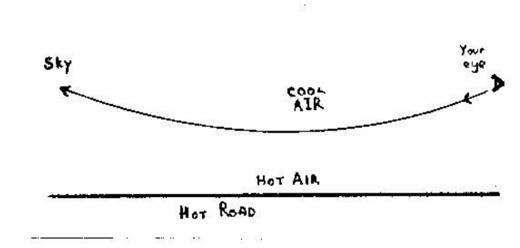
But what is Refraction ?

The Pocket Oxford dictionary says: that it is the deflection of a ray of light etc when it passes obliquely from one medium (water, air, glass etc) to another.



Off to the kitchen and dip a pencil into a bowl of water. It looks as if the pencil is bent where it goes from one medium to another: IE The surface of the water!

Water. water everywhere and not a drop to drink!



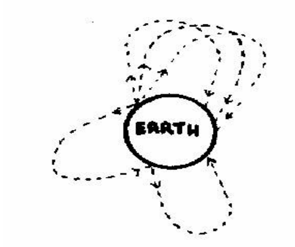
On a hot dry day, look along a clear road..

It will often seem as if there is a puddle In the distance. In fact you are looking through air of different densities and your sight is being bent (refracted) so that you are seeing the sky although you are looking at the road. It is as if you are seeing a reflection of the sky In water.

Now turn this up the other way, replace the hot road with light with radio waves - you have ionospheric refraction.

Refraction in action

The Ionosphere, therefore, bends radio waves so that they come back to earth over the transmitter's horizon. Just think of the great importance of the ionosphere. Over the horizon communication, over a wide range of frequencies Is made possible. The well known long distance (DX) Amateur Bands (14,16,21,24,29 MHz) would be pretty useless were it not for the ionosphere.



Unfortunately it is not so predictable as having a permanent mirror In the sky. As mentioned before, the ionosphere is formed when the suns (X & uV) rays ionise the gasses that surround the earth. Thus there are many factors that affect the formation of the ionosphere.

The forecast is changeable!

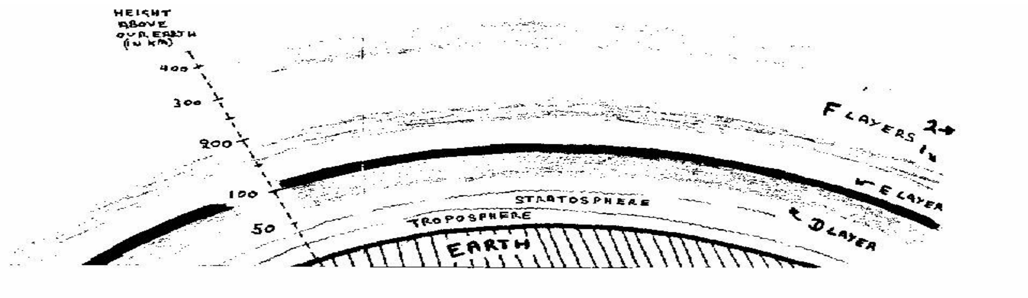
As you might expect the strength of the suns rays will change from day to night and from summer to winter. This, together with changes in the gasses to be ionised, means that the height, thickness and density of the ionosphere is very variable. The position and density of the ionosphere dictate which frequencies will be refracted and by how much. This all means that certain frequencies will be useful to some countries at one time and other frequencies at other times or am other seasons.

Sun Spots

A Sun Spot appears as a dark patch on the sun and causes increased ionisation around our world. Sun Spot activity varies over the years - peaking and dipping (troughing) every eleven years. This extra activity on the sun affects the ionosphere and therefore ionospheric propagation.

Where are these ionised layers?

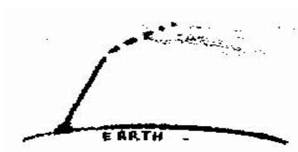
The ionised layers are known as the D, E and *F* layers. The F layer splits into Fl and F2 during the summer daylight hours.



The significance of these layers will vary greatly according to time and season and each will therefore be looked at in more detail.

The D layer

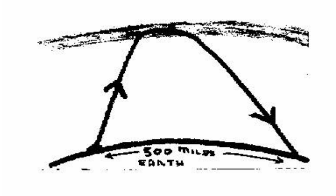
This is the lowest ionised layer being approximately 60 km above us. It is about 25 kms thick and, unfortunately, absorbs rather than refracts radio waves. The state of ionisation depends on the sun, the higher It is in our sky; the higher is the ionisation. There is quite a lot of atmosphere at this height and the ions easily recombine and strong sunshine is necessary to maintain this layer.



The D layer absorption is inversely proportional to the frequency. Thus, low frequency bands (such as i.e. and 3.5 MHz) suffer considerable attenuation during daylight hours and therefore do not reach the upper layers. This limits the lower Amateur Bands to ground wave propagation during the day and dictates the Lower Usable Frequency (LUF) for longer paths.

The E layer

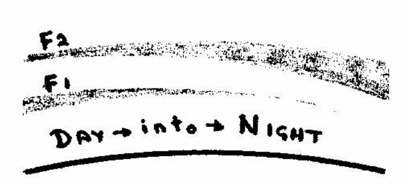
The E layer is from 100 kms to 120 kms above the earth. The atmosphere here, although more rarefied, is enough to dictate that Ions do not have more than a few minutes life after the sun has set.



This is the lowest ionised layer that can usefully be used for ionospheric propagation. The E layer, which will quite happily refract (bend) radio waves during daylight hours, virtually disappears at night. being relatively low, the E layer does not normally result in vast distances of communication. The radio signals are refracted back to earth at distances of hundreds rather that thousands of miles away.

The F laver

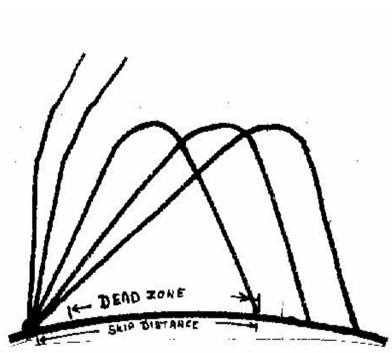
This layer (or layers) is between 140 and 400 kms above the earth.
The atmosphere at this height varies from vary rare to non-existent. The recombination of the ions is therefore very slow. This means that this layer ionises very quickly at sunrise to reach a maximum just after midday. The decay is so slow that the ionised layer remains present all through the darkness hours as well. Of course, it does become a little faded In the early hours, just before it gets its next boost at sun-rise. However once the sun is up, the ionisatlon is quickly back to normal.



During daylight hours the F layer splits into two. The lower part (150-200 kms) disappears at night and the F2 layer approximately doubles its width. This upper (F2) layer is the most important ionised region for long distant communication using "sky waves".

Skv waves

The sky waves can be single or multi-hop. In multi-hop propagation, the radio wave is refracted back to earth where It is reflected up again. This is the way to communicate over the longest distances; to the opposite side of the world. (beyond, If operating "long path").



Skipping

But we do miss a bit!
Radio waves hit the ionosphere at various angles. Those striking at a high angle will pass through and get lost in space. Those hitting the ionosphere obliquely will get refracted back to earth - but some distance away.
Thus, there is an area, beyond the range of the ground wave up to the point where the sky wave returns to earth, that receives no signal. *This is the dead zone.*

Skip Distance

This is the distance between the transmitter and the nearest point on earth where the signal is receivable after having been refracted back from the ionosphere.
The actual skip distance depends on: the time of day, season and most important, the frequency.
Here are some examples:

AMATEUR FREQUENCY		SKIP DISTANCE KMs Noon	and	Midnight
1.9	MH2	0		0
3.6	MHz	0		0
7.1	MHz	0		500
10.1	MHz	350		1000
14.1	MHz	600		1600
16.1	MHz	1200		(These bands
21.1	MHz	1300		(normally only
24.9	MHz	1600		(open during
26.5	MHz	2000		(daylight hours.

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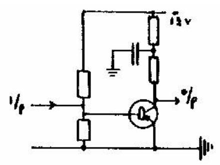
Questions for Lesson 8A *You may have to dig into RAE Manual!*

8A/I) The type of propagation used for contacts between UK and Canada on 14 MHz would be:
a) Ground Wave b) Direct Nave
c) Ionospheric d) Tropospheric

8A/2) The function of the capacitor in this circuit?:
a) Coupling b) Decoupling
c) Tuning d) Quenching



8A/3 What is the desirable bandwidth of an Amateur SSB transmission?
a) 500 Hz b) 2.5 kHz c) 5 kHz d) 10 kHz

8A/4 Which of the following is not affected by the ionosphere?
a) receiver signal strength b) ground Wave c) skip distance d) dead zone

8A/5 Which transmission mode does this symbol represent?
a) SSB b) USB
c) AM c) CW

8A/6 What is the approximate height of the E layer of ionization?
a) 1kM b) 11 kM c) 110 kM d) 1100 kM

8A/7 Which is the most desirable CW (morse) envelope'
a) b) c) d)

A/8 Which is the most .important layer for long distance night communication?
a) D b) E c) Fl d) F2

8A/9 What frequency has a period of 0.04 seconds? (Period is time for 1 cycle)
a) 15 Hz b) 25 Hz c) 50 Hz d) 100 Hz

8A/10) Which of the ionized layers absorbs, rather than refracts, HF signals?
a) D b) E c) F1 d) F2

8A/11 What is the upper frequency limit of the 20 metre Amateur Band?
a) 14.25 MHz b) 14.3 MHz c) 14.35 MHz d) 14.45 MHz

8A/12 A sine wave has an RMS value of 100 Volts. What is its peak voltage?
a) 70.7 Volts b) 63.7 Volts c) 114 Volts d) 141.4 Volts

The next lesson (8B) continues this subject of propagation and looks at the world above 30 MHz.

