How to Design and Erect a Successful Aerial

The Theory of Electro-Magnetic Induction Clearly Explained

By "M.I.R.E."

In this article, the Theory of Electro-Magnetic Induction, or "Lines of Force," as applied to the receiving system, is set forth by M. I. R. E. in an exceptionally able and lucid manner, enabling the most uninitiated experimenters to grasp its principles without effort. Readers will do well to thoroughly digest the theoretical side of the subject, which is intended to throw light upon the practical demonstrations which are to follow. Stress is given to the little appreciated fact that a large aerial is not a vital necessity to multi-valve set owners.

Undoubtedly one of the most vexed subjects amongst those interested in radio is the question of the erection of an aerial, and how to design it, in such a way that maximum efficiency will be obtained.

First of all, let it be stated, that if an aerial is to be erected in a flat, open paddock, where the land is of the average, or better, farming variety, then providing certain well-known principles are followed, the electrical receptivity or efficiency may be predicted to within narrow limits of accuracy. The conditions alter immediately, however, just as soon as the ideal or simple conditions give place to more complicated circumstances, such as the presence of buildings, trees, etc.

It should be distinctly understood that the following remarks are strictly applicable to the reception of signals within the broadcast wave-band, which extends from 220 metres to 580 metres, and particularly with respect to wavelengths between 300 and 450 metres, these being the most frequently used in New Zealand.

POINTS FOR CONSIDERATION.

The main consideration in a flat, open space is to have two wooden masts as high as possible. A "T" type aerial should be used, i.e., with the downleads from the centre, coming straight down to the receiver, which should be installed in a building having as little metal as possible in its construction. From the receiver to the earth connection should be as short as possible. The earth connection preferred is one which makes contact to a water pipe forming part of a town water supply. Stripped of technicalities, this represents an ideal arrangement. Unfortunately, it can seldom be put into practice.

In order to enlighten the inquirer as to why the above is ideal, it is first necessary to consider briefly the theory of operation of an aerial in absorbing energy in the form of ether waves. In order to avoid complicating the explanation, a brief statement of what happens will be made, without detailing why it happens.

"LINES OF FORCE."

If a magnet is laid on a table and a piece of paper is laid over it, and then small pieces of iron (iron filings, for instance) are sprinkled on the paper, the filings will arrange themselves in a regular manner on the paper in such a way as to represent lines drawn from one "pole" to the other. If the magnet is of the same shape as a horseshoe, for instance, the "poles" are represented by the two ends, one being known as the "south" and the other the "north." The lines taken up and indicated by the orderly lines of iron filings, reach in semi-circles from one pole to the other across the gap, the semi-circles reaching out and becoming greater in length as well as radius, as they lie further away from the magnet. These lines are known as "magnetic lines of force," and are always found in close proximity to a magnet.

Now, if a wire (for instance, a piece of copper wire, such as is commonly used in electrical circuits) is caused to move through the magnetic lines of force in such a way as to "cut" them, then an electric current will be set up in that wire. This is the basis of the electric generator.

This action is exactly analagous to what takes place with a wireless aerial. At the transmitter, powerful currents are set up in the aerial, thus creating electric lines of force which extend round about the transmitting aerial and take up positions extending between aerial and earth. By virtue of the oscillating currents taking place in the aerial, the lines of force build up and collapse with tremendous rapidity, in step with the oscillations.

At a wavelength of 360 metres, which is practically the wavelength of 3YA, the frequency at which this action takes place is exactly one million times per second. The result of this disturbance in the electrical (or, perhaps, magnetic) medium, which has been called the "aether," created by this rapid creation and dissipation of the lines of force, is to send out waves which radiate outwards in all directions, with the aerial as a centre. The waves reaching the receiving aerial have a converse effect, because in "cutting" across the aerial wire they represent lines of force and induce electrical currents to flow in the aerial system. To all intents and purposes, therefore, the currents set up in the receiving aerial system represents electrical energy transferred from the transmitter through the aether.

PRINCIPLES APPLIED.

To apply these principles to the case of the receiving system cited at the beginning of this discussion it is only necessary to point out that the more lines cut (ignoring the time factor) or the longer the length of the lines cut means more energy induced, or, in other words, stronger signals. As the wave is advancing vertically, the higher the aerial the more this effect is taken advantage of. Long length of flat top portion of aerial is inconsequent so far as signal strength is concerned when considering the pick-up of the aerial. The length of the aerial must be kept within certain limits purely for purposes of ensuring that, in combination with the tuning arrangements of the receiver, it will function efficiently within the broadcast wave-band so far as tuning is concerned. There is a great deal of misunderstanding on this point, but, broadly speaking, there are the correct relationships between height and length of aerial systems.

ELECTRICAL AND GEOMETRICAL HEIGHT.

The reason it was recommended that wooden masts be used is purely a theoretical one, and that is that the geometrical height of the aerial is not the electrical height. In the case of the ideal T-shaped aerial the electrical height would approximate two-thirds of the geometrical height. If metal masts are used and these are connected to the earth, then the earth is brought so much nearer the aerial at each end, and although the geometrical height remains the same, the electrical height is reduced somewhat.

A building with a metal roof erected under an aerial materially reduces the electrical height, just as the funnels of a steamer do to a ship's aerial system.

DETERMINING FACTORS OF CURRENT FLOW.

The question of a good earth connection introduces a subject which is common to the question of size of wire used in an aerial, and also the question of the use of one or more wires in the overhead system. Suppose water were being forced through a pipe. To get double the water through the pipe in a given time, one of two things would have to be done, either the pressure would have to be doubled or the size of pipe be made twice as large. Therefore, in determining how much water is passed through the pipe there are two controlling factors, pressure and pipe resistance.

In the aerial system (or any electrical system for that matter) there are the same factors determining current flow. With a given height of aerial so many lines of force are cut and this represents a certain pressure available to induce currents to flow in the aerial system. The amount set up is dependent on the resistance offered to its passage in the circuit.

Too small conductors or a bad connection to earth represents resistance which will limit aerial currents, and therefore signal strength. Several conductors in parallel in the overhead system and downleads are therefore theoretically an advantage.

The theoretically ideal aerial described is of the T type. Undoubtedly the most popular type is the L type, and that, one that has the downleads coming down at one end, from a purely practical point of view, this is quite all right, but the reason the T aerial is put forward as superior is because it is absolutely undirectional in its receptivity.

That is it receives equally well north, south, east, or west, whereas the L type has directive effects in the direction in which it is pointing and towards the end from which the downleads are brought down Thus an L aerial pointing north and south and with downleads at the southern end will receive better from a southerly direction than any other point of the compass. If reception is to be carried out from a definite direction then it is obviously an advantage to erect an aerial in this fashion, but it is a questionable arrangement where reception is being carried out from all directions.

In a continued discussion on this subject it is proposed to show that the main considerations in this discussion have been more of a theoretical nature in order to demonstrate principles and in order to throw more light on the discussion of practical points to follow.

LARGE AERIAL NOT A NECESSITY

In conclusion and in addition to the last paragraph it is necessary to point out that a large aerial is not a vital necessity where multi-valve receivers are in use. One of the big things scaring prospective purchasers from investing in radio is the idea that masts and wire must be plastered all round the house in order to instal radio. This is not so. A very modest affair will give all the results desired even with distant reception and the use of an indoor aerial or loop will give complete satisfaction to most people who object to visible outside wires.

So far as obtaining perfect results from an aerial are concerned, it is an obvious but very little appreciated point that if another valve is added to a set, the amplification represented by that valve will more than offset minor, or even major inefficiencies in the aerial system.

Hence the individual who makes his property look like a full-rigged battleship and uses a 4-valve set might just as well use a 5-valve set and be less ambitious with his aerial. Very large aerials are not therefore a necessity, though they may be desirable.

HELPFUL HINTS

IMPROVE YOUR RECEPTION

CRYSTALS IN REFLEX CIRCUITS.

For extreme sensitivity there is nothing to beat a galena crystal when used in conjunction with a fine copper catwhisker. Crystals marketed under various names, ending in "ite," are, in the majority of cases, galena.

DULL EMITTERS BURN OUT.

Don't burn dull emitter valves too bright in order to try to get better signals The filaments may not burn out, but the dull-emitting properties of the valves will be impaired.

BEST POSITION FOR INDOOR AERIAL.

To obtain the best results, an indoor aerial should be as high as possible. The highest indoor position in any house is immediately beneath the roof tiling. An aerial consisting of six or eight parallel wires, attached to insulators, screwed to the under-side of the roof framing, is the best possible arrangement. In actual practice, such an aerial gives excellent results, especially if used in conjunction with a fairly sensitive valve receiving set.

REFLEX RECEIVERS.

If properly wired, a reflex receiver will perform remarkably well. It must be remembered the valves in these receivers are doing double duty, as both radio-frequency amplifier and audio-frequency amplifier at the same time, and therefore cannot perform at maximum efficiency. But reflex does give good results when used properly.

HAND-CAPACITY EFFECTS.

A metal shield will reduce hand capacity effect to a minimum in a set. It has been found that in a well-constructed, carefully designed set, capacity effects are absent.

USE OF BY-PASS CONDENSER.

It is a good plan to use such a fixed condenser, although the set will operate without. It usually improves the control of the regeneration.

RANGE OF CRYSTAL RECEIVER.

The consistent range of a crystal receiver is from 10 to 25 miles. However, under freak conditions, receivers of this type have been known to pick up signals of stations some hundred miles away. Much depends upon the quality, length, and height of the aerial.

LOOSE VALVE CONTACT.

When the valve does not fit properly in its socket, a toothpick or a match whittled down to form a wedge can be placed between the socket and the valve to hold it tightly in place.

CRYSTAL SENSITIVITY.

A sensitive spot on a crystal soon loses its sensitiveness; when one spot is exhausted, find another, until the crystal is finished. Keep your fingers off the crystal.

CONCERNING CONDENSERS.

The fixed condenser in a receiving set should have mica dielectrics for best results. Do not use condensers in which the dielectric is paraffin paper. For the best operation of a set it is important to make sure the condenser is of the proper capacity for the part of the circuit for which it is intended.

CRYSTAL CUPS.

When mounting a crystal in a cup of the type in which the top or cap is screwed down to hold the crystal in place, you will sometimes find, especially if you are using a small fragment of crystal, that the latter cannot be fixed tightly even when the cap is screwed home. To get over this difficulty, take a piece of tinfoil and crumple it up in a small pad, place this in the cup first, to raise the crystal up a little, and then screw down the cap. Add more foil if necessary. If the hole in the cap is too large, roll some foil into a little stem, and bend this round into a ring, and lay on the top of the crystal. Or a brass washer having a smaller hole than that in the crystal cap may be introduced upon the top of the crystal.

EARTH CONNECTION.

A water-pipe is not the only method of making a good earth connection. A large metal object buried will also answer the purpose of a ground. In some cases, where it is impossible to obtain a good ground connection, a counterpoise is used.

HOME-MADE DRY "B" BATTERIES.

These may be constructed by breaking ordinary flashlight batteries in separate cells, and connecting them in series. These batteries usually have from two to three cells, and some extremely larger ones have four. Each cell will have approximately a volt and a half. It will, therefore, require 15 of these cells to make a 22½ volt "B" battery.

PLACE SET NEAR THE GROUND.

It is not commonly known that it is preferable to place the set near the earth, rather than near the aerial. For example, if you have the choice of an attic or a ground floor room for your wireless room, it is better to choose the latter. The lead-in may be fairly long, but the earth lead should be as short as possible.

GRID CURRENT

A NEW THEORY.

Ever since the advent of the first transformer coupled valve audio amplifier we have always guarded against the presence of grid current in the grid-filament circuit of the valves. We have been informed that grid current causes amplitude distortion, a change in the signal wave form, a reduction in the valve amplification, in general everything detrimental to good audio amplification. In fact, all fans have been warned against permitting grid current in any amplifiers.

Now we hear of a new system of audio amplification in which grid current is permissible; in which the amount of grid current usually encountered with very detrimental results in a transformer coupled audio system, has no effect upon the wave form or amplification. This new theory of amplification is propounded by E. E. Hiler, and pertains to tuned double impedance amplification.

DISTORTION ELIMINATED.

The presence of grid current is usually considered as an indication of valve overloading, and is made audible in the loudspeaker by a rasping or blasting sound on certain frequencies. With this new system, it seems as if this form of annoyance is removed. The reason for permitting a certain amount of grid current is founded upon the fact that the momentary change in the grid filament circuit when grid current is present is not reflected back upon the primary circuit of the coupling unit in this system of amplification. Neither is the amplifying operating characteristic of the grid choke altered until the grid filament resistance drops to a very low value.

IMPROVISED PICKUP

ELECTRIFIED GRAMOPHONE.

One of the most interesting developments in gramophone design in the last year has been the introduction of the so-called "electric pick-up" by which the music from the gramophone is reproduced on a loudspeaker operated by a valve amplifier, instead of on the ordinary gramophone reproducer. The new system generally gives a much improved quality of reproduction, and it also makes possible the production of a far greater volume of sound than can be obtained from the ordinary gramophone. This is a distinct advantage when the instrument is being used for dancing. Although the commercially made electric pick-up devices are fairly expensive, a simple experimental pick-up, capable of giving excellent results, can easily be made from an old wireless earpiece. The earpiece is detached from the headband, and the diaphragm beneath the cap is removed by screwing off the cap. The orifice in the cap is enlarged until the cap takes the form of a locking ring, which can be replaced on the earpiece to hold the diaphragm in position. The centre of the diaphragm is carefully burnished with sandpaper and a length of bus bar, or some similar rigid metal rod—an old bicycle spoke will do well—is soldered vertically on to the centre of the diaphragm, using as little solder as possible.

DO NOT DENT DIAPHRAGM.

Care must be taken not to dent the diaphragm. The vertical rod is then bent over in the same shape as the needle arm, which is attached to the diaphragm on the reproducer of an ordinary gramphone, and a needle-holder taken from an old gramophone reproducer is soldered to the other end of it. If no needle-holder is available a light brass screw connecter, which can be bought for about 3d., will do instead. Level with the edge of the receiver cap a light supporting hinge should be attached to the bus bar in the manner in which the supporting hinge at the edge of the reproducer is attached to the needle arm on the ordinary gramophone reproducer.

The connections for the apparatus are simple. One of the two wires in the cord from the headphone is connected to the grid of the first valve in a valve amplifier, and the second wire is connected to the negative terminal of the filament lighting battery. If desired, the pick-up can be attached to a wireless receiver by removing the detector valve from its socket and connecting one of the conductors in the cord to one termial of the primary of the first inter-valve transformer, and the other wire from the cord to the second terminal of the transformer primary. In use the telephone earpiece can be attached to the tone arm of the gramophile by rubber bands, with the needle bearing on the record in the ordinary way. No needle, of course, is used in the gramophone reproducer.

A UNIQUE DEVICE

NOVEL LOUDSPEAKER UNIT.

A striking novelty has just appeared on the New Zealand market in the form of a loudspeaker unit which, when applied to a cupboard, writing table, piano, door, window pane or similar object converts any of these into a loudspeaker. The device is connected to a radio set in a similar manner to that of the ordinary loudspeaker. It may be described as a pocket loudspeaker, the vibrations from which are amplified by the object it rests upon. If used in conjunction with a portable receiving set it can be placed on an empty cigar box or similar receptacle which then becomes a veritable loudspeaker. The various objects may be tested for tone so that the one best adapted for the purpose can be used. Resonance and tonal quality can be extracted from most unexpected objects, and interesting experiments may be carried out in this direction.