

How to Design and Erect a Successful Aerial

Practical application of principles and theories

By "M.I.R.E."

IN last week's issue of this column a discussion was commenced on the question of the design of aerial systems, and it was shown that certain factors of design were theoretically ideal. In this issue the question of the practical application of the principles discussed will be treated. Briefly, the ideal arrangement was shown to be one in which the aerial was as high as possible from a geometrical point of view in order that the electrical height (which is less than the former) should be as great a value as possible. The length of flat-top portion was shown to be a function of tuning rather than receptivity and the sensitivity of L and T designs of aerials insofar as their directional properties are concerned, were dealt with, the T aerial being shown to be uni-directional in receptivity, while the L aerial was found to be directional in a line from the down-lead end.

AN OBVIOUS COURSE.

Now these considerations are theoretical, especially in the case of the height, because the question where space is limited is, what is the best arrangement permissible in terms of the limitations. Very few people are inclined to go in for elaborate arrangements, especially when, as was stressed in our last issue, an elaborate aerial and a 4-valve set, and a modest aerial and a 5-valve set, will give the same results.

There might be a temptation to erect a forty-foot mast, but if a thirty-foot tree is available there is an obvious course to pursue—an extra valve is cheaper than a mast.

SOLVING THE PROBLEM.

Either in town or country the problem of aerial erection is best solved by selecting the two highest points on the property, such that the distance between them plus the length of the down lead does not exceed 150 feet. As far as possible, the whole length of the wire should be in the same horizontal direction, that is to say, if the flat-

top portion of the aerial is erected north and south, the lead-down and in-wires should come straight down and not point in any other direction, east and west for instance, especially if the down-leads are of a length comparable to that of the flat-top. Again it is not good practice to bring the down-leads in an aerial of the design back at an acute angle with respect to the horizontal portion, but the leads should be taken from the flat-top portion either at the centre (thus making a T aerial) or else at such a position as to enable the leads to be dropped vertically to the lead-in tube.

There are all manner of wierd notions in existence regarding the necessity of preserving symmetry of design of aerials in order to obtain balanced flow of currents, but although there is some method in the madness due to interesting phenomena called "reflections," these notions should be forgotten. The preservation of symmetry is neither here nor there when it comes to practical results.

AVOID ACUTE ANGLES.

Before leaving the question, however, it would be desirable to clear up definitely another point much debated amongst laymen (and amongst many people who ought to know better as well, incidentally) and that is, that the down-leads should always be brought down from the higher end of the flat-top, where the flat-top portion is not horizontal (that is, parallel with the ground). Remember the necessity to avoid an acute angle of down-lead to flat-top, so that if such a condition is going to result it would probably be better to use a wire as vertical as possible with the bottom end connected to the lead-in tube and receiver. When an acute angle occurs, although increased, effective, or electrical height is forthcoming, the actual receptivity of the aerial system is reduced, because of the fact that the currents picked up in the downleads, due to ether waves, tend to counter those picked up in the flat-top. If the angle of downlead to flat-top lies between 0 and 80 degrees this will happen to an increasing degree, as the angle becomes more acute. Thus two wires joined at one end (i.e., in series),

and running parallel to one another, should be entirely non-receptive, and this happens in practice.

MULTIPLE WIRE AERIALS.

Reverting to the question of the resistance of an aerial and the necessity to keep any losses at an absolute minimum, it was mentioned in our last issue that it is theoretically desirable to have a number of wires joined in parallel in both the flat-top portion, as well as the down-leads, in order to keep down resistance, and thereby avoid loss of signal strength.

Here, again, practice decides that a single wire is sufficient for reception, at any rate. As a matter of fact, the reason that multiple wire aerials came into being was because ships used them in order to be able to transmit efficiently on 600 metres wavelength. The average height and distance between masts of ships called for a standard design of tuning arrangement on a ship's set, and in order to meet this the number of wires in an aerial was varied according to mast dimensions. Invariably men-o-war used many wires in "squirrelcage" form to cope with the high powers of their transmitters.

To-day we see the majority of merchant ships with only one wire for transmission and reception, owing to new and more flexible designs of tuning arrangements. Here, again, the addition of some amplification in the shape of an extra valve will make one wire aerial perform with the efficiency of a four-wire aerial of a greater height.

A VEXED QUESTION.

The question of the insulation of an aerial is a vexed one. Why should an aerial wire be left bare, and yet kept insulated from masts, stays, etc.? Why does an aerial wire still work if the wire is covered all over with insulation? It is unnecessary to retrace the ground covered in last week's discussion, but it was pointed out that ether waves, in "cutting across" the wires of an aerial, set up electrical currents, which represent the energy to work the receiver.

Now, aether waves are capable of penetrating all insulators without hindrance, but when they strike substances which are conductors they give up their energy in the form of currents. Hence an aerial made of insulated wire is no different to a bare wire, because the aether waves ignore the insulation completely.

However, it is necessary to preserve the currents induced in the wire intact, in order to make full use of them, and the aerial is, therefore, well insulated to prevent their escape to earth, except through the receiver.

Aerials are very often seen with the flat-top portion composed of bare wire, and the down-leads of insulated wire, the impression being that the flat-top portion of the aerial does the picking-up, and the down-leads are for the purpose of carrying the results into the receiver. In view of the preceding explanations, it will be seen that this idea is very wide of the mark, as the down-leads are effective pick-ups, and form part of the active system of the aerial.

PAWNSHOP ADVERTISEMENT.

The practice has grown of fixing a metal ball to an aerial with the object of sometimes increasing the pick-up of the aerial, reduction of static, reduction of interference, etc. The only actual effect is to make an aerial look like an advertisement for a pawnshop. The metal ball increases the capacity slightly, has no material effect in reducing the resistance, its effect on static and interference is nil, and difference in pick-up is only noticeable where the ball is fixed to the top of a mast (without any flat-top) and a wire is brought down to the receiver. With or without the ball, slightly increased results will be noticeable with a local transmitting station when the ball is in circuit. There are many people who will recount wonderful results with these gadgets. The politest way of disposing of such claims is to say that they do not fit in with observed results measured with scientific instruments. Factors governing reception are so varied and legion in number that it is a very difficult thing to say definitely just what improvement

may take place due to some alteration of aerial system. The actual improvement, if any is noted, may be due to something quite different.

Without complicated measuring instruments it is impossible to make comparison of results, because ideas of signal strength cannot be carried in the head even for five minutes to justify a statement of other than very definite alterations.

Reverting to the directive characteristics of L aerials, unless the flat-top portion is at least ten times the height of the downleads there is no marked result. To get really definite results a wire 160 to 150 feet long about a foot or two above the earth is necessary. The Beveridge aerial used by the Transatlantic receiving stations on the American seaboard have a flat-top of over ten miles at a height of 80 feet! These are used on wavelengths approximating 14,000 metres. Directional effects may be often noticed with standard designs of L aerials, but the results are invariably due to either shielding or reradiation from close-by objects, such as buildings, trees, wire fences, etc. An aerial 100 feet long and 20 feet high would show no appreciable directive results if erected in an open paddock. This is not to say that it is inadvisable to erect an aerial east and west with the downleads from the western end if Australian reception is to be concentrated. The advantage gained is worth going after, because every little bit helps.

Here, again, an extra valve will be worth half a dozen directional aerials!

Summed up, then, an aerial should be as high as possible, have no acute angles of down lead with respect to flat-tops, have a short lead from lead-in tube to set, and set to earth connection, and the resistance should be as low as possible.

In practice, however, a compromise will usually have to be effected by making the best of the advantages offering in the shape of trees, etc., but the easiest method is to do the best possible and save worry by bringing a six-valve set in place of the proposed five.

WHY SOME HOME-BUILT SETS FAIL

CAUSES OF UNSATISFACTORY CONDITIONS

I don't like to be too direct in my accusations. In fact (writes "X.Y.Z." in the Melbourne "Listener-in"), I don't like to make accusations at all, and would much prefer to have any of my statements falling into this category termed as assertions.

Nevertheless, there is a question in my mind which has been there ever since I began experimenting with radio many years ago, and it has never been answered. In vain, I have tried to seek the information desired, only to be sidetracked in the end, until I found it necessary to arrive at my own conclusion in the matter, which conclusion is as follows:—

Ever since the early days of the crystal set and the single valve, we have had radio authors. And ever since the advent of radio authors we have had "distance records" which poor, ordinary mortals tried to equal or beat with but little success.

Times innumerable I have casually glanced through a story describing a new circuit or receiver, and, invariably, when I reached that part of the article dealing with "What it Has Done," I became sold through the prospect of receiving interstate stations every night in the week, and sometimes in the afternoon as well.

Now, as I said in the beginning, I don't like to make accusations, but doesn't it seem queer that the designer and author of the story on the "Blank" circuit plus a very few of the builders of this set incorporating the circuit, are the only ones to receive stations "thousands of miles away," while the majority of people who build the set do well to receive broadcasters within a 250-mile radius? It did to me, I know; but never having been able to secure a satisfactory explanation to the question, I set about to learn what I could for myself, and, as a result, I found both contracting parties to be equally to blame, though neither of them suspected that guilt rested on their spotless characters.

STUDYING THE FAN.

Let us view for a moment the actions of the set builder. In the majority of cases the investigator will find him to be a more or less regular "circuit fan." This type of addict is one, like yourself, who, when he sees a new circuit, immediately sets about to "throw it together" and see what it can do.

The first step followed by the "circuit fan" is casually to glance over the list of parts and to summarise what is needed to build the set. One look and he discards at least 50 per cent. of the apparatus listed.

"Two audio transformers," he reads.

"I have a couple of old ones home that will be good enough for a trial," he concludes.

"A five-megohm grid leak is what they specify for the detector. Huh! I don't suppose it would make much difference if I used that old two-megohm grid leak that I have laying around somewhere. They specify two .00035 mfd. variable condensers for tuning the antenna and detector circuits. Well, I can use those old .00035's if I take off a few turns from the coils. And there's another thing, the coils they used are wound on two-inch tubing. That old four-inch cardboard tubing I have at home will serve the purpose just as well if I leave off a few more turns.

"Gosh, this set uses four .5 mfd. by-pass condensers. Those things don't mean much, anyhow, and, besides, it's only a test I'm making, so I guess I can do without them, as well as without the radio frequency choke coil in the plate circuit of the detector valve. As far as rheostats are concerned, I won't have to use them in this test. I'll put six volts directly across the filaments; it ought to work just as well."

So friend hurries home that night and spreads all his apparatus on a broad board, and begins to wire the set with No. 28 wire, or worse.

We might be able to cut the tip off little Johnny's nose and still be able to recognise him, but when we twist his ears, blacken his face, cross his eyes and pull all his teeth, the poor child will find little maternal comfort by saying, "Well, mamma, here I am." And so it is with a radio set. We can take a few liberties and get away with it, but when we start redesigning it, it naturally follows that we have an entirely different set. A set with a hundred links that must be ironed out, and which, even after the flattening process, may be far from desirable.

Let us review just what our friend has done to change the characteristics of the set to such a remarkable degree. First, the use of the old audio transformers in place of the modern type will naturally result in inferior quality. Second, he substituted a two-megohm grid leak for the five-megohm grid leak which was specified. If you know anything at all about radio receiving sets, you will appreciate the importance of the grid leak and, particularly with the regenerative receiver, the rather critical requirements in the matter of the resistance value of this unit. In some of the more unstable regenerative receivers of bygone days, reception from a distant station could be destroyed entirely, merely by changing the value of the grid leak. Thus we find that the set builder, simply by making this substitution, has detracted at least 5 per cent. from the efficiency of the circuit as described.

MAKES DRASTIC CHANGE.

In his next substitution, he performs an operation upon the vitals of the receiver—the radio frequency tuning and neutralising system. In the first place, let us suppose that the receiver called for a detector tuning coil, comprising a primary and a secondary wound on a 2-inch former, the latter coil consisting of 75 turns of a certain size of wire, tapped at the sixteenth turn for neutralisation purposes. The set-builder makes a few comparative calculations and decides that sixty turns would be about right for the .00035 condenser. He then compensates for the fact that he is using a larger diameter tubing and does a little more calculating, reducing the number of turns on the secondary to thirty. However, in many instances, he fails to take note of the fact that the tap for neutralisation must also be changed, and instead of changing the specifications in this respect, he places his tap at the sixteenth turn as originally specified.

He makes his next mistake in eliminating the by-pass condensers, which, despite his belief, do play an important part in the operation of the receiver, though their effect may not be noticeable to the ear on reception from

local stations. His elimination of the choke coil in this particular circuit is fatal, for regeneration is accomplished by feed-back through a midge condenser, which instrument is generally useless without assistance from the choke-coil in forcing back the radio frequency currents into the grid circuit.

In summation of all the substitutions we find the following:—First, the quality of reproduction in the receiver thus "thrown together" is terrible; second, the detector is not functioning at maximum efficiency due to improper value of the grid leak; third, the radio frequency stage is either unbalanced, resulting in squealing, or overbalanced, resulting in weak signals—both conditions being due to improper neutralisation; fourth, unstabilisation, due to failure to by-pass stray radio frequency currents, and, finally, lack of sensitivity is brought about through absence of regeneration in the detector circuit and incorrect grid biasing because of the absence of proper filament control.

AUTHOR TO BLAME, TOO.

However, the designer and author is not entirely without blame for the condition mentioned in the outset of this article. The design and perfection of the receiver he describes may have taken him anywhere from a week to more than a year, and the time elapsed between its completion and the writing of the story describing its construction may be considered, during which period it is quite possible that the receiver or copies of it have been tested many different times, and in many different locations.

Making allowances for the enthusiasm of the designer and author, it is easy to see that he would naturally credit all feats performed by a receiver incorporating his circuit to the system which is of his own invention or sign. Perhaps he does not fully take into consideration the location in which the receiver has been tested. Let us assume that three or four receivers incorporating a new circuit are distributed to various locations for test prior to the description of set for benefit of the public. One of the sets will probably be kept in, say, Melbourne, while another might be sent to a friend residing in, say, Sydney, certain sections of which are notable for their reception of distant stations.

The third set may be sent to a friend in Mildura, where stations to the north and south are easily received, while the fourth set might possibly find a testing place in Gippsland.

TESTS LAST WEEKS.

Let us assume that the test extends over a period of several weeks, during which time the receivers in the outlying districts are piling up some very enviable distance records. When the tests are completed, it is only natural that the designer of the set should combine all the reports of distant reception and credit his receiver with these performances. In the broader sense, however, the circuit is not entirely responsible for the reception it is credited with, since the locations in which the tests were made played a very important part. For greatest accuracy, it might be more equitable when mentioning records made by receiving sets incorporating new circuits to specify the particular location in which the test was made, the time of day and the comparative performances of other receivers, the characteristics of which are more generally known to the average fan.

Thus, we find that both parties are contributors to the disappointments that sometimes follow the building of a new receiver. In analysing my own actions, as well as those of other fans, I have gained a pretty fair idea of the set builder's position, and in fairness to all concerned I am sure that the builders are far more to blame than the designer, since the latter's error, if there is one, lies only in a slight over-enthusiasm, while the builder not only often disregards the carefully planned specifications set forth in the story, but in many cases may be accused of carelessness in building the set.

Radio experiments conducted under the direction of Professor N. I. Adams Jr., of Sloan Laboratory, Yale University, U.S.A., disclose the possibility of using a pair of matched piezo-electric crystals to control two or more broadcasting stations so that they can operate simultaneously on the same wavelength without producing heterodyne howls. This system, Professor Adams believes, may enable networks to use one wave and clear many channels, making it unnecessary to eliminate 300 broadcasters, as has been proposed by Federal Commissioner Pickard.

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